Better Management Practice, Public Health and Sustainable Farming

Pedro B. Bueno, C.V. Mohan, Michael J. Phillips, Koji Yamamoto, Flavio Corsin and Jesper Clausen

Global aquaculture output is shooting towards the 60 M mt level. Since the 1980s, aquaculture production has sustained an average yearly growth of 10%. This rapid growth, attained by increasing farm area, intensification in farming practices and often high density of stocking and structures has contributed much to the supply of seafood. It has also spawned concerns over food safety and aquaculture's own sustainability. This article draws examples from and focuses on coastal aquaculture.

Editors' Note: This is an invited article and we thank NACA for the contribution. The reader gets a feel of how addressing food safety and environmental concerns to meet the requirements of the consumers and society can be a daunting task for small-scale farmers. Probing and trying to establish the links between environmental deterioration, aquatic animal diseases, food-borne illnesses, health hazards from poor aquaculture management and food safety, the article bares the complexity of the effort to encourage and enable farmers, especially the small-scale, to adopt responsible practices. A number of proven and potential technological fixes and management approaches, which the authors review, gives hope. Although some of these might not be easy nor cheap to adopt, there is reason for optimism. Summarizing the experiences from various initiatives of national, regional and international organizations including Thailand's Department of Fisheries, MPEDA and ICAR in India, NACA, SEAFDEC, FAO, WWF, WB, UNEP and others, implemented separately or in collaboration with each other, the authors highlight a fundamental finding: *that adoption of better management by organized farmers leads to more environmentally responsible and economically efficient farming, as well as better quality product — requisites to sustained fish farming, market access and competitiveness*. The authors draw attention to the International Principles for Responsible Shrimp Farming and the efforts going on to translate the principles to practice, and recommend similar collaborative efforts for other species and systems.

Food Safety and Environmental Issues

Health Benefits and Risks

"You are what you eat," goes an old saying. Medical research however, has come up with plenty of reasons to be very careful with what and how much you eat. With seafood, the advice is not to consume frequently the species that may have high mercury content. That said, findings show that consuming fish and shellfish improves one's general health, mental ability and other faculties as well. A study on the risks and benefits of fish and shellfish intake shows that *among adults the benefits of fish intake exceed the potential risks* (D. Mozaffarian and E.B. Rimm, 2006). Eating a variety of seafood is good but frequent consumption (five or more servings a week) is risky especially the species that might have high mercury levels.

(Farmed fish in general are likely to have much lower levels of mercury than their wild counterpart as the feed rations are monitored and they are harvested younger. Mercury accumulates during the life of the fish). Other studies in Britain, suggest the omega-3 fatty acids from fish are even more important than had previously been recognized. For instance, the amount of omega-3 in a pregnant woman's diet helps to determine her child's intelligence, fine-motor skills and propensity for anti-social behavior. Children of women who had consumed the smallest amounts of omega-3 fatty acids during their pregnancies had verbal IQs six points lower than average which could have a serious effect on a country's brainpower if it were widespread.

Much of the concern associated with seafood is food-borne illnesses. Some 200 different types of illness had been identified as being transmitted by food. The Center for Disease Control and Prevention (CDC) of the US estimated in 1999 that there were 76 million cases of gastro intestinal illnesses in the US of which 325 000 required hospitalization and 5000 resulted in death (N.S. Yang, 2003). A 1995 World Health Organization survey estimated that 39 million people worldwide were infested with parasites from eating raw or improperly cooked freshwater fish and crustaceans; of these 38 million lived in Asia. WHO gave the possible reasons as increasing urbanization, human and industrial pollution, improper use of antibiotics, new emerging pathogens, uncontrolled recycling of organic material, increased susceptibility to contaminants, increased consumption of mass-produced foods, introduction of "minimally processed foods", and prolonged rains, droughts or increases in average temperatures which favour the ecologies of pathogens. (This last one gives a preview of the likely impacts of climate change on aquaculture).

Human health risks associated with aquaculture also arise from pathogens and spread of disease vectors, chemicals and toxins and, as WHO listed, abuse of antibiotics. These, however, are largely manageable. Water and insect borne diseases and a range of parasitic worms, pathogenic bacteria and viruses are common to both natural and farm environments. While poorly managed intensive aquaculture may render aquatic animals more susceptible to disease, most health problems of aquatic animals do not have zoonotic potential (they are not transferable from animals to humans) and so far there is no equivalent to a BSE. Human infection comes mainly from consuming raw or inadequately cooked aquatic animals. Most parasitic worms and bacteria are destroyed through cooking and in some cases by storing fish at low temperatures. In addition, epidemiological evidence suggests that the risk to human health is low. Risk also needs to be seen in perspective with better availability of low-cost aquatic animals and better sanitation and food safety protocols, particularly in commercial aquaculture.

Agricultural chemicals, pesticides, veterinary drug residues, and accumulation of other pollutants pose hazards to farm workers and consumers alike. High levels of polychlorinated triphenyls (PCBs), dioxins and other contaminants have been reported in farmed salmon, attributed to the bio-accumulation of contaminated fish meal in feed. The levels of mercury and organochlorides in wild fish as well as farmed, are a public health concern: the latter because of possible feed contamination and, for animals raised in coastal cages, because of land-based discharges.

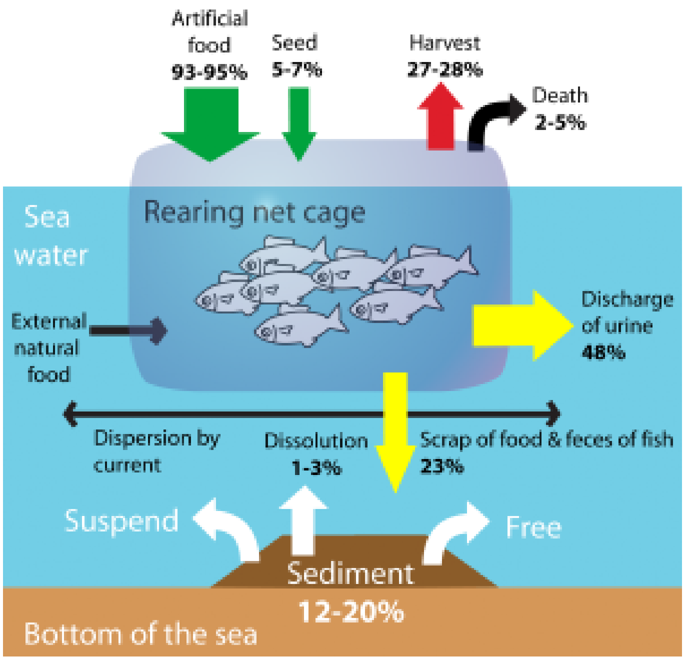
In case of bivalves (oysters, mussels, clams), the risk of human health is not only caused by industrial, agricultural and domestic sewage containing heavy metals, chemicals, pathogenic bacteria and viruses. There are also biotoxins in the water, which are produced by naturally occurring phytoplankton, typically in form of algal blooms, occurring with increasing frequency because of eutrophication of the coastal waters (Australia-New Zealand Food Authority, 2001). The most common shellfish poisonings are paralytic (PSP), diarrhetic (DSP), neurotoxic (NSP), and amnesic shellfish poisoning (ASP). Early warning systems for red tides and responses to harmful algal blooms have been successfully installed in Hong Kong, South Korea, Singapore and Japan in the Asia-Pacific region. Still, shellfish and finfish farming areas infested by toxic algal species may need to run monitoring programs to check for toxic algae in the water and, whenever these are present, carry out regular tests for toxins in seafood products. This can be costly to governments or farmers. Depuration, as well, can be a significant cost item to small-scale growers, which in any case, cannot be readily passed on to consumers.

Drug resistance from the use of veterinary drugs presents another risk — to consumers from ingestion of the drugs or residues leading to development of antibiotic resistance in human pathogens, and to workers from exposure to drugs and drug-resistant pathogens generated from release of drugs in the environment. Guidelines for the proper use of chemicals are now important components of good management practices. In Norway the decreased use of antibiotics is a result of good site selection, one generation per site (site rotation); improved culture management; effective vaccines; strict veterinary control of all farms; and strict rules for movement of live fish.

Pollution

Pollution from land-based sources and coastal fish farms invariably leads to disease outbreak requiring chemical and drug applications. Poor information or lack of good advice leads to farmers' misusing or abusing antibiotics, disinfectants and water quality improving chemicals, which jeopardize the quality and safety of fish products. Poorly sited and densely located fish cages, pens or ponds have caused water pollution that exacerbate disease and parasite outbreaks and, as some suggest, may lead to blooms of harmful algae. Environmental impacts associated with marine finfish cage culture come from nutrient inputs from uneaten fish feed and fish wastes. Although small in comparison with other coastal discharges, these nutrient inputs cause localized water quality degradation and sediment accumulation. In severe cases, this 'self pollution' can lead to cage farms exceeding the capacity of the local environment to provide dissolved oxygen and assimilate wastes, contributing to fish disease outbreaks.

Y. Chang and J. Chen (2006) pointed out that the impacts of sea cage aquaculture on coastal waters may be relatively insignificant compared to the impact of discharge from land-based sources (or the occasional oil spill). A study in Japan however presents a picture of serious organic pollution from highly intensified fish culture in coastal areas. Coastal water pollution from organic matter discharged by mariculture is aptly illustrated below. Calculations placed the level of pollution by mariculture in Japan as equal to the nitrogen discharge from 5-7 million people and the phosphorus discharge from 9-10 million people (T. Maruyama, 1999 cited by Y. Yamamoto and S. Hayase, 2006). Apart from the environmental impacts, a poor image of aquaculture products is feared because of residual medicine and the deterioration of the mariculture grounds and surrounding waters.



Nitrogen balance of mariculture by net cage rearing. (Case study in rainbow trout) (Hal et al 1992, modified)

Environmental Impacts and Benefits of Aquaculture

There is no doubting the links between environmental pollution, aquaculture and public health. Responsible farming practices therefore can prevent or mitigate the adverse impacts on public health as well as provide other benefits, as outlined below:

Negative environmental impacts of irresponsible aquaculture

- loss or degradation of habitats such as mangrove systems
- salination of soil and water
- coastal and freshwater pollution, e.g. contamination of water and fauna through misuse of chemicals and drugs
- alteration of local food webs and ecology
- depletion of wild resources and biodiversity for seed or broodstock
- spread of pathogens to wild stocks
- depletion of wild genetic resources through interactions between wild and cultured populations
- impacts of introduction of exotics

Modified from: "Aquaculture: Changing the Face of the Waters Agriculture and Rural Development Department," World Bank

Technological and Management Options

Reviews presented at the "Future of Mariculture" workshop held in Guangzhou by FAO and NACA and hosted by the Guangzhou Government in June 2006 describe a number of technological solutions and management arrangements to deal with the issues of environmental impacts of, and on, coastal aquaculture. Some considerations for developing BMP in Mariculture and some of the issues and suggested solutions have been or could be incorporated into better management practices, codes of practices, market based incentives and regulations, are presented below:

Environmentally friendly feeds and feeding regimes

Although pellet diets are available for a range of marine finfish as well as some crustaceans, there remain important constraints to the widespread use of compounded diets: Farmer acceptance of pellet diets is low because they see these diets as much more expensive than trash fish. Farmers often do not appreciate that the food conversion ratios of pellet diets (usually 1.2–1.8:1) is dramatically better than that of 'trash' fish (usually 5–10:1, but sometimes higher).

Lack of farmer experience in feeding pellets may result in a lot of wastage. Distribution channels for pellet feed are not widely available in rural areas, which limit accessibility to and increase the cost of feed. Small-scale farmers operating fish cages may not have access to the financial resources necessary to invest in purchase of pellet diets or infrastructure such as refrigeration, finding it easier to collect

Environmental benefits from responsible aquaculture

- agricultural and human waste treatment
- improved habitat diversity and productivity
- water treatment and recycling
- freshwater water storage
- nutrient and heavy metal sink
- reduced water pollution loads
- pest control
- weed control
- disease vector control
- desalinization of saline lands
- restoration of populations of endangered species
- recovery of depleted wild stocks
- preservation of wetlands

: Meeting the Promise and Challenge of Sustainable Aquaculture"
, July 2006. in press.

'trash' fish themselves, or in small amounts as and when financial or 'trash' fish resources are available. Trash fish collection can be an opportunity cost, which in family-operated farms may be easily absorbed, whereas the purchase of pellets is a cash cost. Use of dry pellets rather than wet feeds reduces nutrient inputs through better feed utilization (M.J. Phillips, 1998 and Y.Y. Feng et.al, 2004).

Farmer carrying trash fish (photo by Chen Jiaxin)

Suggested solutions to self-pollution of sea cage sites include: (i) adoption of Better Management Practices (BMPs), including efficient feed formulation and feeding practices; (ii) keeping stocking densities and cage numbers within the carrying capacity of the local environment; (iii) minimal and responsible use of chemicals; (iv) locating cages so that there is adequate water depth below and sufficient water movement to disperse wastes; and (v) moving cages regularly to allow recovery of the sediments of affected sites.

Zoning, co-management and legislation

While there is increasing appreciation of the environmental impacts of mariculture in East and Southeast Asia, many countries lack the legislative framework or effective enforcement. Problems can be addressed by more emphasis on local planning initiatives and co-management frameworks, and zoning of coastal areas. Hong Kong SAR provides an example where the government has designated mariculture zones although critics argue that zoning has allowed too much crowding and localized water pollution (L.W.C. Lai, 2002 and Y.J. Sadovy and P.P.F. Lau, 2002). Zoning of marine fish farming areas has to be accompanied by control measures that limit farm numbers (or fish output, or feed inputs) to ensure effluent loads remain within the capacity of the environment to assimilate wastes. Aquaculture development plans need to consider competing objectives on the use of the coastal lands and water, include regulations that limit aquaculture development within appropriate levels, and devise a robust, cost-effective environmental monitoring system appropriate to tropical mariculture.

Use of low-trophic species

Cultivation of low-trophic-level marine species could alleviate some of the impacts of farming animal species that require high levels of organic inputs, such as marine finfish. There are two ways to achieve this: (i) direct replacement of high-input species with low-input species, *e.g.*, replacing production of carnivorous finfish (such as groupers) with omnivorous species (such as milkfish and rabbitfish); and (ii) promotion of low-trophic-level species that act as 'sinks' for the waste products from high-input aquaculture. Such species include mollusks, sea cucumbers and seaweeds. A constraint to adopting low-trophic-level species is price; most species are relatively low-priced, the exception being sea cucumbers, scallops and abalone.

Phytoremediation

Studies on freshwater decontamination with plants have shown the efficacy of some species, especially water hyacinth, in accumulating heavy metals. But few studies have been conducted on marine macroalgae. Although a number of species such as *Ascophyllum nodosum* and *Sargassum aquifolium* are known to accumulate metals to as much as 30% of the biomass dry weight. Some unicelled marine algae, *Tetraselmis suecica* and *Chlorella* spp. NKG16014 are being used in heavy metal bioremediation. The gametophytes of *Lemna japonica* have demonstrated in experiments their efficiency as heavy metal decontaminator, especially cadmium (Naihao Ye, 2005 cited by Y. Liu, 2006).

Integrated coastal aquaculture

Integrated aquaculture is broadly defined as the culture of a range of trophic-level organisms whereby outputs from one species can be utilized as inputs by another species. China has the best examples of large commercial-scale integrated mariculture where suspended multi-species aquaculture operates at scales of whole bays. For example in Sungo Bay, East of the Shandong Peninsula, scallops are cultivated together with kelp, abalone and fish in cultures extending 8 km offshore (M. Troell, 2006). Integrated practices provide additional income from co-cultured crops and reduce nutrient release to the water. Other benefits are the facilitation for re-circulation of waters (through ammonium removal and oxygenation by seaweeds), which could reduce pumping costs. The additional crop, which is the extractive organism generates an economic value or be used as input to co-cultured species. Additional arguments for integrated mariculture include possible social benefits and diversified production to reduce risk and increase income. But it also entails additional costs such as additional investments, maintenance and need for higher skills.

Offshore cage farming

While a host of technical and economic issues remains to be resolved, offshore cage farming presents an attractive option for governments to promote. Its advantages include expansion of space for mariculture without occupying precious land, abating the eutrophication of seawater, increasing opportunity for employment of displaced fishers and generating new enterprises such as the manufacture of cages and accessory instruments and equipments for monitoring, grading, and feeding. With improved design and better materials, sea cages are better able to withstand typhoon and swift current. It can also be more technically efficient than traditional near-shore cages (J. Chu, 2006)

Rope cage (top) and a submersible cage manufactured by FMIRI,Shanghai (above) (Photos by Chen Jiaxin)

Artificial reef

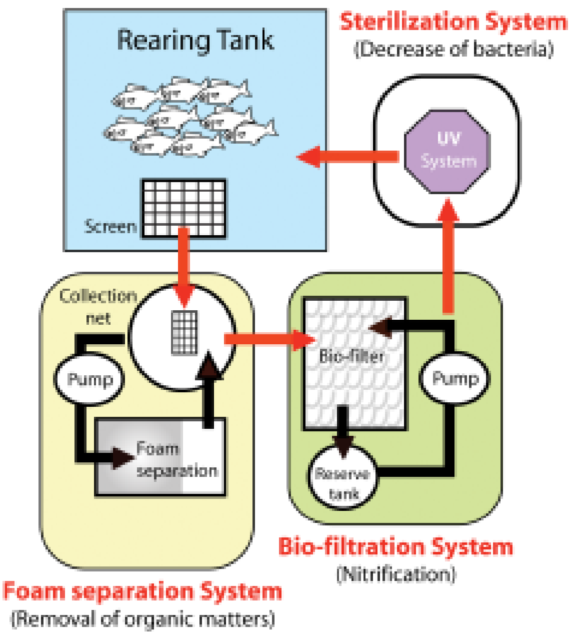
Another promising technique is the use of artificial reef (AR) as biofilter in a fish culture zone. A study in Hongkong showed that it can be an efficient device to remove nutrients from fish farms: i.e., 16 pieces of 3m x 3m x 4m specially-designed AR removed 2352 kg of carbon, 624 kg of nitrogen and 103 kg of phosphate a year (J. Chu, 2006).

Items	Traditional cage	Offshore cage
Survival rate of fish (%)	70%	> 90%
Cage volume (m3)	< 100	> 1000
Capacity against wind (km/hr)	< 100	> 110
Capacity against current (m/s)	< 1	< 1.5
Capacity against wave-height (m)	2	> 6
Life span of cage (year)	< 3	> 10
Sea site suitable the cage	Inshore and sheltered only	Offshore, exposed
Yield (Kg/m^2)	about 5	> 20
Input-output ratio	1 : 1.3 - 1.5	1 : 1.5 - 2.0

Artificial reef with mussel ropes around the structure (photo by Agriculture, Forestry and Conservation Department, Hong Kong)

Land-based closed recirculation system

Closed recirculation systems are designed for "zero emission". This Figure illustrates an almost complete system control, which gives the following benefits: less pollution, less external risk (*e.g.*, disease and bad water quality, *etc*.), stable productivity and lower energy use. Development of the closed recirculation system for seed production of red sea bream started in the Yashima Station in Japan, in 2000.The system consists of: (i) foam separation unit; (ii) bio-filtration system; and (iii) UV system. The foam removes organic matter in the rearing water, the biofilter converts nitrogen waste into less harmful form, and the UV system kills bacteria. The technical efficiency of seed production (of red sea bream) by this system is higher than that of flow-through rearing. Japan plans to use this system for other species that are difficult to produce (Y. Yamamoto and S. Hayase, 2006).



Seed production by closed recirculation system in Yashima station, NCSE, FRA

Closed systems are well developed in some EU countries and Australia. Some Australian farms raising barramundi (*Lates calcalifer*) grow vegetables in hydroponics (also called aquaponics); the vegetables strip the nitrate from the water and are an additional farm product.

Better Management Practices in Aquaculture

An approach to improving the sustainability of aquaculture has been the development of Better Management Practices. BMPs have been widely tried in shrimp culture. The development of BMPs for mariculture particularly on tropical marine finfish started recently. To place BMPs for mariculture in a socio-economic context, a glimpse at the circumstances and prospects of a coastal farming village called Nan Hu in Guangdong Province which provides some insight into the problems faced by coastal fishfarming communities in Southern China, and likely in many other areas in the region, is briefly summarized below.

- The profitability of small cage culturists has gone down,
- Coastal waters are becoming more polluted from land based sources, exacerbated by poor sewage treatment facilities,
- They have suffered from disease outbreaks,
- Cost of production has gone up although prices for certain species (the seed supply of which is not enough) remain good in the Hong Kong and local markets,
- Some have gone back to fishing and, while scallop farming could be more profitable, it is labor intensive for a small family,
- They know of but have no capital to invest in offshore cages, and
- The younger generation has not shown much interest in fishfarming

In contrast, mechanized large scale companies are being established in the area, which are likely to be more cost-efficient and could employ people from the villages.

This social and economic backdrop suggests a difficult pathway to the promotion and adoption of technological and management approaches. In technical advisory-speak the approach would require "a governance framework consisting of an appropriate mix of regulatory, market incentive, and voluntary instruments". Technologies as those described earlier, and regulatory measures as those suggested would enable the farmers to raise aquatic products that are safe and wholesome and reduce the impacts of pollution on and from fishfarming. The benefit to society would be mitigation of pollution and other adverse environmental impacts. The benefit to consumers is safe and quality product. The bottom line for the farmers would be whether or not it makes economic sense to adopt these measures.

Some Lessons from Shrimp Aquaculture

Projects that have promoted the voluntary adoption of BMPs among small shrimp farmers in India and Vietnam and a program on Code of Conduct in shrimp aquaculture in Thailand give evidence of the benefits of being organized into self-help groups or formal associations and adopting better management practices. These range from individual private benefits such as higher production, better chances of increasing profitability, less losses from disease, etc., to social and environmental benefits such as less or non-use of antibiotics and therefore no discharge of these into receiving waters, less pollution, and a better cooperation among players along the value chain.

Thailand's "Farm to Plate" program was launched in 2003 to promote an international image of safe and responsibly produced aquatic food products. This encompassed good aquaculture practices, a code of conduct program in shrimp, traceability schemes, detection of banned chemicals and drugs, HACCP and other standards and quality certification schemes in food handling and processing. For shrimp farming, a Good Aquaculture Practice (GAP) which is food safety-targeted and a Code of Conduct (CoC) program, which is environmentally oriented and designed to reduce disease risks and pollution, were devised. An analysis of the CoC program of Thailand suggests that a voluntary management scheme would need supportive measures largely to improve farmers' perceptions of long-term benefits and reduce perceived risks. A green insurance for instance would reduce perceived risks associated with adoption of the CoC standards (T. Pongthanapanich and E. Roth, 2006).

The analysis also recognizes that farmers organizations would facilitate the provision of assistance and points out that being organized induces self-monitoring and -inspection within the group. As such, implementation of a voluntary scheme is likely to be more effective than using legal sanctions, or more acceptable than using market- based tools to protect the environment.

To sum up, better management practices are adopted voluntarily. For best effect they should be developed with the farmers who are going to use them, and should be adopted by farmer groups. BMPs could be devised to provide an economic incentive for farmers to exceed market-based standards rather than comply, largely to avoid penalty, with a bureaucratically-set standard or piece of regulation. Success in implementing regulations depends on the effectiveness of enforcement, which relies on supportive institutional structure. Enforcing compliance is often difficult and expensive. And, if done with excessive enthusiasm, it could stifle growth, lead to inefficiencies or present an opportunity for corruption.

Conclusion and Way Forward

Regional cooperative activities

The workshop, "Future of Mariculture" had recommended a number of regional activities. Three are relevant to this article:

Review of the COC/GAP/BMP systems for the region

This means working on a basic set of harmonized principles of better management from which commodity- or system-specific principles or standards could be developed. Much work has been done on shrimp but limited attention is being given to mariculture species[1].

Pilot activity on labeling according to emerging BMP for some specific pilot sites and commodities

This will initiate dialogue on the emergence of specific commodity or systems-based BMPs such as *BMP cage mariculture; BMP mollusk mariculture*. As with the shrimp consortium, a consortium model would be developed among institutions to start developing issues-based awareness and information on principal mariculture areas. An expert consultation on one or two key species for setting out some baseline standards for production and quality would be organized.

Special attention on food safety issues

This would include veterinary guides of diseases and allowed therapeutants, contaminants and residues, an agreed list and awareness brochure, and a watch list. Work should also be done towards harmonizing traceability and food safety systems with the needs of importing countries.

Moreover, training on detection and analysis of chemical and drug residues, which requires standardization and harmonization of laboratory facilities and procedures, would be conducted.

To conclude this article, we quote from a World Bank review on aquaculture conducted in 2006, thus, "There is a need for the governance framework for a rapidly expanding aquaculture sector to adapt so that the sector becomes or remains responsible; good environmental practices improve fish health and economic returns; as food safety requirements are harmonized at international levels, quantitative risk

1 International Principles for Responsible Shrimp Farming. 2006. *www.enaca.org/shrimp*. This comprises eight principles that had been synthesized from the outcome of several studies and a series of consultations conducted by the Consortium on Shrimp and the Environment which members are FAO, NACA, WWF, WB and UNEP. The principles and implementation guidelines may be used to develop locally specific codes of practice, better management practices or other management approaches.

assessment and traceability are becoming integral components of aquaculture management; and improved dialogue and coordination among engineers, public health officials, veterinarians and regulators will improve the environmental services from aquaculture, reduce health risks, avoid trade restrictions and improve profitability."

Acknowledgement

This article is based on a paper presented by Pedro Bueno at the International Conference on Environment and Public Health Management, convened by the Croucher Institute for Environmental Science, Hong Kong Baptist University, 7-9 December 2006. Hong Kong China. The paper, which is referenced, may be obtained on request from *pedro.bueno@enaca.org*. *Eds*

Selected Readings

Australia-New Zealand Food Authority. 2001. "Shellfish Toxins in Food: A Toxicological Review and Risk Assessment". Technical Report Series No. 14, November 2001. *www.anzfa.gov.au*

Chang Yaqing and Chen Jiaxin. 2006. "Status of Mariculture in North China," In: Proceedings of the Regional Workshop on the Future of Mariculture, Guangzhou, 7-11 March 2006. FAO/NACA. In press.

Chu, Jim. 2006. "Overview of Mariculture in Hong Kong" In: Proceedings of the Regional Workshop on the Future of Mariculture, Guangzhou, 7-11 March 2006. FAO/NACA. In press.

Feng, Y.Y., Hou, L.C., Ping, N.X., Ling, T.D. and Kyo, C.I. 2004. "Development of mariculture and its impacts in Chinese coastal waters". Reviews in Fish Biology and Fisheries 14**,** 1-10.

Lai, L.W.C. 2002. An overview of research on aquaculture economics and management in Hong Kong. Aquaculture Economics and Management 6**,** 131-152.

Liu Yingjie.2006. "The future of mariculture: a regional approach for responsible development of marine farming in the Asia-Pacific Region". In: Proceedings of the Regional Workshop on the Future of Mariculture, Guangzhou, 7-11 March 2006. FAO/NACA. In press.

Maruyama,T. 1999, cited by Yoshihisa Yamamoto and Shigeo Hayase. 2006. "Status of Mariculture in Japan." In: Proceedings of the Regional Workshop on the Future of Mariculture, Guangzhou, 7-11 March 2006. FAO/NACA. In press.

About The Authors

Pedro B. Bueno, C.V. Mohan, Michael J. Phillips, and Koji Yamamoto are Staff of the Network of Aquaculture Centres in Asia-Pacific (NACA), Bangkok, Thailand: P.B. Bueno is Adviser; C.V. Mohan is the Aquatic Animal Health Management Specialist; M.J. Philipps is the Environmental Specialist; and K. Yamamoto is Research Associate (Shrimp Aquaculture and the Environment).

Flavio Corsin was previously Health Management Expert of NACA assigned to the DANIDA-assisted Support to Brackishwater and Marine Aquaculture Project in Vietnam. Currently, he is a freelance technical adviser working on BMPs on Shrimp and other initiatives with the Government of Vietnam and on the epidemiology and control of the H5N1 Virus with FAO in Vietnam

Jesper Clausen is Associate Professional Officer (Food Safety), FAO Regional Office for Asia and the Pacific (FAO RAP), Bangkok, Thailand.