Investing in knowledge, communications and training/extension for responsible aquaculture

Expert Panel Review 5.1

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Abstract

Knowledge has always been critically important to the development of aquaculture whether we are talking about the earliest aquaculture innovations starting in Asia or the more recent challenges confronting the sector worldwide. This panel reviewed selected national and regional case studies. Key topics for discussion include knowledge production and its communication and use (e.g.

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in new training and extension approaches) among the changing audiences (as aquaculture continues to attract an increasing variety of new stakeholders), and dealing with a widening set of change processes in recent times, often involving a complex mix of governance and social change challenges. We go on to suggest that aquaculture policy-makers, and stakeholders in general, need to better understand knowledge processes such as knowledge translation (implementation), knowledge networks (e.g. the role of farmers' associations) and the use of knowledge platforms and brokers, all aimed at more effective dissemination and adoption of knowledge. Knowledge management by most stakeholders will become increasingly critical to the sustainable development of aquaculture and its movement towards attaining the goals set out in the Bangkok Declaration a decade back.

KEY WORDS: *Aquaculture, Communications, Extension, Knowledge, Sustainable aquaculture, Training.*

Background

Knowledge is defined in the Oxford Dictionary as "familiarity gained by experience or a persons' range of information" and so forth. In the modern context, obtaining, storing, disseminating and sharing of knowledge, in various forms and means and in diverse repositories, have become enormous tasks. As knowledge is acquired through innovations and experiences, its management is becoming increasingly crucial for sustainable development. To set an initial broader context, we begin with two thoughtful quotes on knowledge management strategies:

> *"Our ability to learn what we need for tomorrow is more important than what we know today"*
>
> George Seimans (Seimans, 2005),

and

> *"Experience has long been considered the best teacher of knowledge. Since we cannot experience everything, other people's experiences and hence other people, become the surrogate for knowledge. I store my knowledge in my friends is an axiom for collecting knowledge through collecting people."*
>
> Karen Stephenson (Stephenson, 1998).

Knowledge has been critically important to the development of aquaculture, as in all human endeavours, irrespective of whether we are talking about the earliest aquaculture innovations starting in China or Egypt millennia ago or the more recent breeding and disease challenges in the 1970s and 1980s, now continuing into more recent times. However, few scholarly investigations have attempted to probe aquaculture development through a knowledge lens. Other sectors such as business are examining knowledge in detail (see for example the knowledge economy thinking), the health sector (as we will discuss later) and the information and communications technology (ICT) stakeholders are examining knowledge sharing and management[1] thinking in a variety of very interesting and novel ways. We argue below that the aquaculture sector needs to address this issue and particularly to do so around some of the more recent knowledge translation thinking[2], all as part of the move to improved sustainability in the aquaculture sector and meeting the goals set in the *Bangkok Declaration and Strategy for Aquaculture Development Beyond 2000* (NACA/FAO, 2001a). Knowledge translation thinking has developed in the health sciences and provides a very useful model for aquaculture to mimic, around what we call working at the "aquaface"; a concept that we will return to later in this review.

Some knowledge history: ten years ago, the Bangkok Declaration 2000 and the coming decade

Looking back to the Food and Agriculture Organization of the United Nations (FAO) Technical Conference on Aquaculture in Kyoto in June 1976 (FAO, 1976) and the past global aquaculture conference, the Conference on Aquaculture in the Third Millennium, held in 2000 (NACA/FAO, 2001b), it is clear that there has been recognition of the importance of networking and related forms of knowledge sharing and learning. However, these conferences really did not look at knowledge *per se*. For instance, we note that the three main elements of the Bangkok Declaration and Strategy (NACA/FAO, 2001a) with a strong link to our panel's focus include: 3.1 Investing in people through education and training; 3.2 Investing in research and development; and 3.3 Improving information flow and communication. However, it is difficult to provide much precision on changes in the last ten years based on this material. In general, indicators of change and related quantitative data on key aquaculture change processes are difficult to obtain, and we suggest that a re-examination of these issues with a view to developing quantifiable indicators for the next decade (in preparation for Aquaculture 2020?) should be examined. Later in this paper, we go on to provide some qualitative observations on some of the changes we see taking place that could provide some guidance for such an approach.

Globally, knowledge generation is increasing exponentially, and aquaculture is no exception. Identifying and applying the needed knowledge, and even just keeping pace, present continuing challenges for most of us, and this is particularly so for many of our newer aquaculture stakeholders, especially in our globalized world where communication channels have so rapidly increased and diversified. It is difficult to obtain reliable data on knowledge production, but some rough estimates are as follows. In terms of the science side of our aquaculture knowledge base, there were approximately 42 "aquaculture journals" in a 2006 list[3]. However, we assume that most of us are accessing a wider set of knowledge

1 Knowledge management (KM) comprises a range of strategies and practices used in an organization to identify, create, represent, distribute and enable adoption of insights and experiences.
2 See for example http://web.idrc.ca/openebooks/508-3
3 See "aquaculture journals", http://ag.arizona.edu/azaqua/extension/journals.htm

sources than this focussed journal list. Recent estimates by Bjork, Roos and Lauri (2009) using 2006 data, suggest that the number of science journals (in fact using a reasonably wide view of all sciences, both social and natural) has reached 24 000. Therefore, to give some relative measure, aquaculture journals represent roughly 0.008 percent of this total. More importantly, the total number of articles published in scholarly journals was approximately 1 350 000 and increasing rapidly. Clearly the supply of knowledge is now enormous and growing rapidly, and this has a number of implications.

One of the most persuasive knowledge factors is the shrinking half-life of knowledge. The "half-life of knowledge" is the time span from when knowledge is gained to when it becomes obsolete. Half of what is known today was not known ten years ago. The amount of knowledge in the world has doubled in the past ten years and is doubling every 18 months according to the American Society of Training and Documentation (ASTD)[4]. To combat the shrinking half-life of knowledge, organizations have been forced to develop new methods of deploying instruction (Gonzalez, 2004). Our look at the Conference on Aquaculture in the Third Millennium (NACA/FAO, 2001b) and our plans for 2020 should be viewed with these key concepts in mind.

Aquaculture knowledge management

Is it opportune to re-examine our approach to knowledge? Knowledge management (KM) questions such as: Are most stakeholders able to access the knowledge they need? How might this access be improved? How well do we understand our approach to KM? Coming back to some of the goals of the Phuket conference (NACA/FAO 2011), how well does this knowledge fit with our objectives related to the goals of the Bangkok Declaration? In the following sections, we now move on to examine two aspects of KM around knowledge connectivity/networking thinking and knowledge translation.

Knowledge use, strategic influence and longer term change processes

We are starting to see some analysis in this area, and perhaps we need to be thinking more about influence and impact in our aquaculture KM. Interestingly, Hewitt *et al.* (2009) looked at most of the major American fisheries journals, including some in aquaculture, both in terms of citation-based measures of influence of selected journals as well as cost effectiveness. But most of this analysis does not give us much guidance in terms of our Bangkok Declaration thinking.

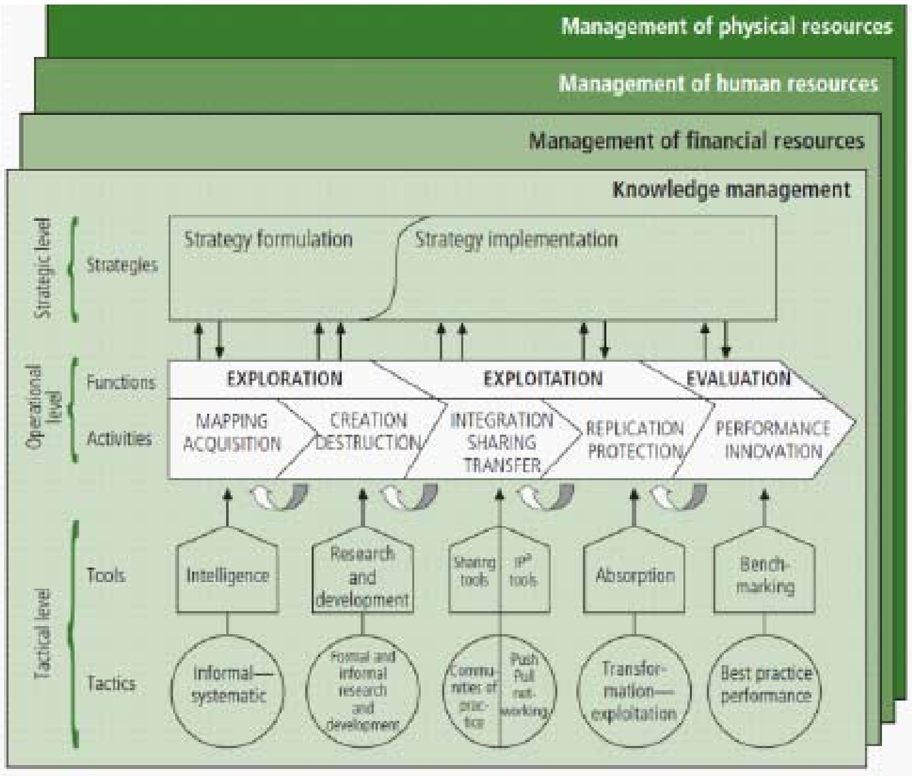
The health sector offers a lot of interesting case material that might provide useful guidance for further work on aquaculture. Value-chain thinking seems to be in vogue of late, and there is increasing examination of this conceptually

[4] www.unt.edu/benchmarks/archives/2004/september04/eis.htm

in other sectors of KM, for example in health (see for instance Figure 1 below which illustrates some of the parts of the KM chain as seen in the health sector). This thinking provides one set of health-based KM examples that seek to subdivide the approach into tactical, operational and strategic levels against formulation to implementation thinking.

Finally, in terms of knowledge use, we suggest that strategic influence (see, for example, International Institute for Sustainable Development (IISD) strategic influence thinking) should receive greater attention in terms of how to more effectively use our knowledge in reaching various users and promoting more sustainability thinking.

FIGURE 1
The knowledge-value chain according to Landry *et al.* (2006)



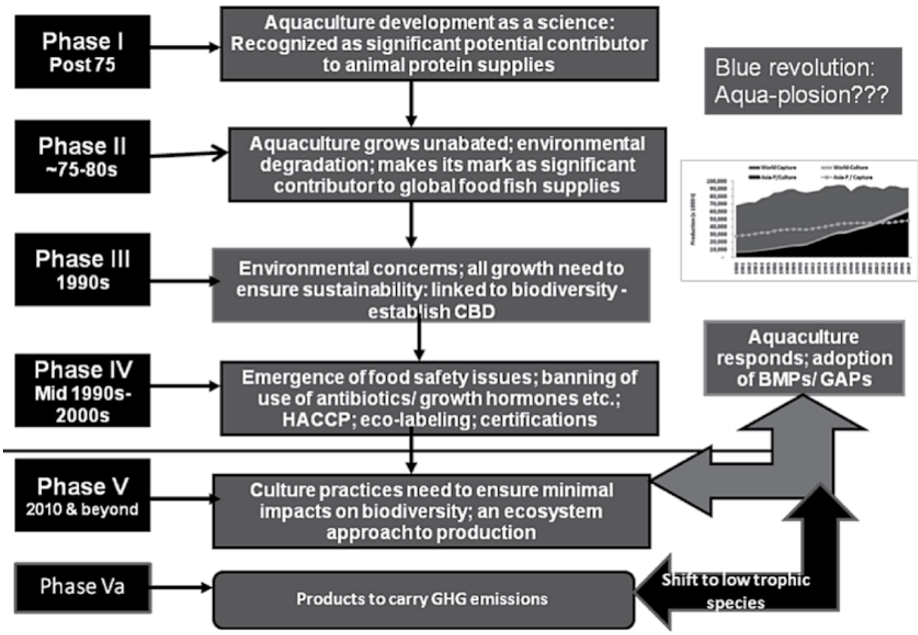
[a] IP = intellectual propriety.

Source: WHO 06.111.

Change and aquaculture development phases

Our knowledge/communications thinking is evolving, at least in part, in concert with the overall past development of the aquaculture sector. Understanding knowledge trends seems fragmented or elusive, particularly in terms of

FIGURE 2
Growth phases in aquaculture



BMPs = better management practices; CBD = Convention on Biodiversity; GAPs= good aquaculture practices; GHG = greenhouse gas; HAACP = hazard analysis and critical control points.

Source: De Silva and Davy (2010).

aquaculture's evolution and its extremely rapid growth in recent years. Some of us have attempted to look at these changes through development phases' thinking (De Silva and Davy, 2010) and the changing knowledge needs as seen in a broad brush fashion in Figure 2.

This initial examination has included some broad analysis of what is working (what we called success stories thinking; see De Silva and Davy, 2010) and in particular, examines success in small-scale aquaculture. This work provided a look back with some initial lessons learned related to the potential issues aquaculture may face as it moves into new future phases and in the context of perceived global changes and community aspirations over the next decade and beyond.

Clearly, the extremely rapid growth of aquaculture has a number of knowledge implications, often not yet attracting much detailed examination. For instance, aquaculture is attracting an increasing variety of new stakeholders as it grows rapidly (but we can find little data or examination of this trend). Linked to this change, aquaculture must also deal with a widening set of change processes and drivers of change; for instance related knowledge sharing related to the

Bangkok Declaration. Scale is another often controversial issue (for example, sustainability and small-scale operations vs large industrial ones) and level concerns (local to national to global), and particularly the latter is becoming of greater importance in recent years, often involving a complex mix of marketing linked increasingly to governance and social organization concerns. Other questions include whether we have adequate paradigms for dealing with the management of knowledge around development, change and sustainability that adequately deal with scale and level differences. Perhaps we need to examine new modes of thinking about the development of aquaculture, such as complex adaptive systems thinking (see Resilience Alliance, www.resalliance.org/) and other conceptual frameworks as part of this process (see De Silva and Davy, 2010 for more background on this issue).

The case-based approach to analyze knowledge management

Our panel reviewed a variety of knowledge and communications experiences through a selected examination of six cases that offer a broad global perspective. A series of lessons learned analyses follow, as part of our initial efforts to summarize knowledge and communications thinking related to these cases. The six case studies are:

(i) catfish farming in Viet Nam,
(ii) small-scale shrimp culture in India,
(iii) marine cage farming in Turkey/Mediterranean Sea,
(iv) salmon farming in Chile,
(v) The European Aquaculture Technology and Innovation Platform, and
(vi) the Network of Aquaculture Centres in Asia-Pacific (NACA) experiences on training, extension, knowledge and communications.

It is expected that such wider knowledge-sharing activities will intensify in the coming decade, guided by the goals set out in the Bangkok Declaration and hopefully further refined and improved at this conference. The specific case summaries are described below.

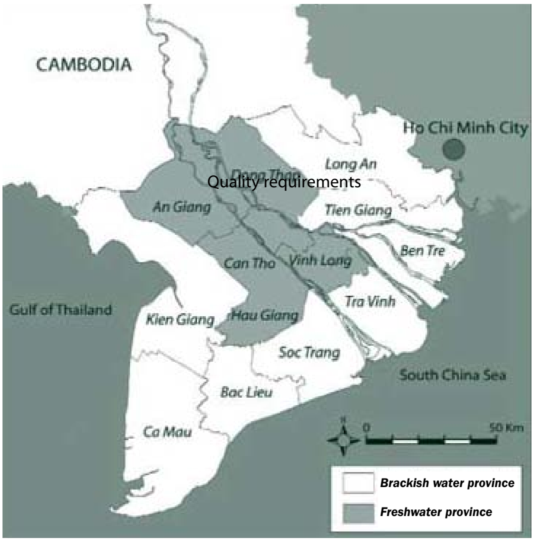
CASE STUDY 1
Striped catfish aquaculture in the Mekong Delta, Viet Nam: a knowledge-based development[5]

Background

The Mekong Delta in the southern part of Viet Nam is the main catfish farming area (Figure 3). The striped catfish (or “tra” catfish) is a single species of the genus *Pangasianodon* (i.e. *P. hypophthalmus*) that occurs in the lower Mekong basin waters of Viet Nam, Cambodia Lao PDR and Thailand. The fish

[5] Prepared by N.T. Phuong, F.B. Davy, B. Ingram and S. De Silva.

FIGURE 3
Main catfish farming areas (central area shaded) in the Mekong Delta



has been farmed in the Mekong Delta for decades, as a home backyard development, primarily providing food fish needs of rural households. In the early phases of striped catfish culture, the seed stock was wild-caught from Cambodian and Vietnamese waters, particularly in the confluence region of the Mekong, Ba Sac and Tonle Sap rivers. The commercial culture in cages, pens and ponds commenced with the development of artificial mass seed production in 2000 (Tuan *et al.*, 2003). The pond culture system quickly expanded more rapidly than either pens or cages, and its production share now accounts for over 98 percent of the total catfish production (Phuong and Oanh, 2009). The unprecedented development of catfish aquaculture in the Mekong Delta has been built on the outcomes of research and technology transfer during the last decade.

Salient points

Development and transfer of seed production technologies: a driving factor from research

The development of seed production technology was a key driving factor in the success of striped catfish farming in Viet Nam. Research on artificial propagation of pangasiid catfish first commenced in 1978 on striped catfish.[6] The first fingerlings were produced in 1979–1980, independently at the Long Dinh Vocational School, Nong Lam University and Can Tho University, but the results were not sufficiently reliable for mass seed production until 1995 (Tuan *et al.*, 2003). However, the period of 1978–1980 can be considered the starting point for research on induced spawning of striped catfish. Research re-commenced in 1995 under a European Union (EU) funded project, which was led by Can Tho University. Partners of this project included the French Agricultural Research Centre for International Development (CIRAD), the Research Institute for Development (IRD) (France), Can Tho University (CTU) and An Giang Fisheries Import-Export Joint Stock Company (AGIFISH) (Viet Nam). The primary achievement of the induced spawning techniques was in 1996,

[6] Presentation by T.T. Xuan on "Some biological characteristics and artificial reproduction of river catfish (*Pangasius micronemus* Bleeker) in the South Vietnam" presented at the International Workshop on the Biological Bases for Aquaculture of Siluriformes, May 24–27/1994, Montpellier, France.

and the full achievement was established in 2000 (Cacot, 1999; Cacot *et al*., 2002). The induced spawning technique for striped catfish was therefore fully developed from scientific research. The transfer of techniques happened almost immediately after the success and involved different approaches. The initial stage started in 1999, when the techniques were transferred to a few advanced private hatcheries with a hands-on approach. The owners of these hatcheries were already experienced in fish hatchery operations and management and therefore, they were able to adapt the techniques rapidly and successfully. The staff of Can Tho University involved in the research played a key role in this stage of the knowledge dissemination. The second key stage of technology transfer was from 2000 to 2002, when the techniques were transferred by short-course training (included theory and hands-on practice) for large numbers of farmers who were hatchery owners or technicians, and non-hatchery operators. Can Tho University and the Research Institute for Aquaculture No. 2 (RIA-2) were two key stakeholders at this phase. A number of current and newly established hatcheries were involved in tra catfish larval production that resulted in significant increases of larval production. In the third period, the techniques were primarily transferred from farmer to farmer and from provincial state-run hatcheries to farmers, whereas the role of institutions (such as CTU and RIA No. 2) became less prominent. In recent years, newly established large-scale hatcheries tend to receive a full package of techniques including hatchery design, operation and transfer from either research and or educational institutions.

The approach to technology transfer for hatchery production of striped catfish varies depending on the development stage of the sector. Stakeholders may require different ways of receiving techniques depending on their target objectives. Experienced farmers require consultation, while other farmers require formal training or even full technology packages.

Development and improvement of grow-out technology: a research-based success

Three main production systems for tra catfish have developed in the Mekong Delta, namely pond, cage and pen culture. The development of these production systems has changed mainly in response to technical developments and economic efficiency. In fact, the catfish production in the Mekong Delta, Viet Nam had commenced with Mekong River catfish (*Pangasius bocourti*) (locally referred to as “basa”) in cages in the early 1960s and striped catfish (locally referred to as “tra”) began in family/backyard ponds in the 1950s using wild-caught fingerlings (see Table 1).

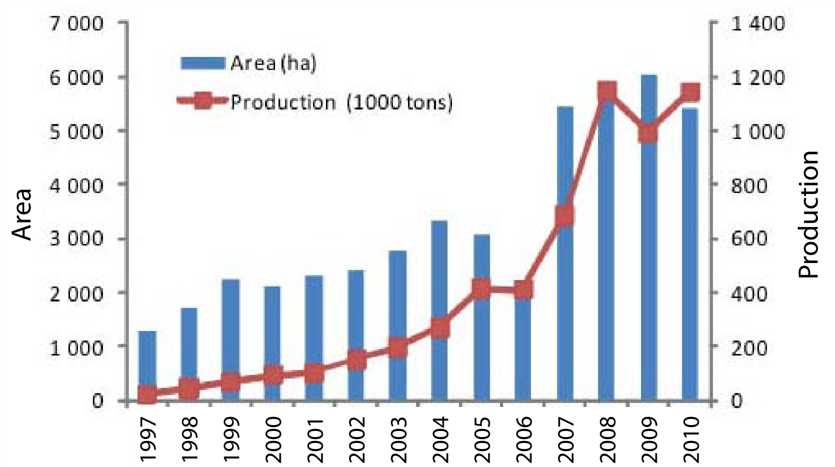
The cage culture of basa catfish was initiated by expatriate Vietnamese in Cambodia who came back to Viet Nam, while pond culture of tra catfish was developed by local farmers. The reduction of fingerling supply of basa catfish and the success of induced spawning of tra catfish are considered two key drivers for the development of tra catfish farming in the Mekong Delta, Viet Nam.

TABLE 1
The timeline of tra catfish seed-production development

Period	Important Events
Prior to 2000	– Wild larval collection and nursery rearing started in the 1940s was a key activity of a number of farmers since 1954. This activity provided seed stocks for home pond culture until the beginning of 2000 when hatchery-reared seed became available.
Late 1970/90s: initial years of research	– Research on induced spawning was initiated in 1979. The first fingerlings were initially produced in 1979 by a joint effort of Long Dinh Vocational School, Nong Lam University and Can Tho University. These initial successes could not be repeated, and research activities were scaled down until solved in1995. The period 1978 to 1980 could be considered as the starting point of research on induced spawning of striped catfish.
1995-1998: successful years	– Research was re-initiated in 1995 under the European Commission, involving the French Agricultural Research Centre (CIRAD), the Research Institute for Development (IRD) France, Can Tho University and An Giang Fisheries Import Export Joint Stock Company (AGIFISH). The induced spawning technique was successful in 1995 with complete success in the following years.
2004-present: rapid growth years	– Striped catfish hatcheries, especially large-scale hatcheries of private companies, were rapidly established. Transfer and consultation on the hatchery operation technique was mainly by CTU and Research Institute for Aquaculture (RIA) No. 2. – Genetic improvement research was initiated in 2002, and the first batch of improved broodstock was obtained and introduced to some selected hatcheries. – The seed production technique for striped catfish can now be done in most freshwater hatcheries in the Mekong Delta and has also been introduced to other parts of Viet Nam. – Consolidation of the sector through the development and adoption of better management practices (BMPs) and a cluster approach to adoption is taking place rapidly. This will enable small-scale farmers to remain economically viable, ensure the sustainability of the sector and most of all, ensure market access.

The intensive production of tra catfish has involved three different systems (e.g. cages, pens and ponds) during the gradual development of culture technology. The first intensive pond culture of tra catfish was conducted in 1981–1982 by a famer in Can Tho City using wild collected fingerlings. The stocking was tested at 10–12 individuals/m^2, and the farm yield was 90–120 tonnes/ha/crop. However, the success of this test case attracted few other farmers to begin tra catfish pond culture in the following years. The high ratio of harvested fish with yellow flesh, which is not exportable, has been a key disadvantage of tra catfish production in ponds. During 1996–1999, many research activities were conducted that focussed on the improvement of feed (e.g. use of commercial pellets instead of home-made feeds) and increase of water exchange in order to improve flesh quality. These studies have lead to significant improvements in culture techniques, flesh colour and yield. The success of tra catfish culture in ponds together with the availability of hatchery-reared fingerlings has also stimulated the development of tra catfish production in cages and pens. Pen culture involves use of a fixed enclosure built on the river bank using metal or bamboo. The cage culture of tra catfish commenced in 2000, due to a reduction of basa catfish wild-collected fingerlings and the high flesh quality (white colour). However, by 2004 these production systems were significantly reduced and became unimportant in tra catfish production. The production from cage and

FIGURE 4
The growth of tra catfish production from 2000–2008



Source: Vietnam's Institute of Fisheries Economics and Planning, 2008, 2009.

pen systems has accounted for less than 2 percent of the total tra catfish production during the last few years. The decline of these culture practices was primarily due to the slower growth rates, higher mortality and frequent disease outbreaks that led to reduced economic efficiency compared to pond practices (Phuong *et al*., 2004).

Tra catfish pond culture continues to develop and has now become an aquaculture activity of immense economic importance. In 2008, there was over 5 300 ha of ponds with a production of 1.2 million tonnes.[7] The technique for this culture system has passed through different developmental stages which have involved innovations and knowledge from both the farmers and the research sector. Generally, the farmers initially innovated many details of the technical package, while the researchers have contributed supplementary details and assisted in solving problems that arose during the period from 1996 to 2000. However, the current intensification in pond production has been significantly improved during the last decade, based on the research activities of universities and research institutes such as CTU and RIA-2. These research achievements have focussed on key technical issues such as stocking density, pond water management, health management, feed and feeding, drugs and chemical use. In 1981–1982, the first farmer in Can Tho City initiated intensive culture of catfish in a few small ponds with low stocking density of 10–12 fish/m^2 and productivity of 90–120 tonnes/ha. By 2008, intensive pond production had expanded to 5 300 ha and the stocking density has increased remarkably up to 52.8 fish/m^2 (Phuong and Oanh, 2010) or 48 fish/m^2 (Phan *et al*. 2009).

[7] Source: Presentation by N.H. Dung on "Vietnam pangasius and world markets" presented at the International Workshop on Pangasius Catfish. Can Tho University, 5–6 December 2008.

The farm yields ranged from 70.0 to 850 tonnes/ha (mean of 406 tonnes/ha) (Phan *et al.*, 2009); about 70 percent of the farmers had shifted from home-made feed to commercial pellets.

The move to more sustainable production of tra catfish in ponds is an important issue for the future of the sector. There have been many standards and practices introduced to farmers at different scales. The first standard, namely SQF-1000 (safe quality food), was introduced by two provincial departments of agriculture and rural development in 2003. This activity has been considered as a starting point for other standards or practices introduced in later years. These start-up activities were conducted by demonstration farms using short-course training for large numbers of farmers. The first organic farming of tra catfish in ponds and pens was introduced to selected farmers by the Binca Seafood GmbH Company[8] in 2004. AquaGAP[9] and GlobalGAP[10] practices in tra catfish pond systems have also been tested at Vinh Hoan Corporation, which produced high-quality fish for specific markets such as the United States of America. A new BMP (Better Management Practices) project has been implemented since 2008 by a partnership that includes CTU, RIA-2, Fisheries Victoria, Australia and the Network of Aquaculture Centres in Asia-Pacific (NACA). The project aims to develop BMP standards for wider application in tra catfish production, including hatchery, nursery and pond grow out, and is attempting to develop sustainable production practices as well as cluster-shared learning approaches among farmers, especially small-scale farmers.

The rapid growth of intensive tra catfish farming has undoubtedly resulted from the technical dissemination conducted by a wide range of parties including universities, research institutes, national and local fisheries and aquaculture extension agencies, trading companies and producers. However, the most effective approach to technical dissemination is still difficult to define, because it has been an integrated process. The technical transfer in the initial phase was done in demonstration farms, conducted by universities, research institutes and local fisheries agencies under local and internationally supported projects. The techniques were disseminated through various channels during the rapid growth phase (2000–2004), such as training courses for farmers, both farmer-managed and researcher-guided demonstration farms, on-farm consultations and regular live programmes on television. Universities, research institutes, local fisheries agencies, companies and advanced farmers have been actively involved in these processes. The transfer of technology has not been as important as in the previous period because farmers are now more knowledgeable.

[8] Binca Seafood GmbH is a German importer of seafood, primarily deep-frozen, from Asia to European markets.

[9] A certification programme for good aquaculture practices (www.aquagap.net).

[10] A private sector body that sets voluntary standards for the certification of production processes of agricultural (including aquaculture) products around the globe (www.globalgap.org/cms/front_content.php?idcat=9).

TABLE 2
Timeline of tra catfish grow-out development: documentation of key knowledge change events

Period	Important Events
1940–1950	Culture in small family ponds using wild-collected fingerlings commenced in An Giang and Dong Thap provinces, which are up-stream of the Mekong River Delta in Viet Nam.
1981–1982: trials of pond culture	First trials of tra catfish intensive culture in small ponds conducted by a farmer in Can Tho City using wild-caught fingerlings.
1996–1999: expansion of pond culture and trials of cage culture	Intensive culture in ponds expanded gradually to other provinces. First trials in cages (replacement of basa catfish) and pens were conducted as well. Both production systems used wild and hatchery-reared fingerlings.
2000–2004: rapid expansion of cage and pond culture	Intensive culture in cages and ponds expanded rapidly. Hatchery-reared fingerlings met the demand for stocking. Productivity was significantly improved. Farmers gradually shifted from homemade to commercial feeds.
2005–present: high increase of productivity	Collapse of tra catfish cage and pen culture occurred. There were significant improvements of pond culture techniques and remarkable increases in productivity. Introduction of sustainable production standards such as SQF-1000, AquaGAP, GlobalGAP and BMPs.

Key lessons and the way forward

Tra catfish farming industry in the Mekong River Delta, Viet Nam has had an unprecedented growth within a decade, perhaps never witnessed before in the global aquaculture sector. This remarkable growth has resulted from scientific achievements as well as farmers' knowledge, perseverance and resilience. The technical dissemination has been implemented by various approaches, contributed to by a wide range of stakeholders such as universities, research institutes, local fishery agencies, companies and advanced farmers. The question now is whether a different KM is needed to consolidate the sector and make it sustainable in time

CASE STUDY 2
Sustainable shrimp aquaculture production through cluster farming approach – The Indian story[11]

Background

The economic benefits of shrimp aquaculture, in particular foreign exchange earnings and provision of employment, are highly important to the Indian economy. Figure 5 depicts the impact of the advent of commercial shrimp aquaculture in the country. The potential area available in the coastal region of the country for shrimp farming is estimated to be about 1.2 million ha. Shrimp farming provides direct employment to about 0.3 million people and ancillary units provide employment to 0.6–0.7 million people (Coastal Aquaculture Authority www.caa.gov.in). Presently, an area of about 157 000 ha is farmed, with an average production of about 100 000 tonnes of shrimp per year over

[11] Prepared by V. Bhat and N. R. Umesh.

the last five years. Farmed shrimp production reached 143 170 tonnes from a farming area of 140 000 ha, and another 42 820 tonnes of scampi (giant freshwater prawn, *Macrobrachium rosenbergii*) were produced from 43,000 ha during 2006–2007, generating about INR40 790 million in export sales, equivalent to USD0.8 billion (Marine Products Export Development Authority, MPEDA[12]). The average productivity has been estimated at 660 kg/ha/year. Cultured shrimp contribute about 50 per cent of the total shrimp exports from India. The technology adopted ranges from traditional, to improved traditional and extensive shrimp farming. About 91 percent of the country's shrimp farmers have a holding of less than 2 ha, 6 percent have between 2 and 5 ha, and the remaining 3 percent have an area of 5 ha or above. Shrimp farms are operated using both leased out government/private lands and landowner-operated holdings. On average, each farmer spends about USD3 000 for one crop. In earlier times, a credit system functioned throughout the sector, operated and controlled primarily by intermediaries. Intermediaries also acted as input suppliers and providers of credit at each stage in the supply chain and were also involved in buying back the harvested shrimp. On average, farmers ended up paying a whopping 30 percent interest on the loans from the intermediaries, which markedly affected the profitability of their operations. Returns from shrimp farming continue to be rewarding, benefiting small-scale farmers and coastal communities, as well as entrepreneurs engaged in seed production, farming operations or ancillary activities. Sustainable utilization of available areas and infrastructure can lead to the development of under-exploited resources, with

FIGURE 5
Development of commercial shrimp culture in India. Export value (MPEDA data)

[12] www.mpeda.com

the potential of generating a large number of jobs and enormous social and economic benefits to the coastal regions of the country, thus improving the quality of life in rural areas.

From 2000 to 2006, the MPEDA carried out a collaborative project with the technical assistance of the Network of Aquaculture Centres in Asia-Pacific (NACA). A number of science-based farm-level managerial interventions were identified that could be relatively easily adopted by the farmers for prevention of white spot disease (WSD) in their ponds and for increasing production, productivity and returns. These interventions were developed into better management practices (BMPs) to be adopted even by small and marginal farmers. The effectiveness of the BMPs was demonstrated in a series of village-level demonstration programmes carried out by the MPEDA-NACA project. Initially, the small farmers were encouraged to come together into informal groups called “aqua clubs”.

In order to promote sector-wide adoption of BMPs, in 2007 MPEDA set up an outreach organization, the National Centre for Sustainable Aquaculture (NaCSA) under its umbrella. The primary objective of NaCSA is to support development of sustainable aquaculture in India through facilitation and empowering the marginalized and poorest of the poor in the aquaculture sector, besides disseminating technologies and information on better practices, sustainable and judicious utilization of the resources, use of science in day to day activities, marketing of the produce, etc.

NaCSA is building capacity at the grass-roots level among the primary producers through disseminating technologies and information on BMPs, and the sustainable and judicious utilization of the resources to produce safe shrimp and a sustainable industry. The core technology around which the BMPs developed was health management, the state of an animal’s health being the expression of several factors including genetics, nutrition and the environment. The BMPs also embodied specific and broad practices that provided the conditions to maintain the well being of the cultured stock. The specific approaches included preventive or curative measures without resorting to (or if possible, with little use of) chemicals; maintenance of water quality and substrate; and proper nutrition and feeding. The broad practices included reducing or coping with the risks of pathogens being introduced into the farms through such practices as synchronized water intake and discharge, simultaneous cropping, observation of early warning signs and notification of neighbours of disease onset, learning from each other, assuring product quality and safety and, overall, acting collectively in their own interest.

In effect, the BMPs embodied the principles of sustainable farming plus a good dose of market-driven thinking. The key to moving these concepts into sustained practices was getting farmers involved and collaborating. Thus, the process commenced with the organization of small-scale farmers into clusters or aqua clubs, particularly grouping farmers in a given area around shared resources and common problems such as the use of a common water supply channel. Such clusters/aqua-clubs subsequently became aquaculture societies with a legal status. The impacts and outcomes of this work of NaCSA included improved shrimp yields, reduced impact on the environment, improved product quality and better relations among players in the market chain. The organization of small-scale farmers into groups and then into more formal societies facilitated the adoption and implementation of BMPs, providing benefits to the farmers, the environment and society. Overall, there were increased shared social and moral norms, which helped transcend narrow self-interests. Interestingly, this process also led to the emergence of farmer leaders in each group who were otherwise obscure until they organized as a group.

Salient points

Farmer society formation and management for knowledge sharing and learning

The farmer groups now established by NaCSA are known officially as Aquaculture Farmers Welfare Societies. A farmer society constitutes a group of aquaculture farmers in a specific locality or farming cluster who implement and manage their aquaculture activities using a participatory and "bottom-up" approach in order to achieve three main objectives; viz. reducing disease risks, reducing costs of production and meeting market demands through sustainable farming. The farmer societies are set up according to a model established by government, registered under the Registration of Societies Act of the respective state governments. These societies are required to submit annual reports and audited statements of accounts to the government and ensure a democratic and transparent management. Each society consists of members comprising from 20–75 farmers who have registered their farms with the government. Membership is voluntary. Each society has a clear organizational structure, including a president and a democratically elected board and has weekly general meetings where farmers can share information and collective decisions can be made. The societies so registered with the Registrar of Societies and voluntarily acceding to adopt a set of code of practices for sustainable shrimp aquaculture are encouraged to register with MPEDA. This entity introduced a scheme for registration of societies for adoption of codes of practices for sustainable aquaculture in the year 2006–07. Under this scheme, MPEDA provides incentives for managing common facilities that would help the farmers to produce quality and safe shrimp and demonstrate eco-friendly sustainable shrimp culture.

Society activities include the collective preparation of a crop calendar two months before stocking to ensure all society and cluster farmers stock their ponds within a two-week period of each other. The maximum stocking density for each society is decided, and society farmers agree not to use any antibiotics or chemicals. High-quality seed is purchased by the societies using a contract hatchery system. Societies agree to follow shared practices such as synchronized water intake and discharge, simultaneous cropping, observing early warning signs of disease onset, learning from each other, assuring product quality and safety and, overall, agree to act collectively. Each society has standard operating procedures (SOPs), and internal control systems (ICS) are being established in societies to ensure compliance with minimum standards by all society members.

Key knowledge-linked BMPs developed and implemented in the project

These include:

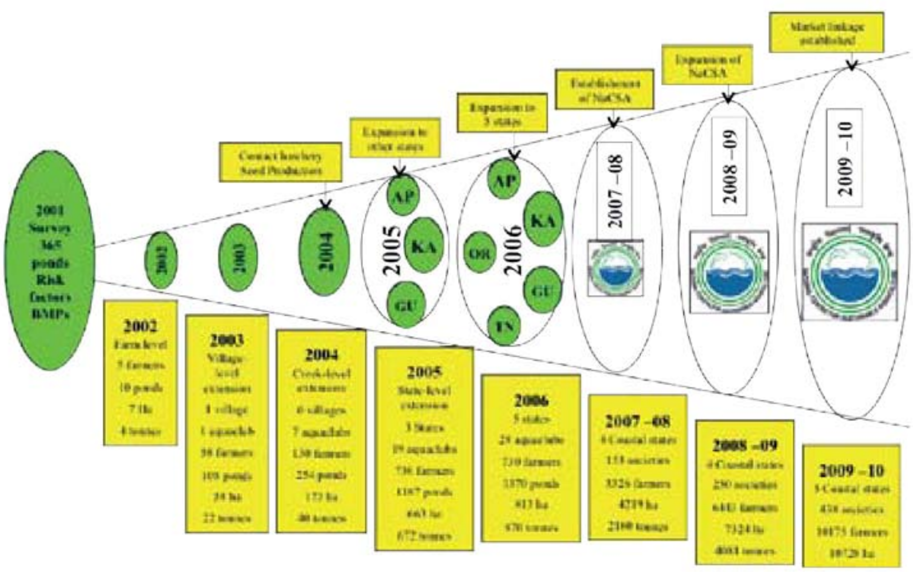
- *Good pond/water preparation*: The soil should be checked for the presence of a black layer, and it should be removed from the pond. Water should be screened at the water intake point to avoid entry of virus-carrying fish and crustaceans or predators/competitors of shrimp. Water depth of at least 80 cm should be maintained in the pond.
- *Good-quality seed selection*: Quality seed is best purchased through the contract hatchery seed procurement system where seed is obtained via a group purchase.
- *Water quality management*: Basic water quality parameters such as dissolved oxygen, pH and alkalinity must be maintained at optimum levels. Water exchange is only when necessary and during critical periods.
- *Feed management*: This includes efficient use of quality feed, demand feeding using check trays, and feeding across the pond using a boat or floating device. Feed conversion ratio (FCR) must be kept below 1:1.5.
- *Pond bottom monitoring*: The pond bottom soil should be monitored on weekly basis for black soil, benthic algae and bad smell, especially at the feeding area or trench, and corrective actions should be taken.
- *Health monitoring and biosecurity arrangements*: No draining or abandoning of disease-affected stocks. Farmer groups are encouraged to discuss common actions that can be taken during disease outbreaks to avoid spreading of disease from one farm to another. Farmers are encouraged to provide bird scare devices.
- *Food safety*: Use of any harmful/banned chemicals like pesticides, antibiotics and pharmacologically active substances should be avoided.
- *Better harvest and postharvest practices*: These include quick harvesting, chill-killing of harvested shrimp and quick transport to the processing plant.
- *Record maintenance/traceability*: A hatchery/pond management record book should be maintained by hatcheries and farms to identify problems in the tank, pond and environment and to rectify these at the earliest time during the production cycle. This is also required for traceability purposes.
- *Environmental awareness*: Improved environmental awareness about mangroves, pollution and waste management is promoted among farmers.

The societies are annually audited by MPEDA for the implementation of BMPs. Societies which fail to implement BMPs would lose registration. Each farmer society has one coordinator selected from among the society members or from the community by society farmers. The society coordinator is trained in society management, BMPs and extension techniques by NaCSA, and is responsible for implementing BMPs in societies and acting as the link between society farmers and NaCSA. Each of the NaCSA field managers coordinates and manages the activities of ten such societies. MPEDA's society scheme provides 50 percent financial assistance for farmers to employ a society coordinator for the initial two years.

Progress made to date

NaCSA has made significant progress in organizing and registering aquaculture societies, with the number of farmers adopting the cluster management approach growing exponentially from five farmers in 2002 (covering 7 ha of area in one state) to 10 175 farmers in 438 societies (covering 10 728 ha) to date in five coastal states. The majority of these societies are in the State of Andhra Pradesh, which produces half of the farmed shrimp in India. Figure 6 provides an illustration of the evolution and progress made in the implementation of the cluster farming concept in India.

FIGURE 6
Progress of implementation of the concept of cluster farming management in India



Source: Umesh *et al.* (2009). Indian States: Andhra Pradesh (AP), Kerala (KA), Gujrat (GU), Orissa (OR), Tamilnadu (TN).

Benefits of organizing aquaculture societies

Empowering small-scale farmers: Organized farmer groups (societies) are one of the key mechanisms for supporting farmer empowerment. They have the potential for cooperative action, which can change the position of the farmer in relation to the opportunity structures and thereby influence the business environment of the farming community. Moreover, small-scale farmers, through organization, can gain an advantage of economies of scale in accessing services and markets, which are otherwise limited to large commercial farmers. The small-scale shrimp farmer groups of India are in a better position today to gain these benefits compared to the situation when they were unorganized. Selected benefits of organizing small-scale farmers include:

- farmers organizations receive legal status;
- improved technical and financial sustainability;
- improved knowledge exchange and sharing of experiences;
- middlemen/agents are eliminated at all levels;
- societies provide a workable model for small-scale farmers to meet market requirements;
- increasing stakeholder interaction and involvement;
- revival of livelihood;
- increased awareness and social responsibility; and
- self-propagating nature of the model.

Some of these are reviewed below.

Improved technical and financial sustainability: The improved technical practices included reducing or coping with the risks of pathogens being introduced into the farms through synchronized water intake and discharge, simultaneous cropping, putting up and observing early warning signs of disease onset, learning from each other, assuring product quality and food safety and, overall, acting collectively. Implementation of simple, science-based farm practices and adoption of cluster farming promoted cooperation among farmers and significantly reduced disease risks in society farms. The prevalence of shrimp disease in the society farms decreased from 82 percent in 2003 to <20 percent in 2009, while in non-society ponds/farms the reduction in disease prevalence was very low during the same period.

Similarly, the society farmers achieved higher profits through increased production, increased size of shrimp, improvement in survival, reduction in disease prevalence, reduced use of chemicals and no use of antibiotics, as well as sharing of many expenses – society farmers share the common expenses related to deepening of canals, seed testing, transportation of inputs, laboratory costs, electricity, etc. Societies also offer better opportunity for common infrastructure development.

Improved knowledge exchange and sharing of experiences: Exchange of information, experience and ideas among farmers was the key for success of societies. Each society typically included a few farmers who were proactive and who quickly grasped the importance of implementation of BMPs. These were the farmers who in turn talked to and convinced other farmers and generally helped the NaCSA team to spread the awareness about BMPs. Farmers in societies make decisions collectively; the functioning of societies is very transparent in a democratic system. There is regular information sharing among farmers during weekly meetings, including that concerning the purchase of quality inputs and selling of the farm produce.

Middlemen/agents are eliminated at all levels: Aquaculture societies are successful in eliminating middlemen in the value chain. Previously middlemen were involved at three stages: in the purchase of seed, in provision of credit and in the purchase of shrimp.

Societies – an ideal model for small-scale farmers to meet market requirements

Over the years, the approach to quality management has assumed greater significance and importance in the seafood sector worldwide, both in production and supply chains. New trends are emerging in production and marketing such as traceability, ecolabelling and certification. For farmers and producers in developing countries, supplying goods for national and international markets can present a life-changing opportunity as well as a challenge. Retailer demand is there – especially for products with ethical and green credentials. The difficulty lies in meeting those retailer needs and identifying the right products at the right time. Developing-country producers often lack the skills to deal with the high demands of export markets, as well as access to capital and business expertise. These factors collectively present a formidable barrier to entry into more sophisticated markets. At the other end of the supply chain, retailers often lack the ability to be able to reliably source quality products that are required for consumers.

Opportunity for fair-trade certification

Of late, farmers are under distress as farm-gate shrimp prices fluctuate based on supply and demand. Those small farmers who are entirely dependent on shrimp farming place their livelihoods at stake every time they stock their pond. A mechanism that would provide access to good markets and a fair price would allow small farmers to maintain their activity and ensure livelihoods. There is need for a fair trade labelling of society produce so that society farmers can get a more stable price that covers at least production and living costs, which is an essential requirement for farmers to provide themselves and their families with a decent standard of living. NaCSA is also exploring opportunities to work with FLO-CERT, the fair trade certification body.

Traceability

A record of traceability is another common requirement from buyers with which it is often hard for small-scale farmers to comply. However, NaCSA has trained society coordinators and farmers in record keeping and supplies them with pond-record books. This enables society farmers to keep full records on general management, key parameters, purchasing and distribution. Satellite maps are also used to trace the pond production, making it much easier for society farmers to meet traceability requirements of buyers. Overall, NaCSA with the help of various experts is developing a comprehensive traceability system linking all the stakeholders involved in the value chain.

Knowledge sharing lessons learned

TABLE 3
Summary of positive knowledge impacts (what worked, is working)

Risks	Positive impacts	Remarks
Disease	– Reduced disease incidence	– 27 percent decrease of disease prevalence in BMP ponds compared to non-BMP ponds
Food safety	– Reduced chemical & no antibiotic use	– Random giant tiger prawn (Penaeus monodon) samples from society ponds tested negative for presence of antibiotics in over 90% of cases – Complete traceability of the product
Market access	– Increased opportunity for market access	– Efficiently managed small-farmer societies provide similar advantage of integrated larger units – Traceable shrimp from societies (traceability from broodstock to pond level)
Financial	– Improved profits – Opportunity for bank credit access	– By reducing the cost of production, profits have been increased. Non-BMP ponds got INR39 (USD0.8) for every INR1 000 (USD20) spent, whereas BMP ponds got INR128 (USD2.6) for the same Investment
Social	– Democratic & transparent societies: ▪ sharing of costs ▪ increased communication ▪ harmony among farmers	– Democratically organized farmer groups – Regular information sharing among farmers – Cooperation in selecting/testing & buying quality seed & other inputs – Farmer field days help farmers to share their successful experiences – Each society has a minimum of ten meetings during the crop period
Environmental	– Lower stocking densities – Reduced pollution – Increasing awareness on environment	– The low stocking density of shrimp ponds in societies (2 to 6 shrimp per m^2) is far below the level when compared to other countries –Two societies have adopted organic aquaculture practices – Abandoned shrimp ponds being revived

Key lessons and the way forward

Effectively engaging with the thousands of aquaculture producers in India and helping them to develop farm-level plans for sustainable development is not an easy task and can only be achieved with the involvement and contribution of the many players involved in the supply chain, from producers to consumers. The exchange of information, experience and ideas among farmers was the key for the success of such societies; for example, sharing information on better market access is essential to address many challenges faced by small-scale shrimp farmers. MPEDA/NaCSA are seeking to link societies directly to a preferred processor or exporter, cutting out the middleman. This type of vertical integration will ensure decreased transaction costs for farmers and processors/exporters, allowing farmers to receive a better price for their produce and to coordinate harvest and postharvest practices to improve the overall quality of the shrimp and maintain traceability.

A critical on-going priority for societies is access to credit and reducing their current interest burden on loans from moneylenders and other private sources. Well-establishing links between societies and output markets are vital to the success of societies. Developing partnerships with local processors provides a good opportunity for societies to access better markets as well as bank credit (agreements with processors provide societies with a market guarantee, which is a major concern of banks). NaCSA continues to work towards bringing processors and farmers together for better market access. The implementation of BMPs by farmers is providing them with an opportunity to create a niche for such products in the global market, which will help in sustaining small farmers' livelihoods in India. Clearly, farmers were able to make use of the pond management and market and related new knowledge sources, using this to change their behaviours towards more sustainable culture systems that both improved the environment and their profitability.

CASE STUDY 3
The Chilean salmon industry: a brief review of its history and the role of knowledge and communications in its development[13]

Background

Chile has had one of the fastest growth rates of the aquaculture sector worldwide with an average annual increase of 18 percent. In 2007, aquaculture exports reached USD2.4 billion with large social and economic impacts, particularly in the southern region where salmon and mussels are being cultured. The Chilean salmon industry only started in the early 1980s and in a very short time became the second-largest producer worldwide of farmed salmon and the largest producer of farmed sea trout. Production presently includes coho (*Oncorhynchus kisutch*), Atlantic (*Salmo salar*) and chinook (*O. tshawytscha*) salmon as well as trout (*O. Mykiss)*, and this industry generates very important impacts in the local communities in the southern regions of Chile, specially in Puerto Montt and the island of Chiloe.

The development of supporting knowledge systems through research and technical expertise has also been critically important in this sector's development.

[13] Prepared by R. Infante and D. Soto.

For instance, once salmon farming became a booming activity, a variety of universities opened new programmes related to aquaculture, at both the technical and engineering level[14], and specific research expertise has developed both locally in the south and in the capital region.

Salient points

The role of institutions and public–private partnerships in transferring and producing new knowledge and technologies

Several new institutions and active partnerships have developed and/or promoted the development of research and technology, often as part of research-business partnerships. Key institutions include Fundación Chile, Corporación de Fomento de la Producción (CORFO) and the Instituto Tecnológico del Salmón (INTESAL, the salmon technological institute created by the salmon farmers association). The government also played an important role through the National Fisheries Council, which supports the Fondo de Investigación Pesquera (FIP, the Fisheries Research Fund). This institution promoted a thorough review of investments in aquaculture research in Chile and their impacts during the past decade (Bravo, 2007). Between 1996 and 2004, Chile invested 0.56 percent of its gross domestic product (GDP) in science and technology in general, while the investment in "aquaculture focussed" research and development (R&D) reached 3.89 percent. Although more emphasis was given to this growing revenue-producing sector, the study also concluded that the investment in research in Chile has not been commensurate with the increase in salmon and mussel production (the most important export commodities). Thus, a large portion of knowledge and technology advances were still being imported from other countries or generated locally at the farm level. On the other hand, a significant proportion of the research investment has gone to the culture of seaweeds and crustaceans; however, the latter has not had an apparent impact on the production of these species. Another important conclusion of the study (drawn from a poll within stakeholders) was that the research in aquaculture was not adequately related to the needs of the sector, particularly the needs of the farmers.

Historically, salmon farming in Chile developed in a couple of decades from small family-owned, almost artisanal production units into vertically integrated large companies, some of which are owned by foreign companies. In fact, foreign firms control about 35 percent of production in Chile, with Norway being the main source of such investment. Most companies generate some of the needed knowledge at the local farm and company level (e.g. 60 percent have their own research programmes; Vergara, 2005). There is no definitive documentation, but it appears that at least part of the initial success of different salmon farms has been achieved through a trial and error knowledge management approach which

[14] Universidad de Los Lagos, Universidad Austral, Universidad Santo Tomás and Universidad San Sebastián are local universities (in the "Lakes region") that currently provide undergraduate and graduate education related to aquaculture.

has often then spread across the whole sector. Other forms of national and local innovation most often driven by the salmon-farming companies in Chile included the increasing production of eggs within the country, genetic improvement programmes and improvements in feed formulation (Parada, 2010). It is worth mentioning that there were key institutions promoting the development of the sector and the transference of technology. For example, Fundación Chile helped develop the salmon industry by applying an innovative technology transfer system that involved the start up and operation of new companies with state-of-the-art technology in high-risk business projects that required intensive investments in research and development. Once these companies became operational and profitable, they were sold off to the private sector. With this approach, Fundación Chile created the Salmones Antártica company in the 1980s, and in later years, other related companies such as Salmones Huillinco, Salmotec and Finamar (Perlman and Juárez-Rubio, 2010).

Recently, however, the industry suffered a major crisis despite what was thought to be a solid knowledge base including relevant knowledge on environmental issues, biosecurity requirements and disease risks. This apparently well-prepared industry suffered major losses associated with its principal species, Atlantic salmon, to the infectious salmon anemia virus (ISAV) (Falk *et al.*, 1997), leading to losses of over USD1billion worth of exports and serious job losses, placing the whole economy of the region in a difficult situation. Therefore, the question remains, were there knowledge/communications gaps in the prevention, development and spread of this disease?

A critical series of knowledge management problems

Back in the 1990s, a new type of bacteria, *Rickettsia*, was discovered in the salmon grown in Chile. The presence of this organism was associated with non-specific mortalities initially referred to as due to a UA (unknown agent), later named as salmon rickettsial syndrome (SRS). This agent mainly causes a complete depletion of the immune system of the fish, and all related salmon species are susceptible.

The sea louse *Caligus rogercresseyi* is an ectoparasite that affects salmonids and also lives on other wild fish in the area. This parasite debilitates the fish by eroding the skin and thus eliminating the natural barrier against fungi and other pathogens. Populations of these parasites can be controlled through better management and the use of various approved drugs. However, the drug approval process is very lengthy, leaving farmers for years with only one approved drug for use throughout these severe outbreaks (Bravo, Sevatdal and Horseberg, 2008).

ISAV had been present in all salmon-producing countries worldwide except apparently Chile until June 2007, when the first case was reported, and since then many other cases appeared, leading to the crises described above. This sanitary problem is complex and illustrates the knowledge and management challenges that go beyond ISA and the presence of other pathogens. The wider production system and related ecosystem factors such as the amount of production on a site, the quality of the smolts and the proximity of other farm sites in the production areas are all aspects that have increased this fish health problem; a future scenario that many others may face. A deeper analysis of some of these aspects, their interactions and solutions might assist others in better understanding the evolution of this problem.

The research and knowledge development process in Chile

In Chile, in general, research and knowledge formation has not been a high priority; Bravo (2007) analyzed Chilean investment in R&D, showing that salmon farming has received about 20 percent of the funds invested in aquaculture R&D, from 1987–2005 approximately USD31 million. However, this investment in research was not commensurate with the export value of the industry (USD2 billion in 2007). This amount represents a much lower relative investment compared to Norway were, for example investments in one biennium (1988-1990) amounted to near USD60 million (Asche, Guttormsen, and Tveterås, 1999). A similar conclusion is revealed by a global analysis of impacts of Atlantic salmon escapes (Thorstad *et al.*, 2008) when referring to the sources and funding of available information. Another important element is that most research has been funded by the government; the private sector has made comparatively smaller contributions, although it is slowly increasing.

INTESAL was created to develop and share knowledge and anticipate solutions between producers, and it's main focus has been related to disease and environment, where it has focused on monitoring of microalgae. Knowledge and related experiences from abroad have also been a very important factor in the KM/sharing and technology changes implemented in Chile. This is likely one of the main factors explaining the rapid growth of Atlantic salmon production. The establishment of research priorities, including the need for additional relevant knowledge, particularly related to the culture environment in southern Chile, is also important for the development of this sector, but its realization is not yet fully achieved. This situation has led to changes; for instance, a new R&D fund administered by CORFO, called INNOVA, which was created eight years ago, is supposed to provide important resources to develop R&D in such areas.

The main knowledge sources on fish disease are from abroad; for example, Norway, Canada, Scotland and the United States of America. These countries have much larger budgets and specialized research teams on such matters. While very useful, this knowledge may not be adequate, particularly in terms of relevance/adaptation to the Chilean environment (e.g. knowledge linked to sea currents at the production sites, models of dispersion, existence of reservoirs of pathogens in local fauna). All this information has to be developed locally, and there are several projects now examining these issues. Nevertheless, the main "know how" (at least in terms of a biosecurity framework) on how to face a disease so dangerous as ISA was not adequately transferred and perhaps more importantly, the available knowledge was not put to practice, an argument presented by Asche *et.al.* (2009). The latter is especially relevant when considering that a large proportion of the production in Chile is in the hands of the same companies producing in Norway, Canada and Scotland, most of whom had already faced ISA in their farms.

Relevant development factors, problems and the role of information sharing

Location/concentration of the industry and provision of infrastructure: The industry in Chile developed in the south because of the favorable natural conditions existing in the area. Although the lack of infrastructure was a limiting factor, the development started where the limitations were less in relative terms. The availability of roads/basic infrastructure increased the probability of competitive costs for both inputs and outputs. Electrical power was also critically important for the operation of processing plants, ice production, etc.; other infrastructure-related support included access to labour, for instance for processing plants. The Chiloé Island area, which has been a center for this development, went through a variety of infrastructural bottlenecks that the industry was able to solve as part of the overall regional development process. New transportation technologies, such as the development of "wellboats",[15] combined with monitoring/control systems for oxygen, ammonia, and temperature of fish are good examples of local knowledge/technology adaptation and development that allowed further development of production into more remote areas where services were not available on site. Yet the movement of these vessels between distant areas, in the absence of biosecurity frameworks and adequately shared information, could have enhanced the spread of ISA.

The risks of maximizing production as only goal: The industry is regulated in terms of location; for instance, the amount that can be produced in each production site is regulated differently depending on the date of authorization of each concession. This was one of the advantages that the industry had for a very long time, allowing a more liberal approach to production and facilitating the rapid growth of the industry over time. However, despite early knowledge on carrying capacity concerns (e.g. Soto, 2000), this was not translated into plans and policies to regulate biomass per unit area in these inner seas. The industry at large has been often criticized for having focused mainly on increased production and short-terms benefits, while over-looking relevant environmental and health considerations (Vera, 2010).

[15] Wellboats are vessels specially designed to transport live fish and perform a diversity of aquaculture services such as harvesting, fish counting and even processing on board.

Fish health and quality of smolts: Another critically important factor, but very difficult to measure, is the quality of smolts. Key issues such as the establishment of common criteria to differentiate quality and to determine the most appropriate vaccines, and the development of more and improved selection criteria to improve the survival rates have to be carefully addressed and shared among farmers. Such issues are now being tackled by research partnerships composed of the private sector and Chilean universities and research institutions, all examples of new knowledge partnerships.

The ISA problem and BMP solutions: As mentioned, the deteriorating sanitary conditions were strongly linked to the appearance of ISA leading to huge mortalities of fish, the closing of more than 200 farm sites, an almost 1 billion dollar loss in exports and more that 20 000 jobs lost in the period between July 2007 and December 2009.

The increasing use of antibiotics in salmon farming in Chile for the last decade suggests that disease has indeed been a long-term problem in the sector. ISA has affected most other producers worldwide since 1990, and it has been known by producers in Chile. However, effective measures that could have prevented the introduction of the disease were not seen as possible given the large size of the industry, the possible and mostly unknown routes of the disease into the country, lack of adequate information sharing and the absence of regulation on these matters. Once the disease was identified in Chile, the spread was very rapid, and the main solution at that stage was to establish management areas that could help isolate and minimize its spread following procedures adopted by the authorities and by the producer's organizations. Despite these measures, spread of the disease occurred in a very short period of time and to a very significant part of the production area of the country.

The discussion of the possibility of developing a "management by area system" took place before the arrival of diseases such as ISA. However preliminary analysis suggested that this system was not feasible due to the potentially huge coordination required by the producers and the loss of independence in decision-making, which none was willing to sacrifice without a formal regulation. The problem was exacerbated by a lack of transparency combined with too much individual thinking and a lack of trust among the farmers themselves and between the farmers and the government (Asche *et.al*., 2009).

The Chilean industry is now being reorganized under new regulations, learning in part from the experiences of other producing countries such as Norway and Canada, and where the same companies are involved, they are learning that greater sharing of knowledge across subsidiaries is valuable. Groups of producers operating in one area are organized and managed as one "aquaculture zone or neighborhood" and compliance is enforced by government agencies. These measures are now in place, and the biomass has also been reduced, combined with coordinated fallow periods and the implementation of sanitary disinfection measures at critical points, all of which seem to have effectively reduced the viral counts and other pathogenic agents in the environment. The coordinated treatment of all farms and the cleaning of all equipment and the effluents of processing plants have also been very important in this process, leading to an expectation that future severe outbreaks should remain very rare and hopefully nonexistent.

BMPs to control future outbreaks have been applied and strongly reinforced since mid-2009. Some are mandatory by law, while others are voluntary through programmes and agreements between producers. All are monitored regarding compliance, which is critical to avoid the negative externalities or poor compliance by some producers.

Key lessons and the way forward

The lesson from this case study is that availability of knowledge "per se" was not enough; knowledge sharing, including the sharing of experiences, did not produce the change(s) of behaviour in time (Asche, *et al.,* 2009). Lessons have been learnt the hard way. How can this behaviour improve in the future? This question is very important but difficult to answer. The main lesson is that changes in practices that involve large investments, transparent sharing of information and new procedures are not very rapidly taken up, as the first adopters are not able to harvest the benefits. All must follow the same rules and bear the costs to reap the shared benefits of lessened disease. In order to make them really effective, they require compliance across the industry; for example, disinfection of transportation units. It is well known that such equipment can assist the transfer of disease, therefore the implementation of "clean procedures" requires that stakeholders at very different points during the production process are well informed to adopt the approved standards and follow audited procedures and regulations.

Traditionally the Chilean farmer has a very independent character; cooperation existed, but farm behaviour was mainly driven by the market and profits. However, the described sanitary catastrophe is forcing a much more collaborative approach among producers, one in which they now recognize a more ecosystem-based approach where all must cooperate with their neighbours and must consider other users of the coastal zones and watersheds. Relevant knowledge must be shared among these stakeholders. The primary objective of the activity must be beyond just farm production (FAO, 2010a) and look more seriously into long-term sustainability (and this includes economic sustainability!). The production at each farm is now managed as part of a wider plan of regulations which group farms in a given production area using defined boundaries that have been drawn on a map. Within each of these area clusters, the producers must share the relevant information and knowledge, coordinate their activities and inform others about the performance of their farms, their problems, treatments, how are the fish behaving, etc. This move to stronger collaboration and more open reporting has established a new knowledge-sharing system which includes the designation of focal points who are named to the authorities as representatives whose duties include provision of up to date information on the situation in the area, current problems and measures for their solution. In summary, group coordination and examination of issues at this larger scale should improve understanding of the changing farming and environmental/oceanographic conditions (e.g. sea current effects on pathogen dispersal). The coordinator or entity that gathers all the information in a specific farming area (or neighbourhood) has to be able to understand/anticipate the knowledge needed, how/what to share and manage in a more integrated and participatory way involving all the concerned producers.

CASE STUDY 4
Investing in research, communications, training and extension for responsible marine aquaculture in Turkey[16]

Background

Turkish aquaculture is a good example of development without tradition. Since the late 1980s, marine finfish aquaculture production has focused on two major species, European seabass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*). In Turkey, marine aquaculture production mostly depends on coastal cage farming, and only a small amount is produced in land-based systems. Ninty-two percent of the cage farms are located in the Aegean Region, where geographical and hydrographical conditions are suitable for the species cultivated (Yucel-Gier, Uslu and Kucuksezgin, 2009). Turkey has great know-how and research capacity, but there is room for more sophisticated organization of these efforts, particularly with regard to implementation; closer linkages with users in general is also needed. R&D in aquaculture is largely done by university fisheries faculties and the research institutes of the Ministry of Agriculture and Rural Affairs (MARA), which is the main state organization authorized for fisheries and aquaculture administration, regulation, protection, promotion and technical assistance. There are 14 fisheries faculties providing undergraduate and graduate education in aquaculture and aquatic sciences. Universities run MSc and PhD research programmes, usually financed by those institutions themselves, or by the Scientific and Technological Council of Turkey (TUBITAK) and by the European Union (EU) Sixth (FP6) and Seventh (FP7) Framework programmes. A Directorate of Aquaculture and Fishery Research (TAGEM) has institutes in Trabzon and Antalya with the capacity to perform aquaculture research alone or in collaboration with other institutions. FP6 and FP7 programmes support research cooperation and integration of research efforts, promote mobility and coordination and invest into mobilizing research in support of other EU policies.

16 Prepared by G. Yucel-Gier.

Okumuş and Deniz (2007) pointed out that Turkish university research has focused upon fish genetics, fish health and management, fish breeding and the development of environmentally friendly aquaculture systems. In addition, it was indicated that Turkish "research results are often left as theses or dissertations or presented and published in scientific conferences and journals"; indeed, there had been a lack of extension work at the ministry level.

Currently, academic research must consider pan-Mediterranean projects, and the demands of the EU are of great importance in motivating and financing research. International institutions, such as the FAO, working in collaboration with MARA, have provided a welcomed stimulation of these efforts. Important projects cofunded by MARA and FAO have taken place. One of these was FAO project TCP-TUR-3101: "Developing a roadmap for Turkish marine aquaculture site selection and zoning using an ecosystem approach to management" (see Soto, White and Yucel, 2009). The objectives of this project were to examine the planning of marine aquaculture, to manage its development with necessary support and to suggest needful transitory actions for the relocation of fish farms. Moreover, the roadmap focused upon an ecological approach, moving towards integrated coastal zone management (ICZM) principles and objectives. A follow-up activity entitled "Indicators for sustainable development of aquaculture and guidelines for their use in the Mediterranean" was organized by FAO and MARA in 2009. This project involved consultation and interaction between the central government, scientists and stakeholders, especially those involved in the socio-economic, governance and ecological dimensions.

The general objectives of R&D for Turkish marine aquaculture within the Mediterranean-EU framework are to be achieved by synergy between research programme and infrastructure, thus avoiding duplication. There is a growing desire within Turkish marine aquaculture to belong to a dynamic and competitive knowledge-based economy linked to Europe. This is so as to be capable of sustainable economic growth which will generate better jobs and promote both social cohesion and respect for the environment. To this end, it is necessary to develop national and international platforms to disseminate research findings throughout society.

Salient points

Research programme: needs analysis

Universities collaborate with TAGEM and TÜBİTAK for the funding of Turkish research needs. There has been a marked tendency for TAGEM, the private sector and the universities to fund as a priority fish health, breeding, farming, genetics and feeding research. At the medium level of priority comes socio-economic research; organic (ecological) fish farming matters are left behind.

Under the EU FP6 program (2002–2006) there are several funded projects dealing with fisheries and aquaculture. There are interesting contrasts between research topics chosen by the fisheries industry and the topics chosen by the aquaculture sector. Fisheries topics have long included the scientific basis of fisheries management and the ecosystem approaches. Research emphasis has also been given to gear selection, to monitoring and to control systems. For aquaculture, the topics usually had been connected with welfare, genomics, breeding, environment, feeds and diseases, rather than with governance and socio-economic matters. The objective of the FP7 program is the development of matters connected with food, agriculture and fisheries, and biotechnology. A European knowledge-based, bio-economy, (KBBE) is being built with the support of policies like the Common Fisheries Policy, (CFP). According to TUBITAK, Turkish researchers have creatively taken part in numerous pan-European developmental consortia (Celikkanat, 2007).

This is a summary of some of the main research outcomes over the period 2003–2008[17]

- A matrix for indicators of interaction between fisheries and fish farms was identified by an FAO AdriaMed project.
- "Indicators on sustainability", coordinated by the Federation of European Aquaculture Producers (FEAP) and the European Aquaculture Society (EAS) were included in the FEAP Code of Conduct.
- A generic methodology to evaluate aquaculture sustainability, with a set of indicators was developed.
- Platforms for the communication and dissemination of EU research projects in fisheries and aquaculture were coordinated by FEAP and published.
- ECASA (Ecosystem Approach to Sustainable Aquaculture) (see www.ecasa.org.uk) evolved, with indicators, an ecosystem approach to aquaculture and a tool box to show links between the environment and aquaculture, together with an effective environmental impact assessment (EIA).
- A SUSTAINAQ project (Sustainable aquaculture production through the use of recirculation systems), funded by EU FP6, identified bottlenecks in Eastern European aquaculture and developed solutions through the use of recirculation systems.
- SEACASE (Sustainable Extensive and Semi-intensive Coastal Aquaculture in Southern Europe) (see www.seacase.org) developed environmentally friendly protocols, quality markers and certification to enhance product value.
- InDAM (Indicators for Sustainable Development of Aquaculture and Guidelines for their use in the Mediterranean) project worked on the cooperative selection of indicators and use guidelines for the sustainable development of Mediterranean aquaculture.
- The FEUFAR (Future of European Fisheries and Aquaculture Research) initiative successfully constructed a list of future research needs.
- EATiP (the European Aquaculture Technology and Innovation Platform) (see www.eatip.eu) highlighted the need for relevant and excellent KM as crucial

[17] www.aquamedproject.net

for the success of aquaculture. This includes a wide range of activities: relevant R&D, dissemination, education, training and technology transfer, communications, networking, image perception of the products and the sector.

The central theme of these research programmes is the on-going development of ever more practical and sophisticated indicators.

One marked change in the direction of Turkish marine aquaculture research was the result of discussions at the Istanbul European Aquaculture 07 Conference. At that time, fish farmers in all coastal areas of Turkey were facing huge and unsupported relocation problems. This had been the result of new Ministry of Environment parameters for siting and monitoring. MARA was able to secure assistance from the FAO to examine the consequential logistical, planning and management problems. A "roadmap" was developed which amounted to a needs analysis with regard to the support, planning and management, and other related matters considered to be a priority and cost-effective research topics. In order to develop a more robust, competitive and sustainable Turkish mariculture sector for the long term, a series of research topics were outlined in this recent "roadmap" and, as such, it marks a significant change in research emphasis. The following research needs were identified:

– environmental management of marine aquaculture, including interaction studies between mariculture, other users of the coastline and the ecosystem;
– improved monitoring, such as by the use of standard methodologies for water quality and sediment analysis, and by developing carrying capacity models for Turkish coastal waters;
– the definition of a feeds and feeding programme;
– quality control of fry;
– fish health;
– investigating and developing the farming of new species such as shi drum (*Umbrina cirrosa*), turbot (*Scophthalmus maximus*), meagre (*Argyrosomus regius*) and brown meagre (*Sciaena umbra*) (these already are marketed in Turkey); further great potential is envisaged for sturgeon (*Acipenser* spp.), common octopus (*Octopus vulgaris*) and sponge;
– developing new technology – improved equipment and mariculture production systems;
– developing awareness of and methodologies for mollusc production;
– automated live food production systems;
– genetics – selection for improved traits (e.g. disease resistance, fillet yield, faster growth and improved feed conversion ratios (FCRs));
– developing assured quality and safety certification methods for the domestic market; and
– developing improved marketing images of mariculture products.

Training, extension services and communication

In Turkey, 14 fisheries faculties provide undergraduate and graduate education in aquaculture and aquatic sciences. Between 300 and 600 students graduated each year in the period 2001–2007. There are 25 other institutions for specialized higher education, known as Higher Schools of Vocational Development, preparing aquaculture technicians for the day to day needs of fish farming. There are also two specialist high schools for aquaculture. Training includes the techniques for the deployment of a complete monitoring strategy, which, hopefully, will eventually apply to all stakeholders. It is to be hoped that all stakeholders involved in the sector will cooperatively assist in the preparation of proposals for courses development, funded by the European Commission's Leonardo da Vinci Programme for education and training[18] in parallel with the review of vocational high schools for aquaculture.

There is a need for increased public awareness of the true nature and benefits of a well-organized aquaculture sector, for the needs of food security, for the development and maintenance of environmental standards and for environmental protection. Much of this should be the responsibility of organizations such as the Official Union of Aquaculture Producers, the Muğla Fish Farmer's Association and the Federation of Aquaculture and Fisheries of Turkey. These support organizations have an increased role to play in the development of media programmes and interaction fora with other stakeholders. Moreover, the private sector must continue to be linked to training institutes, and producers should allow more practical in-service training courses for students to take place on their premises all the year round.

Lessons learnt and the way forward

The Turkish mariculture industry could benefit greatly from technology updating and access to information and technology that is generated and adopted in other countries, especially elsewhere in the Mediterranean. The use of carefully thought-out job specifications itemizing tasks and skills in which aquaculturists of all types and ranks can be supported and appraised should become fundamental to career development and to job satisfaction.

The main R&D challenge for Turkish aquaculture is to improve knowledge and information dissemination and extension services, in connection with putting research findings before a wider audience. To this end, the setting up of an organizational system for promoting two-way information exchange between fish farmers and local and central government on the one hand, and with the public and other stakeholders on the other is needed. With this objective, a task force should be established and indeed, the regular and planned coming together of all stakeholders is a desirable objective. Information flow between the producers and relevant authorities must be enhanced and the provision of state-of-the-art

[18] http://ec.europa.eu/education/lifelong-learning-programme/doc82_en.htm

technical knowledge for producers must be made more readily available. One way to do this is to create an online database and information system in the Turkish language. Participatory input, feedback and awareness of the data to be used for decision-making by the relevant authorities need development at all levels from the ministries to the newest farmer recruits.

MARA-TÜBİTAK, with the support of the federation, unions and associations, should be the responsible agent for constructing a repository for aquaculture information. Modern technology needs to be applied for communication and dissemination of ideas, and to facilitate timely communication and implementation of the latest research results. There are particular opportunities in the areas of text retrieval, bibliographic services, video and photo databases.

CASE STUDY 5
Knowledge, information and dissemination in aquaculture: European position[19]

Background
Research and development
It has been increasingly recognized in Europe that improving communication between the different actors within and affecting the aquaculture sector is a crucial issue for the improvement of "knowledge management", a term that encompasses the title of this case study. Specifically, this case study refers to knowledge generated by research actions and projects achieved within the European arena.

In Europe, only 7–8 percent of research is financed through European funding; this means that 93 percent is funded nationally and usually targets national interests. Consequently, it is considerably easier to organize dissemination and communication of European work – since achieving effective dissemination is a basic condition of grant agreements for research work that receives European funding.

The generation of new knowledge from research and technological development (R&D) actions in aquaculture is made basically on four levels:

– R&D achieved in institutes and universities – targeting knowledge generation, scientific publications, patents;
– R&D achieved in corporate structures (e.g. feed and pharmaceutical companies) – targeting the manufacture and sale of new products to the aquaculture sector;
– R&D achieved on the farm – looking to improving performance, productivity and competitiveness; and

[19] Prepared by C. Hough.

– R&D made in another field but where an opportunity is seen for application in aquaculture – serendipity.

Results of knowledge generated within the academic research sector, unless covered by patents or specific reasons of confidentiality, are usually published in specific scientific journals and may be the subject of communication within conferences. For this science to be able to get through to the farmers, communication/dissemination networks are needed, since it is rare for individual farmers to attend scientific conferences.

Cooperation has always existed between industry and institutional research, particularly if the industry in question does not possess its own research facilities and related human capacities. Inevitably, such cooperation – without public financial support – will be tied to confidentiality and the (potential) commercial advantage of the company that finances the work.

The achievement of research on the farm can be very fruitful, but the results are usually kept in-house since these will usually be considered as the commercial advantage of the farm in question. Since such research tends to be achieved in "operating" rather than "scientific" conditions, it is also rare that such work is published in scientific journals.

Overall, it is the evolution of cooperative research – such as the specific European programmes (see http://cordis.europa.eu; www.feap.info) that involve small and medium-size companies with RTD institutes – that has stimulated a broader approach within the European research sector. Projects within these programmes require the creation of a consortium that is responsible for achieving the work proposed and managing the intellectual property generated. The project objectives have to include clear benefits for the industrial sector involved.

Salient points

Dissemination of knowledge

There are several different components that comprise knowledge and information which require communication actions. These might, as examples, be related to markets, policies, legislation, technology, research or simply knowledge and information about the sector itself. For each component, different structures and networks have evolved and are active at present.

Many of the subsectors of fish farming in Europe have developed as a result of knowledge transferred from successful R&D. As examples, within the major species produced, one can cite the husbandry of salmon, seabass, seabream and turbot. On systems technology, one can refer to cage and tank design, water recirculation technology, feed distribution systems and farm management software.

The knowledge generated for these topics has been disseminated through different networks, which can be broadly described as:

– academic (e.g. scientific journals, scientific meetings);
– academia-industry mix (e.g. conferences, workshops, seminars);
– industrial context (e.g. association meetings, industry-organized workshops)
– development (e.g. FAO, the Organisation for Economic Co-operation and Development (OECD), International Union for the Conservation of Nature (IUCN), Network of Aquaculture Centres in Asia-Pacific (NACA), Worldfish Center)

The formal academic networks focus on scientific excellence, represented by peer-reviewed publications and congresses or conferences organized by academic bodies or societies. Inevitably, much of the specific information generated remains within the academic community since few practicing aquaculturists subscribe to specialist journals or attend purely academic conferences.

Internationally, the academia-industry mix has been developed through the conferences and publications of organizations such as the European Aquaculture Society (EAS) and, at a global level, by the World Aquaculture Society (WAS). At another level, involving policy-makers as well, the FAO makes significant contributions through its regional structures (e.g. the European Inland Fisheries Advisory Commission (EIFAC), the General Fisheries Commission for the Mediterranean (GFCM) and its committees (e.g. the Committee on Fisheries (COFI) and its subcommittees on aquaculture and trade)), its workshops, publications and projects. More recently, other international organizations such as the OECD and the World Organisation for Animal Health (OIE) are contributing through their specific interests in aquaculture.

Within the industry, the structuring of representation through associations has accompanied the sector's development. All European states have regional and national associations that represent the professional sector that is present; most European states have a national association that either represents aquaculture as a sector (e.g. Spanish Marine Aquaculture Producers) or identifiable species producers (e.g. Scottish Salmon Producers). As aquaculture has developed and grown, consultation between governmental and sectoral representatives has increased, generally with the ministry responsible for aquaculture. Usually, this has also been accompanied by links to national scientific institutes and universities that work on aquaculture issues.

This position has developed further with inter-professional organizations that include upstream/downstream sectors and related stakeholders (e.g. the Danish Aquaculture Organisation and the French Inter-professional Committee on Aquaculture). In Europe, since 1969, most of the associative structures representing professional fish farmers have been members of the Federation of European Aquaculture Producers (FEAP), which represents the interests of these associations at the European level. This representation is to provide a communication bridge to the European bodies, such as the European Commission (EC), the European Parliament and the Council of Europe. Within this scope, the FEAP is a member of the EC's Advisory Committee on Fisheries and Aquaculture (ACFA) which examines and debates a wide range of legislative and practical issues that affect the professional sector.

In 1992, a new initiative was created – AquaTT (www.aquatt.ie) – under the EU COMETT (Community action programme in Education and Training for Technology) programme as a University Enterprise Training Partnership (UETP) for the European aquaculture industry. The initial proposal arose from the identification of a need to systematize, coordinate and develop the training requirements of the professional sector through a single body.

1. In Europe, there were thus three European organizations active in "knowledge management", each with their specificities and target audiences. From 1998 onwards, FEAP, EAS and AQUATT (Aquaculture Technology and Training Network) have worked together on a number of successful projects that focused on dissemination and knowledge transfer (Aquaflow[20], Profet and Profet Policy[21]).

The approach to achieving these projects has shifted with time, as a function of changing communication practices (from fax to the Internet) and conditions (wider consultation, transparency). A major change was to move from maximal dissemination of R&D results towards identifying problems and needs for effective R&D through targeted consultation and discussion.

"Profet Policy" not only provided a platform for the communication of R&D results and their relevance to European policies, it also gave the possibility for wider debate on the state of the sector and its objectives and needs.

Adapting to change

This change was reflected in the recognition that all members of the aquaculture value chain should be involved in determining future development policies and actions, defining a vision for the future and the actions needed to attain this. This position was promoted actively within the European economy by the creation of European Technology Platforms[22], an action that started in 2004.

The concept for these was:

– to provide a framework for stakeholders, led by industry, to define R&D priorities, timeframes and action plans on a number of strategically important issues focusing on Europe's future growth, competitiveness and sustainability objectives;

[20] See www.aquaflow.org
[21] See www.profetpolicy.info
[22] See http://cordis.europa.eu/technology-platforms/home_en.html

– to play a key role in ensuring an adequate focus of research funding on areas with a high degree of industrial relevance, by covering the whole economic value chain and by mobilizing public authorities at the national and regional levels; and
– to address technological challenges that can potentially contribute to a number of key policy objectives which are essential for Europe's future competitiveness.

In fostering effective public-private partnerships, technology platforms should have the potential to contribute significantly to European strategies and the use of knowledge for growth. Current contributions show them to be powerful actors in the development of European research policy, in particular in orienting European research programmes to meet better the needs of industry. To achieve this concept, the timely development and deployment of new technologies, the application of new technologies that have a clear view to sustainable development and the restructuring of traditional industrial sectors are objectives of particular application to the aquaculture sector.

The European Aquaculture Technology and Innovation Platform

Discussions on the potential for the creation of a European Aquaculture Technology Platform started in 2006, mobilized by several important players in production, research and feed manufacture. The immediate challenge was how to combine competing interests from the different sectors within a structure that has to have common goals for a common interest.

Defining these goals and achieving clarity in the objectives of the platform took time, particularly since the actions were voluntary. It is fair to say that the initial meetings set the scene, but that the translation of broad ambitions into specific progress and realization of the platform took time. Improving the competitiveness of European aquaculture, based on knowledge and skills, and assuring its long-term sustainability was and remains the core objective of this initiative.

Achieving this was made by using a core group of interest representatives from each subsector of the aquaculture value chain (e.g. producers, researchers, feed manufacturers, processors, fish health specialists, equipment suppliers), who met regularly to define a draft vision document for the future, based on identifiable thematic areas of interest.

While specific scientific and technical issues were identified rapidly, a common issue that was addressed by all participants was the improvement of the efficiency in managing the distribution of knowledge. Consequently, in looking at an operating structure for the platform, five "technical" thematic areas were designated:
– product quality, consumer safety and health;
– technology and systems;

– managing the biological lifecycle;
– sustainable feed production; and
– aquatic animal health and welfare.

Alongside these, three "horizontal" thematic areas were proposed, being:
– integration with the environment;
– socio-economics and management; and
– knowledge management.

In November 2007, a stakeholder meeting of the proposed Technology Platform met to discuss the draft vision document, its actions and structure. At this point, it was agreed to create a formal structure, unlike most other European Technology Platforms, that would be registered as a non-profit association. This decision was motivated by the recognition that many of the goals are long term and that full sectoral commitment was needed for success. In addition, this meant that an adequate fee structure would allow a level of financial autonomy that is needed to promote and organize the platform. The European Aquaculture Technology and Innovation Platform (EATiP[23]) was officially registered in December 2008 and currently has some 60 members from the corporate, research and associative and representative sectors.

As described previously, FEAP-EAS-AQUATT had been involved together in European actions targeting the dissemination of knowledge. With the experience of the development of EATIP, a new approach was formulated as a European initiative that is coordinated by EATIP itself. This project, titled "Aquainnova", will look to achieve four key objectives:
– create an operational framework for dialogue, between the value chain of the aquaculture industry, the research community and the policy-makers,(and that this be based on best governance practices);
– exploit the potential for innovation and technological development in the European aquaculture value chain;
– actively promote the exploitation, dissemination and communication of aquaculture R&D achieved in the EC; and
– improve how RTD and innovation knowledge is managed, disseminated and transferred.

This action will thus not only give a very close focus on how R&D and innovation knowledge is currently managed, both within the academic and industrial sectors, but also assess the best mechanisms for dissemination and communication within the different stakeholder communities.

[23] See: www.eatip.eu

Lessons learned and the way forward

Effective communication depends on careful identification of the target audience, followed by the use of the correct tools/facilities to reach effectively the audience identified. Translating this relatively simple concept to an audience as diverse as the different stakeholders in aquaculture is a big challenge.

Efficient networking, for all interested parties, is essential for the best KM, and the use of existing formal and informal networks is integral to this.

As a consequence, whereas the individual networks of different European bodies have their identifiable target audiences (i.e. their members and participants) and interests, there has been visible growth in a more participative approach to addressing issues of common importance.

While the EATiP is in its early days, it appears that the grouping of different players and interests within a structure that provides coherent and consistent objectives for aquaculture development will assist efficient KM and associated communication actions.

CASE STUDY 6
Investing in knowledge and communications: NACA training and extension experiences[24]

Background – NACA history and mandate

The Network of Aquaculture Centres in Asia-Pacific (NACA) was founded in 1989, with seven member governments, as an intergovernmental organization and is now composed of 18 member governments which together produce over 90 percent of world aquaculture production (by volume). With a mandate to improve the livelihoods of small-scale farmers and contribute to food security and poverty reduction through sustainable aquaculture development and aquatic resource management, NACA seeks to provide a range of training and extension services both through its secretariat, its lead centers and its other partner organizations of the member governments.

Salient points

A brief summary of Asian training and extension (T&E) to date

Education programmes for fisheries appeared in the Asian region at the turn of the last century. After almost a century of effort up to 1980s, a variety of deficiencies in the fisheries education systems were still a major issue (De Silva, 1988, 1991; De Silva, Sim and Phillips, 2000). A faster growth phase of the aquaculture sector in Asia started in the 1980s, and so did aquaculture education (AE). Consequently, the Asian region witnessed a rapid expansion of formal degree education in fisheries, aquaculture, aquatic resources

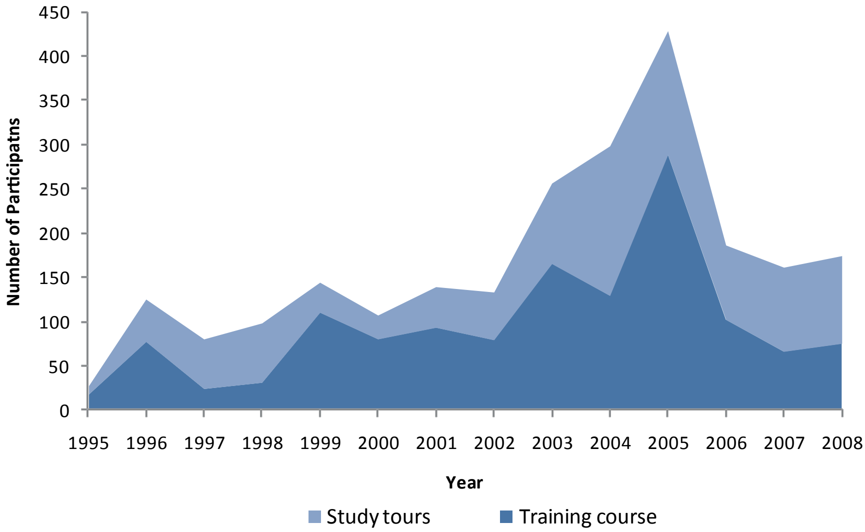
[24] Prepared by Yuan Derun, F. Brian Davy, S. Wilkinson and S.S. De Silva.

management and related disciplines, even to the extent that such courses began to be provided by the distance mode, primarily catering to those already in employment but seeking to enhance their knowledge. At the turn of the new millennium, deficiencies seemed less of a major concern in AE with the shift to a wider diversity of aquaculture practices and an associated diversity of AE combined with changing demand. These were leading to a greater need for AE to address a wide range of issues such as social development, sustainability and resource management (see De Silva, Sim and Phillips, 2000). Training, with its quick response to industrial technology needs and focus on specific skill development and application with flexible and efficient learning approaches has also developed into a highly important educational sector in aquaculture. To date, most educational/research institutes and government extension agencies conduct a wide variety of training activities at the national level; as well, some international/regional training programmes were established by various Asian regional organizations such as the South East Asian Fisheries Development Center (SEAFDEC), Asian Institute of Technology (AIT) and NACA, among many others.

NACA continually tries to respond to the demands of its member governments through the development of new training options. This strategy builds on the diversity of activities and skills of member governments, all of which offer an increasingly wide mix of training options, most of which continue to evolve in response to the changing needs of farmers, governments and other stakeholders. In brief, aquaculture development in the region has been characterized by rapid advances in production technology and diversification of production systems, followed by a more recent marrying of science and social aspects related to management that has led to the development of, for example, BMPs and a cluster approach to their adoption. The latter is able to prepare farmers to comply with emerging issues such as food safety and quality, international trade, environmental concerns and climate change. Consequently, aquaculture training has also been challenged to keep up with and adapt to this rapidly changing mix of issues. These demands include the increasingly diverse training needs, coupled with an increasing diversity of backgrounds of the candidates seeking training. NACA's latest venture into training is to combine with other interested partners to provide a course for developing skills in business management principles for small-scale farmers – the backbone of the aquaculture sector in the region.

Overall, NACA seeks to meet these demands with innovative training approaches that optimize the increasingly constrained training resources. A review of the NACA experiences to date in conducting training in aquaculture for more than the past decade can be summarized as follows: more than 3 000 professionals from 30 countries and from an equally wide mix of backgrounds/organizations were trained in a wide variety of training courses and study tours. In addition, this review outlined some of the history of these training approaches and

FIGURE 7
NACA training summary



Source: Umesh *et al.* (2009). Indian States: Andhra Pradesh (AP), Kerala (KA), Gujrat (GU), Orissa (OR), Tamilnadu (TN).

then examined the lessons learned from the training experiences. In brief, it was suggested that knowledge networking and partnerships that encourage continued shared learning mechanisms to better utilize the diversity of knowledge and training experiences of NACA and its partners have provided a valuable resource. The past supply of training is being examined as part of an evolving examination of future training, including an initial examination of mechanisms to further strengthen these efforts. Optimization of the regional aquaculture training resources, improvement in training efficiency and enhancement of the capacity of training institutions to cope with new challenges coupled with redesigned evaluation and other feedback mechanisms are being examined as part of this review of training efforts.

As can be seen in Figure 7, study tours (e.g. white-leg shrimp farming, feed manufacturing) and regular training courses (e.g. integrated fish farming, marine fish seed production, intensive shrimp farming, shrimp disease management) (see www.enaca.org/ for more details) have been the main training options provided to date. The mix of study tours and training courses continues to evolve, with a priority for study tours likely driven by the large number of development projects in which study tour funding mechanisms are a priority. Although there was a peak demand in 2005, study tours continue to be in high demand throughout the region for a variety of aquaculture stakeholders from many member and non-member countries.

Tools

Training data analysis (e.g. tracer studies) is being coupled with the development of a variety of training tools, and improved evaluation methods are a priority to better guide the development of a new set of capacity development programmes.

New directions

Although the demand for aquaculture training continues to increase, assessment of these needs in order to better provide optimum training services remains the major challenge. NACA is exploring various possibilities for a systematic assessment of aquaculture training needs in the region, including other types of feedback from training participants, better use of staff travel information, regional reviews and workshops, and more proactive interaction with the business sectors (as part of value-chain analysis research).

The current training directions of NACA focus on and are in line with global aquaculture development trends coupled with a look at emerging issues related to small-scale farmers, e.g. lack of adequate business management knowledge and skills, increased competitiveness in a dynamic global environment and increasingly stringent food quality and safety requirements. Apart from continuously organizing training courses on high-demand topics and highly relevant topics such as marine finfish production, NACA is developing a variety of new training courses, for instance on aquaculture business management for small-scale farmers, and BMP and aquaculture certification, respectively. As well, NACA is collaborating with international and regional partners to ensure that the training materials better reflect NACA's decade-long experience in promoting sustainable aquaculture in the region while maximizing the use of international expertise. Skills development, implementation approaches and reaching wider audiences through the Internet and other information and communications technology (ICT) will be new foci for this work. Interested readers should see, for example, the Aceh Indonesia trials on the development of aquaculture service centers using voice over Internet technology (VOIP) to share knowledge among others in their association (Ravikumar and Yamamoto, 2009). Also, NACA has been increasingly experimenting with farmer-based approaches such as farmer to farmer exchanges (e.g. catfish farmers visiting Indian shrimp farmers (NACA News, 2009)).

NACA will continue to provide aquaculture study tours in the region. In addition to examination of farming practices, more in-depth analyses and system comparisons will be added to field visits. Training more closely linked to the major development trends and increasing capture of success stories and lessons learned will be highlighted.

The divide isn't just digital: any discussion of Internet technologies for small-scale farmers needs to acknowledge its limitations. Internet penetration is low in rural areas and also in low-income-earning groups. It is extremely low among people who are both rural and poor. However, having said that:

- Exactly the same is true of printed publications, training courses and most other "traditional" communication/extension approaches, whose application is severely limited by their high costs of production and distribution, literacy and labour constraints.
- Internet penetration is growing rapidly and continues to accelerate, particularly among young people. China already has more Internet users than any other country. Asia already has more Internet users than any other region (Tables 4 and 5).
- Computer prices continue to fall, particularly for small mobile computing devices (phones and netbooks).
- Mobile phones and satellite Internet services are bringing broadband Internet speeds even to the remotest of areas, thereby bridging the physical aspects of the "digital divide", if not the economic ones.
- It is likely that nearly all computers and phones will eventually be networked.

The Internet is not yet "mainstream" enough for direct communication with most farmers in the region. However, it is an important tool for extension agents and others who work with rural communities. Initiatives such as the "Aquachopals" of India or the "One Stop Aqua Shops" and Aceh Aquaculture Communications Centre piloted by NACA have demonstrated that facilitated access to the Internet can be a useful and feasible way to provide services to farming communities. For example, communications links to remote diagnostic expertise and extension services, and audio/video presentations are useful to overcome literacy barriers.

TABLE 4
The Internet: no longer the province of developed countries

	Asia	World
Number of users	657 million (41.2%)	1.596 billion
Average penetration	17.4 %	32.1 %
Growth since 2000	474.9 %	342.2 %

Source: Internet World Stats, Q1 (2009).

TABLE 5
Top five Internet countries

Country/Federation	Number of Internet users (millions)	Penetration (% domestic population)
China	298	22.4 %
European Union	297	60.7 %
United States of America	227	74.7 %
Japan	94	73.8 %
India	81	7.1 %
Brazil	67	34 %

Source: Internet World Stats, Q1 (2009).

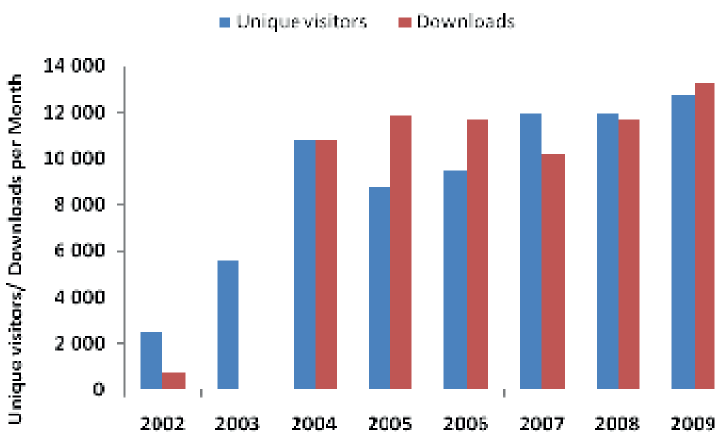
NACA's Website experiences

NACA established its first static Website in 2000. Starting from 2001, the organization adopted a policy of making all publications available for free full-text download from the Website in portable document format (PDF). By the following year, the number of publications distributed in electronic form had exceeded that of hard copies. It quickly became apparent there is an enormous thirst for information on aquaculture development.

NACA moved to a dynamic Website in 2004, using a free open source content management software (presently ImpressCMS, www.impresscms.org), which automated much of the publishing process, making it faster and easier to publish new information. Improvements to the quality of content offered and frequency of publishing led to a large increase in Website traffic (Figure 8). Today the Website attracts around 15 000 unique visitors and 200 000 page views per month, and around 150 000 publications are served per year. The annual operational cost for this is around USD10 000, the bulk of which is for rental of a dedicated virtual private server. The Website has become NACA's most efficient tool for sharing information/knowledge and raising awareness of the organization's activities among participating research centers. However, its application to rural farmers is far more limited.

Recently, NACA has begun publication of an e-mail newsletter which provides subscribers with links back to new content on the Website, boosting traffic by around 25 percent. NACA has also begun to experiment with publishing audio recordings of technical presentations in MP3 format and production of video

FIGURE 8
NACA Website users. Unique visitors refers to unique "IP address" therefore excluding multiple visits from the same computer while there could be multiple downloads from the same IP address (computer)



training materials via Youtube. Another area of development is integration of tools to allow people to share NACA's Website content with their own contacts via social networking services such as Facebook and Twitter.

An integrated approach: new and old media are complementary

Although the Website has proven to be a highly effective communication tool, NACA still produces printed editions of publications, runs training courses and workshops, and does all the things it has traditionally done to communicate with people. Our stakeholders vary widely in their capacity to access and utilize different media, and a blended approach is necessary to maximize accessibility. We try to cross-link media; for example, printed publications carry advertisements for resources on the Website and vice versa to maximize awareness, accessibility and sharing.

The Website has allowed NACA to reach out to more people than ever before, but to a large extent this is a new and different audience. The Website is just another tool in the box, one that will become increasingly more valuable with time, and one that works best used in concert with other media.

Key messages and the way forward

In the past decade, NACA has sought to provide a variety of training services, while the region has witnessed rapid changes in aquaculture development often characterized by rapid advances in production technology, diversification and specialization of production systems. Additionally, there has been a gradual standardization of production processes and an increasing need for rapid adaptation to emerging issues such as food safety and quality, international trade, environmental concerns and climate change. Financial support for extension is facing a variety of challenges, mainly financial constraints (see, for example, FAO 2010b), Consequently, increased production is often not the main priority now; problems in the sector relate to sustainability and meeting the needs of the international market place. Consequently, the NACA Education and Training Program and other training institutions are being challenged to keep up with and adapt to this rapidly changing mixture of issues. In summary, the main future challenges include: the increasing diversity of training needs which no single institution is able to handle properly, the increasingly diverse trainees' backgrounds, the limited training resources and increasing costs, and a less predictable life expectancy of so-called regular courses and enrolments. Additionally, more and more training demands are driven by ad hoc requests, leading to quality concerns and difficulties in needs assessment at different levels around changing demands, timing, and costs. Related issues might also include use of scientists vs. trainers and the use of ICT and particularly the cell phone and various other learning and knowledge-sharing tools. NACA is experimenting with expanded use of ICT; some Web-based training and knowledge sharing models are being developed and mechanisms are being sought to make more free information available to wider sets of recipients, often through expanded and strengthened links among partners.

Overall evaluation of the case studies

Some lessons learned

The case studies described in this review (see Table 6) reaffirm the fundamental importance of knowledge and its management (KM). The case studies also confirm that we have not really looked at this issue adequately, and as we plan for Aquaculture 2020, we should develop a renewed approach to KM. Such an approach should better recognize the significant challenges in dealing with the enormous amount of information/knowledge and the differential and often limited capacities of the various stakeholders to deal with this knowledge. Our review confirms that approaches such as knowledge brokers, knowledge platforms and related mechanisms for sharing, digesting and generally assisting this knowledge management process are working but more needs to be done. Follow-up efforts should give more recognition and pursuit to action research on the various gaps, such as more effective utilization of local or indigenous knowledge and the improved use of links to other stakeholder knowledge experiences. Knowledge sharing seems poised to expand at all levels and scales, but we can expect a variety of challenges in optimal knowledge sharing. This scenario is driven not only by the rapid growth in aquaculture, but also by the increasing number of stakeholders. The accompanying drivers/pressures (e.g. market forces and globalization) provide good examples of these changes, changes that increasingly cross spatial, time and level boundaries. These issues have generally received little attention to date by the aquaculture community. We are also entering into an era where many questions are being increasingly asked about funding priorities, for example, for research. In such a context, the sector is best advised to develop some guidelines on more effective evaluation of research outputs (in relation to funding inputs), as well as develop qualitative measures of the impacts of research on the sector.

Table 6 suggests a set of further overall lessons learnt and a variety of related observations:

- As culture systems developed, and particularly with the consequent intensification, disease and related health management knowledge became an increasingly important issue in all cases, and these changes have mainly taken place in the last ten years and are still on going. In most cases, inadequate knowledge sharing and management was a major constraint, but this lesson apparently needs to be relearned in each instance. This is perhaps one of our most startling findings. This poor knowledge sharing seems driven by competition for markets; stakeholders should take note that improved knowledge sharing on key issues like disease may outweigh traditional individual market-driven competition approaches. Moves toward a wider set of sustainability concerns seem likely to follow a similar trend.
- Improved examination of social organization, participation and shared learning among farmers is suggested, particularly at the implementation level. In general, social science inputs in aquaculture seem slow to develop and the reasons for this remain unclear.

TABLE 6
The six cases examined through a knowledge-communications (K&C) lens, in chronological sequence, including reference to the Bangkok Declaration.

Issue	Viet Nam	India	Turkey	Chile	FEAP Europe	NACA Asia
Early history, common starting points, constraints	– Modest production levels via traditional cage culture system in Viet Nam & region	– Traditional shrimp farming in coastal lagoon systems; disease an increasing problem	– Turkey & Mediterranean seabass/seabream cages start in the1980s – Quick growth – ICZM conflicts. – K&C strengthening needed	– Cage culture in Chile region with very rapid growth over the 1990s – Salmon farmers well organized in farmers association & thought to be well-positioned against crises	– Recently established as a regional producer-led group – Recognition of K&C barriers	– Early regional body with significant training/extension (T&E) including partnerships with Viet Nam & India (cases cited here)
What changed? Main current knowledge management (KM)/ uses	– Rapid increase in production around 2000 when seed supply (research knowledge) & new pond culture systems (farmer knowledge) developed	– Marked reduction in disease problems led by new science-based BMP collaborative system started in 2000 in Andhra Pradesh driven by strong participation & cluster organization of farmers supported by creation of a new national organization (NaCSA)	– Relocation: on shore to off shore in face of tourism demands & environmental impact – Piloting of stakeholder K&C participation through development of indexes for sustainable aquaculture – Similar to other cases where good science played an important role	– Imported “know how” from main salmon countries, as the same companies were involved – Government-funded research increasing but with limited impact on aquaculture production	– Refining knowledge platform around five main KM issues – Strong industry links; use of value chain thinking	– Stronger government & research knowledge links – Regional knowledge sharing (T&E) blended approach to K&C use of Internet and new technologies with more traditional study tours exchanges, etc.
K&C: Who generates main knowledge? Who disseminates knowledge? Who uses this knowledge?	– Farmers, researchers, government develop sharing & using knowledge	– Cluster organizations of farmers effective in sharing of knowledge. Farmers with local agencies used science for health KM, BMPs – NaCSA working closely with farmers on key knowledge issues; e.g. certification and international marketing	– Private sector has large role in the generation of new knowledge. Partnerships between university-farmers and government, but consumer needs more info	– Important role of the private sector in the generation of new knowledge		– Work with farmers at the aquaface; risk assessment initiated; leads to science-based BMP development

TABLE 6 (Continued)

What is working?	– Good science around the key knowledge inputs of breed, feed, disease, etc.	– Good focus on key farmer problems; farmers organized and collaborating/ sharing knowledge	– Good science similar to Viet Nam experience needs media dissemination to encourage full awareness of health, food, environmental impact, etc. In-services training courses needed at all levels	– New management plan set up to confront disease (ISA) problem but too early to judge effectiveness	– Regional networking & neutral broker concept	– Training courses & Website use have continuing strong demand – Involvement with farmer clusters; government, research institutions
Main challenges. What is not (yet?) working and potential solutions or innovations in KM; future implications	– Farmer to farmer & social organization shared learning still in early stages of development	– Value-added marketing & certification coming but takes more time	– K&C platforms needed to enhance current limited economic, marketing, know-how – Governance & implementation efforts need opening-up and up-dating – Training & extension needs more effort – Aquaculture research strategy needs horizontal & vertical revision – ICZM K&C planning involving all stakeholders needs to be developed	– Disease-related knowledge exchange between farms & between companies not open nor rapid – Farmers association as a knowledge-sharing platform needs work – Government regulatory efforts inadequate – Absence of an effective biosecurity framework – Government increasing role in funding research – Government & foreign-owned companies knowledge sharing inadequate – Need stronger "knowledge broker" organizations & a new cluster approach to collaborative farming	– Shared learning using platforms or other mechanisms is slowly starting	– Many small-scale farmers remain difficult to reach; continue to experiment & learn/ adapt – Disseminating the concepts to other countries & commodities – Strengthen the science-based elements/approaches
Main Recommendations	– Continued effort on knowledge sharing among better organized farmers & other stakeholders, including government	– Improving collaboration & shared learning within & across levels (i.e. farmer to farmer, state to state and nationally) works	– International partnerships communications platform experiences positive & expanding	– Increase transparency & efficiency in the transfer of information among companies & between companies & government – Increase sense of the "common good", both public and private		– Continue blended approach to T&E using new & traditional tools – Give farmer innovative aspects to management more prominence & disseminate widely – Main problems linked to funding & coping with expanding training needs

- KM drawing on and sharing lessons learned across a widening set of knowledge systems and resources is needed; e.g. more comparative work examining the potential use of other knowledge sources from outside players of the usual aquaculture partnerships, for example, the World Bank Knowledge for Development (K4D) Group.
- Movement away from a “market-first development model” to a more shared-learning model seems to be happening but needs considerable more work, including promotion as well as seeking a better understanding of costs/benefits.

Understanding change processes

Overall, aquaculture has been, and seems likely to continue to be, a story of growth – extremely rapid growth in some cases (such as outlined in our Chile and Viet Nam cases), but growth that has both positive and negative impacts. In addition, our review suggests that there are much slower development phases, likely of 25–40 year cycles, that have taken place. Such underlying slow change processes have received negligible examination to date but could also provide important insights to improved knowledge on changes in aquaculture and its improved management.

Our selected case studies raise a variety of other growth questions around knowledge production and particularly, its communication and use, for example, in new training and extension knowledge-based thinking, examining how best to get knowledge into the hands of those that most need it, often across a variety of barriers (e.g. language, capacity and access differences), linked to a better understanding of its communication among the changing audiences. All of this is taking place as aquaculture continues to attract an increasing variety of new stakeholders, as it attempts to deal with a widening set of change processes often involving a complex mix of governance and social changes. In recent years, the aquaculture scene has been one of increasing confrontation, often driven by limited understanding and sharing. We suggest that more aquaculture stakeholders need to better understand some of these knowledge processes and expand efforts on newer concepts such as knowledge translations. All are suggested as potential knowledge strategies that are likely to be increasingly critical to the sustainable development of aquaculture and its improvement in attaining the goals set out in the Bangkok Declaration.

Indigenous and farmer knowledge and links to major users

Indigenous farmer-based knowledge and innovation including traditional knowledge has been critically important to the development of this sector. Of course, some of this knowledge has a very long history, over thousands of years in places such as China. However, KM (for example, shared learning at the farmer level in aquaculture) is little studied. This seems to be a niche needing more work, perhaps making better use of the new information and communications tools (ICT) to document and share knowledge at the farm level in particular.

Recently, it has been highlighted that the transformation of Viet Nam catfish farming from a cage-based culture system to a pond-based system was the result of an innovation of a single rural farmer, who has gone on to be one of the main producers of Vietnamese catfish (Anon., 2009). However, this line of thinking seems to have a limited knowledge base to date; perhaps aquaculture needs to reach out more to social and related sciences to encourage more work in this area.

Good science and aquaculture research

In more recent years, for example from the 1970s onward, appropriate research or what we are calling "good science" has played an increasingly important role in aquaculture development. An example of this is our case study on the breeding successes with striped catfish in Viet Nam and how this international partnership of breeding researchers seemed to be one of the critical change events in stimulating the phenomenally rapid expansion of this catfish production system (for more details on this history, see the Viet Nam case study). However, our knowledge base still has significant gaps, for example, on traditional knowledge related to biodiversity and to aquatic genetic resources more generally (e.g. see Phuong and Oanh, 2009). Also, we note the very interesting management ideas coming from some of the traditional fisheries management research (e.g. in Sabah, Malaysia); however, wider sets of such data are extremely limited.

Equally, development of science-based BMPs and their application in management has brought about positive results (Umesh *et al*., 2009). Perhaps this thinking has to be adopted in a wider set of commodity chains and farming systems, with the consequent outcome of not only enhancing economic viability but also being an indirect approach to meeting food quality and food safety requirements of the market place.

Knowledge translation and use

Knowledge translation (KT) is a concern, particularly knowledge that fits well with the needs of aquaculture producers (as highlighted by most of our case studies, for example, those for Europe, Chile and Turkey). We return to this issue later as we discuss the concept of "aquaface thinking[25]" in our later discussion on new directions, but many cases argue for a re-examination and improved understanding in terms of better meeting user knowledge needs.

Knowledge sharing and networking

Linked to the previous lessons learned, continued experimentation with new shared learning ideas such as knowledge platforms (see the European case study) and even more effective use of good old fashioned communications tools and networking (most of our case studies) are suggested.

[25] We coined the term aquaface (cf coalface) to highlight this line of new aquaculture thinking around knowledge translation and related practice and implementation thinking in aquaculture.

Knowledge management

Knowledge management (KM) as an overall process would benefit from a deeper examination (and likely its adaptation) using some of the new thinking around knowledge supply and demand, for instance examination of the use and suitable adaptation of ideas and processes from the health sector.

Strategic Influence and reaching the necessary target audiences

Aquaculture needs to consider more carefully, and perhaps draw on some of the new communications thinking (e.g. Santucci, 2005) and that of strategic influence (e.g. Creech and Willard, 2001) as our collective thinking progresses around sustainability. We note the importance of issues such as developing critically important relationships (see, for example, the thinking of Carolan, 2006) and the need to better engage with key decision-makers and other critically important audiences in this work.

Conclusions

Our review raises a number of questions around whether aquaculture as a sector is adequately and effectively examining/managing available knowledge, both within and across this and related sectors, for example, questions around the development of a better understanding of farmer knowledge, traditional knowledge or some of the new thinking in the social and information/ communication sciences. Such KM examinations might usefully explore some of the barriers to an open (and often critically important) sharing of knowledge. Our Chile case study, for instance, raises a variety of questions about timely sharing of knowledge on disease among farms, as well as with the regulatory authority. Conflicting forces, here perhaps too much driven by perception of market advantage and short-term revenues, led to various forms of secrecy or even critical delays in such knowledge sharing. The result was an on-going series of major crises with costly impacts that continue to have major consequences for most stakeholders in terms of the development of this industry.

At a regional level, it is suggested that the NACA "regional organizational prototype" has paid significant knowledge and other shared learning dividends in facilitating aquaculture growth and sustainability in the Asia-Pacific (see the NACA case study). At the regional scale, for the coming decade, the newly formed Network of Aquaculture in the Americas and the related plans in Africa for redevelopment of similar knowledge-sharing mechanisms provide further future case material for continued examination and lesson learning within and between regions, regions in which aquaculture will continue to follow different but knowledge-linked paths. Work to date around various start-up interregional knowledge-sharing activities suggests a future set of activities for development of optimal knowledge networking globally.

As the Chile case study argues, investment in basic research is at all times very relevant, and governments should strengthen funding for this kind of research. However, more applied and focussed research is also needed, and some countries have found mechanisms to support this, in some cases through public-private partnerships. Such research is very relevant to the solution of very practical problems at the farm level, for example, the development of a needed vaccine or the production of a type of feed for larvae.

More fundamental knowledge questions related to whether aquaculture is meeting the needs of most of its stakeholders (linked to various questions around how such knowledge is being used), need more assessment and detailed examination. Is aquaculture adequately reaching out to various downstream users? Is use of the media taking the appropriate form? In our experience, there is a reluctance to engage around contentious issues such as shrimp and mangroves. Many of our challenges in reaching the goals of the Bangkok Declaration relate to appropriate messaging and reaching wider sets of audiences (who often have very different understandings of the issues). This messaging needs to be appropriately linked to relevant "good science", for instance, and a wider set of lessons learned that will be critical to their changing the behaviours of targeted actors.

Finally, we feel that the science and the process of aquaculture development could learn a great deal from a comparative look at related Knowledge Management thinking in other sectors. For instance, the work in the health sector with a particular focus on the knowledge sharing and knowledge translation thinking (Schryer-Roy, 2005) has led to more effective use of knowledge management for policy change processes as well as its use in health practice. This greatly strengthened implementation of knowledge in terms of "on the ground" changes in aquaculture practice is highly desirable . As mentioned, we see major gaps in aquaculture work to date around what we are calling "aquaface thinking" (a term borrowed from work at the coal face), where KM strategies are strongly linked to this more and better understanding of working at the aquaface or implementation science.

In closing, we return to our opening quotations on knowledge networking and communications thinking and remind all that much of our knowledge will be increasingly stored in our partners, friends, colleagues and neighbours. Therefore, it is advisable to carefully plan and invest more in shared learning and perhaps just being neighbourly beyond the Phuket conference. It may be time to give more attention to being a good aquaculture neighbour!

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