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Marine Ecosystems and Human Well-being: The PICES-Japan MAFF MarWeB Project

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Marine Ecosystems and Human Well-being: The PICES–Japan MAFF MarWeB Project

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Executive Summary

Progress is being made internationally on an ecosystem approach to the management of marine systems, in particular as applied to ecosystem-based fisheries management. This concept has recently been expanded to include people in what are now called coupled marine social-ecological systems. Such concepts can provide an integrated understanding of how ecosystem changes affect human social systems, and *vice versa*. This integrated concept of understanding social-ecological systems in the coastal areas in order to achieve a sustainable balance between these two systems is called *sato-umi* (village seas) in Japanese. In 2012, PICES started an integrated social-ecological systems research project named "Marine Ecosystem Health and Human Well-Being (MarWeB)", which was funded by the Japanese Ministry of Agriculture, Forestry and Fisheries. The key questions of the project were: (a) How do marine ecosystems support human well-being? and (b) How do human communities support sustainable and productive marine ecosystems? This report is the summary of the results from the project.

In this report, various social and natural scientific tools are introduced using real data from case studies to exemplify how to conduct social-ecological systems analysis for marine-dependent communities. Section 2 provides an overview of novel research at the national level on how the member countries of PICES and one of the case study nations (Indonesia) perceive their interactions with the sea. This section sets the general concepts for how people interact with the sea, and identifies important national differences. It uses the concepts of human well-being, and involves peoples' evaluations of their lives and interactions with the sea, such as positive emotions, engagement, satisfaction, and meaning. Because marine ecosystems provide a wide-variety of ecosystem services, some kind of "weighting function" is needed in order to allocate the limited human and financial resources to protect/conserve ecosystem services in socially appropriate ways. The challenge here is that each society or country has its specific priorities based on their cultural and historical backgrounds. At the same time, in order to discuss social-ecological systems approaches at the scale of the entire North Pacific, understanding the differences and commonalities in how well-being is structured among these countries is needed.

Section 3 presents a summary of the first case study focusing on shrimp aquaculture in Indonesia. In this study, local needs were apparent from the beginning, including the prevention of land erosion by abandoned shrimp ponds after the occurrence of shrimp diseases from excessively intensive aquaculture operations. To reduce emissions of high-nutrient effluents into the coastal zone, integrated multi-trophic aquaculture (IMTA) technology was introduced to conduct multi-species aquaculture in a sustainable manner. Also, scientific techniques to monitor impacts to the local marine ecosystems were presented. Section 4 summarises the results from community needs assessments and attempts to implement oyster aquaculture in coastal communities of Guatemala. Guatemala represents a "bottom up", and Indonesia a "top down", example of different approaches to implementing *sato-umi* concepts. In Section 5, the current situation of the nation-wide introduction of marine protected areas in Palau is described.

Section 6 presents comparisons among the case studies. As the final section, Section 7 provides the conclusions, lessons learned and recommendations for how to conduct social-ecological systems (*sato-umi* type) analyses in developing countries around the North Pacific.

In response to the two key questions posed at the outset of this project, we offer the following conclusions:

(a) How do marine ecosystems support human well-being?

The "traditional" biophysical science approach to this question is often framed in terms of food supply and livelihoods. However, this narrow framing leaves out the very important psychological needs of how people relate to the sea. In reality, both psychological and physical needs are required for positive human well-being.

(b) How do human communities support sustainable and productive marine ecosystems?

This is the reciprocal question to that above. It is a more social science-centered view, with the focus on people and what they do, or can do, to ensure or improve healthy marine ecosystems. The actions of people can be detrimental or beneficial to marine ecosystems. These actions become all the more important to consider when the biophysical marine ecosystems are already under stress, for example from a changing climate. This concept of what people can do to cultivate healthy marine ecosystems is at the core of the Japanese concept of *sato-umi*.

One of the strongest lessons learned from these studies was the importance of connecting with organizations in each country which could facilitate and advance the project. In order to conduct social-ecological systems research in an effective and efficient way, close connections with these key organizations and people are needed to understand the concept of marine social-ecological systems, and to be able to translate it into the local context.

要約

漁業管理における生態系アプローチの導入にも代表されるように、生態系に基づく管理の議論が国際的に積み重ねられている。特に近年は、社会生態系という大きな視点に基づき、人間活動を含めた系（システム）の考察が始まっている。このような視点により、生態系の変化が人間社会に与える影響や、またその逆向きの影響について、統合的な理解をもたらしてくれる。特に沿岸域を対象にして、生態系と社会系のバランスを全体として考察するアプローチを日本では里海と呼ぶ。2012 年度より 2016 年度まで、PICES は日本国農林水産省の予算により、社会生態系の統合研究プロジェクト「海洋生態系の健全性と人間福利（MarWeB）」を開始した。その中心的な研究クエスチョンは（a）海の生態系は人間の福利（Well-being）をどのように支えているのか、（b）人間社会はどのように生態系の持続性と生産性を維持できるのか、という 2 つの疑問である。この報告書は、MarWeB プロジェクトの成果概要である。

本報告書では、自然科学・社会科学の様々な分析手法が、現場の生データとともに紹介される。まず第 2 章では、PICES 加盟国およびインドネシアの人々と海とのかかわりについて、心理学的な手法をもちいた比較研究をおこなっている。海洋生態系は様々な生態系サービスをもたらすため、限られた予算で生態系の保全を行うためには、様々な生態系サービスに対して何らかの優先順位付けが必要となる。その優先順位は、各国の社会的背景や歴史によって異なることが示される。また同時に、北太平洋全体の保全を議論するためにも、このような国による差異の科学的把握は重要である。

第 3 章は、インドネシアにおける多栄養段階複合養殖（IMTA）の事例分析結果である。IMTA により沿岸域の汚染を減らし、大量へい死を防ぎ、生産物が多様化され、それが地域で多様に活用されることを分析している。第 4 章は、ガテマラにおける地域ニーズの把握と、その結果にもとづくカキ養殖の導入についてである。インドネシアは比較的トップダウン的なアプローチ、ガテマラはボトムアップ的な事例である。第 5 章では、パラウにおける全国的な海洋保護区導入の現状について紹介する。

第 6 章は事例の比較分析、そして第 7 章は結論と教訓である。まず 2 つの研究クエスチョンについて、(a)については、これまでの伝統的な自然科学的研究アプローチは主に物的な生産に着目しており、それは人々がどのように海とかかわっているかという、非常に重要な側面を見落としてしまうということである。よって、自然科学・社会科学の両方による統合研究が重要であることが明らかとなった。(b)については、より社会科学的なアプローチが重要である。特に、気候変動のように、自然科学的な条件がすでに喫緊な状態にある（人間社会から生態系へのストレスが大きくなっている）場合、人々がいかに海洋生態系を保全できるのか、それをどのように担保するのか、という面が重要であり、それは日本の里海という概念の中心でもある。

本プロジェクトにより得られた最も重要な教訓の一つは、事例研究対象国における窓口の重要性である。キーとなる組織や個人が、社会生態系の概念をよく理解し、そしてそれを現地の文脈に翻訳することが、効果的な研究の実行に不可欠である。

Ringkasan

Kemajuan dalam bidang pengelolaan sumberdaya kelautan dengan pendekatan ekosistem sedang berlangsung secara global di dunia internasional, terutama dalam bidang pengelolaan sumberdaya perikanan berbasis ekosistem. Konsep ini diperluas dengan melibatkan masyarakat ke dalam suatu sistem terintegrasi yang sekarang dikenal sebagai sistem sosio-ekologi kelautan. Konsep semacam ini dapat memberikan pemahaman secara terpadu tentang bagaimana perubahan ekosistem dapat mempengaruhi sistem sosial kehidupan manusia, dan sebaliknya. Konsep terpadu untuk memahami sistem sosio-ekologi di kawasan pesisir untuk mencapai keseimbangan yang berkelanjutan antara kedua sistem ini disebut *sato-umi* (desa-laut) dalam bahasa Jepang. Pada tahun 2012, PICES memulai sebuah proyek penelitian sistem sosio-ekologi terpadu yang diberi nama "Marine Ecosystem Health and Human Well-Being (MarWeB)" atau Ekosistem Kelautan untuk Kesejahteraan Manusia, yang didanai oleh Kementerian Pertanian, Kehutanan dan Perikanan Jepang. Pertanyaan utama dari proyek ini adalah: (a) bagaimana ekosistem laut dapat mendukung kesejahteraan manusia? dan (b) bagaimana masyarakat dapat mendukung pengelolaan ekosistem laut secara berkelanjutan dan produktif? Laporan ini merupakan rangkuman hasil dari proyek MarWeB.

Dalam laporan ini, berbagai perangkat metoda ilmiah sosio-ekologi diperkenalkan dengan menggunakan data riil dari studi kasus untuk memberi contoh bagaimana analisis sistem sosio-ekologi dilakukan untuk masyarakat yang hidupnya bergantung kepada laut. Bagian 2 memberikan gambaran umum tentang penelitian terbaru di tingkat nasional mengenai bagaimana negara-negara anggota PICES dengan studi kasus pada salah satu negara dapat memahami interaksi masyarakat dengan sumberdaya laut. Bagian ini menyampaikan konsep umum tentang bagaimana masyarakat berinteraksi dengan sumberdaya laut, dan mengidentifikasi beberapa perbedaan yang penting secara nasional. Hal in dilakukan dengan menggunakan indikator konsep kesejahteraan masyarakat, dengan melibatkan masyarakat dalam mengevaluasi tentang kehidupan dan interaksi mereka dengan sumberdaya laut, seperti hal-hal yang bersifat positif yang berkaitan dengan keterlibatan mereka dalam suatu kegiatan, kemudian tentang kepuasan dan memaknai arti kehidupan. Mengingat ekosistem laut menyediakan beragam sumberdaya untuk kehidupan manusia, berbagai strategi diperlukan agar sumber daya baik manusia maupun keuangan yang bersifat terbatas dapat dialokasikan atau dimanfaatkan untuk melestarikan sumberdaya laut melalui pendekatan sosio-ekologi. Tantangan yang dihadapi dalam hal ini adalah bagaimana masyarakat atau negara dapat memprioritaskan program yang spesifik untuk mengelola sumberdaya laut secara berkelanjutan berdasarkan latar belakang budaya dan sejarah yang dimilikinya. Pada saat yang sama, untuk membahas pendekatan sistem sosio-ekologi di wilayah Pasifik Utara, pemahaman akan perbedaan dan kesamaan tentang struktur dan ukuran kesejahteraan antara negara sangat diperlukan.

Bagian 3 menyajikan ringkasan studi kasus pertama tentang budidaya udang dan perikanan terintegrasi di Indonesia. Dalam penelitian ini, diketahui bahwa setiap daerah memiliki karakteristik yang berbeda dalam pengembangan budidaya perikanan, termasuk bagaimana mengoptimalkan lahan tambak yang terbengkalai karena kerusakan lingkungan akibat pengembangan budidaya udang secara intensif dalam kurun waktu tahun 1980 an yang menyebabkan timbulnya wabah penyakit pada udang. Untuk mengurangi pencemaran

lingkungan perairan akibat limbah organik di kawasan pesisir, teknologi budidaya perikanan terintegrasi berbasis sistem bioresirkulasi yang dikenal dengan nama integrated multi-tropic aquaculture (IMTA) dengan menggunakan beberapa jenis komoditi budidaya perikanan disarankan untuk dikembangkan dan diterapkan di perairan pesisir Indonesia. Selain itu juga diperkenalkan metode ilmiah untuk memantau dampak lingkungan terhadap ekosistem laut. Bagian 4 merangkum hasil kajian kebutuhan masyarakat dan upaya penerapan budidaya kerang di kawasan pesisir Guatemala. Guatemala dan Indonesia menerapkan sistem yang berbeda dalam menerapkan konsep *sato-umi*. Guatemala menerapkan sistem "bottom up", dan Indonesia dengan sistem "top down". Bagian 5 menyampaikan situasi terkini dari kawasan perlindungan laut di Palau.

Bagian 6 menyajikan perbandingan antar studi kasus, sebagai bagian akhir dari laporan ini, Bagian 7, menyampaikan kesimpulan, pengalaman dan rekomendasi bagaimana menerapkan sistem sosio-ekologi, dan model *sato-umi* dan analisis di negara-negara berkembang sekitar Pasifik Utara. Sebagai tanggapan atas dua pertanyaan utama yang diajukan pada awal proyek ini, kami mengusulkan kesimpulan sebagai berikut.

(a) Bagaimana ekosistem laut dapat mendukung kesejahteraan manusia?

Pendekatan ilmiah secara tradisional melalui pemahaman pengetahuan tentang biofisika untuk menjawab pertanyaan ini, sering dibatasi dalam hal pemahaman tentang pasokan bahan pangan dan mata pencaharian. Namun, padangan yang sempit ini masih menyisakan masalah tentang kebutuhan psikologis yang sangat penting dan diperlukan masyarakat pesisir agar dapat mengelola sumberdaya laut dengan baik dan berkelanjutan. Karena dalam kenyataannya, kebutuhan psikologis dan kondisi fisik sumberdaya laut sangat dibutuhkan untuk mendukung kesejahteraan masyarakat pesisir secara positif.

(b) Bagaimana masyarakat dapat mendukung kelestarian dan produktivitas ekosistem laut?

Pertanyaan ini merupakan pertanyaan timbal balik terhadap pernyataan di atas dan pandangan yang terpusat kepada masalah sosial, dengan fokus pada masyarakat dan apa yang mereka lakukan, atau dapat mereka lakukan untuk menjamin atau memperbaiki stabilitas ekosistem laut, mengingat kegiatan masyarakat dapat merugikan atau menguntungkan kelestarian ekosistem laut. Kegiatan masyarakat menjadi pertimbangan yang perlu mendapat perhatian, ketika kondisi biofisik ekosistem laut mengalami tekanan, seperti masalah perubahan iklim. Konsep tentang apa yang dapat dilakukan masyarakat untuk menjaga stabilitas dan kelestarian ekosistem laut merupakan inti dari konsep yang dikembangkan Jepang dengan nama *sato-umi*.

Salah satu pelajaran yang sangat berharga dari hasil studi ini adalah bagaimana pentingnya menghubungkan suatu organisasi di setiap negara yang dapat memfasilitasi dan mengembangkan suatu proyek. Untuk melakukan penelitian tentang model sistem sosio-ekologi secara efektif dan efisien, diperlukan adanya hubungan yang erat dengan organisasi dan pemegang kunci yang memahami konsep sistem sosia-ekologi kelautan, dan dapat menerjemahkannya ke dalam konteks kedaerahan sesuai dengan potensi sumberdaya lautnya.

Resumen Ejecutivo

Se están logrando avances internacionales en la aplicación de un enfoque ecosistémico a la administración de los sistemas marinos, en particular en lo que respecta a la gestión pesquera basada en consideraciones del ecosistema integral. Este concepto se ha ampliado recientemente para incluir a seres humanos en lo que hoy se conoce como sistemas marinos socio-ecológicos acoplados. Tales conceptos pueden proporcionar una comprensión integrada de cómo los cambios del ecosistema afectan sistemas sociales-humanos, y viceversa. Este concepto integrado de comprensión de los sistemas socio-ecológicos en las zonas costeras con el fin de lograr un equilibrio sostenible entre estos dos sistemas se denomina *sato-umi* (pueblo-mar) en japonés. En 2012, PICES inició un proyecto integrado de investigación de sistemas socio-ecológicos denominado "Salud de Ecosistemas Marinos y Bienestar Humano (MarWeB)", financiado por el Ministerio de Agricultura, Silvicultura y Pesca del Japón. Las preguntas clave del proyecto fueron: a) ¿Cómo sustentan los ecosistemas marinos el bienestar humano? Y b) ¿Cómo apoyan las comunidades humanas ecosistemas marinos sostenibles y productivos? Este informe es el resumen de los resultados del proyecto MarWeB.

En este informe se introducen diversas herramientas sociales y científicas naturales utilizando datos actuales de estudios de casos para ejemplificar cómo realizar análisis de sistemas socio-ecológicos para comunidades dependientes de recursos marinos. La segunda sección ofrece una visión general de la investigación novedosa a nivel nacional sobre cómo las naciones miembras de PICES y una de las naciones de estudio de caso perciben sus interacciones con el mar. Esta sección establece los conceptos generales de cómo las personas interactúan con el mar e identifica importantes diferencias nacionales. Se utiliza los conceptos de bienestar humano e implica la evaluación de las vidas e interacciones de los pueblos con el mar, como las emociones positivas, el compromiso, la satisfacción y el significado. Debido a que los ecosistemas marinos proporcionan una gran variedad de servicios ecosistémicos, se necesita algún tipo de "función de peso relatvio" para asignar los limitados recursos humanos y financieros para proteger / conservar los servicios ecosistémicos de manera socialmente apropiada. El desafío aquí es que cada sociedad o país tiene sus prioridades específicas basadas en sus antecedentes culturales e históricos. Al mismo tiempo, para analizar los enfoques de sistemas socio-ecológicos a escala de todo el Pacífico Norte, es necesario comprender las diferencias y las similitudes en la estructuración del bienestar entre estos países.

La tercera sección presenta un resumen del primer estudio de caso sobre la acuicultura de camarón en Indonesia. En este estudio, las necesidades locales fueron evidentes desde el principio, incluyendo la prevención de la erosión de la tierra por los estanques de camarón abandonados después de la ocurrencia de enfermedades de camarón por operaciones de acuicultura excesivamente intensivas. Para reducir las emisiones de efluentes de alto contenido de nutrientes en la zona costera, se sugirió la tecnología de la acuicultura multi-trófica integrada (IMTA) para llevar a cabo la acuicultura con múltiples especies de manera sostenible. También se introdujeron técnicas científicas para monitorear los impactos a los ecosistemas marinos locales. La cuarta sección resume los resultados de las evaluaciones de las necesidades de la comunidad y los intentos de implementar la acuicultura de ostras en las comunidades costeras de Guatemala. Guatemala representa un caso de "abajo hacia arriba" e Indonesia uno de "arriba hacia abajo" como ejemplos de diferentes maneras para abordar la implementación de los conceptos de *sato-umi*. La

quinta sección describe la situación actual con la introducción a nivel nacional de áreas marinas protegidas en Palau.

La sexta sección presenta comparaciones entre los estudios de casos específicos. En la sección final, la séptima sección, se presentan las conclusiones, las lecciones aprendidas y las recomendaciones sobre cómo llevar a cabo los análisis socio-ecológicos y de tipo *sato-umi* en los países en desarrollo alrededor del Pacífico Norte. En respuesta a las dos preguntas claves planteadas al inicio de este proyecto, ofrecemos las siguientes conclusiones:

(a) ¿Cómo contribuyen los ecosistemas marinos al bienestar humano?

El enfoque "tradicional" de las ciencias biofísicas de esta cuestión suele estar enmarcado en términos de suministro de alimentos y medios de subsistencia. Sin embargo, este marco estrecho deja fuera las necesidades psicológicas muy importantes de cómo la gente se relaciona con el mar. En realidad, las necesidades psicológicas y físicas son necesarias para un bienestar humano positivo.

(b) ¿Cómo apoyan las comunidades humanas ecosistemas marinos sostenibles y productivos?

Esta es la pregunta recíproca a la anterior. Se trata de una visión más centrada en las ciencias sociales, centrada en las personas y en lo que hacen o pueden hacer para asegurar o mejorar ecosistemas marinos sanos. Las acciones de las personas pueden ser perjudiciales o beneficiosas para los ecosistemas marinos. Estas acciones son aún más importantes a tener en cuenta cuando los ecosistemas marinos biofísicos ya están estrésados, por ejemplo, debido a un cambio climático. Este concepto de lo que la gente puede hacer para cultivar ecosistemas marinos sanos es el núcleo del concepto japonés de *sato-umi*.

Una de las lecciones más sólidas que se extrajeron de estos estudios fue la importancia de conectarse con las organizaciones de cada país para facilitar y avanzar el proyecto. Con el fin de llevar a cabo la investigación de sistemas socio-ecológicos de una manera efectiva y eficiente, se necesitan conexiones estrechas con estas organizaciones y personas clave para entender el concepto de sistemas ecológicos marino-sociales y para poder traducirlo a un contexto local.

1 Introduction

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1.1 What is marine ecosystem health, human well-being, and a marine social-ecological systems approach?

Progress is being made internationally on an ecosystem approach to the management of marine systems, in particular as applied to ecosystem-based fisheries management (EBFM: *e.g*., FAO, 2003; Hollowed *et al*., 2011). Recent initiatives have expanded the concept of ecosystem approaches to include people in what have been called coupled marine social-ecological systems (*e.g*., De Young *et al*., 2008; Perry *et al*., 2010; Ommer *et al*., 2011). Good scientific (biophysical or ecological) arguments for management actions are sometimes not accepted or implemented because of the perceived socio-economic or cultural costs. An integrated understanding of how ecosystem changes affect human social systems, and *vice versa*, is essential to improve the stewardship of marine ecosystems (Makino and Criddle, 2013). Social-ecological systems are integrated complex systems that include social (human) and ecological (biophysical) subsystems in complex feedback relationships (Berkes, 2011). These types of relationships occur whenever people interact with the environment (Armitage *et al*., 2017).

PICES has contributed to this progress and explored regional applications of these concepts in the North Pacific through several studies on ecosystem-based management (Jamieson *et al*., 2005, 2010; Makino and Fluharty, 2011). In addition, PICES formed an expert group in 2011 to link the human dimensions of marine ecosystems with the more natural science-based activities of the organization (in what has now, in 2017, become a full scientific committee of PICES http://www.pices.int/members/committees/HD). The second PICES integrative science program, FUTURE (Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems), also has strong linkages with ecosystems and people, which are embedded within its three primary research questions (see below).

Tett *et al*. (2013) provided a discussion of marine ecosystem health, in particular as it is becoming framed in emerging national legislations. They suggested that it should be viewed as an aggregate of contributions from organisms, species and processes within a defined area rather than a single property of an ecosystem. Generic features include: primary photosynthetic production of organic matter is roughly in balance with consumption; nutrient supplies are adequate to support community structure and function; there is sufficient biodiversity to fulfill the necessary bio-geochemical roles; the community structure includes multiple trophic levels and a variety of trophic links between levels; and individual organisms are healthy and reproductively fit. It is important to note that this definition recognizes the localized or defined area aspects of these relationships, and therefore, the issue of how people "see" or frame their environment. Work by

PICES scientists on issues of marine ecosystem-based management approaches has found conceptual differences among PICES member countries with respect to what constitutes a "healthy" ecosystem (Jamieson *et al*., 2010), for example, how to have productive and biodiverse marine ecosystems which include people. Canada, Russia and the United States have generally more natural coastal systems which they are trying to maintain, whereas China, Japan and Korea are dominated by human-influenced marine systems. These different perceptions about ocean health lead to different management objectives and strategies, such as marine protected areas, regulations on fisheries and aquaculture, and relative emphasis on human and non-human needs. These concepts can also be expanded to developing countries where the immediate issues are often framed in terms of "needs for immediate sustenance" *versus* "sustainability" of the marine ecosystem and its fish populations for current and future use.

Recently, the concept of human well-being within marine social-ecological systems has become recognized as an important step forward (Coulthard *et al*., 2011; Charles, 2012). Well-being shifts the perspective from objective measures of sustainable livelihoods (comprised of the physical, social, human, natural, and financial resources available to a community or country) to include the subjective and relational well-being of individuals and communities. This represents a shift from people as exploiters of the ocean to people as integral components of resource sustainability and ecosystem health (Coulthard *et al*., 2011; Charles, 2012). Therefore, taking account of the dynamics of livelihoods and application of well-being can help in the development of policies supporting sustainable and resilient marine social-ecological systems (Charles, 2012). Weeretunge *et al*. (2014) define human well-being in fisheries contexts as a broad concept of social benefits, including both material and non-material goals, such as economic yield, food supplies, employment, safe and non-discriminatory work conditions in fisheries and preservation of ecological values of marine and coastal ecosystems. Jentoft (2000, p. 53) wrote that "viable communities are also an important contribution to the preservation of healthy fish stocks. Thus, before one can hope to rebuild fish stocks, one must start to rebuild communities."

Within a social-ecological systems approach, people are indispensable parts of the system. When setting the objectives of research or the definitions of success, participation of the local (fishing) human community is crucial. The Japanese concept of *sato-umi* represents one version of this humans-in-nature approach in which a healthy ecosystem is seen to nourish human well-being, but human activities are seen as necessary for sustaining ecosystem health. *Sato* means community or village, and *umi* means sea. Therefore, *sato-umi* refers to human communities that have long-standing relationships with marine environments, and in which human interactions have resulted in high marine productivity and biodiversity (Makino, 2011, p. 126; Makino and Fluharty, 2011; United Nations University Institute of Advanced Studies Operating Unit Ishikawa/Kanazawa, 2011). One example is the eelgrass re-establishment and recovery activities undertaken by local community members in the Seto Inland Sea of Japan (Ota and Torii, 2011). Similar types of sea grass and kelp restoration activities have been proposed by local communities in the Strait of Georgia, Canada. The Japanese government has undertaken integrated studies to assess the contributions of social, cultural, economic, and ecological aspects in *sato-umi* type projects in Japan, as part of the Millennium Ecosystem Assessment Sub-Global Assessment program.

As detailed in this report, the identification of local community needs and perceptions about what makes a "good" ecosystem is an important part of designing the scientific analyses and field experiments. This is a necessary process to ensure the research is really intended for the (fishing) community and its people, and not only for the interests of the researchers. Based on the local community needs, or their perception of their needs, scientific analyses can be developed to meet those needs and perceptions.

1.2 Project formation and funding support

In 2012, PICES accepted a request from the Government of Japan to undertake a 5-year project on "Marine ecosystem health and human well-being" to be funded by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan, through the Fisheries Agency of Japan (JFA). The project began in April 2012 and was completed in March 2017. The MAFF contribution was from the Official Development Assistance (ODA) Fund and therefore, involvement of developing Pacific Rim countries in project activities was required. The project principles are reflected in Appendix 1.

The project was directed by a Project Science Team (PST) co-chaired by Drs. Mitsutaku Makino (Fisheries Research and Education Agency, Japan) and R. Ian Perry (Department of Fisheries and Oceans, Canada). All PST members are identified in Appendix 2. The PST Co-Chairmen were responsible for the scientific implementation of the project and annual reporting on its progress to MAFF/JFA and PICES Science Board. Dr. Alexander Bychkov served as the Project Coordinator and was responsible for the management of the fund and for reporting annually on its disposition to MAFF/JFA and PICES Governing Council.

The over-arching project goal was 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 Japan, this concept attracts attention as the *sato-umi* fisheries management system. Considering that global changes are affecting both climate and human social and economic conditions, the key questions of the project were defined as:

(a) How do marine ecosystems support human well-being?

(b) How do human communities support sustainable and productive marine ecosystems?

To achieve these goals, a program of novel research and case studies, involving both the biophysical and social sciences, was constructed, with three developing countries initially selected for the locations of the case studies.

1.3 Structure of this report

In this report, various social and natural scientific tools are introduced with real data to exemplify how to conduct social-ecological systems analysis for marine-dependent communities. Section 2 provides an overview of novel research at the national level on how the member countries of PICES and one of the case study nations (Indonesia) perceive their interactions with the sea. This section sets the general concept for how people interact with the sea, and identifies important national differences. It uses the concepts of human well-being, and involves people's evaluations of their lives and interactions with the sea, such as positive emotions, engagement, satisfaction, and meaning (Diener and Seligman, 2004). Because marine ecosystems provide a wide variety of ecosystem services, some kind of "weighting function" is needed in order to allocate the limited human and financial resources to protect/conserve ecosystem services in socially appropriate ways. The challenge here is that each society or country has its specific priorities based on their cultural and historical backgrounds. A community needs assessment approach is a useful tool to identify these priorities at the community scale. At the same time, in order to discuss social-ecological systems approaches at the scale of the entire North Pacific, understanding the differences and commonalities in how well-being is structured among these countries is needed.

Section 3 presents a summary of the first case study focusing on shrimp aquaculture in Indonesia. Here, the local needs were apparent from the beginning, including the prevention of land erosion by abandoned shrimp ponds after the occurrence of shrimp diseases from excessively intensive aquaculture operations. To help bust economic returns and to reduce emissions of high-nutrient effluents into the coastal zone, integrated multi-trophic aquaculture (IMTA) technology was introduced to conduct multi-species aquaculture in a sustainable manner. Also, scientific techniques to monitor impacts to the local marine ecosystems were presented. A commodity chain analysis was carried out to demonstrate how IMTA can affect human well-being.

Section 4 summarises the results from community needs assessments and attempts to implement oyster aquaculture in coastal communities of Guatemala. Guatemala represents a "bottom up" example and Indonesia a "top down" example of different approaches to implementing *sato-umi* concepts. Detailed results from the studies in sections 2, 3, and 4 are being prepared for publication in the scholarly scientific literature.

Section 5 describes a site visit to Palua as the proposed third case study location. However, for reasons indicated in this section and for funding reasons, further activities in Palau were not implemented.

Section 6 focuses on comparisons among the case studies. As the final section, Section 7 includes conclusions, lessons learned and recommendations for how to conduct social-ecological systems (*sato-umi* type) analyses in developing countries around the North Pacific. This section also briefly describes the guide/manual for practioners who wish to develop social-ecosystem system/*sato-umi* approaches in other areas, and the database that was developed during this project. Appendices are included with additional information from PST meeting reports, scientific sessions, and published articles produced during this project.

2 A Psychological Perspective on "Human Well-being" and the Sea

Mitsutaku Makino[1] and Juri Hori[2]

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2.1 Well-being analysis

Many social and psychological methodologies have contributed to a better understanding of one's sense of value or well-being. While economists focus mainly on economic utility or material wealth (Stevenson and Wolfers, 2008), psychologists have been concentrating more on cultural values in individualism (Diener *et al*., 1993; Hofstede, 2001; Diener and Saligman, 2002). In this section we introduce two approaches for assessing human well-being. The first approach is people's levels of "satisfaction" using the Millennium Ecosystem Assessment's (2005) five components of human well-being as dependent variables. The second is the "well-being cube" composed of 35 "human needs" determined by psychology. It can be used to evaluate the detailed characteristics of people's desired choices and actions in their relationships with the sea and marine ecosystems.

2.2 Millennium Ecosystem Assessment well-being analysis

"Well-being" involves people's positive evaluations of their lives, such as positive emotions, engagement, satisfaction, and meaning (Diener and Saligman, 2004; Oscar, 2011). According to the definition by the Millennium Ecosystem Assessment (MEA, 2005), human well-being (HWB) has multiple constituents including "Security", "Basic material for a good life", "Health", "Good social relationships" and "Freedom of choice and action" (Fig. 2.1).

The strength of the linkages and the potential for mediation differ in different ecosystems and regions, and with different socio-economic factors which mediate the linkages (MEA, 2005). However, the interactions among the five components of human well-being in relation to the sea have not been investigated in previous studies.

Since the concept of human well-being was suggested as a tool for evaluating the subjective benefits derived from ecosystems and environments (MEA, 2005), increasing attention has been paid to the interaction between ecosystems and human society because natural environments are affected by this interdependence (a social-ecological system: Berkes *et al*., 2003; Folke *et al*., 2005; Berkes and Ross, 2013; Reyers *et al*., 2013). Thus, evaluation of the subjective aspects as well as the economic value of ecosystems (*i.e*., ecosystem services) has been considered important for comprehensive evaluation of the value of specific ecosystems and environments (Rice, 2014; Garcia *et al*., 2015).

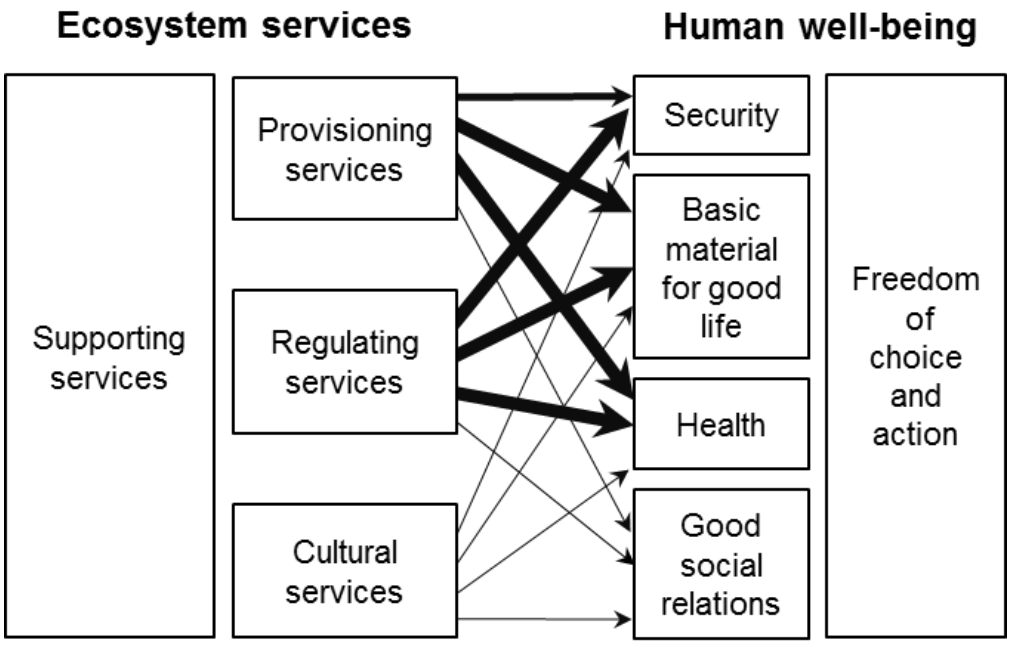

Fig. 2.1 Linkages between categories of ecosystem services and components of human well-being (based on Millennium Ecosystem Assessment, 2005).

2.2.1 Sampling design and questionnaire

The MEA well-being analysis is based on the responses to a web survey utilizing an internet questionnaire or face-to-face interviews. Here, we use data from the MarWeB database[1] in which six PICES member countries are included. In order to minimize the geographical effects in each country, the residence of potential respondents was restricted to within a one hour's drive by car from the coast. The responses were obtained in May 2013 in Japan, August 2013 in the U.S. (Pacific coast), September 2013 in Korea, October 2015 in China, December 2015 in Russia (Pacific coast), and April 2016 in Canada (Pacific coast). Table 2.1 provides the demographics of respondents in each country, with a grand total of 3,238 responses.

Questionnaire items were selected and grouped according to the five components of human well-being ("Basic material for a good life", "Health", "Good social relations", "Security", and "Freedom of choice and action"), as defined by the Millennium Ecosystem Assessment (MEA, 2005). Three to five items were selected for each component: three items for "Freedom of choice and action", four each for "Health", "Good social relations" and "Security", and five for "Basic material for a good life". As a result, a total of 20 items were used in the questionnaire (Table 2.2). Each item was scored by each respondent based on a five-point Likert-type scale, depending on the satisfaction level: 5 = very satisfied, 4 = satisfied, 3 = neither satisfied nor dissatisfied, 2 = dissatisfied and 1 = very dissatisfied. The average and standard deviation of the satisfaction scores were calculated for each item and country.

[1] http://www.pices.int/projects/marweb

Table 2.1 Demographics of respondents in PICES member countries to the web and/or in-person surveys conducted for the "well-being cube" analyses of relationships between people and the sea.

Country	Total number	Number of males	Number of females	Average age	Standard Deviation of average age
Canada	550	275	275	39.4	13.3
China	550	351	199	33.0	6.5
Japan	468	241	227	46.2	13.7
Korea	540	283	257	42.2	13.1
Russia	574	300	274	37.0	12.3
United States	556	279	277	44.6	13.9

Table 2.2 Question items in relation to the five components of human well-being, scored on a five-point scale based on satisfaction level.

Components of human well-being	Question items
Security	• To live with peace of mind and safety • To protect oneself from danger • To use energy and resources appropriately • To give an appropriate response when a disaster strikes
Basic material for a good life	• To secure the basics for a good life • To regulate life-environment (*e.g.* lifeline such as electricity, gas, and water) • To have enough food • To have somewhere comfortable to live • To get daily necessities
Health	• To keep one in good health • To have the capacity to live grow or develop • To feel comfortable • To secure clean air and water
Good social relations	• To produce a good relationship • To cooperate with the social community • To hold someone in high esteem • To be able to support someone
Freedom of choice and action	• To give a child a fair chance to succeed • To have a chance to achieve a goal • To enjoy one's hobbies

2.2.2 Example of the analysis and interpretation

The basic structure of the components of human well-being can be revealed using a structural equation modelling (SEM) approach on the data from the questionnaires. All statistical analyses were conducted using the standard statistic software, such as SPSS Statistics Version 23 (IBM), or SPSS Statistics AMOS Version 23 (IBM). The data from the MarWeB database were used to show how the analysis was conducted.

Structural equation modelling (Duncan, 1975; Wakita *et al*., 2014) was applied to examine possible interactions among the five components of human well-being. First, in order to understand the basic structure of human well-being, SEM was run with the satisfaction scores as dependent variables, based on pooled data obtained from the six PICES member countries. The goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), comparative fit index (CFI), and the root mean square error of approximation (RMSEA) are used as indices for determining the adequacy of the model (Browne and Cudeck, 1992; Hu and Bentler, 1999; Rhoades and O'Leary, 2007; Table 2.3). The model is reliable when GFI, AGFI and CFI are close to 1, and RMSEA < 0.05 (Rhoades and O'Leary, 2007). Standardized partial regression coefficients (β) were calculated in order to investigate the interaction (direction and strength of effects) between the components of human well-being.

Table 2.3 Equations and indices used for the structural equation modelling of the survey responses for the "well-being cube" analysis.

Indices used to evaluate the results of structural equation modeling (SEM)

$$\text{Goodness of Fit Index (GFI)} = 1 - \frac{\text{trace}\left\{(A^{-1}(B-A))^2\right\}}{\text{trace}\left((A^{-1}B)^2\right)}$$

$$\text{Adjusted Goodness of Fit Index (AGFI)} = 1 - \frac{N(N+1)}{2D}(1 - \text{GFI})$$

$$\text{Comparative Fit Index (CFI)} = \frac{(Ci - D) - (C_d - D)}{(C_i - D)}$$

$$\text{Root Mean Square Error of Approximation (RMSEA)} = \sqrt{\frac{(C_d / D - 1)}{(n - 1)}}$$

A = implied covariances
B = observed covariances
C_d = chi-square of default model
C_i = chi-square of independent model
D = degree of freedom
N = number of factors
n = number of samples

The SEM analysis showed high reliability of the model results (Fig. 2.2; $\chi^2(1) = 10.69$, GFI = 1.00, AGFI = 0.98, CFI = 1.00, RMSEA = 0.06). In the model-based characterization of the components of human well-being, "Security", and "Basic material for a good life" functioned as fundamental variables affecting "Freedom of choice and action", while "Good social relations" and "Health" were mediating variables for the other components.

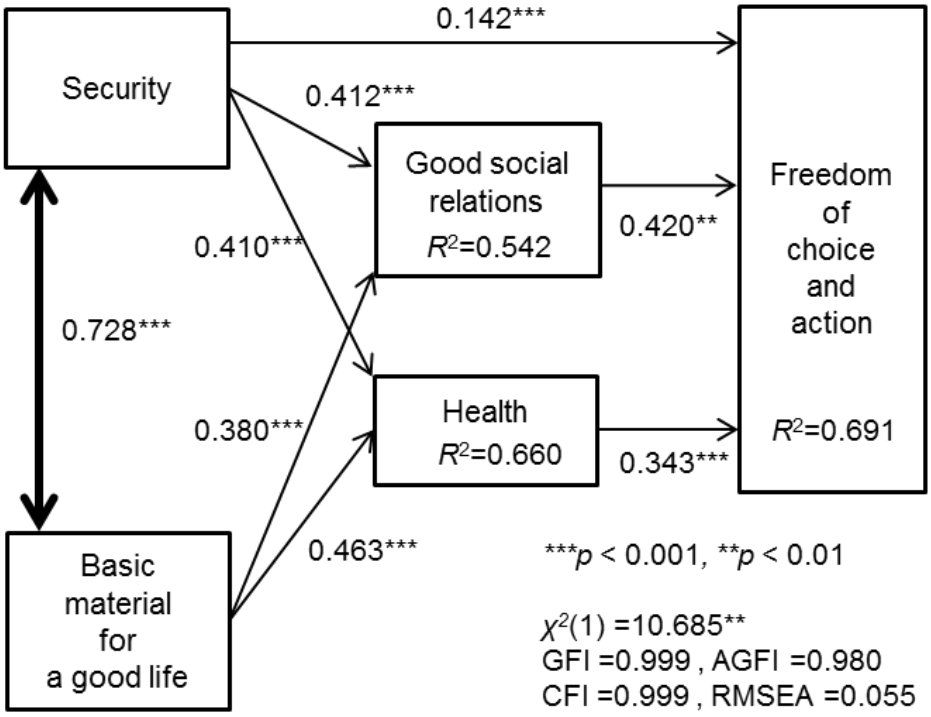

Fig. 2.2 Results of structural equation modelling (SEM) linkages among five components of human well-being. The data from six PICES member countries (n = 3238) were pooled for the analysis to investigate the basic structure of linkages among the five components of human well-being. The best model fit is shown. The thick arrow between "Security" and "Basic material for a good life" indicates interaction, and the number beside the arrow is an explanatory variable (coefficient of correlation = r). Thin arrows between the components indicate one-way effects, and the numbers beside the arrows are structural parameters (standard partial regression coefficient = β). R^2: explanatory variables for the factors by the model; **: $p < 0.01$; ***: $p < 0.001$.

The multiple group structural equation modelling showed a good fit of the model ($\chi^2(6) = 38.84$, GFI = 1.00, AGFI = 0.93, CFI = 1.00, RMSEA = 0.04). The basic structure of the components of human well-being in each country was similar to that derived from the analysis using pooled data from the six member countries (Fig. 2.3), with "Security" and "Basic material for a good life" functioning as fundamental variables, and "Freedom of choice and action" as a dependent variable.

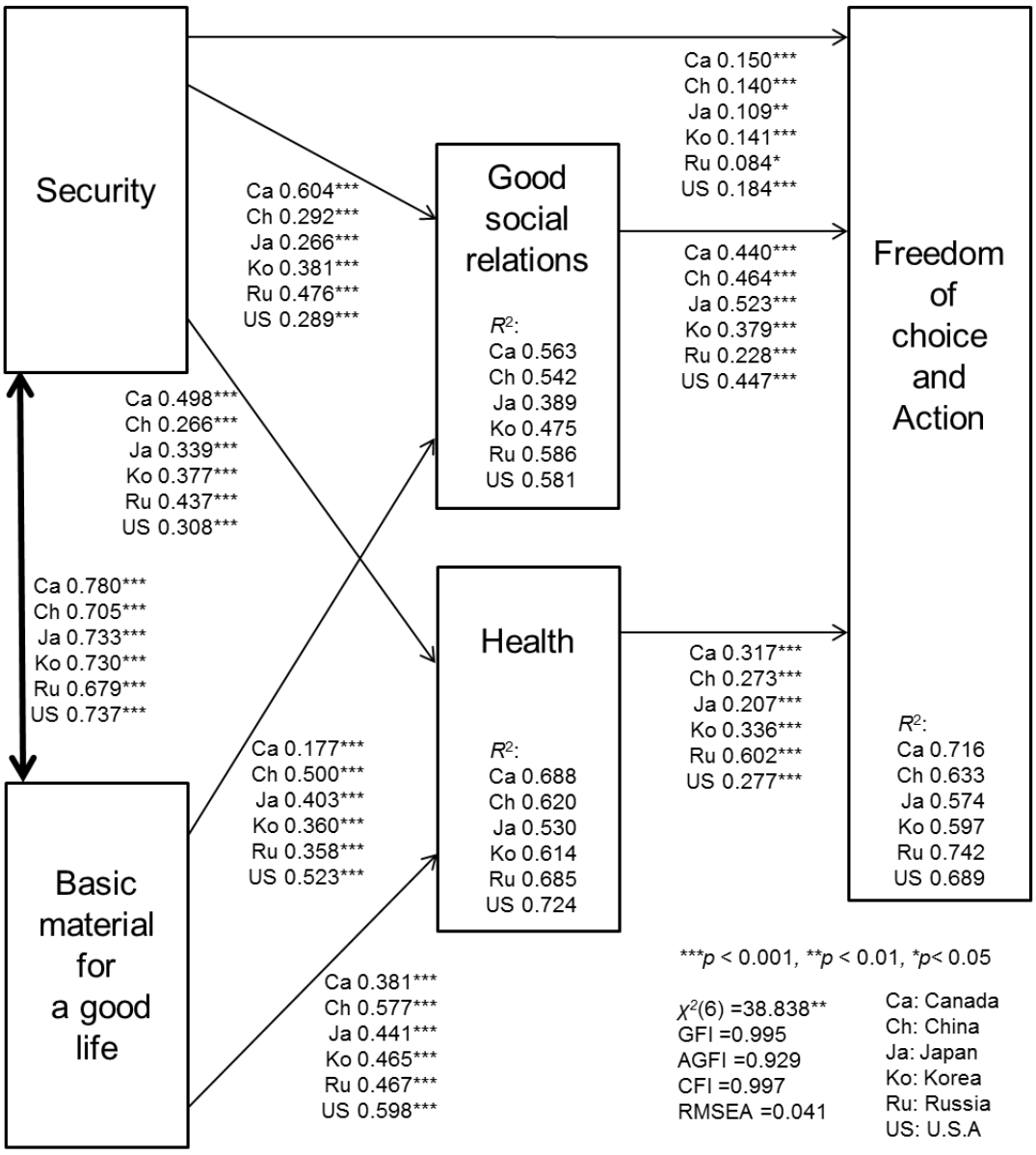

Fig. 2.3 Results of multiple group structural equation modelling for international comparisons of the linkages among the five components of human well-being. The model was run country by country (Canada: n = 550; China: n = 550; Japan: n = 468; Korea: n = 540; Russia: n = 574; USA: n = 556). The linkage structures among the five components of human well-being for each country were expressed in the same manner as for the pooled data shown in Fig. 2.2. Ca, Ch, Ja, Ko, Ru, and US indicate explanatory variables for Canada, China, Japan, Korea, Russia, and the U.S., respectively. The model best fit is shown. The thick arrow between "Security" and "Basic material for a good life" indicates interaction, and the number beside the arrow is an explanatory variable (coefficient of correlation = r). Thin arrows between the components indicate one-way effects, and the numbers beside the arrows are structural parameters (standard partial regression coefficient = β). R^2: explanatory variables for the factors by the model; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$. For example, for "Good social relations" and "Health", the well-being factor "Security" is relatively important in Canada and Russia, while "Basic material for a good life" is important for other countries. Similarly, "Health" is relatively more important for people in Russia to achieve "Freedom of choice and action", while in other countries it is more about "Good social relations".

2.3 *Human "well-being cube" analysis*

The other analytical tool, derived from psychological research, is called the "well-being cube". At the first Project Science Team meeting in Hiroshima (October 11, 2012; see *Appendix 4*), Ms. Juri Hori and Dr. Mitsutaku Makino presented definitions for human well-being from psychological research, and described the concept of the "well-being cube". In this approach, a person's (or community, region, country) perception of their well-being can be located in one or more of 27 cells defined by three axes, each with three categories: the extent of conscious interpretation of their situation, their level of active response to their situation, and their view of how they fit into their world (Perry and Makino, 2013). After discussion with the PICES Section on *Human Dimensions of Marine Systems* (now the PICES Human Dimensions Committee), the "well-being cube" was developed, composed of 35 "human needs" as determined by psychology, which can be used to evaluate the detailed characteristics of people's desired choices and actions in regard to their relationships with the sea (Fig. 2.4).

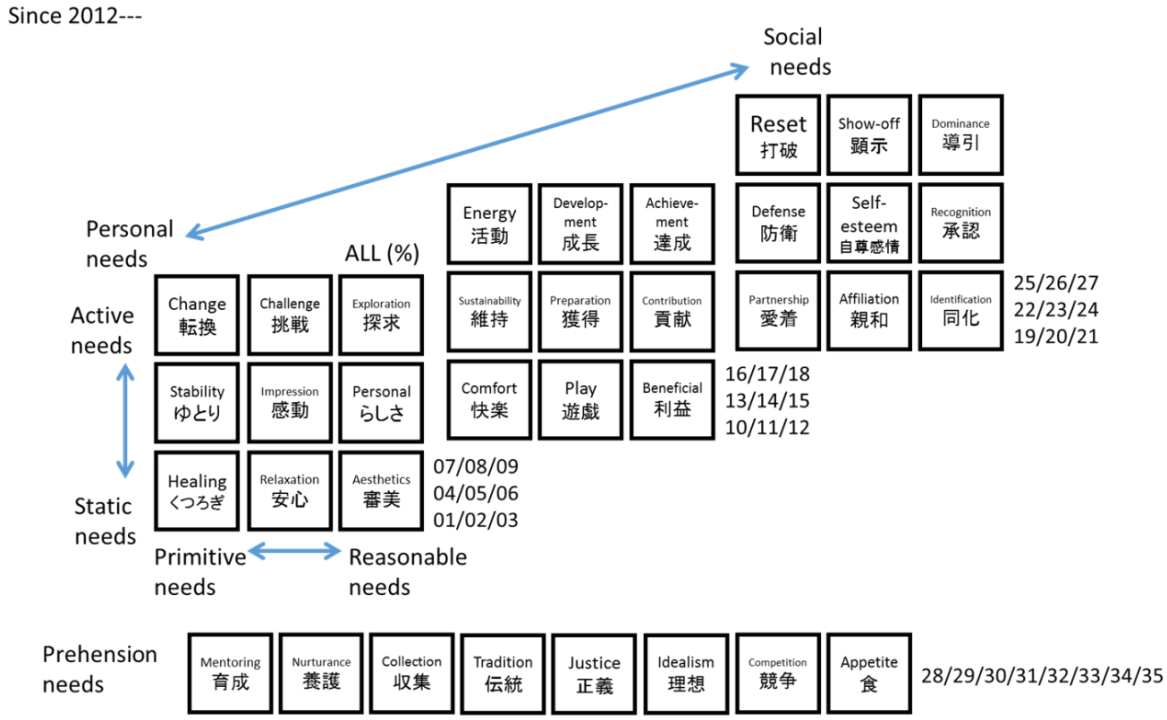

Fig. 2.4 The "well-being cube". The 27 characteristics in the upper part of the figure are considered as constructing a cube with axes of "Personal needs" to "Social needs", "Active needs" to "Static needs", and "Primitive (or basic) needs" to "Reasonable needs". The eight characteristics along the bottom represent additional "Social needs".

2.3.1 Sampling design and questionnaire

The same data from the six PICES member countries in the MarWeB database were used for this analysis. The "well-being cube" (Fig. 2.4) was assessed using 35 items (Table 2.4). Each item was scored by each respondent based on a five-point Likert-type scale, depending on the satisfaction level and the expectation level: 5 = very satisfied/high expectation, 4 = satisfied/some expectation, 3 = neither satisfied nor dissatisfied/neither expectation nor no expectation, 2 = dissatisfied/low expectation, and 1 = very dissatisfied/no expectation. The average and standard deviation of the satisfaction scores were calculated for each item and country.

Table 2.4 Question items used in the "well-being cube" analysis in relation to the sea, scored on a five-point scale based on the respondents' levels of satisfaction and expectation.

Cube no.	Question items
1	Healing : Sense of support, grounding and positivity
2	Relaxation : Feel relieved and secure
3	Aesthetics : Appreciation of beauty, *e.g.*, music, pictures, and other favorite things
4	Stability : Live comfortably with something reliable or dependable
5	Impression : Experience a range of positive feeling
6	Personal : Create own (private) world
7	Change : Change one's direction
8	Challenge : Challenge a new thing
9	Explorations : Gratify one's curiosity
10	Comfort: Feeling comfortable. Be liked by other
11	Play : Indulge in play or a favorite hobby
12	Beneficial : Gaining something without losing others
13	Sustainability : Continues being oneself
14	Preparation : State of being readiness
15	Contribution : Useful for an area or the society
16	Energy : Being energized to do something new
17	Development : Acquire knowledge, experience, and growth
18	Achievement : To reach one's goal
19	Partnership : Create new relationship
20	Affiliation : To be accepted as a peer group member

Table 2.4 Continued.

Cube no.	Question items
21	Identification : Belong to the community and share the same aims
22	Defense : Protect yourself from external harm
23	Self-esteem : Have confidence and pride toward oneself
24	Recognition: How well you are recognized in the community
25	Reset : To break free, restart anew
26	Show off : Desire to show off one's potential
27	Dominance : Have leadership and success in whatever you do
28	Mentoring : Raising and guiding the next generation
29	Nurturance : Help a person and protect them
30	Collection : Collect various things
31	Tradition : Respect family, ethnic and racial tradition
32	Justice : Carry through social justice
33	Idealism: Carry through an idea
34	Competition : To excel through competitiveness
35	Appetite : To feel satisfied

2.3.2 Example of the analysis and interpretation

Internet surveys were conducted for the six PICES member countries. The sample numbers were 550 for Canada and China, 468 for Japan, 540 for Korea, 574 for Russia, and 556 for USA. All the respondents resided within a one hour driving distance from the coast. The results are summarized in a cube diagram (Fig. 2.5). Red shows high expectation and satisfaction, blue shows low expectation and satisfaction, yellow shows high expectation and low satisfaction, and green shows low expectation and high satisfaction. Some initial findings included the fact that all countries surveyed have similar general concepts of human well-being with regard to marine ecosystems. However, the specific understanding of how the marine ecosystem affects human well-being varies among the countries and, therefore, what makes for a desirable relationship between people and the sea is different among countries.

Some of the common features among the six member countries include general perceptions of current conditions and future prospects. For example, the satisfaction and expectations for "Impression" were high in all the countries. This may be interpreted as people in PICES member countries are generally satisfied and have higher expectations of the future, regardless of their ecological condition, economic situation, and culture. In contrast, satisfaction and expectation levels for "Identification", "Collection", and "Competition" were statistically low in all member countries. This may reflect higher uncertainty about the future of marine social and ecological systems. Further investigations of these data are underway, and will be presented elsewhere.

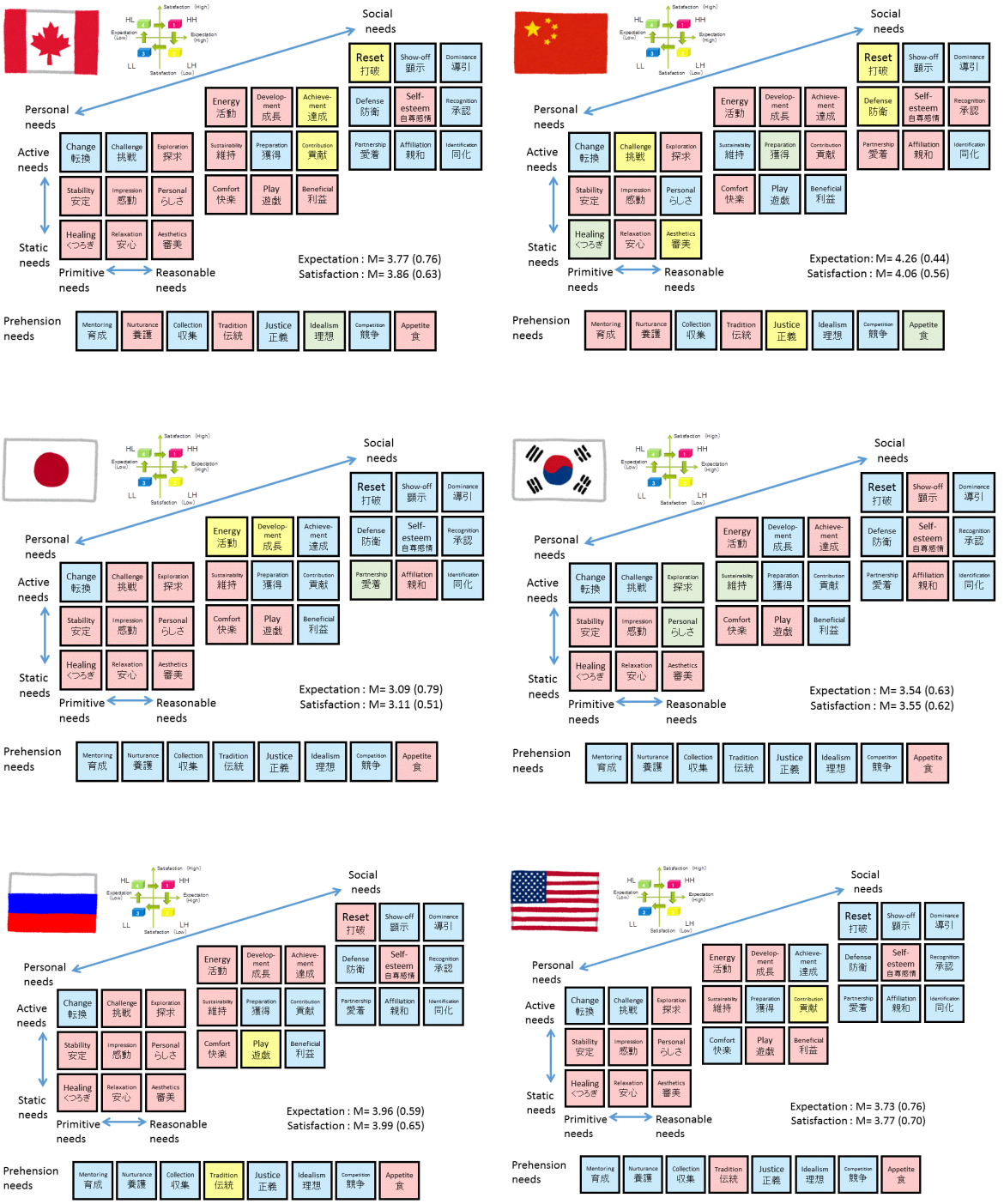

Fig. 2.5 Results of human “well-being cube” analyses in regard to people’s interactions with the sea for each PICES member country. Pink indicates high expectation and high satisfaction, yellow indicates high expectation but low satisfaction, green indicates low expectation but high satisfaction, and blue indicates low expectation and low satisfaction.

2.4 Conclusions

The results from the multiple group structural equation modelling (Fig. 2.3) show that the basic structure of the components of human well-being in PICES member countries are similar, with "Security" and "Basic material for a good life" functioning as fundamental variables, and "Freedom of choice and action" as a dependent variable. At the same time, the relative importance, or "connections" among the components vary from country to country. The "well-being cube" analysis, which is based on psychological needs theory, can provide more details of such differences among countries (Fig. 2.5). Some countries believe that certain specific aspects are more important than others. For example, only people in Russia had high expectations for social needs, and they were often met; the other five countries had low expectations for social needs and low satisfaction in having those met; and all countries (except Russia) had high expectations for personal needs and these were often satisfied.

Understanding the differences among countries is an important first step towards building a consensus for larger-scale marine conservation activities. This is also important information for domestic policy makers, to allocate the limited human and financial resources for ecosystem conservation activities in order to efficiently maximize the well-being of their people. From the science perspective, this information can be used to design research frameworks for marine ecosystem conservation and experiments in order to better address local people's concerns and recognition of critical issues.

3 Case Study 1: Indonesia

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Indonesia is a developing country with a rapidly developing economy and a good relationship with other nations. The region of Karawang (Fig. 3.1) quickly embraced the development of pond aquaculture more than 10 years ago, but disease since has destroyed much of the shrimp aquaculture, leading to large-scale abandonment of ponds, catastrophic erosion, and degradation of a large portion of the frontal coastline. Fish are plentiful in the local markets, but are very small. Local pond aquaculture has been rebounding slowly, with much of it being low-intensity programs using traditional, low-technology approaches. Economic returns from these activities are vital in these communities, and MarWeB's focus was to identify successful methods for integrated multi-trophic aquaculture (IMTA) to help boost economic returns, while at the same time reducing the deleterious effects of pond operations on the water quality in the coastal areas.

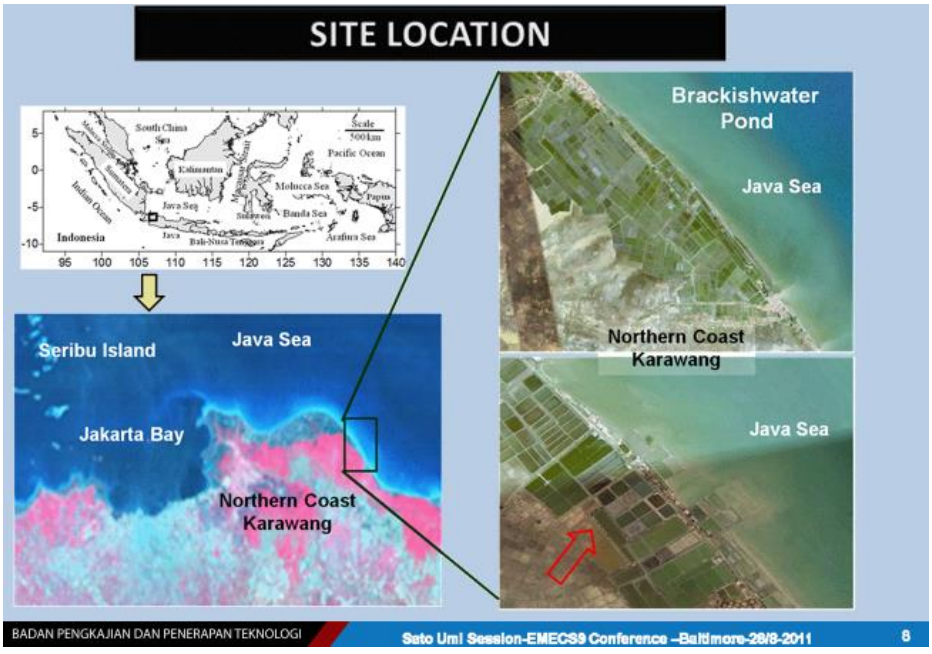


Fig. 3.1 Location of Karawang, Java Island, Indonesia, and the brackish water pond experimental site.

The Indonesia case study has two components: (1) a natural science-based study of IMTA methods for improving the economic return of shrimp and tilapia pond aquaculture, and (2) a social science-based study of markets and human benefits to better understand the potential linkages for further economic development of pond aquaculture and natural fisheries.

3.1 Natural science studies

3.1.1 Project background

The concept of *sato-umi* is where human intervention in coastal and marine areas can increase productivity and diversity of fishery resources, while at the same time maintaining ecosystem resilience. In this case study, we investigated different forms of IMTA in brackish water shrimp and tilapia ponds for the purpose of achieving three goals: (1) maintaining successful production of the primary economic product (shrimp or tilapia), (2) adding economic return to farmers through co-production of other cultured products in ponds, and (3) reducing nutrient discharge from pond operations into coastal waters and thereby improving water quality and reducing adverse impacts on coastal ecosystems.

To be clear, many aquaculture companies utilize medium- and high-intensity production systems that, while enhancing production, are expensive and highly sensitive to small variations. There is high risk for failure in these lucrative operations, so the companies have little motivation to experiment given the uncertainties that IMTA can introduce. Our focus was on developing methods and approaches for low-intensity, low-technology, and limited financial resource conditions that describe community-scale traditional aquaculture in Karawang. The project outcomes are intended to have tangible effects on improving human well-being at the community level.

Traditional pond aquaculture, practiced by local communities in Karawang and elsewhere in Indonesia, is distinguished from larger-scale commercial operations by their simplicity. Shrimp are stocked in open-air dirt ponds at approximately 15 shrimp per m^2 *versus* $\geq$ 300 shrimp per m^2 in concrete tanks for many high-intensity aquaculture operations (similar differences exist in the relative levels of tilapia stocking). The lower density operations generally remove the need for mixing and aeration tools, such as water wheels, that require electricity. These simplified pond systems are logistically very amenable for experimentation with IMTA.

The MarWeB team worked closely 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 towards this goal. The NCBA has experienced, high-quality laboratory analytical capabilities for standard shrimp pond aquaculture operations, but did not have analytical expertise in dissolved nutrient analyses or in phytoplankton identification, particularly for toxic algal species. A MarWeB training workshop held in March 2014 addressed these limitations for both NCBA staff and a number of other local interested participants. Armed with this new analytical capacity, the joint MarWeB–Indonesian team conducted three pond experiments over the three remaining years of the project.

A critical aspect in the experimental design was recognition that these were "community and scientist" endeavours, rather than "scientist and community" experimental programs. Farmers and communities are critically dependent on the successful growth of the primary aquaculture product (shrimp or tilapia). Failure of the pond due to disease or other IMTA-related factors would have devastating impacts on their well-

being; without any economic buffers in these communities, failure can mean hunger or malnutrition. The other consideration was that while our goal was to reduce nutrient loads, high phytoplankton biomass is a critical component of traditional pond aquaculture practices. High phytoplankton biomass is essential as an additional feed source but, more importantly, as a barrier to block light from reaching the floor of the ~1 m deep ponds to limit the growth of grass. So, while one goal of the project is to reduce dissolved nutrients in the pond, there is great concern among farmers that this reduction not be to the detriment of their operations.

Traditional pond aquaculture operations follow scientific and empirically developed procedures, but in practice it remains somewhat of an art. A key enabler for our research goals was the lead aquaculturist at the NCBA who, while keenly focused on efficient shrimp and tilapia production, was willing to consider modifying conditions in their ponds to evaluate IMTA outcomes. The importance of this individual in the community cannot be overstated. His years of experience in the field, both in industry and at the NCBA, has led to him being held in high respect within the aquaculture community; his endorsement will be critical if new aquaculture practices are to be adopted in the community. So, while a purely scientific IMTA study design would push the pond system to determine the boundaries for failure, reports of pond failure to the broader community would condemn all future efforts to implement IMTA. We, therefore, heavily relied on the lead aquaculturist's sense of trepidation in our experimental designs, which greatly limited the amounts of other aquaculture species incorporated in these early experiments.

3.1.2 The pond experiments

Our initial experimental pond system in 2014 comprised four 4000 m^2 ponds at the NCBA in Karawang to test whether the addition of *Gracilaria*, a macroalgal genus widely cultured in Indonesia and elsewhere for both food and industrial processing, and the local clam *Anadara*, affected production of the whiteleg shrimp (*Litopenaeus vannamei*) and a halotolerant *Tilapia* sp. developed by BPPT. In addition to potential economic benefits of *Gracilaria* co-culture, there is anecdotal evidence that it can restrict pathogen growth which could increase the likelihood of successful pond production.

Our IMTA concept was straightforward: the addition of feed to the ponds leads to increased nutrient concentrations that, in turn, fuel growth of *Gracilaria* in addition to phytoplankton (Fig. 3.2). Phytoplankton, in turn, nourish the growth of *Anadara*, and phytoplankton consumption leads to more light and thus more phytoplankton growth, drawing nutrients down further. Overall, the excess production of *Gracilaria* and *Anadara* in the ponds essentially is a "recovery" of lost feed components (and operational costs) that otherwise are released into the coastal waters, leading to degradation of the coastal ecosystem. However, the larger-scale (4000 m^2) pond project proved challenging, both in terms of acquiring and introducing the co-cultured species, and for sampling and management of the ponds. The results showed no significant negative effects of *Anadara* or *Gracilaria* on the growth of shrimp or tilapia although disease in the shrimp control pond required its early harvest, thereby complicating our data interpretations. There was very limited production by *Anadara* or *Gracilaria*, which had been cordoned into small net corrals to limit their interaction with shrimp or fish in the ponds. As a consequence, there were no significant differences in the level of dissolved nutrients at the end of the month-long experiment.

A smaller pond system (1000 m^2) was created in 2015 to replicate the experiment. In this case, the whiteleg shrimp (*Litopenaeus vannamei*) and *Tilapia* sp. showed good growth in all treatments. As before, the insertion of *Gracilaria* holdfasts in the pond sediments was limited to netted corrals, although *Anadara* was spread across the pond sediment interface. The overall product yield of both shrimp and tilapia was less

than NCBA staff had hoped for, even in the controls, for reasons that presumably were related to the water source. Due to the pond locations they were filled mainly with pumped brackish groundwater rather than the normally used brackish canal waters. The 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).

Economic analysis showed that tilapia aquaculture, combined with the cost of *Gracilaria* used in the experiment, led to little if any additional profit. However, the total expenses for IMTA in the shrimp ponds were less (due primarily to lower feed costs). The economic contributions were low for both *Gracilaria* and *Anadara* because of their limited growth in the ponds, despite elevated levels of dissolved nutrients (for *Gracilaria*) and phytoplankton and detrital abundance (for *Anadara*). All but the growing tips of *Gracilaria* were observed to be covered in fine black silt, indicating that growth would have been severely light limited. Similarly, *Anadara* were rarely found open and feeding over the course of the experiment, suggesting stress associated either with hypoxic/anoxic pond sediments or the disturbance from shrimp foraging. That, and recognition that bivalves are not consumed commonly in Karwang communities, led us to discontinue the testing of *Anadara* in our system.

The 2016 pond experiment concentrated on IMTA with shrimp and *Gracilaria*, for logistics considerations and expectation that the simplicity of a two-species IMTA stands a better chance of being implemented by community growers. Two changes were made. First, the abundance of *Gracilaria* added in the previous experiment (0.1 kg/m^2) was too low to have any major impact on dissolved nutrients. However, the repeated demonstration that *Gracilaria* did not negatively impact shrimp (or tilapia) growth gave our lead aquaculturist confidence that larger amounts could be added. Initial consultations centered on increasing this addition by up to 20× (2 kg/m^2), but a more conservative approach was decided upon in which three biomass levels were tested: 0.1, 0.2, and 0.4 kg/m^2 of *Gracilaria*.

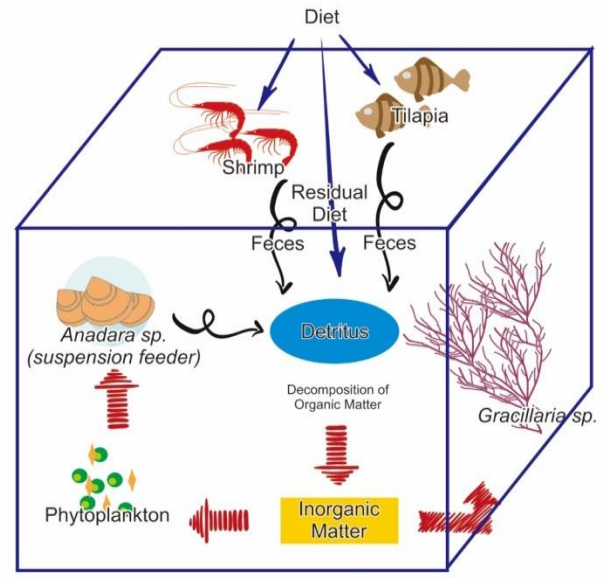


Fig. 3.2 Recycling waste generated by the cultivation of the main species (fish) into a source of energy and nutrients for the cultivation of other commodities, resulting in a product that can be harvested, and can reduce environmental impact (graphic provided by National Center for Brackishwater Aquaculture (NCBA), Karawang, Indonesia).

The second change was in how the *Gracilaria* was incorporated into the ponds. In the previous experiments it was attached to the bottom with only its tips reaching the pond surface. This orientation, plus the buildup of silt on the macroalgal surfaces, led to what we believed was light limitation of growth of *Gracilaria* in 2015. For the 2016 experiment, *Gracilaria* was placed into bamboo floating rafts, keeping it at the pond surface and thereby increasing the light intensities to which it is exposed. The amount of *Gracilaria* per raft was roughly uniform (beginning with only partial coverage), with more rafts being used in the higher *Gracilaria* abundance treatments. Additionally, the rafts were shaken each week to remove, to the extent possible, sorbed and settled silt on the macroalgae, which visually seemed to be effective.

The experimental outcome was a success in that shrimp production was good for traditional pond methods, the harvest quality of shrimp was high, and *Gracilaria* roughly doubled in mass over the first 60 days of the experiment. *Gracilaria* biomass subsequently remained stable, or increased only slightly, between Day 60 and the harvest (Day 110) in the pond treatments. This plateau in biomass was not due to nutrient limitation, but instead was likely related, again, to light limitation from overcrowding of *Gracilaria* on the floating mats. A partial harvest at Day 60 may likely have nearly doubled the *Gracilaria* production over the duration of the experiment.

Dissolved nutrient concentrations in the pond varied with *Gracilaria* biomass, with the 0.4 kg/m^2 pond treatment having lower concentrations of ammonia, nitrate, and nitrite than the 0.1 kg/m^2 treatment. This result was particularly true during the first half of the experiment when *Gracilaria* biomass was increasing. However, nutrient concentrations remained high in all the treatments, and the proportional growth rates of *Gracilaria* were equal in all treatments. By the end of the experiment, with ~45 days of little increase in *Gracilaria* biomass, the differences in dissolved nutrient concentrations among the treatments were small, as the continued input of feed overwhelmed the nutrient dynamics.

Shrimp growth increased in the presence of *Gracilaria*, particularly in the 0.2 kg/m^2 treatment. Anecdotal observations suggest that this increase may have been related to a greater abundance of zooplankton feeding at the macroalgal surfaces, although this difference was not quantified. This outcome indicates that future work should examine the potential role of macroalgae in facilitating zooplankton production in brackish water pond aquaculture.

Surprisingly, the dissolved nutrient concentrations were lowest in the control pond (containg no *Gracilaria*), which appears to run counter to the expectation that the growth of co-cultured macroalgae in the ponds would be a sink for nutrients. There are two potential reasons for this unexpected outcome. First, a local variety of grass began growing rapidly in the control pond within the first month of the experiment. This occurrence is not uncommon in traditional aquaculture, and normally is accompanied by lower phytoplankton abundance (assessed by water color). Our measurements confirmed that phytoplankton cell numbers were lowest in the control relative to the IMTA treatments, and this outcome likely was related to low phosphate concentrations (~ 0.3 µM P). These low phosphate concentrations persisted through Day 60, after which concentrations began to slowly increase. The second factor to consider is that the grass was removed by hand after Day 30, which caused considerable disruption of the sediments (the grass roots were ~10 cm long). Immediately following this removal there was a sharp pulsed increase in the concentrations of nitrite and nitrate in the control pond that lasted until Day 60. This resuspension/disturbance would have injected oxygen into the anoxic/hypoxic sediments, stimulating microbial nitrogen cycling processes. The absence of significant co-occurring increases in ammonia suggests that these pulses may indicate increased denitrification in the sediment and water column, although we cannot confirm this with our data.

The lower phosphate concentrations in the control pond is likely related, in part, to uptake by the growing grass, but these low levels persisted for ~30 days after grass removal. Chemical retention of phosphate in sediments by sorption with calcium carbonate and ferric (oxy)hydroxide surfaces is well established. Indonesian soils are rich in iron, and the pH, temperature, and brackish water conditions would be favorable for the precipitation of calcium carbonate. The extensive sediment disruption, exposing new sediment surfaces to pond water, may have increased phosphorus removal from pond waters, although we cannot confirm this with our data.

The collective findings of the MarWeB pond aquaculture experiments demonstrated that:

- IMTA methods adding *Gracilaria* to shrimp and tilapia aquaculture ponds using low-intensity methods does not negatively affect production, and may in some cases increase shrimp growth;
- Initial additions of 0.4 kg/m^2 *Gracilaria* in floating rafts can double biomass in ~60 days, enhancing economic recovery from pond operations and contributing to markedly lower concentrations of dissolved nutrients;
- Sediment disruption during pond aquaculture may lead to increased denitrification and phosphorus removal, reducing the nutrient loads released by aquaculture operations to coastal waters; and
- Local grasses may be particularly effective in the removal of nutrients from pond wastewaters, suggesting a new approach to low-cost remediation methods to limit pond aquaculture impacts on coastal ecosystems.

All data from 2014–2016 pond aquaculture experiments are available from the MarWeB database[2].

3.2 Social science studies

In Karawang, most shrimp aquaculture operations are destined for overseas markets in developed countries. The challenge, therefore, is to diversify and develop multispecies products and shift them to supply local markets, with the goals of local job creation, local consumption, and the improvement of community well-being.

The social science studies of the Indonesia case study were intended to consider three broad questions:

1. What are the people's needs for marine ecosystem services in Indonesia?
2. How can IMTA respond to these needs, and what are the ecological and social benefits to be delivered by IMTA?
3. How can such effects contribute to human well-being?

Some aspects of these questions can be addressed by the "well-being cube" approach described in Section 2, whereas other aspects require field studies on how people in Indonesia actually affiliate with marine food. The overall goal for this case study was an attempt to introduce "change" to the community, leading to improved well-being in both the natural and social systems. Here, social well-being is interpreted as having free time to spend with family and a wide variety of jobs (a varied seafood commodity chain). An analysis for Indonesia was conducted using the "well-being cube" approach (Fig. 3.3). The data[2] were collected by

[2] http://www.pices.int/projects/marweb

interviewing 200 people in 2014. According to the analysis, the key words for better well-being for the people in this area of Indonesia included "Stability", "Beneficial", "Aesthetic (*e.g.*, food culture and variety)", and "Ability to change".

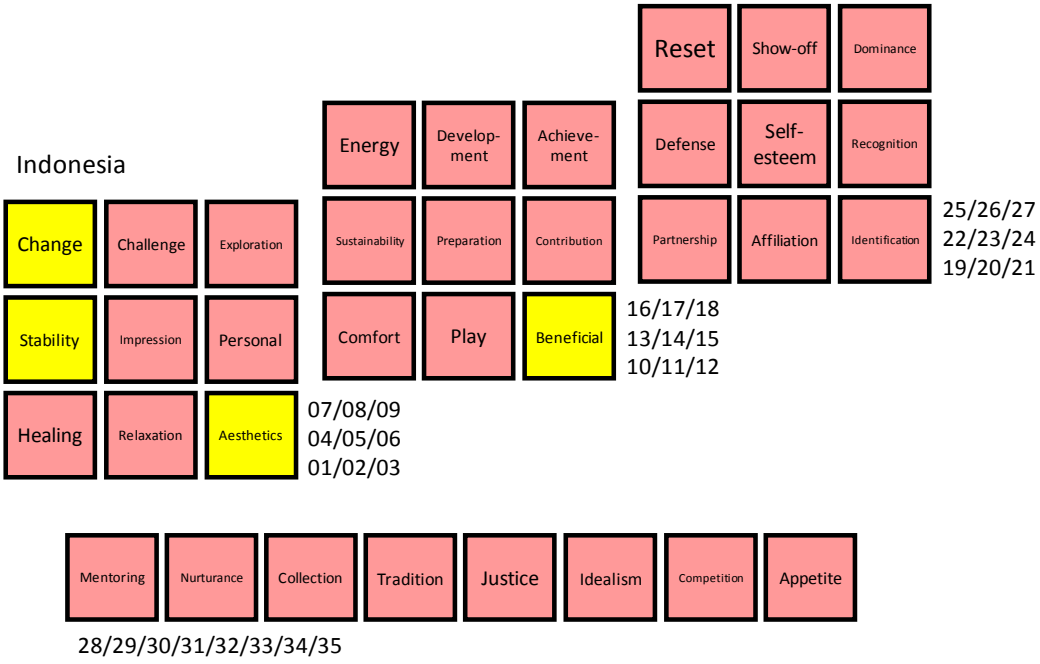
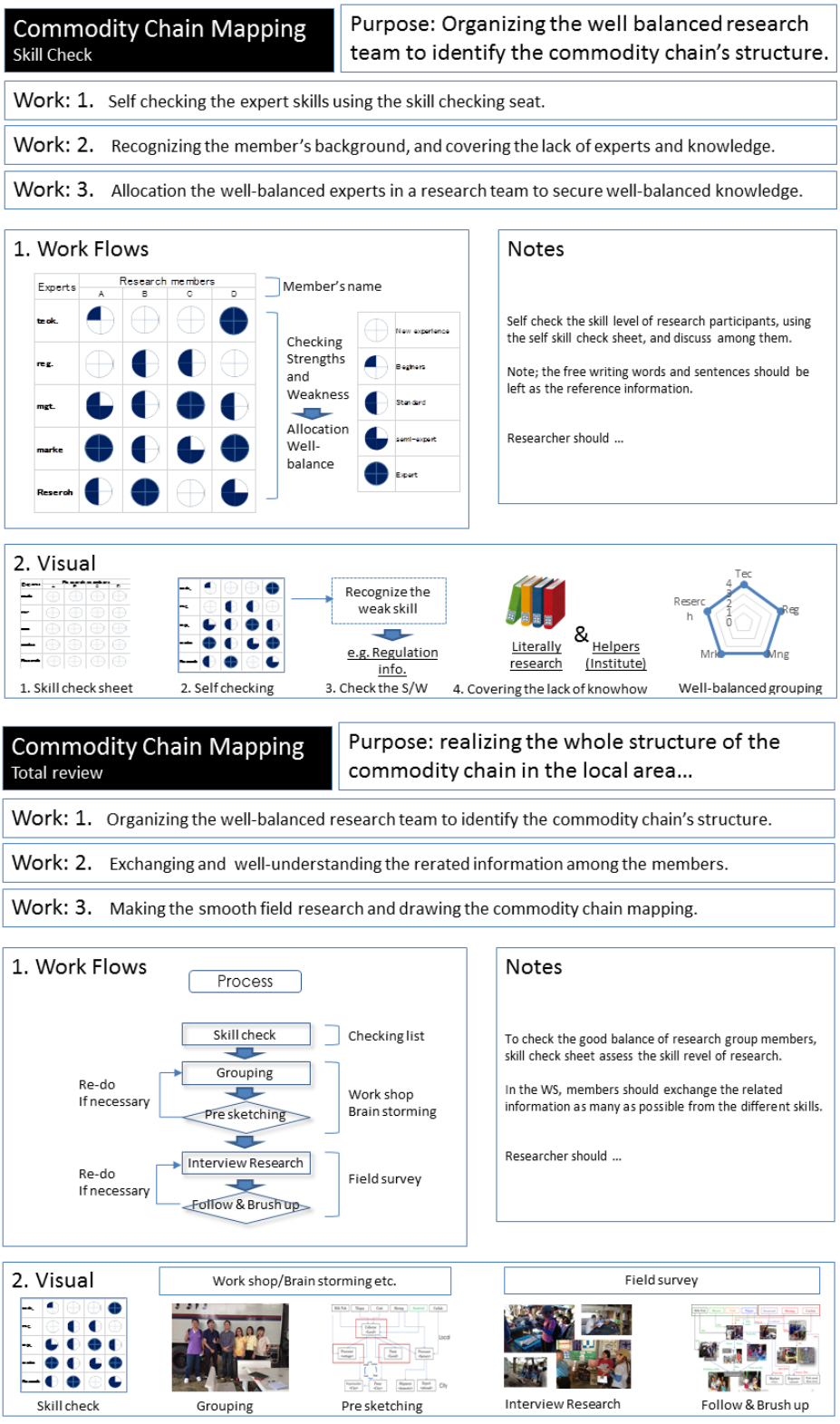


Fig. 3.3 "Well-being cube" analysis for Karawang, Indonesia. Pink indicates high expectation and high satisfaction, and yellow indicates high expectation but low satisfaction.

Therefore, the social science study in Karawang was designed to examine the effects of IMTA on these four keywords. A commodity chain mapping approach was used to identify: (1) what kinds of local businesses are involved in seafood commodities and which ones might benefit from the outcomes of IMTA, (2) who are the consumers, and (3) how much of the multi-species products from IMTA operations (*e.g.*, shrimp, milkfish, crabs, *etc.*) might potentially be consumed. The hope was that by changing shrimp monoculture to IMTA it will be possible to build a sustainable pond culture system and suppress coastal pollution and erosion. In addition, there is a high probability that this could lead to new and diverse job opportunities and ensure a rich variety of seafood available for consumption by the local communities.

Commodity (or supply or value) chain mapping is accomplished by identifying the steps in the process of bringing goods from source to market. It can be used at the local level, *e.g.*, to identify the locations of areas with inadequate access to food (Donkin *et al.*, 1999). A general approach is described at http://www.supplychainopz.com/2011/06/supply-chain-mapping.html, and a step-by-step process for building a commodity chain map is detailed in Box 3.1.

Box 3.1 Step-by-step process for building a commodity chain map, as used for the case study in Karawang, Indonesia.



Commodity Chain Mapping
Pre-sketching

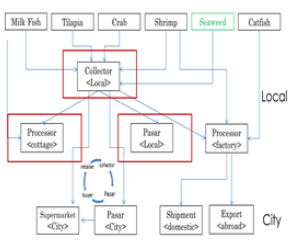
Purpose: Realizing the outline of the local society and the structure through the laugh sketch

Work: 1. Identifying the target species in the research action planning with Biological approach staffs.

Work: 2. Drawing the rough map of the local society structure, basic commodity chain and their life.

Work: 3. Separately drawing the structures, gaps and the interfaces btw Local and Global on the sketch.

1. Work Flows

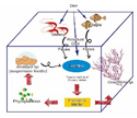


1. Identify the target species

2. Lough sketching of the structure of the local society, while discussing together with the members.

3. Realize and set the interface btw Locality and Globalism in it.

2. Visual


1. Target species


2. Rough sketching


3. Local btw Global

Notes

When identifying the target species, exchanging the related bio-approach information with its expert and its staffs is important.

When being sketch the local structure, you should note that where do they set the marketing target, do they set the target on local or global ? and what of the function do they set in their business?

When being drawing the chains bet local and global, you should have to completely separate the zone of the activities because the target markets and discipline of their actions are different directions.

When thinking the structure and life or management level, you should not mix the information both local and global. Global have an direction to commercial management, locality means the community people's life.

Commodity Chain Mapping
Interview research

Purpose: Gathering the qualitative information quantitative data to map the commodity chains.

Work: 1. Identifying the business players, the commodity flows and networks of their business partners.

Work: 2. Check the business items(species, standards(size, forms etc.) and the users and consumptions.

Work: 3. Finding out of the direction of business network/integration, job creation and the income level.

1. Work Flows

1. Identify the players/stakeholders using the sample pictures

2. Confirm the commodity flows along the player's business operations /stakeholder's consumptions and the networks.

3. Find out the future directions and the possibility for local people's job & life.

2. Visual


1. Interview survey


2. Mapping


3. Verification

Notes

When identifying the players and stakeholders, you should trace them along supply chain flow in the local.

When being research the commodity chain flow, you should note that where (how) do they set the business operation "range" (geographical), and realize the histlolical management "context" of them and the scale while thinking the "range".

When finalizing the commodity chain mapping, you should have a perspective of the commodity chain in order to be grand design of the future map, applying some sinarios, for realizing the well-balanced local society prepared the profitable business system and sustainable local use for local community people.

It is better to repeat the interview survey so that you won't be lack of information or misunderstanding because there are often mis-communication in field survey due to local diarect, technical terms and local name of species.

You should have several verification with the research member because you will be able to brush up some un-clear information.

End Box 3.1

The purposes of commodity chain mapping are:

- Market – identify the features of the market, the flexibility of job creation and the spatial range;
- Functions – identify the products of redistribution, value added, and the steps needed for a wide variety of products;
- Participants – identify the stakeholders, including related persons and organizations; and
- Rules – understand the regulation of business, the sentiments and cultures of the society and human relationships.

In this study, commodity chain mapping was accomplished by in-person interviews in Karawang to identify, for each seafood product (with a focus on those potentially derived from local IMTA), who buys, modifies, transports, and ultimately consumes the products (Fig. 3.4). In the local food supply chain, the "collectors" are the people who obtain the seafood products from the source producer. Their number has been increasing over the past few years, and the commodity chain of Karawang is highly dependent on their activity. They are one of the most important stakeholders in seafood supply in Karawang. Collectors deliver their seafood to buyers, who may then sell this seafood to the export market or to local markets ("pasar"), restaurants, or cottage processors. These latter are the traditional way of processing seafood and can employ many local workers, including family members. Local people then buy and consume the seafood products from these various suppliers. In the seafood export market, the main products from Karawang are shrimp and catfish. These are usually transported to processors where they are frozen and exported abroad, or sometimes further processed in Indonesia as fish meal.

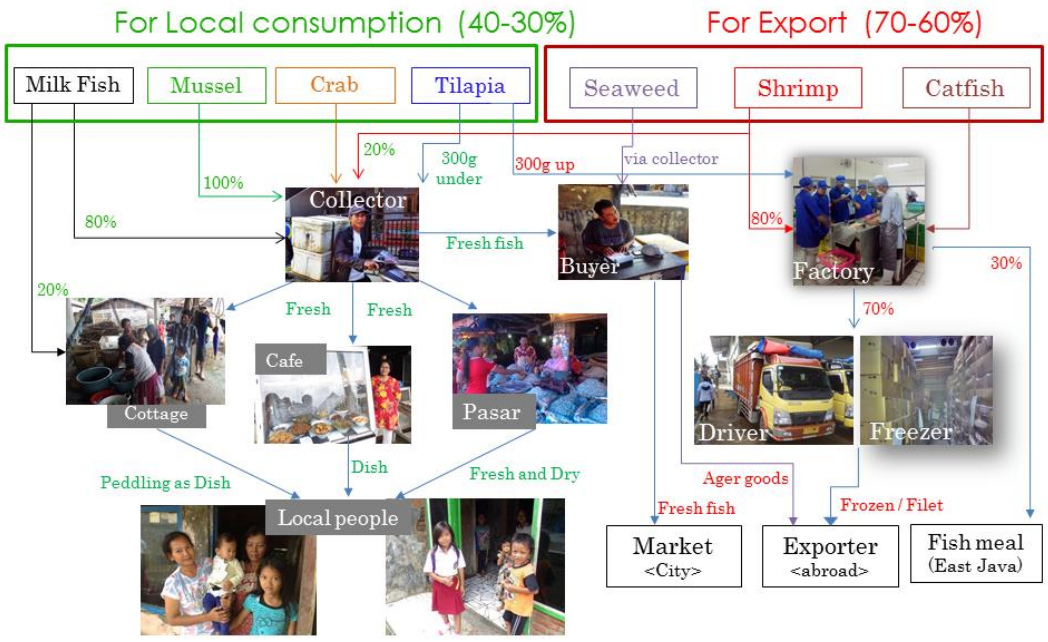


Fig. 3.4 Commodity chain map of the seafood supply in Karawang, Indonesia, separated between the local consumption and export markets. Photos by Masahito Hirota, Fisheries Research and Education Agency of Japan.

A questionnaire developed to facilitate the collection of information for commodity chain mapping is shown in Figure 3.5.

Fig. 3.5 Local community questionnaire used to build the seafood commodity chain map for Karawang, Indonesia. Photos by Masahito Hirota, Fisheries Research and Education Agency of Japan.

3.3 Conclusions

Integrated multi-trophic aquaculture (IMTA) of shrimp, fish, clam, and macroalgal species was conducted to address the problem of mass diseases in shrimp mariculture activities, the coastal erosion of the coastline after the abandonment of the ponds, and to help reduce the release of nutrients to coastal waters caused by pond aquaculture. The experiments show that IMTA can produce more products in terms of volume and number of species in a stable way, while decreasing the wastes from the pond to the sea. The findings will help to chart the way forward toward more sustainable aquaculture activities in this region.

The commodity chain mapping analysis showed that the introduction of IMTA can improve the human well-being in the Karawang area. Safe seafood and the protection of land and coastline by IMTA can improve the sense of "Stability". More jobs and wealth created by IMTA through the commodity chain can improve the sense of "Beneficial" activities. A wider variety of products from IMTA and better water quality can improve the "Aesthetic" sense. Finally, the capacity building workshops organized by this project in 2013 and 2014 strengthened local people's "Ability to change" for better social-ecological systems in Karawang. These outcomes can improve human well-being as defined by the Millennium Ecosystem Assessment (2005), mainly by improving the conditions for "Basic material for a good life". Ultimately, this will lead to "Freedom of choice and action" and to potentially a broader introduction of IMTA to produce a healthy and sustainable ecosystem for the people of Indonesia.

4 Case Study 2: Guatemala

Vera L. Trainer[1], Charles Trick[2], William P. Cochlan[3], Phaedra Henley[2] and Héctor Leonel Carrillo Ovalle[4]

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4.1 Project background

In Guatemala, the removal of marine resources has no effective regulatory control. While there is a proclaimed Guatemalan Fisheries and Aquaculture General Law, there are few regulations that influence the level of recreational, sport, community or commercial fisheries. Yet, the fisheries are tremendously important to the coastal communities as the primary source of nutrition, jobs, social well-being and income. The ability of communities to access marine resources in this unregulated position, while the community population grows, is a classic problem of coastal communities around the world. Marine resources in Guatemala are an example of the "Tragedy of the Commons" (Hardin, 1968) in action and have a clear community-at-risk concern as the community outgrows its dwindling resources (Ostrom *et al*., 2002).

Guatemala has approximately 250 kilometres of coastline along the Pacific coast. A smaller shore along the Atlantic Ocean is also within the Guatemalan territorial waters, but this area is sparsely inhabited and poorly utilized with regard to fishing, making up about 10% of the fishing effort. A summary of fishing activities from the Unión Nacional de Pescadores Conservacionista (UNIPESCA: http://www.unipesca.es) indicates that 95% of fishing activities are performed by small community-based boats (1,400 boats) within 10 km from shore. There are a small number of commercial boats (65) that extend their range to the allowable 200 km limit. Several recent shifts are pertinent to this report:

- The reduction of catch over the last two decades has brought the community fishing effort into the extensive (300 km long) coastal river and lagoon system. UNIPESCA states that 100% of the resources extracted from the coastal system go to subsistence fishing.

- There has been a great shift from pelagic fisheries to shrimp fisheries. This is in parallel with the increased shrimp fisheries along the Middle America region where the shrimp catch has risen from ~1,600 metric tons in the 1960s, to ~3,500 metric tons in 1995 to ~500 metric tons at present. The recent reduction is not due to a reduced fishing effort but to overfishing of this resource.

Guatemala was selected for the second MarWeB case study because of these conditions, and because of excellent personal relationships with key people at the University of San Carlos, Guatemala, which had developed during an earlier PICES MAFF-supported project on "*Development of the prevention systems*

for harmful organisms' expansion in the Pacific Rim" (2007–2012). Similar to the case study in Indonesia, the Guatemala case study comprised a natural science component and a social science component. It was conducted principally at the locations on the Pacific coast of Guatemala shown in Figure 4.1.

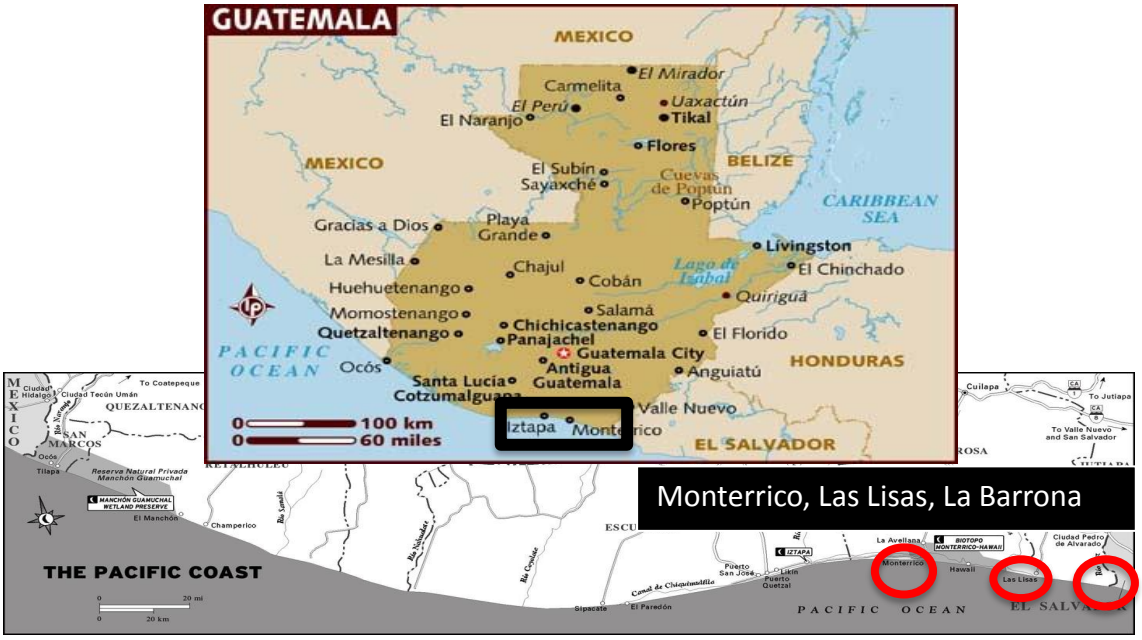

Fig. 4.1 Guatemala case study locations: Monterrico, Las Lisas, and La Barrona (red circles).

The MarWeB case study team first visited their key contact people in Guatemala to discuss the objectives of the project and to introduce the idea of *sato-umi*. During this visit, a poster was presented showing the integrated concept of *sato-umi*. Visual aids were important because of the likelihood of language barriers. A translator (with a science background) was hired who understood and was able to communicate the project concepts effectively.

The plan was to reproduce, as closely as possible, the efforts to develop a *sato-umi* approach in the Guatemala case study which was similar to that being developed in the Indonesia case study. During the first visit, however, it was discovered that there are no endemic macroalgae (seaweeds) in Guatemala. In addition, the large-scale shrimp culture practices in coastal Guatemala have been optimized to prevent disease and to produce the highest yields. These high-intensity aquaculture operations are extremely susceptible to catastrophic loss of shrimp from disease and other factors, so operators are not voluntarily open to experimentation with co-culturing approaches that potentially could lessen downstream environmental impacts. Therefore, the integrated multi-trophic aquaculture approach to implementing *sato-umi* that was being examined in Indonesia did not appear to be practical or appropriate for Guatemala. However, discussions with university colleagues and local coastal residents suggested that we could explore other options for more sustainable fishing practices, for example, through aquaculture and tourism development. A questionnaire was sent to our point people about the fisheries supply chain, including exports, to determine which fisheries could be the focus of the project.

The Guatemala contacts were able to identify and communicate with communities for which the project might be a good fit. The project team and their Guatemala colleagues visited several coastal villages to discuss the MarWeB project goals. An information sheet and poster on *sato-umi* was presented to introduce the concept. Informal interviews were used to begin a community needs assessment (CNA), a systematic process for determining the needs and definable goals of a community. CNAs are typically performed before major actions are taken as part of a strategic planning process.

Two contrasting communities were selected to participate in the project: Las Lisas, a more isolated, with a healthier ecosystem (enough fish in the ocean) and a healthier community (health center, education to the high school level, many community members attended college and returned to work in this community), and Monterrico, a community on the road system but with a degraded ecosystem (people fish in the estuaries with small size mesh (*i.e.*, window screen) to catch every small fish; less fish in the ocean); local shrimp aquaculture benefits only a few, with products exported.

These two communities represented extremes in community responses to the demise of the local fisheries. Community members from Las Lisas were enthusiastic for change that would allow for the return of the resources and the survival of their community. In contrast, community members for Monterrico were very despondent about the future – declaring themselves as the "last fishermen on earth." A CNA was chosen to help understand the differences between these two communities with regard to their relationships to the sea. Could a *sato-umi* approach make a meaningful impact on the triple bottom line: revitalization of sustainable fisheries, provision of ecologically manageable strategies and implementation, and creation of facilities with a demonstrable low environmental impact?

4.2 Natural science studies

The coastline of Guatemala has few locations, such as bays and inlets, which are protected from open ocean conditions. As a consequence, there is little habitat which is suitable for high natural populations of bivalve molluscs or locations suitable for their cultivation. This has meant that 90% of bivalve molluscs in Guatemala are imported from El Salvador, Mexico, Panama, Chile, and USA. However, several areas along Guatemala's Pacific coast have environmental characteristics that could support the culture of bivalve molluscs. Additionally, these areas are important locations for artisanal fishermen, although fishing resources can be highly variable. The cultivation of oysters or other bivalves would allow extra income to the economy of these groups of people, who often live in poverty.

The Center for Marine and Aquaculture (CEMA) at the University of San Carlos, Guatemala, has conducted culture studies with bivalve molluscs since 1998, mainly in the inner harbor of Puerto Quetzal, and reproduction studies in controlled laboratory settings in the experimental station at Monterrico. Previous studies examined the use of longline systems, and assessed growth rates, materials, domestic markets and cultural practices. The MarWeB case study examined how to adapt this longline technology for bivalve culture in the coastal lagoons of La Barrona. The sources of freshwater there have low levels of contamination, and the depths of these coastal lagoons offer a suitable habitat for shellfish culture. The intent was to work with the Integral Fisheries Cooperative Barrona RL to use this as a demonstration project which could be transferred to other coastal communities with similar water characteristics. The specific objectives were to:

- Evaluate the performance of the longline system in La Barrona estuarine lagoons (*e.g.*, Fig. 4.2);
- Measure the productivity of bivalve molluscs (oysters) on the basis of their growth rates and time to reach market size;
- Evaluate the survival rate in the different phases, and the main predators present;
- Adapt or develop culture practices for the optimal management of the system by the Integral Fisheries Cooperative Barrona RL;
- Perform microbiological studies of the product to ensure consumer food safety;
- Assist with finding suitable markets for the sale of the final product by the Integral Fisheries Cooperative Barrona RL.

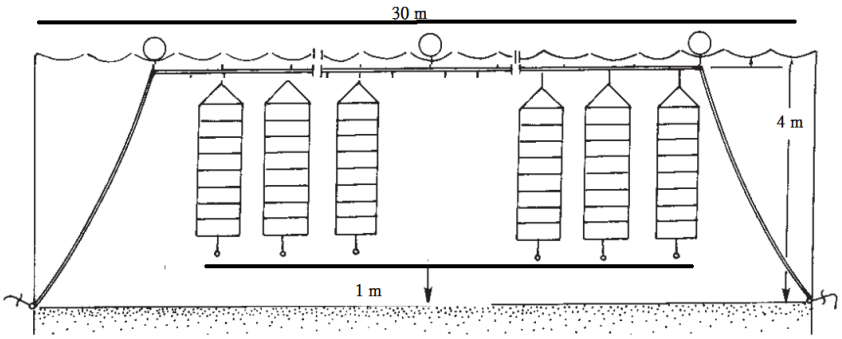

Fig. 4.2 Example of a longline arrangement for culture of the Pacific oyster *Crassostrea gigas*.

Unfortunately, despite strong support in the local community, this project struggled with problems of theft of the equipment and study organisms, and was not able to achieve its goals. However, the community did learn about the principals of oyster aquaculture and what would be required for successful growth of the bivalves if security conditions could be ensured. The results obtained from the trial period demonstrated that culturing of *Crassostrea gigas* is feasible in Guatemala despite relatively low water recirculation rates and a high amount of suspended solids in the water column. *C. gigas* can achieve the commercial market size of 70 mm in diameter in six months. However, the system must be cleaned every 15 days in order to maintain and/or improve these survival rates.

4.3 Social science studies

4.3.1 Methods

Communities along the Pacific coast of Guatemala are true cultural entities. While not historically part of the strongly traditional Quiché (Mayan) culture, movement between communities is limited and culturally restricted. Community members who leave their communities are highly respected when they return, bringing new knowledge to the community. The idea of a mobile community capable of changing with changing resources is not applicable here. Overall, the situation in coastal Guatemala is that communities are seeking self-sufficiency in the wake of strongly declining fisheries potential and have no other agri-economic or eco-tourism ventures.

At the foundation of *sato-umi* (Yanagi, 2008) is the need for fishery-based communities to accept the costs of retooling their economies to allow for the costs of conservation to bring back both the resource and the cultural/community relationship. *Sato-umi* is achieved by establishing local collective structures that enforce the community's interest, and the availability of active conservation measures as options to contribute to biodiversity management through manual work in the ecosystem (Berque and Matsuda, 2013).

The CNA, a process and protocol to gather information on the definable needs of a community (Altschuld and Kumar, 2010), was implemented for Las Lisas and Monterrico. CNAs are performed prior to major actions being taken as part of a strategic planning process and are fundamental to the development of coastal resources views (NOAA, no date). CNAs are critical in "action-learning" projects where surveys and community mapping exercises are used.

Fig. 4.3 Cartoon of interactions between healthy natural systems and healthy human systems in coastal regions, used to facilitate interviews with families in Guatemala (FRA, Japan).

Family interviews were conducted together with scientists and translators to get impressions of family relationships with the sea. A visual aid (*e.g.*, Fig. 4.3) was used to make sure the project concept was understood. The interview questions included:

1. Which thing in this poster is the most important of the sea to your family?
2. Which is the biggest concern of your family?
3. Does your community have to change or is it fine?

Complementing the interview questions was a survey comprised of 34 questions with clickable answers. The questions in general fell into four categories: (1) questions that introduced the process so that the families could familiarize themselves with the clicker system and diminish any anxiety associated with the

survey itself; (2) questions that helped delineate the demographics of the responder; (3) questions that explored 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. The survey was conducted using a computer, projector, and real-time electronic "clickers" which the family could use to input their response, with the results immediately being integrated and presented on the screen, anonymously for the entire room (see the MarWeB database[3] for all questions and responses for Las Lisas and Monterrico). Prior to the survey, the project team was told that community members would be reluctant to share their thoughts with strangers, so it was decided to use the clickers to allow for anonymity of responses. This allowed the team to conduct a CNA in more detail. The team spent a day with the community members and surveyed about 20 families.

4.3.2 Results

The data from the clicker surveys were analyzed by the project team. Summaries of the CNA were provided to the Las Lisas and Monterrico communities as oral presentations, a booklet with photos and comments, and a comprehensive report. The latter included a full synthesis of the survey results, conclusions of the CNA and recommendations.

Demographics

For comparison, the responses were split into the two communities, plus a sub-group of fishermen from Monterrico. The Monterrico fishermen had the largest families (*i.e.*, supporting greater than 7 individuals), with multigenerational fishermen within each family. On average there were more than 4 children per family. In contrast, the traditional (non-fishermen) family in Monterrico was smaller (5–6 people), with fewer children (3–4). The families of Las Lisas were the smallest (5 or less), with 2 children.

Protein needs

Protein for Las Lisas' families came primarily from finfish from the market. The use of fish in the diet was variable, with most families restricting fish meals to one to two meals per month. This was surprising, given that this is an isolated fishing community. The Monterrico community was further removed from fresh seafood as the source of protein. About 50% of the fish consumed came from processed (frozen, non-local fish or canned) fish. They had a higher frequency of fish meals per month compared with Las Lisas communities.

Association with fisheries and alternate fisheries

As an extension of the real loss of natural fisheries, Las Lisas and Monterrico accepted that aquaculture-grown fish is required to maintain their respective community. It was not so much that aquaculture fish would improve the family diet (nutrition) but that aquaculture would improve the economics of the community and, as a result, the quality of life for families. All responders, except the separate group of fishermen responders, recognized that their community is moving away from the sea and needs to create land-based livelihoods. Not surprisingly, the individuals self-designated as fishermen caught fish for the market only, relying on other family members to obtain fish for family use. All families, regardless of location, believed that the availability of fish had declined over the last decade and that the quality of the

[3] http://www.pices.int/projects/marweb

fish caught locally had diminished, often using the term "contaminated". They had no confidence that their community would survive in their current association with natural fisheries. This general view is in contrast to their positive feelings towards the sea – perhaps an acceptance that the sea defines their location, transport, and history – but is no longer a reliable provider. All recognized that meal and protein alternatives that did not originate from their shores are readily available. The path to a new economy was less clear. Most agreed, including fishermen, that there is a need for better education. This could be interpreted two ways – that with the increased investment of time to harvest fish resources for survival, young fishermen must reduce their education substantially, or that education towards improved fisheries or fisheries management is desired. In contrast to the perceived needs of the families, the respondents did not consider a community with increased aquaculture opportunities.

The perception from the survey is that the three responding groups were at different stages of loss with regard to natural fisheries. Monterrico has moved furthest from a natural fisheries community. Its dependence is no longer on fisheries but other economic activities. This is also the community that has exploited the marine resource the most – from the loss of pelagic finfish to the loss of netable resources in the coastal lagoons. They are now netting the coastal rivers and lagoons for subsistence protein using window screens. All indications are that the Monterrico community can no longer rely on their waters for their livelihood. They are also the community most open to whatever new livelihood is available, *i.e*., aquaculture, land-crops, or tourism.

Las Lisas community members still had a strong reliance on the natural marine resources but were open to transportable foods. This community is more isolated from other economic activities and somewhat geographically separated on a coastal peninsula. The responders looked to the natural sea resources for the future, but had an equally strong desire to add land-based aquaculture facilities to their economic foundation. Las Lisas is the community that is in an early stage leading toward the path of lost fisheries – there is a strong sense of loss and insufficient replacement, yet improvements in natural fisheries or improved access to natural fisheries (piers, boat access, *etc*.) are the focus of their future vision. They are optimistic about their community and have a strong desire to increase the "value added" fisheries access by exploring the recreational or eco-tourism markets.

A synthesis of this assessment includes the following:

- Seafood, in particular pelagic finfish and shrimp, is an important component of local diets, and "fishing" is a culturally-determining part of the community;
- Nevertheless, many respondents in these communities expressed a desire to move away from such high dependence on the sea;
- A healthier lifestyle can be facilitated with opportunities for better education, sustainable environmentally-friendly tourism, and environmentally-considerate aquaculture opportunities;
- Protection of the lagoon waters is essential, as these waters are breeding grounds for many major economically valuable species;
- Community-wide, coordinated eco-tourism and fishing trips for tourists could be implemented to create a more sustainable alternative to fishing for sustenance;
- An alternative source of fish-based food supplies must be sought, such as through aquaculture;
- The communities have a relationship with the University of San Carlos and should work with the faculty and researchers to develop sustainable associations.

Through the survey and conversations it was clear that these two communities are at different stages along the path of development. Monterrico has been in a resource-starved existence for some time and is prepared for development that does not include natural marine resources. Community food choices are a concern for the villagers. Here, logical alternatives would be aquaculture. The community vision is firmly directed to shrimp mariculture – a common vision for communities in this region. With many other Guatemalan communities benefitting from shrimp mariculture, it is hard not to want to follow a similar path.

However, shrimp mariculture is a firmly established enterprise in this region of Guatemala. Companies such as Acuamaya are highly visible and highly successful. They have a strong presence in the economic development in the region. They also have a program to assist individuals or communities in developing the shrimp industry – but under their terms. For reasons that are both economically advantageous to Acuamaya and critical for the industry to prosper, Acuamaya will assist if the community follows their strict guidelines (financing, seed stock, rearing timeline, treatment for infectious agents, *etc*.). High-intensity shrimp aquaculture operations in Guatemala do not lend themselves to multi-trophic operations. For example, there is no interest in secondary treatment of wastewater from shrimp ponds since: (1) the wastewater is high volume/high flow and cannot be held for a sufficient period of time to process; (2) any after pond retention is seen as a reservoir of infectious agents, placing the crop at risk; and (3) the "ocean is right there" to serve as a suitable dilution opportunity. In addition, shrimp farming is a large operation with a small economic footprint. It is not a community-intensive activity – it is easily run by a small number of individuals, and the product is shipped elsewhere immediately without any community processing.

Given the present successful shrimp aquaculture operations by these companies, the MarWeB project was unable to make any significant input to this industry. However, a *sato-umi* approach could contribute in the development of alternatives to shrimp farms. It is uncertain why previous ventures into tilapia aquaculture were not maintained, but given the extensive nature of the industry, it is likely that the possibility of an economic success is marginal. Novel alternatives must be sought. While aquaculture may be the future for Monterrico, other alternatives seem appropriate for Las Lisas. Here the natural fisheries are not as depleted as in Monterrico, and economic activities that can involve the fisherman's skills combined with lower pressure on the natural fisheries community should be considered. Expansion of recreational fisheries or eco-tourism would enable the use of the present fishing fleet and community skill set, while allowing the natural fisheries communities to recover. La Lisas is poised to increased education in resource management and development. However, this is an uphill battle as the community is very isolated, lacks facilities for visitors who would participate in the recreational / eco-tourism activities. The community of Las Lisas is still strongly connected to the sea and philosophically poised to alter its world as long as their natural resources are not fully exploited.

Implementation of *sato-umi* in Guatemala will depend upon the building of trust and relationships with the local people, and with shifting the focus from fishing to tourism and other activities. Fishermen suggested that the next generation of fishermen should be fewer and better educated in sustainable business practices. Community leaders were encouraged to use the MarWeB project report as a tool to help secure funding for future eco-friendly development while carefully considering which opportunities best promoted community economic and ecosystem health.

As a result of the CNA, Las Lisas and Monterrico were provided with access to experts in tourism and were encouraged to establish a side project on community aquaculture. This MarWeB project partnership was able to open avenues of collaboration among the local communities on the coast, the military, and the university research community. The project also facilitated communications with leaders of a United Nations Development Program (UNDP) project which is intended to support and expand the five Marine Protected Areas (MPAs) on the Pacific coast of Guatemala.

4.4 Establishment of marine protected areas in Guatemala

Through the interactions and connections with key contacts in Guatemala, the MarWeB project team was contacted by UNDP to assist with developing the conditions to establish MPAs along the Pacific coast of Guatemala. This activity included co-support of a multi-day workshop on "*Exchange of experiences for conservation and sustainable use of biodiversity in protected areas on the marine coast*" attended by university faculty and students and representatives of government ministries. The participants conducted fieldwork with local fishermen to learn about inshore and estuarine fishing operations, the management and challenges associated with finfish and marine products and distribution, and analysis of problems with fishing gear in the multipurpose Natural Reserve of Monterrico. They also participated in a series of interactive sessions on coastal marine issues associated with climate change.

The overall findings and recommendations by the MarWeB project team in regard to elements critical to the establishment of successful MPAs included:

1. **Student input:** The collaboration of students of from Universidad del Valle (University of the Valley) and Universidad de San Carlos de Guatemala (University of San Carlos, Guatemala) with UN project investigators benefits both the UN project and the students. By keeping the students informed of the current issues and challenges (both legal and scientific) of the project, they can help brainstorm and implement solutions to existing and potential problems. In particular, the students were interested in establishing the proper balance between enforcement of fishing rules for fishermen and education of the citizens (both fishermen and non-fishermen alike). This is especially important because of the high rate of illiteracy in coastal Guatemala – enforcement without education is unfair and unproductive and contributes to social injustice for the impacted citizens in a very challenging economic region of Guatemala.

2. **Empowerment of locals:** The students developed strategic solutions to a series of fisheries problems in coastal Guatemala (*e.g.*, preventing the use of illegal fishing nets in estuaries). The solutions included providing outreach to entire family groups, not just males. The inclusion of men, women, and children in the decision-making process allows them to benefit in the outcome and is important to ensure successful recruitment of a wide spectrum of community members as coastal stewards. The "stickers and clickers" approach (using anonymous surveys combined with interesting activities for the children) introduced by the MarWeB project team will be continued in the future by university faculty and students participating in the UN project.

3. **Incentives:** The sea turtle project is an example of successful conservation in coastal Guatemala. By encouraging harvesters to provide 20% of the harvested eggs for conservation, there has been a substantial rebound in turtle populations. This incentive is also supported by enforcement as there is a fine for those who violate the 20% return policy. This strategy could be used as a model for other conservation programs yet to be established, such as exchanging illegal "window screen" type nets for legal ones of a defined and ecologically sustainable mesh size. Fishermen adopting legal nets would be presented with a fishing license, upon demonstrating an understanding of the fishing regulations, while emphasizing to the entire family that they had now joined the realm of coastal stewards (as suggested by a student group during their discussions).

4. **Sustainability:** There has been little discussion in country about how the MPAs in Guatemala will be maintained after the UN project funding ends. The MarWeB project team recommended Guatemala to consider developing partnerships with international experts of the Natural Capital Project and NOAA's International Marine Protected Area Capacity Building Team to develop a plan for sustaining the MPAs into the future.

5. **Partnerships:** Establishing strong partnerships with all the environmental agencies involved in sustaining coastal resources, and protecting the Guatemalan coastal, estuarine and nearshore waters is important. It is essential that all parties responsible for the creation and management of the MPAs have an active role in the development of these areas, and that they continue to be invited to participate in future meetings.

6. **Training of the next generation:** The students are starved for advanced training in subjects such as stock assessment, integrated ecosystem assessment, general oceanography (in particular chemical and biological), and marine biology. Much of their current training is focused on the very practical aspects of establishing and maintaining aquaculture operations. Future opportunities should be sought to bring in international experts to provide training in fisheries and ecosystem science, and to talk about the challenges facing people and coastal life due to climate change. It will be important to provide a translator for locals who want to listen and learn from the lecturers, but do not speak English. A rewarding observation was that two of the leaders of this workshop had participated as students at the University of San Carlos in previous trainings and workshops sponsored by PICES under the Seafood Safety Program. One of them currently oversees Fisheries Resources Regulation, Control and Enforcement on both coasts of Guatemala and the other was a professor of oceanography from the University of San Carlos.

7. **Perceptions of fish and establishment of a supply chain:** The supply chain for fish transport to Guatemala City is poorly developed because it is difficult to get fresh fish to it and other cities in the region. In part, this is due to the lack of education about the nutritional value of fish as a valuable source of protein and essential fatty acids (*e.g.*, omega-3 fatty acids). Guatemala's population residing distant from the coast has the general perception that "fish are smelly, toxic and taboo", which leads to relatively little domestic consumption, and export of much of their fish and shrimp products to other countries with the result that Guatemala is "exporting health." The importance of "eat at home aquaculture" was stressed as a key to future healthy populations of citizens.

8. **Tourism:** The importance of tourism education and responsible commercialization of fisheries cannot be understated. There are many examples in Guatemala of successful implementation of sustainable tourism efforts as an alternative to non-sustainable fishing. For example, the sailfish tourist fishery nets $6,000 per tourist per day, whereas the economic value of harvesting and local selling of sailfish is two orders of magnitude less profitable, as a single sailfish sells for only approximately $75 per fish. The fisheries enforcement groups are attempting to educate coastal communities about the importance of sailfish as a catch-and-release fishery to encourage this profitable and sustainable tourist fishery. Large fines and jail time are the consequence of illegal sailfish capture, processing (*e.g.*, smoking) and domestic sales. Relatively sophisticated and modern methods (*e.g.*, aerial drones) are being used to find illegal sailfish smoking operations and help enforce existing regulations.

4.5 Conclusions

Three needs for the future were identified by the Las Lisas and Monterrico communities:

1. An economy based on tourism;
2. Aquaculture (especially with shrimp) for improving the economy and family nutrition;
3. Education, especially with respect to sustainable fisheries and harmony with the sea (*e.g.*, see Fig. 4.3).

In addition, key factors for a successful project in developing nations such as Guatemala include:

- Careful selection of a country that fits the project objectives;
- Establishment of regular communication with effective "point people" in the country of choice; regular communication *via* Skype (preferred), phone (second choice) or email (last choice) is essential;
- Translation of words and concepts into the spoken language of the country of choice;
- An initial visit to the country to determine whether project objectives match the in-country needs, *e.g.*, whether the "fit" is good;
- Use of questionnaires and in-person interviews with the point people and their collaborators to determine which fisheries and communities could be the subject of the project;
- A second visit to the communities to assess their interest in participating in the project;
- Careful analysis of how the communities needs assessments (CNAs) should be performed (*e.g.*, *via* interview, clicker surveys, other types of surveys);
- Analysis of the CNA, followed by appropriate actions. In the Guatemala case study, this included a booklet with pictures of our work with the community and general concepts of *sato-umi*, a summary document, and a formal presentation of results to the participating families;
- Follow-up actions, including steps to establish local aquaculture and tourism enterprises.

5 Case Study 3: Palau

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5.1 Background

The Republic of Palau (Fig. 5.1) was selected as the potential third case study for the MarWeB project. It was chosen because of its finfish capture fishery focus, and because of its existing networks of community-based fisheries. A country profile of Palau constructed by the UN's Food and Agriculture Organisation is available at http://www.fao.org/fi/oldsite/FCP/en/PLW/profile.htm. A preliminary scouting trip was conducted by Ms. Kimuko Suzuki of the Japan Wildlife Research Center in November 2015 to assess the suitability of Palau as a case study and to identify potential key contacts.

As of November 2015, the marine fishery of Palau was categorized into six types: coastal commercial, coastal subsistence, offshore locally-based, offshore foreign-based, freshwater, and aquaculture. The offshore foreign-based fishery was dominated by foreign fishing vessels mainly exporting tuna and bonito from Palau. The main catch in coastal areas was reef fish such as groupers, snappers, *etc*. which was used mostly for domestic consumption. Fish consumption is decreasing gradually in Palau. However, compared to other small island states in the Pacific region, such as Samoa or the Solomon Islands, the consumption of fish in Palau is relatively high. According to the 2013 Statistical Report published by the government of Palau, the share of fishing was 3.3% of GDP (at current prices). This was down slightly from 3.7% in 2007.

In the human social system, fresh fish are landed and distributed to fish markets and local communities. Sixteen fish markets are operated by fishing associations under the Palau Federation of Fishing Associations (PFFA). However, most commercial fishing associations have ceased operations currently, and the number of fish markets is decreasing. Newly opened hotels and restaurants are trying to get fresh fish directly from local fishermen. As a result, the distribution system through fish markets is not functioning.

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* The authors wish to thank the following for comments and interviews during the site visit: J. Blessam (local fisherman), J. Ise (Director, Koror State, Department of Conservation and Law Enforcement), J. Niitsu (tour operator), P. Rechelluul (fisheries technician, Fish Hatchery Division, Bureau of Marine Resources), S. Remoket (fish market owner).

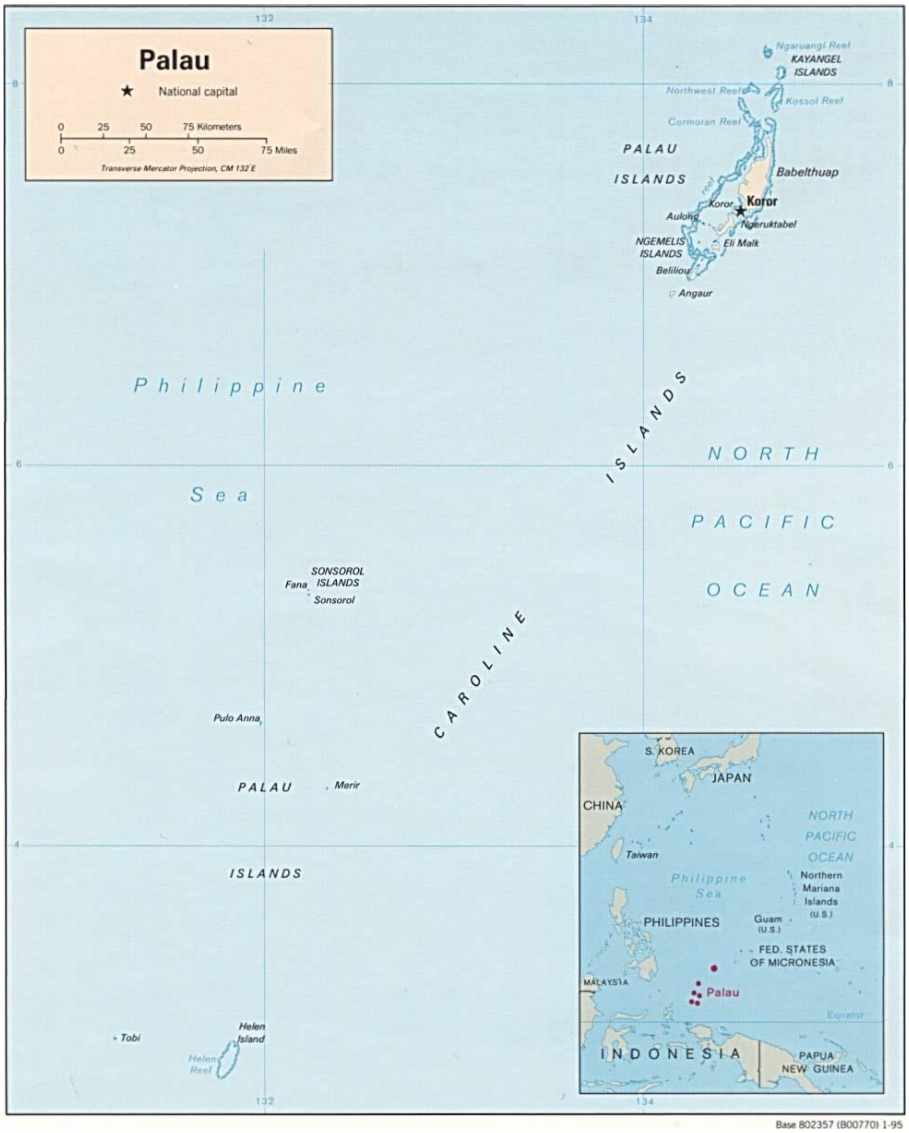

Fig. 5.1 Location of the Republic of Palau in the southwest Pacific. Courtesy of the University of Texas Libraries, The University of Texas at Austin.

5.2 Environmental conservation policy

5.2.1 National level

In 2003, the *Protected Area Network* (PAN) *Act* was adopted to enable the national government to be involved in, and to enhance the efficiency of, protected areas by networking regional activities (*e.g.*, Sasakawa Peace Foundation, 2013). This *Act* defines that the national government should provide technical assistance and develop methods to facilitate effective management of protected areas in the region. The Bureau of PAN, PAN Management Committee, and its Technical Committee were established by the Revised PAN *Act* in 2008 to expedite this network. At the same time, a Green Fee was introduced as a sustainable financial resource.

However, Palau's fishing stocks, including tuna, continued to decline due to foreign-based fisheries. In addition, foreign fishing vessels have negative impacts on Palau's water quality because of waste discharge. As a consequence, and consistent with traditional fishing practices in Palau, the *Palau National Marine Sanctuary Act* was approved in October 2015 to protect the natural resources and marine environment of the country. This *Act* designates 80% of Palau's Exclusive Economic Zone (EEZ) as a fully protected marine reserve in which extractive activities, such as fishing or mining, are prohibited (Fig. 5.2). Slightly larger than the state of California, this sanctuary is the sixth-largest fully protected marine area in the world (Pew Charitable Trusts, 2015). Implementation of the marine sanctuary will take place over a 5-year period, and the number of foreign vessels fishing in these waters will be decreased annually. The remaining 20% of the EEZ, mostly in the nation's coastal waters 12 nautical miles around each of its 250 islands, is being set aside as a Domestic Fishing Zone reserved for local fishermen, and small-scale fisheries are allowed only for domestic markets. The zone is designated to ensure food security in Palau and fish supply for tourists. Monitoring of illegal fishing is a challenge to be addressed. Previously, poaching was monitored by fishing vessels operating in Palau's EEZ, but the monitoring by fishermen cannot be expected once fishing activities are prohibited. Poaching may in fact increase. As a result of this *Act*, the country is expected to lose 5 to 10 million dollars of fishing rights annually from foreign vessels. Palau is actively working to secure funding to strengthen its monitoring systems.

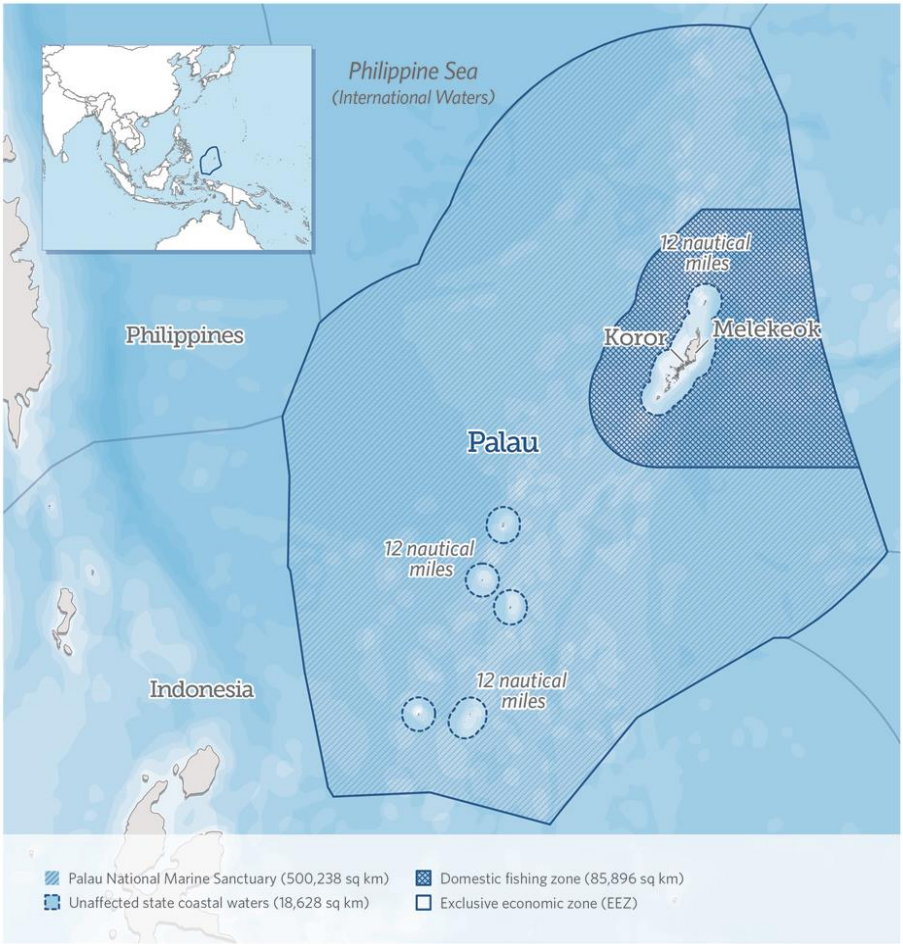

Fig. 5.2 The Palau National Marine Sanctuary (Pew Charitable Trusts, 2015).

5.2.2 State level

Politically, Palau consists of 16 states which are vested with inshore fishery management responsibilities, and a national government with offshore responsibilities. Koror State sets strict regulations for visiting in its Rock Islands Southern Lagoon (RISL) located in southern Koror. RISL is a World Heritage Site and is the most popular tourist site in Palau.

Koror State collects $50 from visitors as an entry fee which is used to strengthen monitoring in the RISL area. There are seven protected areas in the RISL, and all of them 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 belong to the advisory team of the Koror Pride Campaign, which is conducted by the state government to enhance conservation of its marine ecosystems.

5.3 Conclusions

Designation of the National Marine Sanctuary by Palau could have negative impacts not only on the foreign-based fisheries but also on the domestic market. The bycatch of swordfish and mahi mahi, which has represented 20% of the catch, is consumed locally. By restricting the fisheries in the EEZ, this bycatch cannot be distributed in local markets. Local fishermen are allowed to fish in the Domestic Fishing Zone. However, a stable supply of fish from local fishermen is improbable because they do not fish regularly. Consequently, the volume of fish used for local consumption is likely to decrease. In addition, the expected growth in tourism may increase damage to natural resources in Palau's marine environment. For example, in Koror the size of coastal fish appearing in local markets is decreasing, possibly because the growth in demand, with increasing tourism, encourages overfishing. Fish feeding by tourists may also have negative impacts on marine ecosystems in the coastal area. At the same time that the government of Palau has designated 80% of the EEZ as a marine reserve to protect marine ecosystems of the country, it is also promoting the tourism industry as a sustainable use of natural resources. However, negative impacts on marine ecosystems from tourism activites may still occur in spite of conservation efforts carried out by the government.

In conclusion, disseminating the *sato-umi* concept was not appropriate in Palau because the current marine policy of the country is leading to the exclusion of fishing industries. As a consequence, the MarWeB project did not develop Palau as a third case study.

6 Case Study Comparison

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A principal goal of the MarWeB project was to understand marine social-ecological systems, and to explore the concepts of *sato-umi*, in developing countries of the Pacific. The two case studies, (1) development of integrated multi-trophic aquaculture (IMTA) and its potential social benefits relating to shrimp aquaculture in Indonesia, and (2) the investigation of aquaculture and local community needs to increase human well-being in Pacific coastal communities of Guatemala, provide contrasting examples. Our initial plan was to initiate comparable projects in both locations, broadly relating to the development of IMTA as a means to increase marine food variety and mitigate deleterious environmental impacts, and to study their social benefits. While we did follow similar approaches in both case studies, the details were considerably different between the case studies. This was because of the different circumstances of each case study and the interests of the communities involved, underlining the importance of having key contacts and conducting community needs assessments and/or commodity chain mapping in each location. Table 6.1 provides a summary comparison of the key features of the Indonesia and Guatemala case studies.

Both case studies represented combinations of research questions and interventions, situated within a coupled marine social-ecological systems conceptual framework. It is clear that the relationships of marine ecosystem health and human well-being are place-dependent, and it was therefore, crucial to identify the local perceptions of the specific problems in each place. In Indonesia, these problems were well-defined and well-known by all stakeholders, from local shrimp pond operators to government agencies. Over the past 30 years, Karawang Regency in this country has experienced the destruction of mangroves to build intensive brackishwater shrimp ponds, followed by the collapse of these ponds and their shrimp culture activities due to disease, followed by abandonment of the ponds and loss of dike maintenance, leading ultimately to the erosion of the shoreline up to 3 km inland in several locations. In addition, for those ponds that continue to operate, effluent waters released into the coastal ocean are very high in nutrients, risking eutrophication. These issues likely will intensify because the Indonesian government wishes to increase national aquaculture production several-fold over the next few years. Such a well-defined and widely recognized problem has led to support by the government and the willingness of stakeholders to consider a more integrated approach which, if successful, would resolve problems of excessive nutrient inputs into the coastal ocean, increase the variety of seafood produced by the ponds and available to local markets, and (importantly) have no negative impacts on the core production of shrimp. Stakeholders were receptive to a "discovery-based" approach to their problems, and were willing to consider *sato-umi*. It was also helpful that one of the key contacts had previous knowledge and experience of *sato-umi* from other projects with Japan.

Table 6.1 Summary comparison of the key features of each case study.

	Indonesia	Guatemala
History	Over-exploitation (internal)	Over-exploitation (internal and external)
Key contacts	Government scientists	Academic scientists
Population (demographics, affluence)	Many	Few
Drivers of change	Government (top-down)	Community (bottom-up)
Motivation	Sustainable development	Subsistence; resource diversification
Outreach/education	Workshops organised by National government	Local outreach centres
Role of PICES–MarWeB scientists	Advisor to government	Advisor to local university and communities
Commodity pathways	Extensive (local and export consumption)	Simple
Community-scale aquaculture	Discovery-based	Risk-averse
Industry-scale aquaculture	Profit-oriented	Profit-oriented
Shrimp aquaculture	Government promoting change	Industry reluctant to change
Species	Shrimp (plus introduction of non-traditional species, *e.g.*, finfish (tilapia), clams (*Anadara*), seaweed (*Gracillaria*))	Shrimp, oyster
Community assessment	Commodity chain mapping	Community needs assessment

In contrast, shrimp culture in Guatemala is conducted by national or international companies for export markets. Their processes are highly controlled, generally with few direct benefits to local communities. These companies followed a risk-averse strategy and were reluctant to consider any changes, such as IMTA, to their operations. The approach in the Guatemala case study was, therefore, to focus on interacting with local communities to understand their perceptions of their needs, and to work with academic researchers to develop alternative aquaculture options. This resulted in a stronger emphasis being placed on the social science and local community studies. In addition, the communities in the Guatemala study can be considered less economically-developed than the communities studied in Indonesia.

These differences in "initial conditions" also led to differences in who "sees" the presence of social and/or ecological problems, and therefore, the need for solutions. This can be summarized by considering who are the drivers of change in these systems. For example, is it the local community, such as in Guatemala ("bottom-up"), or the government, such as in Indonesia ("top-down")? In Guatemala, the large shrimp industry "sees" no problems, and is reluctant to change existing processes of intensive shrimp culture. The community need is to put food on the table on a daily basis. The motivation in Guatemala is closer to "subsistence". In Indonesia, the government "sees" the problems of declining shrimp production and

environmental degradation, and wants development and change. The government is interested in enabling people to "put food on their tables", but also to improve environmental quality. The motivation in Indonesia is closer to achieving a "sustainable environment" and food supply system.

Human well-being may also be perceived differently in different circumstances, and with different expectations, both within (*e.g*., between the communities of Las Lisas and Monterrico) and across countries (*e.g*., among the different PICES member countries as demonstrated by the well-being analyses in Section 2). It is worth considering where and how well-being can be achieved. In our psychological study in Indonesia of how people relate to the sea (Fig. 3.3), it is clear that safe seafood and the protection of the land and coastline will improve the psychological sense of "Stability". More jobs and wealth created by IMTA through expansion of the commodity chain will improve the sense of a "Beneficial" relationship with the sea. A wider variety of products from IMTA and better water quality will improve the "Aesthetic" sense. Therefore, introduction of IMTA will strengthen people's "Ability to change" and improve the social-ecological systems of Karawang, Indonesia. In the Guatemala study, based on the community needs assessments, there are opportunities for the local community to introduce marine protected areas, eco-tourism, and oyster longline aquaculture technologies.

These two case studies represent different social situations. For example, the practice of "markets" differs between Monterrico, Guatemala, and Karawang, Indonesia. In the former, markets are very local, *e.g*., using small stalls, whereas in the latter, markets are larger and more diverse. However, both studies benefitted from analyses of the human social dynamics in regard to their relationships with the sea, and the problems as they conceptualized them. The larger community of Karawang (in 2010, the population of Karawang City was about 250,000 and the population of the Karawang Regency was about 2.2 million) and the well-developed seafood market systems made the use of the commodity chain approach more appropriate for this region. In contrast, the appropriate method for the much smaller and isolated coastal communities in Guatemala, consisting of a few hundred families, was the more direct community needs assessment. In Guatemala, this approach was also enhanced by the use of the electronic vote-based ("clicker") survey system which provided participants with immediate feedback of the results of each question and was used to engage participants in deeper conversations on the issues raised by the surveys.

7 Summary

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7.1 Overview

Understanding social-ecological dynamics in marine systems, and how to promote it in developing countries, is a very large and complicated topic. Activities need to range from large-scale country overviews and comparisons, to regional and community-scale case studies. Each spatial scale is important, and each spatial scale is necessary to obtain a broader cross-scale understanding of how people relate to the sea and how marine ecosystem health influences human well-being (*e.g.*, Charles, 2001; Perry and Ommer, 2003).

The MarWeB project used studies which included a wide range of spatial scales, from comparisons among PICES member countries (and Indonesia) with respect to how people view their relationships with the sea, to understanding social-ecological dynamics at a regional scale in Indonesia, to comparisons of these dynamics among isolated coastal communities in Guatemala. The country-level comparisons found common attributes in the relationships, such as "Security" and "Basic material for a good life" functioning as fundamental variables, and "Freedom of choice and action" as a dependent variable. People in PICES member countries are generally satisfied and have higher expectations of the future, regardless of their ecological condition, economic situation, and culture. In contrast, satisfaction and expectation levels for "Identification", "Collection", and "Competition" were statistically low in all six member countries. This may reflect higher uncertainty about the future of marine social and ecological systems.

This analysis also found differences among nations. For example, among the East Asian nations studied here, "Good social relationships" strongly influence "Freedom of choice and action" as the most important component in Japan and Korea, whereas "Health" does in Indonesia (Hori and Makino, 2016). Understanding the differences among countries is an important first step towards building a consensus for larger-scale marine conservation activities. This is also important information for domestic policy makers, to allocate the limited human and financial resources for ecosystem conservation activities in order to efficiently maximize well-being of their people. For example, in Indonesia, our study found that safe seafood and the protection of the land and coastline will improve the psychological sense of "Stability". More jobs and wealth created by integrated multi-trophic aquaculture (IMTA) through expansion of the commodity chain will improve the sense of a "Beneficial" relationship with the sea. A wider variety of products from IMTA and better water quality will improve the "Aesthetic" sense. These results can provide justification for, in our study, the introduction of IMTA that might improve the social-ecological systems of Karawang, Indonesia.

7.2 Lessons learned

One of the first, and strongest, lessons learned from these studies is the importance of connecting with organizations in each country which could facilitate and advance the project. This organization and the key people are needed to understand the concept of *sato-umi* or marine social-ecological systems, and to translate it into the local context. In Indonesia, the Agency for the Assessment and Application of Technology (BPPT) in Jakarta, and the National Center for Brackishwater Aquaculture (NCBA) in Karawang, were ideal partners. Members of BPPT were familiar with the concepts of *sato-umi* during previous experience with Japanese researchers in other projects. To identify our second case study, we relied on the experience of the previous PICES–Japan MAFF project on *"Development of the prevention systems for harmful organisms' expansion in the Pacific Rim"* (2007–2012). The process the project team members followed to identify case study countries was to contact colleagues from the Intergovernmental Oceanographic Commission (IOC) of UNESCO who had previous experience working on science projects in developing nations. These colleagues recommended contacting the IOC point people in the Central American and Southeast Asian countries that were the best fits for this project. These key contacts in each country then helped to: (1) define specific objectives and stakeholders, (2) identify how best to assess needs, (3) conduct needs assessments in the most promising target countries, (4) tailor the training to the needs of the country, and (5) find ways to sustain new capacities. For the MarWeB project, a questionnaire was sent to the IOC point people in each country in Central America and Southeast Asia that best fit the MarWeB project goals. Guatemala was ultimately selected because it met the criteria for the MarWeB project goals and because we had established a relationship with the Center for Marine and Aquaculture (CEMA) at the University of San Carlos, Guatemala, in the previous PICES–Japan MAFF project. This resulted in identification of needs, facilitating the best country match and establishing contact with a responsive point person who was committed to the scientific goals of the project.

Other key lessons include:

- The need and time to build relationships and trust, both with the project leaders and key country contacts, but also with the people of the communities participating in the project;
- Persistence;
- Feedback of results – this includes not only feedback of the overall results of the project, often through in-person presentations and visits, but also immediate feedback to surveys, for example the "clicker" surveys which allow anonymity, and can be used to help overcome language and cultural barriers. However, it is very important to carefully develop the questions to be posed to the community;
- Building capacity among local researchers and the communities participating in the project;
- Successful research partnerships, for example, with key contact organizations;
- Developing an understanding of how these activities can help the local contacts, *i.e.*, their personal motivations for participating in this research;
- Collaboration and collaborative decision-making among the project leaders, key contacts, and participating communities, which is essential for decision making;
- Open mindedness and listening are critical skills to employ;
- The lack of capacity (in terms of financial and technical expertise and resources) will constrain what can be done; for example, for some of the IMTA studies it was hoped to conduct complex social-ecological systems modelling, but the capacity for such studies was not available within the time frame of this project.

The use of the appropriate methodology to assess community needs is essential. The results from such analyses can then be used to select and develop how to address these needs (or which needs). For example, the decision to focus on aquaculture as a primary underlying issue in both case studies was driven not only by an understanding of the local problems described by the key contacts, but also by interest from the local communities (as determined from the needs assessments). Community leadership and attentiveness to interests and directions from the community are positives in this approach, but may make comparisons among case studies difficult. In this project, for example, both the Indonesia and Guatemala case studies were begun with ideas of focusing on IMTA and community support, but each evolved in different ways due to community interests and opportunities (or constraints on initial expected opportunities). The problems of implementing oyster aquaculture in coastal Guatemala, including theft and vandalism of the equipment, also illustrates the importance of local situations and difficulties in implementing new techniques, despite the strong interest and commitment of local communities.

7.3 PICES Advisory Report

A shorter, "plain language" version of the main approaches and findings from this project is available as the PICES Advisory Report on "*Improving aquaculture, marine ecosystems and human well-being: A social-ecological systems approach*" on the PICES website at http://www.pices.int/publications/brochures.

7.4 Database

Data collected during the project are available on the PICES website at http://www.pices.int/projects/marweb. This database includes: (1) raw data for the comparative well-being analysis in PICES member countries (see Section 2 in this report); (2) data from the 2014–2016 aguaculture pond experiments in Indonesia (see Section 3); (3) electronic "clicker" survey data for the community needs assessments in Guatemala (see Section 4), and bibliography on the key concepts used in this project, such as social-ecological systems, human well-being and *sato-umi*.

7.5 Conclusions

In response to the two key questions posed at the outset of this project (Section 1.2) we offer the following conclusions.

(a) How do marine ecosystems support human well-being?

The "traditional" biophysical science approach to this question is often framed in terms of food supply and livelihoods. However, this narrow framing leaves out the very important psychological needs of how people relate to the sea, for example as described in Section 2. In reality, both the physical and psychological needs are required for positive human well-being.

(b) How do human communities support sustainable and productive marine ecosystems?

This is the reciprocal question to that above. It is perhaps a more social science-centered view, with the focus on people and what they do, or can do, to ensure or improve healthy marine ecosystems. The actions of people can be detrimental or beneficial to marine ecosystems. These actions become all the more important to consider when biophysical marine ecosystems are already under stress, for example, from a changing climate. This concept of what people can do to cultivate healthy marine ecosystems is at the core of the Japanese concept of *sato-umi*.

8 References

An extensive bibliography on the key concepts used in the MarWeB report is included in the project database at http://meetings.pices.int/projects/MarWeB.

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Appendix 1
MarWeB Principles

1. The overall goal of the project on "*Marine ecosystem health and human well-being*", funded by the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF), through the Fisheries Agency of Japan (JFA), 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 Japan, this concept attracts attentions 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? It is also intended to foster partnerships with non-PICES member countries and related international organizations and 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.

2. The duration of the project is 5 years, with the ending date set as March 31, 2017.

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

   3.1 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 (Section on *Human Dimensions of Marine Systems* (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), and Working Group 28 on *Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors*).

   3.2 The project is directed by a Project Science Team, co-chaired by two PICES scientists, Dr. Mitsutaku Makino (Fisheries Research Agency, Japan, mmakino@affrc.go.jp) and Dr. 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.

   3.3 The Project Science Team 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.

4. The following financial principles agreed by MAFF/JFA and PICES apply to the project:

   - A separate bank account shall be established to deposit the remitted funds;
   - The interest earned by the fund shall be credited to the project and used in consultation with JFA;

- Any funds remaining after the completion of every fiscal year of the project shall be reported and disposed of in consultation with JFA;
- Transfers of up to 10% of allocations between the budget categories are allowed based solely on the decision by the PICES Executive Secretary or a Projects Coordinator designated by the Executive Secretary. In special cases, transfers up to 20% between the budget categories can be authorized by JFA. All transfers shall be reported at the end of the fiscal year;
- A 13% overhead on the annual budget shall be retained by PICES to offset expenses related to the Secretariat's involvement in the project;
- The PICES Executive Secretary or a Project Coordinator is responsible for the management of the fund and annual reporting on its disposition to MAFF/JFA and PICES Governing Council within 120 days after the close of each project year ending March 31. Dr. Alexander Bychkov (bychkov@pices.int) is appointed as the Project Coordinator.

5. Ownership of the outcomes of the project, including materials, data, copyright and intellectual property rights, will be vested to PICES and the Government of Japan. Either Party may use those outcomes, but will give full credit to their source.

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Appendix 3
Annual Progress Reports

Scientific Progress Report for Year 1
April 1, 2012–March 31, 2013

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*". The project began in April 2012, and is expected to be completed by March 31, 2017. Its 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 programs and organizations. 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 (*Appendix 1*, Project Principle 3):

- The Project is expected to have strong connections and interactions with, and involve and support the relevant activities of, the PICES FUTURE (Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems) program (Research Theme 3 on "*How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems?*") and PICES expert groups such as Section on *Human Dimensions of Marine Systems* (S-HD); Section on *Ecology of Harmful Algal Blooms in the North Pacific* (S-HAB), Section on *Climate Change Effects on Marine Ecosystems* (S-CCME), Working Group on *Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors* (WG 28), and Working Group on *Non-indigenous Aquatic Species* (WG 21) among others (Fig. 1). The objectives and activities of the Project are detailed in the workplan.
- 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.
- The PST Co-Chairmen are responsible for the scientific implementation of the project and reporting annually to MAFF/JFA and PICES Science Board. The 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 workplan for the following year.

This progress report summarizes the activities carried out in Year 1 (FY 2012: April 1, 2012–March 31, 2013) and includes a workplan for Year 2 (FY 2013: April 1, 2013–March 31, 2014). The draft budget for Year 2 is provided in the Year 1 financial report being submitted as a separate document simultaneously with this progress report.

2. WORKPLAN FOR YEAR 1

1. Project Science Team formation
   - Establish a Project Science Team to direct the project and organize the first PST meeting.
2. Study site selection
   - Select developing countries in three regions of the North Pacific (Southeast Asia, Central America, and Pacific oceanic islands) as study sites for the project;
   - Gather information for discussion of potential case studies by the PST and initiate preparations for regional workshops.
3. Analytical tools and knowledge bases preparation
   - Develop analytical tools to be applied to the study sites (case studies);
   - Initiate the first social survey on the objective of ecosystem conservation amongst six PICES member countries and three study sites.

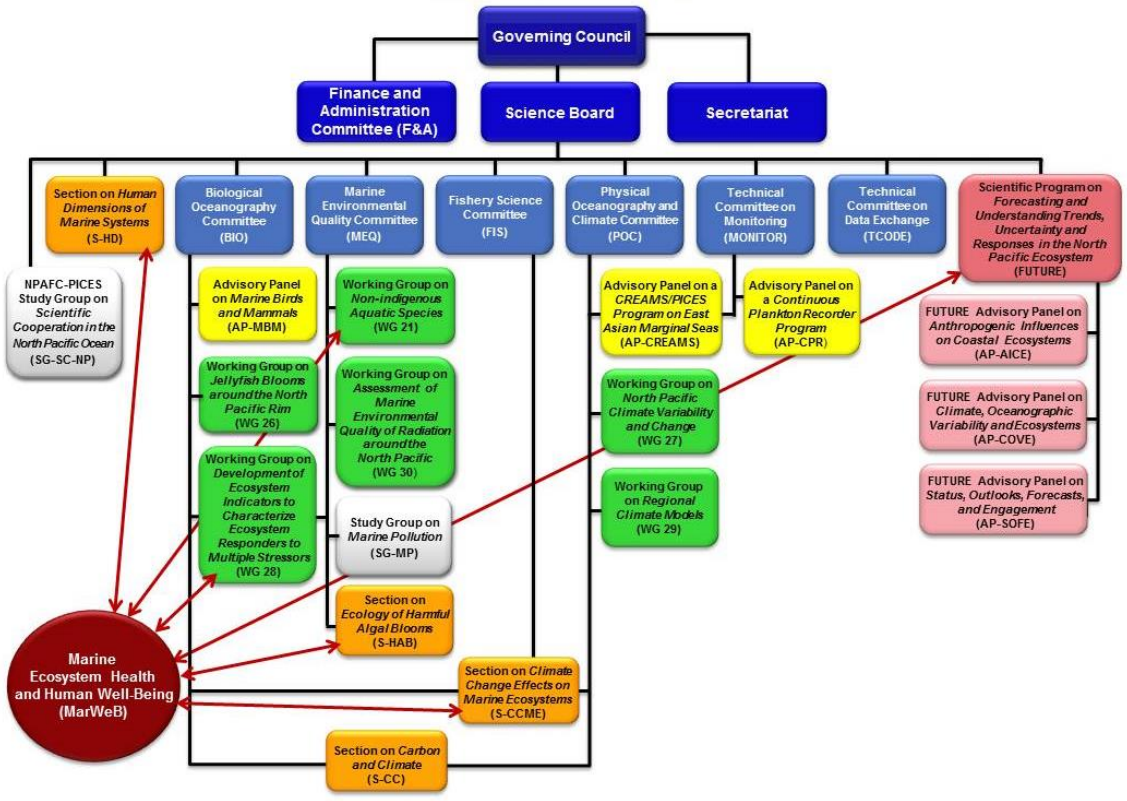

Fig. 1 PICES (North Pacific Marine Science Organization) structure for 2012–2013 showing links between the MarWeB project and expert groups.

3. PROGRESS OF YEAR 1

3.1 Project Science Team

PST membership

The PST was formed in August 2012, in order to make recommendations for the project implementation and review the scientific progress. The PST includes 13 members: 3 from Canada, 3 from Japan, 2 from Korea and 4 from USA, and a representative from the PICES Secretariat (Table 1). A total of six PICES expert groups are represented on the Team: S-HD, S-CCME, S-HAB, WG 28, WG 21, and AP-SOFE (FUTURE Advisory Panel on *Status, Outlooks, Forecasts, and Engagement*).

First PST meeting

The first PST meeting was held October 11, 2012, in conjunction with the PICES 2012 Annual Meeting in Hiroshima, Japan. The main objectives of this meeting were to: 1) share the background information for the project, 2) decide the principal framework, and 3) discuss the workplan and financial allocations for Year 1 of the project. Twelve PST members were in attendance (Absentee: Dr. Dohoon Kim). The report from the meeting is available at http://meetings.pices.int/projects/marweb.

The main results from the meeting can be summarized as follows:

- The review of the previous PICES/MAFF project on "*Development of the prevention systems for harmful organisms' expansion in the Pacific Rim*" (2007–2012) and information on other relevant activities, including the Sato-umi type research related to the Convention on Biological Diversity, United Nations University, *etc*., were presented;
- The principal framework of the project was approved (Table 2);
- Three field sites and their initial workplans were decided as the case study for this project (Table 3);
- The "well-being cube" was introduced as a tool to scientifically analyze the links between the ecosystem conditions and human well-being;
- The construction of a database was approved in order to facilitate the dissemination of the results of this project and to share the knowledge related to marine ecosystem health and human well-being.

3.2 Case study: Indonesia

Three developing countries in three regions of the North Pacific (Southeast Asia, Pacific oceanic islands, and Central America) were selected as study sites for the project. Indonesia was selected because of its large population and aquaculture-intensive industry. Guatemala was chosen because its coastline features an upwelling system favorable for the finfish fishery and aquaculture. Palau was selected because of its focus on the finfish capture fishery and its existing networks of community-based fisheries. It was decided to conduct two training workshops in each of these countries. In Year 1, the main focus was on Indonesia.

Table 1 Membership of the Project Science Team

Name	Affiliation	Country/Group
Dr. Harold Batchelder	Oregon State University	USA/AP-SOFE
Dr. Keith Criddle	University of Alaska, Fairbanks	USA/S-HD
Dr. Masahito Hirota	Fisheries Research Agency	Japan/S-HD
Ms. Juri Hori	Rikkyo University	Japan/S-HD
Dr. Dohoon Kim	National Fisheries Research and Development Institute	Korea/S-HD
Dr. Suam Kim	Pukyong National University	Korea/S-CCME
Dr. Skip McKinnell	PICES Secretariat	PICES Secretariat
Dr. Mitsutaku Makino	Fisheries Research Agency	Japan/S-HD
Dr. Grant Murray	Vancouver Island University	Canada/S-HD
Dr. Ian Perry	Department of Fisheries and Oceans	Canada/WG 28
Dr. Thomas Therriault	Department of Fisheries and Oceans	Canada/WG 21
Dr. Vera Trainer	Northeast Fisheries Science Center	USA/S-HAB
Dr. Mark Wells	University of Maine	USA/S-HAB

Table 2 Principal framework of the MarWeB project

1. Case studies and manual creation in developing countries (3 sites)
2. Well-being cube analysis for the link between ecosystems and human well-being
3. Database construction for better dissemination and sharing of the knowledge

Table 3 Initial workplan for the project

	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Indonesia	1st Workshop	2nd Workshop	Draft manual		Completed manual
Guatemala		1st Workshop	2nd Workshop	Draft manual	Completed manual
Palau (tentative)			1st Workshop	2nd Workshop	Completed manual
Well-being cube analysis	3 PICES member countries	1 of developing countries	1 of developing countries	3 PICES member countries	1 of developing countries
Database construction	Outline decided	Data input	Data input	Data input	Database completed

Many coastal mangroves in Indonesia were cut for advancing shrimp aquaculture in the 1990s, causing much erosion. For example, in one location on the north coast of Java, 3 kilometers of coastline were lost due to this process. The Indonesian Agency for the Assessment and Application of Technology (Badan Pengkajian dan Penerapan Teknologi – BPPT) has developed a concept of managing coastal and marine resources by actively involving the community. This Indonesian concept is called GEMPITA-SPL (Gerakkan Masyarakat Peduli Kelestarian Sumberdaya Perikanan, Pesisir dan Laut) or, in English, SFiCoMS (Sustainable Utilization of Fisheries, Coastal and Marine Resources for the Society). The GEMPITA-SPL concept fits very well within the framework of fishery social-ecological systems (Sato-umi) in the PICES/MAFF project. Based on this concept, BPPT and the Java Department of Fisheries and Marine Affairs initiated a "Gapura" program (Fig. 2) in the northern coastal area of West Java (initially in Karawang) through the development and promotion of environmentally friendly aquaculture technology called integrated multi-trophic aquaculture (IMTA). The expectation is that by applying IMTA, the coastal environment, which has been heavily damaged by shrimp monoculture, can be recovered to become more biodiverse and productive, leading to a balanced and harmonious way to improve the welfare of local communities. Unfortunately, impacts to local systems or environmental quality (nutrients, bacteria, phytoplankton, *etc*.) have not been monitored. The Indonesian government would like to scientifically verify this activity, build capacity, and then disseminate the concept to other areas of the country. Thus, this case study aims to: (1) scientifically verify the benefits of IMTA to the social-ecological systems, (2) develop scientific capacity in Indonesia, and (3) develop a manual for dissemination to other areas in Indonesia.

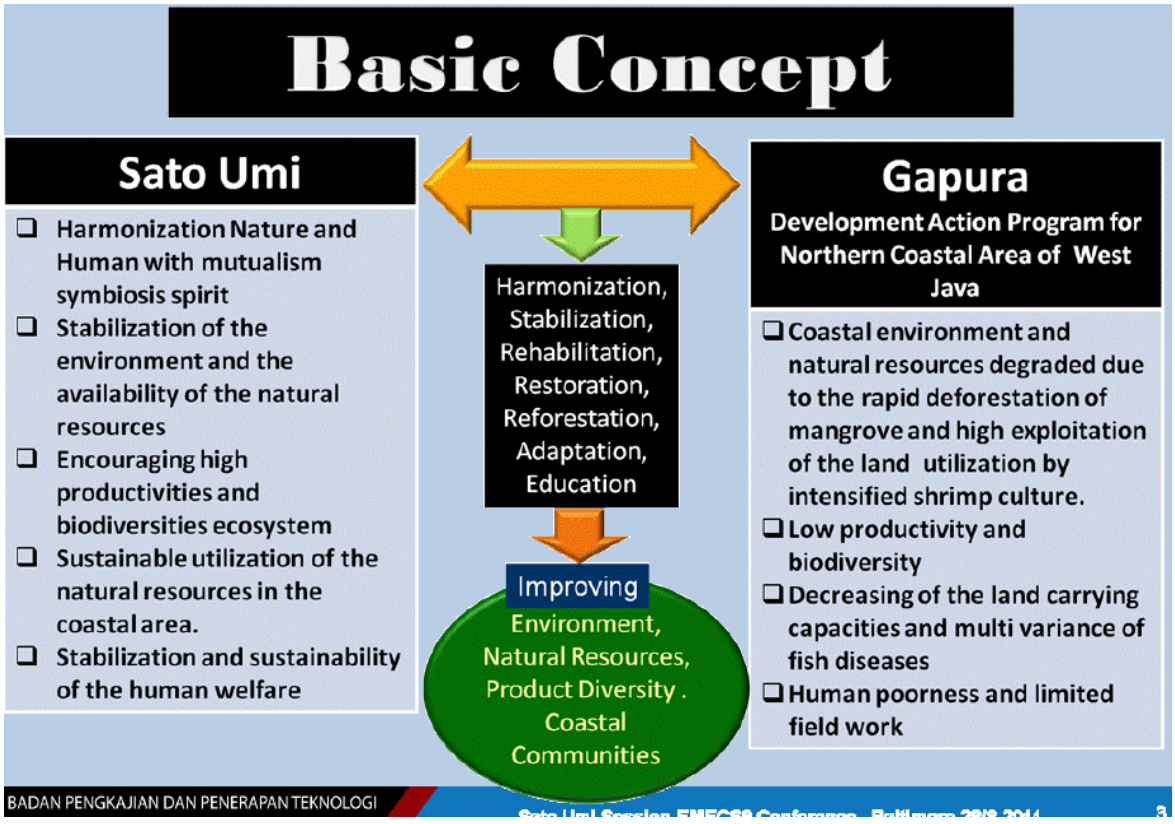

Fig. 2 Relationships between Sato-umi and Gapura concepts (from presentation by S. Sachoemar and T. Yanagi, PICES/BPPT workshop, Jakarta, March 13, 2013).

The planning meeting for this case study was held January 22–23, 2013, at the BPPT Headquarters in Jakarta. Drs. Mitsutaku Makino, Masahito Hirota and Mark Wells participated on behalf of the PST; the Indonesian counterpart was Prof. Suhendar Sachoemar. The objectives of this meeting were to understand the local needs, to prepare the draft agenda for a workshop to be held in March of 2013, and to develop plans for this case study through to March 2017 (the PICES/MAFF project period).

Based on the results of the January 2013 meeting, the first Indonesia training workshop was held March 13, 2013, at the BPPT Headquarters in Jakarta, with a field trip to the site at Karawang on March 14. The objectives of the workshop were to: (1) develop the contents of a manual that will describe GEMPITA-SPL and Gapura experiences in Java Province according to local conditions at some candidate sites, and (2) assess the utility of PICES' scientific tools for enhancing the human well-being of local communities and rehabilitating coastal ecosystem at some candidate sites. It was a high-profile event in Indonesia, with many reports appearing in newspapers, on TV and the web.

A total of 93 participants from Indonesia, Japan, and USA attended the workshop. The PICES/MAFF project was represented by four PST members, Drs. Makino, Hirota, Wells, and William Cochlan. Dr. Makino introduced the project; Dr. Wells described previous activities of PICES in Indonesia and suggested ways that PICES science can support GEMPITA-SPL/Gapura; and Dr. Hirota talked about PICES scientific tools for the analysis of human well-being in coastal societies.

During the workshop, the Sato-umi concept was introduced, detailed local needs were gathered from local stakeholders, and the development of a GEMPITA-SPL/Gapura manual was discussed (a table of contents was prepared) to facilitate the dissemination of GEMPITA-SPL activities in Indonesia. The agreement was reached to conduct a pond experiment in Year 2 of the PICES/MAFF project to examine the natural ecological system and human system benefits of IMTA. A draft protocol for the experiment in sample ponds where GEMPITA-SPL has been implemented and a draft list of parameters to be measured during this experiment was developed. A Letter of Intent between PICES and BPPT was signed to recognize the importance of continued collaborative work on the project. The workshop report and PICES Press article describing this event (Vol. 21, No. 2, pp. 18–19) are available on the project website at http://meetings.pices.int/projects/marweb.

3.3 Analytical tools and database

Analysis of human well-being in relation to environmental conditions

"Well-being" is defined by psychologists as involving people's positive evaluations of their lives such as positive emotions, engagement, satisfaction, and meaning. As indicated in the UN Millennium Ecosystem Assessment, human well-being (HWB) has multiple constituents, such as basic material for a good life, security, health, good social relations, and freedom of choice. The constituents of well-being, 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 and freedom of choice and action, and in part to understand motivations for these choices and actions.

In 2012, a survey of 1000 people in Japan was conducted to develop the method and assess their relationships with the sea. Preliminary results suggest great importance of sea food for well-being among those Japanese people who identified themselves as having high connections with the ocean.

Database construction

The PST discussed the potential content of the "database" and agreed on the following outlines:

- The database could be a bibliography, for example, of social-ecological systems interactions and related references that would be useful for research and capacity building activities.
- It would be desirable for this database to also support the work of the PICES FUTURE program, and to link with the work of PICES WG 28 on human activities (and their related indicators) that affect the ocean.
- The database could also store the techniques, tools, and results developed from the Indonesia and Guatemala case studies and their manuals.

3.4 Other activities

The International Sustainability Unit (ISU) of the UK Prince Charles' Charitable Foundation has a marine program (http://www.pcfisu.org/marine-programme) which was initiated, among other objectives, to help strengthen international consensus around the best solutions for the sustainable management of wild marine fish stocks. The ISU recently released a report based on interviews with fishing communities from 50 different fisheries around the world about the benefits they are experiencing from managing their fisheries more sustainably. The report demonstrates the possibilities for more sustainable management through what is already being achieved. The ISU is now developing a project to implement Fisheries Management Plans (FMP) and Transition Financing, and is considering Vietnam and Central America as primary locations. In this regard, the ISU organized a regional workshop on "*The opportunities of sustainable fisheries in Vietnam: Identifying the transition pathway*" (October 30–31, 2012, Nha Trang, Vietnam), which was co-sponsored by PICES (through this project). Although a useful meeting, it turned out to be somewhat off the main topic of our project. It was recommended that the PST be informed of developments within the ISU but, at this stage, not to actively participate.

4. WORKPLAN FOR YEAR 2

1. Project Science Team Meetings

    - Organize two PST meetings, one inter-sessional and one in conjunction with the 2013 PICES Annual Meeting (October 2013, Nanaimo, Canada).

2. Case Studies

    In Indonesia

    - Set up a pond experiment and carry out a training workshop (leaders: Mark Wells and Mitsutaku Makino);
    - Model the carrying capacity of the experimental pond site (leader: Susanna Nurdjaman, Institute of Technology, Bandung, Indonesia);
    - Conduct social human well-being survey (leaders: Masahito Hirota and Mitsutaku Makino);
    - Initiate preparations for an Indonesia training workshop to be conducted in Year 3.

In Guatemala

- Identify the potential topics to be investigated, which are likely to include issues of integrated multi-trophic aquaculture and local development (to be comparable with the Indonesia case study) and to initiate a field study.

In Palau

- Initiate information gathering for the workshop to be conducted in Year 3.

3. Human well-being surveys

   - Analyze the results from the 2012 human well-being survey in Japan and, based on these results, conduct human well-being surveys in Korea and USA to enable international comparisons.

4. Database

   - Initiate development of the database containing a bibliography of social-ecological systems interactions, the well-being survey data and information from the Indonesia and Guatemala case studies.

Scientific Progress Report for Year 2
April 1, 2013–March 31, 2014

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*". The project began in April 2012, and is expected to be completed by March 31, 2017. Its 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 programs and organizations. 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 (*Appendix 1*):

- 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 reporting annually to MAFF/JFA and PICES Science Board. The 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 workplan for the following year (Project Principle 3.3).

This progress report summarizes the activities carried out for Year 2 (FY 2013: April 1, 2013–March 31, 2014) and includes a workplan for Year 3 (FY 2014: April 1, 2014–March 31, 2015). The financial report for Year 2 is being submitted as a separate document simultaneously with this progress report.

2. WORKPLAN FOR YEAR 2

1. Project Science Team meetings
   - Organize two PST meetings, one inter-sessional and one in conjunction with the 2013 PICES Annual Meeting (October 2013, Nanaimo, Canada).

2. Case studies

   In Indonesia

   - Set up a pond experiment and carry out a nutrient and phytoplankton training workshop;
   - Model the carrying capacity of the experimental pond site;
   - Conduct a social human well-being survey;
   - Initiate preparations for an Indonesia training workshop to be conducted in Year 3.

   In Guatemala

   - Identify the potential topics to be investigated, which are likely to include issues of integrated multi-trophic aquaculture and local development (to be comparable with the Indonesia case study), and to initiate a field study.

   In Palau

   - Initiate information gathering for the workshop to be conducted in Year 3.

3. Human well-being surveys

   - Analyze the results from the 2012 human "well-being" survey in Japan and, based on these results, conduct human "well-being" surveys in Korea and USA to enable international comparisons.

4. Database

   - Initiate development of a database containing a bibliography of social-ecological systems interactions, the well-being survey data and information from the Indonesia and Guatemala case studies.

3. PROGRESS OF YEAR 2

3.1 Project Science Team meetings

The Project Science Team (PST) was established in August 2012 (Year 1) in order to review the scientific progress, and make recommendations on the further implementation of the project. During Year 2, the PST membership was revised to better match the case studies that are being developed. As of June 2014, the PST membership includes 13 scientists: 4 from Canada, 3 from Japan, 2 from Korea, 3 from USA, and a representative from the PICES Secretariat (Table 1). A total of six PICES expert groups are represented on the Team: Section on *Human Dimensions of Marine Systems* (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 *Non-indigenous Aquatic Species* (WG 21), Working Group on *Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors* (WG 28), and FUTURE Scientific Steering Committee (FUTURE SSC) (Fig. 1).

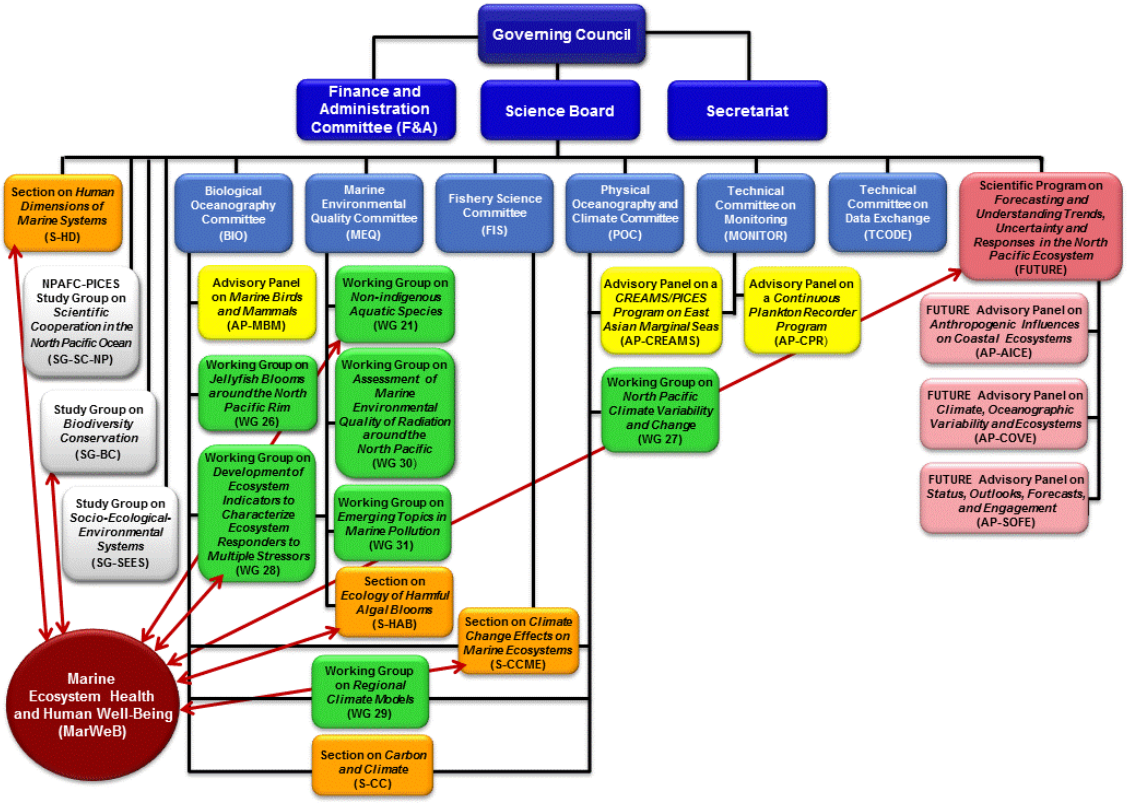

Fig. 1 PICES (North Pacific Marine Science Organization) structure for 2013–2014 showing links between the MarWeB project and expert groups.

Table 1 Membership of the Project Science Team (as of June 2014)

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. Dohoon Kim	National Fisheries Res. and Development Inst.	Korea/S-HD
Dr. Ian Perry	Department of Fisheries and Oceans	Canada/WG 28
Dr. Thomas Therriault	Department of Fisheries and Oceans	Canada/WG 21/FUTURE SSC
Dr. Vera Trainer	Northeast 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 2, two PST meetings were organized. The first meeting was held June 10–12, 2013, in Honolulu, USA, and focused on plans for workshops, experiments and social science surveys in Indonesia. Also, the name "MarWeB", for Marine Ecosystem Health and Human Well-Being, was adopted as an acronym for the project. The second meeting was convened October 10, 2013, in Nanaimo, Canada, in conjunction with the 2013 PICES Annual Meeting, and focused on developing plans for research activities in Guatemala. A ½-day Topic Session on "*Ecological and human social analyses and issues relating to Integrated Multi Trophic Aquaculture (IMTA)*", led by the MarWeB project, was proposed and accepted for the 2014 PICES Annual Meeting (Yeosu, Korea), and is currently being organized. The reports from both of these meetings and other materials, including two PICES Press articles describing the project's goals and activities, are available at http://meetings.pices.int/projects/marweb.

3.2 Case studies

3.2.1 Indonesia

Intensive shrimp aquaculture was 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 due to removal of mangroves and building of coastal shrimp ponds. This has resulted in a current ecological system with intensive shrimp monoculture. The MarWeB project is developing a study on the use of IMTA (including seaweed, shrimp, and fish) to demonstrate low emissions of deleterious materials into the natural environment and to provide alternative sources of protein and livelihoods for the local human population.

During Year 2, MarWeB activities included the following:

- *Ecological systems*
  - Nutrient and phytoplankton training workshop;
  - Preparation for a pond experiment for IMTA;
  - Material circulation box-model development for analysing the carrying capacity of these systems.
- *Social systems*
  - Basic social information collection (*i.e.*, statistics);
  - Commodity chain analysis for IMTA products;
  - Psychological analysis for human "well-being" ("Well-Being Cube" analysis).

Ecological systems

Project activities in Indonesia are being conducted in collaboration with BPPT (Badan Pengkajian dan Penerapan Teknologi; the Agency for the Assessment and Application of Technology, Jakarta), which is a non-departmental government agency under the coordination of the Ministry of Research and Technology, responsible for carrying out government duties in the field of assessment and application of technology. An experimental plan has been developed for a MarWeB-sponsored Gempita (Sato-umi) pond experiment, to be conducted at the National Center for Brackishwater Aquaculture in Karawang. The main purpose of this experiment is to investigate the effects of IMTA on: (1) the economic return of pond operations, and (2) the water quality of the ponds. Water quality is defined in terms of the concentrations of nitrate/nitrite, ammonia, and phosphate, in addition to other parameters (*e.g.*, salinity, oxygen, phytoplankton, bacteria,

etc.). The hypothesis being studied is whether the addition of bivalves (oysters) and 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.

To build the methodological skills to conduct the experiment, a nutrient and phytoplankton training workshop, led by Drs. Mitsutaku Makino and Mark Wells, was held March 25–26, 2014, at the National Center for Brackishwater Aquaculture. There were 16 official Indonesian participants. The workshop was a success, with the objectives fully met and the skills raised to the quality needed for publication of the pond experiment results (Fig. 2). Another training workshop is being planned to be held in Pekalongan in Year 3.

Dr. Susanna Nurdjaman (Bandung Institute of Technology) started the construction of the material circulation box-model in order to analyze the monitoring results from the pond experiment.

Fig. 2 Nutrient and phytoplankton training workshop held March 25–26, 2014, at the National Center for Brackishwater Aquaculture, Karawang, Indonesia.

Social systems

Two social science field surveys were conducted in October 2013 and March 2014, with focus on mapping the commodity chains and collecting statistics in Karawang (Java), and Indonesia more broadly. This information consisted of the 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 (commodities and commodity chain, value and amount of production, price, types of trading partners), and technical matters (original method, costs, environmental damages, new culture methods, strategies/perspectives for the future). Figure 3 shows the commodity chain of the IMTA products, which was developed based on the information from the above two surveys. Also, in February and March 2014, the social survey for well-being ("well-being cube" analysis), which was developed in Year 1, was conducted in Indonesia. A total of 200 samples were collected and now are being analyzed.

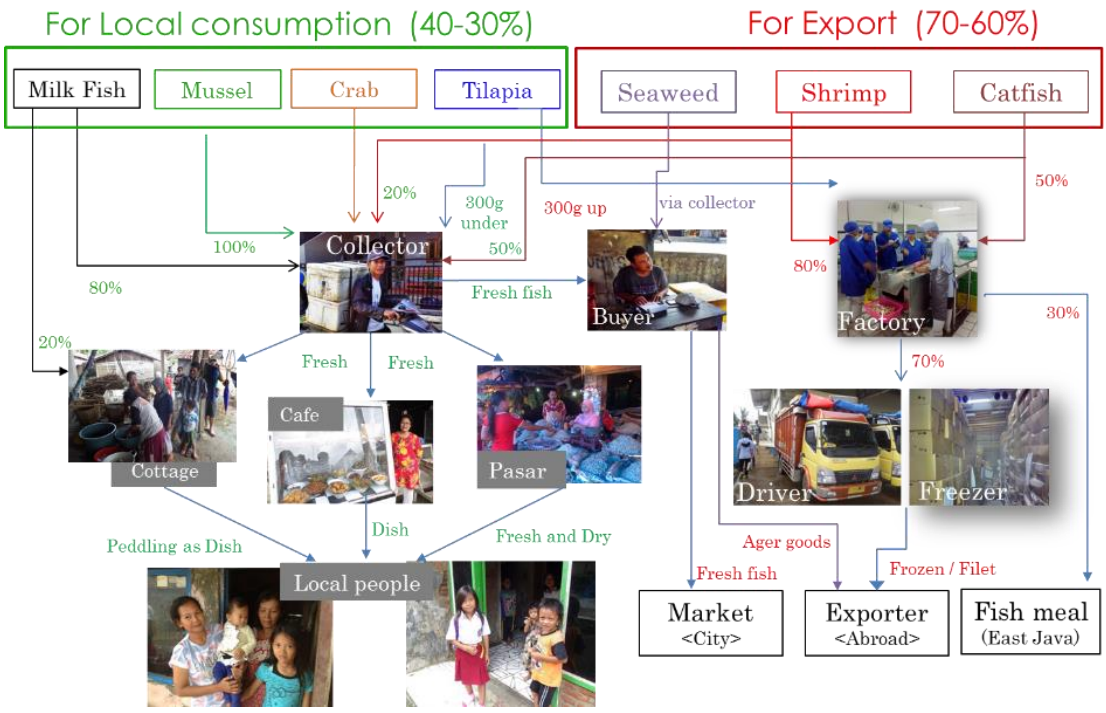

Fig. 3 Commodity chain of the IMTA products in Karawang area, Indonesia.

3.2.2 Guatemala

A scoping visit to Guatemala was conducted from January 27–31, 2014, to assess the possibility of this country being a case study within the MarWeB project to evaluate the relationships between coastal communities and the sea, and the potential to develop the use of IMTA. Four representatives from PICES met and discussed potential options for this work with government representatives, academic researchers, and community leaders and members in Guatemala City, and along portions of the Pacific coast (Fig. 4).

The villages visited were Monterrico, Hawaii, and Las Lisas. It was apparent that complex relationships exist 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. A possible goal for the MarWeB project in Guatemala is being developed in collaboration with Guatemalan experts to expand the economic potential (shellfish aquaculture) to bring greater well-being to coastal communities. This would be a self-sustaining enterprise managed by a Guatemalan cooperative. A project which focusses on oyster aquaculture is proposed in collaboration with University of San Carlos professors, which will consider growth, processing, and marketing aspects.

A social science survey to address "Sato-umi in developing nations" will be developed and applied to Guatemala in collaboration with Guatemalan university faculty and students, and coastal communities.

Fig. 4 At a Pacific coast village during a scoping visit of PICES representatives to Guatemala.

3.2.3 Palau

The original plan for the MarWeB project included 3 case studies: Indonesia, Guatemala, and Palau. However, based on the latest information collected from literature reviews, news media reports, and personal contacts with the people of Palau, it was decided to discontinue Palau as a third case study because of: (1) reductions in the project annual budget and (2) banning of fishing and conversion of all of Palau's Exclusive Economic Zone (EEZ) into a marine protected area. This decision was reported to MAFF/JFA by Dr. Makino.

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

"Well-being" is defined by psychologists as involving people's positive evaluations of their lives such as positive emotions, engagement, satisfaction, and meaning. As indicated in the UN Millennium Ecosystem Assessment, human well-being (HWB) has multiple constituents, including basic material for a good life, freedom of choice and action, health, good social relations, and security. The constituents of well-being, 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.

In Year 1, a survey of 1000 people in Japan was conducted to further develop a methodology and to assess their relationships with the sea. In Year 2, the same type of questionnaire was used to survey 500 people each in Korea and the United States. In addition, as mentioned above, a survey of 200 people was conducted in collaboration with BPPT in several Indonesian provinces to provide data for analysis of well-being in relation to the sea (*i.e.*, in a Sato-umi context). Preliminary analysis of the results from these four countries shows significant differences. Overall results for Indonesia were consistent with a "high expectation"-type outcome, although results separated by different regions within Indonesia showed different outcomes indicating that many important factors are involved. These results are currently being prepared for scientific publication (Fig. 5).

3.4 Database

Development of 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 is continuing.

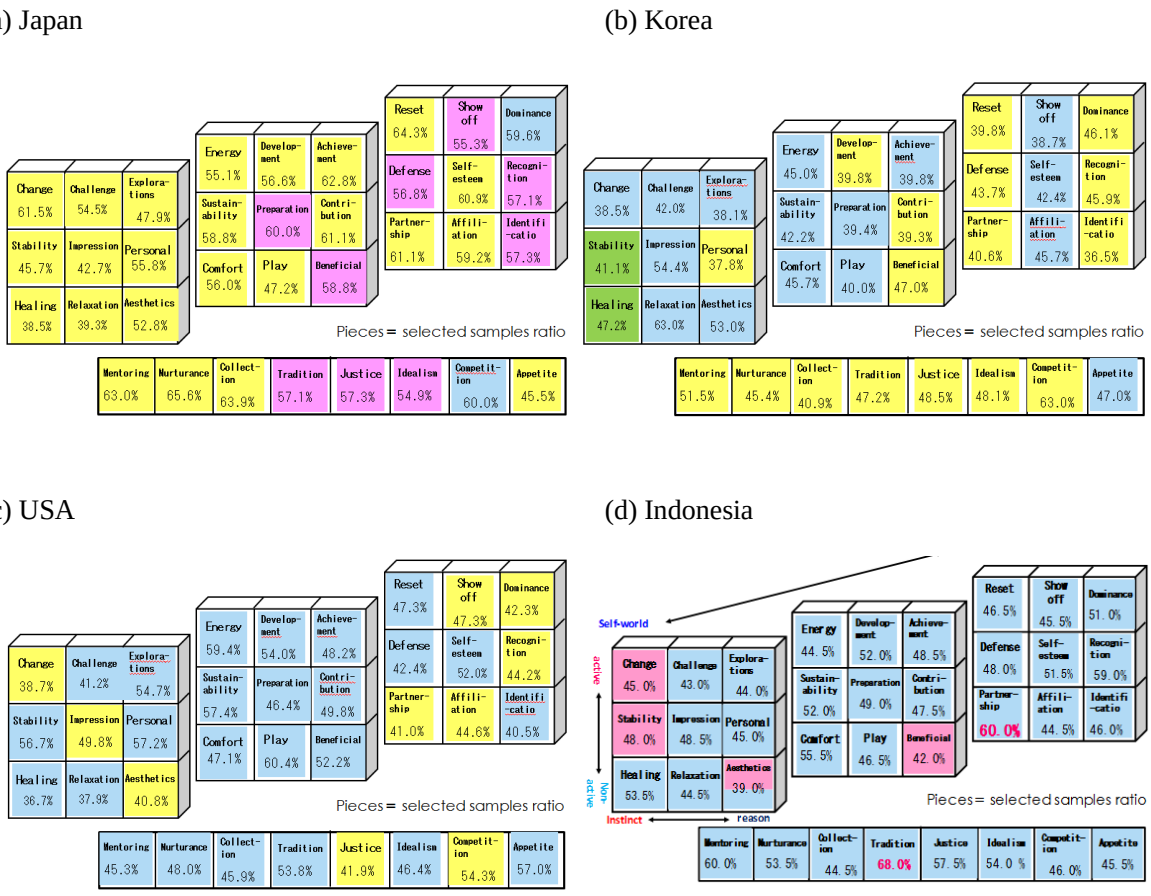

Fig. 5 Preliminary results of the human well-being (HWB) analysis in four countries.

4. WORKPLAN FOR YEAR 3

1. Project Science Team meetings
   - Organize two PST meetings, one inter-sessional (April 2014, Hawaii) and one in conjunction with the 2014 PICES Annual Meeting (October 2014, Yeosu, Korea).
2. Case studies

   In Indonesia
   - Continue the IMTA pond experiment and theoretical modeling of potential carrying capacity with Indonesian partners at the Karawang experimental site;
   - Hold a workshop in Pekalongan for manual development and transfer of lessons learned during the Karawang experiments to a second location;
   - Conduct an additional social survey.

   In Guatemala
   - Design a social survey to understand the local situation;
   - Conduct a social science assessment of "Sato-umi" with local partners;
   - Design and conduct an IMTA experiment, with a focus on development of oyster aquaculture, processing, and marketing in collaboration with local partners.
3. Human well-being surveys
   - Analyze the data and review the results from the human well-being surveys conducted in Japan, Korea, United States, 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;
   - Start to build the on-line access system for sharing the contents of the database.

Scientific Progress Report for Year 3
April 1, 2014–March 31, 2015

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; http://www.pices.int/projects/marweb). The project began in April 2012, with the ending date set as March 31, 2017. Its 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). Considering that global changes are affecting both climate and human social and economic conditions, the project is expected to determine: 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 (*Appendix 1*):

- 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. The 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 workplan for the following year (Project Principle 3.3).

This progress report summarizes the activities carried out for Year 3 (FY 2014: April 1, 2014–March 31, 2015) and includes a workplan for Year 4 (FY 2015: April 1, 2015–March 31, 2016). The financial report for Year 3 is being submitted as a separate document simultaneously with this progress report.

2. WORKPLAN FOR YEAR 3

1. Project Science Team meetings
   - Organize two PST meetings, one inter-sessional (April 2014, Hawaii, USA) and in conjunction with the PICES 2014 Annual Meeting (October 2014, Yeosu, Korea).

2. Case studies

   In Indonesia

   - Continue the multi-trophic aquaculture pond experiment and theoretical modeling of potential carrying capacity with Indonesian partners at the Karawang experimental site, including follow-up site visit by a PST member;
   - Hold a workshop in Pekalongan for manual development and transfer of lessons learned during the Karawang experiments to a second location;
   - Conduct the third social survey.

   In Guatemala

   - Design, and translate into Spanish, a social survey to understand the local situation (*e.g.*, why one community feels it is "healthy" whereas adjacent communities feel they are not "healthy");
   - Carry out a social science assessment of "Sato-umi" with local partners;
   - Design and conduct an IMTA experiment, with a focus on development of oyster aquaculture, processing, and marketing in collaboration with local partners.

3. Human well-being surveys
   - Analyze the data and review the results from the human well-being surveys conducted in Japan, Korea, United States, and Indonesia.

4. Database
   - Continue to develop the database including a bibliography of human–natural systems interactions and the well-being survey data, and information from the Indonesia and Guatemala case studies;
   - Start to build the on-line access system for sharing the contents of the database.

3. PROGRESS OF YEAR 3

3.1 Project Science Team meetings

The Project Science Team (PST) was established in August 2012 (Year 1) in order to review the scientific progress, and make recommendations for the implementation of the project. During Year 3, the PST membership was revised to better match the case studies that are being developed. As of March 2015, the PST membership includes 13 scientists: 4 from Canada, 3 from Japan, 2 from Korea, 3 from USA, and a representative from the PICES Secretariat (Table 1). A total of five PICES expert groups are represented on the Team: Section on *Human Dimensions of Marine Systems* (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) (Fig. 1).

In Year 3, two PST meetings were organized. The first meeting was held April 13, 2014, on the Kohala Coast, Island of Hawaii, Hawaii, USA, in conjunction with the PICES FUTURE Open Science Meeting. The key objectives for that meeting were to: (a) plan for the Guatemala case study, (b) further develop the Indonesia case study, and (c) prepare the detailed workplan for FY 2014–2015. The goal of the second meeting held October 16, 2014, in Yeosu, Korea, in conjunction with the PICES 2014 Annual Meeting

(PICES-2014), was to review progress made since the April meeting. A very successful topic session titled "*Ecological and human social analyses and issues relating to Integrated Multi-Trophic Aquaculture*" was convened at PICES-2014, with a large number of participants, including many not directly related to the MarWeB project. The reports from both PST meetings and other materials are available at http://meetings.pices.int/projects/marweb.

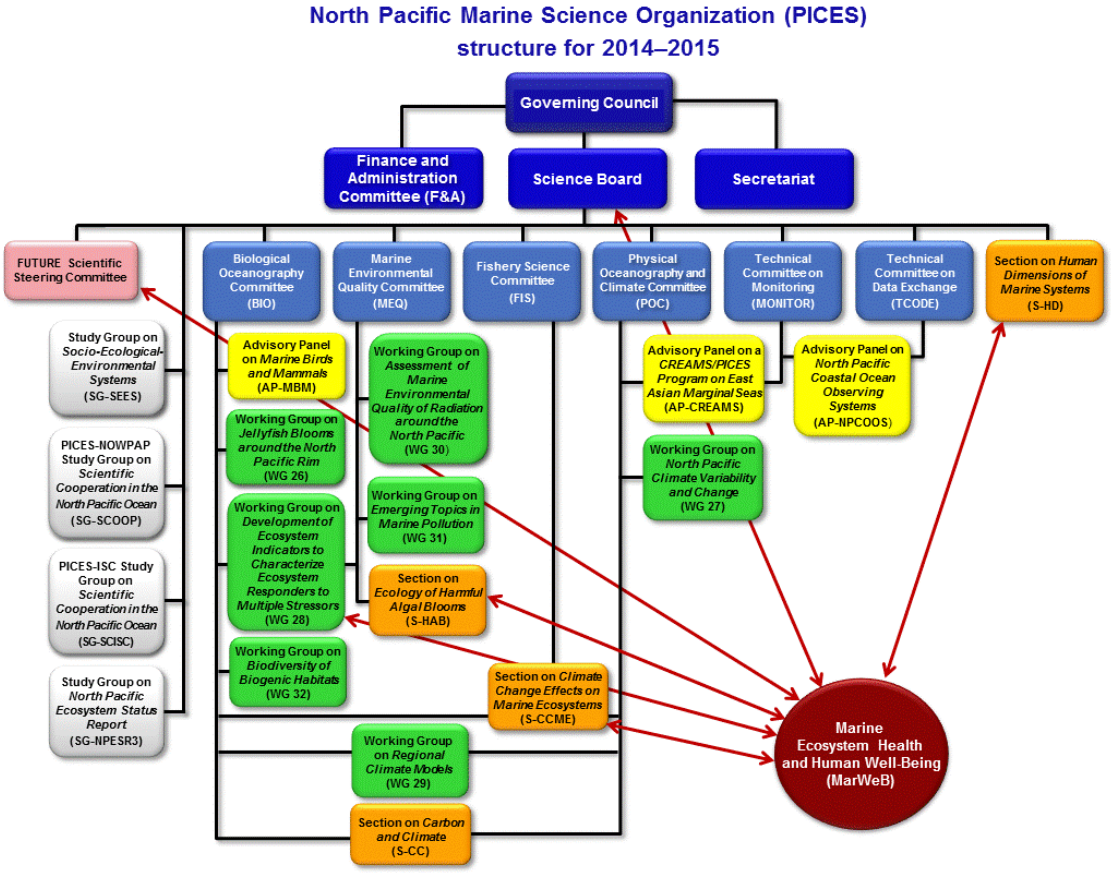

Fig. 1 PICES (North Pacific Marine Science Organization) structure for 2014–2015 showing links between the MarWeB project and expert groups.

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

Name	Affiliation	Country/Group
Dr. Harold Batchelder	PICES Secretariat	PICES
Dr. Keith Criddle	University of Alaska, Fairbanks	USA/S-HD
Dr. Masahito Hirota	Fisheries Research Agency	Japan/S-HD
Ms. Juri Hori	Rikkyo University	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	Korea Maritime Institute	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

3.2 Case studies

3.2.1 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 due to removal of mangroves and building of coastal shrimp ponds. This has resulted in a current ecological system with intensive shrimp monoculture. The MarWeB project, in collaboration with the Agency for the Assessment and Application of Technology (Badan Pengkajian dan Penerapan Teknologi, BPPT) of Indonesia, is conducting a study of the use of integrated multi-trophic aquaculture (IMTA; including seaweed, shrimp, and fish) to demonstrate low emissions of deleterious materials into the natural environment and to provide alternative sources of protein and livelihoods for the local human population.

During Year 3, MarWeB activities in this case study included the following:

- *Ecological systems*
  - A workshop was convened to disseminate the concept of Sato-umi (Gempita) in Indonesia;
  - A pond experiment for IMTA was started;
  - A material circulation box model for analysing the carrying capacity in the pond was constructed.
- *Social systems*
  - Basic social information (*i.e.*, statistics) was collected and analyzed;
  - Commodity chain analysis for IMTA products was revised;

- A preliminary study was started based on an "analytic hierarchy process" (AHP) approach to support local decision-making. AHP is a structured technique for organizing and analyzing complex decisions;
- A psychological survey analysis for well-being (*i.e.*, "well-being cube" analysis) was completed.

Ecological systems

Project activities in Indonesia are being conducted in collaboration with BPPT, which is a non-departmental government agency under the coordination of the Ministry of Research and Technology responsible for carrying out government duties in the field of assessment and application of technology. An experimental plan was developed for the MarWeB-sponsored Gempita (Sato-umi) pond experiment, which was started at the National Center for Brackishwater Aquaculture in Karawang, in August 2014. The main purpose of this experiment is to investigate the effect of IMTA on: (1) the economic return of pond operations, and (2) the water quality of the ponds, defined in terms of the (macro)nutrient concentrations of nitrate/nitrite, ammonia, and phosphate, in addition to other parameters (oxygen, phytoplankton, bacteria, *etc*.). The underlining hypothesis is that the addition of bivalves (*Anadara*) and seaweed (*Gracilaria*) into the aquaculture ponds of fish (*Tilapia* species) or shrimp will allow successful growth of all species, and decrease of macronutrient concentrations in the pond waters.

The optimal pond conditions for shrimp and fish are:

- A high phytoplankton biomass, including diatoms and green algae – phytoplankton provide additional food which enhances the flavor of the shrimp and fish;
- Low light penetration which creates less stress for the shrimp and prevents the growth of seagrass in the pond.

For these reasons, nutrients (nitrate, phosphate) are added in high concentrations at the start, which helps to maintain high biomass of phytoplankton over the duration of the pond experiment.

The experiment was designed using four 4000 m^2 ponds at the National Center for Brackishwater Aquaculture: Pond 1 – Shrimp only, Pond 2 – Shrimp + *Gracilaria* + *Anadara*, Pond 3 – Fish (tilapia) only, and Pond 4 – tilapia + *Gracilaria* + *Anadara*.

Early results suggest the following:

1. There appears to be no negative effect on the shrimp or tilapia weight gain in the ponds with the *Gracilaria* and *Anadara*. This was the main concern.
2. The replenishment of water in the tilapia ponds from the reservoir is a potential source of nutrient variability, but concentrations in all ponds seem to track each other reasonably well (particularly NO_3/NO_2). The implication is that despite the considerable mixing (from paddle mixers), vertical gradients may be forming within the 1 m deep ponds. There also may be variation from site to site within the pond as the water circulates. Collecting vertically integrated samples was suggested.
3. The biggest problem was the high level of nutrients added to the ponds to generate enough plankton to prevent light from reaching the bottom of the pond.

Social systems

A revised commodity chain model was developed (Fig. 2). A "system dynamics" model is being considered to explore the effects of changing parameters (*e.g.*, in the commodity chain), and to examine the impacts of changes to various social parameters. An AHP (Analytic Hierarchy Process) approach is also being investigated to evaluate the choice of scenarios (*e.g.*, the effects on outcomes of intensive culture, polyculture and IMTA approaches). The social survey for the "well-being cube" analysis was completed in Indonesia with the assistance of BPPT, and the results are now being analysed and compared with results from similar surveys in Japan, the United States, and Korea.

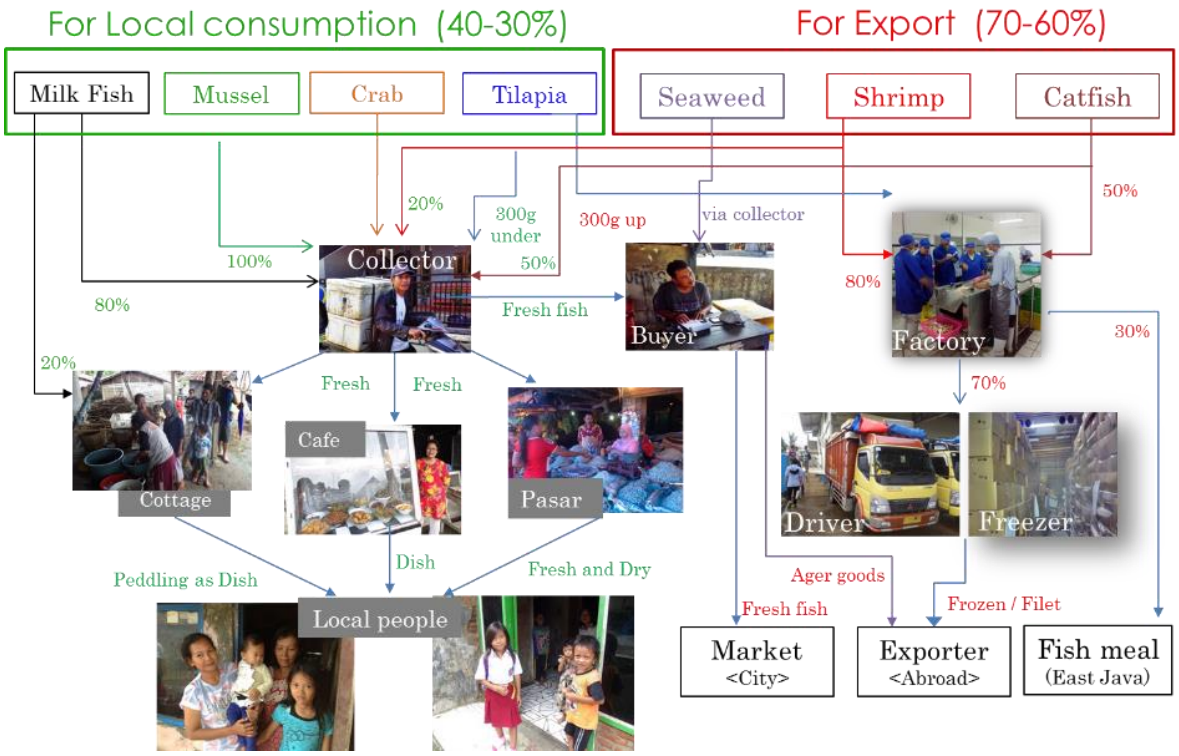

Fig. 2 Commodity chain of the IMTA products in Karawang area, Indonesia (revised).

3.2.2 Guatemala

Much of Year 3 was focused on developing the MarWeB program in Guatemala. Two science themes have been adopted: (1) a focus on multi-trophic aquaculture for the natural science theme, and (2) a social science survey to understand how people and their livelihoods relate to the ocean.

Theme 1 involves collaborating with researchers at the University of San Carlos, Guatemala, and with the Integral Fisheries Cooperative on the Pacific coast of Guatemala, to test the feasibility of growing, processing, and marketing *Crassostrea gigas* (mangrove oyster) using an IMTA approach. The potential outcomes include increased income for coastal people, and improved health and well-being. Specific objectives are: assessing the performance of the longline shellfish culture system in La Barrona estuarine lagoons; determining yield potential of the culture system, including growth rates and time for mollusks to reach market size; evaluating shellfish survival rates during different phases of their growth and assessing

mitigation methods against predation; adapting or developing culture practices appropriate for the management of the system; producing oysters that conform to the microbiologic standards of food safety; and assisting in finding suitable markets for the sale of the final product.

The project is now ongoing. For the first three months, sampling is being done every 2 weeks, and then will switch to once a month for the next 4 months. The monitored parameters are dissolved inorganic nutrients, dissolved oxygen, salinity, temperature, light transmission, and phytoplankton. The monitoring is being carried out by students and faculty using equipment previously provided by the now completed PICES International Seafood Safety Project (ISSP) also funded by MAFF (Fig. 3). That PICES ISSP project provided training in identifying harmful algal species and measuring the toxicity of seafood exposed to toxic algae.

Fig. 3 Students and faculty from the Center for the Study of the Sea and Aquaculture (CEMA) of the University of San Carlos in Guatemala conducting water quality sampling for the oyster culture project and during currently ongoing harmful algal bloom monitoring efforts along the Guatemalan coast.

A mission to Guatemala City and two Pacific coastal towns (Las Lisas and Monterrico) was undertaken from February 26–March 7, 2015 to implement the social survey. These surveys were conducted with approximately 20 families in each of these two coastal towns, using a set of 34 questions with 5 possible answers from a computer to provide anonymity to the respondents. The survey asked questions such as how often the family buys seafood from the market, and whether the ocean provides enough food for the family. The surveys lasted approximately 1 hour, after which students conducted a follow-up interview to explore responses in more detail (Fig. 4).

Fig. 4 PICES MarWeB researcher (facing camera) conducting the follow-up semi-structured interview with families from Monterrico, Guatemala.

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

"Well-being" is defined by psychologists as involving people's positive evaluations of their lives such as positive emotions, engagement, satisfaction, and meaning. As identified in the UN Millennium Ecosystem Assessment, human well-being (HWB) has multiple constituents, including basic material for a good life, freedom of choice and action, health, good social relations, and security. The constituents of well-being, 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). In Year 1, a survey of 1000 people in Japan was conducted to assess their relationships with the sea (Fig. 5). In Year 2, the same questionnaire was used to survey 500 people each in Korea (Fig. 6) and the United States (Fig. 7). In addition to these three PICES member countries, a survey of 200 people was conducted, in collaboration with BPPT, in several Indonesian provinces to provide data for analyses of well-being in relation to the sea (Fig. 8). The well-being cube was built up with human-needs, and it shows distinctions among HWB structure of each country (*pink* shows high expectation and satisfaction need, *blue* is low expectation and low satisfaction need, *yellow* is high expectation and low satisfaction need, and *green* is low expectation and high satisfaction need). Also, a result from the SEM (Structural Equation Modeling) analysis showed the commonalities and differences to achieve "freedom of choice and action" among countries (Fig. 9).

Publication for a peer-review journal is now under preparation. Some initial findings indicate that all countries surveyed have similar general concepts of well-being in regard to the ocean; however, the specific understanding of how the ocean affects human well-being differ among these countries and, therefore, what makes for a desirable relationship between people and the sea is different among countries.

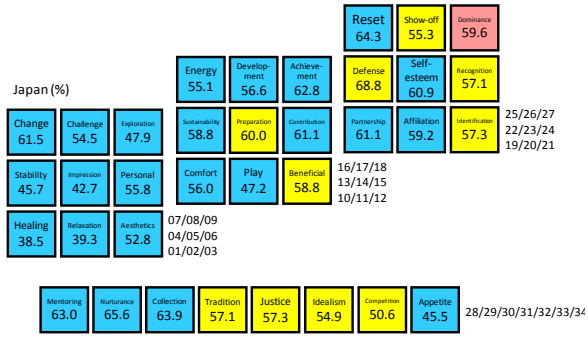

Fig. 5 Japan-CUBE (2012)

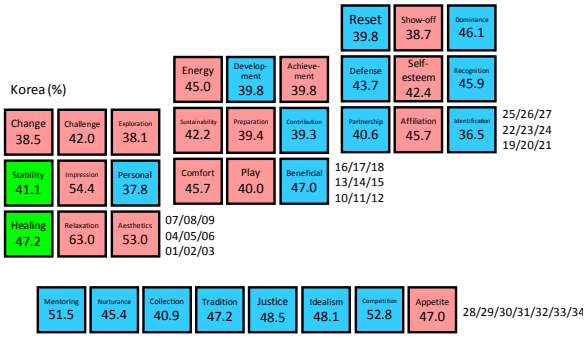

Fig. 6 Korea-CUBE (2013)

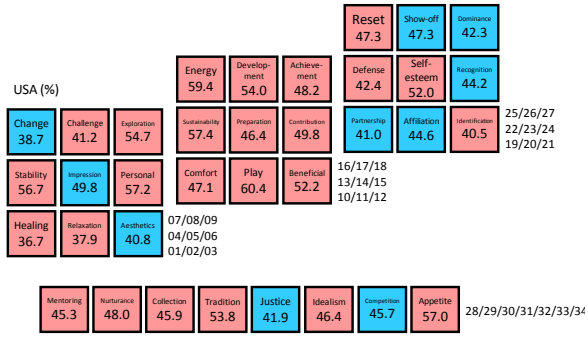

Fig. 7 United States-CUBE (2013)

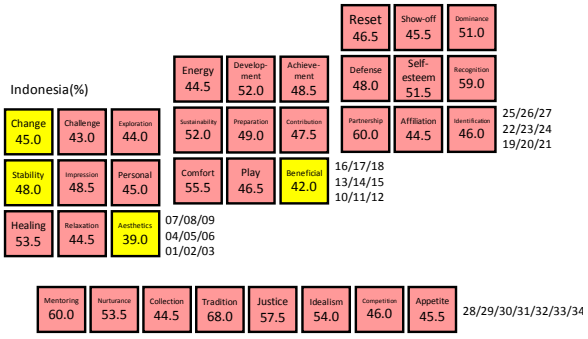

Fig. 8 Indonesia-CUBE (2014)

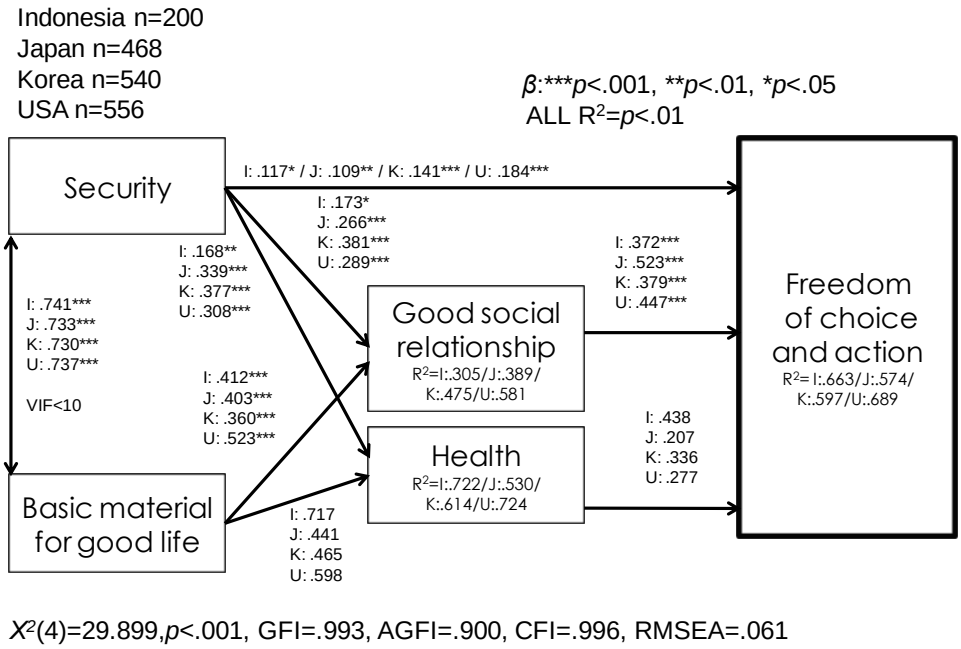

Fig. 9 Structural Equation Modeling of Millennium Ecosystem Assessment (2005) well-being items (multiple group) (2014).

3.4 Database

The database containing a bibliography of human–natural systems interactions and the well-being survey data from the Indonesia and Guatemala case studies is under development.

4. WORKPLAN FOR YEAR 4

1. Project Science Team meetings
   - Organize one Project Science Team meeting in conjunction with 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 the Karawang experimental site, including a site visit by PST members;
   - Organize a workshop to develop a 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 PST on results of the 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, and Indonesia;
   - Conduct web-based surveys in Russia and China.
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.

Scientific Progress Report for 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; http://www.pices.int/projects/marweb). The project began in April 2012, with the ending date set as March 31, 2017. Its 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). Considering that global changes are affecting both climate and human social and economic conditions, the project is expected to determine: 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 (*Appendix 1*):

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- 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 workplan for the following year (Project Principle 3.3).

This progress report summarizes the activities carried out for Year 4 (FY 2015: April 1, 2015–March 31, 2016) and includes a workplan for Year 5 (FY 2016: April 1, 2016–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 a PST meeting in conjunction with 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 the Karawang experimental site, including site visit by PST members;
   - Organize a workshop to develop a 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 MarWeB work and improve their overall health;
   - Report to Guatemalan local people and PST on results of the 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, and Indonesia;
   - Conduct web-based surveys in Russia and China.

3. PROGRESS OF YEAR 4

3.1 Project Science Team meetings

The Project Science Team (PST) 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, 3 from USA, and a representative from the PICES Secretariat (Table 1). A total of five PICES expert groups are represented on the Team: Section on *Human Dimensions of Marine Systems* (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) (Fig. 1).

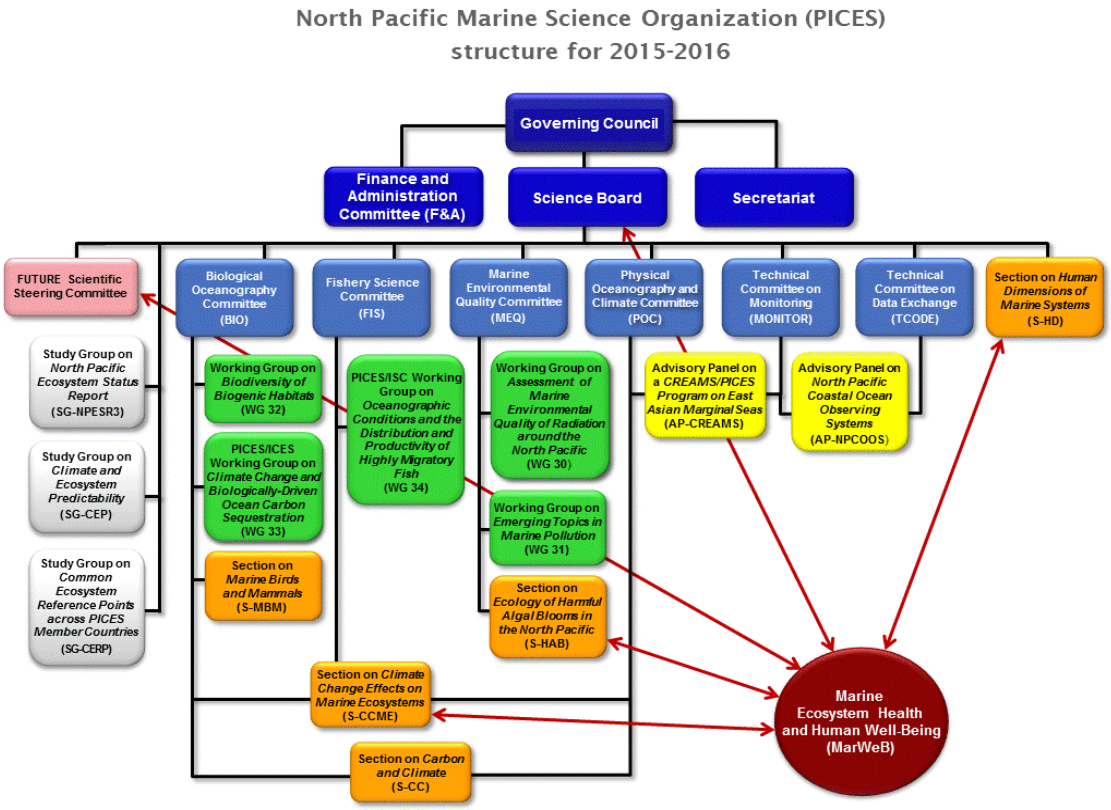

Fig. 1 PICES (North Pacific Marine Science Organization) structure for 2015–2016 showing links between the MarWeB project and expert groups.

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

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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 ("well-being cube" analysis), and (d) prepare the detailed workplan for *FY* 2015–2016. The report from the 2015 PST meeting and other project-related materials are available on the project's website at http://meetings.pices.int/projects/marweb.

3.2 Case studies

3.2.1 Indonesia

Ecological systems

"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 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.

The goal of this MarWeB 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 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 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 algae *Gracilaria*, a common food and industrial aquaculture product, and the clam *Anadara* (Fig. 2). The experimental design comprised two controls (shrimp alone, tilapia alone), two 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.

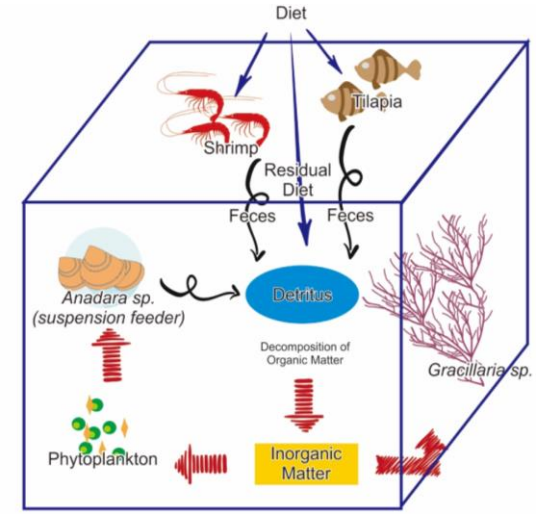


Fig. 2 Recycling waste generated by the cultivation of the main species (fish) into a source of energy and nutrients for the cultivation of other commodities, resulting in a product that can be harvested, and can reduce environmental impact (graphic provided by NCBA).

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, Vol. 24, No. 1, pp. 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 cover Sulawesi. The approach included: (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, Dr. Masahito Hirota, 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.

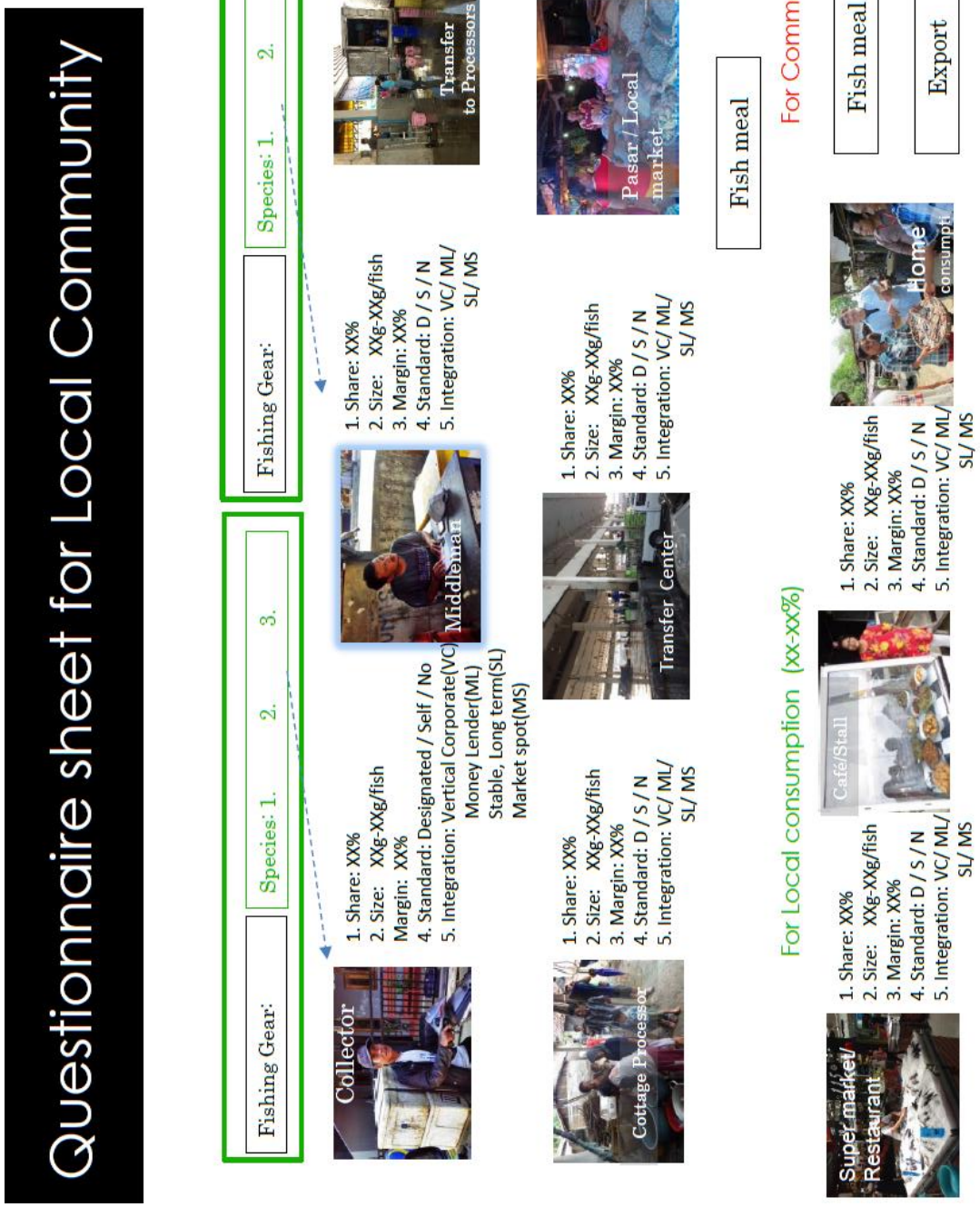


Fig. 3 An example of how the simplified social survey can be presented to develop a marine commodity chain.

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).

The 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 the current 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 (University of San Carlos, Guatemala), the MarWeB team 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 fishermen" 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 regard 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.

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:

For Las Lisas

1. A healthier lifestyle in Las Lisas can be facilitated with opportunities for better education, sustainable, environmentally-friendly tourism, and 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. An alternative source of fish-based food supplies must be sought – such as through aquaculture.

For Monterrico

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 University of San Carlos 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 eco-tourism to flourish.
3. A healthier 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 as an 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 theft 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 with 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 are 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 Exclusive Economic Zone (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 funding to strengthen its monitoring system.

The *Protected Area Network Act* was adopted in 2003 to enable the national government to be involved in, 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 southern 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 in 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 people's positive evaluations of their lives such as positive emotions, engagement, satisfaction, and meaning. As identified in the UN Millennium Ecosystem Assessment, human well-being (HWB) has multiple constituents, including basic material for a good life, freedom of choice and action, 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, Vol. 23, No. 2, pp. 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 each in 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.

4. WORK PLAN FOR YEAR 5

1. Project Science Team meetings

   - Organize two Project Science Team meetings: 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 the Karawang experimental site, including a site visit by PST members;
   - Organize a workshop to develop a 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 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.

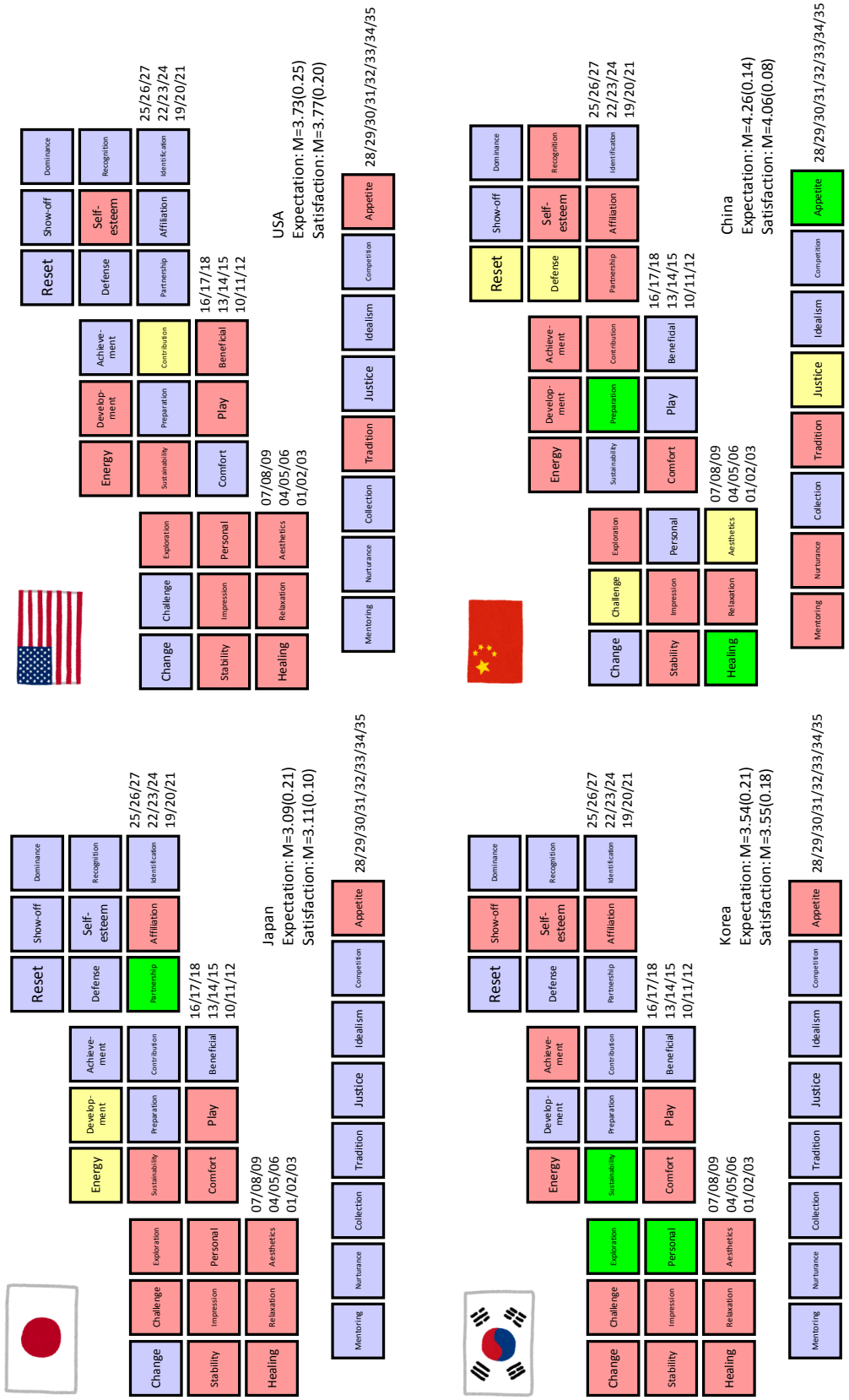


Fig. 4 Preliminary results of the well-being surveys conducted in four PICES countries for the MarWeB project. Pink shows high-expectation and satisfaction needs, blue is low-expectation and satisfaction needs, yellow is high-expectation and low-satisfaction needs, and green is low-expectation and high-satisfaction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

4. 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

   - Conduct synthesis/integration of two case studies;
   - Develop the manual and database.

Appendix 4
Project Science Team Meeting Reports

First Meeting of the Project Science Team
October 11, 2012, Hiroshima, Japan

The first meeting of the Project Science Team (PST) for the PICES project on "*Marine Ecosystem Health and Human Well-Being*", funded by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan, through the Fisheries Agency of Japan (JFA), was held October 11, 2012, in conjunction with the PICES Annual Meeting in Hiroshima, Japan. The meeting was co-chaired by Drs. Mitsutaku Makino (Japan) and Ian Perry (Canada).

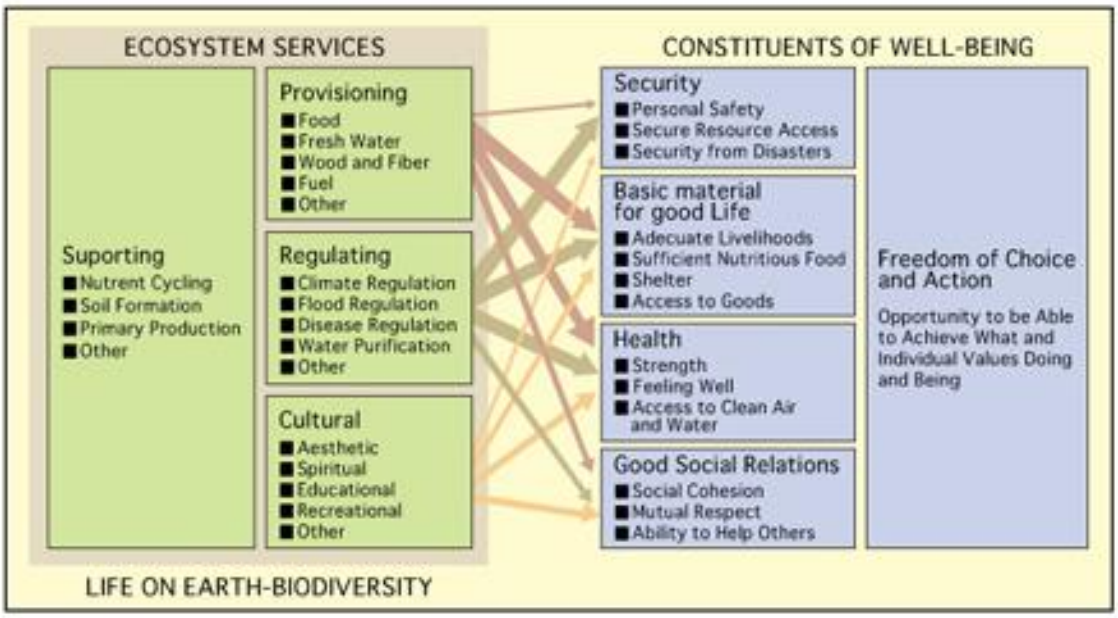
The PST members and meeting participants are identified in *Appendix 1*, and the meeting agenda is presented in *Appendix 2*.

BACKGROUND OF THE PROJECT

- Progress is being made internationally on an ecosystem approach to the management of marine systems.
- Very recently, the concept of human well-being within marine social-ecological systems has become recognized as an important step forward.
- Well-being shifts the perspective from objective measures of sustainable livelihoods (comprised of the physical, social, human, natural, and financial resources available to a community or country) to include the subjective or perceived well-being of individuals and communities. This represents a shift from people as exploiters of the ocean to people as integral components of resource sustainability and ecosystem health (Coulthard *et al*. 2011; Charles 2012).
- The Japanese "Sato-umi" (village-sea) concept is an example of this humans-in-nature approach, in which a healthy ecosystem is seen to nourish human well-being, and human activities are seen as necessary for sustaining ecosystem health. Therefore, this project is proposed and funded by the Japanese government.

Ecosystem services and human well-being was recognized in the UN Millennium Ecosystem Assessment (2005), although it was noted in discussion that the connecting arrows should go both directions (see the chart on next page).

The project 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. 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. The MAFF contribution is from the ODA (Official Development Assistance) Fund and, therefore, involvement of developing Pacific Rim countries in activities is required under this project.



The project lifetime is 5 years: it began in April 2012, with the ending date set as March 31, 2017. The budg*et* allocated for Year 1 (FY 2012: April 1, 2012 – March 31, 2013) was $149,880, and the initial budget breakdown is shown in the following table:

Travel and meetings	Contracts	Equipment	Miscellaneous	Overhead	Total
60,000	49,000	19,600	1,796	19,484	149,880

It was noted that the proposed goals of the project are very general and need to be made much more specific. Aspects of capacity building and the provision of analytical tools should be included and stated explicitly. Both of these (capacity building and tools) should continue to be useful after the project has been completed. When organizing capacity building workshops/courses, the objectives should include the needs and goals of a developing country and its partnering institutions.

The "must do" things under the project include to:

1. Select 3 study sites: Southeast Asia, Pacific oceanic islands and Central America;
2. Conduct research on ecosystem health and human well-being;
3. Organize 2–3 workshops/courses at each site;
4. Construct a "database"';
5. Submit annual reports to MAFF/JFA within 120 days after the close of each project year ending March 31.

It was suggested that the "database"' could be a bibliography, for example, of interactions within human-natural systems and related references that would be useful for research and capacity building activities. It would be desirable for this database to support the work of the PICES FUTURE science program, and to

link with the work of PICES Working Group on *Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors* (WG 28) on indicators of ecosystem responses to multiple stressors regarding human activities (and their related indicators) that affect the ocean.

It would also be desirable for the project to build on and learn from existing efforts, *e.g.*, NOAA's international activities to teach Integrated Ecosystem Analysis approaches in the South Pacific.

Action: Dr. Vera Trainer to provide contact information for these NOAA activities.

The work of this project should be integrated with other PICES activities and expert groups, such as:

- FUTURE Research Theme 3 on "*How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems*";
- Section on *Human Dimensions of Marine Systems* (S-HD);
- Section on *Ecology of Harmful Algal Blooms in the North Pacific* (S-HAB);
- Section on *Climate Change Effects on Marine Ecosystems* (S-CCME);
- WG 28 on *Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors*;
- WG 21 on *Non-indigenous Aquatic Species*;
- WG 29 on *Regional Climate Modeling*.

REVIEW OF WORK RELATED TO THE PROJECT

Dr. Vera Trainer described the HAB (harmful algal bloom) component of the previous MAFF-funded project (2007–2012) on teaching country-specific training courses most required to ensure seafood safety in the Pacific Rim developing countries outside the PICES region (Philippines, Indonesia, and Guatemala). It had the following features:

- A survey sent through the Intergovernmental Oceanographic Committee of UNESCO (IOC) to appropriate national representatives regarding their perception of needs for HAB monitoring in their country (see *Appendix 3* for a sample survey form);
- A follow-up scoping meeting with representatives of agencies in each country selected for training courses and workshops, to refine their needs and goals for training;
- A regional workshop/course organized and conducted in collaboration with local partners;
- A follow-up meeting with the national representatives, to assess the outcomes from the training courses and workshops.

Dr. Trainer expressed her view that teaching the "philosophy of how to do the work" approach was better than teaching a specific issue, so that the participants can have the tools to apply to issues as they emerge rather than fix on a set of specific problems. In addition, it is important that the trainees include those people who are actually doing the work.

Dr. Thomas Therriault commented that the PICES WG 21 on *Non-indigenous Aquatic Species* took a different approach to their 2007–2012 MAFF-funded project. They decided that the issues to be addressed

regarding invasive species were already well-defined and focused their work on developing a database of where invasive species have been observed.

Dr. Keith Criddle noted that the Food and Agriculture Organization of the United Nations (FAO) has developed a training course on ecosystem-based management for fisheries and suggested it could be important to identify the spatial scale and scope of their project.

Action: Dr. Criddle to follow-up and circulate details on this FAO training course.

As human well-being is not always understood the same way by all parties, it was agreed that a process of getting to the "shared objectives" is necessary for the present PICES/MAFF project. The following was suggested as a possible approach:

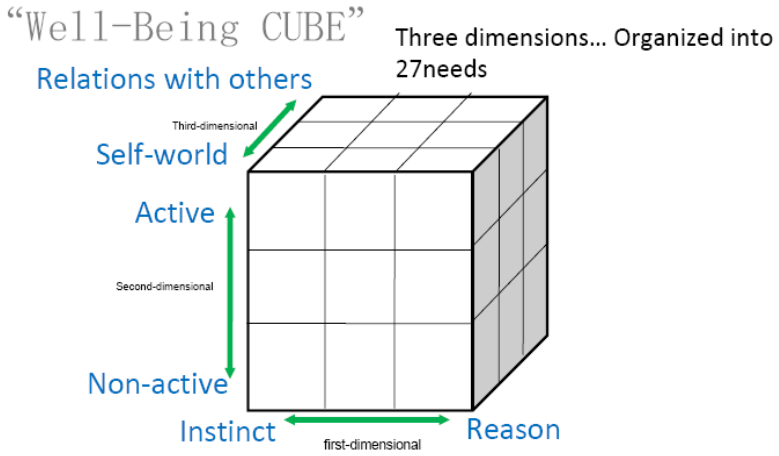
1. The PST selects the countries, and then develops a process and questionnaire for circulating to selected contacts in each country in order to identify the specific issue to be addressed, within the context of marine ecosystem health and human well-being (*i.e*., specific issues within this topic may differ among countries).

2. The project adopts a "responsible template" approach, in which the national representatives define their critical issues, and the PST members help with those issues for which the team has expertise.

3. It was recommended to start with broad objectives within the context of marine ecosystem health and human well-being, then let the national participants define/identify their critical issues within these broad objectives on which subsequent training courses and workshops would focus.

This process requires a clear sense of who the target participants are for what type of training. For example, an important difference between the present project and the 2007–2012 PICES/MAFF project is that the previous one had a very specific training topic related to human and environmental health. The participants at the training workshops were identified as those people who conduct the marine monitoring activities, in particular the laboratory personnel. In contrast, the present project is concerned more with conceptual issues of marine ecosystem health and human well-being. The target participants in such a topic may include representatives of local, regional and/or national government agencies responsible for marine management and representatives of local community groups in marine-dependent communities.

Ms. Juri Hori and Dr. Makino presented definitions for human well-being from psychological research: "*Well-being is a state of being with others and the natural environment which arises where human needs are met, where individuals and groups can act meaningfully to pursue their goals, and where they are satisfied with their way of life*" (Gough *et al*. 2007). They described the concept of the "well-being cube", in which a person (or community, region, or country) can be located in one or more of 27 cells defined by three axes, each with three categories:



The survey discussed above could be used to complete this "cube" analysis for each country, thereby serving as a standard method to compare countries with respect to their needs for marine ecosystem health and human well-being. In addition, this method might be used to compare the responses of the workshop participants to the responses of the broader population from which the participants are drawn, and also, how does the region or community compare with country as a whole. In discussion, it was noted that multiple tools may then be needed to link human well-being analyzed by this method with the necessary ecosystem services.

Action: Ms. Hori and Dr. Makino to prepare a model example to illustrate how this approach might work, and the types of questions that might be developed. This example could include illustrations of how the "well-being cube" analysis links with ecosystem services.

SITE SELECTION

Three countries were discussed for potential training:

- Indonesia: large population, aquaculture-intensive;
- Palau: finfish capture fishery focus, existing networks of community-based fisheries;
- Guatemala: upwelling system, finfish, and aquaculture.

Possible training workshop/course time schedule for these countries:

Year 1: Indonesia
Year 2: Indonesia and Guatemala
Year 3: Guatemala and Palau
Year 4: Palau and Indonesia
Year 5: final synthesis workshop

In addition, the selection of an appropriate site within each country has to be considered, in consultation with the national representatives. Is more than one site per country needed?

Dr. Harold Batchelder indicated that he has a student working on modeling of Meso-American reef systems, and so he keeps track of some issues on those systems. There is a website (http://www.healthyreefs.org/images/pdf/conceptual_framework.pdf) that shows a conceptual framework for those systems, which includes "social well-being", which seems synonymous with "human well-being" as described by Hori and

Makino. The website has several reports that summarize the condition of Meso-American reef systems, and it might be worth exploring these and other similar sites. There is also prior work on "*Coastal systems and human well-being*", and the PST should learn from these efforts.

The reasons for selecting tropical countries as case studies need to be presented and proved to PICES member countries. For example, ENSO processes connect the tropics with PICES member countries at higher latitudes, as does food supply (shrimp and tuna from tropical countries are major imports to PICES member countries).

Action: Dr. Suam Kim to provide Dr. Makino with information on Dr. Sung Yun Hong as a possible contact in Indonesia, and Dr. Trainer to consider leading the program in Guatemala.

WHAT TOOLS CAN PICES PROVIDE?

Within the contexts of sustainable human communities and productive marine ecosystems:

- What are the general concepts leading to sustainable human communities and productive marine ecosystems?
- Where do countries "want" to be within these concepts and where are they now?
- What are the major stresses (for example, climate change) and how might these affect the current state and the transitions to the desired state?
- How does human well-being relate to ecosystem services in these countries?

The PST agreed to consider if a reduction of all potential activities to one, for example aquaculture, or a few activities may help to focus the discussions and training. The initial survey approach and first scoping meeting could be used to identify the larger suite of activities of interest, and if they can be reduced to a smaller number of key activities.

Key outcome: Provide an approach and tools to doing these types of "integrated social-ecological assessments".

NEXT STEPS

By February 2013:

- Select specific objectives and approach for this project;
- Refine "well-being cube" example;
- Set-up a project website for PST members;
- Prepare a draft questionnaire for Indonesia, including identification of potential target participants;
- Identify contacts and conduct the first scoping meeting with appropriate representatives in Indonesia.

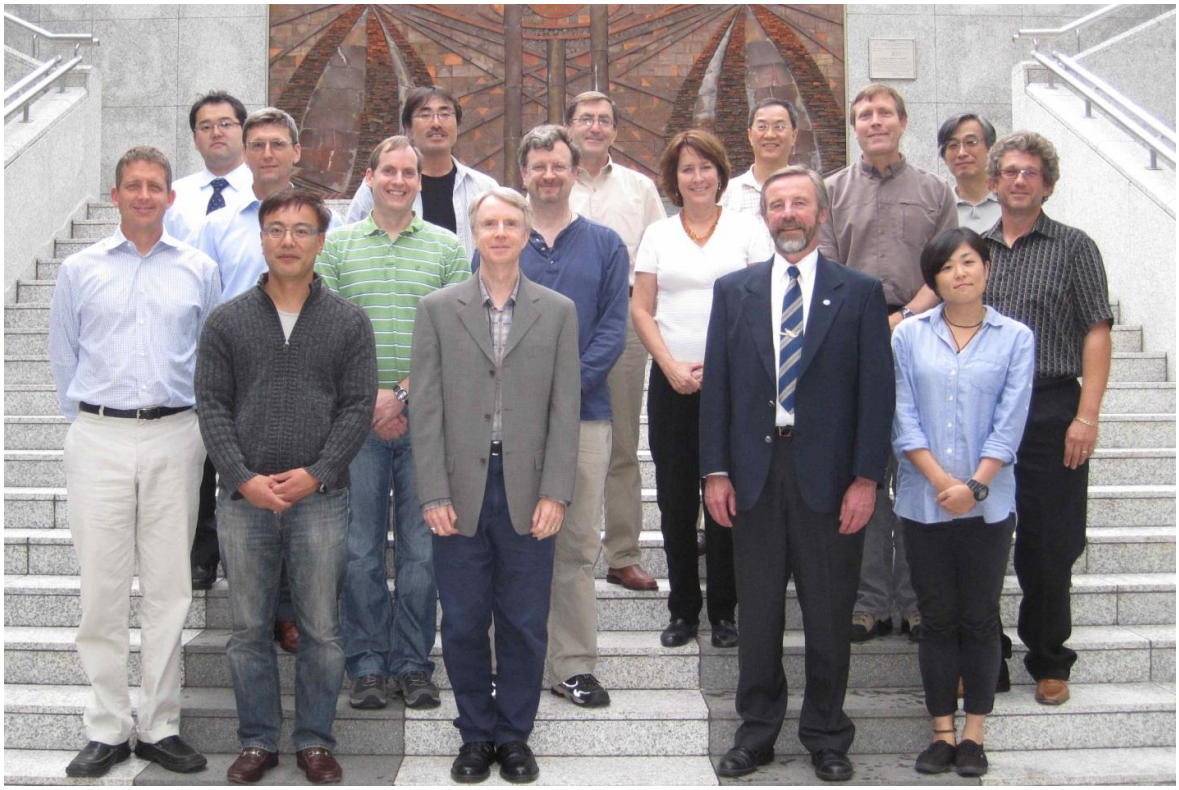
By May 2013:

- Discuss details of a workshop in Indonesia at a PST meeting to be held, possibly, in conjunction with the PICES inter-sessional Science Board meeting (Kaliningrad or St. Petersburg, Russia, week of May 20, 2013), or independently of this inter-sessional meeting, for example, in Hawaii in May 2013.

Appendix 1

Project Science Team members and meeting participants

According to the organizational principles agreed upon by MAFF/JFA and PICES, 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). The PST Co-Chairmen are responsible for the scientific implementation of the project and annual reporting to MAFF/JFA and PICES Science Board. The current PST members are listed in the table below (Drs. Mark Wells and Thomas Therriault were invited to join the PST at the meeting, and both accepted). All participants of the meeting are shown on the group photo.



Participants of the first Project Science Team meeting for the PICES/MAFF project on "Marine ecosystem health and human well-being". Front row: Grant Murray (Canada), Mitsutaku Makino (Japan), Ian Perry (Canada), Skip McKinnell (PICES Deputy Executive Secretary) and Juri Hori (Japan); middle row: Igor Trofimov (Russia), Thomas Therriault (Canada), Harold Batchelder (USA), Vera Trainer (USA), Keith Criddle (USA) and Mark Wells (USA); back row: Takaomi Kaneko (Japan), Masahito Hirota (Japan), Alexander Bychkov (PICES Executive Secretary), Suam Kim (Korea) and Sinjae Yoo (PICES Science Board Chairman).

Table 1 Membership of the Project Science Team

Name	Country	Group
Dr. Grant Murray	Canada	S-HD
Dr. Ian Perry, Co-Chairman	Canada	WG 28
Dr. Thomas Therriault	Canada	WG 21, AICE-AP, MEQ, SB
Dr. Masahito Hirota	Japan	S-HD
Ms. Juri Hori	Japan	S-HD
Dr. Mitsutaku Makino, Co-Chairman	Japan	S-HD
Dr. Dohoon Kim	Korea	S-HD
Dr. Suam Kim	Korea	S-CCME
Dr. Harold Batchelder	USA	AP-SOFE
Dr. Keith Criddle	USA	S-HD
Dr. Vera Trainer	USA	S-HAB
Dr. Mark Wells	USA	S-HAB
Dr. Skip McKinnell	PICES Secretariat	PICES Secretariat

Appendix 2

First Project Science Team meeting agenda

1. Member self-introductions
2. Background of the project (Co-Chairs)
3. Review of work related to the project
   - Previous PICES-MAFF Project, 2007–2012 (Vera Trainer, Mark Wells and Thomas Therriault)
   - IMBER WG on *Human Dimensions* and Current Opinion in Environmental Sustainability (COSUST) Special Issues (Ian Perry)
   - "Sato-umi"-related initiatives in CBD, UNU, *etc*. (Mitsutaku Makino)
   - Others
4. Proposal of research topics by PST members
   - Proposal of candidate sites (Co-Chairs)
   - Potential intersects/synergies with WG 28, S-HD, and other groups and activities within PICES
5. Discussions on the workplan and budget
6. Others

Appendix 3

Questionnaire to assess Pacific member state needs in relation to HAB monitoring and management and strengthened seafood safety

1. Do you see a need for assistance to strengthen capabilities for harmful algae and biotoxin monitoring and management capabilities in your country?

2. Do you see a need for assistance to strengthen capabilities for harmful algae and biotoxin research capabilities in your country?

3. Which authority is responsible for monitoring of harmful algae and biotoxin monitoring in relation to public heath/seafood safety, aquaculture and fisheries in your country?
   a. Institution name & address
   b. Contact person, e-mail

4. Which institution/laboratory is in charge of implementation of monitoring of harmful algae and their biotoxins in relation to public health/seafood safety, aquaculture and fisheries in your country?
   a. Institution name & address
   b. Contact person, e-mail

5. Is there any working relationship between the above institutions and research institutions, for example, when there is a mortality/illness event, which scientists/groups assist regulators in researching the cause of the event?
   a. Research institution name & address
   b. Contact person, e-mail
   c. Please specify nature of this working relationship

6. At which institution/agency is national data on harmful algal events stored?
   a. Institution name & address
   b. Contact person, e-mail

7. Is there an interest by regulators to assure seafood safety of non-exported products?

8. Would there be an interest in your country in sharing knowledge on different approaches and methods in HAB management?
   a. In relation to export markets
   b. In relation to local non-exported fisheries and aquaculture

9. How would you assess the needs for short term technical training (you may indicate more than one, indicate priority with 1 as high, 5 as low priority)

   Regulatory labs and institutions:__ Research labs and institutions:__

   a. Regulatory monitoring and management laboratories:

      __Species identification __Toxicity testing __HAB data management __Introduction to new methodologies __other (please specify)

   b. Research institutions:

      __Species identification __Toxicity testing __HAB data management __Introduction to new methodologies __other (please specify)

10. Are there shortages among the authorities or institutions responsible for HAB monitoring and their laboratories technology (IT, microscopes, analytical facilities, *etc*.) that impede effective monitoring and management of HAB? Please specify.

11. Would there be interest in initiating or strengthening network activities (*e.g*., learning visits to sister labs in the region with a goal to compare methods in species identification or toxicity measurements, *etc*.)?

12. What would you identify as most needed network activities in your country in relation to harmful algae and management of their effects?

13. What would you identify as most needed network activities in your country in relation to harmful algae research?

14. What other needs or comments pertaining to protection of seafood safety from harmful algae events in your country are not covered above?

The answers to this questionnaire were submitted by:

Name: Institution: Address: E-mail:

Second Meeting of the Project Science Team
June 10–12, 2013, Honolulu, Hawaii, USA

The second meeting of the Project Science Team (PST) for the PICES project on "*Marine Ecosystem Health and Human Well-Being*", funded by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan, through the Fisheries Agency of Japan (JFA), was held June 10–12, 2013, in Honolulu, Hawaii, USA. The meeting was co-chaired by Drs. Mitsutaku Makino (Japan) and Ian Perry (Canada).

The meeting participants are identified in *Appendix 1*, and the meeting agenda is presented in *Appendix 2*.

Day 1 – June 10, 2013

The first day of the meeting was devoted to presentations and discussions of project activities, and achievements to date. The project's objective was reiterated as to identify the relationships between sustainable human communities and sustainable marine ecosystems in the North Pacific, under the concept of fishery social-ecological systems. Specifically, 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.

PRINCE'S TRUST WORKSHOP

The International Sustainability Unit (ISU) of the UK Prince Charles' Charitable Foundation has a marine program (http://www.pcfisu.org/marine-programme) which, among other objectives, was initiated to help strengthen consensus around the best solutions for the sustainable management of wild marine fish stocks. Recently, the ISU released a report based on interviews with fishing communities from 50 different fisheries around the world about the benefits they are experiencing from managing their fisheries more sustainably. The report demonstrates the possibilities for more sustainable management through what is already being achieved (http://pcfisu.org/wp-content/uploads/pdfs/TPC1224-Princes-Charities-case-studies-report_WEB-29-03.pdf). The ISU is now developing a project to implement Fisheries Management Plans (FMP) and Transition Financing, and is considering Vietnam and Central America as primary locations. In this regard, the ISU organized a regional workshop on "*The opportunities of sustainable fisheries in Vietnam: Identifying the transition pathway*" (October 30–31, 2012, Nha Trang, Vietnam), which was co-sponsored by PICES (through the PICES/MAFF project). Although a useful meeting, it turned out to be somewhat off the main topic of our project. It was recommended that the project be informed of developments within the ISU but, at this stage, not to actively participate.

RESULTS OF THE TWO INDONESIA WORKSHOPS

The planning meeting for this case study was held January 22–23, 2013, in Jakarta, at the Headquarters of BPPT (Badan Pengkajian dan Penerapan Teknologi; the Agency for the Assessment and Application of Technology), which is a non-departmental government agency under the coordination of the Ministry of Research and Technology responsible for carrying out government duties in the field of assessment and application of technology. Drs. Mitsutaku Makino, Masahito Hirota, and Mark Wells participated on behalf of PICES; the Indonesian counterpart was Prof. Suhendar Sachoemar. The objectives of this meeting were

to understand the local needs, to prepare the draft agenda of the first Indonesia workshop to be held in March of 2013, and to develop plans for this case study through to 2017 (the PICES/MAFF project period).

Local needs were well-defined by local authorities. Many coastal mangroves were cut for the development of shrimp aquaculture in the 1990s, causing much erosion (in one location on the north coast of Java, three kilometers of coastline were lost due to this development). Local government and BPPT started a program called "Gapura" based on the "Sato-umi" concept (Fig. 1). The design stipulates the establishment of multi-trophic aquaculture, including tilapia, shrimp, *Gracilaria*, and green mussel, to be established initially in Karawang (Java). If this is not put into place, there is the danger that the coastal developed areas will be eroded. The current focus is on developing useful products from these aquaculture facilities. However, they have not monitored impacts to local systems or environmental quality (nutrients, bacteria, phytoplankton). The federal government would like to scientifically verify this activity, build capacity, and then disseminate the concept to other areas of Indonesia.

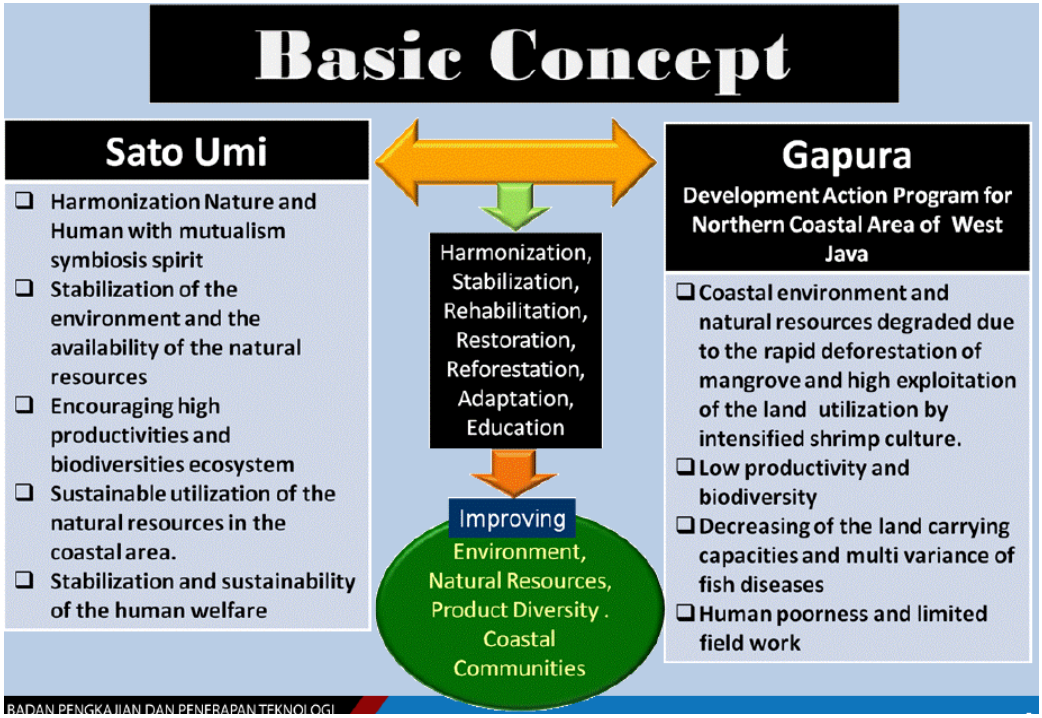


Fig. 1 Relationships between "Sato-umi" and "Gapura" concepts (from presentation by S. Sachoemar and T. Yanagi, PICES/BPPT Workshop, Jakarta, March 13–14, 2013).

The results from the discussion at the January 2013 meeting were used to plan the first Indonesia training workshop, which was held on March 13, 2013, at BPPT Headquarters in Jakarta, with a field trip to the site at Karawang on March 14.

A survey to identify local needs for participation by the PICES/MAFF project was not needed for this case of Indonesia, as these needs were already well determined (improve community welfare in north coastal Java, rehabilitate the coastal ecosystem; improve infrastructure facilities in this region; increase the diversity of fishery products, their value and competitiveness), and the general "Sato-umi" concept was already known (and translated into local concepts). In discussion at the workshop, it became clear that

there were two concepts involved in the implementation of "Sato-umi" in Indonesia: "Gapura", which refers to improved productivity of aquaculture and indicates the pilot study, and "Gempita", which is the broader Indonesian term for "Sato-umi". The intent now is to combine "Gapura" and "Gempita".

The workshop results were presented by Dr. Makino. There was a total of 93 participants from Indonesian agencies, Japan (FRA and MAFF), and USA. In attendance for the PICES/MAFF project were Drs. Makino, Hirota, Wells, and William Cochlan. The workshop had a high profile in Indonesia, with the opening address given by the Director of the BPPT Centre for Agriculture Production Technology and many reports appearing in newspapers, on TV and the web. The draft agenda, workshop report, and related documents are provided in *Appendix 3*. The workshop report and a PICES Press article (Vol. 21, No. 2, pp. 18–19) are also available on the project website at http://www.pices.int/projects/marweb.

There were 6 principal outcomes from the workshop:

- The meeting itself, and a report;
- A letter of intent between PICES and BPPT for continued collaborative work on this project;
- A workshop summary and action plans;
- A draft content of a manual to assist with spreading these concepts to other coastal areas of Indonesia;
- A draft experimental protocol for pond experiments;
- A draft list of parameters to be measured during these pond experiments.

The second day of the workshop was a visit to a local government lab and a national lab in Karawang Province. The PICES participants determined that there is a well-equipped facility to measure a subset of required parameters such as bacteria, viruses, oxygen, nutrients, *etc*. It was proposed to work with Indonesian partners and to conduct pond experiments to examine the natural and human system benefits of multi-trophic aquaculture, which would include tilapia, shrimp, *Gracilaria*, and green mussel. The list of potential parameters to assess is shown in Table 1 in *Appendix 3*. Discussion at the present meeting suggested that environmental parameters be measured both inside and outside (control) of the ponds in order to evaluate impacts external to the ponds.

The elements for a manual for this project were identified as:

1. Introduction for the "Gempita" concept
2. Why we need "Gempita"?
3. How to introduce "Gempita" (technical how-to)
4. How to assess the effectiveness of "Gempita" (scientific how-to)
5. Conclusions
6. Glossary

Discussion on this topic included the following points:

- Value of scoping meeting: In this case the local needs are well-defined; however, an in-person meeting with key local contacts was essential to understand local needs and to plan the joint workshop.
- Need for a formal agreement (LOI): The local partners felt this was important for their internal process.

- What types of research are expected by PICES: It is a key point of discussion and outcome from the meetings. In this case it includes formal research plans.
- Focus of manual appears to be specific to Indonesia (see points below).
- List of parameters (and link to manual).
- Experimental pond: Local and national governments were both willing to contribute a pond to this effort. The research is about increasing output rather than decreasing impact. The shrimp–bivalve–*Gracilaria*–mussel system has not been explored previously, although perhaps additional members to the PST need to be included with expertise in multi-trophic aquaculture in developing regions. It was noted that, to quantify success, study of the social science aspects needs to begin now to provide a baseline for assessing whether human well-being has improved. Such an assessment might include increases in product and also the variety of products, such that employment and self-sufficiency of the community will increase, and there will be added value. Dr. Hirota will visit the community to assess social aspects.

There was also discussion as to the type of manuals that might be required. For example, slightly different manuals with differing amounts of detail (different levels of specificity), with some elements mixed and matched in all, to meet the needs of different audiences are likely necessary:

- Community members in Indonesia – 1 page overview, experiments that have been done;
- Community members in Guatemala – 1 page overview, experiments that have been done;
- Scientific community (PICES) – a more complete analysis of the approach and outcomes, in the context of improving marine ecosystem health and human well-being; perhaps leading to an article in the scholarly scientific literature.

The manuals might include note of things to measure, *e.g.*, with respect to coastal biodiversity, if these pond experiments are successful.

The "lessons learned" from this workshop experience and those of previous MAFF-sponsored projects include:

- Importance of local contacts and scoping meetings in setting the issues and determining what can be done. This also helps with engaging authorities. Most of this work has to be done in person, not by email or Skype, to ensure project objectives fit into the local needs. It is essential to have a strong local contact;
- Local governments put value in the name of PICES. This was a good achievement to hold a workshop with PICES;
- Listening is critical;
- Having a Memorandum of Understanding/Letter of Intent (Agreement) in place might be required;
- Press coverage was important.

"WELL-BEING CUBE" ANALYSIS

Dr. Makino and Ms. Juri Hori presented the concept and initial results from the "well-being cube" analysis, as applied to the survey conducted in Japan. "Well-being" is defined by psychology as "involving people's positive evaluations of their lives, including positive emotions, engagement, satisfaction, and meaning". As stated in the Millennium Ecosystem Assessment (2005), human well-being (HWB) has multiple constituents, such as basic material for a good life, freedom of choice and action, health, good social relations, and security. The constituents of well-being, 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 defined as people's positive states of being satisfied, and freedom of choice and action. The "well-being cube" approach 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 (Fig. 2).

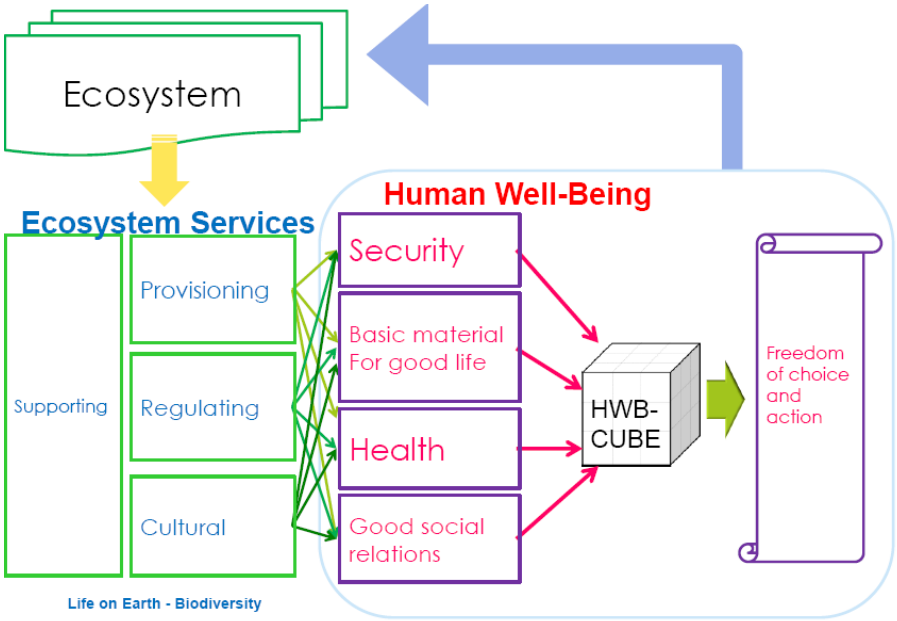


Fig. 2 Example of how the human well-being cube concept can relate ecosystem services to human well-being and freedom of choice and action (from presentation by J. Hori and M. Makino at the second PST meeting, June 10, 2013).

The HWB cube is composed of a combination of 27 human needs, determined by reference to data from previous studies about "human needs". It has three dimensions: primitive or reasoning; level of interaction/ arousal; and relationships about self and others (Fig. 3). This approach permits the scientific calculation of the relationship between the 4 components of well-being and freedom of choice and action (Fig. 4). This concept was tested using a survey of 1000 individuals in Japan, each of whom was asked a set of questions relating to their well-being (Fig. 5). Preliminary results suggest high importance of good social relationships for well-being and freedom of choice among those people who self-identified as having high connections with the ocean.

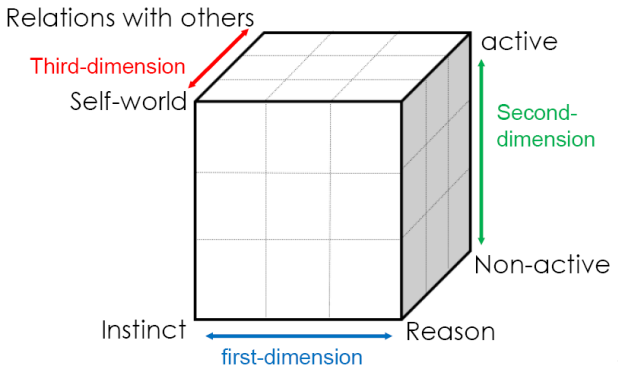


Fig. 3 Conceptual axes for the human well-being cube (from presentation by J. Hori and M. Makino at the second PST meeting, June 10, 2013).

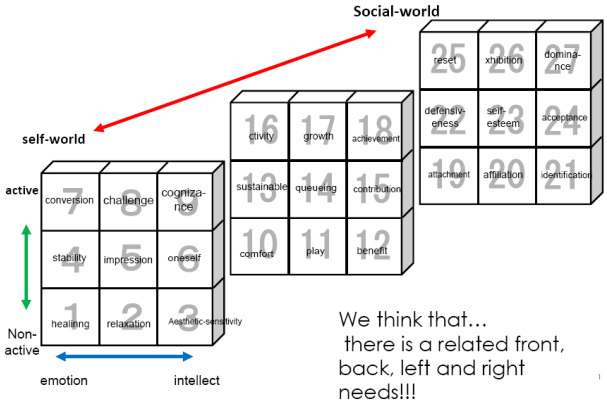


Fig. 4 Components of the 27 cells created within the human well-being cube (from presentation by J. Hori and M. Makino at the second PST meeting, June 10, 2013).

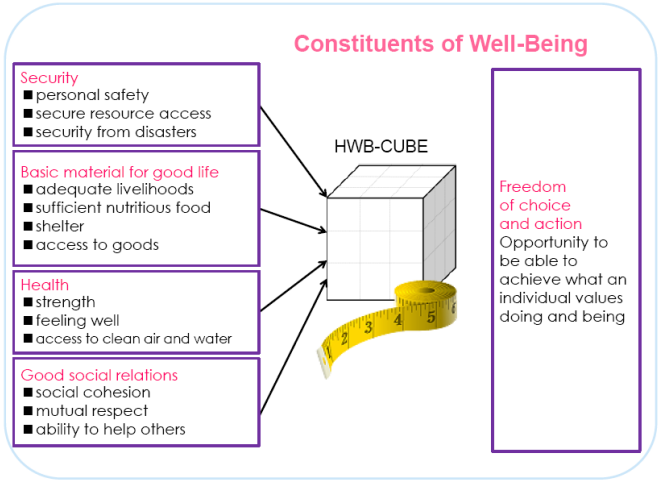


Fig. 5 Relationships among the defined components of human well-being, the HWB cube, and freedom of choice and action (from presentation by J. Hori and M. Makino at the second PST meeting, June 10, 2013).

Day 2 – June 11, 2013

The second day of the meeting was devoted to presentations and discussions of future project activities, plans, and budgets.

INDONESIA CASE STUDY

The follow-up activities for the Indonesian case study were proposed as:

1. Pond experiment and capacity-building training (lead by Drs. Wells and Makino);
2. Community research surveys and human well-being (lead by Drs. Hirota and Makino);
3. Capacity building – proposal by Dr. Susanna Nurdjaman (Institute of Technology, Bandung), who is a former student of Prof. Tetsuo Yanagi);
4. Second Indonesia workshop.

Dr. Nurdjaman has submitted a proposal to conduct research related to the project. Dr. Makino has requested that she contact Prof. Sachoemar to determine how her research will be coordinated with BPPT and PICES activities (at present there appears to be little connection between what she proposes and the experimental pond work). For example, will her group do modeling or will they actually set up the pond and maintain it? It was recommended that the advantage of the proposal at this time would be in modelling some of the initial conditions (*e.g.*, the number of other species to stock, *etc.*).

Action: The PST is generally in favour of this proposal but recommended a limit of $5000 US per year for 3 years; the proponent has to be contacted to improve the details of the work to be done and how it integrates with this project. Lead: Dr. Makino.

It was suggested in discussion that activities in 2013–2014 be focused on development of the pond experiments in Karawang (West Java), with the workshop being held in late 2014 or early 2015 to discuss and disseminate the initial results. A training course could be conducted at the start of the pond experiments. This would best be done in February or March of 2014 because this is good timing for the shrimp and fish farmers, and BPPT obtains its funding in January. It is expected that 3–4 PST members would participate in this training workshop and pond experimental set-up. It was noted that, because of the limited budget for this project, most of the funding would need to come from BPPT (*e.g.*, for the purchase of supplies, in-kind labour, *etc*.). Alternative scenarios should be developed in case their funding is insufficient for all the planned activities.

Discussions then turned to how will the social sciences fit in to the pond study, considering the focus of this project on marine ecosystems and human well-being? A "social" baseline is needed before conducting the pond experiments to provide a comparison to evaluate whether the increased productivity of the ponds plus improved environmental conditions in the vicinity of the ponds have benefitted the local community, or whether the benefits have been shifted outside the local community (*e.g.*, to international markets). Are the additional products from such an integrated multi-trophic aquaculture activity distributed locally to improve human well-being, and how does this compare with shrimp-only facilities? Originally, Dr. Hirota had plans to survey in Indonesia 2–3 times, but this may need to be revised considering the recent budget reductions. The desire is to predict change in profit in the country due to multi-trophic aquaculture. Ideally the surveys would be focused on the multi-trophic aquaculture system: what happens to the products, and how the markets change, ultimately with a recommendation provided to the government regarding how to

establish multi-trophic aquaculture in these environments. It was noted that it may take time (*e.g.*, more than 1 year) for the social benefits of such an integrated multi-trophic aquaculture (IMTA) enterprise to become fully evident. A comparative approach to the surveys was suggested, for example, using the site with the IMTA experimental ponds and another site with only shrimp aquaculture. The focus would then be on the distribution of any additional benefits from the IMTA products and their social benefits.

Dr. Hirota presented a template of the survey planned for Indonesia. This survey includes national and regional industry and fishing community level questions. It was noted that the survey questions must be developed and presented in a context familiar to and understood by the local people. In addition, it was suggested that Dr. Noer Kasanah (Department of Fisheries, Faculty of Agriculture, University Gadjah Mada) might be able to help conduct these social surveys, using her students.

Action: Drs. Makino and Hirota to discuss the approach and locations for the social surveys with BPPT and to develop options (of how, where, *etc.*).

The second Indonesia workshop would draw together the results from the IMTA pond experiments and promote expansion of the concept to other areas of Indonesia. It was recommended to defer this workshop to Year 3 (2014–2015). There is interest on the part of BPPT of having this workshop in a different location, for example South Sulawesi province, to illustrate and promote the results of this activity beyond Karawang. However, at present there does not seem to be an obvious contact in South Sulawesi. The training workshop (suggested for early 2014) could be a possibility to scout for opportunities and contact in South Sulawesi, who might be invited to the training workshop.

GUATEMALA CASE STUDY

Dr. Vera Trainer presented options for the case study in Guatemala. She first briefly reviewed the activities relating to HAB monitoring that was part of the previous PICES/MAFF project, and then proposed the following:

Project #1 possibility – Ecosystem approach to shrimp aquaculture

- Nutrient-laden water being pumped into coastline (tourist areas),
- Interest in making shrimp farms environmentally sustainable,
- Enhance coordination among farms,
- Interest in export.

Project #2 possibility – Marine finfish aquaculture

- Strong interest in Guatemala,
- Efforts have failed to date because of lack of efforts to grow from fingerlings,
- University of San Carlos interest,
- A key objective would be to get fishermen involved in aquaculture – common wholesaler, better price,
- Potential fish species: gar ("ugly" fish, lack of market interest) and tilapia (current prices are not good).

The need for a site visit, possibly in January 2014, was noted, likely using Dr. Leonel Carrillo Ovalle (University of San Carlos, Guatemala) as an initial local contact considering the excellent relationships that

have developed from the previous PICES/MAFF project. In discussion, the PST expressed a preference for the Project #1 option (shrimp aquaculture issues) as it appeared to match better the plans that are being developed for Indonesia. A Guatemala case study could be built around issues of improving coastal water quality near shrimp farms, and the opportunities to use IMTA products for local consumption.

The following needs were identified:

- Social scientist link – for example, Dr. Charles Trick has extensive experience in social science studies in developing nations and is interested in participating in the PICES/MAFF Guatemala effort;
- Locations of coastal shrimp farms;
- Determine target sites for a preliminary visit;
- Determine budget (travel for Guatemalan scientists, translation assistance, supplies?)

The proposal is for an initial scouting visit in January 2014, followed by a workshop later in the year. Discussion also indicated an opportunity for the "people" side and the human well-being aspects to be related to advancing the resilience of local communities and peoples. Dr. McKinnell pointed out that there may be an existing project from Spain working on aquaculture training in Guatemala – this needs further research and possibly discussion with local colleagues.

The following were identified as questions to consider in developing the Guatemala case study:

- Are they most interested in the shrimp aquaculture *vs*. aquacultured fish project?
- Would Acuamaya be interested in collaborating in a multi-trophic experiment? Or any other shrimp farmers would be interested? Would this be an interesting university research project?
- Would we be able to visit them last week of January and discuss this project?
- Would government, university, local farmers be interested in the multi-trophic aquaculture issue?
- Tilapia is consumed domestically and shrimp is exported? Is production of tilipia economically feasible?
- What are the production amounts and values for shrimp and tilapia for the last several years?
- What are the kinds of products (filet or whole, frozen or fresh)?
- What are the number of processing plants and their scale?
- What is the local use of seafood *vs*. what is exported?
- What could be grown for local consumption? Bivalves, seaweed, *etc*. What would the local people eat?
- Where are the shrimp aquaculture facilities in Guatemala?
- Where/who are the distributors?
- Questionnaires for well-being survey – would a minimum of 1000 surveys be possible?
- What is reasonable reimbursement for a 30-min survey in: a) Guatemala City (minimum 500) and b) coast (Monterrico) (minimum 500)

Action: Dr. Trainer to work over the summer 2013 to develop the opportunities and identify issues relating to the Guatemala case study, and to report and provide recommendations for decision at the October 2013 PST meeting.

"WELL-BEING CUBE" FURTHER ACTIVITIES

Activities regarding the "well-being cube" project over the next year were discussed. The survey in Japan was conducted in 2012. The next countries to be surveyed (to start in July 2013) are Korea and the United States. To improve the results with respect to the well-being of people connected in some way to the ocean, it was recommended to focus these surveys on locations closer to the ocean (*e.g.*, the five US states along the Pacific coast) rather than nationwide. Dr. Suam Kim asked for the survey questions to be circulated to the PST once they have been translated into English and Korean. Surveys in 2014 could consider Indonesia and Guatemala to converge with the IMTA experiments, although it was noted that different methods may be needed because of lack of internet access.

Action: Ms. Hori to circulate "well-being cube" survey questions to PST members once they are available in English and Korean.

DATABASE ACTIVITY

Production of a database from this project is one of the deliverables to MAFF. The PST discussed what form this database might take, considering how the project is evolving. The database could:

- Be a bibliography, for example, of publications relating to marine ecosystems and human well-being, Sato-umi, Gempita, and related concepts;
- Link with data from previous PICES/MAFF projects;
- Store the individual responses from the "well-being cube" surveys;
- Store the techniques and tools, and results developed from the Indonesia and Guatemala case studies and their manuals.

PALAU CASE STUDY

Considering the expected budget reductions (see below) one option is to cancel the Palau case study. Another option is to keep it "in reserve" in case one of the leading projects (Indonesia, Guatemala) does not work out. It was recommended to retain the option of conducting a Palau case study but at the moment provide a null budget, and to make clear in the reporting to PICES and MAFF that it may not be continued depending on the future budget situation.

Day 3 – June 12, 2013

BUDGET

The budget situation was discussed, including the impacts of the current and expected future budget reductions. The 2013–2014 draft planning budget (including expenses rolled over from 2012–2013) is presented in Table 1.

Table 1 Draft Year 2 (April 1, 2013–March 31, 2014) budget for the PICES/MAFF project

Category	Itemisation	Allocation	Allocation totals
Travel and meetings			
	Honolulu SSC meeting	est. 6000	13,000
	Nanaimo SSC meeting	10,000	10,000
	Indonesia training workshop & pond expt. setup: 5 people × 8 nights (avg. $100/d)	4,000	
	Flights ($2500 × 5)	12,5000	
	Flights internal ($200 × 3 people)	600	
	Noer University/social participation in training workshop	500	
	Total PICES $17,100	20,000	
	Local expenses $10,000	10,000	
	Social survey scoping meeting (Hirota): flight $1000; $100 per diem × 4 nights	1,500	
	Social survey (Hirota + 2): flight $1000 × 3; $100 × 3 per diem for 8 nights (to take place concurrent with training workshop	6,000	
	Social survey BPPT/local expenses	1,000	
	Total for training workshop, pond expt., social survey		40,000
	"Extra" Indonesia travel support		3,000
	Guatemala: scoping meeting		
	U.S. scientist	2,200	
	Canadian scientist	2,300	
	Japanese scientists	3,300	
	Guatemalan scientist	400	
	Guatemala: Scoping meeting (3 scientists) Total		9,000
	Extra Guatemala travel support		1,500
Contracts			
	"Susanna" contract (Indonesian model)	5,000	5,000
	PICES Secretariat support (additional)	10,000?	15,000
	Well-being cube survey (already paid)	17,000	17,000
	Translate "cube" survey from English to Spanish, and conduct survey in Guatemala	5,000	5,000
Equipment			
	PICES computer upgrades/training equipment	15,000	15,000
Miscellaneous			
	Carry-over from FY 12/13	1,503	1,500
PICES overhead		15,000	15,000
Total			135,000
Total available			135,000

OTHER ISSUES

Project name

A more convenient name for the project is desirable. Suggestions to date include: POWER (People and Ocean Wellness, and Ecosystem Response), Ecopond, MarWeB (Marine Ecosystem Health and Human Well-Being). Other recommendations are needed.

Action: All PST members to suggest short names for this project, or to express their preference for existing recommendations.

Session proposal for PICES-2014

With the evolution of the project towards a focus on integrated multi-trophic aquaculture, it would be beneficial to sponsor a scientific session at the 2014 PICES Annual Meeting (to be held in a Korea) that would present scientific issues and opportunities relating to his topic, in particular with a focus on developing countries in the lower latitudes. The deadline for session proposals is in early September 2013.

Action: Drs. Makino and Perry to lead development of a session proposal on integrated multi-trophic aquaculture (with a focus on developing countries) for submission in September 2013.

PST membership review

With the evolution of a focus for the project on IMTA, it is timely to conduct a review of the PST membership, to see if there is needed expertise currently not on the PST, and if any Team members might wish to step off. For example, it was suggested that an expert on multi-trophic aquaculture, in particular with developing country experience, would be an asset on the PST.

Action: All PST members to express whether they wish to remain on the PST and are interested to participate in the current activities as they are presently evolving.

Project web page

This PICES/MAFF project needs to develop its own web page on the PICES website. Materials are required from the PST to populate this page.

Action: All PST members to provide materials for the project page on the PICES website.

Next PST meeting

Items for the agenda for the next PST meeting were identified as:

- Report on discussions and development of the Guatemala case study (Trainer);
- Update on plans for the Indonesia case study and pond experiments (Makino, Hirota, Wells);
- Early results from the analyses of the "well-being cube" surveys in Japan, USA, Korea (Hori, Makino);
- Report on the Japanese visit to Palau (Makino);
- Decision needed on the use of project funds to support computer upgrades in the Secretariat;
- Develop a project timeline (meetings, field visits, field programs, *etc.*).

RECOMMENDATIONS/ACTION ITEMS

- Project should maintain contact with the International Sustainability Unit (ISU) of the UK Prince Charles' Charitable Foundation to see what collaboration may be possible.
- Propose integration with aquaculture group and its role in promoting human well-being (Topic Session at the 2014 PICES Annual Meeting in Korea?)
- Manual should have a general background on Sato-umi, then two case studies (Indonesia and Guatemala). We may need manuals targeted for different audiences with different levels of specificity.
- Drs. Kim and Makino suggest developing a brochure for the general public.
- Publication in the scientific literature regarding multi-trophic aquaculture, especially if there is commonality between Indonesia and Guatemala (possibly in the journal *Ecology and Society*, Dr. Perry is an editor).
- Modify questions for "well-being cube" analysis to make them more understandable in developing nation without changing content (Ms. Hori and Drs. Makino, Trainer, and Wells).
- Provide well-being survey to show to Indonesian and Guatemalan collaborators (July 1, English version sent by Ms. Hori to Drs. Makino, Trainer, and Wells) – include sending the Korean version to Dr. Kim.
- Discuss social survey logistics with BPPT collaborators (Drs. Makino, Hirota, and Wells) and Dr. Kasanah at University Gadjah Mada (Dr. Hirota) and Dr. Carrillo Ovalle in Guatemala (Dr. Trainer).
- Contact Indonesia (Prof. Sachoemar) about their commitment to providing in-kind support for the experimental ponds (Drs. Makino and Wells).
- Develop over next year an agreement with Prof. Sachoemar on research cooperation (Drs. Makino and Wells).
- Contact Dr. Nurdjaman to determine what is covered in her proposal. What will she be able to contribute to the overall PICES/MAFF project. Is the $5000 an annual cost? What is included in this? (Dr. Makino).
- Find an expert in multi-trophic aquaculture to add to the PST (Drs. Wells and Makino).
- Explore a contact in South Sulawesi during *Year 2* for planning a second workshop in *Year 3* (Dr. Wells).
- Contact Guatemala with "general" questions regarding this project (Dr. Trainer).
- Reporting: Co-chairs to prepare reports for PICES (and MAFF) on project development and activities, 2012–2013 and 2013–2014 budgets – due "NOW".
- Development of session/workshop proposal for PICES-2014 (Drs. Perry and Makino).
- More information/clarification needed on additional contributions from the Secretariat to the project, in terms of financial requirements (Drs. Makino and Perry).

Appendix 1

Meeting participants

Participants of the second Project Science Team meeting for the PICES/MAFF project on "Marine ecosystem health and human well-being". Left to right: Suam Kim (Korea), Skip McKinnell (PICES), Ian Perry (Canada), Mitsutaku Makino (Japan), Vera Trainer (USA), Mark Wells (USA), Juri Hori (Japan), Thomas Therriault (Canada) and Masahito Hirota (Japan).

Appendix 2

Second Project Science Team meeting agenda

Meeting objectives:

- To review activities and accomplishments of the project to date
- To prepare the content of the annual report to MAFF
- To plan activities for remainder of 2013–2014 and future years

Timetable (Names in brackets are the intended discussion leaders):

Day 1 (June 10) "Accomplishments to date" (0900–1700)

1. Welcome and adoption of the agenda (Co-Chairs)
2. Introduction of the project and goals for this meeting (Co-Chairs)
3. Progress reports and discussion on activities to date:
   - Prince's Trust meeting (Makino)
   - Follow-ups from the PST meeting at PICES-2012 (see Background Item #1a and 1b) (Co-Chairs)
   - Results of the Indonesia workshops:
     - Scoping meeting, January 22–23, 2013 (Makino, Hirota)
     - First Workshop, March 13–14, 2013 (Makino, Hirota, Wells)
     - Reports and discussion should review accomplishments, what worked well, what did not work well, next steps, recommendations
   - "Well-being cube" analyses (Hori, Makino)
4. Key outcomes from first year activities, and lessons learned (All)
5. Discussion of elements of Report to MAFF (and PICES) on first year activities

Day 2 (June 11) "Future plans" (0900–1700)

6. Current budget position, and budget reduction issues (Co-Chairs, Secretariat)

   Our project has received a ~20% reduction for 2013–2014 and may receive additional reductions for 2014–2015. We must consider the reduced budget for 2013–2014 and two scenarios for 2014–2015: (a) similar budget as 2013–2014; (b) additional large reduction in 2014–2015
7. Follow-up activities for the Indonesia project (Makino, Hirota)
8. Plans for the Guatemala activities (Trainer, Wells)
9. Plans for activities in Palau (Makino)

   Note our original proposal was for work in Palau to begin in Year 3
10. Database development project (leads: Makino, Hirota)
11. Development of the Manual on "*Marine ecosystem health and human well-being*" / Sato-umi systems (leads: Makino, Hirota)
12. Review budget items for 2013–2014, and tentative items for 2014–2015, and elements for budget report to MAFF for 2013–2014 (All)

Day 3 (June 12) "General issues and collaborations" (0900–1300)

13. UN 1st World Ocean Assessment and PICES Workshop (Therriault, Perry)
14. Potential intersections/synergies with WG 28, S-HD, and other groups within the FUTURE Program and PICES broadly (Perry)
15. Recap of overall project objectives and goals in light of current and planned activities (All)
16. "Name" for our project (Perry)
17. Any other issues
18. Concluding remarks (Makino, Perry)

Appendix 3

Draft Agenda and meeting report from the First Indonesia Workshop

Agency for the Assessment and Application of Technology | **North Pacific Marine Science Organization** | **Fisheries Research Agency of Japan**

DRAFT AGENDA

INTERNATIONAL WORKSHOP ON SATO UMI-GEMPITA SPL-GAPURA

(A New Concept and Model for Sustainable Fisheries, Aquaculture and Coastal Management)
Jakarta, March 13–14, 2013

March, 13: First Commission Room BPPT Bld. II 3rd Fl -JL. M.H. Thamrin No. 8 Jakarta 10340

08.30-09.00 Registration

09.00-09.05 Opening

09.05-09.15 Report and welcome remarks

09.15-09.25 Welcome Remark

09.25-09.45 Opening Remark and introduction of the workshop

09.45-10.15 Keynote Speech of Sato Umi

10.15-10.25 Keynote Address and Opening Workshop

10.25-10.45 MOU, Group photos, Press Release, *etc*.

10.45-11.00 Coffee Break

Session 1 Chairman: M. Husni Amarullah (BPPT)

11.00-11.15 *Harmonization between local wisdom and new technology on the fisheries and coastal management*
Anthropologist (from University)

11.15-11.30 *Coastal restoration and rehabilitation programme to support aquaculture development in Indonesia*
Director General for Marine Coastal and Small Islands, Ministry of Marine Affairs and Fisheries – INA

11.30-11.45 *Aquaculture development in the coastal area*
Director General of Aquaculture – Ministry of Marine Affairs and Fisheries – INA

11.45-12.00 *Infrastructure support in the coastal area*
Director General of Water Resources, Ministry of Public Works – INA

12.00-12.20 Discussion

12.20-13.00 Lunch

Session 2	Chairman: Prof. T. Yanagi–Kyushu University
13.00-13.20	*Sato-Umi, GEMPITA-SPL/SFiCOM-GAPURA Programme in Indonesia* Suhendar I Sachoemar (BPPT, INA)
13.20-13.40	*Past PICES's activities supporting GEMPITA-SPL- SFiCOM and GAPURA in Indonesia* Vera Trainer (NOAA, USA), Mark Wells (Maine System Univ., USA), Charles Trick (Western Univ., Canada)
13.40-14.00	*Well-being analysis for Sato-Umi in Indonesia* Masahito Hirota (FRA, Japan)
14.00-14.20	*Ecosystem modeling of brackishwater pond* Susanna Nurjaman (Bandung Institute of Technology, INA)
14.20-15.00	Discussion
15.00-15.30	Coffee Break*
Session 3	Chairman: Suhendar I Sachoemar (BPPT)
15.30-15.45	*Status and problem of the coastal and fisheries resources management of West Java Province* Head of the Department of Marine and Fisheries in West Java Province
15.45-16.00	*Status and problem of the coastal and fisheries resources management of Bantaeng Region – South Sulawesi Province* Regent of Bantaeng – South Sulawesi Province
16.00-16.15	*Status and problem of the coastal and fisheries resources management of Tanah Bumbu Region – South Kalimantan Province* Regent of Tanah Bumbu – South Kalimantan Province
16.15-17.30	*General discussion, summary and Action Plan launch of Sato-Umi activities* M. Makino (FRA-Japan), Suhendar I Sachoemar (BPPT), Prof. T. Yanagi (Kyushu University), M. Husni Amarullah (BPPT)
17.30-17.45	Closing

*Special meeting for the leader of local government (West Java, Bantaeng, Tanah Bumbu)

March, 14: Field Trip to Karawang (Center for Brackishwater Aquaculture)

06.30-09.30	Heading to Karawang OC and Participants
Chairman	M. Husni Amarullah (BPPT)
09.30-09.45	Welcome Address Head of Center for Brackishwater Aquaculture
09.45-11.15	Field Trip at Center for Breackishwater Aquaculture Head of Center for Brackishwater Aquaculture

11.15-11.30	Heading to Center for Breackishwater and Marine Culture of West Java Province – Karawang OC and Participants
Chairman	Suhendar I Sachoemar (BPPT)
11.30-11.45	Welcome Address Head of Center for Brackishwater and Marine Culture of West Java Province – Karawang
11.45-13.15	Field Trip at Center for Brackishwater and Marine Culture of West Java Province – Karawang OC and Participants
13.15-14.15	Lunch
14.15-16.45	Discussion with local leader of the northern coastal area of west Java communities, Summary and Action Plan Launch of Sato Umi Activities M. Makino (FRA-Japan), Suhendar I Sachoemar (BPPT), Prof. T. Yanagi (Kyushu University)
16.45-17.00	Closing
17.00	Return to Jakarta OC and Participants
March 12	Preliminary meeting at Sari Pan Pacific Hotel 08.00 pm.
March 14	Wrap up meeting on the Bus 17.00-20.00
March 15	Wrap up meeting at BPPT in 01.00 pm

Report of the International Workshop Organized by PICES/MAFF Project on "*Marine Ecosystem Health and Human Well-Being*"

1. BACKGROUND

In 2012, PICES started a project "*Marine ecosystem health and human well-being*", funded by the Ministry of Agriculture Forestry and Fisheries of Japan (MAFF) for 5 years (April 1, 2012 – March 31, 2017). The overall goal of the 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 (known in Japan as the "Sato-umi" fisheries management system). Specifically, considering the global changes in climate and human social and economic conditions, it aims to determine: a) how do marine ecosystems support human well-being? and b) how do human communities support sustainable and productive marine ecosystems? The principal investigators of this project are Drs. Mitsutaku Makino (Japan) and Ian Perry (Canada) whose activities are supported and consulted by the Project Science Team (PST).

Based on the decisions made at the first PST meeting (October 11, 2012, Hiroshima, Japan), the PICES/MAFF project is expected to include holding two workshops in developing countries in three regions of the North Pacific (Southeast Asia, Pacific oceanic islands, and Central America). Indonesia was selected because of its large population and aquaculture-intensive industry. Palau was chosen because of its focus on the finfish capture fishery and its existing networks of community-based fisheries). Guatemala was selected because its coastline features an upwelling system favorable for the finfish fishery and aquaculture). This report is on the first Indonesia workshop held March 13–14, 2013.

2. GEMPITA-SPL CONCEPT IN INDONESIA

The Indonesian Agency for the Assessment and Application of Technology (BPPT) has developed a concept of managing coastal and marine resources by actively involving the community. This Indonesian concept is called GEMPITA-SPL (Gerakkan Masyarakat Peduli Kelestarian Sumberdaya Perikanan, Pesisir dan Laut) or, in the English language version, as SFiCoMS (Sustainable Utilization of Fisheries, Coastal and Marine Resources for the Society). The GEMPITA-SPL or SFiCoMS concept has been implemented in the northern coastal area of Java Development Activities in West Java (Gapura) by BPPT and the local Department of Fisheries and Marine Affairs through the development and promotion of environmentally friendly aquaculture technology called Integrated Multi-Trophic Aquaculture (IMTA). This approach features concepts of bio-recycling in idle and/or marginal brackish water ponds of the northern coastal area of West Java. By applying this concept, the coastal environment which has been heavily damaged by shrimp monoculture can be recovered to become more biodiverse and productive, leading to the improved welfare of local communities. The GEMPITA-SPL concept fits very well within the framework of fishery social-ecological systems (SES) in the PICES/MAFF Project.

3. OUTLINE OF THE WORKSHOP

The first PICES/MAFF project workshop was held March 13–14, 2013, in Jakarta, Indonesia. The workshop was attended by 93 participants from Indonesia, Japan, and the USA. Indonesia was represented by the Ministry of Marine Affairs and Fisheries, Ministry of Research and Technology, Ministry of Environment, Ministry of Public Works, Coordinating Ministry for the Economy, Finance and Industry, Coordinating Ministry for People's Welfare, Ministry of Development of Disadvantaged Areas, Ministry

for National Development Planning, Food Security Agency of the Ministry of Agriculture, Bandung Institute of Technology, Bogor Agriculture University, and local governments.

The objectives of the workshop were to:

1. Develop the contents of a manual that will describe GEMPITA-SPL/SFiCoMS and Gapura experiences in Java Province according to local conditions at some candidate sites;
2. Assess the utility of PICES' scientific tools for enhancing the human well-being of local communities and for rehabilitating the coastal ecosystem at some candidate sites.

The first day of the workshop took place at the Main Commission Hall of BPPT's Headquarters in Jakarta. It started with a welcome by Ms. Nenie Yustiningsih (Director of the Center for Agricultural Production Technology of BPPT), followed by opening remarks and introduction by Dr. Makino (Fig. 1). The keynote speech was delivered by Professor Tetsuo Yanagi (Kyushu University, Japan). The opening of the workshop was formally announced by Dr. Listyani Wijayanti (Deputy Chairman of BPPT). A total of 10 presentations were given on the first day. Dr. Mark Wells (University of Maine, USA; Fig. 2) described previous activities of PICES in Indonesia and suggested ways that PICES science can support GEMPITA-SPL. Dr. Masahito Hirota (National Research Institute of Fisheries Science, Fisheries Research Agency, Japan) talked about how PICES scientific tools can support the analysis of well-being in coastal societies.

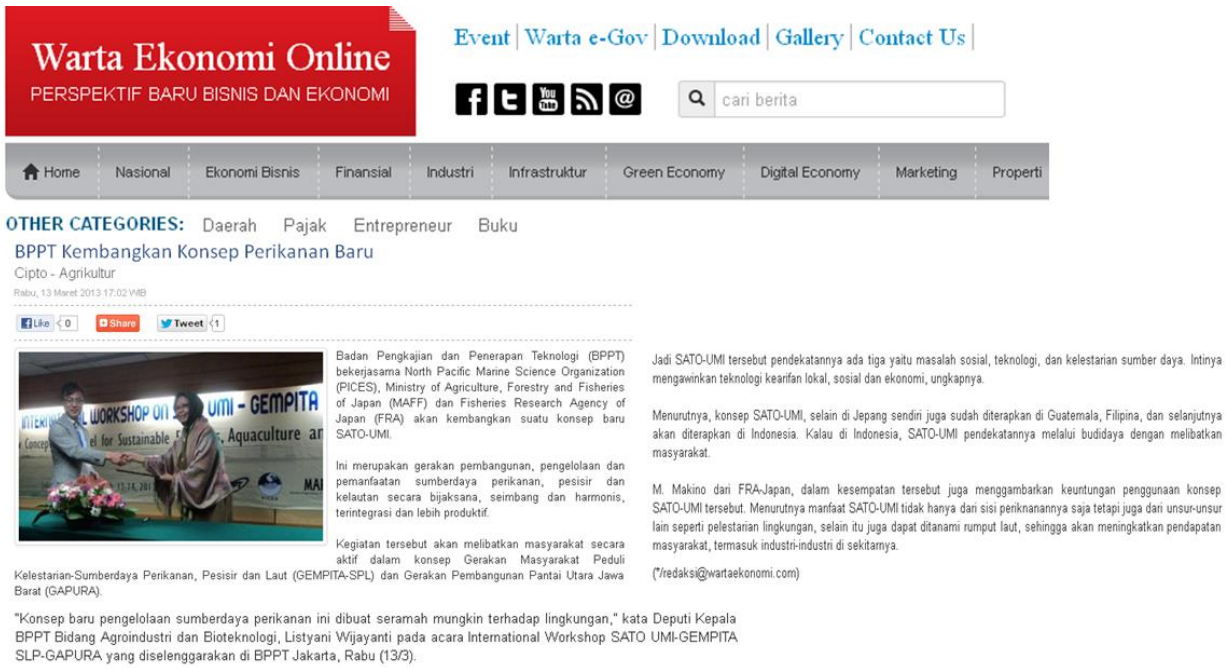
The second day featured a field trip to the Karawang area of West Java where BPPT has developed GEMPITA-SPL (Fig. 3). Participants visited the Center for Brackishwater and Marine Culture of West Java Province and the National Center for Brackishwater Aquaculture to observe aquaculture ponds that applied the GEMPITA-SPL approach, and had discussions with local stakeholders (fishers, managers, *etc*.).

Fig. 1 Dr. Mitsutaku Makino giving opening remarks and introduction at the workshop.

Fig. 2 Panel discussion including participation by Drs. Masahito Hirota (far left) and Mark Wells (center).

Fig. 3 Field trip to the West Java area.

The workshop attracted serious attention from the Indonesian media, with many reports appearing in newspapers, on TV and internet news (Fig. 4).



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Badan Pengkajian dan Penerapan Teknologi (BPPT) bekerjasama North Pacific Marine Science Organization (PICES), Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF) dan Fisheries Research Agency of Japan (FRA) akan kembangkan suatu konsep baru SATO-UMI.

Ini merupakan gerakan pembangunan, pengelolaan dan pemanfaatan sumberdaya perikanan, pesisir dan kelautan secara bijaksana, seimbang dan harmonis, terintegrasi dan lebih produktif.

Kegiatan tersebut akan melibatkan masyarakat secara aktif dalam konsep Gerakan Masyarakat Peduli Kelestarian-Sumberdaya Perikanan, Pesisir dan Laut (GEMPITA-SPL) dan Gerakan Pembangunan Pantai Utara Jawa Barat (GAPURA).

"Konsep baru pengelolaan sumberdaya perikanan ini dibuat seramah mungkin terhadap lingkungan," kata Deputi Kepala BPPT Bidang Agroindustri dan Bioteknologi, Listyani Wijayanti pada acara International Workshop SATO UMI-GEMPITA SLP-GAPURA yang diselenggarakan di BPPT Jakarta, Rabu (13/3).

Jadi SATO-UMI tersebut pendekatannya ada tiga yaitu masalah sosial, teknologi, dan kelestarian sumber daya. Intinya mengawinkan teknologi kearifan lokal, sosial dan ekonomi, ungkapnya.

Menurutnya, konsep SATO-UMI, selain di Jepang sendiri juga sudah diterapkan di Guatemala, Filipina, dan selanjutnya akan diterapkan di Indonesia. Kalau di Indonesia, SATO-UMI pendekatannya melalui budidaya dengan melibatkan masyarakat.

M. Makino dari FRA-Japan, dalam kesempatan tersebut juga menggambarkan keuntungan penggunaan konsep SATO-UMI tersebut. Menurutnya manfaat SATO-UMI tidak hanya dari sisi periknanannya saja tetapi juga dari unsur-unsur lain seperti pelestarian lingkungan, selain itu juga dapat ditanami rumput laut, sehingga akan meningkatkan pendapatan masyarakat, termasuk industri-industri di sekitarnya.

(*/redaksi@wartaekonomi.com)

Fig. 4 Media report about the LOI (Letter of Intent) signing ceremony by Dr. Makino and Dr. Listyani (BPPT Vice Chairman).

4. THE MAIN OUTPUTS FROM THE WORKSHOP AND THE NEXT STEPS OF THE PICES/MAFF PROJECT

Many important outcomes have come from the workshop (March 13–14) and from discussions held the next day (March 15). The first outcome was a Letter of Intent (LOI; see below) between PICES and BPPT to recognize the benefits to their respective institutions of establishing an international link. The second outcome was a draft list of parameters to evaluate GEMPITA-SPL performance (Table 1). In close coordination with Indonesian scientists, PICES scientists will support the assessment of these parameters in sample ponds where GEMPITA-SPL has been implemented. A third outcome was a table of contents developed for a manual to facilitate the dissemination of GEMPITA-SPL activities in Indonesia (Table 2). These main outcomes will be discussed at the second PST meeting to be held June 11–12, 2013, in Honolulu, Hawaii, USA. Based on the advice and comments from this meeting, the second Indonesia workshop will be held in March 2014.

In addition to this Indonesian case study, the PICES/MAFF project will initiate activities in Guatemala in 2013, and in Palau in 2014. A progress report on these areas will be provided soon.

Table 1 Draft list of parameters to assess the performance of GEMPITA-SPL

Aquaculture production parameter	Marine ecosystem parameter	Social system parameters
1. Production (Number of species, Kg, Value). We have statistics.	1. Dissolved oxygen	1. Number of employment (farmer, processers, distributers, retailers)
2. Quality of aquaculture products: changes in size and weight.	2. Nutrient concentrations, chemical species, and ratios; nitrate/nitrite and ammonium. P, Si	2. Multiple (synergy) effects (distribution, value chain, *etc*.)
3. Costs of production: costs for feeds, seeds, labor, operation costs.	3. Water transparency	3. Added values (production, processing, distribution)
4. Disease: shrimp-virus (see 2–7), # of dead. Fish-bacteria/pathogen (pending) Shellfish-toxins (pending)	4. Phytoplankton abundance and species composition	4. Social Infrastructure (hospital, health care, disaster protection (evacuation plan, hazard map), Information system (IT), *etc*.)
5. Recovery of non-used ponds we can try	5. Bacteria abundance	5. Industrial Infrastructure (fish market and supply chain)
6. Other parameters?: origin of the seeds.	6. Virus abundance	6. Education system (technical skill, food security, processing, *etc*.)
	7. Sediment quality pre-ASV, post-ASV (ion selective electrode)	7. Average/range of income (farmer, processers, distributers, retailers)
	8. Temperature and salinity	

Table 2 The contents of GEMPITA-SPL Manual (Ver. 1)

Executive Summary

1. Introduction for the concept of GEMPITA-SPL
   S1 Concept of Sato-umi (by Prof. Yanagi)
   S2 Concept of Gempita (by Dr. Suhendar)
2. Why we need Gempita (the expected outcome from Gempita to ecosystem and community)
   S1 Ecological system perspective
   S2 Social system perspective
3. How to introduce Gempita (technical how-to)
4. How to assess the effectiveness of Gempita (scientific assessment how-to)
5. Conclusion
6. Glossary

Agency for the Assessment and Application of Technology

North Pacific Marine Science Organization

LETTER OF INTENT

Between

AGENCY FOR THE ASSESSMENT AND APPLICATION OF TECHNOLOGY (BADAN PENGKAJIAN DAN PENERAPAN TEKNOLOGI / BPPT)

And

North Pacific Marine Science Organization (PICES)

Concerning

THE DISSEMINATION OF "SATO-UMI" GEMPITA-SPL/SFiCoMSCONCEPT IN INDONESIA

1. The Agency for the Assessment and Application of Technology (Badan Pengkajian dan Penerapan Teknologi/BPPT) and the North Pacific Marine Science Organization (PICES), hereinafter referred to as the "Parties", enter into this Letter of Intent (LOI) by recognizing the benefits to their respective institutions from the establishment of international links.

2. In the spirit of better and responsible management of global earth resources utilization, and in order to enhance the economic situation of the people and the region's sustainability, through *wisdom harmonization of science and technology – natural resources and environment – humans*, which is getting urgent to implement in Indonesia, BPPT and PICES agree to promote the dissemination of the "Sato-Umi" concept in Indonesia, through the PICES/MAFF Project on "*Marine Ecosystem Health and Human Wellbeing*".

3. The LOI implementation will be followed by the preparation of an Agreement on Development Research Co-operation within 6 (six) months from the signing of the LOI.

4. The LOI shall be in effect until March 31, 2017, or otherwise terminated in writing with at least one month's advance notice of the intention of termination by the Parties.

The LOI shall be executed in two (2) copies in English, both Parties will retain one copy each.

Jakarta, _____

(Signature) _____
(Name)

Deputy Chairman of BPPT
For Agroindustry and Biotechnology

(Signature) _____
(Name)

Representative of PICES

Alexander Bychkov
Executive Secretary

Mitsutaku Makino and Ian Perry
PI of the PICES/MAFF Project on
"Marine Ecosystem Health and Human Well being"

Agency for the Assessment and Application of Technology | North Pacific Marine Science Organization | Ministry of Agriculture, Forestry and Fisheries | Fisheries Research Agency of Japan

INTERNATIONAL WORKSHOP ON
SATO-UMI – GEMPITA SPL – GAPURA IN INDONESIA

SUMMARY AND ACTION PLAN

1. The theme of International Workshop on SATO-UMI - GEMPITA SPL - GAPURA is "The Concepts and New Models of Fisheries Resource Management, Coastal and Marine Resources Sustainably" with main focus on aquaculture was held in Jakarta, Indonesia on March 13th, 2013. The workshop hosted by BPPT in collaboration with PICES (the North Pacific Marine Science Organization). Welcome Remarks of the workshop by Ir.Nenie Yustiningsih, M.Sc, the Director of Center for Agricultural Production Technology of BPPT, Opening Remarks and Workshop Explanations by Dr. Mitsutaku Makino from Fisheries Research Agency of Japan, Key Note Speech by Prof. Dr. Tetsuo Yanagi from Kyushu University, Japan and Opening Workshop by Dr. Listyani Wijayanti, the Deputy Chairman of BPPT for Agro-industry Technology and Biotechnology.

2. A signing Letter of Intend (LoI) is held between Dr. Listyani Wijayanti, Deputy Chairman of BPPT and Dr. Mitsutaku Makino, Secretary and PI of PICES on "Dissemination and Implementation of SATO-UMI - GEMPITA SPL - GAPURA concept in Indonesia," which will soon be followed by the signing of the Agreement on Development Research Cooperation.

3. The workshop is attended by 93 participants from Japan (Ministry of Agriculture, Forestry and Fisheries of Japan; Fisheries Research Agency of Japan, Kyushu University), the United States (University of Maine, San Fransisco State University, USAID), and from Indonesia i.e the Ministry of Marine Affairs and Fisheries, the Ministry of Research and Technology, LIPI, BPPT, Bandung Institute of Technology, Bogor Agriculture University, Ministry of Environment, Ministry of Public Works, Coordinating Ministry for the Economy, Finance and Industry, Coordinating Ministry for People's Welfare,

1

Ministry of Development of Disadvantaged Areas, Ministry for National Development Planning (Bappenas), Ministry of Cooperation and Small Medium Enterpise (UKM), Food Security Agency of the Ministry of Agriculture, Department of Fisheries and Marine Resources, local government from West Java Province, District of Anambas Riau Island Province, District of Bantaeng South Sulawesi Province, District of Tanah Bumbu South Kalimantan and participants of the Indonesian Aquaculture Society, Association of Fishpond Farmers in North Coast of Java. Institute of Aquaculture, Fisheries entrepreneurs, community leaders, the farmers and other relevant stakeholders. A total of 10 papers were presented and discussed in this workshop.

4. Outline Executive Summary and Action Plan of the workshop are as follows:

1) SATO-UMI is a concept of fisheries management in coastal and marine environment which will be implemented in a harmonious coexistence of nature and human-being in Indonesia. The SATO-UMI concept has harmonized with Indonesia Govt Law (UU) No 27 year of 2007.
2) It will be applied in various countries (Japan, Philippine, Guatemala, etc.) and the one is in Indonesia of which focusing in aquaculture.
3) Aquaculture is a main activity which supports the increase production of fisheries as well as economically important to coastal communities in Indonesia. For achieving responsible and sustainable aquaculture it should be required in a harmony of fish resources – technology – and human awareness especially supported by local wisdom.
4) A concept of human well being on Sato Umi (Gempita SPL) consists of: Harness, industrial operation, social infrastructure should be considered.
5) The Implementation SATO-UMI - GEMPITA SPL - GAPURA in Indonesia will be coordinated by BPPT. The scopes of the implementation activities include:
   a) Harmonization, synchronization and integration of Indonesian Local Wisdoms and New Technologies in the Fisheries and Coastal Management
   b) Assessment and application of technology related to SATO-UMI

c) Model development of SATO-UMI implementation is to get higher productivity and biodiversity i.e shrimp polyculture with Tilapia, Seaweed, and Green Mussel in Karawang District, West Java
d) People Empowerment in the Coastal Area
e) Monitoring and evaluation of program activities
f) International Workshop and training

6) The SATO-UMI concept has been interested by some district regions in Indonesia such as 1) Karawang District of West Java Province, 2) Bantaeng District of South Sulawesi Province, 3) Anambas District of Riau Islands Province 4) Tanah Bumbu District of South Kalimantan Province, and 5) Pekalongan City of Central Java Province which have specific local problems for aquaculture.

5. This workshop will be followed by field visits (field trips) on March 14th, 2013 to sites in the Center for Brackishwater and Sea Water Aquaculture and in the Central Aquaculture Business Services under the Ministry of Marine Affairs and Fisheries located in Karawang District of West Java Province

Jakarta, March, 13th 2013

The Organizing Committee

Suhendar I. Sachoemar	Mitsutaku Makino
The Agency for the Assessment and Application of Technology	The North Pacific Marine Science Organization

3

Third Meeting of the Project Science Team

October 10, 2013, Nanaimo, Canada

The third 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 October 10, 2013, in conjunction with the PICES Annual Meeting in Nanaimo, British Columbia, Canada. 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 second PST meeting (June 10–12, 2013, Honolulu, USA), specifically:

- Planning for the Indonesia and Guatemala case studies,
- Advances in the "well-being cube" analysis,
- Development of a workplan for 2014–2015.

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

Progress is being made internationally on an ecosystem approach to the management of marine systems. Very recently, the concept of human well-being within marine social-ecological systems has become recognized as an important step forward. Well-being shifts the perspective from objective measures of sustainable livelihoods (comprised of the physical, social, human, natural, and financial resources available to a community or country) to include the subjective or perceived well-being of individuals and communities. This represents a shift from people as exploiters of the ocean to people as integral components of resource sustainability and ecosystem health (Coulthard *et al*. 2011, *Global Environmental Change*, 21: 453–463; Charles 2012, *Current Opinion in Environmental Sustainability*, 4: 351–357). The Japanese concept of "Sato-umi" (village–sea) is one version of this humans-in-nature approach, in which a healthy ecosystem is seen to nourish human well-being, but human activities are seen as necessary for sustaining ecosystem health. (*e.g.*, United Nations University Institute of Advanced Studies Operating Unit Ishikawa/Kanazawa (2011); Biological and Cultural Diversity in Coastal Communities, Exploring the Potential of Sato-umi for Implementing the Ecosystem Approach in the Japanese Archipelago. Secretariat of the Convention on Biological Diversity, Montreal, Technical Series no. 61). Therefore, this project is proposed and funded by the government of Japan. The project lifespan is 5 years, with the ending date set as March 31, 2017.

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.

The project should be integrated with other PICES activities and expert groups such as:

- FUTURE Research Theme 3 on "*How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems?*";
- Section on *Human Dimensions of Marine Systems* (S-HD);
- Section on *Ecology of Harmful Algal Blooms in the North Pacific* (S-HAB);
- Section on *Climate Change Effects on Marine Ecosystems (*S-CCME);
- WG 28 on *Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors*;
- WG 21 on *Non-indigenous Aquatic Species*.

Major activities to date include:

- First PST meeting in conjunction with PICES-2012 (October 11, 2012, Hiroshima, Japan,);
- Scoping meeting (January 23–23, 2013) and first Indonesia workshop (March 13–14, 2013, Jakarta and Karawang, Indonesia);
- Second PST meeting (June 10–12, 2013, Honolulu, USA);
- Social survey scoping meeting (October 2–3, 2013, Jakarta, Indonesia);
- Progress and financial reports for Year 1 (FY 2012: April 1, 2012–March 31, 2013) submitted to MAFF;
- Two articles in PICES Press newsletter: Vol. 21, No. 1 (winter 2013) and Vol. 21, No. 2 (summer 2013).

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 posted on the project website (http://www.pices.int/projects/marweb).

3.2 Results of the second PST meeting

The report from the second PST meeting (June 10–12, 2013, Honolulu, USA) is available on the project website (http://www.pices.int/projects/marweb).

3.3 Pond experiments and research plan in Karawang, Indonesia

Plans are progressing for a pond experiment in Indonesia. Three potential options with different focal species were presented (with their anticipated project costs) and discussed:

- Fish–seaweed–bivalves ($27,000);
- Shrimp–seaweed–bivalves ($30,000);
- Milk fish–crabs–bivalves ($17,000).

Overall, it was felt the total costs were too high, and beyond the project (shrinking) budget. Dr. Mark Wells suggested that the extent of work needed to be trimmed to better match the budget available for this work in Year 2 (about $43,000).

3.4 Plans for social science research in Indonesia related to the project

1. Dr. Masahito Hirota reported how multiple use of the products from marine activities (multi-utility: processing of multiple species by the same people) provides welfare and benefits for people's livelihoods in the fishing areas (Fig. 1).
2. In Karawang, Indonesia, shrimp aquaculture expanded from 2002 to 2009, but subsequently collapsed due to degradation of the ecosystem. Local consumption should be encouraged rather than relying on exports, but the question remains how local consumption can be "regulated".
3. A social survey scoping meeting with fishers, traders, wholesalers and processors took place October 2–3, 2013, involving: (a) mapping of commodity chains (Fig. 2), (b) confirmation of a checklist and guideline for field work (see discussion from the second PST meeting at http://meetings.pices.int/projects/marweb); (c) what can be done to assist the "well-being cube" analysis, and (d) confirmation of data items.
4. Shrimp have normally been used for the export market only, whereas in multi-trophic aquaculture and livelihood contexts, other products (seaweed and bivalves) could be used locally. Traditionally, the export-oriented shrimp monoculture activities do not contribute seafood protein to the local community, but integrated multi-trophic aquaculture (IMTA) might.
5. A milk fish experiment and shrimp experiment would provide a nice contrast of local (milk fish) *vs.* export (shrimp) market commodities.
6. Which bivalves should be included in the pond experiments? At present, there is no market for bivalves because of general fears of *Vibrio* and other infections/diseases. Therefore, there is some uncertainty about the acceptability of bivalves to the local market. *Gracilaria* (algae) is consumed primarily for agar. There is a benefit to using the system that directly benefits the food (diet) of the local people.

The PST was informed that Indonesia (BPPT) would like a more formal agreement with PICES, similar to that signed between Guatemala (University of San Carlos, Guatemala) and PICES for the 2007–2012 MAFF-funded project on the "*Development of the prevention systems for harmful organisms' expansion in the Pacific Rim*". This needs to be discussed with the PICES Secretariat.

3.5 Plans for research activities and workshops in Guatemala

1. Dr. Vera Trainer reported on conversations with Guatemalan colleagues, Lic. Leonel Carrillo and Lic. Carolina Marroquin (University of San Carlos, Guatemala).
2. Fisheries export is among the top 25 exported goods in Guatemala, increasing by about 6% from 2010 to 2011 (which is small relative to other exported products).

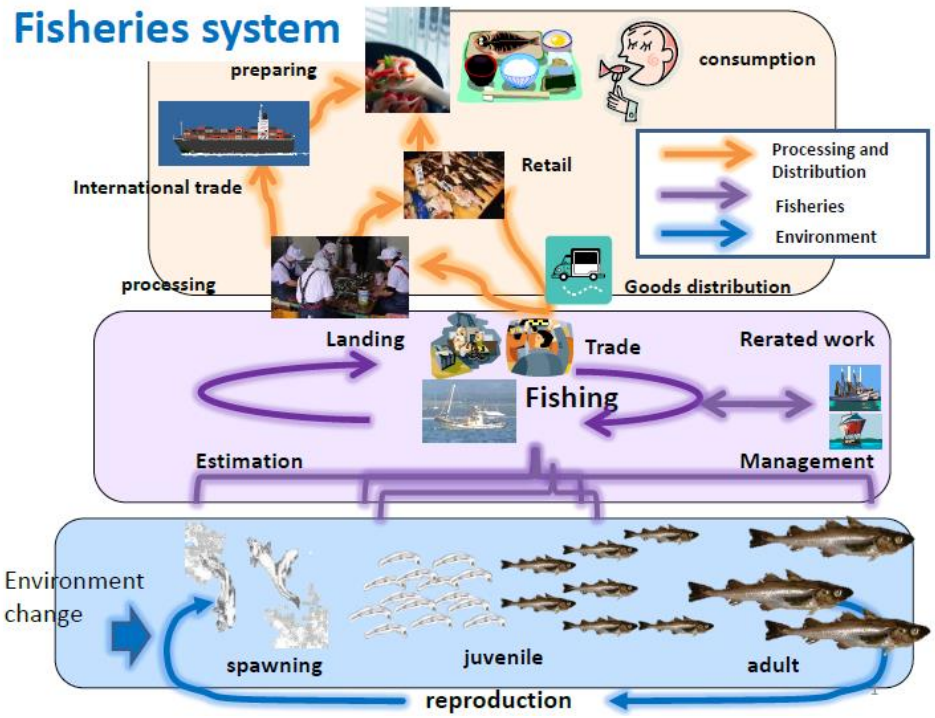


Fig. 1 An example of an integrated social-ecological fishery system. This example is for walleye pollock in Japan (Makino and Sakurai, 2014, Fisheries Science 80: 227–236). It is representative of a similar system in Indonesia, illustrating the integration of fish biology, fishing, processing, and marketing activities.

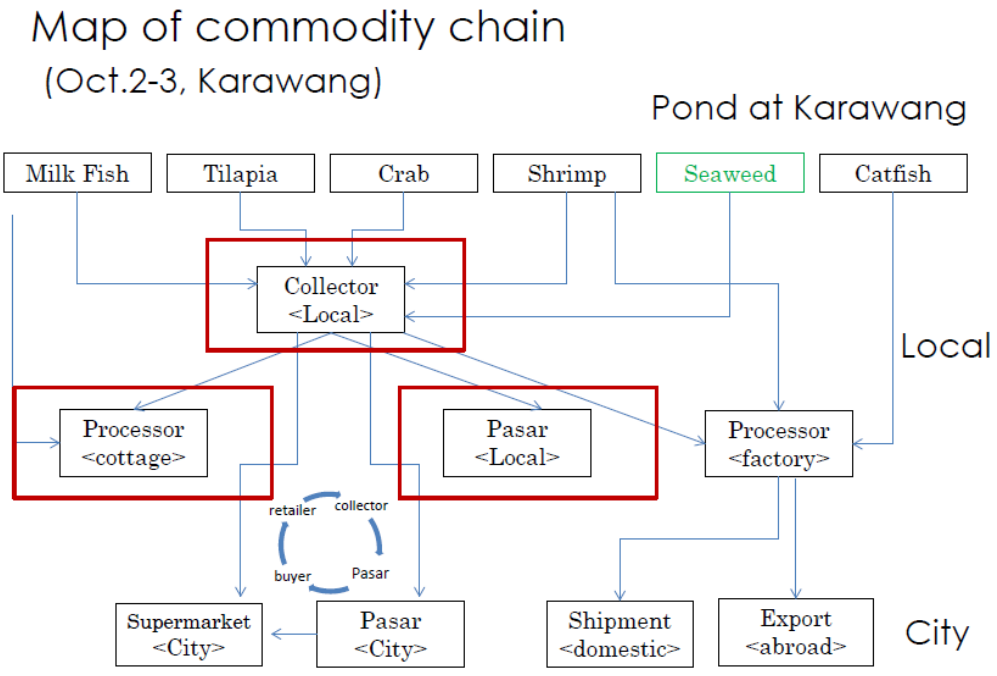


Fig. 2 Definition of the commodity chain for the pond culture in Karawang, Indonesia (from presentation by M. Hirota at the third PST meeting, October 10, 2013).

3. Fish, shellfish and seafood generally are too expensive for locals, except for the very wealthy. The majority of these products are exported. However, shrimp are sold fresh in markets and frozen in supermarkets. Products sold domestically are bought by intermediates who then re-sell them in terminal markets. Distributors sell to final consumers or door-to-door. Some small-scale fish mariculture projects have been tried, but have not progressed.
4. Shrimp aquaculture: Previously, large shrimp were cultured, but in last 6 years small-scale shrimp producers have generated about 2.5 million pounds ($8M/yr) – a 25% increase in last 3–5 years. Typically, culture activities start in February–March, grow during the warm period, reach a certain size, and then are harvested for domestic consumption.
5. Locals would prefer marine finfish and bivalves. They do not eat seaweeds. There likely needs to be an economic benefit to growing seaweeds because the population is generally very poor. It was noted that Dr. Thierry Chopin (seaweed expert from Canada's East Coast) is working on using seaweeds to capture excess nutrients in aquaculture operations. However, this is technologically difficult. The initial goal is to use seaweeds for bioremediation in these culture operations. In multi-trophic aquaculture bivalves must be cultured immediately adjacent to finfish; it has been observed that bivalves may grow faster in IMTA settings.
6. Shrimp culture in Indonesia is done in brackishwater ponds, with nutrient-laden water pumped into coastal waters. In Guatemala, there is interest in making shrimp farms environmentally sustainable, enhancing coordination among farms, and in exports.
7. Two possible projects were presented and discussed:

   Project #1 – *Ecosystem approach to shrimp aquaculture*

   - Nutrient-laden water being pumped into coastline (tourist areas);
   - Interest in making shrimp farms environmentally sustainable;
   - Enhancing coordination among farms;
   - Interest in exporting.

   Project #2 – *Marine finfish aquaculture*

   - Efforts have failed to date because of no attempts have been made to grow from fingerlings;
   - Fishers need to become involved in aquaculture – using a common wholesaler gets a better price;
   - Prices have not been good for fish species considered not 'attractive', literally for Gar (an "ugly fish"), and for tilapia.
   - Fish aquaculture would be the best option to improve food security and give coastal residents a way to improve their income, whereas shrimp aquaculture would be the best option to promote aquaculture, create jobs and promote small- to mid-sized companies.
8. A social scientist from Guatemala, who has experience in how tilapia production might influence development, suggested that, at a cost of $50/day, social science questionnaires could be given by students in coastal communities. To obtain 1000 surveys, many small communities would need to be visited. Note that the coastal area is very narrow – approximately 10 km from the sea is considered the maximum distance for marine influences. Participants could request supplies for their town, such as children's books for the library, trash cans for the beach, supplies for school, *etc*. instead of payment.

However, an outreach activity would need to be conducted first to explain the benefits of this project to the community.

9. Dr. Trainer's impressions of starting a project:
   - The University of San Carlos is very interested in a multi-trophic aquaculture project;
   - The focus should be on small shrimp farms (~3) as model systems;
   - Visit those farms during the scouting mission;
   - Work with small shrimp farms to develop bivalve or tilapia culture; these would be primarily for domestic consumption;
   - Bivalve culture will have to consider pollutants and bacteria (wastewater is contaminated);
   - Consider using seaweed for fertilizer or oil;
   - Shellfish culture is mostly on sand substrate, with little seed. The Japanese have supplied oyster seed in El Salvador, which has worked well. Can we find these Japanese contacts for Guatemala?
   - It is difficult to keep people interested in the long term, so we need to see progress;
   - Smaller shrimp farms stock 3–4 times per year. Shrimp reach 12–13 g in 15 weeks for local markets. Growing seasons are March–June/July, then August–September. It rains in between these times and salinity goes down. The multi-trophic aquaculture product needs to be salinity, temperature, and solids tolerant.
10. A clear, unified vision for the project, and what kind of support or benefits partners can expect (economic, training, supplies) needs to be determined;
11. Decisions needed for the Guatemala project:
    - The Guatemalan partners need a clear idea of what the project hopes to achieve.
    - What kind of support or benefits can partners expect to receive (economic, training, supplies, other)?
    - What benefits will the University of San Carlos gain?
    - How will we measure the project benefits?
    - Who is our specialist in IMTA? Will this person participate in the scouting mission?
    - Who is going on the scouting mission? When? Suggested scouting meeting dates: January 27–31 or April 7–11. Farmers and the University have down time in January. The first stocking of shrimp ponds is in the second week of February (white spot disease occurs when T < 26°C). Open in mid-March.
    - Should the social scientist at the University of San Carlos be included? Should we meet with her during the scouting meeting?
    - How and when will social science surveys be conducted?
    - Is an MOU required?
12. A budget of $11,000 (expenses for 4 visiting scientists – 1 from Canada, 2 from Japan and 1 from USA) for a 5-day scouting trip, with a visit to shrimp or fish farms, was presented.

Discussion on this presentation included the following points:

The Guatemala project needs a clear idea of what is hoped to be achieved. We need a vision of the social science survey. How many responses are needed? Should the focus be on immediate coastal recipients? What should be the focal community for the survey?

After Dr. Hirota's brief preview of his questionnaire prepared for Indonesia (this questionnaire focuses on coastal communities, with indices discussed at the second PST meeting in Honolulu, based on the World Ocean Assessment), the PST members agreed that collaborating with social scientists in Guatemala is critical. Shrimp aquaculture (Option 1) is becoming more sustainable, so seems to have a higher probability of success. Basic social surveys should consider the needs/uses of seaweed, and the effects on markets of increased production of small shrimp. Other PST members questioned why it was necessary to do this. Was it a model for increasing income, employment, or healthier diet – at what cost to the environment quality? What other species could be co-produced with shrimp aquaculture—what do you eat; what would you eat? It was imperative to start with social surveys and clearly identify the goal. There needs to be a reduction in eutrophication – water quality needs to be improved to favor tourism, *etc*. We need to specify the advantages of the proposed changes – Is tourism a benefit, or is there a local bias against tourism, because they are multinational corporations?

The anticipated outcomes of the project are a database and manuals. One possible outcome might be to mitigate waste disposal processing (waste processing is an ecological service that is underappreciated) in Guatemala; there is a need to treat the waste.

Project goals should be to: (1) mitigate nutrient loading (environmental stewardship), (2) provide employment, (3) provide food security (protein), and (4) improve human well-being. Social science surveys should be conducted first. Research initiatives may need to include possible training and education to implement IMTA.

Another suggestion was to do a "walk through", to get a flavor of the types of producers and commodity pathways. A workshop could be held to identify the importance/relevance to marine environment – this would help to set up the direction we want to go; it could be community-participatory based to get personal investment in the project and would give PST members the opportunity to meet with government officials and small shrimp farm operators. Members should contact Dr. Trainer if they are interested in participating.

3.6 Well-being cube (WB-cube) analysis progress

"Well-being cube" analysis is a methodology for understanding the content and structure of human well-being. Based on psychological science, the WB-cube measures the detailed characteristics of choices and actions people want to make. Therefore, using WB-cube analysis we can determine people's needs to generate scientific information which PICES can provide for better human well-being. Surveys have been completed for Korea, Japan, and USA. Initial results were presented, and look very encouraging.

1. Background: Ecosystems→services→well-being (security, materials for a food life, health, good social relations);
2. WB-cube analysis can be confusing – the questions are subject to interpretation and experience of the survey participant/conductor.

Discussion included questions about how the analysis was done and how the data were normalized within country or across countries.

3.7 Project name and web page

A more convenient name for the PICES/MAFF project was accepted by the PST – MarWeB (Marine Ecosystem Health and Human Well-Being). A MarWeB web page was established on the PICES website (http://www.pices.int/projects/marweb) and is being populated.

4. PROPOSALS FOR RESEARCH TOPICS/SESSIONS

A MarWeB Topic Session on "*Ecological and human social analyses and issues relating to Integrated Multi Trophic Aquaculture*" was proposed and ultimately accepted for PICES-2014 in Yeosu, Korea (*Appendix 3*).

5. PROJECT MANAGEMENT

Possible PST membership changes were discussed. Dr. Skip McKinnell resigned from the PST, and was thanked for his service. Potential additional expertise include: IMTA, aquaculture, developing countries. The following new members were suggested: Mark Flaherty (University of Victoria, Canada), Charles Trick (University of Western Ontario, Canada), and Thierry Chopin (University of New Brunswick, Canada).

6. BUDGET FOR YEAR 3

Suggestions for the Year 3 budget (FY 2014: April 1, 2014 – March 31, 2015) included:

- A possible PST meeting in April 2014 or early June 2014;
- Moving $14K currently held in equipment into other activities (perhaps Indonesia related);
- A publication of "well-being cube" results in a peer-reviewed journal;
- The need for a translator for the Guatemala scoping trip.

To date, the budget and workplan for Year 3:

- Rough budget shows: FUTURE OSM – $14K; Indonesia case study – $19K; Guatemala case study – $35K; "well-being cube" analysis – $9K; PICES Secretariat – $10K; PICES overhead – $13K).
- The need to develop a multi-year budget plan was recognized, in particular for field projects such as those in Indonesia and Guatemala.

7. OTHER MATTERS

The presentation to Science Board on October 19, 2013 (at the 2013 PICES Annual Meeting) highlighted the following three major initiatives:

- Social-ecological interactions related to IMTA in Indonesia;
- Social-ecological interactions related to small-scale shrimp aquaculture in Guatemala;
- Development of the "well-being cube" approach to assessing national well-being related to marine systems.

Other issues/challenges: Replacement of PST membership; declining MAFF funding

Appendix 1

Project Science Team membership

Harold (Hal) Batchelder	Oregon State University, USA
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)	Department of Fisheries and Oceans, Canada
Thomas Therriault	Department of Fisheries and Oceans, Canada
Vera Trainer	Northwest Fisheries Science Center, NOAA-Fisheries, USA
Mark Wells	University of Maine, USA

Participants of the third Project Science Team meeting for the PICES/MAFF project on "Marine ecosystem health and well-being". Left to right: Vera Trainer (USA), Sinjae Yoo (Science Board Chairman), Masahito Hirota (Japan), Juri Hori (Japan), Hiroyuki Shimada (Japan), Grant Murray (Canada), Thomas Therriault (Canada), Harold (Hal) Batchelder (USA), Keith Criddle (USA), Alexander Bychkov (PICES), Charles Trick (Canada), Suam Kim (Korea); kneeling: Co-Chairmen – Mitsutaku Makino (Japan) and R. Ian Perry (Canada).

Appendix 2

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 second PST meeting in Hawaii (Co-Chairs)
   - 3.3 Pond experiments and research plan in Karawang, Indonesia (Mark Wells)
   - 3.4 Plans for social research in Indonesia related to the project (Masahito Hirota)
   - 3.5 Plans for the research activities and workshops in Guatemala (Vera Trainer and Charles Trick)
   - 3.6 Progress of the "well-being cube" analysis (Juri Hori)
   - 3.7 Project name and web page (Co-Chairs)
   - 3.8 Other reports
4. Proposal of research topics/sessions
   - 4.1 Topic Session proposals for PICES-2014 (Masahito Hirota)
   - 4.2 Potential intersects/synergies with WG 28, S-HD, and other groups within PICES and FUTURE Program
   - 4.3 Other proposals
5. Project management
   - 5.1 Discussion on possible revision of the PST membership
6. Budget for Year 3 (April 1, 2014 – March 31, 2015)
7. Other matters
8. Concluding remarks

Appendix 3

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).

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://www.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, San Francisco State University, 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 macroalgae 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 macroalgae 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:

For social science pillar

- 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).

For multi-trophic aquaculture pillar

- 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) to enhance the culture of oysters. Its goal was to test the feasibility of growing, processing and marketing *Crassiostrea 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 regard to the oyster culture project, it was noted that to grow oysters and get them to market would likely take more than one year. Therefore, funds may be needed for a second year of this 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 chain 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 the 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 the "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.

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).

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 the 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 United States (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.

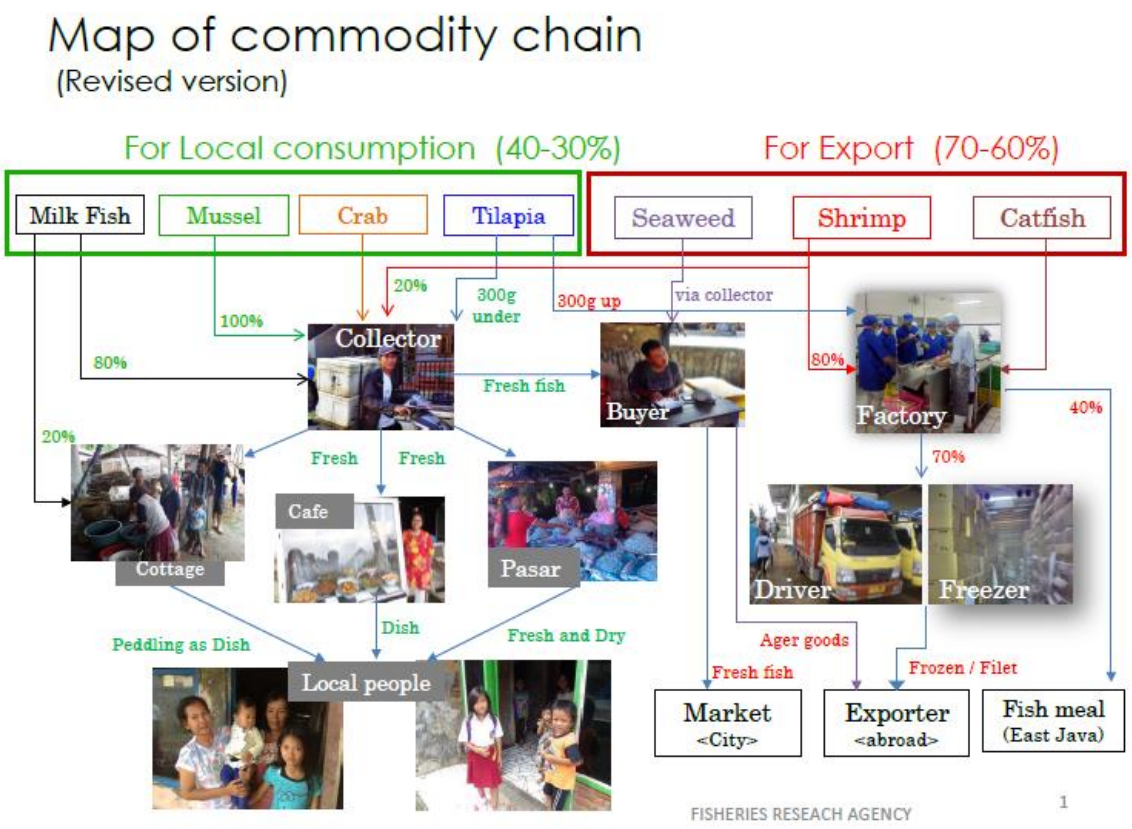


Fig. 1 Revised commodity chain map for marine aquaculture products in Karawang, Indonesia (from presentation by M. Hirota at the fourth PST meeting, April 13, 2014).

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 18:00.

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)	Department of Fisheries and Oceans, Canada
Thomas Therriault	Department of Fisheries and Oceans, 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, Juri 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, andcommunity 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 macroalgae 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 macroalgae to areas of the coast that do not naturally have macroalgae, (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 regard 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 fishermen, 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 farms affecting marine and estuary life, (2) effluent from sugar cane releases following heavy rains that 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. José Manuel Díaz, 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 a 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 waters (tolerate salinity up to 32 ppt) – can be called "cherry snapper" instead of tilapia. There is a possibility for multi-trophic 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 (macroalgae) 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 macroalgae 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

<u>Social survey</u>

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 U.S. 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 macroalgae 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 multi-trophic 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 × 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:

Two times per week: 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 5

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).

Fifth Meeting of the Project Science Team
October 16, 2014, Yeosu, Korea

The fifth 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 October 16, 2014, in conjunction with the 2014 PICES Annual Meeting in Yeosu, Korea.

The meeting objective was to review progress from the fourth PST meeting in April 2014 and plans for FY 2015, in particular: a) development of the Guatemala case study and b) further development of the Indonesia case study.

The meeting was co-chaired by Drs. Mitsutaku Makino (Japan) and Ian Perry (Canada). All PST members (*Appendix 1*) and the Project Coordinator, Dr. Alexander Bychkov, attended the meeting.

1. ADOPTION OF THE AGENDA

The agenda was adopted as proposed (*Appendix 2*). The PST welcomed its new members, Dr. Jongoh Nam (Maritime Institute, Korea) and Dr. Charles Trick (University of Western Ontario, Canada).

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. 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 briefly reviewed the background and context for the project and 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 in conjunction with the FUTURE Open Science Meeting (April 13, 2014, Kohala Coast, Hawaii, USA);
- Progress and financial reports for Year 1 (April 1, 2012 – March 31, 2013) and Year 2 (April 1, 2013 – March 31, 2014) submitted to MAFF;
- Two articles published in PICES Press: Vol. 21, No. 1 (winter 2013) and Vol. 21, No. 2 (summer 2013);

- Fifth PST meeting in conjunction with PICES-2014 (October 16, 2014, Yeosu, Korea; this meeting);
- MarWeB Topic Session on "*Ecological and human social analyses and issues relating to Integrated Multi Trophic Aquaculture*" to be convened at PICES-2014.

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

3. PROGRESS REPORTS

The MarWeB project has focussed on three major initiatives:

1. Social-ecological interactions related to integrated multi-trophic aquaculture (IMTA) in Indonesia;
2. Social-ecological interactions related to small-scale shrimp aquaculture in Guatemala;
3. Development of the "well-being cube" approach to assessing national well-being related to marine systems.

3.1 Annual Reports for Science Board and MAFF/JFA

The progress and financial reports for Year 2 (FY 2013: April 1, 2013 – March 31, 2014), accepted by MAFF/JFA, were presented for information and are available at the project website. The progress report includes a glossary for Japanese readers. Drafts of progress and financial reports for Year 3 (FY 2014: April 1, 2014 – March 31, 2015) are due in June 2015 for submission to MAFF/JFA in July 2015.

3.2 Report of the fourth PST meeting

Dr. Perry briefly reviewed the report from the fourth PST meeting held April 13, 2014, in conjunction with the PICES FUTURE Open Science Meeting at the Hapuna Beach Prince Hotel, Kohala Coast, Hawaii, USA. The report was approved with no changes and is now available at the project website.

3.3 Development of the research activities in Guatemala

Based on an evaluation of existing shrimp-focused aquaculture in Guatemala, and considering the interests and goals of the MarWeb project (and comparability with the project activities in Indonesia), a focus on multi-trophic aquaculture for science pillar is recommended. The goal would be to 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.

It was proposed to support an oyster study led by Lic. Leonel Carrillo and Lic. Carolina Marroquin (University of San Carlos, Guatemala). The objective would be to test the feasibility of growing, processing and marketing *Crassostrea gigas* (mangrove oyster) with the Integral Fisheries Cooperative on the Pacific coast of Guatemala. The potential outcomes include income for coastal people, and improved health and well-being.

Specific objectives are to:

- Assess the performance of the longline shellfish culture system in La Barrona estuarine lagoons;

- Determine yield potential of the culture system, including growth rates and time for mollusks to reach market size;
- Evaluate shellfish survival rates during different phases of their growth and assess mitigation methods against predation;
- Adapt or develop culture practices appropriate for the management of the system;
- Produce oysters that conform to the microbiologic standards of food safety;
- Assist in finding suitable markets for the sale of the final product.

The anticipated results include:

- Start the commercial production of *C. gigas* in the southern region of Guatemala, using a cooperative model;
- Within a year, it is anticipated that this community will earn income from oyster sales to allow reinvestment in their own businesses and to improve their financial situation;
- Partially meet the domestic demand of consumption of oysters, which is currently met by imports paid in dollars;
- Validate a system of commercial production of bivalve mollusks, which could be replicated in other regions with similar environmental characteristics.

In discussion, it was noted that *C. gigas* is a common invasive species world-wide, and Drs. Trainer and Trick were asked to check if there is any concern about introducing it to this region or it is already present. Also, questions were raised as to whether the local communities have the legal rights to this aquaculture, *i.e*., who "owns" the water and who would benefit from this activity?

Dr. Trick presented the concept of a "participatory needs assessment". In this approach, success is considered to result from a step-wise process: (1) to develop a questionnaire to understand two things within a community, specifically what they want, and what are they missing? and (2) to develop a way to measure "success" if changes were to occur. For example, in the case of Guatemala the problem is to establish how shrimp aquaculture can enhance the community's sense of well-being and purpose. The level of literacy was noted, and the use of disposed cameras was suggested. It was recommended that Dr. Trick begin a community needs assessment for the social aspects of this project.

Actions:

- Drs. Trainer and Trick to check on whether *C. gigas* is already present in Guatemala, and if there are any legal issues around ownership of rights to coastal waters;
- Dr. Trick to begin a community needs assessment for the social aspects of this project.

3.4 Development of the research activities in 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 the 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 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 include the following:

Ecological systems

- Workshop 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 (August 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–).

The first pond experiment at the National Center for Brackishwater Aquaculture in Karawang started in August 2014. The main purpose of this experiment is to investigate the effect of IMTA on: (1) the economic return of pond operations, and (2) the water quality of the ponds, defined in terms of the (macro-)nutrient concentrations of nitrate/nitrite, ammonia, and phosphate, in addition to other parameters (*e.g.*, oxygen, phytoplankton, bacteria, *etc*.). The underlining hypothesis is that the addition of bivalves (*Anadara*) and seaweed (*Gracilaria*) into the aquaculture ponds of fish (*Tilapia* species) or shrimp will allow successful growth of all species, and decrease of macronutrient concentrations.

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 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 experiment.

The experiment was designed using four 4000 m^2 ponds: Pond 1 – Shrimp only, Pond 2 – Shrimp + *Gracilaria* + *Anadara*, Pond 3 – Fish (tilapia) only, and Pond 4 – tilapia + *Gracilaria* + *Anadara*. All ponds were prepared for a mid-August start (delayed to allow them to dry out sufficiently before adding the brackish water). Water to the ponds was drawn from a tidal canal, mixed with river water to establish a low salinity (~17–25 mg/kg).

Early results suggest the following:

1. There appears to be no negative effect on the shrimp or tilapia weight gain in the ponds with the *Gracilaria* and *Anadara*. This was the main concern.

2. The replenishment of water in the tilapia ponds from the reservoir is a potential source of nutrient variability, but concentrations in all ponds seem to track each other reasonably well (particularly NO_3/NO_2). The implication is that despite the considerable mixing (from paddle mixers), vertical gradients may be forming within the 1 m deep ponds. There also may be variation from site to site within the pond as the water circulates. Collecting vertically integrated samples was suggested.
3. The biggest problem was the high level of nutrients added to the ponds to generate enough plankton to prevent light from reaching the bottom of the pond.

The social science studies in Indonesia have been very active. A revised commodity chain model was presented (Fig. 1). Dr. Hirota recommended moving towards a "system dynamics" model approach to explore the effects of changing parameters (*e.g.*, in the commodity chain), and examining the impacts of changes to various social parameters (Fig. 2). An AHP approach was suggested to evaluate the choice of scenarios, *e.g.*, the effects on outcomes of intensive culture, polyculture, and IMTA approaches.

Actions:

- Dr. Makino to discuss with Prof. Suhendar the possibility to develop the "natural" process manual (major project outcome), based on the pond results;
- Dr. Hirota to produce a description and application of the social aspects for the MarWeB report and the project website;
- Dr. Wells to continue overseeing the pond experiments and interpreting the results.

3.5 Topic Session on IMTA at PICES-2014

The IMTA Topic Session was briefly reviewed by the co-convenors. The schedule of speakers is provided in *Appendix 3*. In addition, a small field trip to visit Korean aquaculture sites was arranged by Dr. Nam.

3.6 Other reports

A brief presentation on progress with the "well-being cube" analysis was given by Ms. Juri Hori. She pointed out that all the countries surveyed to date (Japan, Indonesia, Korea, USA) have similar processes of well-being with respect to the ocean. However, the well-being of the ocean's bounty has different meanings, depending on the country. Therefore, the concept of what is a "desirable ocean" differs from country to country. Also, the conservation strategy may change from person to person, even within each country. The analyses are progressing towards a paper in a peer-reviewed journal.

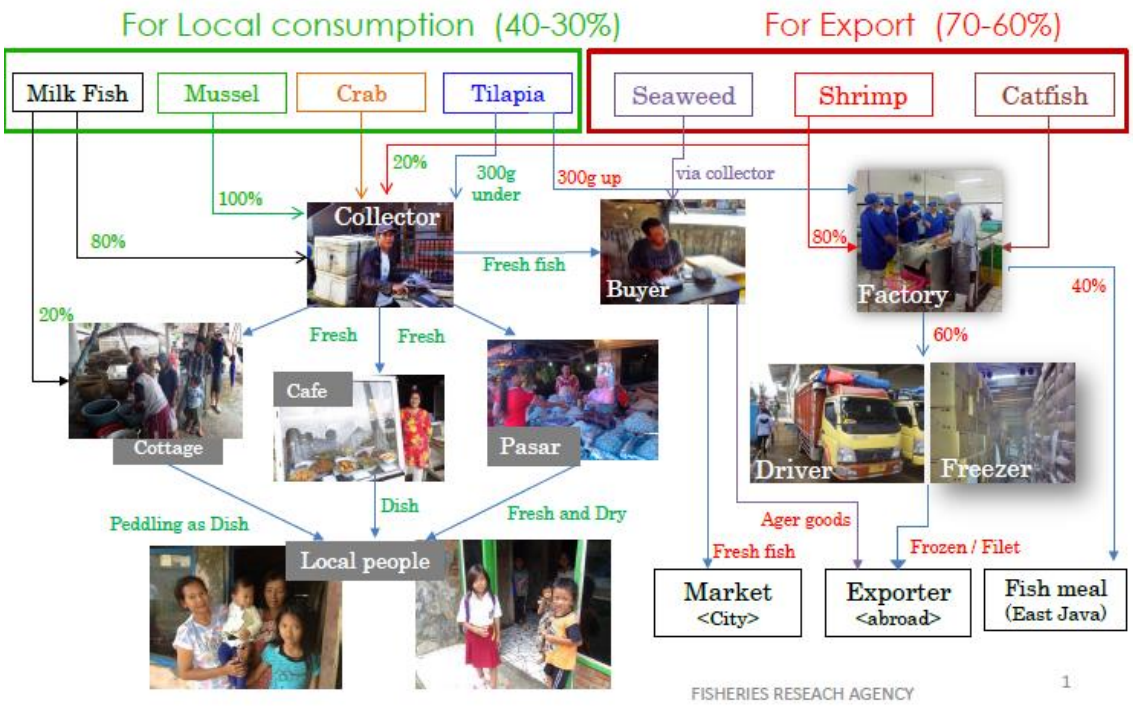


Fig. 1 Revised commodity chain map for marine aquaculture products in Karawang, Indonesia (from presentation by M. Hirota at the fifth PST meeting, October 16, 2014).

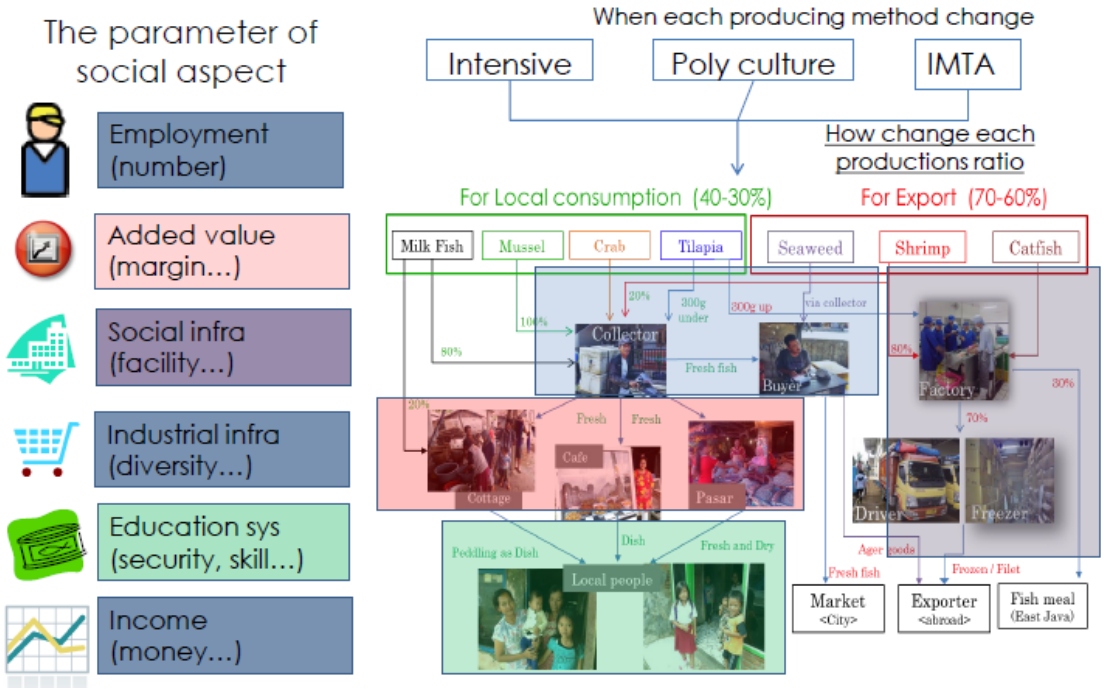


Fig. 2 Example of social parameters that could be varied in a dynamic systems model approach, to understand potential impacts on outcomes (from presentation by M. Hirota at the fifth PST meeting, October 16, 2014).

4. PROJECT MANAGEMENT

4.1 Possible revision of PST membership

Dr. Makino recommended that Dr. Osamu Tamaru (Japan) be invited to join the PST to help with the social dynamical analyses.

4.2 Discussion on the FY 2014 budget

The budget breakdown for Year 3 of the project (FY 2014: April 1, 2014 – March 31, 2015), as proposed at the fourth PST meeting in April 2014, is presented in Table 1.

5. DISCUSSIONS ON THE FY 2015 WORKPLAN AND BUDGET

The estimated budget for Year 4 of the project (FY 2015: April 1, 2015 – March 31, 2016) is $85,000. There may be a small carry-over of unspent funds from FY 2014, and this will be confirmed once the accounting for Year 3 has been completed.

The PST decided there were too many uncertainties and projects in action as of October 2014 to create a reasonable draft budget for FY 2015 (for example, the Indonesian pond experiments are on-going, and the field trips and a Community Needs Assessment survey in Guatemala is planned for early in 2015. There was also discussion of whether an inter-sessional PST meeting would be needed. It was noted that there were inter-sessional meetings in 2013 and 2014, and these were felt to be extremely useful for concentrated planning and budgeting. The option of having an inter-sessional meeting in 2015 was left open, depending on progress by the Indonesia and Guatemala case studies. A starter budget for MarWeB activities in 2015–2016, to be completed by correspondence or at an inter-sessional meeting, is presented in Table 2.

Table 1 Proposed MarWeB budget breakdown for Project Year 3 (FY 2014)

Indonesia		
Follow-up visit by Dr. Wells in June 2014 (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
Meetings		
Travel support for Hawaii FUTURE OSM meeting	8,000	25,000
Travel support for PICES 2014 Annual Meeting (Yeosu, Korea; incl. invited speakers):	16,000	
IMTA field trip in Yeosu	1,000	
TOTAL		**105,000**

Table 2 Proposed MarWeB budget breakdown for Project Year 4 (FY 2015)

	Activity/Event	Expense type	Amount	Section total
PICES overhead		Overhead	10,000	10,000
Cube analyses	500 questionnaires for "well-being cube" survey in Russia (telephone survey conducted by a Japanese company)	Contract	8,000	8,000
Indonesia	Workshop for manual development (led by Dr. Suhendar Sachoemar)	Contract	9,000	13,000
	Follow-up visit(s) to Karawang for instruction/advice for pond experiment	Travel	4,000	
Guatemala	Workshop for manual development	Travel	15,000	35,000
	Workshop for manual development	Contract	20,000	
Equipment		Equipment	1,000	1,000
PST Meetings	Travel support for a possible inter-sessional meeting (location TBD)	Travel/Meetings	??	16,000
	Travel support for PICES 2015 Annual Meeting (Qingdao, China)	Travel/Meetings	16,000	
TOTAL				**83,000**

6. OTHER BUSINESS

There was brief discussion of opportunities for MarWeb topic sessions at the upcoming 2016 PICES Annual Meeting and the ICES/PICES Symposium on "*Understanding marine socio-ecological systems: Including the human dimension in Integrated Ecosystem Assessments*" (May 30–June 3, 2016, Brest, France), and the possible PICES Human Dimension Conference. No decisions were made.

7. CONCLUDING REMARKS

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

Appendix 1

Project Science Team membership

Harold (Hal) P. Batchelder	PICES Secretariat
Keith R. Criddle	University of Alaska, Fairbanks, USA
Masahito Hirota	Fisheries Research Agency, Japan
Juri Hori	Rikkyo University, Japan
Suam Kim	Pukyong National University, Korea
Mitsutaku Makino (Co-Chairman)	Fisheries Research Agency, Japan
Grant Murray	Institute for Coastal Research, Canada
Jongoh Nam	Maritime Institute, Korea
Ian Perry (Co-Chairman)	Department of Fisheries and Oceans, Canada
Thomas Therriault	Department of Fisheries and Oceans, Canada
Vera Trainer	Northwest Fisheries Science Center, NOAA Fisheries, USA
Charles Trick	University of Western Ontario, Canada
Mark Wells	University of Maine, USA

Participants of the fifth Project Science Team meeting for the PICES/MAFF project on "Marine ecosystem health and well-being" (left to right): Vera Trainer (USA), Harold Batchelder (PICES), Charles Trick (Canada), Thomas Therriault (Canada), Mitsutaku Makino (Japan; Co-Chairman), Grant Murray (Canada), Ian Perry (Canada; Co-Chairman), Mark Wells (USA), Jonghoh Nam (Korea), Keith Criddle (USA), Juri Hori (Japan), Masahito Hirota (Japan). Not shown: Alexander Bychkov (PICES) and Suam Kim (Korea).

Appendix 2

Fifth Project Science Team meeting agenda

1. Introductions and 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 Report of the fourth PST meeting (Co-Chairs)
   - 3.3 Development of research activities in Guatemala (Vera Trainer, Charles Trick)
   - 3.4 Development of the research activities in Indonesia (Mark Wells, Masahito Hirota)
   - 3.5 Topic Session on IMTA at PICES-2014 (Masahito Hirota, Mark Wells, Grant Murray)
   - 3.6 Other reports ("well-being cube" analysis, PICES Press, *etc*.)
4. Project management
   - 4.1 Revision of PST membership
   - 4.2 Discussion on the FY 2014 budget
5. Discussions on the FY 2015 workplan and budget
6. Other business
7. Concluding remarks

Appendix 3

MarWeB Topic Session (S11) at PICES 2014 Annual Meeting (Yeosu, Korea)

"*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).

Wednesday, October 22 (09:00-12:30)

09:00 Introduction by Session Convenors

09:05 *Integrated Multi-Trophic Aquaculture (IMTA): An environmentally, economically and societally responsible aquanomic approach to farming the sea with many variations (Invited)*
Thierry Chopin

09:35 *Obtaining a social license for IMTA: Challenges and opportunities in British Columbia, Canada (Invited)*
Mark Flaherty

10:05 *The effect of multi-trophic aquaculture on nutrient loading in fish and shrimp ponds, Karawang Indonesia*
Mark L. Wells, Mitsutaku Makino, Suhendar I. Sachoemar and Masahito Hirota

10:45 *Dissemination of Sato-umi for sustainable aquaculture development in Indonesia (Invited)*
Suhendar I. Sachoemar, Tetsuo Yanagi, Mitsutaku Makino, Mark L. Wells, Masahito Hirota and Ratu Siti Aliah

11:15 *Implementation of Sato-umi concept at pond aquaculture in Karawang, Indonesia (Invited)*
Susanna Nurdjaman, Tetsuo Yanagi and Suhendar I. Sachoemar

11:45 *Social-ecological studies towards the integrated management of local fisheries in North-Eastern Hokkaido, Japan*
Emmanuel A. Sweke, Rotaro Okazaki, Yumi Kobayashi, Mitsutaku Makino and Yasunori Sakurai

12:05 Discussion

Posters S11

S11-P1 *Parasites of marine fishes and climate change: Implications for Korean aquaculture*
B.A. Venmathi Maran and Jung-Goo Myoung

S11-P2 *Accumulation of lactate in the coelomic fluid of sea urchins under stress suggests the switching-on of anaerobic glycolysis*
Konstantin A. Drozdov, Anatoliy L. Drozdov and Lidia T. Kovekovdova

Sixth Meeting of the Project Science Team
October 14, 2015, Qingdao, China

The sixth 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 October 14, 2015, in conjunction with the 2015 PICES Annual Meeting in Qingdao, China. The meeting objective was to review progress from the fifth PST meeting in October 2014 and plans for FY 2016 (final year of the project), in particular: a) consistency among case studies and b) concrete and specific image for the final products of this project (manual and database).

The meeting was co-chaired by Drs. Mitsutaku Makino (Japan) and Ian Perry (Canada). The Project Science Team members and meeting participants are identified in *Appendix 1*.

1. ADOPTION OF THE AGENDA

The agenda was adopted as proposed (*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. 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 briefly reviewed the background and context for the project and 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 in conjunction with the FUTURE Open Science Meeting (April 13, 2014, Kohala Coast, Hawaii, USA);
- Fifth PST meeting in conjunction with PICES-2014 (October 16, 2014, Yeosu, Korea);
- MarWeB Topic Session on "*Ecological and human social analyses and issues relating to Integrated Multi Trophic Aquaculture*" convened at PICES-2014 (October 22, 2014, Yeosu, Korea);
- Third Indonesia workshop (November 25–26, 2014, Pekalongan, Indonesia);

- Social survey and data collection in Guatemala;
- Follow-up visit and first social survey at several locations in Guatemala (February 26–March 7, 2015);
- Follow-up visit by Dr. Mark Wells for overseeing the pond experiment (March 5–10, 2015, Indonesia);
- Third Indonesia social survey (September 2015),
- Fourth Indonesia workshop (October 7–8, 2015, Karawang, Indonesia);
- Progress and financial reports for Year 1 (FY 2012: April 1, 2012 – March 31, 2013), Year 2 (FY 2013: April 1, 2013 – March 31, 2014), and Year 3 (FY 2014: April 1, 2014 – March 31, 2015) submitted to MAFF;
- Four articles published in PICES Press: Vol. 21, No. 1 (winter 2013), Vol. 21, No. 2 (summer 2013), and two articles in Vol. 23, No. 2 (summer 2015);
- Sixth PST meeting in conjunction with PICES-2015 (October 14, 2015, Qingdao, China; this meeting).

Reports from previous PST meetings, annual progress and financial reports, and other project-related materials are available on the project's website at http://www.pices.int/projects/marweb.

3. PROGRESS REPORTS

The MarWeB project has focussed on three major initiatives:

1. Social-ecological interactions related to integrated multi-trophic aquaculture in Indonesia;
2. Social-ecological interactions related to small-scale shrimp aquaculture in Guatemala;
3. Development of the "well-being cube" approach to assessing national well-being related to marine systems.

3.1 Annual Reports for Science Board and MAFF/JFA

The progress and financial reports for Year 3 (FY 2014: April 1, 2014 – March 31, 2015) were presented for information and are available at the project website. The progress report includes a glossary for Japanese readers. Drafts of progress and financial reports for Year 4 (FY 2015: April 1, 2015 – March 31, 2016) are due in April 2016 for preliminary presentation at MAFF/JFA in May 2016.

3.2 Report of the fifth PST meeting

Dr. Perry briefly reviewed the report from the fifth PST meeting held October 16, 2014, in conjunction with the 2014 PICES Annual Meeting in Yeosu, Korea. No revisions were requested.

3.3 Development of the research activities in Indonesia

Natural science studies

This project is investigating social-ecological interactions related to integrated multi-trophic aquaculture (IMTA) in Indonesia. The purpose of the pond experiment initiated in August 2014 is to investigate the effect of IMTA to: (1) increase the economic return of pond operation, and 2) improve the water quality of

the ponds to reduce the release of nutrients to coastal waters. The underlining hypothesis is that the addition of bivalves (*Anadara*) and seaweed (*Gracilaria*) into the aquaculture ponds of fish (*Tilapia* species) or shrimp will allow successful growth of all species, and decrease of macronutrient concentrations.

In summary, the preliminary results from the experiments include:

- Nutrient release must decrease from shrimp and tilapia pond aquaculture to coastal waters;
- The question is whether co-culture of *Gracilaria* and *Anadara* with shrimp and tilapia will decrease dissolved nutrient levels – too soon to tell, but not looking good;
- Early results indicate that inclusion of *Gracilaria* and *Anadara* does not decrease the growth of shrimp or tilapia – this may be an important source of additional income for communities;
- The addition of co-cultured species into the ponds affects the phytoplankton community composition — benefits to the quality of shrimp and tilapia – the reasons for this shift are not yet known.

Social science studies

These studies are investigating social-ecological interactions related to IMTA in Indonesia and have focused on the development of commodity chains and how people valued their marine environment. The overall intent is to advance an integrated understanding of the fisheries system (*e.g.*, Fig. 1). In 2015, this research was expanded to cover Sulawesi. The approach included: (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 activity, Dr. Masahito Hirota, comparisons of methods to identify how people interact with their marine environment have been adjusted 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 2.

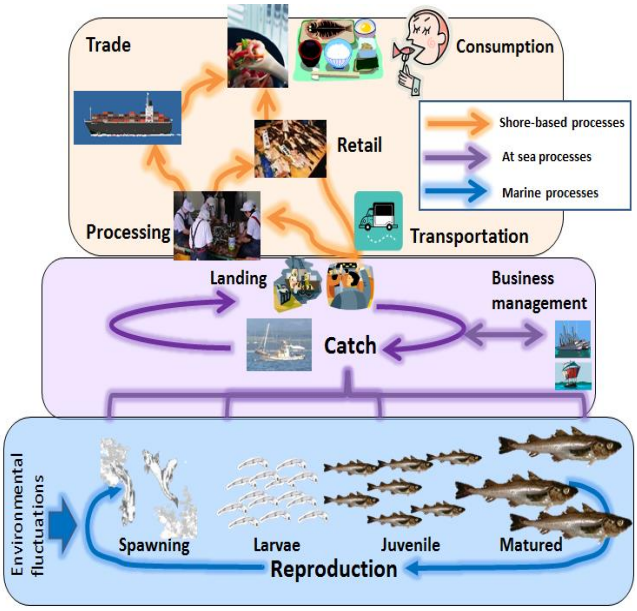


Fig. 1 A concept for an integrated approach to fisheries.

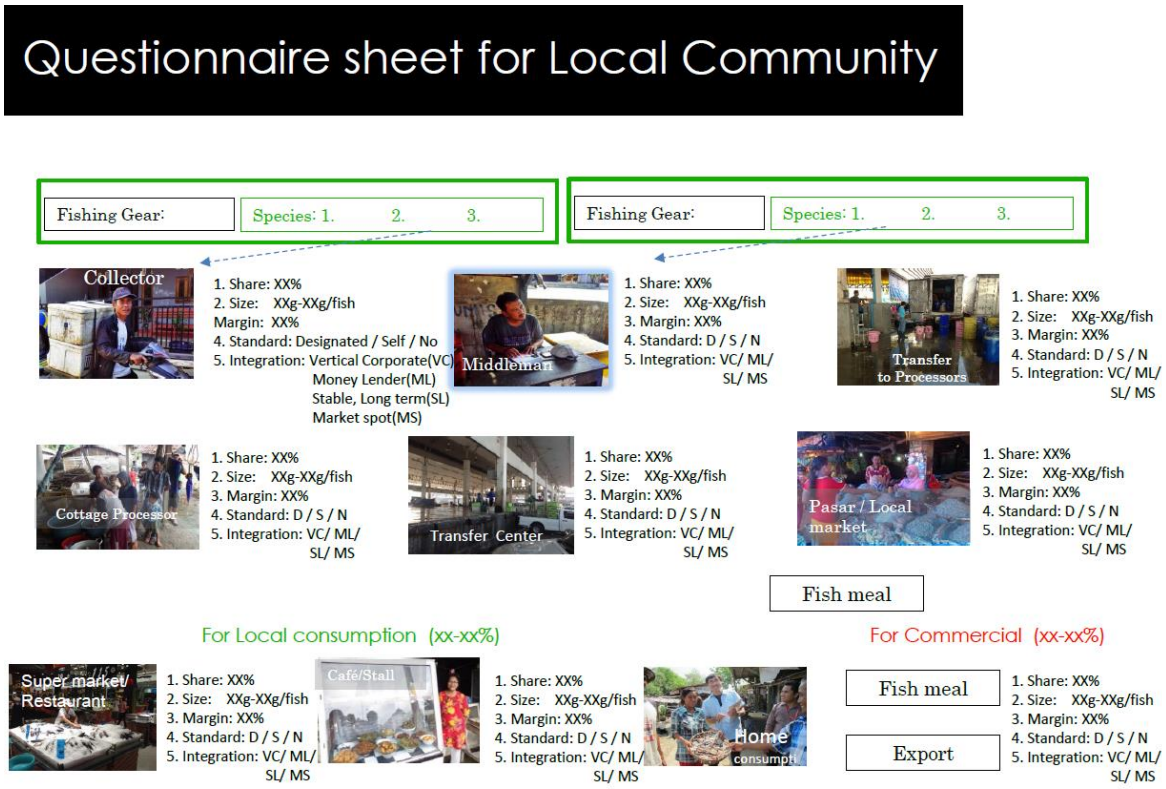


Fig. 2 An example of how the simplified social survey can be presented to develop a marine commodity chain (from presentation by M. Hirota at the sixth PST meeting, October 14, 2015).

Recommended activities for Year 4 (FY 2015: April 1, 2015 – March 31, 2016) include: (1) a meeting to interpret pond experiment results, (2) an additional pond experiment, (3) analyses of existing social data and trial of a new format, and (4) linking social analysis with pond experiment.

3.4 Development of the research activities in Guatemala

The MarWeB project activities in Guatemala during Year 4 were focused on two studies: (1) a Community Needs Assessment of two small coastal communities in regards to social-ecological interactions related to small-scale shrimp aquaculture and (2) an oyster aquaculture project (for cross-comparisons with MarWeB activities in Indonesia).

The Community Needs Assessment was conducted at two small coastal communities: Las Lisas and Monterrico. These two communities represent extremes in community responses to the demise of the local fisheries. Community members from Las Lisas were enthusiastic for change that would allow for the return of the resources and the survival of their community. Community members for Monterrico were mostly despondent about the future – declaring themselves as the "last fishermen on earth." Questions were asked that probed the demand and accessibility of fish/protein supply, and that examined the willingness of villagers to change their relationship with fisheries resources. Responses indicated that fishermen could supply fish for their family, but not enough for community. Protein from fresh finfish contributes 1–2 meals per month in Las Lisas, somewhat less for Monterrico. As a consequence, the communities rely on canned fish and frozen non-local products. Fish abundances have declined over the last decade, and the

quality of the fish caught locally has diminished; the term "contaminated" was used often. There was no confidence that communities would survive with the present association with natural fisheries. This response is in contrast to the positive feelings towards the sea – perhaps an acceptance that the sea defines their location, transport, and history – but is no longer a reliable provider. The path to the new economy was less clear. Most agreed there is a need for better education. Fishermen clearly stated that more education was needed.

Recommended activities for Year 5 (FY 2016: April 1, 2016 – March 31, 2017) include:

- Community Needs Assessment to communities – presentation and feedback;
- Establish shrimp aquaculture for transitioning to community ($5–6 K);
- Continue oyster aquaculture project (no additional funds);
- Explore pairing of shrimp and oyster aquaculture;
- Visit to Guatemala, a group to include an expert(s) from the Indonesia case study.

3.5 Case study in Palau

A cast study visit to Palau was requested by MAFF. Ms. Kumiko Suzuki, research scientist from the Japan Wildlife Research Center (JWRC) will travel to Palau in November 2015 in order to assess the feasibility of Palau as a study site of the MarWeB project. After the visit, she will work with Dr. Makino to prepare a report summarizing the visit outcomes.

3.6 Findings of each case and consistency among cases

Following these case study reports, discussions focused on plans for next year, and how to integrate the outcomes from different case studies into the MarWeB manual and final report. The outcomes from these discussions are reported in 4.1 below.

3.7 Update on "well-being cube" work

As Ms. Juri Hori was unable to attend this meeting, a summary of the work on the "well-being cube" was presented by Dr. Makino. The "well-being cube" was developed to understand the structure of human well-being (HWB) in relation to the sea (*i.e.*, in a Sato-umi context). A short paper describing this approach is available in PICES Press (Hori, J. 2015. *A psychological perspective on "human well-being": an international comparison of the well-being structur*e. PICES Press, Vol. 23, No. 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 each in 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 each in China and Russia. In Year 5 (2016), this survey will be conducted in Canada.

4. FINAL PRODUCTS AND SUMMARY PRESENTATIONS

4.1 Manual development

Three key items should be represented in the manual:

1. Knowledge behind the tasks, including concepts, goals, concrete activities, relationships among activities, technical terms, *etc*.
2. Procedures/steps to do the tasks, such as flowcharts, steps of each activity, tips, *etc*.
3. Quality/standard for the tasks, including guidelines, criteria for judgements, qualities to be achieved, *etc*.

Rather than a general manual, the MarWeB outcome manual should provide an overview of Sato-umi and human-environment/social-ecological systems. It should then build from the two case studies, and include lessons learned and recommendations. It should also include links to the database (case studies data, bibliography, *etc*.). Consideration needs to be given to the intended readers of this manual, which will help define the manual format. MAFF has agreed that one manual will be sufficient, which would include lessons learned and integration from all of the MarweB case study activities. The expectation is that this manual would be posted on the PICES website, rather than printed in hard copy (although that is also an option for communication with local communities in Indonesia and Guatemala, in which case the manual would also need to be translated).

Six steps for manual development were recommended:

1. Clarification of objectives
   - What is the goal? Who will use it? Why is the manual needed? How/when will the manual be used?
2. Formation of the manual writing team
   - Setting the timetable, assigning the roles for authors, management of the writing process (progress report, data management, sharing the manuscripts/data, share the tools/software)
3. Development of the manual structure
   - Establishing the contents (structure of the manual), list of technical terms, concepts, basic knowledge, *etc*.
4. Organize the manual
   - Collect/arrange the information of each part, develop the flowchart of process, define/explain the unit of activities, *etc*.
5. Organize the judgment standard/criteria and tips for users
   - Set the judgment criteria for completing each activity, explain the matters to keep in mind, to-do and not-to-do, tips, develop the check list, often asked questions/mistakes, *etc*.
6. Write the text

Ms. Hori suggested putting the emphasis on the local situation, not the conceptual framework of the project itself, not requiring drastic changes but moderate and gradual improvements, emphasising the "beauty" of the goal to be achieved, and using photos of group activities (collective activities by people).

The outline for the manual was proposed as:

1. Introduction (Concept)
2. Why we need it? (Necessity)
3. How to introduce it? (Procedure)
4. How to assess it? (Quality standard)
5. Glossary

It was suggested that the main objective for the manual is to help local people work through their own specific situations towards the desired end result, under the general concept of Sato-umi (or marine ecosystem health and human well-being). It could include identifying the social–natural science interface, discussing social science survey methods (the methods used in MarWeB differed between the two case studies), and comparison of integrated results between the two case studies. An inter-sessional workshop was proposed to focus on the development of this manual.

4.2 Database development

The database could consist of a bibliography on relevant topics such as social-ecological systems, Sato-umi, IMTA, oyster aquaculture, well-being, *etc*. It could also include data from the pond (Indonesia) and oyster (Guatemala) experiments, data from the social surveys (Indonesia, Guatemala), and data from the "well-being cube" analyses (PICES member countries). The database should also be linked to the manual, so that the database provides the "raw" information for the manual. The database would be small, and so, perhaps, could be hosted on the PICES server.

Outstanding questions for discussion include:

- What "topics" or "key words" should be covered by the bibliography?
- How to conduct it? (Dr. Makino is prepared to lead this activity, but needs help for reviewing the product by each member country.)
- How will the data (social and ecological data from 2 cases and cube analyses) be prepared, and by whom?
- What should the database look like (structure)?
- Timeline (Deadline March 2017)

4.3 Possible need for an inter-sessional MarWeB meeting to work on product development

An inter-sessional meeting was felt to be needed to focus on product development. It was proposed to have this meeting in June 2016 in Victoria, Canada.

4.4 Presentations from MarWeb at major symposia/meetings

A MarWeB presentation at the ICES-led international symposium on "*Understanding marine socio-ecological systems: Including the human dimension in Integrated Ecosystem Assessments*" (June 2016, Brest, France) was suggested, with the potential funding included for a speaker. This would explain what the project is about, and raise its profile internationally. Dr. Keith Criddle, who is also one of the symposium convenors, or Dr. Grant Murray were proposed to represent MarWeB.

A MarWeb presentation at the PICES 2016 Annual Meeting was also suggested, for further discussion at the (possible) June 2016 inter-sessional meeting.

5. PROJECT MANAGEMENT

The estimated budget for the fifth year of the project (FY 2016: April 1, 2016 – March 31, 2017) is $60,000. There may be a small carry-over of unspent funds from FY 2015, and this will be confirmed once the accounting for Year 4 has been completed. The preliminary allocations for Year 5 are shown in Table 1. It should be noted that the proposed budget does not include allocations for an inter-sessional PST meeting and for travel support of a MarWeB speaker to the ICES human dimensions symposium, and the PICES overhead, which has been paid by each of the previous financial years. A request was made to use this overhead to cover the costs for the proposed inter-sessional PST meeting.

Table 1 Proposed MarWeB budget breakdown for Project Year 5 (FY 2016)

Indonesia		
Pond experiment	15,000	20,000
Social survey	5,000	
Guatemala		
Oyster project and follow up visit	23,000	23,000
Well-being cube		
Social survey in Canada	7,000	7,000
Meetings		
Travel support for 2016 PICES Annual Meeting	10,000	10,000
TOTAL		**60,000**

6. OTHER MATTERS

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

Appendix 1

Project Science Team membership

Harold (Hal) P. Batchelder	PICES Secretariat
Keith R. Criddle*	University of Alaska, Fairbanks, USA
Masahito Hirota	Fisheries Research Agency, Japan
Juri Hori*	Rikkyo University, Japan
Suam Kim	Pukyong National University, Korea
Mitsutaku Makino (Co-Chairman)	Fisheries Research Agency, Japan
Grant Murray	Institute for Coastal Research, Canada
Jongoh Nam*	Maritime Institute, Korea
Ian Perry (Co-Chairman)	Department of Fisheries and Oceans, Canada
Thomas Therriault	Department of Fisheries and Oceans, Canada
Vera Trainer	Northwest Fisheries Science Center, NOAA Fisheries, USA
Charles Trick	University of Western Ontario, Canada
Mark Wells	University of Maine, USA

* Unable to participate in the 2015 meeting

Participants of the sixth Project Science Team meeting for the PICES/MAFF project on "Marine ecosystem health and well-being" (left to right): Alexander Bychkov (PICES), Grant Murray (Canada), Suam Kim (Korea), Ian Perry (Canada; Co-Chairman), Masahito Hirota (Japan), Vera Trainer (USA), Harold Batchelder (PICES), Thomas Therriault (Canada), Charles Trick, Mitsutaku Makino (Japan; Co-Chairman) and Mark Wells (USA).

Appendix 2

Sixth Project Science Team meeting agenda

1. Adoption of the agenda
2. Introduction to the project (Mitsutaku Makino)
3. Progress reports
   - 3.1 Annual Reports for Science Board and MAFF/JFA (Co-Chairs)
   - 3.2 Summary of the fifth PST meeting (Co-Chairs)
   - 3.3 Case study in Indonesia (Mark Wells, Masahito Hirota)
   - 3.4 Case study in Guatemala (Vera Trainer and Charles Trick)
   - 3.5 Case study in Palau (Mitsutaku Makino)
   - 3.6 Findings of each case and consistency among cases (All)
   - 3.7 Update on "well-being cube" work (Mitsutaku Makino)
4. Final products and summary presentations
   - 4.1 Manual development
   - 4.2 Database development
   - 4.3 Possible need for an inter-sessional meeting to work on product development
   - 4.4 Presentations from MarWeb at major symposia/meetings:
     - ICES-led symposium on human dimensions in fisheries (June 2016, Brest, France),
     - 2016 PICES Annual Meeting (November 2016, San Diego, USA),
     - PICES human dimension symposium (spring 2018, Japan?)
   - 4.5 Others
5. Project management
   - 5.1 Project Science Team membership
   - 5.2 Year 4 (FY 2015) workplan and budget execution (Alexander Bychkov)
   - 5.3 Year 5 (FY 2016) workplan and budget
6. Other matters (related expert groups in PICES, PICES Press, publications, *etc*.)

Seventh Meeting of the Project Science Team
June 22–24, 2016, Victoria, Canada

The seventh 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 June 22–24, 2016, in Victoria, Canada.

The meeting was co-chaired by Drs. Mitsutaku Makino (Japan) and Ian Perry (Canada). The Project Science Team members and meeting participants are identified in *Appendix 1*.

1. ADOPTION OF THE AGENDA

The agenda was adopted as proposed (*Appendix 2*).

2. INTRODUCTION TO THE MEETING

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. 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 do human communities support sustainable and productive marine ecosystems.

Dr. Makino briefly reviewed the background and context for the project and pointed out that objectives for this meeting are to discuss: (1) the features that integrate all of the MarWeB activities, in particular lessons learned from two case studies as to what they tell us about marine ecosystem health and human well-being, and how to implement them in practice, and (2) the plan for the manual and the database development with concrete timetable. It was noted that final products are to be submitted to MAFF/JFA by the end of July 2017 and that reports from previous PST meetings, annual progress and financial reports, and other project-related materials are available on the project's website at http://meetings.pices.int/projects/marweb.

3. PROGRESS REPORTS

The MarWeB project has focussed on three major initiatives:

1. Social-ecological interactions related to integrated multi-trophic aquaculture in Indonesia;
2. Social-ecological interactions related to small-scale shrimp aquaculture in Guatemala;
3. Development of the "well-being cube" approach to assessing national well-being related to marine systems.

3.1 Case study in Guatemala

The Guatemala case study was conducted at the locations on the Pacific Coast shown in Figure 1, and the following vital aspects of the studied communities were apparent:

- Seafood, in particular pelagic finfish and shrimp, is an important component of local diets;

- "Fishing" is a culturally-determining part of the community, but many in these communities expressed a desire to move away from such high dependence on the sea.

Implementation of Sato-umi in Guatemala depended upon the building of trust and relationships with local people, and with shifting the focus from fishing to eco-tourism and other activities. Fishermen see the future as a balance, and suggest that the next generation of fishermen should be fewer and better educated in sustainable business practices. Creation of sustainable, targeted tourist activities requiring local expertise would provide visitors with a richer, home-grown, more comprehensive experience. But how can these communities achieve this goal? For example, what are the foundations that will support a sustainable project? what product development is needed? and what are the considerations for a community tourism project?

Fig 1 Guatemala case study locations: Monterrico, Las Lisas, and La Barrona.

Three needs for the future were identified by the communities: (1) an economy based on tourism, (2) aquaculture for improving the economy and family nutrition (especially with shrimp), and (3) education, especially with respect to sustainable fisheries and harmony with the sea (*e.g.*, see Fig. 2).

Fig. 2 Cartoon of interactions between healthy natural systems and healthy human systems in coastal regions (FRA, Japan).

To date, the Guatemala case study has the following recommendations:

- A healthier lifestyle can be facilitated with opportunities for better education, sustainable environmentally-friendly tourism, and environmentally-considerate aquaculture opportunities.
- Protection of the lagoon waters is essential, as these waters are breeding grounds for many major economically valuable species.
- Community-wide, coordinated eco-tourism and fishing trips for tourists can be implemented to create a more sustainable alternative to fishing for sustenance.
- An alternative source of fish-based food supplies must be sought, such as aquaculture.
- The communities have a relationship with the University of San Carlos and should work with the faculty and researchers to develop sustainable associations.

In contrasting the MarWeB case studies, it would be helpful to describe that the studied communities are in different ecosystems (*e.g.*, no seaweeds in Guatemala in contrast to Indonesia), and have different business context for shrimp, both within the two villages compared in Guatemala and with Indonesia.

A second project in Guatemala concerned the culture of the Pacific oyster *Crassiostrea gigas* in the coastal estuary at La Barrona. Its primary objectives were to determine: (1) the productivity of bivalve mollusks, (2) growth rates and time needed for then to reach a market size, and (3) survival at different phases of culture. Unfortunately, this project struggled with problems of theft of the equipment and study organisms.

The Guatemala case study team proposed the following workplan for 2017:

- Engage with a UNDP (United Nations Development Program) project on "Conservation and sustainable use of biodiversity in coastal and marine protected areas" intended to support and expand the five Marine Protected Areas (MPAs) on the Pacific coast of Guatemala, and synergize the results of the MarWeB project with their plans to create marine protected areas in the communities of Las Lisas and Monterrico; carry out a final trip to the communities to facilitate their communications with leaders of the UNDP project;
- Continue the oyster project by providing further advice to the community of La Barrona (no additional funding is needed);
- 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 a sustainable aquaculture pond in the coastal region.

3.2 Case study in Indonesia

As with Guatemala, Indonesia is an under-developed country, and is relatively poor, but with a much larger population and better connections to the outside world. The region of Karawang developed pond aquaculture about 10 years ago, but disease has since wiped out most shrimp, and the ponds have largely been abandoned, leaving a degraded area. Fish are plentiful in the local markets, but are very small. The MarWeB project's focus was to identify methods to help boost economic returns for this activity and to reduce deleterious water quality *via* multi-trophic aquaculture.

The Indonesia case study has two components: (1) a natural science-based study of improving pond aquaculture and (2) a social science-based study of markets and human benefits.

Pond experiment

The approach was experimental, using Integrated Multi-trophic Aquaculture (IMTA) methods that are amenable to the low-intensity, low technology, and limited financial resource conditions of community-scale aquaculture in Karawang, Indonesia. The goal is to identify project outcomes that have tangible effects on improving human well-being in this region. The focus here has been to optimize the balance between:

- Maximum harvest of the primary aquaculture product (shrimp or tilapia),
- Added income through by-production of co-cultured food or marine products, and
- Minimum excess nutrient discharge from these operations into coastal waters, which currently leads to degradation of coastal ecosystems.

The 2015 experiment was more successful than in 2014 in that the whiteleg shrimp (*Litopenaeus vannamei*) and *Tilapia* sp. showed good growth in all treatments. The overall product yield was less than NCBA (National Center for Brackishwater Aquaculture) staff had hoped for (even in the controls), for reasons they do not know. One difference between years was that the ponds were filled with brackish canal water in 2014, but brackish groundwater in 2015. The 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). Neither

Gracilaria nor *Anadara* showed significant growth over the experiment in 2015, despite elevated levels of dissolve nutrients (for *Gracilaria*) and phytoplankton and detrital abundance (for *Anadara*).

In 2016, the plan was to concentrate on shrimp aquaculture and leave out tilapia: the IMTA shrimp showed a tangible profit, and the simplicity of a two-species IMTA stands a better chance of being implemented by community growers. *Gracilaria* would be used but not *Anadara*, because there was no growth of *Anadara* in previous experiments and it is not common in the region. There also is anecdotal evidence that *Gracilaria* may restrict pathogen growth. In addition, the abundance of *Gracilaria* in the ponds was increased from the current 0.1 kg/m^2 to three treatments of 0.5, 1.0, and 2.0 kg/m^2. *Gracilaria* in the ponds was also placed on floating rafts rather than attaching it to the bottom in an attempt to increase its growth by increasing the light intensities to which it is exposed.

Social studies

- What are the people's needs for marine ecosystem services in Indonesia (well-being cube analysis)?
- How can IMTA respond to these needs? What are the ecological and social benefits to be delivered by IMTA?
- How can such effects contribute to human well-being (for example, analysed using a structural equation modelling approach to human well-being)?

The Indonesian case study attempted to introduce "change" to the community in both the natural and social systems, leading to improved well-being. Well-being here is interpreted to mean having free time to spend with family, and a wide variety of jobs (a varied commodity chain). Using the well-being cube approach, well-being concepts for the community involved economic growth and local capacity building. Key words included stability, beneficial, aesthetic (*e.g.*, food culture and variety), and the ability to change.

The well-being cube analysis identified psychological needs for marine ecosystem services in Indonesia. IMTA can meet these needs by six expected effects: (1) more food, (2) safer food, (3) more jobs, (4) more wealth, (5) better water quality, and (6) protection of land and coastline. These effects improve the human well-being as defined by the Millennium Ecosystem Assessment (2005), mainly *via* "basic material for good life". This leads to "freedom of choice and action" and to a broader introduction of IMTA, *etc*. for producing a healthy and sustainable ecosystem for Indonesian people. Recent studies by Kasperski *et al*. (Amber Himes-Cornell and Stephen Kasperski. 2016. Using socio-economic and fisheries involvement indices to understand Alaska fishing community well-being. *Coastal Management* 44: 36–70) may be useful as a guide to potential analyses of the Indonesia data.

3.3 Case study comparisons

The section on case study comparisons in the MarWeB scientific report could include the following components:

- Features that integrate activities;
- Lessons learned;
- Interactions between the social and ecological systems;
- How to implement the case studies;

- Importance of community involvement, *i.e.*, reflections on the process;
- Recommendations;
- Ways forward/next steps.

Both case studies are combinations of research questions, and interventions, *i.e.* attempts to fix the identified problems (*e.g.*, *via* IMTA), but there are points to recognise regarding similarities and differences of case studies.

The comparison could contrast shrimp aquaculture in both countries, *e.g.*,

- Compare top-down *versus* bottom-up drivers of change, and who "sees" the presence of a social and/or ecological problem, and the need for solutions:
    - Indonesia: Government "sees" the problems, and wants development and change. Government is interested to enable people to put food "on their tables", but also to improve environmental quality. The motivation in Indonesia may be to achieve a "sustainable environment".
    - Guatemala: Large industry "sees" no problems, and therefore is reluctant to change the existing processes of intensive shrimp culture. The community need is to put food on the table on a daily basis. The motivation in Guatemala may be "subsistence".
- Indonesia appears to have developed a "discovery-based" process, *e.g.*, the introduction of IMTA. The government plans to increase aquaculture significantly, and the concept of well-being can help identify non-economic consequences of such intensive aquaculture development.
- Guatemala appears to have developed a "risk-averse" process, *e.g.*, do not change what is working now.

The MarWeB report should be in the PICES Scientific Reports series. It could be organised as different activities, for example:

- Large-scale comparisons of people's responses and feelings towards the sea, *i.e.*, well-being cube analyses;
- Case study comparisons, as examples of "Sato-umi" type approaches with respect to people and how they feel about the sea;
- Descriptions of the manual, and database, to accompany the scientific report.

The Introduction should address the conceptual difference (*e.g.*, as identified in PICES Working Group 19 report (PICES Scientific Report 37, 2010). For example, how can we have productive and biodiverse marine ecosystems which include people? PICES WG 19 concluded that concepts differ among PICES member countries with respect to what constitutes a "healthy" ecosystem. For example, the United States, Canada, and Russia have generally more natural systems which they are trying to maintain, whereas Japan, Korea, and China have more human-dominated systems. These different perceptions lead, in North America, to concepts or marine protected areas whose objectives are largely to protect and preserve existing (relatively undeveloped) conditions, whereas for East Asian nations concepts in which people are fully part of the system are more realistic goals.

The use of a livelihoods approach could be a helpful way to compare these two case studies which could also be used to contrast the importance of wild fisheries and aquaculture to these communities. For example, where is each case study on the same scale of fisheries/aquaculture development? When fisheries are in

decline, aquaculture is often seen as an alternative. But what are the local problems and issues for developing such approaches? What are the local (and social) benefits of developing integrated multi-trophic aquaculture?

The report should include the following elements and considerations:

- Features that integrate all of our activities, lessons learned, interactions between social and ecological systems, how to implement it, recommendations, way forward, *etc*.;
- Similarities: Problems in capture fisheries and introduction of aquaculture, including both research questions and interventions, key person/local point person (academic);
- Differences: Structure of shrimp farming industry, top-down *vs*. bottom-up, outsiders, livelihoods;
- Need to be careful to define concepts correctly for local situations. For example, the practice of "markets" differs between Guatemala and Indonesia. In the former, markets are very local, for example using small stalls, whereas in the latter markets are larger and more diverse.
- The Guatemala case study was highly successful at reporting back to the communities on the results of their "clicker" surveys, and including a booklet of photos taken during the meetings (so that participants, and others in the villages, could show themselves present and participating in the meetings);
- What can be learned from the Guatemala oyster experiment in La Barrona (and its problems) regarding how to apply similar experimental studies to other communities that indicate aquaculture as a solution?
- From the Indonesia case study, the manual could describe how the pond experiments were conducted, and why they were chosen;
- The use of the commodity chain approach, and how to create a commodity chain in the local community, could be a useful method to compare and contrast different case studies.

General lessons learned:

- Relationship building and trust;
- Persistence;
- Feedback of results;
- Investment of time and effort;
- Building capacity of local researchers and people;
- Successful research partnerships;
- How do these activities help the local point-people/contacts, *i.e*., their personal motivations?

Lessons learned from the Guatemala case study:

- Clicker surveys allow anonymity, and help to overcome language and cultural barriers. It is very important to carefully develop the questions to be posed to the community;
- Collaboration is essential for decision making (not the "big daddy" approach);
- Open mindedness and listening are critical;
- An in-country "point person" is essential for consultations and to provide a "feedback loop" in regard to the activities and for interpreting the outcomes.

Negative lessons learned:

- Declining budget;
- Lack of capacity (*e.g.*, complex social-ecological systems modelling) – may need to provide direct support or direct collaborations, rather than *via* contracts;
- Community leadership/directions are positive, but may make comparisons among case studies difficult, for example, both case studies were begun with ideas of IMTA and community support, but each evolved in different ways due to community interests and directions.

The following identifies key aspects of marine social-ecological systems, and how they compare between Guatemala and Indonesia:

	Guatemala	**Indonesia**
Driving change	Community (bottom-up)	Government (top-down)
Shrimp aquaculture	Industry reluctant to change	Government promoting change
Key contacts	Academic scientists	Government scientists
History	Over-exploitation (internal and external)	Over-exploitation (internal)
Community-scale aquaculture	Risk-averse	Discovery-based
Motivation	Subsistence	Sustainable development
Industry-scale aquaculture	Profit-oriented	Profit
Outreach/education	Local outreach centres	Workshops organised by federal government
Role of PICES scientists	Advisor to local university and communities	Advisor to government
Population (demographics, affluence)	Few	Many
Commodity change	Simple	Extensive (local and export consumption)

Well-being, and how this was addressed or manifested differently in each case study, may provide a helpful integrating concept. Where, and how, is well-being achieved? This also relates to each community's self-concept of well-being, *e.g.*, the contrast between the different perceptions of community well-being between Montericco and Las Lisas in Guatemala. This can also be compared with the results for well-being from the well-being cube analyses.

4. MANUAL DEVELOPMENT

A general "Manual", providing an overview of the social-ecological systems approach and Sato-umi for local government officers and researchers in developing countries, is expected. It was recommended to consider the manual as a PICES Advisory Report (see, as an example, the Advisory Report on "*Fisheries and Ecosystem Responses to Recent Regime Shifts in the North Pacific*" at http://www.pices.int/publications/brochures). The date for submission of this report to MAFF is July 31, 2017.

The process would be to develop the longer PICES Scientific Report (as described above), from which core material would be extracted and reformatted as a general "how-to" manual of an advisory report. For example, the Advisory Report would have about 12–16 pages, many pictures, a focus on lessons learned and recommended approaches, with perhaps case studies and the well-being cube approach as "boxes" to explain and highlight how things were done in these studies. The beginning should highlight a broad definition of well-being, and ecosystem health, *etc*., and how (and why) this was implemented in this project. It should also point out the importance of starting with broad questions, and then refining these in discussions with the local communities and/or governments. The outcome of this process may then require changes to the expertise of the project team.

Additional points to consider include:

- Why we choose these particular case studies, and how to select case studies, *i.e*., criteria for selection:
  - Importance of existing connections and relationships (for example, in this project case studies were selected in part based on previous relationships, including those established during the previous MAFF-funded PICES projects);
  - Selection considered "degraded" systems – therefore, we do not want to "sustain" these systems, but to help them improve.
- For successful projects it would essential to have:
  - Dedicated in-country co-participants, for example, from the university in the case of Guatemala or from the state agency in the case of Indonesia;
  - A dedicated interpreter who understands the project and Project Science Team needs, as well as enthusiastic locals who can provide translation.

Based on discussions and comparison of the two case studies, it was recommended that the manual include elements such as:

- Local needs identification (community needs assessments, clicker survey, well-being cube analysis, hearings, *etc*.) for "healthy and sustainable ecosystems";
- How to define human well-being, and its complementary question about how to define healthy marine ecosystems; Indonesia may be a "more developed" version of Guatemala in regard to responding to these questions;
- Interventions: the use of new technologies, activities, or operations (eco-tourism, oyster aquaculture, IMTA, education, *etc*.) to meet such needs;
- Scientists/universities/government / international organizations and programs (UNDP, NGOs, *etc*.) are important for outreach and training processes;
- "Point people" are the key to making every step successful;
- "Trial and error" is to be expected (*e.g*., the Indonesia pond experiments);
- Declines in fishing are common, as are intentions to supplement with aquaculture.

Appendix 3 provides a first draft outline for the manual contents.

Manual and database development timeline:

- Zero order draft of the Scientific Report, suggestions of the manual contents: October 3, 2016;
- Writing the manual: November and December 2016;
- Visit to Guatemala and Indonesia: January 2017;
- Final draft (both Scientific Report and manual) and draft bibliography: March 31, 2017;
- Circulate and update the bibliography, prepare the project presentations, prepare the raw data from two case studies: April to June 2017;
- Submission: The end of July 31, 2017.

5. DATABASE DEVELOPMENT

Appendix 4 provides a first draft outline of the database contents. This could include:

Bibliography on relevant topics (social-ecological systems, Sato-umi, IMTA, oyster aquaculture, well-being, *etc*.)

- List of references as a searchable Word document;
- Published papers on a password-protected site (noting copyright issues with commercially-published papers);
- References to literature cited in our MarWeB publications/reports;
- List of key words for specific topic areas that can be used to obtain recent papers;
- "Must-read" references for key topic areas (similar to Current Opinion in Environmental Studies highlighting) to be identified during report sections writing;
- Base bibliography of well-being in English to be provided by Dr. Murray who has a student working on this topic.
- Activity to be led by Dr. Makino and completed by the end of March 2017.

Photos

- Lots of photos were taken during the case studies, including photos of people;
- No problem with non-people photos, but we are likely not going to be able to post people photos due to privacy issues.

Data (from the pond experiments in Indonesia and oyster experiments in Guatemala; from the social surveys in Indonesia and Guatemala, and from the "well-being cube" analysis in PICES member countries)

- Likely no problem with posting raw data (*e.g*. from the "clicker" surveys in Guatemala);
- Need adequate meta-data and descriptors;
- Need to clear posting data with case study partners;
- Need some work to provide English translations (*e.g.*, the well-being cube study questions from Japanese).

The database should be linked to the manual, so that it provides the "raw" information for the manual. The database would be small, and so, perhaps, could be hosted on the PICES server.

It was also agreed to build a MarWeB Final Presentation and make it available on the project website for all to use. It was suggested that perhaps two presentations are needed: one more general and high-level and the other with more scientific details.

6. OTHER MATTERS

6.1 Budget and proposed allocations for Year 5

The MAFF contribution for Year 5 of the project (April 1, 2016 – March 31, 2017) is $66,989. Moving the Year 4 account balance of $7,411 to Year 5 brings the total available funding for the final year of the project to $74,400. The proposed Year 5 budget breakdown is shown Table 1 (Year 4 balance is credited to "Contracts").

Table 1 Proposed budget breakdown for Year 5

Category	Year 5 allocation	Year 4 balance	Total allocation
Travel and meetings	28,089		35,500
Contracts	29,400		29,400
Equipment and supplies			
Miscellaneous	791		791
Overhead	8,709		8,709
Total	**66,989**	**7,411**	**74,400**

A budget of $25,000 was requested for the final project work in Guatemala:

1. Final trip to Guatemala (1 week in Jan/Feb 2017) – $10,000 (assuming that the UN project pays local costs);
2. Nutrient analysis and consulting on sustainable aquaculture outreach – $7,000 (contract);
3. Translation services – $5,000 (contract);
4. Guatemala student and PI liaisons and supplies – $3,000.

6.2 Topic session proposal for PICES 2017

A proposal for a 1-day Topic Session to be held at the 2017 PICES Annual Meeting (Vladivostok, Russia) will be developed by PST Co-Chairs during the summer, circulated for discussion and submitted through the PICES online system in September. The session focus would be on well-being, or social-ecological marine systems, and should include links among social and natural sciences. Suggested session titles are: "*Well-being in marine resources management*" or "*Marine ecosystem health and human well-being*". Though the session description should expand beyond the scope of the project, it is expected to have two presentations from each MarWeB case study, plus an introduction and a concluding presentation. Dr. Makino will contact Dr. Tetsuo Yanagi for a possible contribution.

6.3 Potential next MAFF-supported project

A new MAFF-supported project, involving natural and social scientists, is still being developed. The anticipated project duration is 3 years, with funding at the level of $100,000 CAD per year. The project emphases are on capacity building in local communities, local food security, and manual development for social assessments, and project keywords are Sato-umi and blue growth aquaculture. Expected case study locations are Indonesia and Vietnam.

The meeting concluded at 12:00 on June 24. The next PST meeting will take place on November 2, 2016, in conjunction with the 25th Annual Meeting of PICES.

Appendix 1

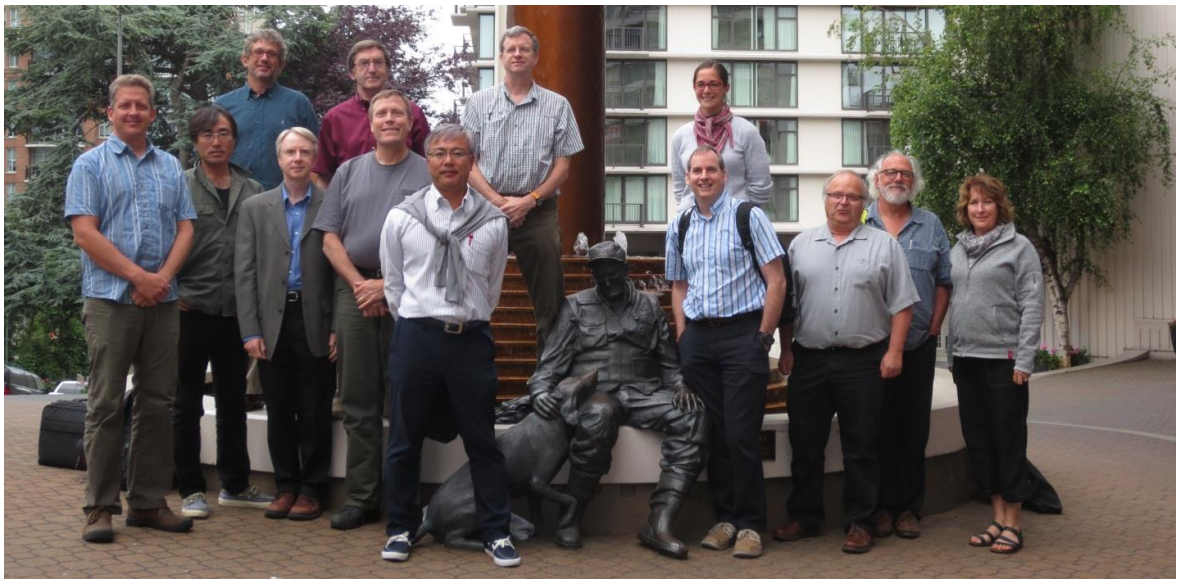
Project Science Team membership

Harold (Hal) P. Batchelder	PICES Secretariat
Keith R. Criddle	University of Alaska, Fairbanks, USA
Masahito Hirota	Fisheries Research Agency, Japan
Juri Hori*	Rikkyo University, Japan
Suam Kim*	Pukyong National University, Korea
Mitsutaku Makino (Co-Chairman)	Fisheries Research Agency, Japan
Grant Murray	Institute for Coastal Research/Duke University, Canada/USA
Jongoh Nam*	Maritime Institute, Korea
Ian Perry (Co-Chairman)	Department of Fisheries and Oceans, Canada
Thomas Therriault	Department of Fisheries and Oceans, Canada
Vera Trainer	Northwest Fisheries Science Center, NOAA Fisheries, USA
Charles Trick	University of Western Ontario, Canada
Mark Wells	University of Maine, USA

* Unable to participate in the meeting

Additional participants in the 2016 Victoria meeting:

Robin Brown	PICES Executive Secretary
Alexander Bychkov	PICES Special Projects Coordinator
Elizabeth Figus	University of Alaska, Fairbanks, USA



Participants of the seventh Project Science Team meeting for the PICES/MAFF project on "Marine ecosystem health and well-being" (left to right): Grant Murray (Canada), Masahito Hirota (Japan), Mark Wells (USA), Ian Perry (Canada; Co-Chairman), Alexander Bychkov (PICES), Keith Criddle (USA), Mitsutaku Makino (Japan; Co-Chairman), Harold Batchelder (PICES), Thomas Therriault (Canada), Elizabeth Figus (USA), Robin Brown (PICES), Charles Trick (Canada), and Vera Trainer (USA).

Appendix 2

Seventh Project Science Team meeting agenda

1. Adoption of the agenda
2. Introduction to the meeting (Co-Chairs)
3. Progress reports from two case studies
   - 3.1 Case study in Guatemala (V. Trainer and C. Trick)
   - 3.2 Case study in Indonesia (M. Wells, M. Hirota and M. Makino)
   - 3.3 Discussion: Features that integrate all of MarWeB activities, lessons learned, interactions between social and ecological systems, how to implement it, recommendations, way forward, *etc*.
4. Manual development
   - 4.1 Contents and outlines
   - 4.2 Role allotment
   - 4.3 Timetable till March 2017
5. Database development
   - 5.1 Contents and outlines
   - 5.2 Role allotment
   - 5.3 Timetable till March 20176.
6. Other matters (PICES-2017 Topic Session, other related project in the future, *etc*.)

Appendix 3

Contents of the Manual (Draft)

1. Introduction (M. Makino and I. Perry)
   1.1 What is the Social-Ecological Systems (SES) approach?
   1.2 Why it is useful for local fishing community?
2. Procedures for the fisheries SES analysis (M. Makino and I. Perry)
   2.1 Identification of site and point person
   2.2 Identification of local needs
   2.3 Potential intervention and SES impact assessment
   2.4 Outreach
3. Case study (1): Oyster aquaculture in Guatemala (V. Trainer and C. Trick)
   3.1 Identification of site and point person
   3.2 Identification of local needs
   3.3 Potential intervention and SES impact assessment
   3.4 Outreach
4. Case study (2): IMTA for shrimp aquaculture in Indonesia (M. Wells, M. Hirota, J. Hori and M. Makino)
   4.1 Identification of site and point person
   4.2 Identification of local needs
   4.3 Potential intervention and SES impact assessment
   4.4 Outreach
5. Conclusions (M. Makino, I. Perry and all)
   5.1 How marine ecosystems support human well-being
   5.2 How human community support “ideal” or “healthy” marine ecosystems

Appendix 4

Contents of the Database (Draft)

1. Presentations, articles, and reports about MarWeB Project.
2. Bibliography on SES approach, Sato-umi, IMTA, oyster aquaculture, commodity chain analysis, well-being analysis, community analysis, *etc*.
3. Data from case studies (Guatemala, Indonesia, photographs, *etc*.).

Eighth Meeting of the Project Science Team
November 2, 2016, San Diego, USA

The eighth 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 November 2, 2016, in conjunction with the 2016 PICES Annual Meeting in San Diego, USA.

The meeting was co-chaired by Drs. Mitsutaku Makino (Japan) and Ian Perry (Canada). The Project Science Team members and meeting participants are identified in *Appendix 1*.

1. ADOPTION OF THE AGENDA

The agenda was adopted as proposed (*Appendix 2*).

2. INTRODUCTION OF THE MEETING

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. 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.

The meeting objectives were to finalize: (1) the research, especially, the two case studies in Indonesia and Guatemala and human well-being analysis and (2) the timetable until the end of this project, especially the manual and database development.

Reports from previous PST meetings, annual progress and financial reports, and other project-related materials are available on the project's website at http://meetings.pices.int/projects/marweb.

3. BUDGET SITUATION

The Project Coordinator, Dr. Alexander Bychkov, noted the MarWeB project is in its final year, and all final reports must be submitted to MAFF by July 31, 2017. It was suggested in discussion that a meeting of a few members of the Project Science Team may be needed to discuss issues that are likely to arise as the PICES Scientific Report and Advisory Report/Manual are being finalized. One opportunity for a low-cost meeting would be to hold it coincident with the Small Pelagics Symposium (March 6–11, 2017, in Victoria, Canada) as a number of Project Science Team members will attend that symposium or live nearby.

It was recommended that some of the remaining funds for the project be made available to assist with a final visit to Guatemala in January–February 2017, and preparation of the final reports and assembly of data, photos and the bibliography that will comprise the MarWeB database. Funding for the publication of the Scientific Report and Advisory Report is expected to come from the PICES general publication budget.

4. PROGRESS REPORTS

The MarWeB project has focussed on three major initiatives:

1. Social-ecological interactions related to integrated multi-trophic aquaculture in Indonesia;
2. Social-ecological interactions related to small-scale shrimp aquaculture in Guatemala;
3. Development of the "well-being cube" approach to assessing national well-being related to marine systems.

4.1 Guatemala case study

Conclusions to date from the Guatemala case study included:

- Tourism is not just for visitors, but improves life for the whole community by bringing in opportunities for education and income for community members – women, men, and children.
- A healthier lifestyle can be facilitated with opportunities for better education, sustainable environmentally-friendly tourism, and environmentally-considerate aquaculture opportunities.
- Protection of the lagoon waters is essential, as these waters are breeding grounds for many major economically-valuable species.
- Community-wide, coordinated eco-tourism and fishing trips for tourists can be implemented to create a more sustainable alternative to fishing for sustenance.
- Alternative source of fish-based food supplies must be sought – such as through aquaculture.
- The communities have a relationship with the University of San Carlos and should work with the faculty and researchers to develop sustainable associations.

The oyster aquaculture trial study had difficulties with theft of installations. However, the community was very enthusiastic about the project. The results obtained from the trial period demonstrate that culturing of *Crassostrea gigas* is feasible in Guatemala despite relatively low water recirculation rates and a high amount of suspended solids in the water column. *C. gigas* can achieve the commercial market size of 70 mm in diameter in six months; however, the system must be cleaned every 15 days in order to maintain and/or improve the survival rates.

Lessons from the Guatemala case study in regard to establishing a Sato-umi type approach to people and the sea included:

- The "clicker" surveys allow anonymity (language and cultural barriers);
- Collaboration is essential for decision making (not the "big daddy" approach);
- Open mindedness and listening are critical;
- An in-country constantly consulted "point person" is needed (feedback loop);
- Oyster culture can work as an alternative to high intensity shrimp culture.

A final visit to Guatemala is planned for February 2017 in order to facilitate communications among these communities and leaders of a United Nations Development Program (UNDP) project intended to support and expand the five Marine Protected Areas on the Pacific coast of Guatemala.

4.2 Indonesia case study

Dr. Masahito Hirota presented his work on a commodity chain analysis of seafood in Karawang Province, and how the products from the MarWeB Integrated Multi-Trophic Aquaculture (IMTA) study may benefit the community. It was recommended that this material be included in the Scientific Report and the Advisory Report/Manual from this project. It was also suggested that the Advisory and Scientific reports comment on the common steps for social science surveys conducted in Indonesia and Guatemala (*i.e*., the commodity chain analysis in Indonesia and the community needs assessment in Guatemala), but also note their differences due to the different local situations.

Dr. Mark Wells described progress in the pond experiments in Indonesia, specifically in regard to reducing nutrients and generating new products using an IMTA approach. Our local MarWeB scientific collaborators were beginning to make positive progress, perhaps in part as a result of becoming more familiar with these new approaches. A paper in the primary scientific literature is being planned.

4.3 Well-being cube study

Dr. Makino presented the latest results on the well-being cube study on behalf of Ms. Juri Hori. He noted the recent publication of a paper on this subject: Hori, J., and Makino, M. 2016. Analysis and international comparison of structure of human well-being provided by marine ecosystem services. *Bull. Japan Soc. Fish. Oceanogr*., 80(3): 199–206 (in Japanese with English Abstract). The abstract of this paper states:

In order to evaluate how the marine ecosystems and social environments affect human well-being, feeling of satisfaction according to the five components of human well-being defined by the Millennium Ecosystem Assessment (Security, Basic material for good life, Health, Good social relations, and Freedom of choice and action) was examined by means of questionnaires. Structural Equation Modeling (SEM) analysis was applied to visualize the basic structure of human well-being and to compare among three Asian countries (Japan, Korea and Indonesia) which are highly dependent on fisheries. The SEM analysis showed that the three countries shared a common basic structure of the human well-being, with the five components interacting with each other. However, the intensity of interaction between each component differed among the three countries. "Good social relationship" strongly influences "Freedom of choice and action" as the most important component in Japan and Korea, while "Health" does in Indonesia. Consideration of the differences in the structure of human well-being among the countries is suggested to be important for better conservation and management of marine ecosystems.

4.4 Discussion

The Project Science Team recommended the Scientific Report and Advisory Report should include these scientific outputs, possibly highlighted as boxes to the main text. An example of Sato-umi in practice should be included as an additional box. It was also noted that the relationships of marine ecosystem health and human well-being are place-dependent, as demonstrated for example, by the outcomes of the well-being cube analyses and by comparisons among the three communities in the Guatemala case study. Therefore, there is a need to identify the local perceptions of the specific problems faced by these communities (and hence the importance of the community needs assessment and commodity chain analyses).

5. MANUAL AND DATABASE DEVELOPMENT

It was recommended that the manual focus on the format of a PICES Advisory Report. Contents of the database were recommended to include:

Bibliography on relevant topics (social-ecological systems, Sato-umi, IMTA, oyster aquaculture, well-being, *etc*.)

- List of references as a searchable Word document;
- Published papers on a password-protected site (noting copyright issues with commercially-published papers);
- List of key words for specific topic areas that can be used to obtain recent papers;
- "Must-read" references for key topic areas (similar to Current Opinion in Environmental Studies highlighting) to be identified during report sections writing;
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- Activity to be led by Dr. Makino and completed by the end of March 2017.

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Data (from the pond experiments in Indonesia and oyster experiments in Guatemala; from the social surveys in Indonesia and Guatemala, and from the "well-being cube" analysis in PICES member countries)

- Likely no problem with posting raw data (*e.g*. from the "clicker" surveys in Guatemala);
- Need adequate meta-data and descriptors;
- Need to clear posting data with case study partners;
- Need some work to provide English translations (*e.g*., the well-being cube study questions from Japanese).

6. OTHER MATTERS

6.1 Topic session proposal for PICES-2017

A topic session proposal for PICES-2017 (Vladivostok, Russia) is included in *Appendix 3*.

6.2 Next PICES-MAFF project for 2017–2019

Dr. Hirota presented a proposal for the next PICES-MAFF project, "*Building capacity for ecosystem-based management in small-scale nearshore fisheries impacted by coastal zone development*" (tentative title), recommended for 2017–2019.

Dr. Makino thanked the participants for their ongoing efforts in support of the MarWeB project. The meeting was adjourned at 18:00.

Appendix 1

Project Science Team membership

Harold (Hal) P. Batchelder	PICES Secretariat
Keith R. Criddle	University of Alaska, Fairbanks, USA
Masahito Hirota	Fisheries Research Agency, Japan
Juri Hori*	Rikkyo University, Japan
Suam Kim	Pukyong National University, Korea
Mitsutaku Makino (Co-Chairman)	Fisheries Research Agency, Japan
Grant Murray	Institute for Coastal Research, Canada
Jongoh Nam*	Maritime Institute, Korea
Ian Perry (Co-Chairman)	Department of Fisheries and Oceans, Canada
Thomas Therriault	Department of Fisheries and Oceans, Canada
Vera Trainer	Northwest Fisheries Science Center, NOAA Fisheries, USA
Charles Trick*	University of Western Ontario, Canada
Mark Wells	University of Maine, USA

* Unable to participate in the meeting

Additional participants in the 2016 Victoria meeting:

Alexander Bychkov	PICES Special Projects Coordinator
Toyomitsu Horii	Fisheries Research and Education Agency, Japan

Participants of the eighth Project Science Team meeting for the PICES/MAFF project on "Marine ecosystem health and well-being" (left to right): Masahito Hirota (Japan), Mark Wells (USA), Keith Criddle (USA), Alexander Bychkov (PICES), Mitsutaku Makino (Japan; Co-Chairman), Vera Trainer (USA), Thomas Therriault (Canada), Suam Kim (Korea), Toyomitsu Horii (Japan), Harold Batchelder (PICES) and Ian Perry (Canada; Co-Chairman).

Appendix 2

Eighth Project Science Team meeting agenda

1. Adoption of the agenda
2. Introduction to the meeting (Mitsutaku Makino)
3. Budget situation (Alexander Bychkov)
4. Final progress reports
   - 4.1 Case study in Guatemala (Vera Trainer and Charles Trick)
   - 4.2 Case study in Indonesia (Mark Wells, Masahito Hirota)
   - 4.3 Well-being analysis (Mitsutaku Makino)
   - 4.4 Discussion
5. Manual and database development
   - 5.1 Contents and outline (Mitsutaku Makino)
   - 5.2 Timetable till March 2017
6. Next steps
   - 6.1 Topic session proposal for PICES-2017 (Ian Perry)
   - 6.2 Next PICES-MAFF Project for 2017–2019 (Masahito Hirota)

Appendix 3

MarWeB Topic Session (S8) for PICES-2017 (Vladivostok, Russia)

"Marine ecosystem health and human well-being: A social-ecological systems approach"

Co-Convenors: Keith R. Criddle (USA), Mitsutaku Makino (Japan), Ian Perry (Canada) and Mark Wells (USA)

Invited Speakers:

Suhendar I Sachoemar (Agency for the Assessment and Application of Technology, Indonesia) Charles Trick (Western University, Canada)

Ecosystem-based fisheries management seeks to restore, enhance, and protect living resources, their habitats, and ecological relationships to sustain all fisheries and provide for balanced ecosystems. Progress has been made internationally toward adopting ecosystem-based fisheries management of marine systems (EBFM), with PICES countries contributing through regional applications in the North Pacific. Examples are: the Study Group on *Ecosystem-based Management Science and its Application to the North Pacific* (SG-EBM: 2003–2004) and the Working Group on *Ecosystem-based Management Science and its Application to the North Pacific* (WG 19: 2004–2009). Recent initiatives have expanded the concept of ecosystem approaches to include human influences, both positive and negative, which is emerging as coupled marine social-ecological studies. An integrated understanding of how ecosystem changes affect human social systems and their well-being, and *vice versa*, is critical to improve environmental stewardship. The PICES Study Group on *Human Dimensions* (SG-HD: 2009–2011), Section on *Human Dimensions of Marine Systems* (S-HD: 2011), and PICES-MAFF Project on "Marine Ecosystem Health and Human Well-

Being" (MarWeB: 2012–2017) have contributed to progress in ecosystem-based management efforts in the North Pacific. Also, cooperation with other international scientific organizations and programs has been developing, such as MSEAS-2016, which was co-sponsored by ICES, PICES, IFREMER, *etc*. Key questions of that structure for these scientific activities are: (a) How do marine ecosystems support human well-being? and (b) How do human communities support sustainable and productive marine ecosystems? This session welcomes papers that address any aspect of marine social-ecological systems, and particularly research that focuses on the above two questions.

Appendix 5
Session Descriptions and Summaries at PICES Annual Meetings

PICES-2014, Yeosu, Korea
October 16–26, 2014

MarWeb Topic Session (S11)

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), 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)
Suhendar I Sachoemar (Agency for the Assessment and Application of Technology (BPPT), Indonesia)

Background

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 invertebrates), 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 expected presentations on case studies of how to implement and conduct IMTA activities in order to reduce negative impacts to the quality of the local environment and improve the well-being of the local human communities. Of special interest are examples of activities in tropical and semi-tropical locations, 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)".

Summary of presentations

This session was convened on October 22, and started with the introduction by Dr. Masahito Hirota (Japan), stating that the objective of the session is to seek how to implement and conduct IMTA effectively, and contribute to PICES-MAFF MarWeB project. A total of 8 presentations (6 oral and 2 posters) were made, and about 25 participants actively discussed the social and ecological aspects of IMTA.

The first invited speaker, Dr. Thierry Chopin (Canada) reviewed the IMTA concept and the history of IMTA. He introduced many cases demonstrating that IMTA is extremely flexible in terms of component species, location, objectives, *etc*., and discussed various ways of utilizing IMTA for more efficient nutrient recycling in the sustainable society, including a social system of Nutrient Trading Credit (NTC) that is similar to carbon trading credit (CTC).

The second invited speaker, Dr. Mark Flaherty (Canada) focused on the social aspects of IMTA. He reviewed the aquaculture controversy in British Columbia (BC), where the development of aquaculture in coastal areas has been the subject of longstanding increasingly polarized debate of a wide rage of stakeholders. There is a great social resistance in some quarters to the commercial aquaculture of salmon. Many coastal communities, especially that of the First Nations, believe that the wild salmon fishery is more important and oppose commercial salmon aquaculture. However, some First Nations communities embrace aquaculture as an important source of jobs and economic development. Based on the interview conducted in BC, he discussed how improved understanding of IMTA by First Nation people can be facilitated.

Dr. Mark Wells (USA) discussed the ongoing MAFF-funded IMTA experimental study in Karawang, Indonesia. The IMTA in this case includes shrimp/tilapia, *Gracilaria* and *Anadara*. Based on the results of the IMTA pond experiment, there were no negative effects on the production of shrimp and tilapia. The effects on water quality (N, P, Si, Chl) was also discussed. He reported the shrimp-only pond was damaged by the white-spot disease, while IMTA pond was not. Though it is tempting to suggest that IMTA may have contributed to white spot resistance, there is no direct evidence for this effect.

In his invited talk, Dr. Suhendar Sachoamer (Indonesia) reviewed the Blue Economy Policy and dissemination of the Sato-umi concept and IMTA activities in his country. In Indonesia, the huge issue is the erosion of land because of the destruction of the mangrove forest for making shrimp aquaculture pond and abandonment of the ponds after the white-spot disease. IMTA can be a tool to rehabilitate the diseased aquaculture pond, to re-create jobs for coastal communities, and to protect the coastline against the erosion.

The final invited speaker, Dr. Susanna Nurdjaman (Indonesia), presented the many issues relating to the aquaculture in Indonesia, such as diseases, mangrove destruction, coastal water degradation, biosecurity, *etc*. She emphasized the difficulty of changing the mindset of the local people, but suggested that the concept of Sato-Umi (harmony of coastal human life and the coastal ecosystem biodiversity) can be a clue. She also presented her future plan on the material circulation model.

Mr. Emmanuel Sweke (Japan) introduced a social-ecological systems study on the coastal fisheries in the Eastern part of Hokkaido, Japan. Using data from the Akkeshi area and the Erimo area, he discussed cumulative effects from the climate change (sea surface temperature), boat size, demography, local people's perception to the local fisheries.

Dr. B.A. Venmathi Maran (Korea) presented a poster on how climate change may affect the distribution of tropical and subtropical fishes, and their associated parasite fauna, and the implications of this process for Korea's lucrative sea-cage aquaculture industry. He highlighted that the parasitic copepod and monogenean fauna of marine fishes is relatively well documented in the neighboring countries, but very little is known about parasitic copepods infecting marine fish on the Korean peninsula.

Dr. Konstantin Drozdov's poster was on the accumulation of lactate in the coelomic fluid of sea urchins under conditions of hypoxia. This accumulation from the anaerobic digestion of glucose is an indicator that sea urchins are capable of anaerobic metabolism.

The discussion part of the session was chaired by Dr. Wells and included a wide range of issues such as the influences from legal regulations, societal perception of IMTA, acceptability by the commercial farmers, differences between Asia and the Western World, effects and scale of nutrient reduction, *etc*.

Some overall comments:

- The social dimension acceptance of IMTA differs greatly between developed and developing countries. The latter are ready to accept new methods that can be demonstrated to have limited negative environmental effects, while strong resistance to IMTA is routed in some developed countries, fueled in large part by media rather than scientific dissemination.
- Implementation of IMTA may be easier in developing countries; limitations in some developed countries (Canada in particular) are due to the highly restrictive regulatory environment policies.
- For the environmental benefits, regulations surrounding IMTA must be followed by enforcement actions. This may be problematic in some developing countries.

List of papers

Oral presenations

Integrated Multi-Trophic Aquaculture (IMTA): An environmentally, economically and societally responsible aquanomic approach to farming the sea with many variations (Invited)
Thierry Chopin

Obtaining a social license for IMTA: Challenges and opportunities in British Columbia, Canada (Invited)
Mark Flaherty

The effect of multi-trophic aquaculture on nutrient loading in fish and shrimp ponds, Karawang Indonesia
Mark L. Wells, Mitsutaku Makino, Suhendar I. Sachoemar and Masahito Hirota

Dissemination of SATO UMI for sustainable aquaculture development in Indonesia (Invited)
Suhendar I. Sachoemar, Tetsuo Yanagi, Mitsutaku Makino, Mark L. Wells, Masahito Hirota and Ratu Siti Aliah

Implementation of SATO UMI concept at pond aquaculture in Karawang, Indonesia (Invited)
Susanna Nurdjaman, Tetsuo Yanagi and Suhendar I. Sachoemar

Social-ecological studies towards the integrated management of local fisheries in North- Eastern Hokkaido, Japan
Emmanuel A. Sweke, Rotaro Okazaki, Yumi Kobayashi, Mitsutaku Makino and Yasunori Sakurai

Poster presentations

Accumulation of lactate in the coelomic fluid of sea urchins under stress suggests the switching-on of anaerobic glycolysis
Konstantin A. Drozdov, Anatoliy L. Drozdov and Lidia T. Kovekovdova

PICES-2017, Vladivostok, Russia
September 22–October 1, 2017

HD-Paper

Marine ecosystem health and human well-being: A social-ecological systems approach

Co-Convenors: *Keith Criddle (USA), Mitsutaku Makino (Japan), Ian Perry (Canada), Mark Wells (USA)*

Invited Speakers:
Suhendar I Sachoemar (Agency for the Assessment and Application of Technology (BPPT), Indonesia)
Charles Trick (Western University, Canada)

Background

Ecosystem-based fisheries management seeks to restore, enhance, and protect living resources, their habitats, and ecological relationships to sustain all fisheries and provide for balanced ecosystems. Progress has been made internationally toward adopting ecosystem-based fisheries management of marine systems (EBFM), with PICES countries contributing through regional applications in the North Pacific. Examples are the Study Group on *Ecosystem-based Management Science and its Application to the North Pacific* (SG-EBM: 2003–2004) and the Working Group on *Ecosystem-based Management Science and its Application to the North Pacific* (WG 19: 2004–2009). Recent initiatives have expanded the concept of ecosystem to include human influences, both positive and negative, which is emerging as coupled marine social-ecological studies. An integrated understanding of how ecosystem changes affect human social systems and their well-being, and *vice versa*, is critical to improve environmental stewardship. The PICES Study Group on *Human Dimensions* (SG-HD: 2009–2011), Section on *Human Dimensions of Marine Systems* (S-HD: 2011–2016), and PICES/MAFF Project on "Marine Ecosystem Health and Human Well-being" (MarWeB: 2012–2017) have contributed to ecosystem-based management efforts in the North Pacific. Also, cooperation with other international scientific organizations/programs has been developing, such as MSEAS 2016 which was co-sponsored by PICES, ICES, IFREMER, *etc*. Key questions that structure these scientific activities are: (a) how do marine ecosystems support human well-being? and (b) how do human communities support sustainable and productive marine ecosystems? This Session is expected to address all aspects of marine socio-ecologic systems, and particularly research on the above two questions.

Appendix 6
PICES Press Articles Related to MarWeB

New PICES MAFF-Sponsored Project on "*Marine Ecosystem Health and Human Well-Being*"

by R. Ian Perry and Mitsutaku Makino

Progress is being made internationally on an ecosystem approach to the management of marine systems, in particular as applied to ecosystem-based fisheries management (EBFM; FAO 2003; Hollowed *et al*. 2011). PICES has contributed to this progress and explored regional applications to the North Pacific, through the activities of the ecosystem-based management Study Group and Working Group reports (Jamieson *et al*. 2005, 2010). Recent initiatives at the global level have expanded the concept of ecosystem approaches to include people in what have been called coupled marine social-ecological systems (*e.g*., De Young *et al*. 2008; Ommer *et al*. 2011). PICES has also contributed to these initiatives (Makino and Fluharty 2011) and has recently formed an expert group to develop the human dimensions of marine ecosystems (Section on *Human Dimensions of Marine Systems*, http://www.pices.int/members/sections/S-HD.aspx). The second PICES integrative program, FUTURE (Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems), also has significant activities and strong linkages with ecosystems and people, through its Advisory Panels on *Anthropogenic Influences on Coastal Ecosystems* (AP-AICE; http://www.pices.int/members/advisory_panels/AICE-AP.aspx) and on *Status, Outlooks, Forecasts and Engagement* (AP-SOFE; http://www.pices.int/members/advisory_panels/SOFE-AP.aspx).

Very recently, the concept of human well-being within marine social-ecological systems has become recognized as an important step forward (Coulthard *et al*. 2011; Charles 2012). Well-being shifts the perspective from objective measures of sustainable livelihoods (comprised of the physical, social, human, natural, and financial resources available to a community or country) to include the subjective or perceived well-being of individuals and communities. This represents a shift from people as exploiters of the ocean to people as integral components of resource sustainability and ecosystem health (Coulthard *et al*. 2011; Charles 2012). Therefore, taking account of the dynamics of livelihoods and the concept of well-being can help with the development of policies supporting sustainable and resilient marine social-ecological systems (Charles 2012).

The Japanese concept of *sato-umi* represents one version of this humans-in-nature approach, in which a healthy ecosystem is seen to nourish human well-being, but human activities are seen as necessary for sustaining ecosystem health (Fig. 1). *Sato* means community or village, and *umi* means sea. Therefore, *sato-umi* refers to marine environments that have long-standing relationships with human communities, and in which human interactions have resulted in high marine productivity and biodiversity (Makino 2011, p. 126; Makino and Fluharty 2011). The activities to re-establish and promote the recovery of sea grass beds that have been undertaken by local community members near Yokohama are one example. Comparable types of sea grass and kelp restoration activities have been proposed by local communities in the Strait of Georgia, Canada. The Japanese government has undertaken integrated studies to assess the contributions of social, cultural, economic, and ecological aspects in *sato-umi* type projects in Japan (Yanagi 2012).

Fig. 1 Image of sato-umi (coastal village and sea): fishing villages, fisheries operations, aquaculture, swimming, shellfish gathering, sport fishing (angling), nature observation, urban area, etc. (source: United Nation University (2010), Japan Satoyama Sato-umi Assessment).

As a result of generous funding provided by the government of Japan, through its Ministry of Agriculture, Forestry and Fisheries (MAFF), PICES has developed a new project to explore these issues of marine social-ecological systems and *sato-umi* in the North Pacific. The goal of this PICES project on "*Marine ecosystem health and human well-being*" is to identify the relationships between sustainable human communities and sustainable marine ecosystems in the North Pacific, under the concept of fishery social-ecological systems. Specifically, considering the global changes in climate and human social and economic conditions, the project is expected to answer the following questions: (a) how do marine ecosystems support human well-being? and (b) how do human communities support sustainable and productive marine ecosystems?

This goal links directly with the PICES FUTURE Research Theme 3 on "How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems?", specifically questions 3.1 (*What are the*

dominant anthropogenic pressures in coastal marine ecosystems and how are they changing?) and 3.3 (*How do multiple anthropogenic stressors interact to alter the structure and function of these systems, and what are the cumulate effects?*). In addition, the project will integrate, support, and expand on the activities of several PICES expert groups, including the new Section on *Human Dimensions*, and Working Group 28 on *Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors*.

A Task Team was established for the project, which had its first meeting at the 2012 PICES Annual Meeting in Hiroshima, Japan (Fig. 2). The meeting reviewed the outputs of this project that are expected by the government of Japan, and outlined the approach and a broad plan for implementation of the project over the next 5 years. The expected outputs include: selection of study sites in Southeast Asia, oceanic Pacific islands, and Central America (3 sites in total); research on ecosystem health and human well-being; workshops at each site; and construction of a database, for example, of case studies of where and how a social-ecological (*sato-umi*) systems approach may be applied. Workshops will be held in three developing countries around the North Pacific to explore their use of marine social-ecological (*sato-umi*) concepts in marine activities, and to develop training manuals for the application of such concepts to help improve the sustainability of both natural marine ecosystems and their dependent human communities. The three countries proposed as main case studies are Indonesia (large population, aquaculture-intensive), Palau (finfish capture fishery focus; existing networks of community-based fisheries) and Guatemala (upwelling system; finfish and aquaculture). The main question to be asked is what tools can PICES provide these countries with respect to developing a social-ecological (*sato-umi*) approach to marine systems. The key outcome will be to provide an approach and tools that advance the following types of 'integrated social-ecological assessments':

- What are the general concepts leading to sustainable human communities and productive marine ecosystems?
- Where does each country and local community 'want' to be within these concepts?
- Where are they now?
- What are the major stresses, for example climate change, and how might these affect the current state and the transitions to the desired state?
- How does human well-being relate to ecosystem services in these countries and locations?

One tool, from psychological research, that will be explored is called the "well-being cube". At the meeting in Hiroshima, Drs. Juri Hori and Mitsutaku Makino presented definitions for human well-being from psychological research, and described the concept of the "well-being cube". In this approach, a person's (or community, region, or country) perception of their well-being can be located in one or more of 27 cells defined by three axes, each with three

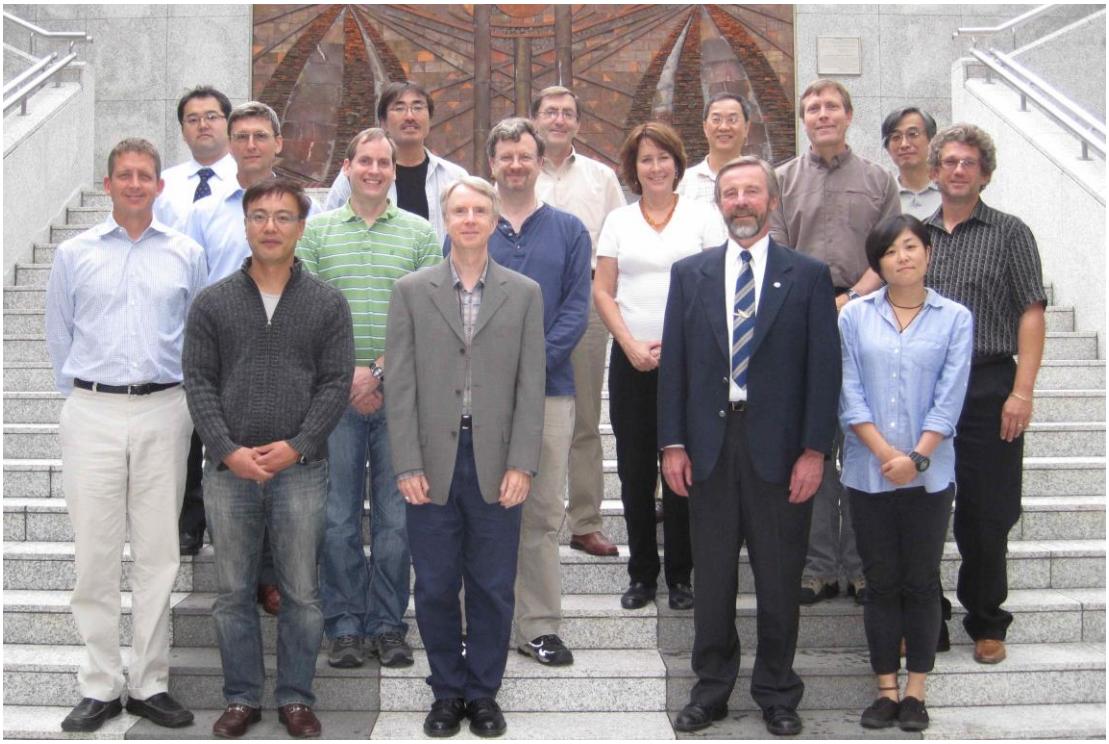

Fig. 2 Participants and Task Team members at the first meeting of the PICES MAFF-sponsored project on "Marine ecosystem health and human well-being", October 11, 2012, Hiroshima, Japan. From left to right, front row: Grant Murray, Mitsutaku Makino, Ian Perry, Skip McKinnell and Juri Hori; middle row: Igor Trofimov, Thomas Therriault, Harold (Hal) Batchelder, Vera Trainer, Keith Criddle and Mark Wells; back row: Takaomi Kaneko, Masahito Hirota, Alexander Bychkov, Suam Kim and Sinjae Yoo.

categories: the extent of conscious interpretation of their situation, their level of active response to their situation, and their view of how they fit into their world (Fig. 3).

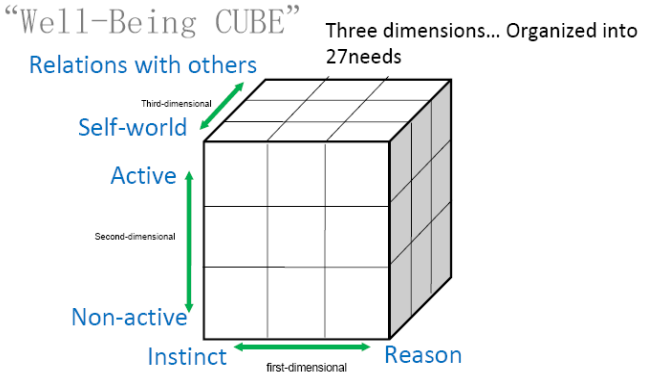

Fig. 3 Example of the "well-being cube" concept for human interactions with their environment.

The first workshop is being organized for Indonesia in March of 2013. Indonesia already has some knowledge and experience with the *sato-umi* concept as applied to coastal aquaculture and local community systems. The goal of this first workshop will be to use broad scientific and local knowledge to develop the contents of a manual on this approach for use in other coastal communities of Indonesia, and to assess the applicability of scientific tools for describing and applying these concepts in real situations. The results of this experience will be presented and discussed at the second meeting of the project Task Team, scheduled for June 2013.

This 5-year MAFF-sponsored PICES project is planned to provide many opportunities to test and support the activities and contributions of several PICES expert groups and the FUTURE program.

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Dr. Mitsutaku Makino (mmakino@affrc.go.jp; see group photo) co-chairs the new PICES project on "Marine ecosystem health and human well-being" and PICES Section on Human Dimensions (he was a former Chairman of PICES Study Group on Human Dimensions). His major is institutional and economic analysis of marine policies, including fisheries management and ecosystem-based management. He is currently the Head of the Fisheries Management Group at the National Research Institute of Fisheries Science, Fisheries Research Agency of Japan, and a member of many international research activities such as IUCN Commission of Ecosystem Management (CEM) Fisheries Expert Group (FEG), IMBER Human Dimension Working Group, United Nation University Sustainable Ocean Initiative. Also, he is now serving as an editor of ICES Journal of Marine Science as well as a Scientific Committee member of the Japanese Society of Ocean Policy. He teaches several courses at Japanese universities (Hokkaido University, Yokohama National University, Nagasaki University, Tokyo Agricultural University, etc.) as an Associate Professor. One of his major publications in recent years is "Fisheries Management in Japan", which was published by Springer in autumn 2011.

Dr. Ian Perry (Ian.Perry@dfo-mpo.gc.ca; see group photo) co-chairs the new PICES project on "Marine ecosystem health and human well-being" and PICES Working Group on Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors. He is a research scientist with Fisheries and Oceans Canada (DFO) at the Pacific Biological Station (PBS) in Nanaimo, BC. In addition, Ian is an Adjunct Professor at the Fisheries Centre of the University of British Columbia, and has taught courses on fisheries oceanography at universities in Canada, Chile, and Portugal. He currently heads the Ecosystem Approaches Program at PBS, and is one of two leaders for the DFO Strait of Georgia Ecosystem Research Initiative. His research expertise includes the effects of the environment on finfish and invertebrates; the structure and function of marine ecosystems; ecosystem-based approaches to the management of marine resources; the human dimensions of marine ecosystem changes; and scientific leadership of international and inter-governmental programs on marine ecosystems and global change. Ian is a former Chairman of the international Global Ocean Ecosystem Dynamics (GLOBEC) program, whose goal was to understand how global changes affect the abundance, diversity and productivity of marine populations, and a former Chairman of the Science Board for PICES. He is a past Editor for the scientific journal Fisheries Oceanography, and is presently an Associate Editor for the journal Ecology and Society, and a member of the Editorial Boards for Fisheries Oceanography and Current Opinion in Environmental Sustainability.

PICES-MAFF Project on Marine Ecosystem Health and Human Well-Being: Indonesia Workshop

by Mitsutaku Makino

Background

In April 2012, PICES began a 5-year project on *Marine Ecosystem Health and Human Well-Being* funded by the Ministry of Agriculture Forestry and Fisheries of Japan (MAFF). The goal of the project is to identify relationships between sustainable human communities and productive marine ecosystems in the North Pacific under the concept of fishery social-ecological systems. In Japan, this concept is known 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 will be directed by a Project Team, co-chaired by Drs. Mitsutaku Makino (Fisheries Research Agency, Japan) and Ian Perry (Fisheries and Oceans Canada).

At its first meeting (October 11, 2012, in Hiroshima, Japan), the Project Team decided to conduct two workshops in developing countries in each of three regions of the North Pacific (Southeast Asia, Pacific oceanic islands, and Central America). Indonesia was selected because of its large population and aquaculture-intensive industry. Palau was chosen because of its focus on finfish capture fisheries and its existing networks of community-based fisheries. Finally, Guatemala was selected because its coastline features an upwelling system favourable for finfish fisheries and aquaculture.

GEMPITA-SPL concept in Indonesia

The Indonesian Agency for the Assessment and Application of Technology (BPPT) has developed a concept of managing coastal and marine resources in a balanced, harmonious, integrated, and productive environment by actively involving the community. Their concept is called GEMPITA-SPL (Gerakkan Masyarakat Peduli Kelestarian Sumberdaya Perikanan, Pesisir dan Laut) or in the English language version as SFiCoMS (Sustainable Utilization of Fisheries, Coastal and Marine Resources for the Society).

The GEMPITA-SPL concept has been implemented in the northern coastal area of West Java by BPPT and the local Department of Fisheries and Marine Affairs. It fosters the development and promotion of environmentally friendly aquaculture technology using Integrated Multi-Trophic Aquaculture (IMTA). This approach features concepts of bio-recycling in idle and/or marginal brackish water ponds in the northern part of western Java. Coastal areas that had been damaged by shrimp monoculture are being transformed into productive systems that feature a balanced and harmonious approach and greater biodiversity to improve the welfare of local communities. This concept fits very well within the framework of fishery social-ecological systems in the PICES-MAFF project.

Indonesia workshop

The first PICES-MAFF project workshop was held on March 13–14, 2013, with a total of 93 participants from Indonesia, Japan, and the United States of America. Indonesia was represented by the Ministry of Marine Affairs and Fisheries, Ministry of Research and Technology, Ministry of Environment, Ministry of Public Works, Coordinating Ministry for the Economy, Finance and Industry, Coordinating Ministry for People's Welfare, Ministry of Development of Disadvantaged Areas, Ministry for National Development Planning, Food Security Agency of the Ministry of Agriculture, Bandung Institute of Technology, Bogor Agriculture University, and local governments. The objectives of the workshop were:

- To develop the contents of a manual that will describe GEMPITA-SPL experiences in Java province according to local conditions in some candidate sites;
- To assess the utility of PICES' scientific tools for enhancing the human well-being of local communities and for rehabilitating coastal ecosystems in some candidate sites.

The first day of the workshop was spent at the Main Commission Hall of BPPT headquarters in Jakarta. It started with a welcome by Ms. Nenie Yustiningsih (Director of the Center for Agricultural Production Technology of BPPT),

Dr. Mitsutaku Makino (mmakino@affrc.go.jp) co-chairs the PICES Section on Human Dimensions of Marine Ecosystems and co-leads the PICES-MAFF project on "Marine ecosystem health and human well-being". His major scientific interests are institutional and economic analysis of marine policies, including fisheries management and ecosystem-based management. He is currently the Head of the Fisheries Management Group at the National Research Institute of Fisheries Science, Fisheries Research Agency of Japan, and a member of many international research activities such as the IUCN Commission of Ecosystem Management (CEM) Fisheries Expert Group (FEG), IMBER Human Dimension Working Group, United Nations University Sustainable Ocean Initiative. Also, he is now serving as an editor of ICES Journal of Marine Science as well as a Scientific Committee member of the Japanese Society of Ocean Policy.

Fig. 1 Dr. Mitsutaku Makino giving opening remarks and introduction at the PICES-MAFF workshop in Jakarta, Indonesia.

Fig. 2 Panel discussion including participation by Drs. Masahito Hirota (far left) and Mark Wells (center).

followed by opening remarks and introduction by Dr. Makino (Fig. 1). The keynote speech was made by Professor Tetsuo Yanagi from Kyushu University, Japan. The opening of the workshop was declared by Dr. Listyani Wijayanti (Deputy Chairman of BPPT). A total of 10 presentations were given on this day. A Project Team member, Dr. Mark Wells (University of Maine, U.S.A.; Fig. 2) described previous activities of PICES in Indonesia and suggested ways that PICES science can support GEMPITA-SPL. Another member of the Project Team, Dr. Masahito Hirota (National Research Institute of Fisheries Science, Fisheries Research Agency, Japan) talked about how PICES scientific tools can support the analysis of well-being in the coastal societies (Fig. 2).

The second day featured a field trip to the Karawan area of West Java, where the BPPT has developed GEMPITA-SPL. Participants visited the Center for Brackishwater and Marine Culture of West Java Province and the National Center for Brackishwater Aquaculture to observe aquaculture ponds that applied the GEMPITA-SPL approach, and had discussions with local stakeholders (fishers, managers, *etc.*).

The workshop attracted serious attention from the Indonesian media, with many reports appearing in newspapers, on TV and web news (Fig. 3).

Results and next steps

Discussions following the workshop led to the idea of a Letter of Intent (LOI) between PICES and BPPT to recognize the benefits to their respective institutions of establishing international links (Fig. 3). The second output was a draft list of parameters to assess GEMPITA-SPL performance. In close coordination with Indonesian scientists, PICES scientists will support the assessment of these parameters in sample ponds where GEMPITA-SPL has been implemented. A table of contents for a GEMPITA-SPL manual was drafted to facilitate the dissemination of GEMPITA-SPL activities in Indonesia. These will be discussed at the second meeting of the PICES-MAFF Project Team to be held June 11–12, 2013, in Honolulu. Based on the advice and comments from this meeting, a second Indonesian workshop will be held around March 2014.

Fig. 3 Media report about the LOI signing ceremony involving Dr. Makino and Dr. Listyani (BPPT Vice Chairman).

A psychological perspective on "human well-being": An international comparison of the well-being structure

by Juri Hori

Introduction

"Well-being" involves peoples' positive evaluations of their lives, such as positive emotions, engagement, satisfaction, and meaning (Diener and Seligman, 2004; Oscar, 2011). According to the definition by the Millennium Ecosystem Assessment (MA), human well-being (HWB) has multiple constituents including security, basic material for a good life, health, good social relations and freedom of choice and action (Fig. 1).

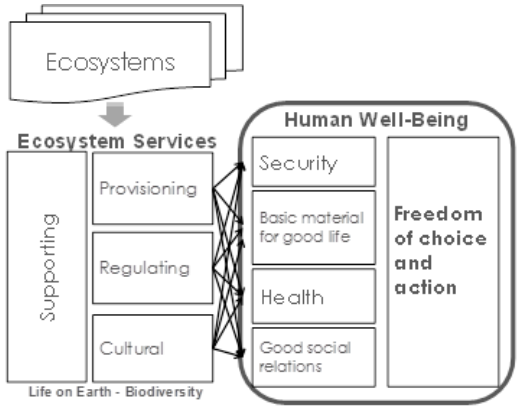

Fig. 1 Linkages between Ecosystem Services and Human Well-being (Ecosystems and human well-being: Synthesis report, 2005).

The PICES Section on *Human Dimensions of Marine Systems* (S-HD) is conducting a study on how HWB relates to marine ecosystem services in the North Pacific. This research is a part of a 5-year project on "*Marine Ecosystem Health and Human Well-Being*" (MarWeB) supported by the by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan.

How do we measure HWB?

Many social and psychological methodologies have contributed to a better understanding of one's sense of value or well-being. While economists focus mainly on economic utility or material wealth (Stevenson *et al*., 2008), psychologists have been concentrating more on cultural values in individualism (Diener *et al*., 1993; Hofstede, 2001; Diener and Seligman, 2002).

Here, we present results from two approaches for assessing HWB. First, we measured people's levels of "satisfaction" using the MA's five components of HWB as dependent variables (see Fig. 1, right-hand panel) and analyzed the inter-relationships among them. Second, we developed the "Well-being CUBE", composed of 35 "human needs" determined by psychology, which can evaluate the detailed characteristics of people's desired choices and actions (Fig. 2).

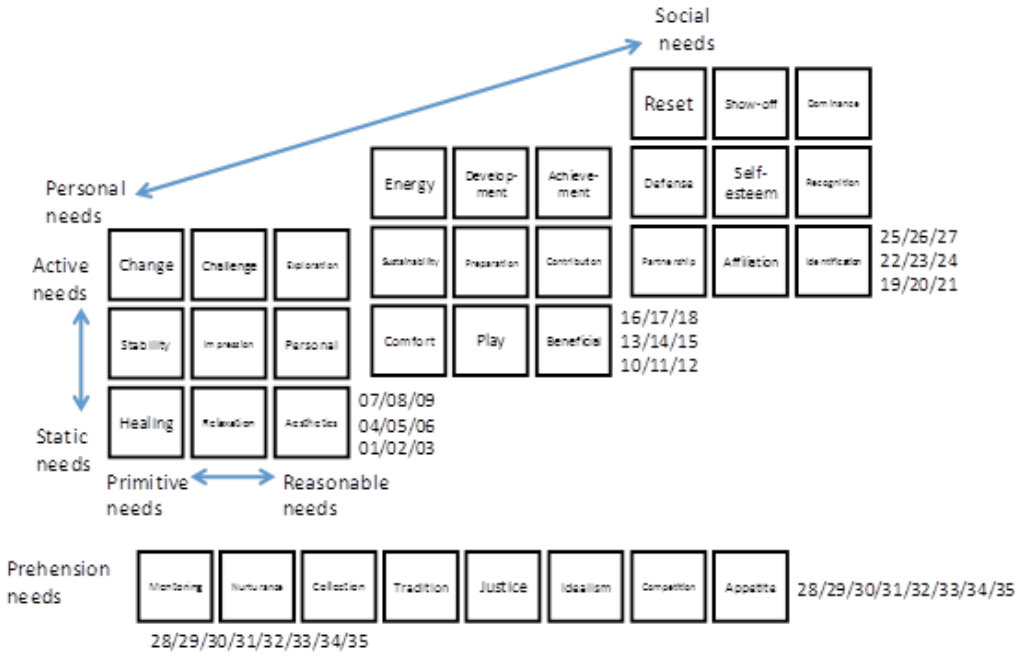

Fig. 2 Well-being CUBE composed of 35 human needs.

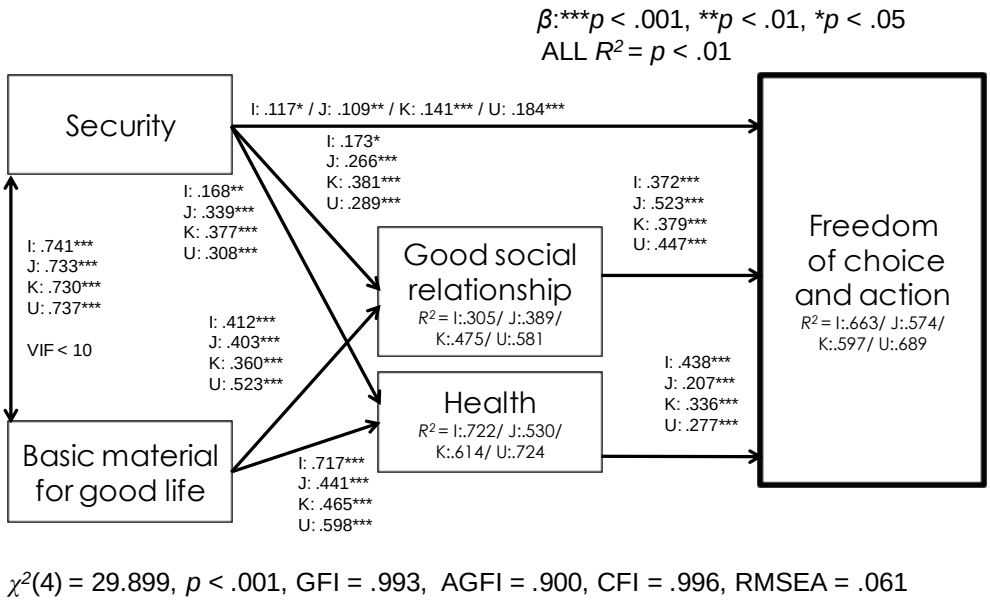

Fig. 3 Structural Equation Modeling (SEM) of the Millennium Ecosystem Assessment (MA) human well-being (HWB) (I = Indonesia, J = Japan, K = Korea, U = United States).

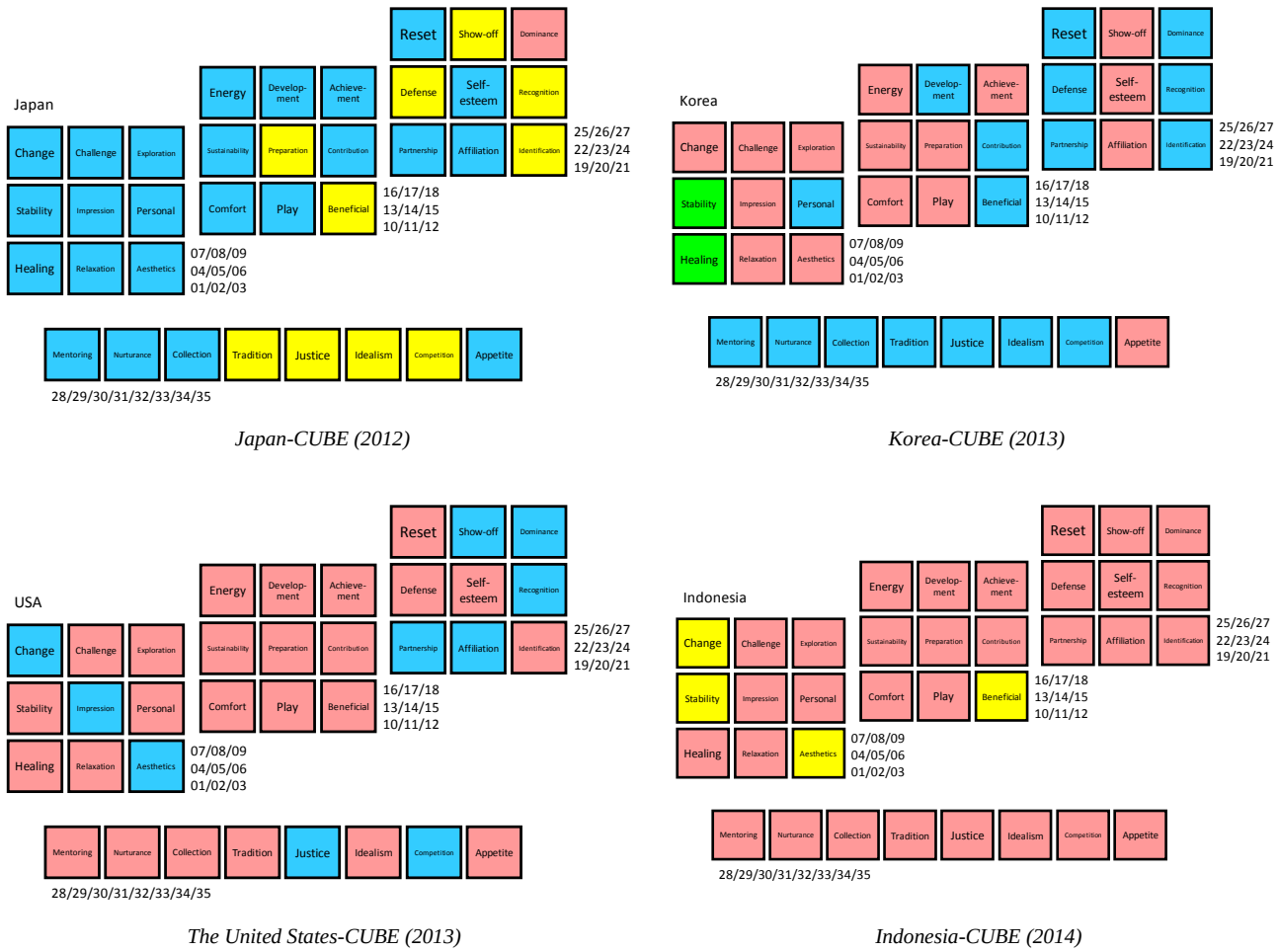

Fig. 4 Preliminary results of the human well-being (HWB) analysis in four countries.

Method

We measured the five components of the MA's HWB using 20 items. Each item was answered on a 1 to 5 scale ranging from "Very Dissatisfied" to "Very Satisfied". The Well-being CUBE (Fig. 2) was assessed using 35 items scored on a scale ranging from 1 to 5 ("Very Dissatisfied" to "Very Satisfied" and "No Expectation" to "High Expectation").

The first survey of 1000 people in Japan was conducted in 2012 to assess their relationships with the sea and to further develop a methodology. In 2013, the same questionnaire was used to survey 500 people in Korea and the United States. In 2014, we carried out a survey of 200 people in Indonesia.

The results from Structural Equation Modeling (SEM) analysis showed that each country has the same structure of the MA's HWB, but the primary paths to "freedom of choice and action" differ from country to country (Fig. 3). In the SEM, the structural model includes the relationships among the latent constructs. In Figure 3, one-headed arrows represent regression relationships, while the two-headed arrow represents correlational relations.

Preliminary results and next steps

The results from the Well-being CUBE analysis are summarized in Figure 4. *Red* shows high-expectation and satisfaction need, *blue* is low-expectation and satisfaction need, *yellow* is high-expectation and low-satisfaction need, and *green* is low-expectation and high-satisfaction need. Clear differences are evident among the four sampled countries.

Some initial findings include the fact that all countries surveyed have similar general concepts of HWB with regard to marine ecosystems. However, the specific understanding of how the marine ecosystem affects HWB differs among the countries and, therefore, what makes for a desirable relationship between people and the sea is different among countries. In order to grasp the big picture of HWB in the North Pacific, we are planning to collect data in the rest of the PICES member countries (Canada, China, and Russia) and in Guatemala within the lifespan of the MarWeB project.

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A good relationship between local communities and seafood diversity

by Masahito Hirota

Background

Brackish waters, especially shrimp pond cultures, have been widely developed since the 1980s in South East Asian countries. However, deforestation for building ponds, and later, their abandonment due to mass diseases in cultures, have resulted in serious environmental degradation. Now, these problems are becoming a threat to the livelihood of the local inhabitants, giving rise to social instability at the local community level. To consider how to rectify this condition, the PICES Section on *Human Dimensions of Marine Systems*, in collaboration with the Agency for the Assessment and Application of Technology (Badan Pengkajian dan Penerapan Teknologi, BPPT) of Indonesia, is studying the use of an environmentally friendly aquaculture technology called *Integrated multiple trophic aquaculture* (IMTA – a method of aquaculture in which fish, scallop and seaweed are managed tropically by bio-recycling so that the by-products from one species are used as food or fertilizer for another) to remediate the environment while applying a social science approach by working together with the local community. This research is a part of a 5-year project on "*Marine Ecosystem Health and Human Well-Being*" (MarWeB) supported by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan.

Activities

A work plan has been developed for a MarWeB-sponsored pond experiment, to be conducted at the National Center for Brackishwater Aquaculture in Karawang (Java Island, east from the Indonesian capital, Jakarta). The main purpose this experiment is to investigate the effects of IMTA on the economic return of pond operations, and the pond water quality defined in terms of macronutrient concentrations. The hypothesis being studied is whether the addition of bivalves and seaweed into the aquaculture ponds of fish or shrimp will allow successful growth of all species, and decrease the macronutrient concentrations in the pond waters.

To build the skills needed to conduct the pond experiment, a nutrient and phytoplankton training workshop, led by Drs. Mark Wells and Mitsutaku Makino, was held March 25–26, 2014, at the National Center for Brackishwater Aquaculture. Sixteen local Indonesian scientists participated (Fig. 1). The workshop was a success, with the objectives fully met and the methodological skills raised to the quality required for publication of the pond experiment results.

Using a social science approach, a commodity chain map of the IMTA products in the Karawang area (Fig. 2) has been prepared to assess what kind of businesses are locally supported, who consumers are, and how much is consumed of the multi-species produced from the IMTA (shrimps, milkfish, crab, *etc.*). We expect that, by changing shrimp monoculture to IMTA, it will be possible to retain sustainable pond culture, and suppress coastal erosion. In addition, there is high probability this will lead to new diverse job creations, and will ensure a rich variety of seafood as ingredients of everyday life in the community.

Spreading information on the effects of IMTA to the community

To establish IMTA, it is indispensable that communities receive correct and comprehensive information about this approach. Of course, shrimp monoculture is highly profitable and is an important source of employment, but to ensure sustainability, it is critical to present a well-balanced understanding of the IMTA benefits to the local population. To extend relevant information, the MarWeB project, in

Fig. 1 Participants of the Nutrient and phytoplankton training workshop held March 25–26, 2014, at the National Center for Brackishwater Aquaculture, Karawang, Indonesia.

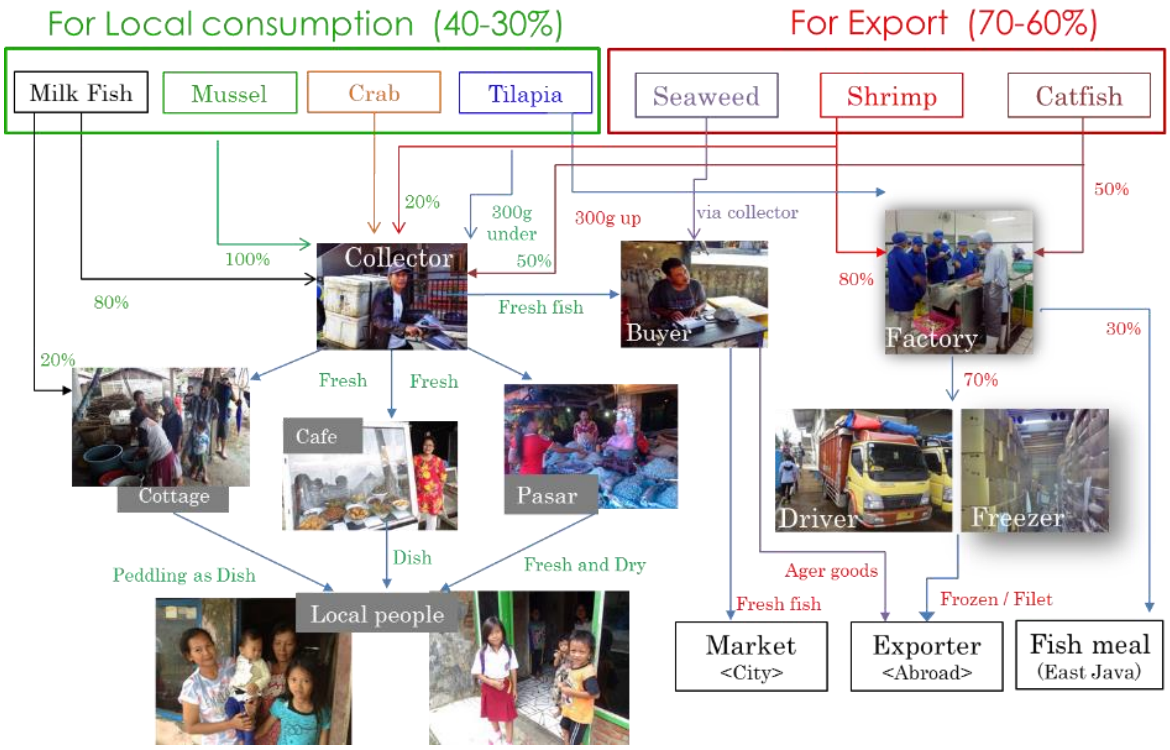

Fig. 2 The commodity chain map of IMTA products in the Karawang area, Indonesia.

cooperation with BPPT, has held two international workshops in Indonesia in March 2013 and March 2014 (for a review of the first workshop see PICES Press, 2013, Vol. 21, No. 2, pp. 18–19). These workshops drew not only local and international scientists, concerned with pond aquaculture, but also attracted special attention of the Indonesian press. Through the mass media, we have successfully raised the awareness of the general public about seafood sustainability. For the future, it is expected that the Indonesian community will establish and lead local IMTA programs in order to rectify their own well-being.

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Moving towards more sustainable shrimp and tilapia aquaculture in Karawang, Indonesia

by Mark L. Wells, Mitsutaku Makino, and Masahito Hirota and Ian Perry

Marine and brackish water aquaculture provides much of the world's shrimp and fish supplies to markets (FAO, 2014) and represents a growing source of nutrition and economic strength in developing nations. This situation is particularly true for Indonesia which is undertaking an enormous expansion of pond aquaculture development over the next several years. However, large-scale pond aquaculture introduces large quantities of nitrogen and phosphorus into coastal waters. The challenge for Indonesia will be to achieve this expansion without eutrophication of coastal regions, and the resulting devastation to the natural cultural, fisheries and tourism resources.

Brackish water pond aquaculture can be broadly separated into two strategies: high intensity systems having shrimp densities, for example, from 300-400 per m^3, and low intensity pond systems at an order of magnitude lower densities. High intensity systems offer high economic returns but require relatively large initial investment, and hyper-strict controls of growth and feeding conditions to avoid disaster, akin to a high-wire acrobatic act. Once these requirements have been successfully met, there is little incentive to experiment with these lucrative operations to mitigate nutrient waste generation.

Low intensity pond aquaculture, on the other hand, is a "lower tech" approach where conditions can stray more from the knife edge constraints of high intensity aquaculture system operations. This greater leeway in pond conditions makes low intensity growing operations more widespread, where they dominate the aquaculture industry in many developing nations. This is particularly true for most Indonesian growers.

As part of its work to develop an expanded concept of ecosystem approaches which includes people (Social-Ecological Systems approach), the PICES Marine Ecosystem Health and Human Well-being (MarWeB; see Perry and Makino, 2013) project has been testing approaches to multitrophic aquaculture in Indonesia. This project is funded by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan through the Fisheries Research Agency of Japan (FRA). The PICES project team is collaborating with the Agency for the Assessment and Application of Technology (BPPT), Indonesia, and the National Center for Brackishwater Aquaculture, Karawang, Indonesia. The purpose of the project has been to incorporate the macroalga *Gracilaria* and the clam *Anadara* into shrimp and tilapia pond aquaculture (*i.e.*, co-culture) and to evaluate their effects on dissolved nutrient concentrations in pond waters. Co-culture methods, where species are mixed within the pond, are more challenging than sequential pond systems (*i.e.*, a product pond and a mitigation pond) but are far more practical if the right formula can be developed. A secondary benefit of multitrophic aquaculture is that the pond by-products, in this case harvestable biomass of *Gracilaria* and *Anadara*, can provide additional economic benefits to growers, greater nutrition and job creation to the surrounding communities, which themselves cannot afford the shrimp produced for export markets.

The two experiments performed to date have provided good insights to the operational and scientific challenges of co-culturing shrimp and tilapia with macroalgae and bivalves. Brackishwater ponds in the experimental system range from 1000–4000 m^2 in area but with a depth of 1 m (Fig. 1). These systems are maintained to prevent light from reaching the pond floor (to avoid the massive growth of aquatic grasses), have high trophic transfer efficiencies (*e.g.*, 1 kg of tilapia produced per 1.3 kg of feed added), but still generate high excess nutrient loads (~0.1 mole N/L, or approximately 10,000 times that in coastal waters).

The initial project goals have been to establish methods of co-culture that do not jeopardize the health or production of shrimp and tilapia. Results from the two experiments to date clearly show no detrimental health effects from co-culturing (Fig. 2) and indeed fish production may be slightly greater in the presence of seaweed and bivalves. It seems clear that, at least at the levels used in our experiments, farmers can benefit using the multitrophic strategy by increasing the economic yield in their ponds.

Fig. 1 A 1000 m^2 brackishwater pond containing tilapia, seen here as the orange discolouration at the pond surface during feeding. The Gracilaria *was placed in net pens at several places within the pond to prevent tilapia feeding upon it.*

Fig. 2 A passive net sample of shrimp from the co-cultured pond. The shrimp, attracted to the bottom placed net with food, are raised by hand to measure their size and appearance as an indication of their health.

The impact of co-culture on reducing dissolved nutrient levels has been less successful. Analysis of the last experiment completed in November 2015 is still underway, but the co-culture conditions appear not to have significantly decreased dissolved nutrient concentrations. A lower ratio of *Gracilaria* and *Anadara* to product (shrimp or tilapia biomass) was used in these initial experiments to minimize the chance of negative impacts. The next experiment planned for 2016 will test the effects of higher quantities of algae and bivalves.

A positive outcome of the multitrophic strategy was the creation of a phytoplankton assemblage dominated by diatoms, relative to dominance by flagellates in the standard, product-only ponds. Diatom-dominated pond systems are coveted because they impart desirable flavour characteristics that bring higher prices.

A major challenge to scientists working to increase the sustainability of low intensity brackishwater pond aquaculture is that the individuals and community organizations operating these farms are critically dependent on their success. Failed experiments can have drastic real-world impacts on these communities. Working with our colleagues at BPPT and the National Center for Brackishwater Aquaculture in Karawang has provided an important venue to facilitate the development of strategies for more sustainable pond aquaculture, and through their interactions with local farmers help to implement these practices in the future.

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A community needs assessment for coastal Guatemala – Balancing ocean and human health

by Vera L. Trainer, Charles G. Trick and William P. Cochlan

Background

In collaboration with our colleagues at the Universidad de San Carlos de Guatemala, we have engaged in a series of conversations with community members from two villages along the Pacific coast of Guatemala – Las Lisas and Monterrico. Our goal was to identify the factors that influence the balance between sustainable human communities and productive marine ecosystems in Guatemala. Specifically, considering the on-going global changes in climate, and human social and economic conditions, the Marine Ecosystem Health and Well-Being (MarWeb) project objectives are two-fold: 1) to determine how marine ecosystems support human well-being; and 2) to identify how human communities support sustainable and productive marine ecosystems. This is a shift from the traditional role where people are exploiters of the ocean to one where people are integral components of resource sustainability and ecosystem health. This concept, called "Sato-umi" in Japanese, recognizes the well-balanced availability of various ecosystem services, together with effective management of coastal seas.

To address the project goal, on our initial visit in January 2014, our overarching question for the communities was simply, "What is your relationship with the sea?" The fishermen and fisherwomen of both villages responded that the sea is their life and while fishing is a struggle and challenging occupation, they wished to create a balanced and sustainable approach to fishing, both for themselves and for future generations. Collectively, they accepted responsibility for the dwindling fish stocks – and confided that they had participated in the overfishing of their estuaries and coastal waterways. In one community, the fishers felt that they were 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. These fishers conveyed a strong need for more understanding, and a demand for directed action from the PICES team of scientists. In other words, they were looking for someone to help them take the initiative steps to facilitate the needed changes to ensure economic and ecological sustainability.

The primary purpose of our second visit in February 2015 was to perform a Community Needs Assessment (CNA) on the communities of Las Lisas and Monterrico with the adjacent seas. A CNA is a systematic process for determining the 'needs' (*e.g.*, economic, nutritional, and social) and the definable 'goals' of a community. CNAs are performed before major actions are implemented as part of a strategic planning process. CNAs can assist in directing resources and energies into creating the desired future of a community and can be used to address needs, or 'gaps' between current conditions and desired conditions. For example, in response to the "last fisherman" statement – Did the community want to invest in rebuilding the fishing industry or in recreating the community, where fishing would be just a part of the mosaic of needed changes?

For the CNAs of Las Lisas and Monterrico, we conducted both surveys and directed interviews. We spent a day with the community members of each village and surveyed 20 families (Las Lisas) and 29 families (Monterrico) using a 'clicker technology' response system. The responses from family representatives were anonymous but after each question, the group response was made known to all the respondents. With follow-up discussions, the diversity of answers could be probed further, revealing a deeper understanding of the various answers to the initial question.

The questionnaire was comprised of 34 questions, with clickable answers. The questions in general fell into four probing areas: 1) questions to introduce the process so that the families could familiarize themselves with the clicker system 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.

The community of Las Lisas wishes to preserve their ocean resources for the next generation.


Left: The fishers of Monterrico; right: the children of Las Lisas.

From our discussions and answers to the survey, we considered the following:
The fishers view the future as a balance – the next generation of fishers must be a smaller group that is better educated in sustainable business practices. The communities also need to divert some of their fishing efforts to aquaculture activities. The fishers are already aware that a lower fishing intensity is necessary to allow the fish stocks to recover, but this is contrasted by the intense demand for fish. Already the canals and inter-coastal waterways are extremely overfished, and the resultant removal of young fish stocks prevents them from contributing to coastal fisheries recovery. Until the fishing pressures in the inter-coastal waters are significantly reduced, there will be little improvement in the coastal fisheries. The desire for an alternative to traditional fisheries – using aquaculture – is steadfast. However, because the Las Lisas community is remote and does not have access to a good road system, the pursuit of aquaculture for non-local sales will be a challenge. Whatever aquaculture is chosen, sustainability is key: these efforts must result in a sustainable operation, and must not create unsupportive environmental conditions that result in reduced ecosystem health.

Recommendations for the communities

During our third visit in February 2016, summaries of the CNAs were provided to both communities as an oral presentation, a summary booklet with photos and comments, and a comprehensive report. The latter included a full synthesis of the survey results, conclusions of the CNA and recommendations provided by the PICES team. These reports and summaries were given to the communities so they could see 'first hand' that their concerns were represented in the reports, and that they could be used to assist community leaders in writing proposals for future projects. Community leaders were encouraged to use the report as a tool to help secure funding for future eco-friendly development while carefully considering which opportunities best promoted both community economic and ecosystem health. A synthesis of the major recommendations from the report include:

1. A healthier lifestyle can be facilitated with opportunities for better education; sustainable, environmentally-friendly tourism; and 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 sustenance.
4. An alternative source of fish-based food supplies must be sought – such as through aquaculture.
5. The communities have a relationship with the Universidad de San Carlos de Guatemala and should work with the faculty and researchers to develop sustainable associations.

Las Lisas.

Reading the booklet summarizing the CNA survey results.

The way forward

As an integral part of our recommendations to the communities, we invited Mr. Max Baldetti, a Guatemala citizen and graduate of the Center for the Study of the Sea and Aquaculture at the Universidad de San Carlos de Guatemala, and the country's only certified adventure sport guide, to provide a series of lectures on sustainable tourism. He spoke about how Guatemala is a 'mega-diverse' country providing diverse opportunities for tourists to climb mountains and volcanoes, hike in the jungles, paddle on the rivers and mangroves, as well as engage in a variety of other potential activities. He mentioned that, "….when you enjoy the coastal environment, you give it value. When it has value, you wish to preserve it and it becomes sustainable." He spoke about his background in tourism and his experiences growing up in both the United States and Guatemala, in particular, his increased appreciation of the sea in the Monterrico region during in his boyhood. He strongly promoted the idea that tourism is not just for visitors, but improves life for the whole community by bringing in opportunities for education and income for community members – women, men, children – who all can be involved in tourist activities. Max stressed that that tourism can provide many opportunities for women who wish to participate, and that once tourist activities are developed and become sustainable, they can be shared with children to educate them about their native environment. He mentioned that the potential for enhancing tourism needed to be driven by a local desire to serve the entire community. Various efforts have been made to start tourist activities in coastal Guatemala, but mostly in isolation or by guides from Antigua or Guatemala City. Max suggested that the creation of sustainable, targeted tourist activities requiring local expertise would provide visitors with a richer, home-grown, more comprehensive experience. The result of such efforts would be that tourist agencies in the big cities would need the services of local guides and would then be motivated to promote tours that use local knowledge and expertise. Some examples of tours incorporating local knowledge included fishing trips followed by a cooking class in a local home, mangrove activities together with local arts and crafts, and local bird watching.

Max Baldetti discussing ecotourism with the people of Monterrico.

In another related part of the project, we have been working with the poor coastal community of La Barrona, near the Guatemalan border with El Salvador, to develop an oyster aquaculture operation that hopefully can be transferred to other coastal communities. *Crassiostrea gigas* and *C. cortesiensis*, have been cultivated in Guatemala as part of past research projects, but these species have not been used in aquaculture efforts in the natural environment. Through the MarWeb project, *C. gigas* seed was purchased from El Salvador, and the oysters were grown for 2–3 months in the shallow waters of the Pacific Naval Base San José Port Escuintla until they were large enough to survive the higher sediment load in the waters of the La Barrona estuary. There, the fishery cooperative at La Barrona has the legal rights to work in the mangrove area and will continue to grow the

Fishing in the estuary.

Meeting with the community members of La Barrona at the Naval Base.

oysters into maturity. A 3-year agreement with the Guatemala Navy to use a small area of the San José port facility for the oysters' initial growth phase will benefit the and will strengthen the relationship between the community and the Navy. This collaborative project with the Guatemala Navy, oyster aquaculture experts from the Universidad de San Carlos, and La Barrona, serves as a model for bringing an alternative food source to an impoverished community in a developing nation.

This MarWeb project partnership has opened avenues of collaboration among the local communities on the coast, the military – formerly alienated from academics and the public, and the University research community. Although the project duration is only 4 years, we hope that these partnerships will continue well into the future. In 2017, we will make a final trip to the communities to facilitate their communications with leaders of a United Nations Development Program (UNDP) project intended to support and expand the five Marine Protected Areas (MPAs) on the Pacific coast of Guatemala. This proposed trip by PICES team members is dependent on adequate funding from PICES and UNDP. We hope that the knowledge gained from these communities will help them strike a balance between economic success and preservation of the beauty and sustainability of the ocean.

Acknowledgements The authors wish to express their deep appreciation to Dr. Leonel Carrillo and Ms. Dora Carolina Marroquin of the Universidad de San Carlos de Guatemala who have dedicated much effort and logistical support to this project. In addition, we thank Mr. Julian Herndon, formerly of San Francisco State University and currently at NOAA's Pacific Marine Environmental Laboratory in Seattle, Washington, who provided excellent cultural and linguistic services for this project's success. We are grateful for their collaboration, friendship and professionalism. We thank the people of Las Lisas, Monterrico and La Barrona for sharing their knowledge and their time with us.

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PICES MarWeb project collaborates with the United Nations program on the development of Marine Protected Areas in Guatemala

by Vera L. Trainer, William P. Cochlan, Julian Herndon and Charles G. Trick

Background

The PICES/MAFF Marine Ecosystem Health and Well-Being (MarWeb) project and the United Nations project on the "*Conservation and sustainable use of biodiversity in coastal and marine protected areas*" supported a multi-day workshop for an "Exchange of experiences for conservation and sustainable use of biodiversity in protected areas on the marine coast" in which 21 senior undergraduate and graduate (licentiate – a step beyond a bachelor's degree, but not quite a master's degree) students participated from the Biology and Aquaculture departments from Universidad del Valle (University of the Valley) and Universidad de San Carlos de Guatemala (University of San Carlos), respectively. These students had diverse interests—from phytoplankton to marine mammals, anthropology to pollution, fisheries management and coastal conservation. In collaboration with experts from the North Pacific Marine Science Organization (PICES), the National Oceanic and Atmospheric Administration (NOAA), the Romberg Tiburon Center for Environmental Studies (RTC) of San Francisco State University and Western University in Ontario, Canada, under the leadership of the Director of Regulations of Fisheries and Aquaculture, Ministry of Agriculture, Ranching, and Food (DIPESCA-MAGA), the participants conducted fieldwork with local fishers to learn about inshore and estuarine fishing operations, the management and challenges associated with fin-fish and marine products and distribution, analysis of case studies on problems with fishing gear in the multipurpose Natural Reserve of Monterrico, on the Pacific coast of Guatemala, and participated in a series of interactive seminar sessions on coastal marine issues associated with climate change.

Overview

On February 6-10, 2017, Drs. Vera Trainer, Charles Trick, and William Cochlan and Mr. Julian Herndon traveled to Monterrico, Guatemala to visit with personnel from DIPESCA (Fisheries and Aquaculture Agency), the National Forest Institute (INAB), Ministry of Environment and Natural Resources (MARN), the Protected Areas National Council (CONAP), the Center for Conservation Studies (CECON) and the Association for Rescue & Conservation of Wildlife (ARCAS). The primary goal of this visit was to share our goals and transfer our knowledge obtained from the PICES-supported MarWeb project with the investigators leading a new United Nations funded project on the establishment of five Marine Protected Areas (MPAs) in Pacific coastal Guatemala. The plan for these five MPAs is being designed by the lead organizations

The students and instructors of the joint PICES and Director of Regulations of Fisheries and Aquaculture, Ministry of Agriculture, Ranching, and Food (DIPESCA-MAGA) training class in Monterrico, Guatemala.

listed above. We followed an agenda that included representatives from each of the collaborating agencies, followed by student fieldwork and discussion of strategies for project success. We discussed in detail the design of these MPAs, including how to promote sustainable fishing while respecting the needs of families, how best to communicate the science to a population with broadly variable education levels, and how to sustain MPAs into the future. This training session supported an exchange of experiences for conservation and sustainable use of biodiversity in protected areas on the coast.

Elements critical to the establishment of successful Marine Protected Areas

Overall project findings and recommendations by MarWeb investigators were:

1. ***Student input.*** The collaboration of students from the University of San Carlos and University of the Valley with UN project investigators benefits both the UN project and the students. By keeping the students informed of the current issues and challenges (both legal and scientific) of the project, they can help brainstorm and implement pro-active solutions to known and potential problems. In particular, the students were interested in establishing the proper balance between enforcement of fishing rules for fishers and education of the citizens – both fishers and non-fishers alike. This is particularly important because of the high rate of illiteracy in coastal Guatemala – enforcement without education is unfair, unproductive and contributes to social injustice for the impacted citizens in a very challenging economic region of Guatemala.

A fisherman casting his net in the estuary near Monterrico, Guatemala.

2. ***Empowerment of locals.*** The students developed strategic solutions to a series of fisheries problems in coastal Guatemala (*e.g.*, preventing the use of illegal fishing nets in estuaries). The solutions included providing outreach to entire family groups, not just male fishers. The inclusion of men, women, and children in the decision-making process, allowing them to have enthusiasm in the outcome, is important to ensure successful recruitment of a wide spectrum of community members as coastal stewards. The "stickers and clickers" approach (using anonymous surveys combined with interesting activities for the children) introduced by the MarWeb project will be continued in the future by the university faculty and students participating in the UN project.

3. ***Incentives.*** The sea turtle project is an example of successful conservation in coastal Guatemala. By offering an incentive for harvesters to provide 20% of the harvested eggs for conservation, there has been a substantial rebound in turtle populations. This incentive is also supported by enforcement as there is a fine for those who violate the 20% return policy. This strategy could be used as a model for other conservation programs yet to be established, such as exchanging illegal 'window screen' type nets for legal ones of a defined and ecologically sustainable mesh size. Those adopting legal nets would be presented with a fishing license to the fisher of the family upon demonstrating an understanding of the fishing regulations while emphasizing to the entire family that they have now joined the realm of coastal stewards (this was suggested by a student group during their discussions).

Olive Ridley sea turtles were released after being collected and hatched under the protection of ARCAS, the Wildlife Rescue and Conservation Agency, a collaborator in the establishment of MPAs in Pacific Guatemala

The students studying the species of fish caught in the estuary.

4. ***Sustainability.*** There has been little discussion in country about how the MPAs established in Guatemala will be maintained after the UN project funding ends. We have suggested that Guatemala should consider developing partnerships with international experts of the Natural Capital Project and NOAA's International Marine Protected Area Capacity Building Team to develop a plan for sustaining the MPAs into the future.

5. ***Partnerships.*** It is critical to establish strong partnerships with all the environmental agencies playing important roles in sustaining coastal resources and protecting the Guatemalan coastal, estuarine and nearshore waters. It is essential that all parties responsible for the creation and management of the MPAs have an active role in the development of these areas, and that they continue to be invited and participate in future meetings.

6. ***Training of the next generation.*** The students are starved for advanced training in subjects such as stock assessment, integrated ecosystem assessment, and general oceanography (in particular, chemical and biological) and marine biology. Much of their current training is focused on the very practical aspects of establishing and maintaining aquaculture operations. Future opportunities should be sought to bring in international experts to provide training in fisheries, ecosystem science, and the challenges facing people and coastal organisms due to climate change. It will be important to provide a translator for locals who want to listen and learn from the lecturers, but don't understand English fluently. A rewarding observation was that two of the leaders of this workshop had participated in previous trainings and workshops sponsored by PICES under the Seafood Safety Program as students at the University of San Carlos. Currently, one of them oversees Fisheries Resources Regulation, Control and Enforcement on both coasts of Guatemala and another was the professor for the oceanography class from the University of San Carlos. Both of these individuals have put their prior PICES experience to good use in Guatemala.

7. ***Perceptions of fish and establishment of a supply chain.*** The supply chain for fish transport to Guatemala City is not well developed in that it is difficult to get fresh fish to it and other cities in Guatemala. In part, this is due to the lack of education about the nutritional value of fish as a valuable source of protein and essential fatty acids (*e.g.*, omega-3 fatty acids). The Guatemalan public has the general perception that "fish are smelly, toxic and taboo", which leads to relatively little domestic consumption, and export of much of their fish and shrimp products to other countries, with the result that "Guatemala is exporting health." The importance of "eat at home aquaculture" was stressed as a key to future healthy Guatemalan population.

8. ***Tourism.*** The importance of tourism education and responsible commercialization of fisheries cannot be understated. There are many examples in Guatemala of successful implementation of sustainable tourism efforts as an alternative to non-sustainable fishing in Guatemala. For example, the sailfish tourist fishery nets $6,000 US per tourist per day, whereas the economic value of harvesting and local selling of sailfish is two orders of magnitude less profitable as a single sailfish sells for only about $75 per fish. The fisheries enforcement groups are attempting to educate coastal communities about the importance of sailfish as a catch-and-release fishery to sustain this profitable and sustainable tourist fishery. Heavy fines and jail time are the consequence of illegal sailfish capture, processing (*e.g.*, smoking) and domestic sales, and relatively sophisticated and modern methods (*e.g.*, aerial drones) are used to find illegal sailfish smoking operations and help enforce existing regulations.

In summary, we concluded that it is essential that we listen to community members and not tell them what to do, but certainly provide guidance where needed. This helps promote the important message that community members are the coastal stewards, not experts from outside of the country, who must protect the ocean resources for future generations. We witnessed through discussions with fishers, community members, project leads and students that the fishers and other coastal dwellers are very interested in gaining knowledge on ocean changes in order to learn and lead as coastal stewards. It will be important to capitalize on their interest and motivation to become more responsible guardians of their marine resources, and to provide our expert assistance when possible and requested. A series of community lectures could help bridge the gap between researchers and coastal stewards/coastal community members. Moving forward, the agencies involved in the UN project should work closely together, including working closely with the next generation (students) to maximize the impact of their work. In particular, those agencies that are responsible for each of the five MPAs must work collaboratively, learning from the successes and failures in each of the areas.

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Front cover figure

Top: An experimental pond at the National Center for Brackishwater Aquaculture, Karawang, Indonesia.
Bottom: A fisherman casting his net in the Monterrico estuary, Guatemala.