FISH for the PEOPLE

A Special Publication for the Promotion of Sustainable Fisheries for Food Security in the ASEAN Region

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Cover: *Drying fish, Kampong Leuang, Cambodia (Photo by courtesy of FACT)*

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EDITORIAL

Since the establishment of the General Agreement on Tariffs and Trade (GATT) in 1947, and its subsequent restructuring in 1994 into the World Trade Organization (WTO), the globalisation of trade has accelerated. But more recently, global trade has both evolved and diversified. Bilateral Free Trade Agreements (FTAs) and Regional Trade Agreements (RTAs) are relatively recent developments, and are often perceived as more effective mechanisms for promoting trade between countries. Accordingly, the number of such agreements worldwide proliferated from just a mere thirty in 1990 to hundreds in 2006.

While these trade agreements help to tear down barriers, they are also perceived as dividing the world into trading blocks with different rules and standards. Fish trade is not treated separately from other trade issues, and fisheries products are generally included in FTAs. Neither is fish trade promoted by any fishery agencies at the national or international level. Special attention needs to be given to fish trade issues, as fishery products may actually be more sensitive than any other food commodities in terms of hygiene and safety for the consumers, due to their highly perishable nature.

Although trade issues have previously been a relatively secondary agenda in the international or regional fisheries arena, they are now becoming increasingly important. In Southeast Asia, various fisheries-related meetings have recently addressed trade-related issues, but these have tended to focus mostly on regional concerns that global trade promotion does not always suit the specific regional situation. More explanation is needed about how global markets can accommodate small and medium entrepreneurs and producers so typically dominant in the region.

Among the issues discussed in this issue of *Fish for the People*, trade – both at the international level and at the regional level – takes the lion share of the coverage. Several authors explore the issues of fish trade from different perspectives, although all focus on small-scale fishers and fish farmers who dominate the fishery sector in Southeast Asia. In the end, it comes down to the same issue: how can we promote fair trade among fishing communities to ensure that responsible fishing practices are promoted, that they get proper access to market, be it national, regional or even international, and ultimately, that they can secure sustainable livelihoods through value-added production and sustainable fisheries, and that the income generated from this trade is equitably distributed among stakeholders.

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Another important theme raised in this issue, and in regional fora, is fishery subsidies. Subsidies in fisheries are an important trade issue often raised in the international arena as well, especially these days. A general-ban approach to fishery subsidies, as promoted by some countries, may in the future cause serious problems not only in developing countries but also among developed nations. Rather, as always, wisdom lies between the two extremes. An approach such as that advocated by ASEAN-SEAFDEC member countries that which prohibits only subsidies which have direct negative impacts on fisheries resources, would be more amenable to the needs of each country, and more logical because fisheries subsidies negotiation starts with the aim of supplementing the global effort to achieve sustainable fisheries. In this matter, it is necessary to recognize that subsidies can play a positive role in promoting sustainable fisheries and practices, and of course development and poverty alleviation. Also, as highlighted in this issue of *Fish for the People*, we cannot attribute all the blame for the current levels of overcapacity and overfishing primarily to subsidies.

Experience has shown that for a fisheries management system to be sustainable, we do not only need for the system to be effective and ecologically sound, but also that the global market is conducive to sustainable practices. At present, sustainable fisheries are being practiced in a number of countries, including some sub-sectors in Southeast Asia. But the ability of the fishers concerned to maintain sustainability in their fisheries and the possibility for others to move towards sustainable fisheries is being undermined by a global market characterized by subsidized overcapacity in the large-scale fishing sector, and other market distortions affecting fisheries and fish products that discourage fishing communities in developing countries to get their share of the profit. It is now up to ASEAN to respond to the challenge as there are still opportunities that sound trade negotiations at WTO can address some of these problems.

Olivier Delahaye Gamucci

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FISH for the PEOPLE is a special publication produced by the Southeast Asian Fisheries Development Center (SEAFDEC) every six months as part of the ASEAN-SEAFDEC Special 5-year Program to promote sustainable fisheries for food security in the ASEAN region.

Dried fish products, Kampong Luang, Cambodia (Photo by courtesy of Simon R. Bush)

One Village, One Fisheries Product (FOVOP): Seeking "Only One, not Number One[1]"

By Yasuhisa Kato

Introduction

It is surprising to see that the Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region, adopted by the ASEAN fisheries-related Ministers as a regional fisheries common policy at the ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security in the New Millennium: Fish for the People in 2001, did not mention poverty alleviation even once! It should also be noted that popularization of the implementation of "the Resolution and Plan of Action" is the main policy basis for the publication of the magazine *Fish for the People*. Does this mean that poverty is not a problem for fisheries in the Southeast Asian region?

It is not only in the ASEAN region fisheries policy is silent on poverty alleviation. Developing countries worldwide have rarely addressed how the fisheries sector can alleviate poverty in the Poverty Reduction Strategy Papers (PRSPs) that are produced as one of the main conditions for concession lending by the International Monetary Fund (IMF) and World Bank to developing countries. This is amply demonstrated by Andy Thorpe in a recent FAO publication[2]. Dr Thorpe analyzed the PRSPs produced by 129 developing countries, and found that the fishery sector is largely neglected. Such a situation can have negative impacts in relation to external assistance to the fisheries sector in developing countries. The paper does not include an analysis of why such opportunities have been missed and leaves this study to future research. So to date we do not have a coherent explanation for why this neglect occurs so consistently throughout the world.

[1] For this expression, I am grateful to Ms Rika Fujioka, who examined the concept of OTOP in her doctoral studies at the School of Oriental and African Studies (SOAS), University of London.

[2] 'Mainstreaming fisheries into national development and poverty reduction strategy: Current situation and opportunities', FAO Fisheries Circular, No. 997, FAO 2005.120p

Despite the absence of an explanation, the facts themselves speak volumes. They indicate that government support services for fisheries may have structural problems when it comes to taking care of social and economic problems in their respective countries, especially when it comes to supporting the poor. Is it related to the fact that fisheries activities, which are mainly conducted at sea, might be relatively invisible to civil society? This would be confirmed by the general observation that most governmental fisheries-related agencies in Southeast Asia have the mandate to support the fisheries industry, especially in terms of technology development, and therefore have a technically oriented staff, with biological and engineering backgrounds rather than social or economic affinities. Government services that systematically deal with poverty alleviation for the sector, in this context, are much less visible within the governmental structure. The facts explain that these poverty alleviation activities for fishing communities have habitually been conducted mainly under project-based activities with the support of external donors, or mandated to other government agencies such as the Ministry of Interior or the Ministry of Social Welfare.

Now, thanks to the general economic development in most ASEAN member countries, is it possible that poverty alleviation is no longer relevant to the fisheries sector agenda? Certainly not! When discussing poverty in the context of the fisheries sector, it is essential to caution against undue optimism. Although effective fisheries management has been implemented in many places in the region, effective management systems are still largely missing, and the generally deteriorating situation of fisheries resources can only lead to a deterioration in the livelihoods of fishing households.

Vicious cycle to poverty

A serious problem in achieving sustainable fisheries, especially for small-scale fisheries in the Southeast Asian region, is over-capacity across the sector – too many fishers are competing with each other for dwindling fisheries resources. Due to difficulties involved in establishing appropriate fisheries management systems in coastal areas in the region, fisheries have to date been largely unregulated, with open access to fisheries resources (the so-called 'race to fish'). Declining trends of daily catches are making fisheries livelihoods much increasingly vulnerable, and it is easy to envisage a future in which many households dependent on small-scale fisheries will be characterized by chronic poverty. But there are few ready options to alleviate poverty, especially considering the lack of alternative income-generating opportunities in rural fishing communities. People usually have little choice but to continue to be a small-scale fisher. Using illegal and destructive fishing gear and practices then becomes increasingly attractive as a desperate short-term attempt to maintain a livelihood. This vicious cycle would further aggravate the social, economic and financial status, as well as the ecological status of the aquatic resource base.

A vain discussion?

When sustainable fisheries development is promoted in the region, fisheries managers and decision makers often receive ambivalent comments on poverty issues from government technical officers. Discussing the requirements of fisheries management for small-scale coastal fisheries, one might hear the comment that "fisheries management for such a sub-sector might not be required because authoritative management arrangements might only add an additional burden to people who are already socially and economically weak". To which one might reply, "It might be true, if the management actions are provided in an authoritative manner". You may also want to add "But can we leave them as they are? Since the resource situation is deteriorating, their situation will be further marginalized unless appropriate support is provided". "What kind of support?" would be the appropriate question at this stage; but more likely you will hear "Well … I do not know."

Let us consider another case. When we discuss the overcapacity of small-scale coastal fisheries, other people might comment: "You cannot freeze the number of boats of these poor people! They cannot survive if we limit their access to fishing". OK then, but "How do we solve the overcapacity problem?" "Well … We have to provide alternate work opportunities for them in their communities."

People know the difficulties faced by small-scale fishers. The problem, however, is that we cannot find a way to improve the fisheries management systems for these small-scale fisheries. Our discussion sometimes focuses on the root causes of the problem, which are linked to social and economic dimensions, but at this stage, government fisheries officers do not usually find the conversation to their liking, or simply have difficulties in comprehending what is discussed and follow-up action needed, due to their own weak mandate and capacity in the matter. We find ourselves then jumping back to square one. [We know fisheries management problems.] [We can not propose a system with only technical dimensions, but must also consider the social and economic situation.] [Unfortunately, these social and economical related needs and actions are not specifically mandated to fisheries management authorities.] [Under such circumstance, we are sorry but we cannot improve our fisheries management system.]

Addressing institutional weaknesses

If this is the case, what is the real problem? Can we attribute it to Departments of Fisheries in various Southeast Asian nations not being the agencies mandated to improve the socio-economic dimensions of fisheries? Haven't these needs been identified as the bottleneck to promote an appropriate fisheries management system for coastal fisheries? If so, we could seriously discuss what strategies might address these institutional weaknesses, so that fisheries-related agencies can intervene appropriately to improve the socio-economic conditions prevailing in fishing communities.

Along these lines, I would like to develop a preliminary reflection on a system of economic activation in fisheries communities that would not rely on large-scale assistance by competent agencies such as those under Ministries of Social Welfare.

While we have seen above the consequences of not managing fisheries, which leads to vulnerability and in turn poverty, we have not discussed ways for the fishing community to obtain maximum benefits from fish and the fisheries products they are producing. This, to date, has not effectively been achieved due to social and other problems.

Obtaining a decent share of the benefit from the fish

Traditional marketing systems are in most cases dominated by the so-called middlemen', who purchase fishers' catch, often as fresh fish, in order to sell it through their own marketing channels that will ultimately reach retailers and consumers. There is typically an ongoing tension between fishers and middlemen. Fishers are paid very little for the fish they catch, while middlemen take the risk of locating an eventual buyer, and usually of lending money to the fisher. The arrangement is sometime fair, sometime not so.

However, even if the deal is fair, fishers do not normally obtain a decent share of the benefits from their catch if these are sold simply as fresh fish, especially in the peak season. Processing fish is a problem, as in most cases they are not in the position to initiate a small business that would add value to their catch, considering their limited technical and financial capacity. In addition, those who manage to produce fisheries value-added products must then face a competitive marketing situation with fisheries products developed elsewhere, often by large fisheries industries. This chain of events would seriously affect the promotion of feasible economic activities in rural coastal areas.

Fresh fish for sale in Pakse market, Lao PDR (Photo by courtesy of Simon R. Bush)

A Japanese success story…

In 1979, Mr. Morihiko Hiramatsu, the Governor of Oita Prefecture in Japan, proposed a "One Village, One Product (OVOP)" movement to provide greater motivation for the rural people to take an active role and activate the rural economy by mobilizing various assets available and unique to these rural communities. Over 25 years, such movement has been successfully developed in Oita but also in other Prefectures of Japan. It has been recognized as a great source of differentiated products that can be successfully marketed to customers nationally and internationally. OVOP has revitalized rural communities by mobilizing rural people, especially women.

Through comprehensive human resource development activities, the OVOP movement has reviewed the specificities of local communities, with a focus not on limitations and shortcomings but on the untapped potential of people in communities, identifying potential products and activities that can be economically, financially and socially activated and sustained in each respective rural community.

... Replicated throughout Southeast Asia

The Japanese OVOP initiative and its approach, strongly bottom-up, has been replicated and developed in many developing countries as a mean to develop and activate rural communities and improve their status, motivating the people and mobilizing the unique but locally available technical skills and materials.

Countries in Southeast Asia which have promoted the "One Village, One Product" concept are Cambodia ("One Village, One Product"), Indonesia ("Back to Village"), Lao PDR ("Neuang Muang, Neuang Phalittaphan"), Malaysia ("Satu Kampung, Satu Produk"), Philippines ("One Barangay, One Product") and Thailand ("One Tambon, One Product - OTOP").

Thailand in particular stands out with the rapid success of its "One Tambon, One Product" initiative, which has proved to be a highly effective means of exploring new ways to promote rural products. OTOP targeted both rural development and the promotion of internationally tradable products. Its success was accomplished in a short period of time, and was largely due to the setting up of a special nationwide support system centrally coordinated by a special unit in the Office of the Prime Minister. The support offered to local communities has included support to the communities in promoting and marketing OTOP products, including export promotion.

The success of OTOP in Thailand demonstrates the potential for promoting the OVOP principle in other countries and localities.

Export market for fisheries products?

Now, let us think about the principles behind the OVOP movement, to see whether it can be applicable for social

OTOP products of Thailand

and economic improvement of fishing communities, and possibly to some extent for addressing poverty issues in fisher communities. What coastal communities have in common with other rural communities should be left for large-scale rural development activities; the focus should be placed on what make fishing communities different from others.

The main target of government promotion of OTOP was the export market. Given this aim, OTOP has to develop very high quality products. To do so, the promotional system of OTOP successfully encouraged competition among the communities which joined the scheme through the provision of quality certification, authorizing the producer to use the OTOP packaging and marketing channels. Such certification was done using a 'stars' system. The system aims overall to encourage producing 'Number One Product' – a top quality product with the highest star ranking, five star, in order to gain and maintain a competitive position in the export market.

Since one of the objectives of the Thai initiative has been the promotion of local products for export, let us also start to think about such potential for fishery products. Food safety is a keen concern of international markets. Stringent and high level trade regulations under WTO such as SPS (Sanitary and Phytosanitary Measures), Codex Alimentarius, and other recommended measures such as HACCP (Hazard Analysis Critical Control Points) greatly disadvantage fisheries communities attempting to develop and promote local fisheries products for the international market by operating on a backyard scale. It is too ambitious to attempt to develop rapidly a system that could meet international requirements on sanitary and other issues such as

packaging, considering the current technical and financial capacity and the status of the group of people who would produce fisheries products in rural fishing communities. Export promotion of fisheries products produced in rural fishing communities is not an appropriate option at this stage.

The special situation of backyard produced fisheries products

The lack of any possibility to export artisanal fisheries products is exacerbated by the perishable nature of fish. These are negative factors militating against the development of value-added products in the fishing communities. Public support, moreover, tends to focus on the production and management side of small-scale fisheries, while marketing is usually not much considered, as it is considered that the industry can handle this part on its own. One has to remember that marketing people for small-scale fisheries (middlemen) have an ambiguous nature, and do not always cooperate well with fishers, and neither are they always fair. Certainly, under this system, small-scale fishermen are vulnerable to abuse.

We are again focusing on the negative side of the issue. What are the benefits to fishing communities?

Let's consider what kind of campaign might be developed to promote fisheries products, with the goal of providing positive economic effects on rural fishing communities, by developing an appropriate system that takes all due account of the special circumstances of fisheries. Going back to the original principle of OVOP, what would the main strategy of a One Village, One Fisheries Product (FOVOP) be? OVOP has been distinguished by its objective to produce products and activities differentiated from one tambon (sub-district) to another. Considering that we are not aiming at export, we might envisage that FOVOP should promote its activities with a strategy to produce "Only One Product" instead of a "Number One Product."

Backyard processing of fishery products by women group in Thailand

Visualizing FOVOP activities

How should we visualize FOVOP activities? Let me start with a simple analysis of the current economic activities of fishing communities. Many communities have over the years attempted to add value to their catch by processing fisheries products. These efforts have not always been successful, frequently due to marketing constraints. The groups of people who develop these products on a backyard scale do not normally have knowledge on how to sell, as they have a lack of marketing skills and no strategy. Eventually, they have to entrust their products to existing marketing professionals and local marketing channels in the areas. However, as they do not know about marketing strategy or consumers' demand, the outcomes of using such channels often do not live up to their expectations.

Another constraint, as mentioned above, is that their products are not in a position to compete with similar products produced on an industrial scale. This last point is worth stressing because it is largely because of the failure to adopt an appropriate marketing strategy, as the products are usually promoted in competition with industrial ones, seeking to be 'Number One Products'. A strategy seeking 'Only One Product' instead of 'Number One Product' would reduce competition from industry, but would require local producers to identify and promote a unique and differentiated artisanal product and related activities from each particular community.

Then, the next question would need to be "What are the unique and differentiated product and activities for a particular community?" The product might not necessarily be limited to a fisheries product but could be anything relevant. It might be an activity, that could be sold outside the community mobilizing materials and skills available in the community, provided that it is related to aquatic environment and resources.

Below are some ideas for further exploring types of products and services that could be promoted:

- Is the community known to people as a producing site of a unique aquatic animal? Are there any specific aquatic products, including resources such as seaweed or shells, that could be sold outside while facing less competition others?

- Has the community developed a unique harvesting method? Special (and usually environmentally friendly) harvesting methods, such as crab banks or use of JTEDs or TEDs, etc. can be promoted under a local eco-labelling scheme that can be unique and would face less competition with others.
- Does the community have a special aquatic environment that could be promoted through eco-tourism or a 'traditional' festival?
- Is the community reputed for the production of specialized fisheries products or handicrafts? Specific products obtained through the use of special seasonings, recipes or other processing techniques or handicraft skills have the potential for marketing outside the community without facing excessively tough competition.

The list above is certainly not exhaustive, but tentative listing of such ideas could be greatly improved if countries in the region could share their experience on the activation of economic activities or revitalization of rural communities. Such a process would also be facilitated and could be better visualized through discussion and formulation of applicable strategies to promote social and economic activities in the fishing communities. SEAFDEC is now planning to promote FOVOP through one of its new projects, which should start in early 2007.

Promote intra-regional trade

Let us give some more thoughts on another aspect of the marketing strategy. If export promotion is not the objective of FOVOP, we have to think about what (and who) could be the target for sales of local fisheries products. It is understood that the promotion and marketing of value-added fisheries products requires a suitable cultural background from consumers to be successful. Food habits are historically developed and of a conservative nature, and they are not likely to change or adapt fast. In the Southeast Asian region, which is composed of ten countries, a culture of eating fish is firmly anchored. This habit is much diversified, and there is acceptance for a wide range of fisheries products.

With such similarities between cultures, where eating and fish are closely linked, and considering other similar social factors, an exchange and sharing of regional experiences among the ten ASEAN countries in terms of the motivations driving the people, or the production of value-added products and other activities specific to each locality, would be very useful. If properly encouraged, this could be a strong regional advantage to support the proposed FOVOP in the region, rather than a weaker promotion on a country basis. This ultimately should lead us to think about the potential to promote intra-regional trade of artisanal fishery products. Based on this recognition, regional promotional work of FOVOP would be accepted.

But let us look beyond distribution, and consider how to sell FOVOP products to the consumer. In the case of OVOP, there has been a successful initiative to sell their local products at an antenna shop called 'Station of the Road', located along the major roads and built with support from the Ministry of Land, Infrastructure and Transport. The people travelling along the road by car can drop at the shop and enjoy a bit of shopping by browsing local products. Various temporary stalls are a widespread sight along the roads of Southeast Asian countries, and most of the time these are selling local products. Considering these local stalls and more centralized shops, we have the basis for developing some strategies for marketing FOVOP products.

Conclusion

We daily encounter the waves of globalization, with everybody facing the standardization of rules, specifications, codes, systems and habits. In such global conditions, 'Number One Product' can be appreciated as an attempt to enforce standardization in a competitive situation. However, coming back to local fisheries communities, such a global movement will only provide a negative impact as it does not fit well with rural conditions in Southeast Asia or elsewhere in the developing world. A strategy such as 'Only One Product' should be considered and promoted in order to support the socio-economic development of people in the coastal communities.

About the author

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Small-scale traders, Chau Doc, Vietnam (Bush)

Fish Trade, Food and Income Security: Constraints and Barriers Faced by Small-Scale Fishers, Farmers and Traders in the Lower Mekong Basin

By Simon R. Bush and Le Nguyet Minh

Introduction

Freshwater fish and other aquatic animals are important sustainable sources of protein and income for nearly 65 million people living in the Lower Mekong Basin. However, increased infrastructure development, widening economic disparities between rural and urban areas, and rapid economic regionalization of the markets in the Basin are collectively threatening the sustainability of water resources. The implications of these changes for small-scale fishers and farmers to secure food and income are not well understood. Faced with the pressures of economic development, riparian countries must initiate policy and management strategies to protect and sustain their aquatic resources.

This article examines the role of market access to fish trade networks and value added production to maintaining food and income security of small-scale fishers and farmers. Drawing on a study conducted in early 2005 in selected sites of Southern Lao, Tonle Sap in Cambodia and the Mekong Delta in Vietnam, we propose, that first, food and income security is directly linked to the ability of small-scale fishers and farmers to access the flows of fish and fish products between markets, and second, that this access must be seen as the combination of political, cultural and social forces that influence power and control between fishers, farmers and traders. The empirical results demonstrate how fish trade generates enormous benefits for increasingly fewer traders, at the expense of smaller stakeholders. The complex, multi-scale and socially embedded nature of rural markets presents a challenge of how to best support pro-poor trade. Policy and management which ignores this complexity will not be able to sustain natural resources, nor the livelihoods dependent on them.

Livelihoods, artisanal fish trade and governance

A sustainable livelihood is comprised of capabilities, assets and activities that allow people to cope and recover from stress and shocks while maintaining and building on those capabilities and assets, and providing for future generations (Ellis 2000). An important feature of sustainable livelihoods is the capability to diversify between a number of agricultural, non-agricultural and natural resource collection activities in order to spread risk and reduce vulnerability to environmental, social or political disturbances. Fishery-based livelihoods are widely understood to be one of the most risk prone activities in rural communities; as fishers are vulnerable to a range of environmental change and extractive pressures to which they have little control (Allison and Ellis 2001). Although these livelihoods should not be seen outside of the wider rural economy, more attention should be given to ensuring that fishers have sufficient capability to maximise the potential of existing catch thereby avoiding overexploitation.

Most fishery-based livelihoods in the Lower Mekong Basin are semi-subsistence in nature. They depend on catching fish and other aquatic animals for personal consumption and supplement income through trade that is most often highly localised. This dependency, nonetheless, differs considerably throughout the Basin, dependent on the location of the fishery, the availability of species, distance from markets, price fluctuations, individual capacity, and relationships with traders. In order to develop policy strategies that promote equitable benefits from rural trade, it is necessary to understand how small fishers and farmers cope with and adapt to risk and vulnerability in the context of maintaining their livelihood.

Mekong fisheries governance needs to move beyond the decentralisation of management through state sanctioned regulations and instead address the devolution of power to develop capacity of fishers and farmers to not only control their resources but also better negotiate their access to income through the market (**Box 1**). This calls for new forms of governance which offers inclusive decision making processes, addresses question of power and recognises the organic linkage between local and regional as well as formal and informal processes. If developed in a participatory and transparent way, such an approach can enhance the access of the poor to trade and provide them the opportunities to reduce their vulnerability.

Fishery-based livelihoods in the Mekong Basin

The multiple contexts in which livelihoods exist in each country is an imperative starting point for understanding the existing and potential capability of fishers and farmers to increase access and diversification in fish trade, and the potential for increasing food and income security.

Box 1. Governance

'Governance' offers new ways of understanding the increasingly complex institutional arrangements over competing claims and decision making in public policy. In combination with a more detailed examination of relationships between traders and producers in fish trade networks governance offers a way of understanding how various groups negotiate their positions and are combined in decision making processes over resource utilisation. Both state and non-state actors need to analyse these issues of power and control before suitable interventions are devised that promote responsible fisheries management while also enable people to maintain food and income security.

Southern Lao PDR

Fisheries in Southern Lao PDR are characterized as small-scale and seasonal, practiced by predominantly semi-subsistence communities dependent on a combination of seasonal fishing activities to maintain food and income security. Seasonal fisheries target the migrations of both large-size, high-value species and locally consumed small-size, low-value species. The fish trading networks from these areas, once extensive, are increasingly concentrated along new roads and controlled by a smaller number of large-scale traders.

The government policy of economic liberalization and regional integration has led to the rapid transition of many rural livelihoods toward a market economy. Yet, across the country, people lack commercial skills and knowledge to effectively compete in national and international trade. The relatively strong dependency of rural Lao communities on the natural economy, including living aquatic resources, and the lack of non-fishery-based income opportunities,

River fishery, Attapeu, Lao PDR; and Nakasang market, Khong District, Lao PDR (Bush)

Processed snakehead fillets, Long Xuyen, Vietnam (Bush)

makes them more vulnerable in adapting to this seemingly inevitable transformation.

Mekong Delta (Vietnam)
Small-scale farmers use a number of strategies, ranging from the VAC systems (*Vuon-Ao-Chuong* meaning integrated garden, pond and livestock), used for family consumption and local trade, to large intensive fish cage culture sold directly to processing companies for export markets. Capture fisheries are accessible to the majority of the households who mostly fish the extensive canal systems and flooded areas during the wet seasons. The catch is dominated by small species that are either consumed locally, or sold as feed to aquaculture. The specific contribution to food and income security is not well understood.

Fishers and farmers in the Delta are exposed to rapid economic change and associated environmental change. With government support focused on export-led trade, the number of small and medium-scale intensive farming systems have increased, while the capacity for effective economic management has lagged behind. This disparity is increasingly seen as a key factor in limiting the ability of poorer farmers to take advantage of rapid change in infrastructure development.

Furthermore, while communities in the Delta are well integrated into a market economy, they are increasingly vulnerable to international market fluctuations. Development activities, especially in fisheries, have not being given due attention, especially concerning post-production and the barriers to trade faced by poor fishers and farmers dependent on low value capture fisheries.

Tonle Sap (Cambodia)
Floating communities living over the lake are comprised of some of the only full-time fishers in the Mekong Basin, dependent on a variety of seasonal fisheries. Most are landless Khmer, Vietnamese or Cham people with limited alternative sources of income. Despite state reforms to the fishery sector since 2000, small-scale fishers remain highly vulnerable as large-scale concessionaires continue to utilize illegal fishing gears, increasing their share of fish thereby restricting small-scale fishers' income and the potential for food security.

The Tonle Sap fish trading systems facilitate a high volume of trade concentrated in three main landing ports. Export markets are increasingly controlled by efficient, capital intensive, large-scale traders and trading associations. In contrast, domestic fish markets are 'traditional and habitual', characterized by high levels of informal taxes and gratuities arbitrarily paid to a range of government sanctioned concessionaires, and a lack of managerial and entrepreneurial skill, the combination of which resulting in 'low quality' and 'low value' fish and fish products. The complexity of ownership and diffuse trading systems have hindered a clear understanding and working solution to address the main barriers faced by small fishers and traders.

Promoting equitable fish trade

Equitable access (**Box 2**) and value-added production (**Box 3**) can be improved by addressing the specific social, cultural and political constraints that farmers and fishers face. This is best achieved by developing individual capacity to negotiate access and more efficiently compete in trade.

Infrastructure

Infrastructure development is a major focus of national governments and multi-national institutions when addressing market development throughout the Basin. Further attention is needed to determine the effectiveness of physical infrastructure, such as roads and market places, and the potential of what might be termed 'social infrastructure', including both professional and personal relationships.

Box 2. Market access

(From Ribot, Jesse C., and Nancy L. Peluso. 2003. A Theory of Access. Rural Sociology 68 (2):153-181.)

Market access is defined as the *ability,* rather than the *right*, to benefit from social relationships and institutions limiting participation in trade. In particular, access is a form of *social capital* comprised of trust, rules, norms and sanctions used to establish and maintain participation in trade.

Fishers and traders in each country negotiate their positioning within trade networks through a broad set of cultural and societal factors. Market access is most often limited by: i) the availability of marketable fish, ii) flexible, low interest finance, and iii) the ability to negotiate trade relations with traders and middlemen. In addition, access is controlled by a combination of debt-tied and social obligations based on ethnic, familial and socio-political ties between fishers and traders. Often the importance of the initial credit transaction is secondary to the social obligation of the fisher to ensure supply to the traders with which they are indebted.

Despite often being grouped together as 'middlemen', the traders, collectors and wholesalers that facilitate trade are comprised of a diverse range of individuals who negotiate their position in response to prevailing social and environmental conditions. Although widely perceived as exploitative to small-scale fishers and farmers, these 'middlemen' play an important entrepreneurial role in trade; absorbing considerable risk and financing market access for otherwise disenfranchised people.

Box 3. Value-added production

Value-addition is broadly defined as post-harvest activities that increase the value of fresh fish. It is a form of *human capital* and *financial capital* that includes knowledge and skills, and investment needed to produce products including (but not limited to) dried, smoked and fermented fish.

Fish processing is traditionally linked to surplus catches in the wet season migrations. Excess fish is preserved for sale and consumption later in the year. Small-scale operators appear to maintain considerable control over fish processing, especially traditional activities such as fermented fish sauce.

Nevertheless, this pattern is changing throughout the Basin. As transport infrastructure improves, investment by people from outside often long established networks are taking over processing and value-added activities. This, in turn, leads to increased investment in preservation technologies and drastically reduced transit times to market, making more fresh fish sold to market. Nonetheless, a series of value adding activities have emerged in the Delta and Tonle Sap which focus on increased efficiency and specialization in value chains using a number of pre-processing and re-processing techniques.

- *Diversity of products* – a range of products including dried, smoked, and fermented fish have increased market share as demand has increased in growing urban markets. However, with greater control by larger traders, the access of small-scale fishers and farmers to higher income from retail markets has diminished.
- *Cultural importance of traditional products* – the demand for specific traditional products has increased in both Laos and Cambodia. However, it appears that demand is guided by ethnicity, which may restrict the potential for alternative, innovative value-added products.
- *Grading and labelling* – value-addition includes skill-based activities such as grading and labelling, requiring fishers and farmers to use market information and coordinate surpluses and deficits in supply and demand. Responses to market and resource fluctuations occur over extended periods allowing however they remain limited by their daily need for cash, the variable quantity of suitable species, as well the technical and marketing expertise.
- *Economies of scale* – The significant investment required for commercial fish processing indicates a fundamental obstacle to small-scale fishers in getting extra income. It is widely evident that larger, more powerful operators manage to force the price down and effectively out-compete household level operators.

- *Physical infrastructure* is promoted as an important precursor to facilitating national and regional trade flows. However, there is little understanding of the impact of physical access on competition and increasing the value for rural poor communities, and neglects social issues of power, control and ethnicity.
- *Social infrastructure* development is critical in improving the capacity of the poor and disenfranchised to access markets and value added production. Collective efforts could be promoted in extension policy and supported in legislation (e.g. cooperatives and community fisheries law) to increase bargaining power and reduce exposure of individuals and households to both economic and environmental risk. The benefits are twofold. First, state supported legitimacy gives groups the autonomy to access formal finance, advertising and tax incentives, and second, greater bargaining power increases confidence of these groups to assess and negotiate their trade arrangements.

Economic management

Since the 1980s, economic management has resulted in a series of market reforms in all three countries that have led rural markets through a simultaneous process of liberalization and regional integration. After decades of conflict and isolation, both national and local economies alike are opening up to both domestic and regional trade with positive and negative impacts on fishers and farmers.

- *Fiscal decentralisation and taxation* – each country has developed local taxation systems, targeting the largely externalized natural resource trade, including living aquatic resource. However, due to the isolation and the *ad hoc* way in which legislation and accountability has been enforced, state jurisdiction has failed to supplant established customary, and often exploitative, patriarchal systems of control. For example, informal taxes or gratuities are then imposed arbitrarily by local elites who control transport thereby increasing costs of producers.
- *Regional and global markets* – exposure to international markets appears to have positive and negative affects on small-scale farmers. Both customary and formal institutions that address financial risk should be promoted to mitigate the impacts of global economic fluctuations, protecting already vulnerable farmers and fishers.
- *Economic and business management* – the poor performance of fishers and farmers to win high prices for their produce is often associated with a lack of market expertise. Capacity building of both individuals and farmer groups to better understand market processes will encourage stronger negotiating power and fairer market access.

Production management

Increasing the production of fish is widely perceived by government and communities alike as a way of gaining access to markets. In each case the burden is on the state, rather than individuals or communities, to address the socially and culturally embedded constraints on increasing access and value added production.

- *Aquaculture* is noted by government and communities alike as showing the greatest potential for filling the growing deficit between supply and demand. However, the ability of farmers to adopt and practice aquaculture is not well understood, nor is the contribution to increasing market access and value added production.
- *Fisheries enhancement* – is also noted as having the potential to supplement declining stocks. Its

Long Xuyen Fish market, Vietnam (Bush)

contribution to secure livelihoods for small stakeholders is not yet well understood except in small enclosed water bodies. In addition, widespread promotion may encourage a false expectation of stock improvement, and subsequently higher fishing effort, leading to further overexploitation.

While production is an important aspect of agricultural and fisheries management, aquaculture and enhanced fisheries should not be developed in lieu of the responsible management of existing capture fisheries resources. Capture fish remain the most valuable to the majority of rural communities in the Basin in terms of both food and income security, and should be supported in both government and non-government policy.

Supporting food and income security

Governments and non-government agencies have an opportunity to improve market access and value-added production in order to support food and income security of fish dependent people. Identifying the specific roles that different fish species and products play in the livelihoods of small fishers, farmers and traders alike is an important starting point to addressing the wider social vulnerability to resource decline and market fluctuation. A number of key factors need to be recognised. These include:

- *Consumption of fish and fish products* – The soaring prices of large and scarce fish species means that fishers and farmers mainly consume smaller non-marketable fish. For example, large native fish are a consistent source of income, often used to purchase 'luxury' food products such as canned fish and mackerel. This 'protein exchange' has implications for both the management of fish stocks and trade agreements across the Basin. More research is needed to better understand the role that different species play in providing income and nutrition.
- *Changes to value added production* – Fermenting and drying fish remains an important income generating activity throughout the Basin. Increased physical access to markets and the decline in transport times means that there is a shift in post production activities. Fishers are forced to sell their catch fresh in order to speed up cash flow, which in turn has changed patterns of their food and income security.
- *Social and financial debt* – Traders, fishers and farmers alike are dependent on their ability to secure a supply of fish by retaining trading capital and relations. Middlemen minimize their risk through indebting fishers and supplement fish trade with alternative products. More research is needed to identify the role of social and financial debt in securing both food and income.
- *Employment* – A large work force is employed in fishing, farming and value adding activities. It is not only the number of jobs created that improves food and income security, but how wealth is distributed within familial and community networks, especially between seasons.

Food and income security of fishers, farmers and traders is limited by their ability to participate in a range of social, familial and financial arrangements. Specialization and intensification in production restrict their ability to either invest in existing activities or diversify into new activities. As the financial costs of fishing, farming and trading increase, control over production is concentrated within a smaller, and more powerful group. Assistance to fishers needs to support diversification of livelihood activities outside the fishery in order to minimize their vulnerability to both resource decline and market fluctuation.

40 tons of prahok, Chnnouk Tru, Cambodia (FACT)

Priorities for research and development support

Development agencies and governments alike have an opportunity to promote better market access and value-added production of fish products for small fishers, farmers and traders. The challenge remains to address the diversity and complexity of local conditions while also promoting systemic change through regional sharing and cooperation. Attention must go to mainstreaming a market-based approach to fisheries development and management in each of the countries identifying the pervasive role of markets and trade on livelihood decisions that exploit fishery resources. Priorities include:

- Developing a strategic research agenda across the Basin advocating: i) the shared importance of fish for food and income security; and ii) the complexity of local trade dynamics and their contribution to national and regional economies. Specific attention should be given to the dynamics between economic regionalisation, market liberalization, resource access and transforming local semi-subsistence livelihoods.
- Facilitating more equitable access to trade and value added production through cooperation between government, non-government and community stakeholders. Greater awareness of participatory resource governance strategies is required to develop interventions that address barriers to benefit sharing through issues of exclusion, power and control within local social, cultural or political processes.
- Advocating and supporting taxation strategies that encourage local investment in fish trade. Specific attention should be given to building the capacity of local government to identify and strategically implement pro-poor taxation. Greater support to alternative financing services for small-scale production and trade should also addressed, giving specific attention to the social and cultural constraints of credit provision in existing trade systems.
- Promoting value-added production strategies that include alternative activities such as packaging, labelling and grading. Attention should be focused on improving efficiency and returns from current levels of production and catch through activities that build on existing socially embedded systems of control in fishing communities instead of promoting capital-intensive activities.
- Supporting collective, community-based strategies for organizing marketing initiatives which maximize bargaining power and market share in both new and established trade networks. Any support to collective action by small stakeholders to develop their

competition through supply chain management should be sensitive to the previous failures of cooperatives in some countries.

The equitable use of fishery resources in the Lower Mekong Basin requires governments to look beyond sustainable production to a fair distribution of wealth and nutrition. This calls for an integrated approach: first, ensuring the generation of sustainable wealth through the improvement of both fish farming *and* responsible fisheries management, and second, ensuring that this wealth contributes both to national economic growth and to the improvement of poor and marginalized natural resource-based livelihoods. In order to achieve this, resource managers must widen their view of what and who constitutes the fishery, so that trade and traders are seen as an integral component of both fishery management and the maintenance of food and income security.

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Selected reading

Allison, Edward H., and Frank Ellis. 2001. 'The livelihoods approach and management of small-scale fisheries'. *Marine Policy* 25:377-388.

Ellis, Frank. 2000. *Rural Livelihoods and Diversity in Developing Countries*. Oxford: Oxford University Press.

Keskinen, Marko. 2003. 'The great diversity of livelihoods? Socio-economic survey of the Tonle Sap lake'. WUP-FIN Socio-economic studies on Tonle Sap Report No. 8.

Yim, C. and B. McKenney. 2003. 'Fish Exports from the Great Lake to Thailand: An Analysis of Trade Constraints, Governance, and the Climate for Growth'. Phnom Penh: CDRI Working Paper 27.

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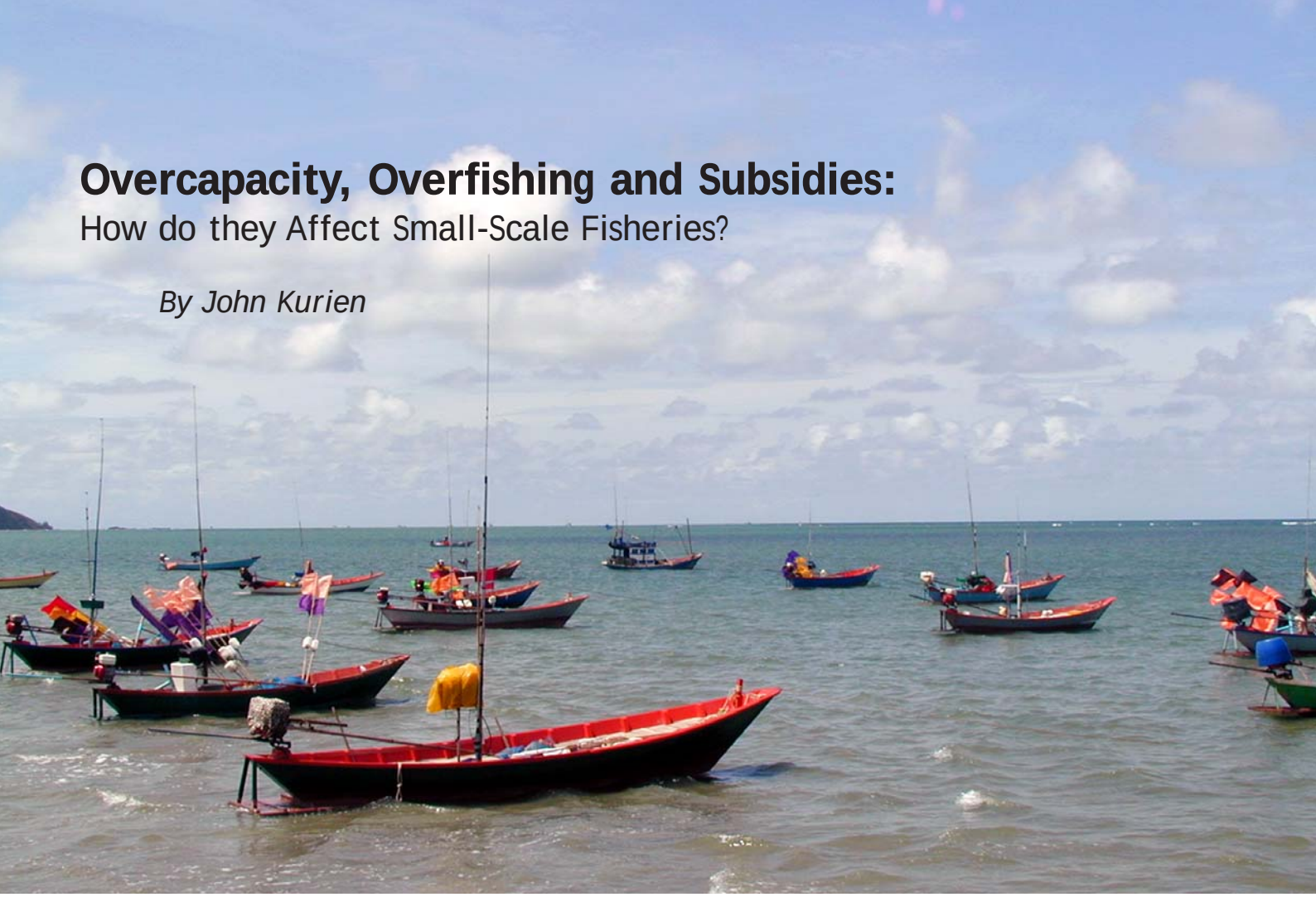
Grading fish for market, Kampong Leuang , Cambodia (Photo by courtesy of Bush)

Overcapacity, Overfishing and Subsidies:
How do they Affect Small-Scale Fisheries?

By John Kurien



Introduction

In recent years, the twin issues of overcapacity and overfishing have engaged the attention of fishery experts around the world. Many conferences and workshop sessions organised by the FAO, the WTO and leading global environmental organisations such as WWF have gone to great lengths to highlight that the major problem facing world fisheries today pertain to these inseparable issues. While much of the criticism has been targeted at industrial fishing operations, many attempts have been made to bring small-scale fisheries into the debate. It is still necessary to ask whether all this brainstorming has led to greater clarity on the matter. Some reports of the conferences and meetings suggest that there has often been much storm and little brain!

What is more disturbing has been the recent 'discovery' that the main driving force behind overcapacity and overfishing are the large quantities of subsidies which have been given to fishing units around the world. It has been argued that clear proof of this comes from the fact that despite global fishing costs being higher than global fishing revenues, fishing fleets continue to fish. This 'irrational' action is attributed to the fact that subsidies given by governments are underwriting the operating losses. A famous FAO study published in 1992, which analysed the costs and earnings of the global fishing fleet, is offered as the empirical basis for this conclusion.

In this short article, I would like to make two points. First, I want to highlight that this attempt to relate overcapacity and overfishing primarily to subsidies arises from a faulty understanding of the factors that promote fleet capacity building, which in turn lead to overfishing. Second, I will make a more detailed analysis of data from the 1992 study to show that if indeed subsidies are a major factor in underwriting losses in global fishery, then this is restricted to the industrial, large-scale fisheries operations. Small-scale fisheries are not beneficiaries of this largesse.

Overcapacity, Overfishing and Subsidies

The main factors behind overcapacity and overfishing can be summarized as follows:

1. The principal explanation for the expansion of fishing activity, at a given level of technology, and subsequently for the physical expansion of harvesting capacity, is the expansion of the (global) market for fish.

2. The second explanatory factor is changes in technology. This can be seen as an autonomous development that may create sector-specific technological innovations, and result in their widespread diffusion. However, diffusion and technological change are greatly spurred in the presence of factor (1) above. The nature of the technology will greatly condition the fishing activity and the harvesting capacity.
3. The third explanatory factor is institutional arrangements for access rights to the resource. Closed and limited access has previously been a barrier to entry into the sector. Changes in the rules and norms governing access, particularly a movement towards more open access, have created incentives for more fishing activity and fishing capacity. This is exacerbated when factor (1) or (2), or both, are present.
4. The fourth factor is the expansion of fish processing capacity in response to one or more of the above factors. The requirement for raw material for processing creates the demand for expansion of the backward linkages into the fishing activity and harvesting capacity.
5. The fifth factor is the support or subsidies in the system. The encouragement provided directly or indirectly by government or private sources (for example, by multinational fishing companies) plays a role in enhancing fishing activity and harvesting capacity. The extent to which this support is sustained will depend on the individual or joint presence of the four factors above.

Each of these factors, alone or in combination, will have a bearing on the level of fishing activity and harvesting capacity that is created and sustained in a fishery. It is also clear that *subsidies alone* are not a necessary condition for overcapacity and overfishing. However, when subsidies – particularly those intended to enhance the vessel or gear capacity – are added to the other factors they can hasten the process, and when taken to an extreme, this can lead rapidly to overcapacity and overcapitalisation in the fishery and create unhappy economic, social and ecological consequences.

The current global attention to subsidies in terms of the role they play in enhancing fishing activity and expanding harvesting capacity is therefore exaggerated. This is particularly so from the perspective of developing countries, and more particularly from the standpoint of the least developed among them. Placing a check on excessive fishing activity and capacity, if they do exist, will first require taking a much closer look at the factors mentioned in (1) to (3), namely *markets, technology and institutions*. Attempting to discipline subsidies will attain meaning and

effectiveness only in that context. Now let us turn to small-scale fisheries.

Small-Scale Fisheries in this Scenario

In the development decades – 1950s to 1970s – discussions in fisheries centred around the need to increase fishing effort and fishing capacity. The popular paradigm was that the natural progression of all the world's fishing was necessarily towards the industrial mode. What remained unsaid was the strong belief that the small-scale fishing units in the world, particularly in the developing countries, would gradually disappear – rapidly in some countries and slowly in others.

Consequently, small-scale fishing was neglected in fishery policy in most developing countries. They were certainly not the recipients of official patronage in the form of loans and subsidies. But they endured despite the neglect and the discrimination: over half a century down the line, the small-scale fisheries sector remains vibrant, and accounts for anything between one-half and three-quarters of fish production in most developing maritime states. In the 21st century, the sector is being 'rediscovered' as the right structure for marine fisheries in tropical developing countries.

How do we define the sector? Smallness is a relative measure. What is small-scale in one country may be exceptionally large in another. In the WTO debate, there was an attempt to define 'artisanal' fishing units, and exempt them from the disciplines of subsidies. However, this approach is not without complications of its own. For example, many artisanal fishing units can be larger than some modern small-scale fishing units.

This issue of definition could be approached by proposing that the fishing units in any country can be split into three groups. Two of them can be unambiguously defined. The amorphous third group can be clubbed together as the "other fishing units" of that country. The small-scale sector can be defined as being composed of artisanal and other fishing units.

At the *top end*, we define *large-scale fishing units* as those fishing units that should be listed in Lloyds Register.
At the *bottom end*, we define *artisanal fishing units* as those fishing units that use non-automatic gear deployment or hauling devices.

In the *middle*, we define *other fishing units* as the remaining fishing units in the respective country.

The advantage of this approach is that the criteria are simple and without ambiguity, and can be uniformly applied. The administrative costs of assessment are greatly minimised and subject to very minimal adverse selection. However, the approach does not negate the dissimilarities and diversity within a fishery or between countries.

All over the world, artisanal fishing units, as defined above, can be exempt from any subsidy disciplines. In developed countries, the subsidies given to both large-scale fishing units and other fishing units should be subject to current subsidies disciplines of the WTO. In the developing countries, taken as a whole, only subsidies given to the 'large-scale fishing units' should be subject to current subsidies disciplines of the WTO, if at all.

Is Overcapacity and Overfishing in Small-Scale Fisheries Due to Subsidies?

Now let us turn to the much quoted in the landmark 1992 FAO study to show that by no stretch of imagination can we say that small-scale fisheries are guilty of receiving large subsidies. By that measure we can also argue that the contribution of subsidies to overcapacity and overfishing is small.

The FAO study was a first attempt to assess the economic health of the global fishing fleet. Given the data limitations, the analysis made was of a very aggregate nature. It hid the huge variations that existed between countries and fleet types in this regard. Capital investment and running costs differed so widely. Assessing the economics of the global fishing fleet by adding factory trawlers with sailing vessels is like assessing food intake of fish by adding up the diets of whales and anchovies.

The main purpose of that study was to make an approximation of the costs and revenues of the global fishing fleet and show that the operating costs were in excess of the revenues. Personal communications with Francis Christy, the main author of the FAO report, indicate that it was mere coincidence that available data and the interest in the FAO to work out these global aggregates of costs and earning came together in the late 1980s. The idea of the authors was only to give a first approximation. They provided details of the mode of calculation and also provided more disaggregated data in Appendices so that others could make their own calculations and more nuanced conclusions. The study made a global estimate of total costs over gross earnings to be in the order of USD 20 billion, and suggested that this gap must have been largely filled by subsidies. The study also stated that total annual operating costs (excluding labour) were equal to total annual gross revenues of USD 70 billion.

We have made a more discerning and disaggregated analysis (**Table 1**) of the famous FAO 1992 study, using the Appendix tables provided in the original study, to show how deceptive and misleading global aggregates can be when dealing with a realm of such wide diversity.

Table 1 Break-up of the replacement costs and operating costs of the global fishing fleet (1989) based on the FAO (1992) calculations

	Global fleet	Industrial fleet	Undecked boats	Decked
Number	3,235,710(100)	35,710(1.1)	2,100,000(65)	1,100,000(33.9)
Replacement cost(USD billion)	319.0	229.0(71.8)	2.1(0.65)	87.9(27.55)
Annual maintenance*(USD billion)	30.2	20.18	0.12	9.90
Insurance*(USD billion)	7.19	4.43	0.12	2.64
Supplies and gear*(USD billion)	18.50	7.98	0.84	9.68
Fuel*(USD billion)	14.06	6.12	2.17	5.77
Labour(USD billion)	22.71	11.31	3.15	8.25
TOTAL OPERATING COSTS(USD billion)	**69.95(100 %)**	**38.71(55.3 %)**	**6.4(9.2 %)**	**24.84(35.5 %)**

(Note: Total Operating Costs are the summation of the costs marked with *)
Source: Calculated from Appendix Table 2, 3, 4 and 5 of the FAO-SOFA 1992 Report

Of the world's 3.24 million fishing vessels in 1992, slightly over one percent were industrial vessels. These accounted for about 72 percent of the global capital replacement costs and 55 percent of the global annual operating costs. On the other hand, the 2.1 million undecked[1] fishing, practically all of which are found in developing countries and comprising 65 percent of the global fishing fleet, account for a mere 0.65 percent of the capital replacement value and only 9 percent of the annual global operating costs. As we are not able to provide a similar disaggregated analysis of the revenues (due to the lack of data) it will be hard to make any affirmative statements about the gap between costs and revenues in the industrial fishing fleet and the undecked fishing fleet.

However, a simple calculation shows that for the undecked fishing vessels, the annual operating costs per vessel were about USD 3,000 per year. The FAO study further assumes that the undecked boats fished for 180 days in a year. This would imply a daily gross operating cost of USD 17 only. The gross revenues per vessel would likely be at least as much as there is unlikely to be a deficit in their aggregate operations. Even if we assume that the world has an 'overcapacity' of undecked fishing boats, the argument that subsidies are the cause is hard to accept.

Similarly for the decked vessels, the annual operating costs per vessel are about USD 22,600 and using the same assumption of 180 days would imply a daily gross operating cost of USD 140 only. Here too the possibility of a deficit in aggregate operations, though possible, is unlikely to be very significant. The presence of overcapacity in the decked vessels is thus likely to be small.

From our above analysis, it is clear that we have to look beyond the single factor of subsidies to understand the dynamics of fishing capacity. Moreover, it should be clear that if subsidies are a causative factor in overcapacity, it will be almost exclusively in the industrial fishing fleet that accounts for just one percent of the fishing units in the world.

Conclusion

Overcapacity and overfishing are real phenomena in world fisheries today. We must take cognisance of this reality, and take all possible measures to bring the phenomena under control. This paper aims to highlight that the paths by which global fisheries reached this state of affairs are

complex. The current cacophony highlighting subsidies as the main villain actively prevents us from making a causative analysis of the problem. Moreover, it is unfair to treat all the fishing fleet of the world as being guilty of overcapacity and overfishing.

A more nuanced understanding using the data provided by the famous FAO 1992 study reveals that a very small share of the world's fishing fleets account for the larger deficit between costs and earnings of the global fleet. The small-scale fishing fleet, made up of undecked – artisanal – and decked fishing units, although accounting for 98 percent of the world's fishing fleet, can hardly be accused of large-scale use of subsidies to build up overcapacity leading to overfishing. This is not to suggest that overcapacity and overfishing are not in themselves problems for small-scale fishing. The point is that the full explanation may have to be sought in more complex factors relating to markets, technology and institutions, and not just largesse arising from subsidies.

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[1] Fishing boats other than industrial class vessels can be broadly classified in to two groups: decked and undecked. All the undecked vessels may safely be classified as artisanal fishing units, as gear retrieval devices are technically difficult to use on them.

Fish Sperm Cryopreservation

for Genetic Improvement and Conservation in Southeast Asia

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Introduction

Fish farmers are beginning to look more often to genetic improvement for gains in production. But improving the genetics of fish species can take a long time. With most fish, for example, it is difficult to keep track of individual males or females and thus the process of developing breeding stocks and improved lines could take a decade or more. At the same time fish managers are looking for ways to protect endangered species. Conservation programs require large populations to ensure biodiversity but for threatened and endangered species the numbers of fish are steadily decreasing. Cryopreservation can help in both of these situations. The availability of frozen sperm is a proven technique for developing, maintaining, and distributing genetic

The Two Questions Most Frequently Asked About Sperm Cryopreservation

Question #1: How long will the samples last?
Cryopreservation is a form of time travel. At cryogenic temperatures such as that of liquid nitrogen (-196 C), all biological activity ceases. That means for the frozen samples, time has stopped. Theoretically, the samples will last indefinitely, however, background radiation could cause damage to the DNA (which would not be repaired because the repair enzymes are not active when frozen). This damage could accumulate and in theory limit the lifetime of samples to thousands of years. In practical terms, the actual lifetime of samples is constrained by the quality and reliability of the storage facility. If the samples are repeatedly removed from liquid nitrogen (for example when someone is looking for particular containers) they can become damaged by warming to temperatures that are still well below 0 C. The bottom line is that with proper handling and security procedures, frozen sperm samples from fish should retain their ability to fertilize eggs long after the humans that froze the samples have died. Through cryopreservation we can truly pass our work on to our descendants.

Question # 2: Sperm is only half of the equation, what about the eggs?
There is a persistent notion that only "half of the genetics" of a species are passed on with sperm. In reality, half of the genetic makeup of *any individual* is passed on from the father (or mother for that matter); essentially all of the genetic variation within a species or population can be passed on through sperm other than the few specific genes associated with sex determination or sex-linked traits in those species where the female gamete determines the sex of the offspring (the so-called "ZZ-ZW" systems seen in birds and snakes and some fishes). The bottom line is that sperm can deliver the genetics necessary for conservation of endangered species, or for genetic improvement in aquaculture. Indeed, milk production in dairy cows is improved by genetic selection on bulls through cryopreserved sperm (i.e., the genetics of the father are used to improve the milk production of the daughter).

In addition, people sometimes feel that cryopreservation of sperm is of limited value if eggs are not available. However, there is no better way to ensure the availability of sperm when needed to fertilize a few precious eggs than by holding it ready by cryopreservation (fresh sperm can sometimes not be collected from males when eggs are available). In addition, in the extreme case where only frozen sperm remains from an *extinct species*, it is possible to inactivate the nucleus (DNA) of an egg from a closely related species and fertilize it with thawed sperm of the extinct species. The application of temperature change or certain chemicals at the specific time of cell division can be used to create offspring that contain only the DNA from the sperm (all-paternal inheritance). This naturally occurring process, called androgenesis, can be used in the hatchery to resurrect the genetics of an extinct species through cryopreserved sperm. This is admittedly a worst-case scenario, but it demonstrates that we should not hold back conservation programs and cryopreservation because of a fear that eggs may not be available. It also points out the importance of further research on the cryopreservation of embryos and larvae, which is currently successful in invertebrates such as oysters.

improvement in livestock, and provides great unexploited potential for fish breeding. In addition the availability of frozen sperm allows conservation programs to make a genetic bank of many males and increases the potential breeding population size to ensure that proper genetic combinations are produced in breeding of endangered species. In this way development of a single technology — cryopreservation — can assist two great needs in Southeast Asia: poverty alleviation through improved aquaculture and conservation of threatened and endangered fish species.

The promise offered by cryopreservation, however, resides in the future, and this raises a number of questions. First, what is cryopreservation? Second, how is it done and how can it be applied in this region? What will be needed to realize the tremendous advantages that it offers? This article will attempt to address some of these questions and provide models and suggestions to assist in the overall process of making the application of cryopreservation to Asian fish a reality.

Initial research success in sperm cryopreservation came more than 50 years ago for aquatic species and livestock. However, since then cryopreserved sperm of livestock has grown into roughly a billion-dollar global industry, while despite work in more than 200 species, cryopreservation of aquatic species sperm remains essentially a research activity with little commercial application. Most aquatic research work has focused on large-bodied aquaculture and commercial fish, such as salmon, carps, and catfish. Other groups such as mollusks, represented by commercially important oyster and abalone species, have received a fair amount of attention as well. However, only a handful of studies have addressed sperm cryopreservation in endangered species, or in small fish, which are becoming increasingly important in biomedical research and in the aquarium trade.

Application of cryopreservation for poverty alleviation?

There is growing evidence that many of the cultured fish stocks in rural Southeast Asia are now significantly degraded because of poor broodstock management practices. Most small-scale farms would benefit from improving their broodstock. In the future it may be impossible to replace or revitalize these fish as wild stocks are likely to be lost through either over exploitation or the destruction of their natural habitats. Bringing in semen is also a simple and relatively inexpensive way to outbreed fish stocks in remote areas once a network is set in place, as shown by the successful case of bull semen industry worldwide.

Overall, this work has yielded techniques that are being applied with varying levels of success around the world. However, barriers to expanded application include a diverse and widely distributed technical literature base, procedural problems, small and uneven sperm volumes, variable results, a general lack of access to the technology, and most importantly, the lack of standardization in practices and reporting. This report will focus on the needs and opportunities for future research and application of cryopreservation in freshwater fish. For the more technically inclined reader several excellent scientific review articles are available that focus on sperm cryopreservation in freshwater fish (**Table 1**). It should be noted here that the term “fish” is an artificial collective of more than 25,000 species characterized more by their differences than by their similarities. To discuss cryopreservation within fish is thus a balancing act of attempting to generalize observations into basic principles while acknowledging the considerable diversity that exists across these organisms.

Table 1. Examples of review articles, books, and special journal issues addressing cryopreservation of large-bodied freshwater fish.

Short Title	Citation
Biology, handling and storage of salmonid spermatozoa	Scott and Baynes, 1980
Fish gamete preservation and spermatozoan physiology	Stoss, 1983
Live preservation of fish gametes	Leung and Jamieson, 1991
Cryopreservation of fish spermatozoa	Rana, 1995
Cryopreservation in aquatic species (book)	Tiersch and Mazik (editors), 2000
Cryopreservation of gametes in aquatic species (special issue)	Lahnsteiner (editor), 2000
Cryopreservation of finfish and shellfish gametes	Chao and Liao, 2001
Techniques of genetic resource banking in fish	Billard and Zhang, 2001
Cryopreservation of gametes and embryos of aquatic species	Zhang, 2004
Cryopreservation and short-term storage of sturgeon sperm	Billard et al., 2004
Semen cryopreservation in catfish species	Viveiros, 2005

What is Cryopreservation?

The scientific research of cryobiology and cryopreservation can be traced back to the 1950s after the discovery of the protective qualities of glycerol for freezing of fowl sperm by Polge and colleagues. The first studies of fish sperm cryopreservation were published soon after by Blaxter in 1953, and since then hundreds of scientific papers have been published on research around the world. Cryopreservation is a process where biological materials such as cells and tissues are preserved by cooling to very low temperatures, typically, -196°C (for liquid nitrogen), yet remain viable after later warming to temperatures above 0°C. In essence, cryopreservation involves the removal of excess water from the inside of the cell to the exterior where it can form ice. Successful procedures balance the formation of ice crystals within the cells against excessive dehydration which damages cellular structures. For sperm cryopreservation, this process typically includes a series of steps (described in the sections below): 1) sperm collection and dilution, 2) refrigerated (non-frozen) storage and shipping of samples, 3) examination of sperm quality by microscope, 4) addition of cryoprotectants, 5) packaging of the samples, 6) freezing, 7) frozen storage procedures, 8) thawing, 9) use for fertilization, and 10) production of early life stages for assessment of cryopreservation success. Protocol establishment involves evaluation and optimization of multiple factors at each step (e.g., the type and concentration for each cryoprotectant), and recognition of the interactions among the steps (e.g. between cryoprotectant and cooling rate).

1) Sperm Collection and Dilution

Usually sperm from ripe males can be obtained during the spawning season by either stripping or by crushing of dissected testis. Stripping of sperm involves collection directly from the male into a sterile tube. Care must be taken to avoid contamination of the sperm with dirt, feces, water or urine. Dissection usually involves killing of the male and careful removal of the testis with scissors and forceps. Care must also be taken to avoid contamination with bacteria due to cutting of the intestine. Once removed, the testis is rinsed to remove blood and extra tissues are dissected away. The cleaned testis is weighed and placed in a container with an appropriate amount of extender solution (typically a buffer) before it is crushed. The sperm are released and the solution is filtered to remove pieces of tissue.

Dilution after sperm collection is necessary to maximize the volume for efficient use and for research of various factors. Dilution is usually in the range of one part of sperm to one to four parts of extender solution. Extreme dilution of sperm samples (e.g., 1:50) has been found to reduce sperm motility in mammals, fish and oysters. The term “extender” refers to a solution of salts, sometimes including organic compounds such as sugars that help to maintain sperm viability prior to and during the freezing process (e.g., Hanks’ balanced salt solution). The nature of the effect of extenders is based on the control of pH and salt concentration as well as the supply of energy, and can extend the functional life and fertilizing capability of the sperm. Usually, the extender is a balanced salt buffer of specific pH and osmotic strength. Sometimes other components such as egg yolk and milk are added, but they usually offer little benefit and can interfere with viewing of the samples with a microscope.

Extenders have been developed for many species. Hanks’ balanced salt solution has been used successfully in our laboratory with sperm of more than 50 species, but simple solutions such as 1% unbuffered salt (sodium chloride) have been used with good results. With appropriate testing, extenders can be prepared in large batches and be stored frozen until use. Use of extenders provides increased storage time and dilutes the sperm to a greater volume, making the sperm easier to work with. Extenders can be sterilized by passage through a filter or by autoclaving (if this does not affect the ingredients) and should be refrigerated. This is especially important for extenders that contain sugars. Antibiotics can be added to extenders to reduce the growth of bacteria that reduce sperm viability. Antibiotics at high concentrations can be toxic to sperm cells, therefore, concentrations should be optimized for each species.

The collection and transfer of sperm from fish poses concerns for unintended transfer of microbial organisms. Contamination of samples can occur during collection, processing, storage, and transport. Generally, proper sanitation during collection is essential for limiting the spread and growth of microorganisms such as bacteria, viruses, fungi, mycoplasmas, and parasites. Materials and equipment used to freeze samples should be sterile. Following good practice guidelines for handling and processing of samples is especially important for wild-caught animals where disease-free status cannot be guaranteed.

2) Refrigerated (non-frozen) Storage and Shipping of Samples

Sperm samples can be stored at 4 °C in an ice chest or refrigerator, but care should be taken to avoid accidental freezing of samples. In general, sperm samples are stored in shallow containers with the lids loosely attached to allow oxygenation of the sperm cells during storage.

Supplementation with pure oxygen gas has been shown to increase storage time, but could also be inadvisable depending on the species. Containers should only be partially filled, leaving a large air space between the sperm sample and lid and are inspected daily to provide mixing of the sperm cells. If not mixed, the cells can collect at the bottom and deteriorate.

It is often necessary to ship or transport refrigerated sperm or blood samples for analysis and cryopreservation. Frozen samples can then be shipped back to the original location (e.g., a hatchery) in shipping dewars for use at a later date. Typically it is essential that the samples remain unfrozen prior to cryopreservation. Although this would seem to be simple, experience indicates that samples are often destroyed by improper practices during shipment. There are several precautions that can be used to prevent such losses. The first is to ensure that the samples do not come in direct contact with ice or gel packs in the cooler. A simple cardboard divider can be useful for this (**Figure 1**), as is the precaution of wrapping the gel packs in paper towels. It is important to keep in mind that for warmwater fish we are trying to prevent the samples from becoming heated, not in keeping them as near freezing as possible. For valuable samples, a temperature data logger or a thermometer that records maximum and minimum temperatures can be included.

Collection and shipping of samples often requires more time than expected. It is a good idea to verify the address and phone number of the recipient well before the day of shipping. If storage time is a constraint, collections can be scheduled to finish at the time of shipping, although this requires careful planning. We have found that the best approach is to collect and ship samples in a preliminary rehearsal to identify problems and to avoid loss of valuable samples or data. This rehearsal should be performed using the same procedures and schedule planned for the actual samples, especially if factors such as automobile traffic can interfere with the schedule. The recipient should be notified when the samples are sent and should know when and where the samples will be delivered. Samples should be evaluated before they are shipped, and should be evaluated again immediately upon receipt. With sperm, for example, percent motility and general characteristics (e.g., color, presence of gelling) can be evaluated.

3) Examination of Sperm Quality by Microscope

Most fish spawn by releasing sperm and eggs into the water, a process called external fertilization. Unless certain ions are involved (such as potassium), in freshwater species, sperm motility (swimming) can be activated by reducing the salt concentration of the sperm solution (referred to as a "hypotonic" solution) in comparison to the blood concentration ("isotonic" solution). In marine species, sperm motility can be activated by increasing the salt concentration ("hypertonic" solution). Once activated, the sperm have a short life span (1-2 minutes) of active motility. Thus the sperm need be maintained in an extender with proper salt concentration (usually nearly isotonic to the blood plasma) to inhibit undesired sperm activation during refrigerated storage or cryopreservation.

In some species of fish, sperm remain motile for short periods of time (less than 20 seconds). This makes estimation of motility difficult and samples may need to be evaluated several times to produce an accurate estimate. The use of activating solutions can increase the duration of motility in some species, but complete knowledge of the effects of osmotic activation should be understood for a species before such activation solutions are used. In other species, such as some marine fish, sperm can remain active for as long as 30 min, which simplifies estimation of motility. It is important to ensure that sufficient dilution of sperm is used to elicit maximal activation for each sample.

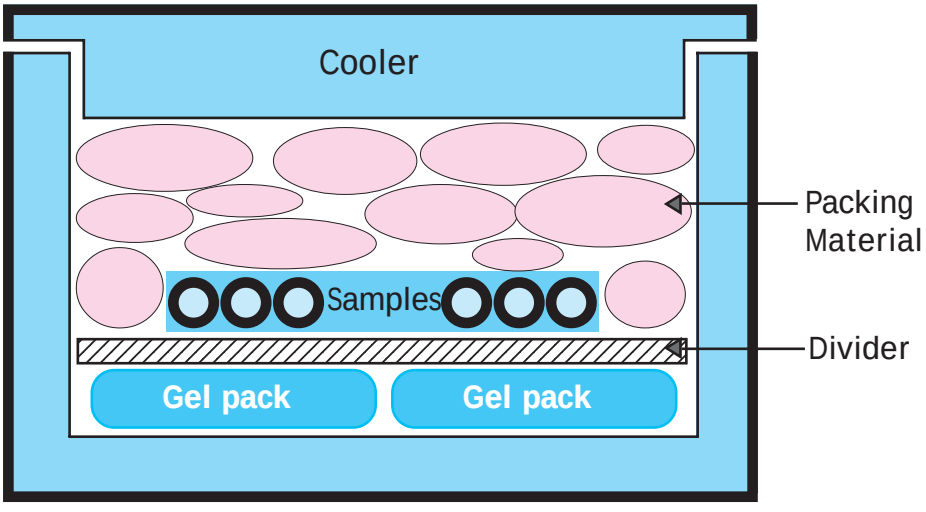


Figure 1. Proper packaging of samples for refrigerated storage during shipment. Samples should be placed in a waterproof bag with protection from freezing during shipment

For estimation of percent motility, only sperm that are actively swimming in a forward motion should be included. Sperm that remain in place with only a vibratory movement should not be included. The procedure can be practiced to ensure that sperm movements are not due to swirling of the activating solution or random movement. Some microscopic organisms (e.g. bacteria) are motile and can be mistaken for sperm by inexperienced observers. The exact procedure used for motility estimation should be reported in sufficient detail to assist in making comparisons among studies.

4) Addition of Cryoprotectants

Typical cryopreservation of sperm cells involves the use of chemicals called cryoprotectants and slow freezing to produce cellular dehydration and shrinkage. Cryoprotectants are chemicals used to protect cells from damage during freezing and thawing, and are classified by whether they penetrate the cell (referred to as "permeating") or remain outside of the cell ("non-permeating"). Although their mechanisms of action are as yet not completely understood, permeating cryoprotectants such as dimethyl sulfoxide are believed to help reduce damage due to the formation of ice crystals within sperm cells. They also help reduce the dehydration damage that occurs when water leaves the cell to become ice in the surrounding solution. Non-permeating cryoprotectants such as sugars and polymers are believed to help stabilize the membrane during cryopreservation. Too little cryoprotectant entering the cell before cooling reduces effectiveness, whereas too much causes swelling and rupture during thawing and dilution.

In addition, cryoprotectants are often toxic to cells, and thus the choice of the types of cryoprotectant and their optimal concentration (a balance between protection and toxicity) has been the focus for numerous studies. After the addition of cryoprotectants to sperm, time is needed for the cryoprotectant to permeate the cells. This is referred to as the equilibration time. For most circumstances it can be set at 15 to 30 min, but it can be varied depending on the type and concentration of cryoprotectant being used. If the necessary concentration of cryoprotectant is toxic to the cells, the equilibration time of rapidly permeating cryoprotectants such as DMSO can be shortened to the minimum time required for filling of straws.

5) Packaging of Samples for Freezing

In cryopreservation, packaging of samples for freezing and storing is important to standardize cooling rate, and to assure sample identification. Various containers have been used for fish sperm, including drinking straws, glass capillary tubes, and plastic cryovials. Plastic French straws have been in use for livestock sperm for decades. These straws come in one-half and one-quarter milliliter volumes, and are produced in over 20 colors. The use of French straws offers the advantages of efficient and reliable sample identification by permanent printing on colored straws, sample safety by complete sealing of the straw, and standardization of the cooling and thawing processes because of their thermal properties and large surface area in relation to their volume.

Proper labeling of cryopreserved samples is essential. Usually samples are in storage for weeks, months, or even years before they are thawed. Improperly labeled samples can cause delays in processing, and even worse, could cause genetic contamination of pure stocks of fish. The necessity for proper labeling cannot be overemphasized. The value of samples is directly proportional to the quality of labeling information and record keeping. Unlabeled or poorly labeled samples are essentially worthless and can even be detrimental. At the minimum, straws used for research should be labeled to indicate fish identification number, cryoprotectant, and cryoprotectant concentration. A simple method for labeling is to use straw color for identification of cryoprotectant and a system of marks on the straws to identify fish number and cryoprotectant concentration. If possible, more sophisticated labeling, such as pre-printed straws, should be considered even for research applications. Straws intended for archiving and breeding uses should receive the best labeling possible (e.g., **Figure 2**).

6) Freezing

The choice of optimal cooling rate has been another major focus of numerous studies of sperm cryopreservation. To be considered as optimal, a rate should be slow enough to minimize the amount of ice crystals that form within the sperm cells (below a damaging level) and yet be rapid enough to minimize the length of time cells are exposed to what is referred to as the "solution effect", which is the concentration and precipitation of materials that occurs when solubility limits are exceeded during the dehydration caused by ice formation. There are a number of methods that can be used for freezing. These include the use of computer-controlled freezers which offer precise and reproducible rates, but are usually expensive. Simpler and cheaper freezing is available by suspending samples above liquid nitrogen in a styrofoam cooler, although this is a less reproducible approach. Samples can also be suspended in the neck of a storage dewar. With these latter two methods, the height of the samples above the liquid nitrogen offers control of the temperature and cooling rate.

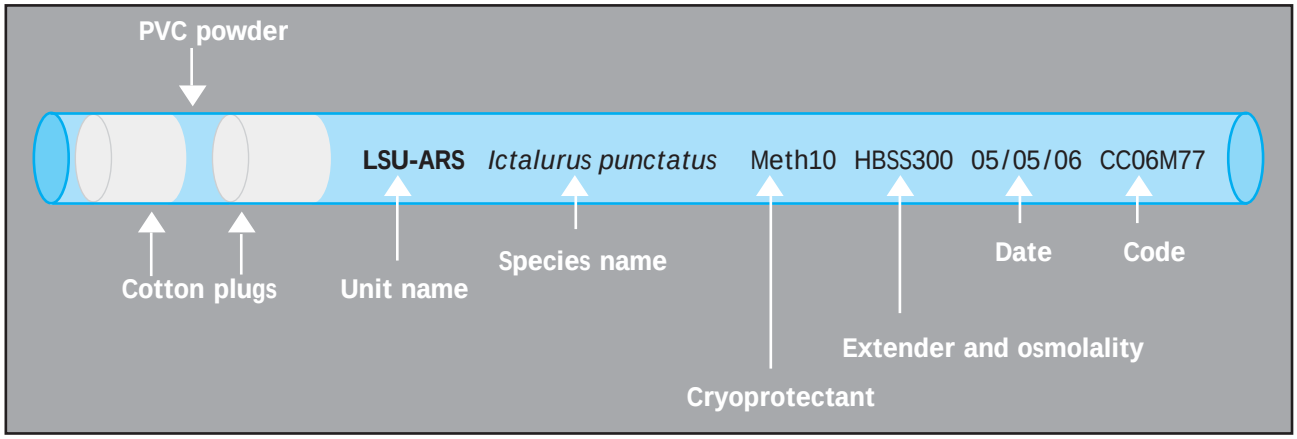


Figure 2. An example of the labeling possible for use with standard French straws. One end comes with a factory plug that is sealed by moistening with sperm suspension. This labeling is produced by a specialized laser printer. In this example, sperm from a channel catfish (*Ictalurus punctatus*) were frozen using 10% methanol ("Meth 10") as the cryoprotectant and Hanks' balanced salt solution prepared at 300 mOsmol/kg ("HBSS300") as the extender. An inventory code is used for identification of individual animals where "CC06M77" refers to "channel catfish 2006 (year) male 77 (adapted from Tiersch and Jenkins, 2003).

Another method is to use a shipping dewar which is a container designed to allow liquid nitrogen to be safely transported. The liquid nitrogen is adsorbed by a filler material within the sides of the dewar allowing maintenance of cryogenic temperatures without the dangers of spills. Nitrogen-vapor shipping dewars were designed to transport cryopreserved materials and to maintain cryogenic temperatures for as long as 3 weeks, but they can also be used to freeze samples in situations where other freezing options are not available (such as in field applications). To freeze in shipping dewars, straws are placed in goblets (plastic cups) and fastened on aluminum canes (holders). The canes are placed in the canister and lowered into the dewar. After 30 minutes the samples should have reached temperatures below -100 °C and can safely be moved to storage dewars. Alternatively, the samples can be left in the shipping dewar if a storage dewar is not available. Cooling rates can be manipulated to some extent by varying container (e.g. straw) size, position within the dewar (top or bottom) or the number of straws per goblet. In addition, straws can also be frozen individually without canes or goblets. The cooling rate can be monitored by use of a thermocouple and recorder. Cooling rates will vary in shipping dewars due to a variety of factors including the time since filling, the number of straws being frozen and the amount of use.

Safety first

Safety precautions are necessary when working with liquid nitrogen. Insulated gloves and safety glasses should always be worn when handling liquid nitrogen. Never place objects cooled by liquid nitrogen against unprotected skin. Use only containers designed for use with liquid nitrogen. Use proper transfer equipment to move and handle samples. Never use hollow rods or tubes as dipsticks, because liquid nitrogen can be driven out of the open end. The opening of any liquid nitrogen container should never be covered or plugged because considerable pressure will build up as the liquid nitrogen vaporizes. In addition, nitrogen gas can collect in closed areas, displacing the air, and create a potential suffocation hazard, so all work should be performed in well-ventilated areas.

7) Frozen Storage Procedures

Storage dewars are designed to safely store cryopreserved samples in liquid nitrogen (-196 C) for extended periods of time. They use a vacuum chamber to provide insulation (**Figure 3**). Liquid nitrogen within the dewar will evaporate over time and must be replaced. The use of alarms on storage dewars is highly desirable. The alarm sounds when the temperature at a probe rises above a certain level, indicating that liquid nitrogen needs to be added to the dewar. The positioning of the sensing probe should take into account the margin of safety required between the sounding of the alarm and the replenishment of liquid nitrogen. For example, would you feel safe with 1 day or 1 week before the uppermost samples began to thaw? The alarm should remain on at all times and be tested regularly. A periodic visual check is also advised in case the alarm should fail. A log book for liquid nitrogen additions can help identify a possible failure of the vacuum seal and assist in estimating storage costs. Care should be taken to ensure that the outer casing of the dewar is not punctured.

The loss of vacuum will boil off the liquid nitrogen rapidly. Rough handling can cause weakening of the inner neck area, and reduce the working lifetime of the dewar. A roller base will allow safe and easy movement of the dewar.

When removing samples from storage dewars, keep the canister as far down in the dewar as possible to avoid unnecessary thawing of the remaining samples. Remove the samples quickly (an inventory database and proper labeling will reduce searching time) and transfer the samples to liquid nitrogen contained in a styrofoam ice chest. Careless handling of frozen samples can allow them to warm to temperatures that allow formation of intracellular ice crystals, which will damage the cells.

8) Thawing

In general, rapid thawing is preferred to minimize the damage associated with recrystalization (the coalescence of small ice crystals into large crystals during thawing). Samples should be removed from the storage dewar and transferred immediately to a styrofoam ice chest containing liquid nitrogen. This ensures that the samples will not thaw prematurely due to handling. The 0.5-mL straws are held in a 40 to 50 °C water bath (a thermos or small ice chest will work) for ~7 seconds. Specific times and temperatures should to be optimized for the particular species. We have tested a range of thawing temperatures (e.g. from 0 to 60 °C) to optimize protocols for many species. As a rule of thumb, samples are thawed when air bubbles within the straw can move freely within the liquid. The use of transparent or translucent straws will aid in viewing the sample. The samples should be cool to the touch when thawed, not warm.

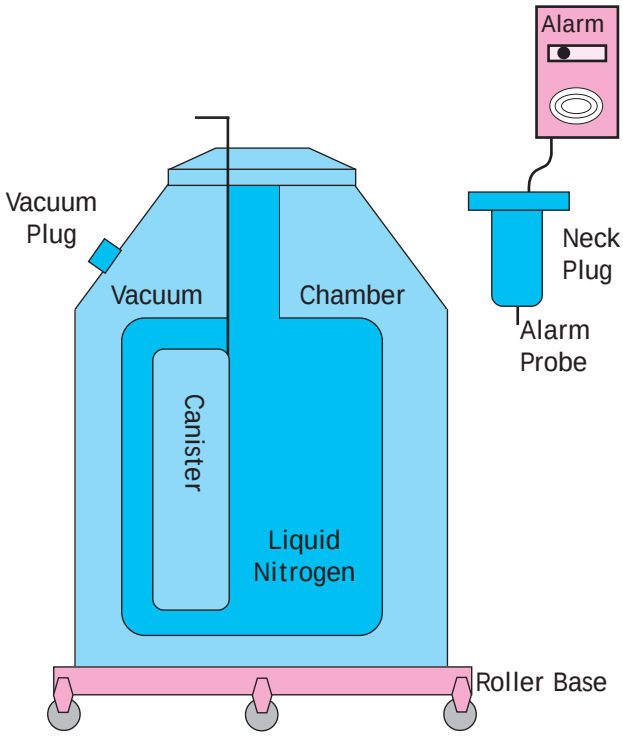


Figure 3. Diagram of a liquid nitrogen storage dewar (with permission from Wayman and Tiersch).

Sperm motility should be estimated after thawing as described above. Qualitative observations of thawed sperm can be quite helpful in evaluating protocols. For example, if the sperm cells are visibly damaged, the cryoprotectant concentration may have been too low, or the cooling rate may have been too rapid. Conversely, if the cell morphology is intact although the sperm are immotile, the concentration of the cryoprotectant may have been too high. This would be confirmed by a reduction in the motility observed immediately before freezing.

9) Use for Fertilization

Artificial spawning involves the collection from females of unfertilized eggs to be combined with sperm. Unless testing has shown otherwise, it is generally best to minimize the time between thawing of sperm and fertilization. After thawing, sperm samples are added to eggs and thoroughly mixed, and the gametes are activated with an appropriate solution (this is called the “dry method”). Other fertilization methods are available and can be evaluated for use with any particular species. Fresh sperm samples can be used to fertilize other batches of eggs to serve as a test for egg quality. After ~5 minutes, additional water is added to water-harden the eggs. Percent fertilization can be determined to evaluate gamete quality. Estimates of sperm concentration can be made by a number of methods, and can be used to calculate the ratio of sperm to eggs.

Artificial spawning in this way allows for a variety of crosses such as the use of one male to fertilize eggs from several females, or for the eggs of one female to be fertilized by sperm from several males. This can lead to a breeding matrix where a group of select males can be mated with a group of select females to develop populations with distinctive traits. By having assayed the parents for genetic markers, breeders can develop broodstocks with enhanced characteristics, such as growth rate or disease resistance. Such a process can also be used to cross two different species to develop hybrids with improved traits, although precautions should be taken to prevent the accidental escape of the hybrid fish into the wild.

10) Production of Early Life Stages for Assessment of Cryopreservation Success

With respect to cryobiology, it is important to note that even simple cells such as sperm have a high degree of internal complexity. The various structures within a sperm

cell represent different functional compartments that can each require different optimal conditions, and thus can each exhibit differential responses to cryopreservation. This can cause a variety of damages and outcomes. For example, damage to the tail could interfere with motility whereas damage to the head could interfere with embryonic development. Sperm quality is a generic term that encompasses proper function of a combination of cellular structures (such as the head, membrane, and tail) that can be superficially evaluated individually by specific assays or in aggregate by examining factors such as the capacity of sperm to fertilize eggs that hatch and develop normally. For this reason it is important to evaluate the quality of thawed sperm by fertilizing eggs and monitoring the development of the offspring.

Current Status of Fish Sperm Cryopreservation

For sperm cryopreservation to become a reliable, cost-effective tool for genetic banking in aquatic species, the overall process needs to be improved, and the approach needs to be integrated into an efficient large-scale platform that links with genetic and biological databases, long-term storage capabilities, inventory management, quality control, sample distribution pathways, biosecurity assurance, utilization and disposal practices, and a sound cryobiological foundation. Numerous studies in sperm cryopreservation have been devoted to optimizing specific components of cryopreservation procedures. However, aside from those factors mentioned above, other factors such as sample density, freezing container, starting temperatures, final temperatures (before plunging into liquid nitrogen), and dilution and cryoprotectant removal after thawing can also affect results. Therefore, procedures must be tailored for each species or population based upon a thorough understanding of cellular properties.

A current problem in cryopreservation research is the lack of standardization within the scientific literature for aquatic species in each step involved in the process. Comparisons among different studies are difficult to perform and could be invalid in most cases due to the procedural and reporting variations across studies. Optimization of protocols without standardization offers little value for the improvement of existing methods and results, especially for the future development of commercial application. Controversy and inconsistency would be reduced if more congruent approaches were utilized and results among various studies could be directly compared. Suggestions for improvement include the creation and widespread acceptance of standard references to assist in harmonizing terminology, and the development and utilization of standardized educational programs. Standardization of research practices and reporting could be accomplished through establishment of guidelines for publication of results. Once in place the guidelines could be made available to journal editors and reviewers to assist in evaluation of research reports.

The Future Prospects and Models for Application of Cryopreservation in Fish

Cryopreservation research and application each require consideration of an interconnected series of activities and this involves more than simple freezing of samples. A successful program involves integrated practices for sample collection, refrigerated storage, freezing, thawing, rules for use and disposal, transfer agreements, and database development. This concept is usually described within the activities of a germplasm repository at a single facility (**Figure 4**). The application of cryopreservation offers many benefits. With respect to commercialization, the benefits of cryopreservation include at least five levels of improvements that address existing industries and the creation of new industries.

1) Cryopreservation, at a minimum, can be used to improve existing hatchery operations by providing sperm on demand and greatly simplifying the timing of induced spawning. This prevents the problem, for example, of collecting ripe eggs, but not having sperm available to fertilize them.

2) Frozen sperm can greatly enhance efficient use of facilities and create new opportunities in the hatchery by eliminating the need to maintain live males. Potentially all of the resources in a hatchery, which are typically limited, could be diverted to use for females and larvae.

3) Valuable genetic lineages that currently exist, such as endangered species, research models or improved farmed strains can be protected by storage of frozen sperm. This could be very important for species such as shellfish in which valuable broodstocks must be stored in natural waters.

4) Cryopreservation opens the door for rapid genetic improvement. Frozen sperm can be used in breeding programs to create new improved lines and shape the genetic resources available for aquaculture operations. A dramatic example of this potential opportunity is provided by the dairy industry, which relies almost entirely upon cryopreserved sperm to produce improvements in milk yields.

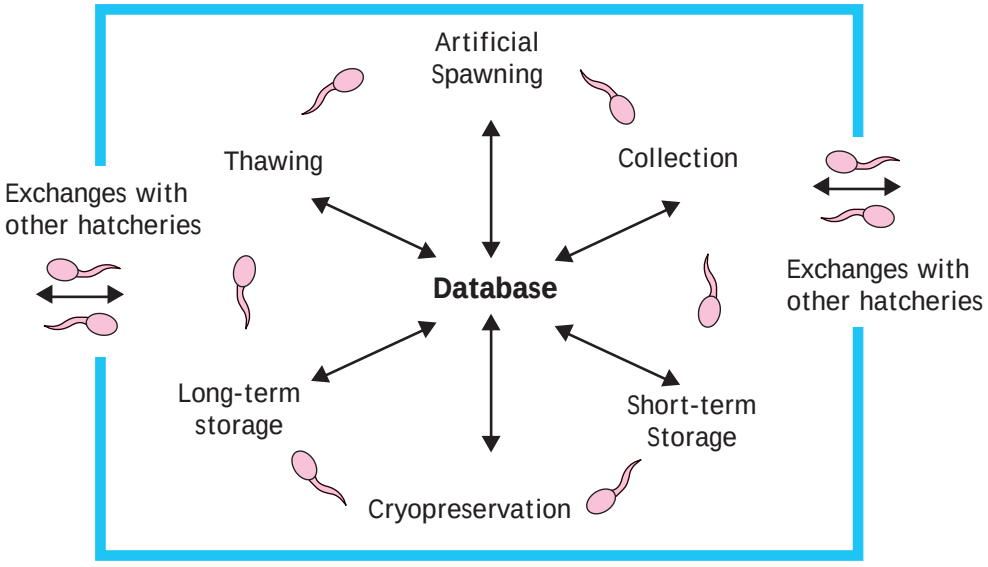


Figure 4. Activities of fish sperm cryopreservation at a single location (linked in a circle). Consecutive components are shown as a clockwise flow of sperm and two-way arrows are used to indicate maintenance of a centralized database for information on motility, quality control points (shown as sperm), fertilization, and inventory. Refrigerated (right side) and frozen sperm (left) can leave the facility (with permission from Caffey and Tiersch).

5) Cryopreserved sperm of aquatic species will at some point, likely within the coming decade, become an entirely new industry itself. The global market for dairy bull sperm is around 1 billion dollars each year. Large, highly valuable global markets for cryopreserved sperm of aquatic species are now on the horizon.

Sperm cryopreservation in aquatic species is only beginning to find application on a commercial scale. The development of this new industry is constrained by a number of factors including the technical requirements for scaling-up to commercial operations during the transition from research. This problem has been addressed by research in our laboratory over the past 10 years that documents the feasibility of utilizing commercial dairy cryopreservation facilities to provide a jumpstart for cryopreservation in aquatic species such as catfish and oysters. The dairy bull industry provides a business model for developing commercial application for cryopreserved sperm of fish (**Figure 5**). In addition, industries such as this can provide equipment, protocols, facilities, and distribution networks that can be adopted for use with fish sperm.

Other challenges for commercial development include disease concerns for sample transfers, pricing structures, and product quality control issues. The presence of a cooperative framework across species can assist finding

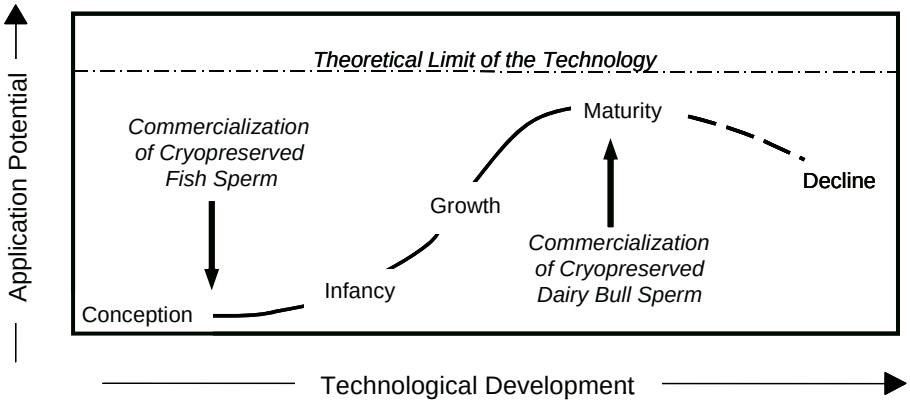


Figure 5. Conceptualized market life cycle for application of cryopreservation technology. Cryopreservation of dairy bull sperm is an example of a mature technology, while the commercialization of fish sperm cryopreservation is currently somewhere between conception and infancy (with permission from Caffey and Tiersch).

solutions for problems such as these. A model for developing multi-species repositories for genetic resources comes from the newly formed National Animal Germplasm Program (NAGP) of the United States Department of Agriculture (USDA). The NAGP is patterned after the well-established USDA National Plant Germplasm System. The NAGP has committees for beef and dairy cattle, swine, goats and sheep, poultry, and aquatic species. The Aquatic Species Committee brings together members from universities, industry, and federal agencies. A structure such as this could assist development of repositories within and among Southeast Asian countries. Indeed, a useful model for aquatic species everywhere is the development of an integrated repository system that incorporates a single or a few well-equipped, experienced central facilities that carry out most of the cryopreservation work using samples or broodstock sent to the facility. Other facilities can serve as satellite repositories to protect backup samples, and as user endpoints for the samples such as hatcheries (**Figure 6**).

The cryopreservation research in our laboratory at the LSU Agricultural Center is intended to assist the transition from cryopreservation research to application through work on protocol standardization, gamete quality, sample labeling, and database development to provide a repository to protect genetic resources, including endangered species, and to assist in developing existing and future industries for culture of aquatic species. Work such as this needs to be done in Southeast Asia as well. Overall, beyond the initial development of facilities, procedures, and training of personnel, the largest practical constraints to realization of a cryopreservation industry for fish is at present the absence of uniform quality control practices, industry standards, and appropriate disease transfer safeguards. The control of the movement of pathogens into and out of a facility or area is referred to as biosecurity. This topic will assume great importance in the future for use and transfer of frozen samples.

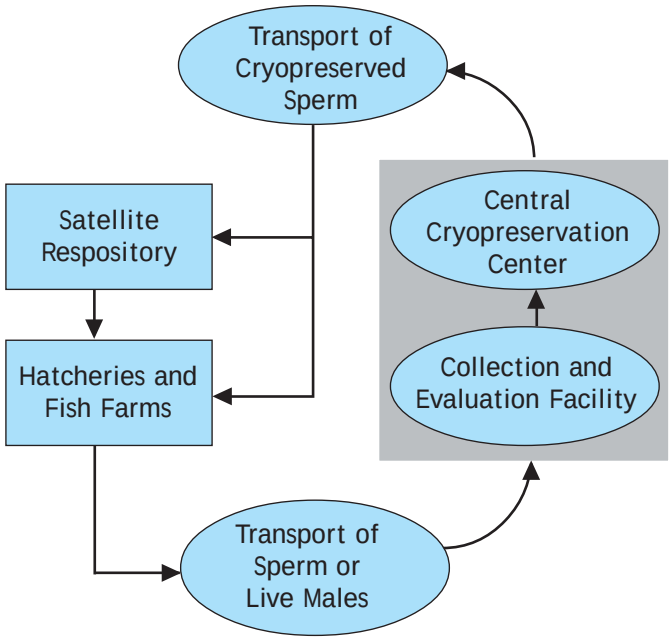


Figure 6. A model for a simple germplasm repository system based on three physical locations (shown in rectangles) providing a quarantine area for incoming samples, archival storage (central repository), backup storage (satellite repository), and production and use of sperm (working hatchery). Activities are shown in ovals, and transfers of samples are shown by arrows.

Caveats for application of cryopreservation to threatened and endangered (T & E) species

1) Technology is seductive and not always necessary.
2) The techniques of cryopreservation are unrefined or non-existent for most species.
3) Cryopreservation is a tool, not a final solution.
4) Cryopreservation does not protect habitat.
5) Cryopreservation does not replace existing management plans.
6) Cryopreservation can buy time or be a waste of resources.
7) There are few ethical guidelines for the application of cryopreservation to conservation.

In order for cryopreservation to assume a functioning role in assisting aquaculture production and aquatic species conservation it has to proceed beyond development of the initial technical requirements. A series of activities are required to be in place for full-scale application. These activities have not yet been fully implemented anywhere for any aquatic species. There are problems and barriers at each step, but getting started is usually the hardest part. The entry-level requirements for equipment, facilities, and training are high and force potential users to focus on technology development and technical problems. However after this hurdle is passed, the focus can shift to coordination of activities and realization of the great opportunities provided by cryopreservation. A final phase of maturation in application would see cooperation and connections forming among governmental agencies, non-governmental organizations, academic institutions, and private companies.

The major activities in this potential pathway for application are listed below:

1) Development of *technical capabilities and facilities* at well-funded and secure locations.
2) Establishment of *training programs* for procedural efficiency, and recruiting of personnel.
3) Development of *appropriate biosecurity safeguards* to control movement of pathogens in and out of facilities.
4) Development of a *functioning storage repository*, with rules for use and disposal of samples, and with appropriate security for basic services (e.g., electricity, liquid nitrogen, refrigeration capabilities, and aeration for aquaria and holding tanks)
5) Implementation of archival *labeling of samples and the creation of robust databases* capable of handling biological information concerning samples (including geographical information system (GIS) data on collections), and maintaining correct inventory and identification of sample locations.
6) Further development of capabilities *computing and information transfer* including the ability to interact and exchange information with other databases.
7) Increasing of the sample processing capabilities to enable *high throughput of samples*. This would include installation and use of automated or semi-automated equipment for labeling, filling, and sealing of straws, and the procurement of commercial-scale freezing and storage capabilities.
8) After central facilities have developed strong operational capabilities, a sustained effort should be made to develop *cooperation with other organizations* and facilities. These relationships can include sharing of samples, capabilities and expertise. Efforts should be made to link cryopreservation with existing or planned activities such as fish sampling programs or cooperation with specialized hatcheries during spawning seasons.
9) To assist interactions among organizations, basic arrangements should be discussed and put forth as *formal transfer agreements* that can be negotiated and put in place to describe things such as responsibilities, rights, and ownership of samples.
10) Because different facilities will have different approaches there should be establishment of *quality control protocols and standardization* of labeling, terminology, reporting of results, and databases.
11) Essentially, individual repositories can at this point be linked by *establishment of a full repository system*, and end users of cryopreserved sperm, such as both small-scale and commercial hatcheries and farms can interact with this system.
12) *Coordinated regional activities* can take place in individual countries or be administered across borders to encompass river systems or ecosystems.

Ethics discussion topics for application of cryopreservation to conservation

1) Cryopreservation is a form of time travel.
2) We cannot be certain of how frozen samples will be used in the future.
3) Use and disposal of cryopreserved samples will require rules.
4) Quality control and quality assurance will be required.
5) The value of frozen samples is determined by record-keeping and database management.
6) Cryopreserved material can be used for genetic reconstitution instead of production.
7) Genetic management can be intentional or unintentional.
8) Organisms considered to be desirable or innocuous today, may not be so in the future.
9) Diseases of today could be worse when reintroduced in the future.
10) We cannot predict the interactions of today's organisms with those of the future.
11) Species do not live in isolation: it takes a community.
12) Resource allocation is necessary for cryopreservation.
13) Cryopreservation could be viewed as mitigation for development activity.
14) Private sector involvement is possible for cryopreservation of T & E species.
15) Saving a species can transform it.

Acknowledgements

This work was supported in part by funding from USDA-SBIR, USDA-CSREES, the National Institutes of Health, and the National and Louisiana Sea Grant College Program. This manuscript was approved for publication by the Director of the Louisiana Agricultural Experiment Station.

Regional Training on the Cryopreservation of Freshwater Fish Semen

From 7 to 12 August 2006, SEAFDEC held a one week training aiming at introducing the principles and main applications of cryopreservation of aquatic species in the Southeast Asian region. Researchers from the different SEAFDEC member countries were invited to participate to a seminar which was followed by a hands-on workshop hosted by the Thai Department of Fisheries at the Aquatic Animal Genetic Research and Development Institute (AAGRDI) located in Pathumthani, which has state of the art facilities. The author was invited in the capacity of resource person and shared his experience and expertise acquired at LSU Agricultural Center. Other experts from the region were also invited to share their experience with the researchers from the region, notably Dr. Amrit Bart from the Asian Institute of Technology and Dr. Veerapong Vuthiphandchai from Burapha University.

The training aimed at being a first step toward a more widespread use of cryopreservation as an important tool for the promotion of aquaculture and the conservation of endangered fish species, with a special focus on freshwater species. While the activities had a strong focus on technology, a discussion was initiated on what could be the applications of cryopreservation of aquatic species in Southeast Asia. Benefits were identified during the dialogue between regional participants both for commercial and small-scale fish farming, as well as for the conservation of endangered freshwater species. Such a regional exchange of ideas was found essential and the participants emphasized that it should be continued in the future. Possibilities for doing so under a similar SEAFDEC initiative will be explored.

Regional Training on the Cryopreservation of Freshwater Fish Semen

Readings

A comprehensive reading offering a good overview and insights:

Tiersch TR and Mazik PM (editors). 2000. Cryopreservation in Aquatic Species. World Aquaculture Society. Baton Rouge, Louisiana, USA. 439 pages.

Additional readings:

Billard R and Zhang T. 2001. Techniques of genetic resource banking in fish. Pages 156-170 in: *Cryobanking the Genetic Resource: Wildlife Conservation for the Future?* Watson PF and Holt WV, editors. Taylor and Francis, London.

Billard R, Cosson J, Noveiri SB, Pourkazemi M. 2004. Cryopreservation and short-term storage of sturgeon sperm, a review. *Aquaculture* 236:1–9.

Chao N-H and Chiu Liao I. 2001. Cryopreservation of finfish and shellfish gametes and embryos. *Aquaculture* 197:161–189.

Lahnsteiner F. 2000. Introduction to the special issue on 'Cryopreservation of gametes in aquatic species'. *Aquaculture Research* 31:229-229.

Leung LKP and Jamieson BGM. 1991 . Live preservation of fish gametes. Pages 245-269 in: *Fish Evolution and Systematics*: *Evidence from Spermatozoa*, Cambridge, UK.

Rana KJ. 1995. Cryopreservation of fish spermatozoa. Pages 151-165 in: *Methods in Molecular Biology: Cryopreservation and Freeze-drying Protocols*, Day JG and McCellan MR, editors.

Scott AP and Baynes SM. 1980. A review of the biology, handling and storage of salmonid spermatozoa. *Journal of Fish Biology* 17:707-739.

Stoss J. 1983. Fish gamate preservation and spermatozoan physiology. Pages 305-350 in: *Fish Physiology, Volume IX, Part B, Behavior and Fertility Control.* Hoar WS, Randall DJ, and Donaldson EM, editors. Orlando, Florida.

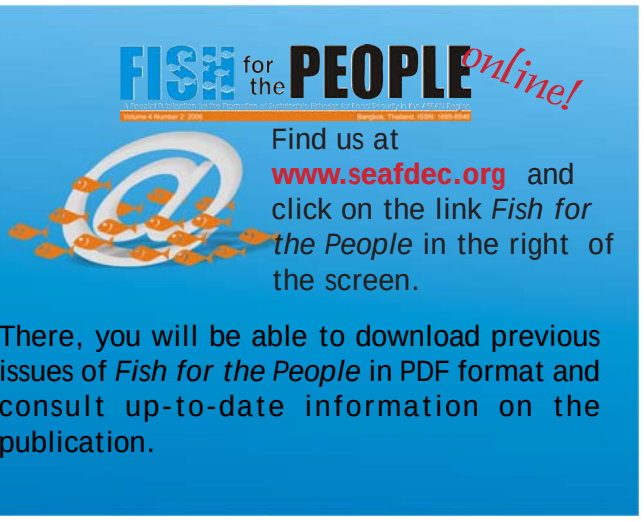
Tiersch TR and Jenkins JA. 2003. Biosecurity considerations for cryopreserved gametes and early life stages of aquatic species. Pages 171-198 in: *Biosecurity in Aquaculture Production Systems: Exclusion of Pathogens and Other Undesirables.* World Aquaculture Society, Baton Rouge.

Viveiros ATM. 2005. Semen cryopreservation in catfish species, with particular emphasis on the African catfish. *Animal Breeding Abstracts* 73(2)1N-9N.

Zhang T. 2004. Cryopreservation of gametes and embryos of aquatic species. Pages 415-435 in: *Life in the Frozen State*. Fuller B, Lane N and Benson E, editors. CRC Press, New York.

ABOUT THE AUTHOR

Dr. Terrence Tiersch is a Professor of aquaculture genetics, and has worked at the Aquaculture Research Station of the Louisiana State University Agricultural Center in Baton Rouge since 1992. In 2000 he was the lead editor of the book entitled Cryopreservation in Aquatic Species which is the only comprehensive reference work in the field. He serves as Chairman of the Aquatic Species Committee of the USDA National Animal Germplasm Program. The author can be reached at *TTiersch@agcenter.lsu.edu.*



INVITATION TO CORRESPONDING WRITERS

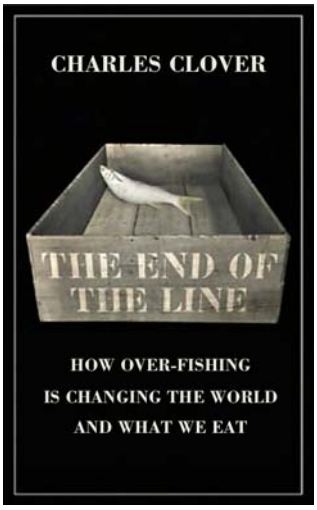
With many issues of *Fish for the People* already published, we hope that we have given you a good idea of the aims and general tone of the publication. Recently, we have been publishing more articles from external contributors. We are further inviting contributions from writers interested in promoting relevant issues on fisheries in developing countries. While the publication will continue to focus on the Southeast Asian region, future issues can address relevant issues from other tropical regions.

Fish for the People is a policy-orientated publication. It is not a forum for publication of research findings, nor is it intended to provide detailed technical information. The publication targets not only experts or scientists, but also other traditionally less technically-oriented fisheries stakeholders, such as policy-makers, donors, government staff, managers, and more generally, an informed lay public with an interest in how our fisheries are managed.

Readable, accessible articles that address the various issues discussed at the ASEAN-SEAFDEC Millennium Conference are most desired. Articles should focus on newly emerging issues relevant to sustainable regional or tropical fisheries management. They should present important issues with clear regional messages, emphases, thrusts, problem areas, and propositions for improving current situations.

Through *Fish for the People*, we hope that authors will gain the attention and consideration of targeted fisheries stakeholders, and contribute to the future achievement of more sustainable fisheries.

Correspondence related to editorial matters should be sent to *fish@seafdec.org*



Delusions of Fisheries Management and the Appetite for Fish: How Markets and Politics Perpetuate Over-Fishing

Title: The End of the Line – How overfishing is changing the world and what we eat
ISBN: 0-09-189781-5
Author: Charles Clover
Publication:2004
Pages: 314
Price: 7.99
Publisher: Ebury Press, London, England
Where to get it: *www.randomhouse.co.uk*

The dire state of world fish stocks is compelling evidence of the general failure of fisheries management. With ever-declining global fisheries resources, efforts to manage the remaining resources, to regulate their use and to reverse the downward trend are on the rise and intensifying – and all too frequently failing. With the roots of the decline of fisheries resources usually identified as overfishing caused by overcapacity and increasing fishing effort, remedies that may reverse the downward trend are well known: effort and capacity limitations, catch limitations and the establishment of areas which are permanently and/or temporarily closed to fishing. Why then, if the causes and the solutions to the problem of declining fisheries resources are so well known, are examples of successful fishery management so rare, and the few that may be considered successful, so controversial?

In 'The End of the Line', Charles Clover, a former environment editor of The Daily Telegraph, provides insights into the global fishing industry. He investigates the forces that drive the industry and uncovers political failures and fishy, self-delusional politics that claim to end the overexploitation of the world's fish resources, but in reality sustain the continually increasing efforts to chase the ever-decreasing fish stocks around the globe. Efforts to restore global fish stocks and maintain global fishing operations on a sustainable level need to address these factors and forces in order to avoid more failures and in order to restore trust and confidence in fisheries management.

Taking bluefin tuna as an example, Clover starts his account of how the multi-billion dollar seafood industry has driven the exploitation of the oceans' fish resources to the brink of extinction. The trail he follows reaches from fish markets in Tokyo and Madrid to fishing ports in Senegal, Newfoundland and Scotland. It covers associated fishing grounds like Georges Bank, the areas of upwelling off the West African coast, the North Sea, and the international waters around Antarctica. Clover's journey uncovers the connections between the international demand for seafood, the efforts of the industry to meet this demand and the political patronage this industry is enjoying around the world. Clover is one of the few who do not blame fisheries scientists and their models for getting it wrong, but the industry and the politics and politicians supporting the industry for not listening to the scientists and their advice and watering down whatever recommendations they get from them. Clover's views are strong and controversial; he does not want to be neutral and attacks whoever he thinks stands in the way of protecting the world's remaining fish stocks. This includes all the international fisheries management bodies and agreements, gourmet chefs who specialize in seafood, seafood companies, the European Union and even the Food and Agricultural Organization of the United Nations.

Acknowledging potential social problems and consequences, Clover strongly supports the introduction of property rights into fisheries in form of quota systems and quotes Iceland as a successful

example for effective fisheries management. Pointing at some cases of marine protected areas, he sees great potential in permanently closing large areas of the oceans to fishing. Clover provokes, but not for the sake of provocation. His intention is to stir the readers – mostly western fish eating readers – into thinking about the processes that bring the fish to their plates. For him, consumers can play a decisive role in bringing about change in the ways fish are caught. Confronted with the degradation of the oceans' resources and the danger of not only big fish like bluefin tuna and other going extinct, Clover's hope lies in the general public's wakening up to these threats and starting to question the rights of a few to indiscriminately exploit a common resource, which belongs to everybody and not just to those who go fishing either for a living or for pleasure or both.

The one-sidedness of Clover's arguments may be unsettling to some readers; others, particularly those who are stakeholders in fisheries – be they fishers, processors or managers – may denounce the book as the ill-informed rantings of a layman who lacks the deeper understanding necessary to participate in debates about fisheries management. However, this book will most certainly help the reader to understand the "true price of fish that is not written on the menu", as Clover himself puts it.

NEW PUBLICATION!

The importance of inland fishery resources and the need for establishment of effective data and information collection system to support fisheries management was addressed as the key fundamental for the project on *Information Gathering for Capture Inland Fisheries in ASEAN Countries*. As part of the project, a series of study on the taxonomy of inland fish in Myanmar was conducted by SEAFDEC in collaboration with the Department of Fisheries, Myanmar, and with technical assistance from several fisheries biologists from Thailand.

During 2002-2004, several surveys were conducted to collect fish specimens from northern, middle, and southern parts of Myanmar to represent the inland fish species of the country. The results of all the surveys were recently published in a publication on '*Inland Fishes of Myanmar*'. Information provided includes species identification in a systematic classification, and supplemental description e.g. diagnostic characteristics, sizes, habitat and biology and their distribution in river basins, etc.

Coastal Livelihood Opportunities in Cambodia

By Anna Beloff

With decreasing fish stocks and the rapid development of coastal areas, Cambodia is facing a challenge in maintaining these areas as profitable on a long-term sustainable basis. Marine resources are quickly depleted completely if planning decisions for coastal development are made too hastily, and where there is a lack of support to low-income local communities, most of which base their whole income generation and subsistence on fishing practises. Therefore measures to be taken must include not only changes in policy level but also grass-root education and training with local communities that provide them with opportunities and possibilities for maintaining their livelihoods in the changing environment.

The changing environment

Cambodia's coastal area is 435km long, with a wide range of coastal habitats that include mangrove forests, sea grass beds, white sandy beaches, open sea and coral reefs, and a total area coverage of 55,600 km^2. The Exclusive Economic Zone area on the relatively shallow coastline (average depth 50m) includes 69 islands, and 28,065 km^2 of coastal zone has been identified as coral reefs (Department of Fisheries, 2005). The total coastal population living in this area is about 1 million. Administratively, the coastal zone is divided into two provinces (Koh Kong and Kampot) and two municipalities (Sihanoukville and Kep).

Cambodian marine waters have been reported by FAO as some of the most productive in the world. Most people living in coastal areas make their living from fishing, trading, tourism and timber processing. Sixty percent of this population is involved in marine fishing, which is mainly artisanal and small-scale fishery. The Cambodian fish export market is still in the development stage, lacking foreign and local investment as well as proper processing facilities for fish products. Due to the lack of an established cold-chain, most fish products end up in nearby local markets and restaurants. Several districts in Koh Kong province have established more commercial fishing, and have already developed export markets, primarily in Thailand.

The number of motorized vessels in coastal areas was recorded in 2001 at over 5,300, most of which were concentrated in Koh Kong Province. This number is estimated to have increased in the past few years. Women living in coastal areas work in peeling crabs, processing of fish sauce and paste (*prahok*), repairing and manufacturing fishing gear and selling fish products in the markets. The collection of invertebrates by fishers using snorkels and masks is popular in inshore waters, which provide a high proportion of the daily protein needs of local people. This is most relevant during the dry season, when the lack of water for both irrigation and drinking causes major livelihood problems on coastal areas.

The present Fisheries Law imposes several restrictions on marine fisheries. These include prohibitions on trawling in water less than 20 m deep, restrictions on gear types and sizes, bans on destructive fishing methods, such as electronic fishing, and poison and dynamite fishing, boat licenses for boats exceeding a maximum specified size, and fishing licenses and permits for both local and foreign commercial fishing boats. According to the Department of Fisheries, most of the fishers in Kampot and Kep use traditional fishing gear, such as gill net, crab net and long line. The greatest commercial fishing pressure comes from foreign vessels fishing illegally on Cambodian waters. These efficient trawlers clear large coastal areas from all age-class fishes, and destroy the bottom composition, and with it marine resources and local people's livelihoods. This trawling can only be stopped by transparent and efficient non-corrupt interference by fisheries authorities. In recent years, most coastal shrimp trawlers have ceased

Photo: A typical cambodian coastal village; and the whole family is working (Beloff)

operation, while it seems that shrimp gill-netters have increased. In 1998, the depletion of shrimp stocks led to a crash in shrimp fishing, but since then Cambodia has risen to fifth among shrimp exporting countries. In 2004, the registered marine fisheries production was in total 55,800 tons (DoF statistics). This total catch includes commercially important fish species, low-value fish and shrimp, cephalopods, crabs, gastropods and bivalves. From 2000, the marine fish catch has grown almost 20,000 tons and the proportion of so-called 'trash-fish' to the total catch is increasing, indicating continuing declines in high-value species such as large tuna and grouper, and fishing down the food chain. From Cambodia's total yearly catch, this constitutes only 17%, but as mentioned earlier, the catch has almost doubled in past couple of years.

Compared to inland fisheries, marine fishing does not appear to have a clear seasonality for local residents. On the other hand, seasonal changes in inland fisheries and farming practises causes seasonal migration to coastal areas. In the dry season, some people from inland provinces move to coastal areas as an optional livelihood in the lack of opportunities in their own areas. This generates a greater seasonal pressure on coastal fisheries. It also affects conservation efforts in some places, with migrants using destructive fishing methods, which might be attributed to their lacking any long-term interest in the fishing areas concerned. Currently, coastal areas are second after Phnom Penh in migration from other areas in country.

Recently, mangrove coverage has decreased rapidly due to increasing demand for charcoal and building materials. The impact of the degradation of mangrove forest coverage on coastal fish stocks and their recruitment cannot be estimated due to a lack of research and hence data on fish stocks and marine resources. The general view is still that exploitation of Cambodian marine fishery resources comes close to exceeding the maximum sustainable yield, and therefore means of assessing new options are required both at the policy level and in terms of livelihoods.

Options available – sustainability and rationality?

The importance of generating subsistence activities, diversification of livelihood options and increasing the resilience of declining marine fisheries resources are therefore essential to people whose livelihoods depend on coastal areas of Cambodia. Much effort has been put into vocational skills training in order to create supportive or alternative livelihoods. The few projects working in coastal areas have to date been concentrated on creating new opportunities by training people as hair-dressers and mechanics. But in follow up evaluation, it appears that subsequently few of the young people trained have succeeded in finding or creating work for themselves.

Interest in ecotourism, tourism, and the related development of infrastructure is growing all the time. But tourism does not create many opportunities for the coastal poor, who lack the needed skills and capital. Ecotourism and tourism in general provide excellent opportunities for coastal people when they are properly planned using integrated approaches, linking multi-use areas with ecotourism and developing the vocational skills needed.

Other sectors developing at this moment include garment manufacturing, salt production, cement production and seafood processing. These work opportunities are concentrated around the towns of Koh Kong and Sihanoukville. Most rural coastal areas and islands lack these opportunities.

Seaweeds

One interesting option for coastal areas is seaweed production. Seaweed production in country increased from 3,500 tons in 2001 to 16,840 tons by 2004. Estimates from last year indicate higher production values than this. Production had already started in Cambodia in 1999 when a Malaysian company provided free seaweed stems to fishers in Kampot Province, and general information on how to plant and culture it. The concession area for seaweed farming given to this company by the government (Ministry for Agriculture, Forestry and Fisheries) covers 4,100 ha, and is valid from 2000 to 2030. Different species of seaweed were initially introduced, but in the end *Kappaphycus* seaweed was selected as the main species for cultivation.

Small-scale coastal fishers landing their harvest of seaweed (Beloff)

In the past couple of years, seaweed production in the selected villages has completely changed the livelihoods of local fishers. Villages previously dependent on fishing have adapted exceptionally to seaweed farming, and the former fishers have found new livelihoods and small-scale seaweed farmers. The establishment of seaweed farms has also provided more work options for women living in the area. Men are responsible for planting the seaweed in off-shore areas in deeper water. Women handle the rest of the work, tying the new stems to the support ropes as well as removing the fully-grown seaweed, drying it and finally cleaning it. The seaweed produced at this moment has around 50% water content, and is dirty, with small shells and sand attached, when brought to the processing facilities, so the company still has to process it further before packing. This creates extra labour costs for the processor that reduces the amount of money paid to the small-scale farmer.

woman at work (Beloff)

The introduction of seaweed farming practices in villages living nearby the already established concession areas is a future option. The current farmers welcome new outsiders to join the cultivation of seaweed, saying that the economic returns from seaweed are so good that even new entrants are welcome in the same area. According to these seaweed farmers, all of their time is now used for seaweed farming, and as a result the amount of fish in the area has increased with the decreased interest of local people in fishing. The companies seem to have very little interest in how farmers are managing the concession area among different small-scale farmers as long as seaweed is provided without delay to the processing facilities. The growing interest due to the high-market value of seaweed has created even greater interest among new entrepreneurs entering this area.

But as always, the situation is now deteriorating as bigger players start to invest ever greater sums in the sector. There is discussion among fisheries authorities about the environmental impact of seaweed aquaculture and its damaging effect on local ecosystems. Concerns have been raised about the changes in nutrition cycle and sedimentation as well as changes in habitat that affect the population structure of different species. For example, in Kampot Bay there have been sightings of dugong (*Dugong dugon*), whose natural foraging areas the sea-grass beds, may be jeopardized by seaweed farming. In many areas, a thorough environmental assessment was not performed before establishment of new cultivation sites, and some anecdotal suggests the establishment of seaweed farms on coral reef areas or other unsuitable areas such as extensive sea-grass areas. Anecdotal evidence from small-scale seaweed farmers from Prek Ampil village indicates an increase in fish stocks which in their opinion is based on the fact that almost no fishing other than subsistence is done anymore, due to an increase of income via the seaweed farming.

Another negative side-effect is currently placing local fishers in a difficult position. Conflicts between different companies and some authorities have been recorded, apparently triggered by demands for compensation for "evaluation of seaweed farming practises" and "official visits to the sites". This is causing a considerable additional financial burden for the private sector, and might soon threaten the profitability of production. This could force companies to move to other countries, where they would have better opportunities to sustain themselves. If most companies shift their production to other countries, this would deteriorate the competition between different seaweed entrepreneurs for seaweed supply from small-scale farmers, creating a monopoly market with low market-prices for farmers. As income decreases for former fishers, they would change back to their former livelihoods as fishers, again further depleting already decreased fish stocks in the area.

The absence of policies and laws relevant to seaweed aquaculture management and practises, coupled with the lack of transparent enforcement, all point to an urgent need to enhance management capacity for the seaweed industry. This is to protect the interests of all stakeholders (private industry, local fishers and authorities with concern over sustainable use of the country's natural resources), and to manage the growing seaweed aquaculture industry in a way that will maintain ecologically and financially sustainable best practises.

Only way forward

Cambodian coastal areas offer excellent opportunities for development. New roads are being built that will greatly improve infrastructure and transportation. In coming years, export markets will open and create greater demand for new products. The same will happen to tourism, accelerating the pace of change for local communities. How well prepared these communities are to participate in the growing economy and at the same time to take care of their natural resources, depends on the government's interest in helping their own people to adapt to this change. The same includes donors who sometimes seem to follow one another in funding interest and policy support. The need to change funding and interest flow towards coastal areas of Cambodia is now, and not after all its marine resources have already been lost.

At the fishmarket... (Beloff)

About the Author

Anna Beloff, M.Sc. in Hydrobiology, currently works as Natural Resource Management Officer in FAO Cambodia under the United Nations Volunteer Program. She has particular interest in sustainable coastal development issues and fisheries co-management initiatives, especially in South-East Asia.

Events Calendar

Date	Venue	Events	Organizer
		2006	
7-11 August	Pontianak, Indonesia	Training Course on Fish Quality Preservation and Safety (HACCP)	SEAFDEC/MFRD
7-12 Aug	Thailand	Regional Training on Cryopreservation of Freshwater Fish Semen	SEAFDEC/Secretariat
22 Aug-21 Sep	Thailand	International Training Course on Coastal Fisheries Management and Extension Methodology	SEAFDEC/TD
28 Aug-1 Sep	Philippines	Training Course on Fish Quality Preservation and Safety (HACCP)	SEAFDEC/MFRD
29-31 Aug	Bohol, Philippines	Special Senior Officials Meeting (SSOM) of 27th Meeting of the ASEAN Ministers on Agriculture and Forestry (AMAF)	ASEAN
29 Aug-1 Sep	Ho Chi Minh, Vietnam	On-Site Training on Heavy Metals Analysis	SEAFDEC/MFRD
4-8 Sep	BFAR-MCS	On-site Training on Larval Fish Identification	SEAFDEC/TD
4 Sep–12 Feb 07	E-learning	AquaHealth Online: Principles of Health Management in Aquaculture	SEAFDEC/AQD
11-15 Sep	Phuket, Thailand	The 21st Session of the Asia and Pacific Commission on Agricultural Statistics	FAO
12-15 Sep	Indonesia	Farm-Based Feed Preparation for Freshwater Aquaculture (BIMP-EAGA Project)	SEAFDEC/AQD
14 Sep	Pakse, Lao PDR	Fish Releasing Ceremony in Lao PDR	SEAFDEC/Secretariat
18 Sep	Phuket, Thailand	ASEAN-SEAFDEC Regional Technical Consultation on International Fisheries Related Issues	SEAFDEC/Secretariat
19-22 Sep	Phuket, Thailand	Regional Technical Consultation on the HRD for Fisheries Management and Management of Fishing Capacity	SEAFDEC/Secretariat
20-22 Sep	Antique, Philippines	On-site training on Seabass Culture	SEAFDEC/AQD
27-29 Sep	Bangkok, Thailand	Regional Workshop on Coastal Area Planning and Management in Asia Tsunami-affected Countries	FAO/RAP
27-29 Sep	Iloilo, Philippines	On-Site Training on Histamine Analysis	SEAFDEC/MFRD
2-5 Oct	Samut Prakarn, Thailand	Regional Workshop on the Implementation of TEDs and JTEDs for Reduction of By-catch in Southeast Asia	SEAFDEC/TD
3-5 Oct	Rayong Province, Thailand	The National and International Technical Seminar on Rayong-Set Net Fisheries and it's Technology Transfer	SEAFDEC/TD
1-2 Nov	Bangkok, Thailand	ASEAN-Australia Development Co-operation Program: ASEAN Workshop on ASEAN Fish and Fish Products Safety Project	SEAFDEC/MFRD
1-4 Nov	Indonesia	8th Meeting of the Regional Working Group for the Fisheries Component of the UNEP/GEF Project: Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand	UNEP/GEF
21-24 Nov	Siem Reap, Cambodia	ASEAN-SEAFDEC Regional Conference on Pelagic Fisheries and Its Management	SEAFDEC/MFRDMD
27-29 Nov	Thailand	Expert Meeting on Fishery Statistics, Information, and Indicators	SEAFDEC/Secretariat
27 Nov-1 Dec	Malaysia	On-Site Training on Pesticide Residues Analysis	SEAFDEC/MFRD
4-7 Dec	Thailand	29th Meeting of SEAFDEC Program Committee	SEAFDEC/Secretariat
8 Dec	Thailand	9th Meeting of the ASEAN-SEAFDEC Fisheries Consultative Group	SEAFDEC/Secretariat
12-16 Dec	Hainan, China	The East Asian Seas Congress 2006	PEMSEA

Southeast Asian Fisheries Development Center (SEAFDEC)

What is SEAFDEC?

SEAFDEC is an autonomous intergovernmental body established as a regional treaty organization in 1967 to promote sustainable fisheries development in Southeast Asia.

Objectives

SEAFDEC aims specifically to develop fishery potentials in the region through training, research and information services in order to improve food supply through rational utilization of fisheries resources in the region.

Functions

To achieve its objectives the Center has the following functions:

1. To offer training courses, and to organize workshops and seminars, in fishing technology, marine engineering, extension methodology, post-harvest technology, and aquaculture;
2. To conduct research and development in fishing gear technology, fishing ground surveys, post-harvest technology and aquaculture, to examine problems related to the handling of fish at sea and quality control, and to undertake studies on the fisheries resources in the region; and
3. To arrange for the transfer of technology to the countries in the region and to make available the printed and non-printed media, which include the publication of statistical bulletins for the exchange and dissemination related to fisheries and aquaculture development.

Membership

SEAFDEC members are the ASEAN Member Countries (Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam) and Japan.

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In the occasion of the Millennium Conference, a drawing contest was organized for the children among ASEAN-SEAFDEC Member Countries, on the theme of "*Fish and the Culture*". This is the best drawing from Cambodia.