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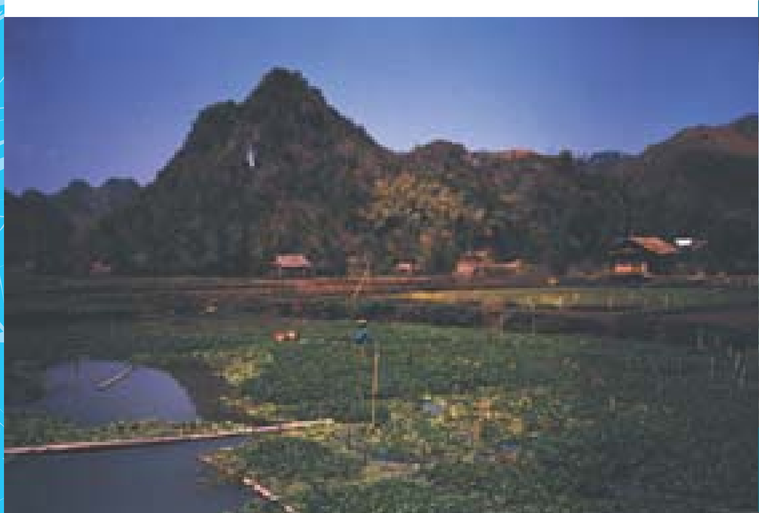

FAO AQUACULTURE NEWSLETTER FAO AQU
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FAO Aquaculture Statistics 1998 Highlights

The FAO statistics on aquaculture production for 1998 have recently been released by the Fishery Information, Data and Statistics Unit. A comparison between 1997 and 1998 aquaculture production data reveals that:

- **The total world production of aquatic species (excluding plants) in 1998 increased by 2.04 mmt or 7.07 percent to 30.86 million metric tonnes. The value of this production was US$ 47,080 million, which represents an increase of US$ 1,270 million or 2.76 percent.**
- **Inland water aquatic animal production increased by 6.53 percent to 18.73 mmt with a 4.33 percent increase in value. The marine aquatic animal production increased by 0.89 mmt or 7.91 percent and was valued at US$ 22,310 million.**
- **Production of Pacific cupped oyster (*Crassostrea gigas*) increased by 15.61 percent to become the principal species farmed, overtaking silver carp *(Hypophthalmichthys molitrix)* with a total production of 3.44 mmt. During the year, giant tiger prawn *(Penaeus monodon)* production increased by 8.80 percent to 578,000 mt.**
- **China, India and Japan retained their positions as the world's first three largest aquaculture producers, while Bangladesh overtook Indonesia to become fourth by producing 0.58 mmt, which is an increase of over 70,000 mt or 13.87 percent.**
- **World seaweed production increased by 1.36 mmt or 18.88 percent to 8.57 mmt.**

A detailed analysis of 1998 aquaculture production statistics will be made available to the FAN readers in future issues of FAN. The latest data can be accessed from http://www.fao.org/fi/statist/summtab/default.asp

Cover photos: Multiple-use water bodies

top left: The integration of carp pond culture, pig farming, fruit trees, tubers and other crops is a traditional approach to ensure food security in the poor upland regions of Viet Nam;

bottom left: Ethnic minorities practice a wide range of aquaculture activities for human and livestock consumption in north-western Viet Nam (courtesy of M. Halwart);

right: Integrated chicken and tilapia pond culture with aquatic macrophytes to stabilize bank and provide additional feed in northeastern Thailand (courtesy of D. Bartley).

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BRIDGING THE GAP

Mario Pedini
Fishery Resources Division

Can aquaculture meet the additional demand for fishery products?

This article is based on the author's keynote speech at the annual meeting of the World Aquaculture Society (WAS), Sydney, Australia, May 1999.

Introduction

The future of the aquaculture sector is of interest to both planners and the industry. This interest has been heightened by the growing importance of aquaculture in global fish supplies and the fact that capture fisheries probably will not be able to meet the growing demand for fish as the world population expands. Past attempts to forecast the future of aquaculture were carried out in a global context. For the annual meeting of the World Aquaculture Society (WAS), I tried to arrive at the global picture by evaluating and summing up the regional pictures. Information and time permitting, a sharper image could have been derived by analysis of individual countries, or at least the major producers, as this would have allowed a better understanding of the main factors which influence the future of the sector.

One of the main shortcomings of past attempts to forecast aquaculture production was that the sector was considered in relative isolation. The fact that aquaculture is simply another source of protein, competing in domestic and international markets with other forms of protein, was seldom taken into consideration. In addition, past evaluations were carried out by examining past growth rates and then extrapolating using those same values. That approach does not take into account the fact that the expansion of the production base requires an enabling environment, including encouraging market conditions, investment, increased natural resources, etc.

Further, global figures for population growth were used to estimate demand, but these figures mask the differences in population growth among regions. Data on population growth projections are available in sufficient detail and permit relatively accurate projections of population growth and structure in the medium term[1].

The question which was posed by the WAS for the keynote address was: with a rapidly growing population and almost stagnant capture fisheries, can aquaculture meet the challenge to provide food for the masses in the future?

To answer the question properly, the following factors need to be considered:

- population growth trends by region;
- the potential for increasing production from capture fisheries in the different fishing areas and the possibilities to access these resources;
- the feasibility of using more natural resources, such as land and water, for aquaculture production;
- the potential for additional production from aquaculture including culture-based fisheries,
- the role of external factors which influence the sector, such as economic development trends, including purchasing power of the population;
- government development policies; and
- the impact of potential technological advances.

The accuracy of the analysis was constrained by a number of facts:

- the accuracy of the statistical data over time, in particular for capture fisheries and aquaculture production;
- the lack of information on availability of natural resources for aquaculture production, and economic valuation of their alternative uses;
- the absence of reliable models to forecast medium and long term scenarios for macro-economic development;
- very limited information on internal and export market capacity in major producing countries; and
- the blend of physical, economic and social factors, which differs among countries and further complicates the difficulty of creating typologies even at the regional level.

Table 1. Demand projections (fishery products) for Africa and Asia

Continent	1984	1996	2000	2010A	2010B	Increase A over 1996	Increase B over 1996
Africa							
Population (millions)	525.10	722.75	797.15	992.33	992.33		
Per caput supply (kg)	7.86	6.80	6.80	6.80	7.48		
Total supply (1,000 t)	**4,129,400**	**4,912,174**	**5,420,607**	**6,747,816**	**7,422,598**	**1,835,642**	**2,510,424**
Asia							
Population (millions)	2,858.99	3,494.14	3,736.17	4,151.73	4,151.73		
Per caput supply (kg)	10.32	17.69	17.69	17.69	19.46		
Total supply (t)	**29,514,200**	**61,819,290**	**66,092,820**	**73,444,048**	**80,788,453**	**11,624,758**	**18,969,163**

In view of these constraints, this analysis was based on the main factors for which data were more readily available. Firstly, projected population growth and animal and fish protein consumption of the regions were briefly examined. Then, the supply situation and trends of capture fisheries were reviewed, including possibilities for expansion of production and access to fishing areas. Finally, growth rates of aquaculture observed during the last decade were briefly reviewed. The concluding section tried to put these three components of the analysis together on a regional basis and to visualize their interaction, taking into consideration the forecast of regional economic development[2].

Population growth trends and protein consumption patterns

World population in 1998 was estimated at 5,928.8 million with an annual growth rate of 1.4 percent. It is expected to grow to 6,831.7 million by 2010 and to 8,039.1 million by 2025, with substantial differences in growth rates between countries and regions. Protein consumption patterns and the ratios of fish consumption to total protein consumption also differ significantly. Table 1 shows overall demand in Asia and Africa, by year 2010, calculated on the basis of two scenarios: (A) a constant per caput supply based on 1996 level and (B) a 10 percent increase over 1996 levels. **In Africa**, maintaining the present low supply levels implies an increase of supply, by 2010, of 37.4 percent over the 1996 level. Improving per caput supplies (scenario B) would require an increase of 51.1 percent in overall supply. There is a high preference for fish, with a fish/animal protein consumption ratio (1996) of 19-19.5 percent, second only to Asia. **The Asian situation** implies an increase in overall supply for scenario A (maintaining 1996 per caput supplies to 2010) of 18 percent, and 30.7 percent for scenario B. In this region, fish supply increased from 10.6 kg/caput in 1984 to 17.9 kg/caput in 1997, while the fish /animal protein ratio remained constant at about 26-27.5 percent — the highest in the world.

The European situation is characterized by stagnant population growth and a slight but progressive increase in the consumption of fish products. Accordingly, an increase in supply of about one million tonnes (t) will be required only for a 10 percent increase (over 1996) in per caput consumption. In the case of **North and Central America**, scenario A entails an increase in supply of 16.7 percent (1.25 million tonnes), and B about 28.4 percent (2.13 million tonnes). Although this region has a high protein per caput supply, it has a relatively low fish/animal protein consumption ratio, an indication of preference for meat products.

The additional requirements for **South America** would amount to 20 percent (0.65 million tonnes) and 32 percent (1.05 million tonnes) in scenario A and B respectively. There is apparent preference for meat products although the per caput fish supply seems to have increased substantially. Oceania is a region with a small population but with high dependence on fish in the diet. This would put additional requirements at 17.2 percent (95 000 t) for scenario A and 29 percent (160 000 t) for scenario B. The situation of **the former USSR** countries is anomalous in that annual consumption of fish products decreased from a high 28 kg/caput in 1984 to 11.8 kg in 1996 due to the economic transition and changes in the operation of their fishing fleets. Since population growth is expected to be modest, only a small additional demand of 17 000 t will be needed for scenario A, compared to over 360 000 t for scenario B.

Global requirements for increased fish production in 2010 based on the sum of regional requirements (at 1996 per caput supply) are estimated at 15.5 million tonnes, with 75 percent of the demand from Asia and 12 percent from Africa. These seem to be the two regions where efforts need to be concentrated

Table 2. Marine capture fisheries by continent (1,000 t) and average annual growth rates (APRs)							
Region	1984	1990	1991	1994	1997	APR 91-97	APR 94-97
Asia	32,663.61	36,336.71	35,948.36	39,080.00	43,963.39	3.4	4.0
America, South	10,627.45	14,472.61	15,361.12	22,538.20	17,431.22	2.1	-8.2
Europe	12,619.36	10,591.25	10,572.13	11,901.49	12,840.73	3.3	2.6
America, North	7,687.51	9,324.88	8,749.82	8,443.75	8,113.86	-1.2	-1.3
Africa	4,070.14	5,088.79	4,745.69	5,144.10	5,723.88	3.2	3.6
Former USSR area	10,431.41	10,034.93	9,217.92	4,387.54	5,380.05	-8.6	7.0
Oceania	520.12	729.96	784.81	843.00	1,004.19	4.2	6.0
Other nei *	8.00	120.18	119.11	164.80	81.50	*	*
Total	**78,627.59**	**86,699.31**	**85,498.96**	**92,502.87**	**94,538.82**	**1.7**	**0.7**

* artificial grouping for statistical analysis only

to increase fish supply, if present levels are to be maintained. A 10 percent increase above 1996 per caput supply would require 26 million tonnes, of which 72 percent would be required in Asia and 9.6 percent in Africa.

Contribution from capture fisheries

To what extent can capture fisheries help meet this additional demand? Global production for all uses from capture fisheries reached 94.5 million tonnes in 1997 (Table 2) with an increase of only 200 000 t over 1996 (29.5 million tonnes were for non-food uses). This increase was mainly due to inland capture fisheries. These figures confirm the levelling of production from marine capture fisheries globally, noted in earlier years. As can be seen from the APRs (average annual percent growth rate) in Table 2, the last four years registered a considerable decrease in the growth rate of landings at the global level, falling below the rate of population growth of 1,38 percent.

Fishing areas with some potential for expansion include: **the Northwestern Pacific, Western Central Pacific and the Eastern and Western Indian Ocean** (FAO Fisheries Department, 1998)[3]. However, these are also the areas where there are more stocks with uncertain status of exploitation. It is difficult therefore to assess the potential additional supplies from those areas. Furthermore, any additional supply is not available to all countries. In the case of the **Northwest Pacific**, four countries (P.R. China, Japan, the Russian Federation and the Republic of Korea) land 96 percent of the total catch. In the case of the **Western and Eastern Indian Ocean**, five countries (India, Thailand, Myanmar, Indonesia and Malaysia) land 62 percent of the total catch, although there are several countries fishing in these two areas with substantial landings.

Areas showing a declining trend after reaching maximum production over a decade ago include the **NW Atlantic, SE Atlantic, and Eastern Central Atlantic**. Areas in which catches seem to have stabilized or are declining are: **NE Atlantic, SW Atlantic, Eastern Central Pacific, NE Pacific, and Mediterranean and Black Sea** (FAO Fisheries Department, 1998)[3].

It appears therefore that any additional contribution from capture fisheries will derive from increased landings in the four fishing areas mentioned above (i.e. in addition to the 42 million tonnes landed presently from these areas). It is more than likely that this additional catch will benefit mainly Asian countries.

There are also three other potential, but so far problematic, sources of supply from marine capture fisheries, which have been much debated but without viable solutions as yet: the reduction of discards and by-catch, estimated at 20 million tonnes, the utilization for human consumption of the catch currently being reduced to fish meal and fish oils (about 29.5 million tonnes in 1997), and non conventional resources, e.g. mesopelagics, krill, and oceanic squid, which may total 60 million tonnes.

Aquaculture production trends

The other source of supply of fishery products is aquaculture. Production statistics and average annual growth rates for the various continents are given in Table 3a and 3b respectively. In 1997, production increase was 2.13 million tonnes (6.2 percent) over 1996, and Asia contributed 91 percent of the total. Annual growth rates in **Asia** started to decline in the second half of the 1990s, while fast growth was recorded in **North and South America**. **South America** has maintained a growth rate over 20 percent in the period 1994-97 thanks mainly to Chile. **Africa** and **Oceania** showed almost no growth in 1997, and the republics of **the former USSR** showed what hopefully might be a change in trend (from an earlier decline of 13 percent in the early 1990s): a 5.5 percent increase in production over 1996.

Table 3a. Aquaculture production(t)

Region	1984	1995	1996	1997	Rank (1997)
Asia	8,472,335	28,488,358	30,911,114	32,770,370	1
Europe	931,662	1,486,026	1,592,010	1,655,262	2
America, North	363,096	559,084	562,382	647,758	3
America, South	57,777	409,450	539,328	642,998	4
Africa	36,685	104,815	120,865	121,905	5
Former USSR area	270,754	129,439	104,176	109,863	6
Oceania	19,900	94,681	102,156	102,012	7
TOTAL (millions t)	**10.15**	**31.27**	**33.93**	**36.05**	

Table 3b. Aquaculture growth rate trends

Region	APR 84-90	APR 91-97	APR 94-97	APR 96-97	APR 84- 97
Asia	9.3	12.8	9.2	6.0	11.0
America, North	2.1	5.5	6.8	15.2	4.6
America, South	21.5	16.5	23.4	19.2	20.4
Africa	14.4	4.6	8.4	0.9	9.7
Former USSR area	7.6	-13.3	-11.0	5.5	-6.7
Oceania	13.4	7.9	12.3	-0.1	13.4
Global average	8.8	12.0	9.1	6.2	10.2

A few of the 179 countries practising aquaculture account for the majority of the production. Out of the total 36.05 million tonnes produced, 15 countries contributed about 94 percent of the total in 1997, and the top ten accounted for 89 percent (Table 4). Production has been driven by the fast growth rate in P.R. China, which has been, for all the periods considered, higher than the average global growth rate. The P.R. China produced two thirds of the total world production. Projections, based on regression analysis, indicate that the production expected for year 2000 in P.R. China could reach about 35 million tonnes, provided that development conditions are maintained.

Some emerging countries have shown a steady rapid growth in the last four years (e.g. Bangladesh and Viet Nam in Asia, Chile in South America and Norway in Europe). However, there is also a worrying decrease in the growth rate of the sector in some important countries. In general, if the APRs for 1991-97 and 1994-97 periods (Table 4) are compared, a generalized slowdown of growth is apparent.

Regional Analysis

There are a number of basic and important questions, related to the supply of fish products that could strongly influence future developments. These are:

- Can unconventional fishery resources be tapped in an economic way?
- Can discards be used economically?
- Can the governance of commercial fish stocks be improved in the short term?
- Will trade in fisheries products increase from the present estimate of 40 percent of the catch?
- To what level can aquaculture increase its share in the use of resources without serious conflicts?
- Can indicators of sustainability be developed as a warning system for production ceilings in aquaculture?

Finding answers to these questions is very important. The quantities involved in capture fisheries are very large and could easily modify the entire supply picture (e.g. unconventional resources may exceed 60 million tonnes, and discards add another 20 million tonnes). A better governance of stocks could also lead to the recovery of some stocks. However, it is my personal opinion that the political will and human and financial resources required to modify the present situation of governance, in particular in developing countries, could only be achieved in the long term. It is also evident that urgent work remains to be done to permit assessment of the availability of natural resources for aquaculture production and their economic valuation, the potential gains from sustainable intensification of aquaculture production, and the potential impact of technological and other advances on future production.

Cultural factors will also affect the development of aquaculture. The growing concern about the impact of aquaculture on the environment and of other resource users on aquaculture, as well as possible unsustainable use of resources, may limit both future consumer acceptance of aquaculture products and the expansion of the sector. Clear and valid indicators for sustainability of the various aquaculture practices are still to be developed.

In addition, we should not forget that aquaculture is perceived as a competitive user of resources and as an interesting economic option only in a few countries in the world. Being a novel technology in many countries it has to make its place in the economic arena and this is not always easy.

Table 4. Major aquaculture producers (t), 1997

Country	1984	1990	1994	1997	Rank (1997)	APR 91-97	APR 94-97	APR 96-97	APR 84-97
China	3,830,077	7,952,632	17,097,920	24,030,313	1	17.6	12.0	8.2	15.2
India	510,000	1,012,121	1,527,796	1,776,450	2	6.5	5.2	-0.4	10.1
Japan	1,207,962	1,369,680	1,420,461	1,339,861	3	-0.2	-1.9	-0.7	0.8
Korea, Republic of	679,342	788,565	1,092,988	1,040,270	4	4.7	-1.6	16.0	3.3
Philippines	478,345	671,116	869,083	957,548	5	5.6	3.3	-2.4	5.5
Indonesia	330,764	599,824	699,522	911,610	6	7.0	9.2	3.5	8.1
Thailand	116,244	291,719	509,800	575,901	7	8.5	4.1	4.4	13.1
Bangladesh	122,842	194,278	319,820	512,738	8	16.7	17.0	14.0	11.6
Viet Nam	119,000	162,076	223,056	492,000	9	19.6	30.2	19.7	11.5
Korea, Dem. People's Rep.	694,800	900,000	817,039	489,321	10	-10.5	-15.7	-37.5	-2.7
United States of America	326,453	315,448	390,781	438,331	11	3.2	3.9	11.4	2.3
Chile	8,611	70,464	183,747	375,113	12	23.6	26.9	16.1	33.7
Norway	25,869	150,028	218,457	366,281	13	14.7	18.8	13.9	22.6
France	192,609	256,653	280,954	287,609	14	2.7	0.8	0.7	3.1
Taiwan Province of China	245,199	344,129	287,803	270,112	15	-1.3	-2.1	-0.8	0.7
Other	1,264,092	1,752,151	1,784,451	2,186,710		4.3	7.0	7.1	4.3
TOTAL	10,152,209	16,830,884	27,723,678	36,050,168	120	12.0	9.1	6.2	10.2

At the beginning of this article I mentioned the need to consider the general economic climate that influences investment and consumption patterns and therefore also possibilities for aquaculture development. The expansion of aquaculture production or any other economic activity will require funds and a clientele to which the product could be sold. Consumers will also modify their habits depending upon their purchasing power and this is governed by prevailing economic conditions. Macroeconomic climate can act as an accelerator or as a brake for development, in particular for development based on new technologies.

The economic crisis with regional or global repercussions like the one experienced in 1997-98 that affected strongly Asia and the former USSR republics, limited investment in general, including in aquaculture, particularly in countries where aquaculture was not yet an important economic activity. Similar economic difficulties may lead to similar patterns in other regions. Regarding the 1997 crisis, the World Bank[4] was not optimistic and did not provide a clear projection on the evolution of the crisis. The report singled out, as a serious concern, the lack of models to predict evolution of economic conditions, and forecast a slow recovery for the medium term. This lack of a clear forecast of economic growth in developing countries, and on the impact and possible time frame for the solution of the financial crisis, has limited the possibility to recalibrate the projections based on analysis of fish supply.

Since my presentation at the 1999 WAS meeting, the Fisheries Department has continued working on methods to estimate potential fish demand. A recent attempt was published in late 1999[5]. In that study, due to the lack of data on price time series (needed to obtain estimates of price elasticities) and on evolution of purchasing power in the individual countries, GDP was used as an indicator for demand projections. This is not entirely satisfactory, but provided a projection. Another study is ongoing to estimate future fish supply and demand through the insertion of information on fish commodities in the standard FAO food demand model that has been used for all agricultural commodities. This new study will do separate analyses for freshwater fish, marine fish, crustaceans, mollusc, and other aquatic animals.

If we try to combine the available information gathered on the regions on population growth, supply of fisheries products and general economic information, we arrive at the following regional scenarios for the year 2010.

Africa

Taking into account population trends, the state of commercial fish stocks and the potential for increased catches from capture fisheries and production from aquaculture, Africa seems to present the most difficult situation. The continent would need an additional 1.8 million tonnes to maintain 1996 per caput supply levels in 2010. Given the poor prospects for increasing the supply from capture fisheries in the medium term, it would be a major challenge to raise aquaculture annual production by 1.84 million tonnes. Furthermore, considering that aquaculture production in 1997 was only 120 000 t, of which more than half was from Egypt, and that annual growth in the 1990s has been below 9 percent, a huge effort in terms of investment and organization of production would be required to meet this target, at a time in which the economic situation of the continent is not positive[4].

Asia

In terms of additional production, the Asian requirements for 2010 are considerable (11.6 million tonnes and 19 million tonnes for the two scenarios respectively). Scenario A could be met with annual growth rates on the order of 2.5-3 percent, while scenario B would require a sustained annual growth rate of almost 4 percent. As Asia has had a growth rate in the 1991-1997 period of 12 percent, both targets would seem to be attainable. However, there has been a progressive and worrying reduction of growth rates in recent years, to an annual growth rate of 6 percent in 1996-97. This may be due to a progressive saturation of the P.R. China's capacity and may anticipate a plateau in production in the medium term. However, an economic recovery in the region may again encourage investment in aquaculture. Accordingly it is very likely that aquaculture will be able to meet demand under both scenarios. It should be remembered, nevertheless, that the four fishing areas with projected potentials for expansion are being exploited mainly by Asian countries, and that a contribution to the incremental fish supply requirements can also come from capture fisheries.

Europe

Since the population growth rate is not increasing, the challenge will be to maintain the supply derived from imports, which is already considerable and has been growing steadily in the 1990s (Laureti, in press)[6]. A sustained annual growth rate of 3 to 4 percent will be needed to produce the one million tonnes needed to increase per caput supplies by 10 percent by 2010. This is similar to recorded recent growth rates and may be possible. Much depends on whether growing environmental concerns and the closer scrutiny of sustainable forms of production do not slow down expansion of the intensive and highly competitive forms of aquaculture production that are typical of the region.

Former USSR

The former USSR republics have limited population growth in common with Europe. This simplifies the task of the aquaculture industry which should grow by only 17 000 t to meet the challenge of maintaining 1996 supply levels, and 360 000 t if it has to increase supply by 10 percent. This second scenario means essentially recovering the aquaculture production levels that this region had in 1990. After a number of years of sharp decline in production, there are signs of recovery of production that still need to be still confirmed. The future of aquaculture in these republics seems to be more linked to programmes aimed at economic recovery and to institutional changes that remain uncertain, than to the physical possibilities for expansion of production.

North America

The challenge is considerable, given the relatively limited production levels and the difficulty to increase exploitation of marine stocks. Recorded aquaculture growth rates do not support the production of an additional 1.25 million tonnes (an increase of 200 percent in 13 years) needed to maintain the 1996 supply level. More likely, the region will increase its imports and diversify with other forms of animal protein supply since there is not a clear preference for fish protein.

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South America

South America would require an additional 650 000 t to maintain the 1996 supply level, or double the 1997 production, and 1 million tonnes in the case of a 10 percent expansion of per caput supply. However, this is a region where the Pacific coast is potentially very rich in fish although historically exposed to large variations in catch due to climatic factors. It is rather difficult to predict the stock situation, especially for pelagics, in the next ten years. Aquaculture production in the region is expanding rapidly, thanks essentially to the efforts of the private sector in a few countries. However, the bulk of the production is oriented to export. Since large countries like Brazil and Mexico are now promoting aquaculture development, both for domestic and export markets, and the sector is growing rapidly in countries like Chile, it can be expected that at least the first target (scenario A) will be met but with production coming from a few countries.

Oceania

Oceania will require only an increase of 100 000 t to maintain the 1996 supply level, a doubling of the present aquaculture production, and 160 000 t to increase the supply by 10 percent. The region should not have major problems to meet the challenge if a proper environment for growth is provided for the sector. Capture fisheries in New Zealand for the South West Pacific have shown also an increasing trend and could contribute significantly to meet supply targets.

In conclusion, aquaculture seems to have the potential to meet the challenge in most regions. Filling the gap at global level would require a continuous growth rate of 4 percent to maintain 1996 per caput supply levels. However, the global view does not identify the growth needs of individual countries nor highlight the relatively limited amount of trade of aquaculture products. Countries like P.R. China, for example, could surpass the requirements of their domestic market, but it remains to be seen whether scarcity in other countries is going to lead to increased exports or to a modification of production in order to meet the needs of export markets.

1 Population data used in this article are from the United States Bureau of Census.
2 The analysis is related to conventional resources for which sufficiently detailed and long time series exist. The possibilities of exploiting krill, mesopelagic stocks or oceanic squids are not considered.
3 FAO Fisheries Department. 1998. The State of World Fisheries and Aquaculture, 1998. Rome, FAO. 112pp.
4 World Bank Annual Report 1998.
5 Ye, Y. Historical consumption and future demand for fish and fishery products: Exploratory calculations for the years 2015/2030. FAO Fisheries Circular. No. 946. Rome, FAO. 1999. 31pp.
6 Laureti, E. (comp.). (In press). Fish and fishery products: world apparent consumption statistics based on food balance sheets (1961-1997). FAO Fisheries Circular. No. 821, Rev. 5. Rome, FAO.

Responsible Ornamental Fisheries

Devin Bartley
Fishery Resources Division

At the invitation of the organizers, Dr Devin Bartley attended the World Conference on Ornamental Fish (Aquarama 1999) in Singapore. The conference was attended by people from industry, academia, non-governmental organizations (primarily trade NGO's), and hobbyists. The following article contains the main points from Dr Bartley's presentation entitled, "Responsible Ornamental Fisheries" given at the special session on Trade and Conservation; additional information presented by other participants is also included. See also a related story on Ornamental Fish on the FAO News & Highlights web site at: http://www.fao.org/NEWS/1999/990901-e.htm

The ornamental fish sector is an extensive and global component of international trade, fisheries, aquaculture and development. However, the scope of this sector and the impact on human and aquatic communities are often unappreciated and often not accurately known. Global statistics reported to FAO from Members indicate that the export value in 1996 of ornamental fishes was US$206,603,000, while the import value was US$321,251,000. Since 1985 the value of the international trade in ornamental exports has increased at an average growth rate of approximately 14 percent per year (Figure 1). Developing countries account for about 63 percent of the export value. The value of the entire *industry,* when non-exported product, wages, retail sales and associated materials are considered (Figure 2), has been estimated at US$15,000 million. Such a vast and important industry has the potential to contribute to the sustainable development of aquatic resources, but may face challenges due to increased attention to environmental and social issues.

With the levelling or decline in production form many capture fisheries (Figure 3), people are trying to find other ways of using aquatic biodiversity. One option is the sustainable harvest and culture of ornamental fishes. In many developing areas the harvest of fresh and marine ornamental fish provides income where little other options exist for practical employment.

The conservation and sustainable use of ornamental fishery resources, as well as ensuring that benefits are equitably shared by resource providers, are important issues in the face of habitat loss and degradation, harmful fishing practices (over-fishing and destructive fishing, such as the use of cyanide), international trade and introduction of exotic species. These issues are now being addressed by the international community through the Code of Conduct for Responsible Fisheries, the Convention on Biological Diversity (CBD), the Convention on International Trade in Endangered Species of Fauna and Flora (CITES) and others (Table 1).

According to Dr Kevan Main of Harbor Branch Oceengraphic Institution, the majority (> 90 percent) of freshwater ornamental fish are captive bred whereas only about 25 of 8,000 marine ornamental species can be easily raised. However, there is also a strong push to breed and domesticate many high value marine species. The ornamental fish industry relies on the export and import of introduced species, therefore, industry NGOs have taken steps to educate importers, retailers and consumers on the proper handling of ornamental fish to minimize environmental risks. The industry also uses coral, both as dried decoration and as living components of fish tanks. International trade in hard corals is restricted by CITES, and many soft corals, which are not restricted have hard coral bases to which they are attached and as such, the soft corals also become restricted under CITES. Industry NGO's point out that about 3,000 mts of coral are traded in the ornamental fish industry, but hundreds of thousands or millions of tonnes and live coral are mined for

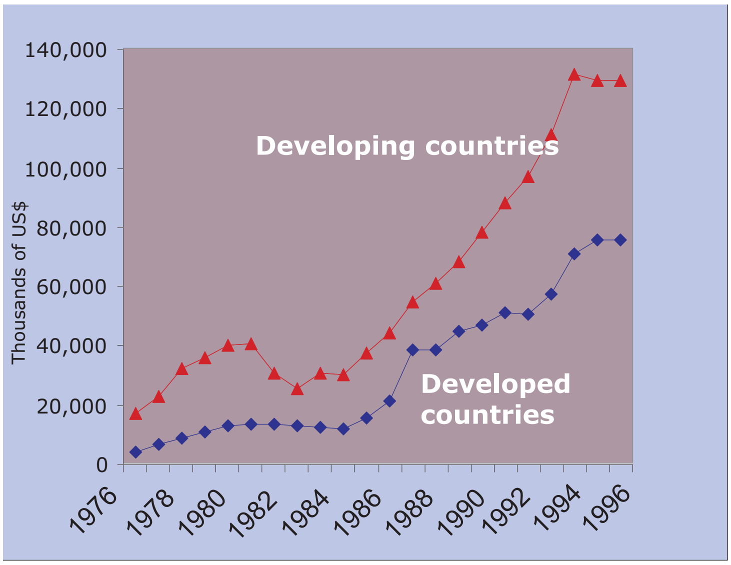

Figure 1. Export value of the ornamental fish trade in developed and developing countries, according to FAO Statistics.

construction purposes (Ornamental Aquatic Trade Association information).

Although the FAO Code of Conduct for Responsible Fisheries does not specifically mention ornamental fisheries, they are assumed to be covered by the Code. The Ornamental Aquatic Trade Association (OATA) has also created a Code of Conduct for the aquarium industry in the UK (http://www.ornamentalfish.org/). Other technical publications and diploma and certificate programmes on water quality, biology and fish health have also been created by industry NGOs . These industry guidelines will help ensure fish welfare and environmental protection.

Although FAO has not been too involved with the ornamental fish industry, there are issues that emerged during the Conference that are of concern and may warrant some involvement from the Fisheries Department:

- Improvement of fishery and trade statistics – It was reported that approx. 8,000 species of marine fish are traded in the industry and most of these are missing from FAO statistics; reporting to FAO is inconsistent due to different countries evaluation of commodities;
- Destructive fishing practices - Some estimates indicate that 20,000 fishers may be using sodium cyanide to capture coral reef fishes that destroys coral reefs and other organisms, and results in eventual death of harvested fish.
- Aquaculture development – of the 8,000 marine species traded, approximately 25 can be bred and cultured. There is a strong move to breed and domesticate high value marine species and endangered species (Figure 4). However,

Figure 2. Ornamental fish, sold in plastic bags in Bangkok's "Chat o Chak" market, support activity in related articles such as fish food, aquarium supplies and plants.

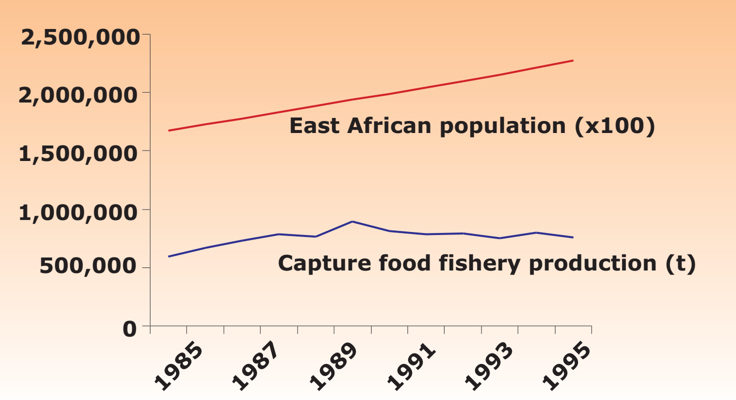

Figure 3. East Africa, example of an area, i.e. the Great Lakes of Africa, where capture of ornamental fish trade is practised in light of stagnating food fisheries and increased population growth. Capture food fishery production total from seven East African countries and their population total (FAO and UN Statistics).

farming runs of the risk of displacing small-scale harvesters in areas such as Sri Lanka.

- Income generation – In areas with little other options for environmentally sustainable development, some ornamental fisheries are extremely lucrative, for example Dr Wijisekara stated that ornamental fish account for 8 percent of the volume of exported fish from Sri Lanka, but this represents 70 percent of the value. Market access and availability will hinder development in remote areas such as many Pacific Island States.

- Involvement of women – Some culturing and tending of grow-out areas are predominately run by women such as in coral culture in the Solomon Islands.

- Competition from other sectors – Harvest of cardinal tetras in the Rio Negro, Brazil, is competing with a developing sport fishery for large cichlids. As in other uses of freshwater, there are always moves to divert water for agriculture without a full appreciation of the biological resources, e.g. ornamental and food fishes, that are present in water bodies.

- Increased valuation of aquatic resources – Organisms with no value as a food fish have often been destroyed or the habitat that supports them has been degraded; however their value as an ornamental fish provides motivation for fishery management and conservation as in the case of freshwater stingrays from Amazonia.

- Certification and labelling – In light of harmful fishing practices and the potential of overfishing, there is a movement to certify ornamental fishes that are sustainably harvested. For the marine industry this effort is being coordinated by the newly established Marine Aquarium Council with its new Director Dr Paul Holthus.

- Technology transfer – Several speakers, including fishery officers from Sri Lanka, noted that lack of adequate technology transfer in the areas of captive breeding, systems design, and disease diagnosis and treatment was hindering development of the industry.

- Bio-piracy – John Dawes of Aquatic Consultancy brought up the possibility where a fish is taken from a country and traded in the industry by another party without compensation to the country of origin. Sponges and species of gorgonians (soft coral) may be collected or farmed for bio-active compounds that may become valuable pharmaceutical products. This is similar, but not identical, to the concept of Farmers' Rights under the FAO Commission on Genetic Resources for Food and Agriculture. Systems of prior informed consent may need to be developed in this area. However, there are many species in aquaculture that are traded internationally with no compensation for the country of origin, e.g. tilapia, salmon, carps, etc.

The purpose of FAO participation in the Conference was to acquaint the ornamental fish industry with international efforts that may impinge on them and to highlight the FAO Code of Conduct for Responsible Fisheries, as well as for FAO to learn more about this industry. There was strong support from those in attendance to have some involvement of FAO in helping the industry continue to develop responsible practices.

Figure 4. Indonesian farm licensed to raise and sell the endangered ornamental Golden Dragon Fish, *Scleropagus formosas* (inset). Under CITES, each farm-raised fish must be tagged and the sale monitored to ensure wild stocks are not being traded.

The ornamental fish industry and the people that rely on this for livelihood can help ensure that international trade continues in a responsible manner and that the international community does not overly restrict the industry, by becoming aware of the issues and by following and promoting responsible practices that ensure conservation and equitable benefit sharing. Actions toward this end would include, *inter alia*:

- Eco-labelling to ensure sustainable harvest or growing conditions and humane treatment of animals;
- Creation and adoption of voluntary codes of conduct, such as those in the UK, and best practices such as are being developed by Marine Aquarium Council;
- Avoidance of controversial genetic technologies or the creation of novel life forms;
- Health certification for transboundary movements of aquatic animals;
- Promotion of domesticated ornamental fish where appropriate and the promotion of sustainable harvest of natural populations where appropriate;
- Promotion of public zoos and aquaria and other educational fora;
- Encourage more accurate reporting by national governments;
- Encourage species and habitat recovery programmes.

The participants noted the lack of accurate information regarding:

- Status of natural populations harvested for the industry;
- Ornamental aquaculture production; and
- Number and species exported

and suggested that an improved information system and accurate reporting were crucial for the continued growth of the industry.

In light of the above, FI may wish to examine more closely the ornamental fish industry with an initial focus toward improving the information base. FAO Fisheries and the Ornamental Aquatic Trade Association have often exchanged information and have enjoyed an informal, but productive, relationship in the past.

Table 1 – Some important international groups that deal with aspects of the ornamental fish industry

Organization	Mandate	Notes	Contact information
Convention on International Trade in Endangered Species of Fauna and Flora (CITES)	Protection of species that are or may become endangered through international trade	CITES has a 20-year history of influencing trade. It is a legally binding instrument with decisions implemented quickly and directly through listing species on "Appendices" which then restricts trade.	http://www.wcmc.org.uk /CITES/english/index.html
Convention on Biological Diversity (CBD)	Conservation and sustainable use of biological diversity and the fair and equitable sharing of benefits derived from such use.	As CITES, a legally binding instrument, but more recently ratified and with decisions not as easily nor directly implemented. Alien species, upon which the ornamental fish industry is based, has been identified as a principle cause in the loss of aquatic biodiversity.	http://www.biodiv.org
World Trade Organization (WTO)	Liberalization of international trade	Singapore, for example, has almost no tariffs on 107 export items, including live ornamental fishes, from least-developed countries as part of an initiative to improve market access for least-developed countries.	http://www.wto.org
International Office of Epizootics (OIE)	The prevention of the spread of disease	OIE maintains lists of diseases and zones of their occurrence or absence that can be used to restrict trade	http://www.oie.int
World Conservation Union (IUCN)	General conservation	Maintains "Red List" of threatened species that include aquarium species such as dragonfish, *Scleropagus formosas*. Their Species Survival Commission contains specialized groups of experts working on conservation of specific taxon or habitats which include some ornamental species such as coral reefs, freshwater fishes, and sturgeon.	http://www.iucn.org /themes/ssc/siteindx.htm
Ornamental Aquatic Trade Association (OATA)	Industry NGO promoting responsible ornamental fish trade and consumer practice	Active public awareness and information programme and strong industry advocate in international fora.	http://www.ornamentalfish.org/
Ornamental Fish International (OFI)	Worldwide organization representing the ornamental fish industry for the trade of animals, plants and equipment	Source of international trade and biological information on ornamental fish, plants and aquarium supplies.	http://www.ornamental-fish-int.org
Aquatic Conservation Network (CAN)	Conservation of aquatic life with an emphasis on freshwater fishes	Maintains an international directory of aquarists to foster communication and also publishes guidelines for captive breeding of threatened and endangered fishes.	http://www.acn.ca/index.html
Marine Aquarium Council	To promote and conserve the marine aquarium industry, the marine organisms it is based on, and the habitat that supports them.	Is developing "best practices" and a certification programme for sustainably harvested marine aquarium fishes.	http://www.aquariumcouncil.org/

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DNA-based molecular diagnostic techniques:

Research needs for standardization and validation of the detection of aquatic animal pathogens and diseases

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During 7-9 February 1999, FAO in collaboration with NACA, ACIAR, CSIRO, and DFID conducted an Expert Workshop on DNA-based Molecular Diagnostic Techniques: Research Needs for Standardization and Validation of the Detection of Aquatic Animal Pathogens and Diseases. Twenty-two experts, most of them who are currently working on the development of DNA-based rapid diagnostic techniques for the detection of aquatic animal pathogens, and representatives from other concerned agencies participated in this workshop which was held at NACA Headquarters (Bangkok, Thailand). The workshop comprised a series of papers on issues related to the use and limitations of DNA-based diagnostic technologies and related research needs, and a series of selected focus groups considering finfish, mollusc and shrimp pathogens. The report of the workshop together with the review papers are being published as a FAO Fisheries Technical Report. This article outlines the background and the major findings and recommendations from the workshop.

Impact of disease on aquaculture

Disease outbreaks are recognized as a significant constraint to aquaculture production and trade, affecting both the economic development and socioeconomic revenue of the sector in many countries in the world. Disease is now recognized as the primary limiting factor for shrimp farming today, and the impact of aquatic animal diseases on sustainable rural livelihoods also been duly recognized among the communities where aquaculture plays a role in rural development. Various factors have been related to the apparent increased incidence of disease. Environmental factors and poor water quality, sometimes resulting from increased self-pollution due to effluent discharge and pathogen transfer via movements of aquatic organisms, appear to be an important underlying cause of such epizootics.

The effective control and treatment of diseases of aquatic animals requires access to diagnostic tests that are rapid, reliable and highly sensitive. In many cases, post-mortem necropsy and histopathology have been the primary methods for the diagnosis of fish and shellfish diseases. However, these methods often lack specificity and many pathogens are difficult to detect when present in low numbers or when there are no clinical signs of disease (Ambrosia and De Wall, 1990). Direct culture of pathogens is also widely used for detection and diagnosis. However, these methods are time-consuming and costly, and, for shrimp and other crustaceans, cell lines suitable for virus culture have not been available.

Role of DNA-based technologies in diagnosis and pathogen detection

Efforts to overcome these problems have led to the development of immunoassay and DNA-based diagnostic methods including fluorescent antibody tests (FAT), enzyme-linked immunosorbent assays (ELISA), radioimmunoassay (RIA), *in situ* hybridization (ISH), dot blot hybridization (DBH) and polymerase chain reaction (PCR) amplification techniques. The use of DNA-based methods derives from the premise that each species of pathogen carries unique DNA or RNA sequences that differentiate it from other organisms. The techniques offer high sensitivity and specificity, and diagnostic kits allowing rapid screening for the presence of pathogen DNA are moving rapidly from development in specialized laboratories to routine application. DNA probes are expected to find increasing use in routine disease monitoring and treatment programmes in aquaculture, in field epidemiology and in efforts to prevent the international spread of pathogens.

DNA-based methods have been used in diagnosis and for detection of many economically important viral pathogens of cultured finfish and penaeid shrimp. For finfish, tests have been developed for pathogens such as channel catfish virus (CCV), infectious haematopoietic necrosis virus (IHNV), infectious pancreatic necrosis virus (IPNV), viral hemorrhagic septicemia virus (VHSV), viral nervous necrosis virus (VNNV) and *Renibacterium salmoninarum* (see Muroga, 1997; Plumb, 1997). Striped jack (*Pseudocaranx dentex*) broodstock have been screened with the aid of PRC for VNNV, permitting selection of PCR-negative spawners as an effective means of preventing vertical transmission of this pathogenic virus to the larval offspring (Muroga, 1997).

DNA-based detection methods for detection of penaeid shrimp viruses are now used routinely in a number of laboratories around the world. These include probes for such diseases as white spot syndrome virus (WSSV), yellow head virus (YHV), infectious haematopoietic and infectious hypodermal and haematopoeitic necrosis virus (IHHNV) and Taura syndrome virus (TSV) which pose the greatest threat to world shrimp culture production (Lotz, 1997). DNA probes have also been developed for an intracellular parasite and bacteria infecting shrimp. DNA-based techniques will have an important role to play in efforts to develop sustainable shrimp culture in Asia and elsewhere. Production facilities in Thailand are currently using PCR techniques to screen shrimp post-larvae for WSSV. Culturing such larvae in closed (biosecure) or semi-closed culture systems can prevent or minimize viral infections, leading to a viable shrimp industry. The development of specific pathogen-free shrimp stocks will also depend on the use of reliable detection techniques.

The further development and use of DNA-based diagnostic techniques will also assist international efforts to control the introduction of exotic diseases into new geographic areas. Reliable and rapid techniques are needed by national and regional diagnostic laboratories to screen imported fish and shellfish for important pathogens. The Office International des Epizooties (OIE) or World Animal Health Organization, is a veterinary organization with 147 member countries. The OIE (through its Fish Diseases Commission) is responsible for tracking diseases of fish and shellfish that have a serious economic impact on aquaculture and capture fisheries. There is considerable potential to apply DNA-based methods for OIE testing if they can meet the stringent criteria of a standardized, validated, accurate, reliable and accessible diagnostic technique.

Impediments to the use of DNA-based diagnostic techniques

Although offering considerable potential, the routine use of DNA-based diagnostic techniques is hampered by a number of potential problems (Chanratchakool *et al*., 1998). The extreme sensitivity of these methods allows the detection of target DNA present at very low levels. However, positive results provide little quantitative assessment of the infection level, and do not indicate whether the pathogen is replicating or causing disease in the species tested. Thus, carrier status and viability of the pathogen are not determined using DNA-probes. The extremely high specificity of these tests, coupled with the ability of many viruses to rapidly change in genetic structure, can result in failure to detect a virus that has altered its genetic profile. Large differences in sensitivity are related to the PCR method used. PCR methodologies are highly susceptible to contamination by foreign DNA during processing that may result in false positives. PCR tests must be conducted in very well managed, clean laboratories. "False negatives" are easily caused by the selection of inappropriate host tissue sources for detection of the pathogen in question, incorrect choice of DNA extraction method, or low pathogen prevalence in the population sampled. DNA-based detection and diagnostic methods have the potential for widespread application of in aquaculture. As the technology is already being adopted rapidly in developing countries in Asia, there is an urgent need to address these issues and to develop an action plan for research and training activities that will facilitate more effective utilization.

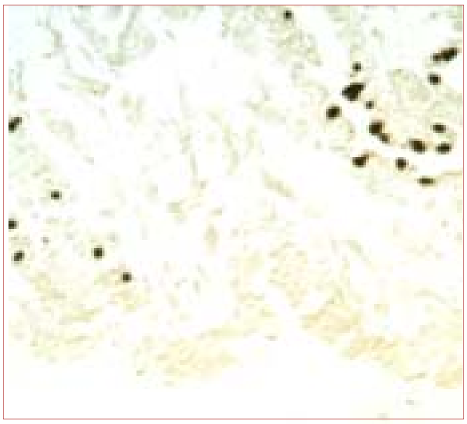

Figure 1. *In situ* hybridization

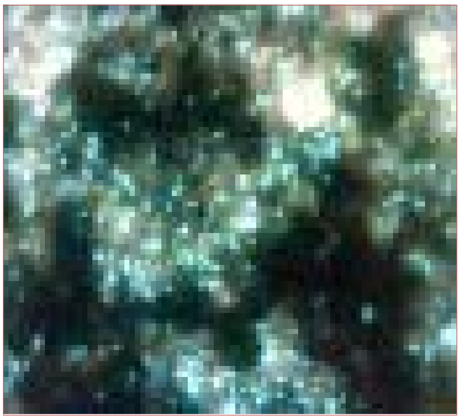

Figure 2. Fluorescence Antibody Test

The expert workshop

The main objectives of the workshop was to (a) identify and prioritize research areas where the introduction and use of nuclear and related technologies is likely to have the most significant impact on improving disease diagnosis, with emphasis on diseases affecting aquaculture, in developing countries, (b) evaluate needs for rapid diagnostic techniques for the principal diseases of cultured fish and shellfish, (c) review the status of research towards meeting these needs, (d) identify problems and key constraints related to establishing international standards for protocols and procedures for such tests and make recommendations towards their solution, and (e) make recommendations for research programmes to be developed by FAO, and other interested and concerned agencies and institutions, to assist developing countries to develop, standardize and validate nuclear related, DNA-based rapid diagnostic tools for major aquatic animal pathogens.

Key outcomes and recommendations

General comments

There is considerable scope for more effective use of DNA-based methods of pathogen detection and disease diagnosis in Asia-Pacific aquaculture. However, implementation of standardized practices that produce reliable, useful and comparable data will require a significant investment in research, training and infrastructure development. Effective implementation will also be assisted by enhanced communication between aquatic animal health practitioners in the region and scientists with expertise in disease diagnosis and pathogen detection.

Although there are some common themes, it is also evident that there are significant differences in the current relevance of DNA-based methods of pathogen detection for the different aquaculture sectors. DNA-based methods are particularly suitable for detection and diagnosis of shrimp and mollusc pathogens because of the absence of an antibody response in invertebrates and lack of suitable cell lines for virus cultivation. In shrimp, the primary pathogens are well known and many DNA-based methods have already been developed. However, in molluscs there is very limited knowledge of pathogens and few diagnostic procedures of any kind are being employed in the Asia-Pacific region. In fish, antibody and culture-based diagnostic methods are available and considered to be robust and effective for routine diagnostic applications. As such, DNA-based methods in fish appear to be most suitable for confirmatory diagnosis and rapid screening of low level or unapparent infections. To achieve maximum impact, it is essential that research and training programmes recognize these differences and are tailored to reflect current levels of knowledge and sector-specific needs.

Where DNA-based tests are available and/or suitable, the most significant impediment to effective implementation is the lack of standardised methodologies that are validated for specific applications. There is a need for international agreement on methodologies that have been rigorously evaluated and accredited for specific applications in disease diagnosis and pathogen screening. There is also a need to ensure that tests are performed by trained staff with access to standardized reagents and suitably equipped laboratories.

Because of existing limitations on the reliability and accessibility of the methods, international standards recommended by OIE do not presently include DNA-based methodologies. However, the potentially high sensitivity, specificity, and relatively low cost (to other detection procedures) of these tests, and the economic returns experienced through accurate detection of serious pathogens has resulted in a surprisingly rapid adoption rate in Asia, particularly for shrimp pathogens. Therefore, it is essential that DNA-based tests are assessed on their merits against existing technologies and that programmes to achieve improved performance and international standardization should be developed. It is also essential that these programmes should assist and complement the activities of OIE in obtaining internationally agreed test standards.

Research needs

There are a number of pathogens for which DNA-based test methodologies are published or available commercially. However, in general, further research is required before standardized and validated DNA-based test protocols can be implemented for disease diagnosis and pathogen detection in the major aquaculture sectors in the Asia-Pacific region. Research needs vary for each pathogen depending on the existing knowledge base and state of the technology.

Recommendation *Programmes of international research cooperation should be developed and coordinated by FAO/NACA. The research should be conducted by managed collaborative networks and provide the information and technology necessary for delivery of suitably specific and validated tests for pathogens of fish, shrimp and molluscs in the Asia-Pacific region. Two research programmes are proposed:*

Programme A: Identification and characterization of potential pathogens of molluscs, shrimp and fish in the Asia-Pacific region.

This programme should focus on improving the knowledge base by identification of new and emerging pathogens (through health screening, epidemiological investigation and subsequent molecular characterisation), relating pathogens in the region to those described elsewhere, and defining the extent of genetic variation between related pathogens in the region. The programme should include the following priority projects:

- Health screening and pathogen identification in molluscs;
- Characterization of WSSV and YHV strain and pathotype variation in prawns;
- Characterization of *Haplosporidium*, *Marteilia* and *Perkinsus* spp. infecting molluscs in Asia;
- Characterization of VNNV strain variation in grouper and other fish of economic importance;
- Characterization of emerging fish diseases including red spot and streptococcal infections.

Programme B: Development and validation of DNA-based diagnostic and detection methods for diseases of aquaculture in the Asian region.

This programme should draw on information currently available or obtained from Programme A to develop suitably specific DNA-based diagnostic methods and to evaluate and validate the methods for disease diagnosis and pathogen screening programmes. The research programme should include the following priority projects:

- Standardization and validation of group and strain-specific DNA-based detection tests for WSSV and YHV-complex viruses;
- Development and validation of species and strain-specific DNA-based detection tests for mycobacteriosis, viral nervous necrosis and epizootic ulcerative syndrome in Asia-Pacific;
- Development and validation of DNA-based detection tests for *Haplosporidium*, *Marteilia* and *Perkinsus* spp. in Asia-Pacific.

Training needs

The implementation of effective DNA-based diagnosis is severely constrained by the availability of scientists and technicians with skills in pathology and molecular diagnostic technologies.

Recommendation. *FAO/NACA should develop training programmes for staff from key laboratories in the region. Training is required in the following priority areas:*

- The use of standard histopathological methods for health screening of fish and molluscs.
- The use of standard DNA-based methods for pathogen detection including sample collection, application of test protocols and the analysis and interpretation of test results. Initially, training should focus on detection of shrimp pathogens.

Communication needs

There is a need to improve communication links between practitioners and scientists with recognised expertise in disease diagnosis and pathogen detection.

Recommendation. *FAO/NACA should establish and maintain species-based (fish, molluscs, shrimp) communication networks of diagnostic practitioners and internationally recognized experts in aquatic animal health. Activities of the networks should include:*

- Exchange on information pathogen distribution in the Asia-Pacific region and the availability of diagnostic tests and reagents;
- Development of cooperative research projects and training programmes;
- Development of cooperative programmes for test validation and laboratory accreditation.

International standardization

Lack of standardization of tests and test protocols is a major impediment to effective implementation of DNA-based methods in the Asia-Pacific region. Standardisation requires international agreement and cooperation in test selection, practitioner training and laboratory accreditation. Improvements in the reproducibility, validity and comparability of data resulting from accreditation will also assist OIE in assessing the suitability of DNA-based methods for detection of listed pathogens.

Recommendation. *FAO/NACA should develop a programme of accreditation of standard DNA-based tests and laboratories with the required standards of operation and expertise to conduct the tests effectively. The programme should be administered by NACA through pathogen-specific reference laboratories with the following functions:*

- Maintain accredited tests and reagents including reference standards.
- Monitor standards and provide technical advise to accredited laboratories.
- Provide definitive diagnosis in difficult or unusual cases.
- Archive pathogens for future reference.

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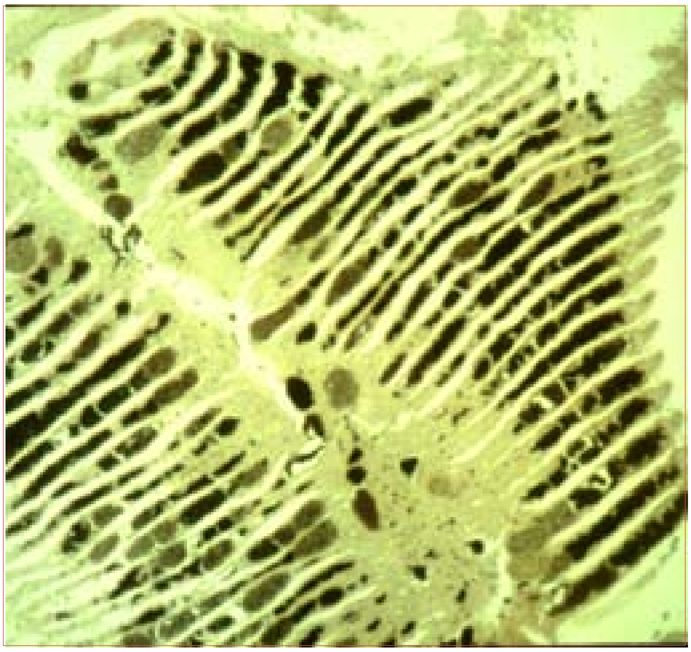

Figure 3. *In situ* hybridization

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Photos courtesy of Drs Gene Burreson (USA) and Sharon McGladdery (Canada)

EXPERT CONSULTATION ON THE PROPOSED COFI SUB-COMMITTEE ON AQUACULTURE

From 28 to 29 February 2000 FAO convened an Expert Consultation on the Proposed Sub-committee on Aquaculture of the Committee on Fisheries in the FAO Regional Office for Asia and the Pacific, Bangkok. The Consultation was attended by 33 participants from 14 countries, two regional intergovernmental organizations, two international non-governmental organizations and the FAO Secretariat. The Consultation was welcomed by Mr Dong Quinsong, Deputy Regional Representative and Officer-in-Charge of FAO's Regional Office for Asia and the Pacific. The Consultation elected Mr Glenn Hurry as Chairperson of the Consultation, and Mr Yugraj Singh Yadava was as Vice-Chairperson. Mr Jiansan Jia, Chief Inland Water Resources and Aquaculture Service, Fisheries Department, FAO, provided an introduction on the purpose and background for the Consultation.

The report of the Expert Consultation will be published by FAO in due course. The Consultation adopted the report on 29 February 2000 and recommended that it be presented to the 24th Session of the Committee on Fisheries (COFI). Following is a summary of the discussions and findings of the meeting.

Background to the Expert Consultation

At the 22nd Session of COFI held at FAO Headquarters in March 1997, the importance of aquaculture as a major provider of food and income was emphasized. Aquaculture has expanded to one of the fastest growing food production sectors, continuously exceeding annual peaks in global production and value, with global production and value levels reaching 36.1 million tonnes in 1997 (1998: 39.4 million tonnes) and with a total value of US$50.4 billion in 1997 (1998: US$52.5 billion). Developing countries produce about 90 percent of total global aquaculture output for both domestic consumption and export. Low-income food-deficit countries account for over 80 percent of global aquaculture production. The report of the 22nd Session of COFI stated, "Given the increasing importance of aquaculture as a means of providing employment and contributing to food security, the Chinese delegation proposed that a sub-committee on aquaculture be established under the Committee's auspices. Owing to budgetary constraints and other factors, some delegations questioned whether such a sub-committee needed to be established or if the work could be accomplished by the Committee. A number of delegations supported the Chinese proposal."

At its 23rd Session in 1999, COFI again, "agreed that sustainable aquaculture could have high potential in securing food availability and poverty alleviation in developing countries. There was broad support in the Committee to the proposal to establish a COFI Sub-Committee on aquaculture. Noting that extra-budgetary funds for such a body had not yet been identified, suggestion was made that consideration be given to funding such a sub-committee from Regular Programme resources. The Committee agreed that the above priorities should be reflected in the Programme of Work and Budget 2000-2001". In order to reduce costs it was considered opportune to hold the Consultation in conjunction with the Conference on Aquaculture in the Third Millennium, which was organized by the Network of Aquaculture Centers in Asia and the Pacific (NACA) in cooperation with FAO and hosted by the Government of Thailand, on 20-25 February 2000 in Bangkok.

The objectives of the Expert Consultation were to:

- to review key issues in aquaculture and to determine those of international importance requiring the establishment of an intergovernmental forum for the development of norms and action aiming at sustainable contribution of aquaculture to food security and economic development in FAO member countries;
- to study the practical implications of the establishment of the proposed Sub-committee on Aquaculture, including the determination of benefits for FAO member countries and interested parties and the financial implications of holding regular biennial meetings;

- to elaborate and draft Terms of Reference and Rules of Procedure of, and outline a possible Programme of Activities for the Sub-committee, including a draft agenda for the first two sessions of the Sub-committee.

The findings of the Expert Consultation

The Expert Consultation concurred:

- with the growing contribution of aquaculture to global food security and economic development;
- with the diversity of international trends that present challenges to the sector and call for greater international cooperation and normative work;
- with the increasing need to address aquaculture in food security issues in a global forum; and
- that a Sub-committee dealing with these issues would facilitate and complement the work of COFI.

The Consultation confirmed that a global intergovernmental mechanism is needed that can provide the opportunity for information exchange, discussion and consensus-building among various parties interested in global aquaculture development and provide means to advise and guide COFI and FAO. The Consultation confirmed that the growing importance of aquaculture and its interactions justified a specific focus.

The Consultation noted the statement of the 1999 Ministerial Meeting on Fisheries, "FAO is the most appropriate forum for addressing vital global fisheries issues and accordingly call on the Organization to assign higher priority and increased share of FAO's regular programme resources to its fisheries programme activities". The Consultation considered that FAO provides the best mechanism for meeting these needs in that FAO (i) provides a global forum for comprehensive, open and transparent treatment of technical, trade, and policy topics, (ii) provides an official interface between governments and links to other relevant organizations, and (iii) is a repository of data from Members and a source of information on aquaculture and fisheries.

The subsidiary and statutory bodies of FAO are valuable fora to aid Members in implementation of the FAO Medium-term Strategy. However, the creation of new bodies within FAO must be undertaken carefully to ensure efficacy and efficiency. The Consultation concluded that the establishment of a Sub-committee would be in line with Conference Resolution 13/97 "Review of FAO Statutory Bodies". The Consultation agreed that the aquaculture sector is sufficiently important to justify the expenditure of funds on the Sub-committee and Members of FAO would be better served by such a Sub-committee.

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In light of the above considerations the Consultation concluded that the formation of a Sub-committee was justified. The Consultation discussed a wide range of relevant issues to be addressed by the Sub-committee, and drafted a set of terms of reference as well as possible elements for a future programme of activities for the Sub-committee for consideration by the next meeting of COFI.

Future programme of action

The Consultation discussed possible contributions of the Sub-committee to sustainable aquaculture development. In selecting and prioritizing the major issues and key areas of international concern, the Consultation emphasized the critical importance of addressing issues of food security and poverty alleviation at local, national, regional and global levels. The role of aquaculture for enhancing food security, alleviating poverty and fostering economic development was therefore considered a primary priority. The Consultation identified six key areas to be addressed by the Sub-committee, as follows:

- The role of aquaculture in food security, economic development and poverty alleviation;
- Consumer issues (food safety, quality and certification);
- Human resource development (training and education), research and extension;
- Environmental aspects of aquaculture development;
- Institutional capacity building and policy development; and
- Statistics, data and information management.

Three specific areas were identified as warranting high priority and immediate attention because of their potential impact and their links with ongoing activities of FAO:

- Improving the collection and analysis of statistics leading to the documentation and quantification of the unfulfilled and fulfilled potential of aquaculture to increase food security and poverty alleviation;
- Support of the implementation of the FAO Code of Conduct for Responsible Fisheries through the development and refinement of best management practices in aquaculture;
- Enhancement of institutional capacity building through networking and strengthened regional and interregional collaboration in all areas and in particular in Africa and Latin America and the Caribbean.

The Consultation felt that these three areas and the identification of appropriate follow-up activities could be considered as elements of the provisional agenda for the first meeting of the Sub-committee. The participant from the P.R. China indicated that there is an offer from his government to host the first meeting of the Sub-committee on Aquaculture and cover local costs.

Workshop on Census of

Structural Aquaculture Statistics

Within the programme of support to national preparation of holding the 2000 round of the World Census of Agriculture, the FAO Statistics Division and the Fishery Department 's Information, Data and Statistics Unit (FIDI), in collaboration with the National Statistical Office of Thailand (NSO) held a 5-day training workshop at which representatives of 14 Asian countries participated. This workshop concluded a series of meetings held in recent years in Asia, where the aquaculture sector is of growing importance, to foster the knowledge of the sector and improve its monitoring. In particular the fifteenth session of the Asia and Pacific Commission on Agricultural Statistics (APCAS) held in 1994 recommended the inclusion of aquaculture in the agricultural census programme (WCA 2000 programme).

The objective of the workshop was to discuss different technological and methodological aspects of undertaking an agricultural census and their application for collecting structural data (e.g. size and type of culture facilities, employment, infrastructure etc) on aquaculture, not only -as it was the case in past rounds of the WCA- by means of very few questions concerning the structure of mixed agri-aqua farms, but through the promotion of a comprehensive inquiry of the structural characteristics of households or economic units practising exclusively fish farming.

A participatory approach was adopted for the workshop. Country reports presented by the participants were interspersed by lectures/ discussions by FAO staff and resource persons on agricultural census taking. Topics included methodological aspects of frame surveys; merits of complete enumeration and sample coverage; quality control and sampling and non-sampling errors; census items in general and aquaculture in particular -including demographic characteristics and employment; tabulation, analysis and dissemination of census results. Items considered essential (e.g. area, types and ownership of culture facilities, seed or ongrowing production activities) for aquaculture were discussed in greater detail. Part of the discussions was on the use of new technologies for conducting census and collecting routinely data and on the importance of planning from early stages the computerized processing of the collected data and their analysis.

A special session was devoted to the NSO, Thailand, on their approaches and experiences of conducting their fishery census.

The workshop sessions took the form of short lectures followed by active participation by all the participants on pertinent issues and constraints relating to including the collection of aquaculture structural statistics within the WCA 2000 programme, other possible mechanisms (e.g. population census, fishery census, livestock census) for collecting structural data and on aquaculture statistics in general.

The purpose of collecting structural and production aquaculture data was stressed and the increasing need for such data in monitoring access to and competition for natural resources, such as land and water, as well as efficiency of land use was emphasised. Although the primary objective of the workshop was to focus on the agricultural census, some participants (e.g. Bangladesh, The Democratic Republic of Korea and Nepal) indicated by way of their country papers and comments that aquaculture monitoring as a whole was in its infancy. Others (e.g. Thailand, the Philippines, Indonesia, the Republic of Korea) reported that the census was inextricably linked with detailed aquaculture sample surveys and annual production surveys. The participants indicated that in many countries all approaches for aquaculture monitoring face fundamental but common problems. Monitoring was often hampered by lack of or an outdated aquaculture frame or listing which made the verification of collected data difficult. Some participants mentioned that inland aquaculture is poorly or not properly recorded due to lack of a frame, while the large numbers of scattered and remote locations of aquaculture units in rural areas was difficult and costly to record. Majority of the participants identified the definition of aquaculture and its separation from fisheries a major problem and considered the FAO tabular guidelines on classification of fisheries activities into aquaculture, enhanced and traditional capture fisheries of practical value in this regard. In addition, discussions also revealed that poor intra- as well as international harmonisation of aquaculture terms (e.g. definition of aquaculture) and variables (e.g. pond area, size of facilities, etc) have hampered the collection of quality data at the grass roots level. Some participants stated

Agriculture 2000 (WCA 2000)

Hat-Yai, Songkhla, Thailand, 28th February-3 March 2000

that the lack of a proper national statistical system made collection of aquaculture statistics a challenge and this together with the lack of or poor capacity to access and disaggregate, aggregated data (e.g. China) made the verification of aquaculture data problematic for the national statistical office. In this regard the participants appreciated presentations on new information technologies (such as specialised computer software) at the workshop. Other considerations included low national priority for monitoring the sector and inadequate allocation of financial resources, particularly when the information has to be collected from a large number of small villages (600 000 in the case of India).

The decision to invite national participants, from the Department of Fisheries (DOF) as well as the NSO was vindicated by the common observation and discussion that co-ordination, co-operation and integration required between the DOF and NSO for monitoring aquaculture was minimal at best. In this regard the outcome of the recommendations on national actions for the improvement of aquaculture monitoring from an earlier SEAFDEC/FAO consultation held in Bangkok in September 1999 on variables and terminology was emphasised.

It was reassuring to note that the workshop had stimulated country participants to explore further the mechanisms for including aquaculture questions on structure or strengthen the questions already planned within the WCA 2000 programme or other censuses such as population census to obtain a frame for detailed aquaculture survey.

Methodological improvements are always timely and commendable. The collation of annual aquaculture statistics reported to FAO by Member and Non-Member countries has been an ongoing activity in FIDI since 1984. At the local and national level the accuracy of these data is a prime function of the national capacity and amount of resource available to understand the structure of the sector. This structure provides the basis from which sampling frames can be derived for the routine collection of the aquaculture data and derivation of indicators that are required for timely and appropriate sector development and tracking of policy. Accurate knowledge of structural characteristics also provides the basis on which aquaculture production and other data can be measured and verified.

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Bangkok 2000 Conference on Aquaculture in the Third Millennium

The first major international Conference on Aquaculture organized by FAO was held in Kyoto, Japan in 1976. The Conference adopted the Kyoto Declaration on Aquaculture. In February 2000, about 540 participants from 69 countries and more than 200 government and non-governmental organizations participated in the Conference on Aquaculture in the Third Millennium in Bangkok, Thailand. This conference was organized by the Network of Aquaculture Centres in Asia-Pacific (NACA) and FAO and hosted by the Government of Thailand. Additional support was provided by the European Union, Australian Agency for International Development (AUSAID), Canadian International Development Agency, the Danish Centre for Environment and Development (DANCED), the Department of Agriculture, Forestry and Fisheries of Australia (AFFA), the Rockefeller Brothers Fund, and the World Bank-Netherlands Partnership.

Throughout 1999, NACA and FAO facilitated the preparation of reviews on aquaculture developments in Africa, Asia, Europe, Latin America, North America, countries of the former USSR, the Near East, and Pacific Island nations and held expert meetings to consider major trends in aquaculture development. Fourteen thematic reviews on selected aspects of aquaculture were promoted and eight overviews on key issues were prepared for presentation and discussion at the Conference. All participants to the Conference received extended summaries of all material prepared. Twenty plenary presentations and discussions, and twelve workshop sessions facilitated by expert panels enabled participants to discuss and prioritize major issues and strategic actions for follow-up.

Major themes discussed included policy-making and planning for sustainable aquaculture development (covering food security and poverty alleviation, rural development, stakeholder involvement, incentives, legal and institutional frameworks), technological and R&D priorities (including systems/species, genetics, health management, nutrition/feeding, culture-based fisheries), human resource development, international trade, product quality and safety and marketing, regional/inter-regional cooperation, financing and institutional support.

Against this background, the Conference participants discussed priorities and strategies for the development of aquaculture for the next two decades, in the light of the future economic, social and environmental issues and advances in aquaculture technologies. Based on these deliberations, the participants adopted the Bangkok Declaration and Strategy for Aquaculture Development Beyond 2000. The Conference encouraged countries and interested stakeholders to incorporate in their strategies for aquaculture development the key strategy elements identified during this Conference. The key strategy elements recommended are:

- Investing in people through education and training
- Investing in research and development
- Improving information flow and communication
- Improving food security
- Improving social sustainability
- Improving environmental sustainability
- Integrating aquaculture into rural development
- Investing in aquaculture development
- Applying innovations in aquaculture
- Managing aquatic animal health
- Improving nutrition in aquaculture
- Applying genetics to aquaculture
- Applying biotechnology
- Improving enhancements and culture-based fisheries
- Improving food quality and safety
- Promoting market development and trade
- Strengthening institutional support
- Supporting strong regional and inter-regional co-operation

A major international trade exhibition "Aquaculture and Seafood Fair 2000" was held in conjunction with the Conference, as a showcase for aquaculture products and related technologies, and provided opportunities for producers, manufacturers and service providers to exchange information with other farmers, and with scientists, researchers, technologists and policy-makers participating in the Conference. Full details of the Conference, including the full text of the Bangkok Declaration and Strategy for Aquaculture Development Beyond 2000 will be published in FAN 25.

Read FAN 25 - A Special Issue on Conference on Aquaculture in the Third Millennium

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Dear Readers of FAN 24,

If you notice some slight differences between this issue and previous issues of FAN, it may be because Dr Ziad Shehadeh, , Senior Fishery Resources Officer (Aquaculture) and who served as the Editor of FAN for 6 years, retired from FAO Fisheries Department on 1 February 2000. A US citizen of Lebanese extraction, Dr Shehadeh earned a B.Sc. from the American University of Beirut in agriculture, a M.Sc. from the University of Michigan in fisheries biology and a Ph.D. from the University of California at Los Angeles in zoology.

Dr Shehadeh's first post-doctoral experience was with the Oceanic Institute in Hawaii, where he became well known for his research on the reproductive biology and physiology of the grey mullet. His first service with the FAO Fisheries Department was as Fishery Resources Officer (Aquaculture) from 1972 to 1976; following FAO he joined the International Center for Living Aquatic Resources Management (ICLARM, 1976-82) as Associate Director and subsequently served as its Director-General. After ICLARM, he then moved to Kuwait where he directed and helped develop the Mariculture and Fisheries Department of the Kuwait Institute for Scientific Research (KISR, 1982-90) into a recognized centre of excellence in the region. Circumstances beyond his control forced him to leave KISR (i.e. the Gulf War) and he took a one-year appointment with the UNDP/World Bank-supported post as Executive Secretary for International Fisheries Research, where he coordinated follow up on the Study of International Fisheries Research (SIFR). He rejoined the FAO Fisheries Department in 1994 as Senior Fishery Resources Officer.

Dr Shehadeh's main responsibilities at FAO since 1994 included the supervision of the normative aquaculture program, with special technical responsibility for finfish mariculture and development trends, and technical backstopping of field projects in the Near East and North Africa region. He was largely responsible for the preparation and evolution of the FAO Review of the State of World Aquaculture and the FAO Aquaculture Newsletter (FAN).

Dr Shehadeh intends to continue his professional career on fulltime basis and has relocated temporarily to Rockville, Maryland. He can be reached at:

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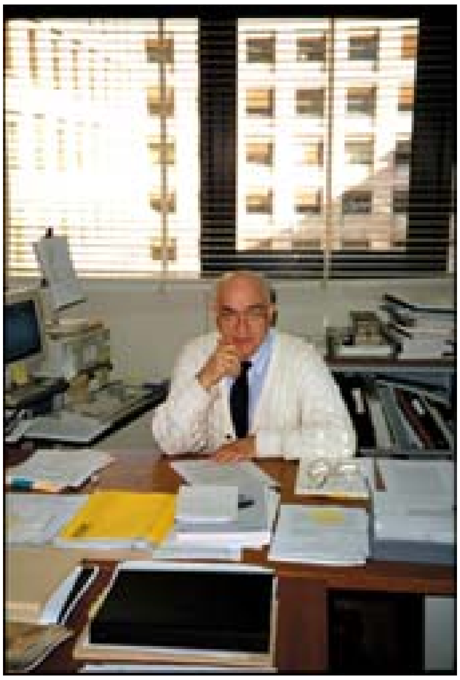
We have jointly taken over the responsibility of editing FAN until we can find a suitable replacement for Ziad, which will not be easy. Ziad has done an excellent job of raising the quality (both in content and aesthetics) of this newsletter and of ensuring that it includes information on important issues from all facets of aquaculture development relevant to FAO and its Members. We hope to include all the regular features that Ziad made a useful part of the newsletter, and we will do our best to include information on aquaculture developments from FAO staff in the field and at headquarters. We wish Ziad and his family a grand time in all their new endeavours.

The editors.



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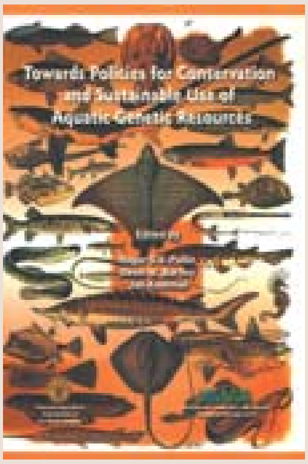
Tave, D. 1999. Inbreeding and brood stock management. FAO Fisheries Technical Paper. No. 392. Rome, FAO. 122 pp.

This manual, written for extension workers, aquaculturists, and those who work with natural resource management programmes, primarily deals with the problems caused by unwanted inbreeding in cultured fish populations and describes management techniques that can be used to prevent or minimize inbreeding. The manual also describes how inbreeding can be used to improve captive populations of fish. The manual contains chapters on: basic genetics and the genetics of inbreeding; how to determine individual inbreeding values when pedigrees are known; how to determine the average inbreeding value in a population when pedigrees are not known; genetic drift, which is random changes in gene frequency; how inbreeding programmes can be used to improve cultured populations of food fish; how to prevent inbreeding depression and loss of genetic variance in farmed populations; and recommendations on how to manage cultured populations of fish to prevent unwanted inbreeding and genetic drift from depressing productivity, profits, and survival. One of the most important aspects of managing a closed population of fish at a fish farm or fish culture station is the management of the population's effective breeding number, because inbreeding is inversely related to the effective breeding number. Techniques to determine and manage the effective breeding number are described, and recommended mininum effective breeding numbers are provided for a variety of farm sizes and fish culture goals. A number of culture techniques can affect inbreeding, and ways to modify them so there is minimal impact on inbreeding are discussed. Finally, ways to minimize inbreeding during selective breeding programmes are described.

Pullin, R.S.V., D.M. Bartley and J.Kooiman, Editors. 1999. Towards policies for conservation and sustainable use of aquatic genetic resources. ICLARM Conf. Proc. 59, 277 pp.



FIRI is pleased to announce the publication, Towards policies for conservation and sustainable use of aquatic genetic resources, edited by R.S.V. Pullin, D.M. Bartley and J. Kooiman (ICLARM Conference Proceedings 59, 1999). The publication represents the proceedings from the ICLARM/FAO Bellagio Conference held in Bellagio Italy, 14 to 18 April 1998. As Dr Louise Fresco, currently Assistant Director-General of the Agriculture Department FAO states in the Foreword to the proceedings, "... the development of sound policies governing the use of aquatic genetic resources has, in general, lagged behind the impressive technical developments. ... this volume represents one of the first efforts at bringing together the diverse information necessary for the development of policies for the sustainable use and conservation of aquatic genetic resources." The proceedings include a wide range of disciplines, such as aquatic biology, aquaculture, population genetics, fish breeding, governance of natural resources, fisheries, public awareness, intellectual property rights, and law, that will all play a role in policy formulation. For information on how to order please contact Devin M. Bartley (devin.bartley@fao.org) or ICLARM Publication Unit Manager PO BOX 500, GPO, 10670 Penang, MALAYSIA (iclarm@cgiar.org).

Fernando, C.H. and M. Halwart. 2000. Possibilities for the integration of fish farming into irrigation systems. Fisheries Management and Ecology, Vol. 7, p. 45-54.

Abstract: Harvesting fish in irrigation systems, sometimes involving some form of husbandry or even culture, is a practice which dates back at least two millennia. Although seldom recorded, it seems to have been widespread in the tropics and subtropics, especially in rice fields. In the present century, improved management for land-based crops and the demands for the successful raising of aquatic organisms were not generally compatible, but with the advent of integrated crop protection, this situation has changed drastically. Moreover, irrigation systems using stored or diverted water have increased exponentially during the past 50 years, but fish farming within these irrigated systems has not expanded equally, and therefore, there is now a huge potential for this integrated enterprise. A systematic approach to fish farming development at irrigation system level which will make this integration a viable enterprise is proposed.

The whole range of aquatic habitats created by irrigation systems can be integrated with fish farming. Small and large irrigation reservoirs, the extensive network of irrigation canals, the irrigated fields themselves, as well as adjacent ponds or aquatic refuges of various sorts are all potentials sites for nursing or grow-out fish. In many countries, there is now relatively easy access to fish seed, even in inland areas. Permanent water bodies should be stocked with a central pool of culture species harvested from short-lived habitats which serve as nurseries. A flexible system of moving culture fish within the system of habitats should be feasible. For example, stocking material for reservoirs can be obtained from irrigated rice fields where the short maturation period of the crop only permits the harvest of fingerlings. If a pragmatic and flexible approach is made to use all habitats for fish production, there could be a year-round supply of fish and a minimum wastage of stocks of cultured fish.

The use of high-yielding fish of good quality is essential for economic viability. In areas where a high diversity of fish with a requisite biomass of desirable species already exists, these indigenous fish can be harvested, but their yields may only be adequate for low-income rural areas. Common carp, *Cyprinus carpio* L., has traditionally been a preferred cultured species. Tilapia are proposed as an alternative because these fish are cheap to raise, give high yields and are also quite palatable.

Aside from economic revenues, this type of integration also involves ecological and social benefits. High densities of fish in irrigation systems enhance the yield of land crops, alleviate the pressure of terrestrial and aquatic pests, and lower the populations of vectors of diseases of man and domestic animals.

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FAO Aquaculture Newsletter

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The FAO Aquaculture Newsletter (FAN) is issued three times a year by the Inland Water Resources and Aquaculture Service, Fishery Resources Division, of FAO's Fisheries Department, Rome, Italy. It presents articles and views from the FAO aquaculture programme and discusses various aspects of aquaculture as seen from the perspective of both Headquarters and the field programme. Articles are contributed by FAO staff from within and outside the Fisheries Department, from FAO regional offices and field projects, by FAO consultants and, occasionally, by invitation from other sources. FAN is distributed free of charge to various institutions, scientists, planners and managers in Member Countries and has a current circulation of about 3,000 copies.

It is also available on the FAO internet Home Page:
http://www.fao.org/waicent/faoinfo/fishery/newslet/newslet.htm

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