MAFF
Ministry of Agriculture, Forestry and Fisheries

Improving aquaculture, marine ecosystems and human well-being

A Social-Ecological Systems Approach

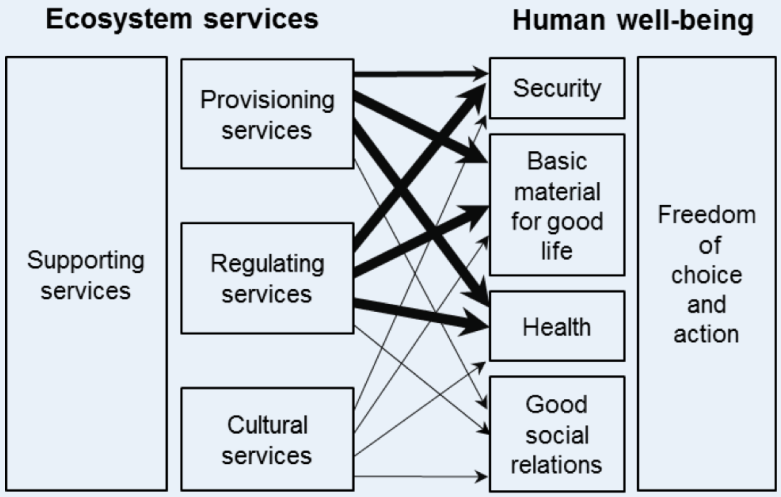


WHAT IS A SOCIAL-ECOLOGICAL SYSTEM?

Progress is being made internationally on an ecosystem approach to the management of marine systems, in particular as applied to ecosystem-based fisheries management[1]. This concept has recently been expanded to include people in what are now called coupled marine social-ecological systems[2] (Box 1). An integrated understanding of how ecosystem changes affect human social systems, and vice versa, is critical to improve the stewardship of marine ecosystems[3]. Social-ecological systems are integrated complex systems that include social (human) and ecological (biophysical) subsystems in complex feedback relationships[4]. These types of relationships occur whenever people interact with the sea[5].

BOX 1: EXAMPLES OF SOCIAL-ECOLOGICAL SYSTEM CONCEPTS

2005[6]



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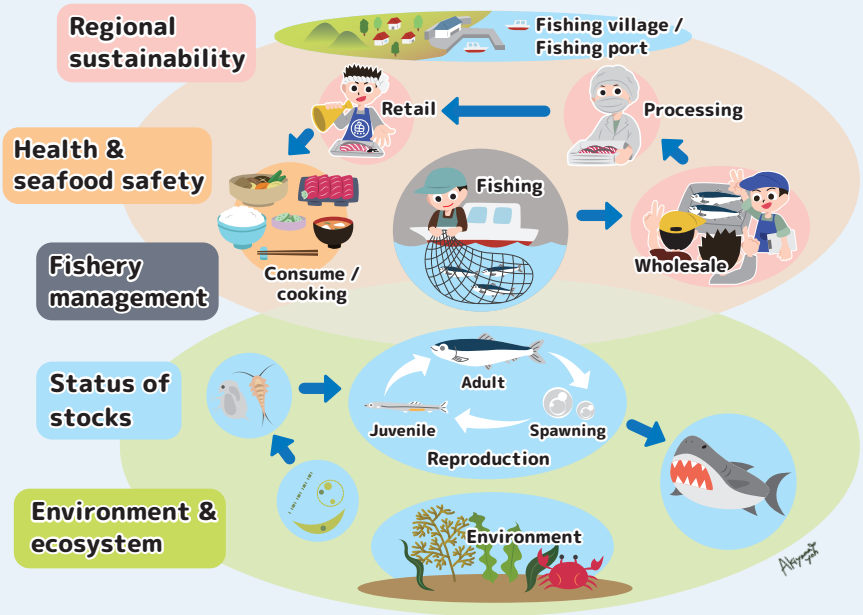
2016[7]



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SOCIAL-ECOLOGICAL SYSTEMS AND PICES

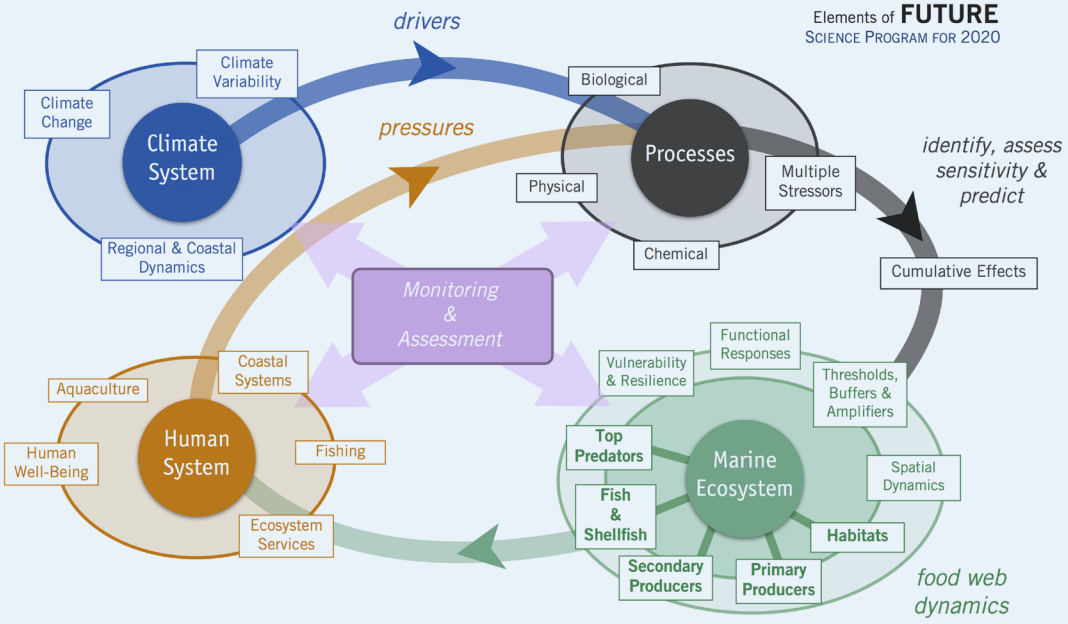
PICES has contributed to this progress and explored regional applications of these concepts in the North Pacific through several studies on ecosystem-based management[8]. PICES recently expanded these activities by forming a scientific committee to link the human dimensions of marine ecosystems with the more natural science-based activities of the organization. The 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 (Box 2). PICES scientists concluded that concepts about what constitutes a healthy marine ecosystem differ among PICES member countries. For example, Canada, Russia and the United States have generally more natural systems which they are trying to maintain, whereas China, Japan and Korea have more human-dominated marine systems. One conclusion is that communities or nations have different perceptions about ocean health, which lead to different management objectives and strategies, such as marine protected areas, regulations on fisheries and aquaculture, and relative emphases on human and non-human needs. These concepts can also be expanded to developing countries, for which the immediate issues are often the need for food and livelihoods today versus sustainability of the marine ecosystem and its fish populations for future use.

BOX 2: PICES FUTURE PROGRAM

FUTURE is an integrative scientific program undertaken by the member countries and affiliates of PICES to understand how marine ecosystems in the North Pacific respond to climate change and human activities, to forecast ecosystem status based on a contemporary understanding of how nature functions, and to communicate new insights to its members, governments, stakeholders and the public. The three key questions of this program are:

1. What determines an ecosystem's intrinsic resilience and vulnerability to natural and anthropogenic forcing?
2. How do ecosystems respond to natural and anthropogenic forcing, and how might they change in the future?
3. How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems?

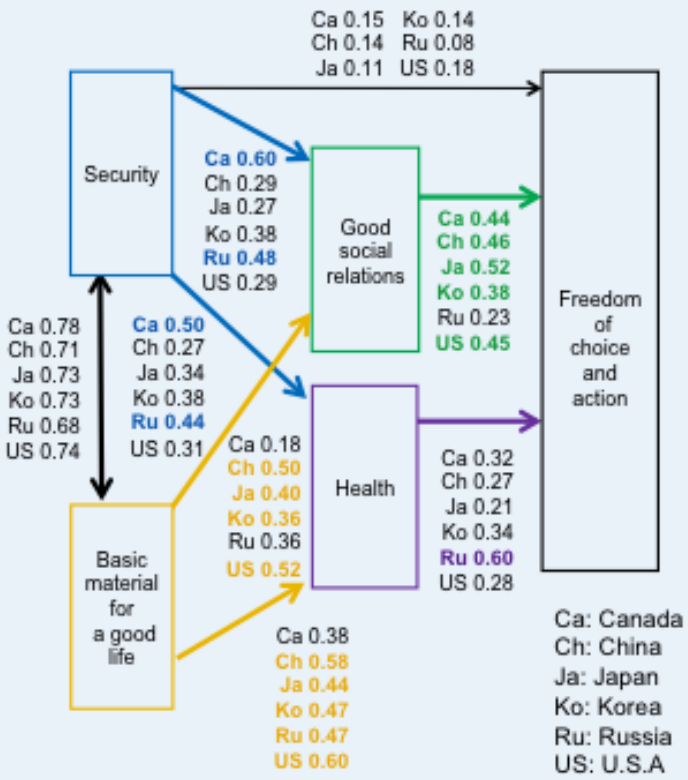
For more details, see the FUTURE website (http://www.pices.int/Scientific-Programs/FUTURE).



HUMAN WELL-BEING AND "SATO-UMI"

The concept of human well-being within marine social-ecological systems has become recognized as an important advancement[9]. Well-being shifts the perspective from objective measures of sustainable livelihoods (such as the physical, social, human, natural, and financial resources available to a community) to include the subjective and relational well-being of individuals and communities (Box 3). This represents a shift from people as exploiters of the ocean to people as integral components of resource sustainability and ecosystem health. Well-being in a fisheries context is defined as a broad conception 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[10]. Furthermore, "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"[11]. Under this social-ecological systems approach, people are indispensable parts of the system (Box 4). When setting the objectives of research or the definitions of success, participation of the local (fishing) human community is crucial. Therefore, 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 just for the interests of the researchers. Based on the local community needs, or their perception of their requirements, scientific analyses can be developed to meet those perceptions and needs.

BOX 3: STRUCTURE OF WELL-BEING IN PICES MEMBER COUNTRIES



About 500 people in each PICES member country were surveyed to understand how they valued the sea. This figure represents the statistical analysis of the results. The basic structure is the same among the six countries, but the relative importance of each well-being factor (i.e., basic materials for a good life, security, health, good social relations, freedom of choice and action) is different. For example, for good social relations and health, the well-being factor "security" is relatively more important in Canada and Russia, while "basic material for a good life" is more important for other countries. Similarly, "health" is relatively more important for people in Russia to achieve freedom of choice and action, whereas in other countries it is more about good social relations. For more details about this analysis, see PICES Scientific Report No. 52.

BOX 4: SATO-UMI

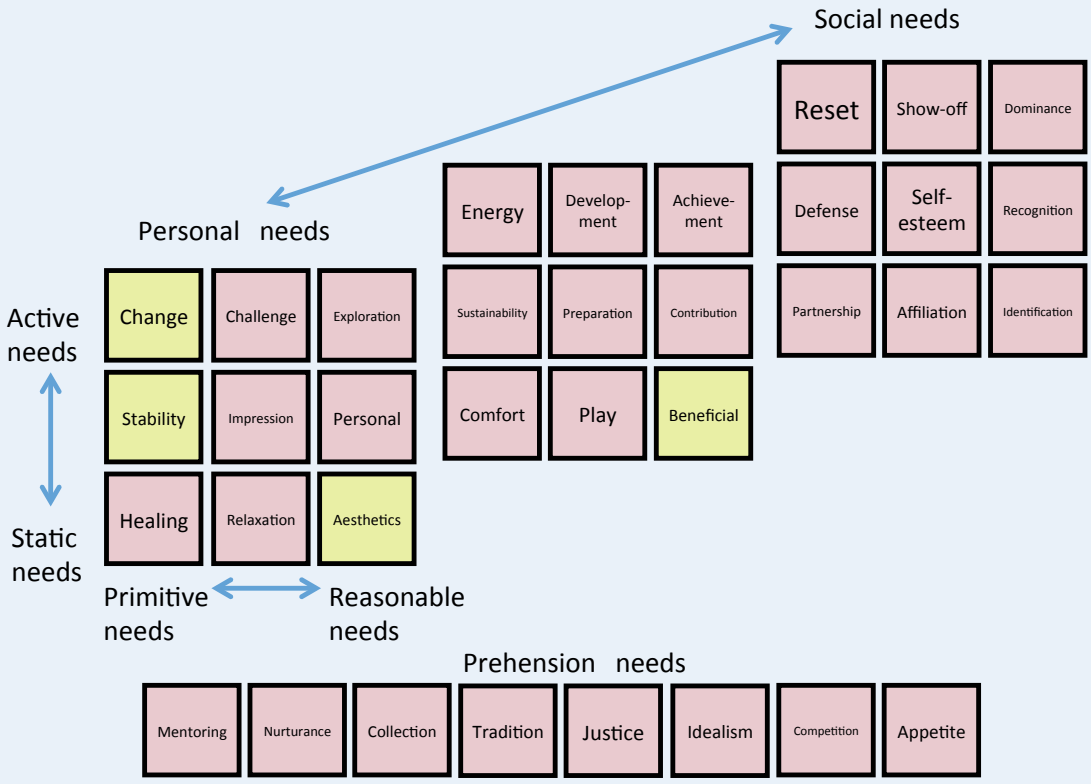
The Japanese concept of *Sato-umi* represents one version of this humans-in-nature approach, in which a healthy ecosystem is seen to nourish human well-being, but human activities are seen as necessary for sustaining ecosystem health. *Sato* means community or village, and umi means sea or coast. Therefore, *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[12].

Permission granted for the use of this image from the Sato-umi Net website (https://www.env.go.jp/water/heisa/satoumi/en/01_e.html) by the Ministry of the Environment, Japan

UNDERSTANDING HUMAN WELL-BEING IN LOCAL COMMUNITIES AND HOW IT RELATES TO THE SEA

Opinions of what is a "good ecosystem" can differ among countries, employment sectors, and communities. Understanding people's needs, and their perceptions of their needs, is crucial to meaningful social-ecological systems analyses. This can be done in several ways. One new method is the well-being cube analysis[13] that is based on psychological theory (Box 5). Another approach is to conduct a Community Needs Assessment[14]. This is a process to gather information on the perceived needs of a community[15]. However, language barriers are often obstacles in communicating with local people. Therefore, a translator who is able to speak the local language but who also understands and is able to communicate social-ecological systems concepts effectively (i.e., a translator who has a scientific background) is very important. Visual aids such as photos, posters or videos can also be useful to facilitate communications. In some situations, community members may be reluctant to share their thoughts with strangers or other community members. Inexpensive technologies are available to preserve anonymity while also tabulating community opinion (Box 6).

BOX 5: WELL-BEING CUBE ANALYSIS (INDONESIA CASE STUDY)



This figure shows that people in Indonesia need the psychological attributes of "Stability", "Beneficial", "Aesthetics" and "Change" to improve their well-being in relation to the sea (pink squares indicate high expectation and high satisfaction, and yellow squares indicate high expectation and low satisfaction by Indonesian people). Therefore, social-ecological systems analyses in this region should focus on these four needs. For more details about this analysis, see PICES Scientific Report No. 52.

BOX 6: TECHNOLOGIES FOR COMMUNITY NEEDS ASSESSMENTS

In Guatemala, a computer, projector, and real-time electronic 'clickers' were used to quickly and anonymously gather and present the integrated responses to survey questions during a community meeting. In this study, the communities surveyed believe that seafood is important, especially finfish and shrimp. The possibility of introducing eco-tourism and environmentally-considerate oyster aquaculture was another outcome from the meeting.

NEW SOLUTIONS TO MEET LOCAL NEEDS

It is a researcher's role to propose feasible solutions to meet local people's needs without increasing the burden on the ecosystem. For example, in Karawang, Indonesia, the concept of Integrated Multi-Trophic Aquaculture (IMTA) technology (Box 7) was introduced to help decrease coastal pollution from aquaculture ponds, prevent mass diseases of shrimp in the ponds, increase the number of species produced from the aquaculture ponds, and ultimately to achieve sustainable use of the coastline. Along the Pacific coast of Guatemala, a new technology of oyster longline aquaculture was introduced, marine protected areas were proposed, and the development of eco-tourism was recommended to the local communities. In addition, personal connections were made among people from research institutes and organizations in Guatemala with the local communities to help achieve these recommendations.

BOX 7: INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA)

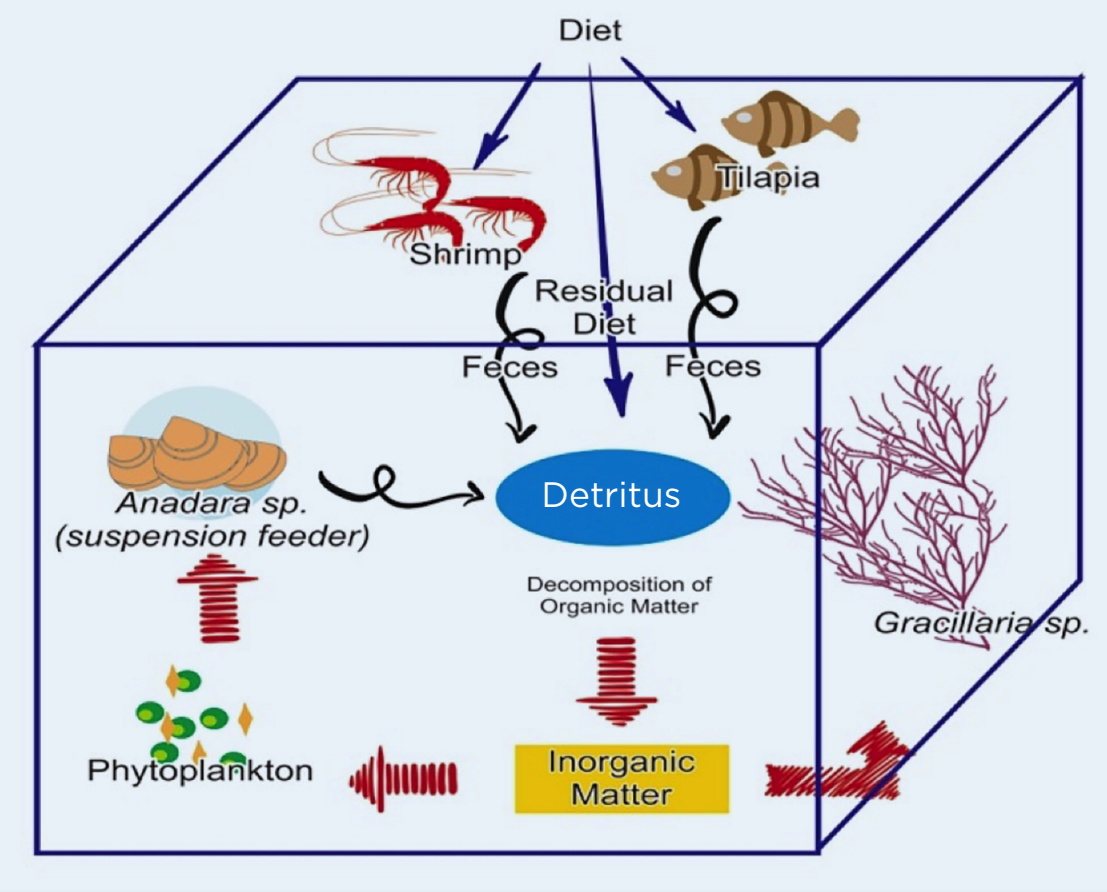


Diagram of the experimental pond at the National Center for Brackishwater Aquaculture, Karawang, Indonesia.

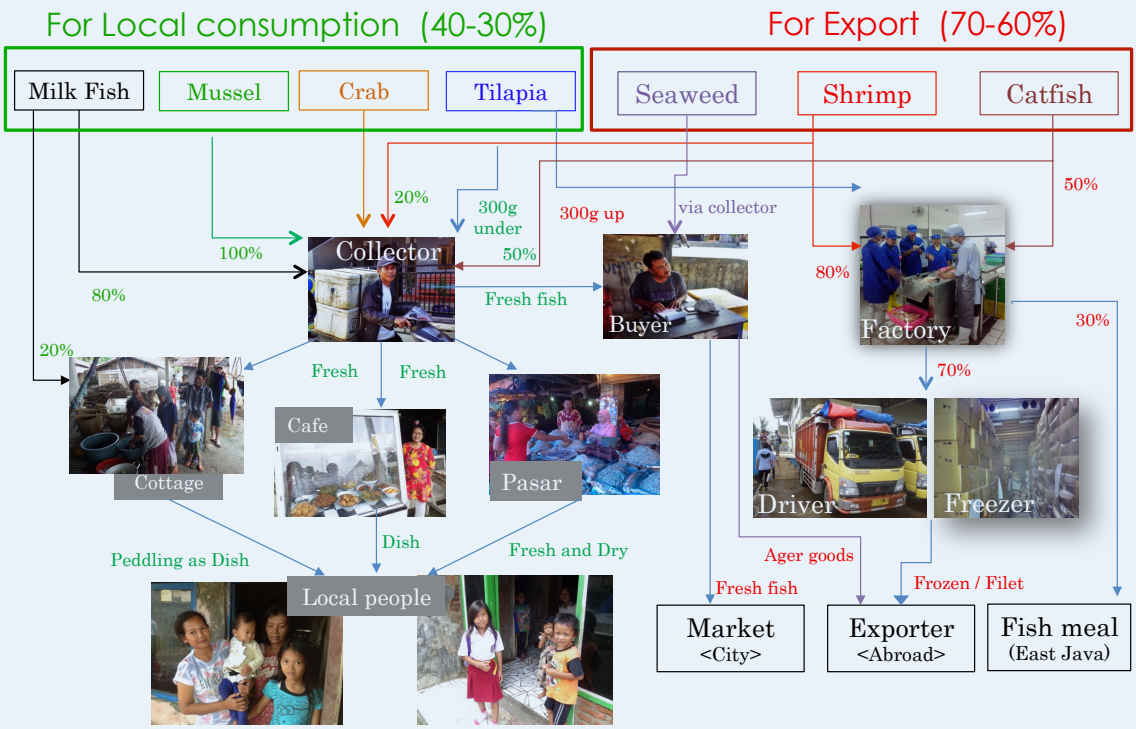
To reduce the flow of excess nutrients from the ponds into the coastal ocean, and to diversify food products for local communities, an Integrated Multi-Trophic Aquaculture (IMTA) approach was implemented that included phytoplankton, seagrasses (*Gracilaria* sp.), suspension-feeding clams (*Anadara* sp.), fish (*Tilapia* sp.), and shrimp (the main production target species).

CONNECTING THE SOCIAL AND ECOLOGICAL SYSTEMS

The next step of a social-ecological analysis is to identify the interactions among the social and ecological systems, and their impacts to human well-being. The introduction of IMTA technology to Indonesian coastal communities is expected to achieve sustainable use of the coastal ocean. Increasing the number of cultured species will increase the seafood available to the community, which will increase seafood-related jobs and food self-sufficiency of the community (Box 8). Decreasing pollution means better water quality, safer seafood, and a more beautiful coastline. The prevention of mass diseases of shrimp means that local people can sustainably use the coastline, which will prevent abandonment of the shrimp ponds and erosion of the coast.

What are the links to human well-being? Safe seafood and protection of the land and coastline will improve the psychological sense of "stability". More jobs and wealth created by IMTA through expansion of a 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.

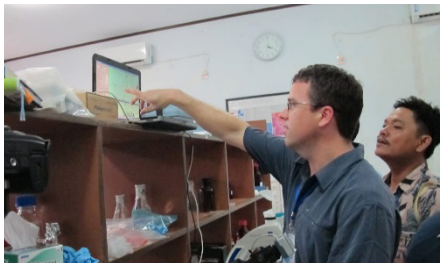
BOX 8: COMMODITY CHAIN MAP OF SEAFOOD SUPPLY IN KARAWANG, INDONESIA



In Karawang, Indonesia, shrimp is too expensive for local people. Thus, currently almost all shrimp produced from local aquaculture ponds is frozen and exported. Introduction of IMTA means that other products in addition to shrimp (e.g., fish, seagrasses, and clams) can be supplied to the local seafood market. This diagram shows the expected distribution within the markets of Karawang[16] and indicates that IMTA can potentially increase the number of jobs and self-sufficiency rate of the people in the community.

RESEARCHING TOGETHER: DISSEMINATION AND CAPACITY BUILDING FOR ADAPTATION

Eventually, local communities must take the lead and conduct their own research on social-ecological systems. Therefore, collaboration with local stakeholders, especially in terms of dissemination of the results and capacity building of local researchers and technicians, is crucial for communities to develop their own research programs.



CONCLUSIONS

Using a social-ecological systems approach means additional efforts beyond traditional discipline-based research activities. First, close communication is needed with local people to identify their needs and the structure of their psychological well-being in relation to the sea. This is a collaborative process for designing and defining the research framework to tackle difficult real-world problems. Sometimes, anonymity in responses to survey questions, e.g., for community needs assessments, can be important, especially in small communities. Open-mindedness and listening are critical. A key contact person in the country, or better, in the community, is essential for consultations and to provide feedback in regard to interpreting the outcomes of the activities. Relationship building, trust, persistence, and feedback of results to the communities are key attributes for success. Knowledge from both the natural and social sciences needs to be integrated to address these issues. Most importantly, understanding the interaction between social and ecological systems and their effects on human well-being is demanding work, but it can also be very rewarding. One researcher cannot do it all – a multidisciplinary team is needed. If researchers from wide-ranging disciplines can work together under the social-ecological systems framework, scientific knowledge on coupled human/nature questions in the North Pacific and developing nations will progress rapidly. Among the most important legacies of these projects are the skills and interests of the communities to continue this work themselves. Therefore, collaboration with local stakeholders for co-dissemination of information is critical. In addition, capacity-building of local researchers and technicians is vital so they can further develop their own research programs, which will lead to increased resilience of local communities[17].

FURTHER READING

1 FAO, 2003. FAO Fisheries Technical Paper, No. 443. Rome, FAO, 71 pp.; Hollowed *et al.*, 2011. Fish and Fisheries 12: 189–208.

2 De Young *et al.*, 2008. FAO Fisheries Technical Paper, No. 489. Rome, FAO, 152 pp.; Ommer *et al.* (Eds.), 2011. World Fisheries: A Social-Ecological Analysis. Fisheries and Aquatic Resources Series, Wiley-Blackwells, Oxford.

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7 SH"U"N project (http://sh-u-n.fra.go.jp/shun/?lang=en), Fisheries Research and Education Agency, Japan.

8 Jamieson *et al.,* 2005. PICES Scientific Report No. 29, 77 pp; Jamieson *et al.,* 2010. PICES Scientific Report No. 37, 166 pp.; Makino and Fluharty, 2011. PICES Scientific Report No. 39, 40 pp.

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11 Jentoft, 2000. Marine Policy 24: 53–60.

12 Makino, 2011. Fisheries Management in Japan. Springer, Heidelberg, 200 pp.

13 Hori, 2015. PICES Press 23(2): 28–30.

14 For information on how to conduct a Needs Assessment, see https://coast.noaa.gov/needsassessment/#/

15 Altschuld and Kumar, 2010. Needs Assessment: An Overview. Sage, Thousand Oaks.

16 Hirota, 2015. PICES Press 23(2): 31/40.

17 Keeler *et al.*, 2017. BioScience 67: 591–592; Trainer *et al.,* 2017. PICES Press 25(2): 31–34.

FRONT COVER PHOTOS:

Main: A fisherman casting his net in the Monterrico estuary (Guatemala)

Top left: Local marketers selling fish on an Indonesian beach

Top centre: Drying seaweed at the beach (Indonesia)

Top right: An experimental pond at the National Center for Brackishwater Aquaculture, Karawang, Indonesia

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Source for more information:
Makino, M. and Perry, R.I. (Eds.) 2017.
Marine Ecosystems and Human Well-being: The PICES/MAFF project MarWeB.
PICES Scientific Report No. 52, 235 pp.
The report is available on the PICES website at http://www.pices.int/publications/scientific-reports.

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