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Report of the

FAO EXPERT WORKSHOP ON THE USE OF WILD FISH AND/OR OTHER AQUATIC SPECIES AS FEED IN AQUACULTURE AND ITS IMPLICATIONS TO FOOD SECURITY AND POVERTY ALLEVIATION

Kochi, India, 16–18 November 2007

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PREPARATION OF THIS DOCUMENT

This is the final version of the report of the FAO Expert Workshop on the Use of Wild Fish and/or Other Aquatic Species as Feed in Aquaculture and its Implications to Food Security and Poverty Alleviation held in Kochi, India, from 16 to 18 November 2007, in collaboration with the Marine Products Export Development Authority (MPEDA), India. The workshop was organized by the FAO Fisheries and Aquaculture Department as a part of the consultative process of the component 4 of the ongoing project *Towards Sustainable Aquaculture: Selected Issues and Guidelines* (GCP/INT/936/JPN). The project is funded by the Government of Japan and is implemented by the Aquaculture Management and Conservation Service (FIMA) of the FAO Fisheries and Aquaculture Department.

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ABSTRACT

The FAO Expert Workshop on the Use of Wild Fish and/or Other Aquatic Species as Feed in Aquaculture and its Implications to Food Security and Poverty Alleviation was convened in Kochi, India, from 16 to 18 November 2007. It was attended by a wide range of researchers, development specialists and industrial experts in aquaculture from around the globe and was hosted by the Marine Products Export Development Authority (MPEDA), India. The workshop was organized with three objectives: a) to review and analyse the status and trends of feed/reduction fisheries and the use of low-value/trash fish in aquaculture production; b) to identify key issues and challenges for sustainability of these fisheries in relation to food security, poverty alleviation, long-term ecological sustainability and environment; and c) to prepare an outline for technical guidelines on the "Use of wild fish and other aquatic species as feed in aquaculture". The workshop consisted of technical presentations and working group discussions. The technical presentations were intended to orient the participants about the interregional commonalities, differences and issues pertaining to the use of wild fish as feed in aquaculture and included regional reviews, case studies, a global synthesis and a number of invited presentations. The workshop served to address the following thematic areas and other issues of significance emerging from the regional reviews and case studies: a) fisheries management; b) policy development; c) food security; d) poverty alleviation; e) social and ethical issues; and f) aquaculture technology and development. Following several working group deliberations, the workshop agreed on a series of principles and guidelines on the use of wild fish as feed in aquaculture, concluded that such use should be governed by the above guiding principles and recommended a number of actions for the FAO to undertake to address issues raised. The workshop proceedings including the working group discussions and recommendations, regional reviews, case studies and global synthesis will form the basis of two major documents: a) an FAO Fisheries Technical Paper "Fish as feed inputs for aquaculture and its implication to food security and poverty alleviation"; and b) FAO Technical Guidelines for Responsible Fisheries on the "Use of wild fish and other aquatic species as feed in aquaculture". The Technical Paper that will include the global synthesis, regional reviews and case studies, as well as a summary of key issues and findings on the status and trends in feed/reduction fisheries is currently in preparation and will be published in due course.

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BACKGROUND TO THE WORKSHOP

The issue: use of wild fish as feed

1. In 2005, the global aquaculture production (including aquatic plants) was estimated at 62.96 million tonnes and valued at US$78.38 billion (FAO, 2007). The average annual percent growth rate (APR) of the aquaculture sector between 1990 and 2004 was 9.4 percent. Aquaculture has contributed significantly to food security and poverty alleviation in different parts of the world in parallel with the development of profit-oriented entrepreneurship (Hasan, 2001). Along with this growth, there has been an increasing trend within most developed and many developing countries towards the use of compounded pelleted feeds for farmed finfish and crustaceans, and some molluscs.

2. In 2005, about 28.2 million tonnes or 44.8 percent of total global aquaculture production (excluding filter-feeding species such as silver carp and bighead carp) was dependent upon the direct use of feed, either as a single dietary ingredient, farm-made aquafeed or by the use of industrially manufactured compounded aquafeeds (FAO, 2007). Compounded feeds are used both for the production of lower-value (in marketing terms) staple food-fish species such as non-filter feeding carps, tilapia, catfish and milkfish, as well as higher-value species such as marine finfish, salmonids, marine shrimp, and freshwater eels and crustaceans.

3. Fishmeal and fish oil are two major dietary ingredients used in compounded aquafeeds. Total estimated compound aquafeed production in 2006 was about 25.4 million tonnes (Gill, 2007). It is estimated that in 2006 the aquaculture sector consumed about 3.06 million tonnes or 56.0 percent of world fishmeal production and 0.78 million tonnes or 87.0 percent of total fish oil production (Tacon, 2007). In 2006, the total global industrial feed output exceeded 635 million tonnes to which the aquafeed industry contributed only four percent (Gill, 2007). In addition to fishmeal and fish oil used in compounded and farm-made aquafeeds, low-value fish or "trash" fish is used in different parts of the world as a complete or supplementary feed for farmed fish, crustaceans and a few molluscan species. It is generally estimated that an approximate 5 to 6 million tonnes of low-value/trash fish are used as direct feed in aquaculture world-wide (Tacon, Hasan and Subasinghe, 2006), particularly for marine carnivorous fish species in the People's Republic of China and in several Southeast Asian countries (e.g. Viet Nam, Indonesia, Thailand), marine crustaceans (lobsters and crabs) and certain freshwater fish species. Other fishery products used in the production of aquafeeds are krill meal, squid meal, squid liver powder and squid oil, shrimp meal and crab meal, and the market size for these products within aquafeeds is currently estimated to be about 0.29 million tonnes (range: 0.19 to 0.52 million tonnes) (Tacon, Hasan and Subasinghe, 2006). Finfish and crustacean aquaculture is therefore, highly dependent upon capture fisheries for sourcing feed inputs, either in the form of fishmeal and fish oil, low-value/trash fish or other marine resources.

4. Although capture fisheries provide a significant input for the growth of aquaculture production, questions surrounding the ethics and long-term sustainability of this practice are often raised. The global fishmeal industry observes that there might not be enough demand (i.e. for direct human consumption) for 90 percent of the wild-caught fish that is reduced to fishmeal. However on a regional or on an individual country basis it is possible that a good proportion of the reduction fishery products is simply not available for human consumption, though if available a certain portion of it would certainly have been consumed. In Asia and Africa, small-pelagic fish are an important component of the diet of lakeside and coastal communities. In several countries the increasing demand for pelagic fish by the animal feed industry is reducing the availability of fresh fish for poor communities, and this has a negative impact on food security. Nevertheless, it has also been shown that reduction fisheries and downstream animal production activities contribute to employment generation and eventually contribute to improved living standards and hence food security (Hecht and Jones, 2007). This may be the case when the fishmeal is used in the country of origin, i.e. employment generated through the production of fishmeal as well as created through the aquaculture or the animal feed industries where fishmeal is used in aquafeeds.

5. The situation in Europe and the Americas, however, is very different from that in Africa and Asia. The catch of the large feed fisheries targeted for fishmeal and fish oil in Europe is considered to have little alternative uses (Huntington, 2007), although use of species like blue whiting, capelin, anchovy, herring and sprat for direct human consumption is a possibility. However the proportion that goes for human consumption depends largely on economic and cultural factors rather than on technical limitations. Despite the relatively low cost of products originating from small pelagic fisheries, it is unlikely that they would contribute significantly towards ensuring the food security in any part of Western Europe, largely due to the ready availability of other nutritional options. Although Japanese and Eastern European markets have shown interest in utilizing feed fish species such as capelin for human consumption, the volumes are low and are not likely to grow significantly. In case of Latin America, some fish species (e.g. mackerel, anchovy), even though acceptable for direct human consumption, are available in too large quantities relative to the size of nearby markets.

6. Further, there are issues related to the long-term ecological sustainability of reduction/feed fisheries. Feed fish are mainly short lived, small pelagic fish that show a high level of inter-annual variability that may depend upon extrinsic, often climate-related factors. For example, the Peruvian anchovy fishery (which represented over a quarter or 28.5 percent of the total estimated marine fisheries landings destined for reduction in 2003) is extremely vulnerable to the El Niño southern oscillation events (Tacon, Hasan and Subasinghe, 2006). Although the high levels of fecundity of small pelagic fish species and the relatively short life cycles permit stocks to recover relatively quickly and thus provide a certain degree of protection from high levels of exploitation, the consequences of stock variability on natural predators, as well as the contribution of fishing mortality to these variations in stock sizes, are not fully understood.

7. Although quality and price are the main determinants for fishmeal purchasers in the aquafeeds industry, the sustainability of feed fish sources is beginning to become increasingly important. At present, most buyers depend upon the FIN "Sustainability Dossier"[1] for information on what stocks are "sustainable" or not, but there is a recognized need for a comprehensive analytical framework that integrates target stock assessment with the wider ecosystem linkages (Huntington, 2007).

8. The above scenarios, therefore, call for a comprehensive study and analysis to determine the sustainability of feed fisheries in relation to food security, poverty alleviation, long-term ecological sustainability and environment and indeed the growth and sustainability of important subsectors of the aquaculture industry.

The context

9. With funding from the Government of Japan, the Aquaculture Management and Conservation Service (FIMA) of FAO is implementing a project *Towards Sustainable Aquaculture: Selected Issues and Guidelines* (GCP/INT/936/JPN). Of the five key thematic areas identified for targeted action under the above project, Component 4 of the project addresses the issue of "Use of wild fish and/or other aquatic species to feed cultured fish and its implications to food security and poverty alleviation". Component 4 would assess and review the status and trends of wild fish being used as aquafeeds, the types of uses for aquaculture (fresh or processed), the relative amount used for aquaculture and the potential alternative uses e.g. for human consumption. The project is expected to develop policy and technical guidelines on sustainability issues of reduction/feed fisheries, including its improved management and the criteria for its sustainable use as aquafeeds. This is expected to

[1] Fishmeal Information Network (FIN) Sustainability Dossier, an annually updated assessment initiated by the Grain and Feed Trade Association (GAFTA) and funded by the UK Seafish Industry Authority (SFIA). FIN aims to provide the latest information available about fishmeal and its role in livestock production. A key element of this is the assurance that fishmeal is produced from fish stocks that are properly monitored according to independent scientific advice and managed to ensure that supplies are not over-fished, or from the recycled trimmings from the food fish processing sector.
(http://www.nautilus-consultants.co.uk/seafeeds/Files/IFFO-sustainability%20dossier.pdf)

assist policy-makers to decide ways and means of utilizing low-value fish, inter alia through development and application of methodologies to estimate optimal allocations of fish for animal and human purposes.

10. Under this component, four regional reviews (Africa and the Near East, Asia and Pacific, Europe and Latin America and North America) and five country-specific case studies from Asia and Latin America were conducted. The regional reviews specifically addressed the role of feed and reduction fisheries that may impinge on food security and poverty alleviation in these four regions and elsewhere, including sustainability of these finite resources and environmental implication of the direct use of fish as feed. On the basis of the four regional reviews and the five case studies, an attempt was made to develop a global perspective on the status, trends, issues and challenges confronting reduction fisheries and use of fish as feeds.

SCOPE AND ORGANIZATION OF THE WORKSHOP

11. As a part of the consultative process and to review and analyse critical issues related to the use of wild fish to feed aquaculture species, a targeted Workshop on the Use of Wild Fish and/or Other Aquatic Species as Feed in Aquaculture and its Implications to Food Security and Poverty Alleviation was convened in Kochi, India, from 16 to 18 November 2007.

Objectives

12. The workshop was organized with three objectives: a) to review and analyse the status and trends of feed/reduction fisheries and use of low-value/trash fish in aquaculture; b) to identify key issues and challenges for sustainability of these fisheries in relation to food security, poverty alleviation, long-term ecological sustainability and environment; and c) to prepare an outline for technical guidelines on “Use of wild fish and other aquatic species as feed in aquaculture”.

Outputs

13. The workshop proceedings including the working group discussions and recommendations, regional reviews, case studies and global synthesis will form the basis of two major documents:

- FAO Fisheries Technical Paper entitled “Fish as feed inputs for aquaculture and its implication to food security and poverty alleviation”; and
- FAO Technical Guidelines for Responsible Fisheries entitled “Use of wild fish and other aquatic species as feed in aquaculture”.

14. The Technical Paper that will include the global synthesis, regional reviews and case studies, as well as a summary of key issues and findings on the status and trends in feed/reduction fisheries is currently in preparation and will be published in due course.

Participants and workshop venue

15. The workshop brought together acknowledged international experts in the relevant fields, including the authors of regional reviews, case studies, global synthesis and experts from government agencies, universities, international and regional organizations and private industries and organizations (altogether 23 participants from Africa, Asia, Australia, Europe, North America and Latin America attended the workshop). The workshop was hosted by the Marine Products Export Development Authority (MPEDA), India, and was held at the Avenue Regent Hotel, M.G. Road, Ernakulam, Kochi. The opening ceremony of the workshop was inaugurated by Mr G. Mohan Kumar, Chairman, MPEDA and graced by Dr Mohan Joseph Modayil, Director, Central Marine Fisheries Research Institute (CMFRI), Kochi, India, as a guest of honour. Mr B. Vishnu Bhat of MPEDA, India, and Professor Chris G Carter of the University of Tasmania, Tasmania, Australia, were unanimously elected respectively as Chair and Co-chair of the workshop.

***Modus operandi* of the workshop**

16. A number of working documents including regional reviews, global synthesis, case studies and related FAO Fisheries Circulars/Technical Papers were circulated among the participants prior to and during the workshop. The workshop convened both in plenary and in working groups. In plenary, participants heard technical presentations intended to orient them about the interregional commonalities, differences and issues pertaining to the use of wild fish as feed in aquaculture. These presentations included regional reviews, case studies, related research topics and a global synthesis.

17. The workshop served to address the following thematic areas and other issues of significance emerging from the regional reviews and case studies:

- Fisheries management
- Policy development
- Food security
- Poverty alleviation
- Social and ethical issues and
- Aquaculture technology and development

18. The participants were divided into two main working groups namely; 1) *policy development, food security and poverty alleviation* issues and 2) *aquaculture technology and development* issues. A further working group on *fisheries management* was also convened on an ad hoc basis. The two main working groups were tasked with developing guiding principles and recommendations for FAO on steps to develop the guiding principles into technical guidelines. To guide the discussions, each working group was advised to focus on not more than three to five principles, although this was not considered an absolute limit. The working groups were asked to provide comments and recommendations for each of the issues identified. Following several working group deliberations and subsequent reporting to plenary, the workshop agreed on a series of principles and guidelines covering the issues compiled by the working groups.

19. The workshop agenda and timetable is given in Appendix I and list of participants in Appendix II. A technical Secretariat comprising of Dr Mohammad R. Hasan and Dr Matthias Halwart (FAO Aquaculture Management and Conservation Service), Dr Cécile Brugère (FAO Development and Planning Service); and Dr Simon Funge-Smith (FAO Regional Office for Asia and the Pacific) was responsible for technical coordination. Appendix III contains a glossary, Appendix IV a summary of statements made during opening and closing ceremonies and Appendix V summaries of technical presentations.

PRINCIPLES AND GUIDELINES ON THE USE OF WILD FISH AS FEED IN AQUACULTURE

20. The workshop considered that the use of fish as feed is acceptable, but should be governed by the following principles:

Principle 1: Aquaculture should not utilize resources from unsustainable fisheries.

- Where a reduction fishery/feed fishery is not under close management, the aquaculture sector, as a stakeholder, should insist that concrete action must be taken to introduce management measures (CCRF[2] Article 9.1.2[3], Article 9.1.3[4]).

[2] Code of Conduct for Responsible Fisheries (FAO, 1995)

[3] CCRF Article 9.1.2: States should promote responsible development and management of aquaculture, including an advance evaluation of the effects of aquaculture development on genetic diversity and ecosystem integrity, based on the best available scientific information.

- Consumers are encouraged to demand products from those producers who adopt sustainable practices.
- While recognizing that the bulk of some fisheries cater for the reduction industry, fish should be harvested and landed to maximize its use for direct human consumption.

Fisheries management considerations

Principle 2: Guidelines for responsible fisheries should be employed where wild aquatic organisms are harvested for use as feed (CCRF Article 9.1.4[5]).

This principle applies to the major reduction fisheries of the world, which are typically managed fisheries and the stock is specifically targeted for use as feed. In other cases, fish as feed is derived from fisheries that are not managed. Examples of this are where low-value/trash fish are directly targeted for use as feed and in other cases, derived as bycatch from targeted fisheries and landed for use as feed.

- When evaluating existing or proposed operations producing fish for feed, the impact on the harvested fish and the ecosystem must be assessed in terms of sustainability, habitat and social implications.
- Fish for feed should come from a managed fishery or be subject to a management arrangement (e.g. under a regional fisheries management organization [RFMO]). Fish for feed may come from fisheries outside national waters and therefore not be subject to a national fishery management plan. Steps should be taken to ensure responsible and sustainable fishing to enforce conservation and management measures.
- The capture of fish from artisanal fisheries may not be under a comprehensive management regime, but may still be subject to local regulation. Where this fish is being used as both food and feed, the overriding considerations are the equitable allocation and sustainable use of the resource.
- Where aquaculture operations are dependent upon fish for feed, research and development that reduces this dependence should be promoted. During this process, best practices for management, handling and quality control of this production should be employed.

Ecosystem and environmental impacts

Principle 3: Reduction fishery and feed fishery operations should not significantly impact the environment or create significant negative ecosystem-level impacts, including impacts on biodiversity.

- Where the bycatch of a fishery forms a significant part of the catch, ecosystem level impacts may include growth overfishing of bycatch species. Where this occurs, specific management measures must be introduced for the bycatch component. Targets should be to minimize growth overfishing, catch of non target species and juveniles and to reduce discarding.
- The fishing of fish for feed should not significantly impact biodiversity. Research is needed on the effects of biomass removal from specific trophic levels on ecosystem functioning.
- The use of fish for feed should not present a significant risk of disease and contaminant transfer, either to the aquaculture stock, or to wild fish species that exist in the receiving ecosystem. In case of risk of disease transfer, wild aquatic organisms for feed in aquaculture should be processed to reduce this risk.

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[4] CCRF Article 9.1.3: States should produce and regularly update aquaculture development strategies and plans, as required, to ensure that aquaculture development is ecologically sustainable and to allow the rational use of resources shared by aquaculture and other activities.

[5] CCRF Article 9.1.4: States should ensure that the livelihoods of local communities, and their access to fishing grounds, are not negatively affected by aquaculture developments.

Ethical issues and responsible use

Principle 4: Using fish as feed should not adversely impact the livelihoods and compromise food security of poor and vulnerable groups.

- The use of fish as feed in some regions contributes to the livelihoods of many small-scale fishers and farmers. However understanding the negative social impacts stemming from the use of fish for feed is necessary. It is recognized that there are inevitable trade-offs relating to resource allocation. Therefore in the application of the principles on such practices, care should be taken to mitigate negative social and economic impacts.

Principle 5: The use of fish as feed should not be permitted to be governed by market forces alone.

- Policies need to be developed and implemented to ensure equitable access to fish resources and to safeguard food security.
- Markets (allocation of resources) and economic incentives should not operate against the interests of the poor and against the goal of environmental sustainability.

Principle 6: Formulation of policies related to the use of fish as feed should not exclude other users of this primary resource.

- Fish as feed is used for many purposes, including non-human food commodities; consequently there is a need for dialogue and participation among resource users.
- The outcome of this dialogue should be the development of policies and the application of economic measures and regulations that ensure equitable and ethical resource allocation.

Aquaculture technology and development

Principle 7: Aquaculture should be encouraged to make a progressive move away from using wet fish as feed to formulated/compound feeds.

Such formulated/compound feeds[6] (which include industrially produced pelleted feed and farm-made aquafeeds) are preferable, as they increase the flexibility of raw material options and allow the potential for additional control over such characteristics as product consistency, nutritional quality, transport volume, stability and hygiene. The use of formulated feeds should lead to improved environmental performance and enhanced overall efficiency at farm level.

It is recognized that the use of formulated feeds may not be appropriate in all circumstances, especially in locations with poor infrastructure or where wet fish supplies are available from sustainable fisheries. This issue should be treated on a case-by-case basis using cost-benefit analyses that incorporate environmental and social parameters where possible.

- As a first step, suitable raw materials should be identified from both aquatic and terrestrial sources. Use of these raw materials from alternative sources must not transfer risk[7] to fish and to human health.

[6] A feed composed of several ingredients of vegetable or animal origin in their natural state, fresh or preserved, or products derived from the industrial processing thereof, or organic or inorganic substances, whether or not containing additives, for oral feeding in the form of a complete feed.

[7] Presence of dioxin (polychlorinated dibenzo-para dioxins [PCDDs] and polychlorinated dibenzofurans [PCDFs], dioxin-like PCBs (polychlorinated biphenyls [PCB]) and other environmental contaminants in feed ingredients of aquatic origin, endogenous antinutritional and adventitious toxic factors in plant ingredients, transmissible spongiform encephalopathies (TSEs, also known as prion diseases) in rendered animal products (e.g. meat meal, bone bean, meat and bone meal) and risk of transfer of avian influenza or bird flu and other zoonotic agents from poultry by products.

- Consideration should be given to culture of aquafeed resources, e.g. polychaetes, algae, Artemia, molluscs, etc.
- The use of locally available raw materials obtained from sustainable sources should be promoted whenever possible, including fishmeal for aquafeed production.
- Where most of the ingredients are imported, centralized feed production at the port of entry is likely to be the preferred option for logistical reasons.
- Where appropriate, develop and promote local fishmeal and aquafeed manufacturing sectors to both address specific local needs and to improve access to formulated feeds, as this will provide additional livelihood opportunities to local populations.
- All fishmeal and aquafeed manufacture must meet minimal environmental standards and product quality requirements.
- Feed manufacturers and suppliers have a responsibility to provide appropriate quality feeds and to assist farmers in managing and presenting these feeds on-farm in ways that facilitate efficient and optimal uptake by the stock[8] (CCRF Article 9.4.3[9]). There is an additional responsibility to declare all raw materials used in feed manufacture and the final nutritional composition.
- In certain regions, plans may be drawn up aiming to rationalize the number of farmed species that are dependent upon fish for feed. This will have a positive effect on feed development, sector logistics and farm-level performance.
- It is important to identify and address the perceived concerns, barriers, threats and risks to the adoption of new feed technologies and raw material alternatives.
- Education, extension and demonstration, best management practices (BMPs), training and capacity-building are required to promote the adoption of new feed technologies, aquafeed manufacture and the use of alternative raw material.

Principle 8: The use of fish as feed should not compromise food safety and quality of aquaculture products.

- The quality and freshness of raw aquatic materials should be maintained at all stages in the supply chain.
- As persistent contaminants may be concentrated in feed fish, monitoring and control should ensure that levels be minimized in the finished feed and final products, in accordance with internationally recognized standards, to ensure that food safety and product quality are maintained.
- It is recognized that it is sometimes feasible to reduce contaminant content to acceptable levels using processing technologies.

Principle 9: The use of alternative raw materials (both animal and plant) should not compromise food safety and quality of aquaculture products.

- It should be considered that the use of alternative materials may introduce additional risks such as pesticide contamination, antibiotics, genetically modified organism (GMO) side effects, TSEs as well as sustainability issues.
- Intraspecies recycling is an increasing practice in certain regions, and it is considered that this is not an advisable practice for biosecurity concerns and to avoid the potential accumulation of environmental contaminants.
- When feeding materials are derived from other fish, comprehensive monitoring should be undertaken to determine possible negative impacts.
- If cultured raw materials are incorporated into aquafeeds, then specific care should be taken to ensure that unacceptable antibiotic residues are not incorporated into the final feed.

[8] FAO Technical Guidelines for Responsible Fisheries No. 5, Aquaculture development (page 29): Selection and use of feeds and additives (http://www.fao.org/DOCREP/003/W4493E/W4493E00.HTM).

[9] CCRF Article 9.4.3: States should promote efforts which improve selection and use of appropriate feeds, feed additives and fertilizers, including manures.

- It is important to increase the awareness of risks associated with the diversification of raw materials utilized for aquafeeds. It is therefore important to develop and standardize risk assessment methodologies as well as establish monitoring and control procedures for the management of alternative raw material use.
- There is a need to develop appropriate communication strategies aimed at informing final consumers about the benefits and risks of fish fed on alternative materials.

Statistics and information needs for management

Principle 10: Management of fisheries requires a sound knowledge base and a decision-making process based on the participation of different stakeholders (e.g. capture fishery operators, traders, fishmeal producers, aquaculture operators).

- In many cases the historical trends in the catch and composition, catch per unit effort (CPUE), quality of catch and economic value, etc., of the fisheries that are producing fish for feed are poorly recorded. This is particularly the case for fish that are the product of mixed assemblage multi-gear fisheries where there is non-selective targeting. Larger reduction fisheries are generally better understood, managed and monitored.
- It is important that the long-term trends in these capture fisheries are monitored to enable more concrete management measures to be put in place and the "real" value of the fisheries to be established. This will also allow more effective decision making concerning the trade-off between the use of catch for food or its diversion into feeds.
- The aquaculture subsectors have varying demands for types and quantities of fish for feed. It is important when discussing the use of resources that the aquaculture subsector using that resource is clearly identified.
- The amount of fish that is caught and utilized for feeds should be reported. It is the responsibility of the state where the fish is landed to report on the usage of fish for feeds.

FINAL RECOMMENDATIONS

Recommendations of the Workshop to FAO

21. The Workshop convened in plenary to compile a series of recommendations to FAO that might expedite the adoption of the draft technical guidelines developed by the working groups:

- The principles and specific guidelines/recommendations agreed upon by the workshop should be reviewed by the Workshop Secretariat to identify those recommendations that can be acted upon by FAO.
- The principles and specific guidelines agreed upon by the workshop must be validated by the Workshop Secretariat against existing FAO guidelines on responsible fisheries (e.g. the CCRF) to ensure consistency in the use of terms and in objectives.
- In order to address the use of fish as feed in aquaculture and other sectors and to determine the significance of such uses on food security and poverty alleviation, the following three immediate actions are recommended:
    i. The level of knowledge and information concerning some fisheries that are currently providing fish for feed is insufficient for effective decision-making and resource allocation. The working group therefore recommends:
        a. That for each of the regions focus is placed on the review and examination of a number of case studies that should: (i) contain time series data showing the composition and trend of catches in feed fisheries; (ii) review the impacts on the stocks exploited in feed fisheries; (iii) evaluate the different uses and channels of disposal for the fish caught; (iv) develop allocation models based on this information and data; and (v) assess the impact of the allocation models on food security in each case.

b. That FAO strongly encourage its member countries to improve their reporting of the fisheries catch for non-direct human consumption and start to provide this information as an annually updated data set. The importance of using this information for good fisheries management was emphasized.

ii. In order to encourage fish farmers to move away from fresh or non-formulated feeds towards formulated feeds, there is a need to better inform farmers and the aquaculture sector regarding the opportunities provided by formulated feeds and the limitations concerning the direct use of fish as feeds.

iii. FAO should initiate a dialogue among all sectors that use fish as feed (e.g. aquaculture, animal feed sector, pet food industry), both globally and at the regional level, to build awareness and consensus on the ethical usage of finite fisheries resources.

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APPENDIX I

Workshop agenda and timetable

TIME	ACTIVITIES
15 November	
	Arrival of the participants in Kochi
16 November – Workshop day 1	
0830-0900	Registration
Session I: Opening and welcome remarks	
09.00-09.45	• Welcome – Mr B. Vishnu Bhat, Director, MPEDA • Opening remarks – Mohammad R. Hasan, FAO • Inauguration – Mr G. Mohan Kumar, IAS, Chairman, MPEDA • Address by the Guest of Honour – Mohan Joseph Modayil, Director, CMFRI • Introduction of the participants • Election of chair • Vote of thanks – Mr P.N. Vinod
09.45-10.00	Introduction and objectives of the Workshop – Mohammad R. Hasan (FAO)
Session II: Presentation of Regional Reviews: Key Issues (20 minutes for each presentation) Chair: B. Vishnu Bhat; Co-chair: Prof Chris G. Carter; Rapporteur: Tim Huntington/Thomas Hecht	
10.00-10.20	Use of wild fish and other aquatic organisms as feed in aquaculture – a review of practices and implications in **Africa and the Near East**: key issues to be addressed – Thomas Hecht
10.20-10.40	Use of wild fish and other aquatic organisms as feed in aquaculture – a review of practices and implications in the **Asia Pacific region:** key issues to be addressed – Sena S. De Silva
10.40-11.00	Use of wild fish and other aquatic organisms as feed in aquaculture – a review of practices and implications in **Europe:** key issues to be addressed – Tim Huntington
11.00-11.20	Use of wild fish and other aquatic organisms as feed in – aquaculture – a review of practices and implications in the **Americas:** key issues to be addressed – Albert G.J. Tacon
11.20-12.00	General discussion on regional reviews
12.00-13.30	Lunch
Session III: Presentation of case studies and invited presentations (20 minutes for each presentation) Chair: B. Vishnu Bhat; Co-chair: Prof. Chris G. Carter; Rapporteur: Tim Huntington	
13.30-14.50	• The global production of fishmeal and fish oil – Andrew Jackson, IFFO • Status and trends on the use of small pelagic species for reduction fisheries and for human consumption in South American countries-key issues to be addressed – Adrián J. Hernández, Universidad Católica de Temuco, Chile • Impact of low value/trash fish use in aquaculture in Asia-Pacific – Simon Funge-Smith, FAORAP • Use of low value/trash fish in coastal and marine aquaculture in Asian countries-emerging trends and key issues to be addressed – Sih Yang Sim, NACA
14.50-15.40	General discussion on case studies
15.40-16.00	Coffee/tea break
Session IV: Presentation of synthesis of regional reviews and case studies Chair: B. Vishnu Bhat; Co-chair: Prof Chris G. Carter; Rapporteur: Thomas Hecht	
16.00-16.50	• Global study on the existing and projected competition between humans and aquaculture for pelagic forage fish species: approach and preliminary findings – Albert G.J. Tacon

	• Use of wild fish and/or other aquatic species as feed in aquaculture and its implications to food security and poverty alleviation- a **global** synthesis – Tim Huntington
16.50-17.40	Discussion on global synthesis
20.00-22.00	Reception dinner hosted by FAO (Hotel Avenue Regent, Kochi)
17 November – Workshop day 2	
Session VI: Working Group discussions Chair: B. Vishnu Bhat; Co-chair: Prof Chris G. Carter; Rapporteur: Mohammad R. Hasan/Tim Huntigton	
08.30-09.00	Mechanisms and guidelines for Working Group (WG) Discussions – Simon Funge-Smith (FAO)
09.00-10.30	• Working Group break up for discussions
10.30-10.50	Coffee/tea break
10.50-11.10	**Presentation on innovative experience/ideas** Assessing performance of ingredients and diets through understanding nutritional physiology of fish – Prof. Chris G. Carter, University of Tasmania
11.00-12.40	Working Group discussions continue
12.40-14.00	Lunch
14.00-15.40	Working Group discussions continue
15.40-16.00	Coffee/tea break
16.00-16.20	**Presentation on innovative experience/ideas** Economic themes of the use of fish in aquafeeds – Cécile Brugère, FAO, Rome
16.20-17.30	Working Group preparation for plenary presentation
17.30-18.00	Presentation of preliminary findings of working group discussion – Tim Huntington/Matthias Halwart
20.00-22.00	Closing dinner in boat cruise in the Cochin backwaters hosted by MPEDA
18 November – Workshop day 3	
Session VI (contd.): Working Group discussions Chair: B. Vishnu Bhat; Co-chair: Prof Chris G. Carter; Rapporteur: Cécile Brugère	
08.30-09.00	Wrap-up on preliminary findings of working group discussion using to identify gaps on key issues
09.00-12.00	Working Group preparation for plenary presentation
10.30-10.45	Coffee
12.00-12.30	Working Group I – presentation to plenary – Sena S. De Silva
12.30-13.00	Working Group II – presentation to plenary – Matthias Halwart
13.00-14.00	Lunch
14.00-15.30	Working Group Chairpersons, Rapporteurs and Technical Secretariat to finalize Workshop recommendations
15.30-16.00	Coffee/tea break
Session VIII: Presentation of Final Workshop Recommendations in Plenary	
16.00-17.30	Presentation of summary recommendations of the Workshop Secretariat Discussion, next steps – Matthias Halwart
17.30-18.00	Wrap up and closure – Mohammad R. Hasan and G. Mohan Kumar
19 November 2007	
	Participants depart from Kochi

APPENDIX II

List of participants

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APPENDIX III

Glossary[1]

Artisanal fisheries
Traditional fisheries involving fishing households (as opposed to commercial companies), using relatively little capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption. Artisanal fisheries can be subsistence or commercial fisheries, providing mainly for local consumption, although products from artisanal fisheries may also be exported. Sometimes referred to as small-scale fisheries.

Baitfish
Bait fish are (mainly pelagic) small fish (e.g. sardines or pilchards) caught for use as bait to attract larger predatory fish. (http://en.wikipedia.org/wiki/Bait_fish). Other definition: Live fish (e.g. minnows, tilapia, goldfish) that are produced commercially in aquaculture to be used as live bait.

Bycatch
Part of a catch of a fishing unit taken incidentally in addition to the target species towards which fishing effort is directed. Some or all of it may be returned to the sea as discards, usually dead or dying.

Compound feeds
A feed composed of several ingredients of vegetable or animal origin in their natural state, fresh or preserved, or products derived from the industrial processing thereof, or organic or inorganic substances, whether or not containing additives, for oral feeding in the form of a complete feed.

Discard (ing)[2]
To release or return fish to the sea, dead or alive, from a fishing vessel.

Feed fish
Fish (or any other aquatic species) of whatever kind used for animal/aquaculture feeds, either processed into fishmeal or fish oil or used in fresh form.

Feed fishery
A dedicated fishery that catches fish for use as feed in aquaculture/animal feed that are either processed into fishmeal or fish oil or used in fresh form.

Fish (= all aquatic species)
Literally, a cold-blooded lower vertebrate that has fins, gills and scales (usually) and lives in water. Used as a collective term, includes molluscs, crustaceans and any aquatic animal that is harvested.

Fishmeal
Protein-rich meal derived from processing whole fish (usually small pelagic fish and bycatch) as well as residues and by-products from fish processing plants (fish offal).

Fish oil
Oil extracted from whole fish or from fish waste.

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[1] Unless otherwise mentioned, all definitions of the terminologies used in the glossary were adapted either from FAO Fisheries Glossary (http://www.fao.org/fi/glossary/default.asp) or FAO Glossary of aquaculture (http://www.fao.org/fi/glossary/aquaculture/default.asp).

[2] Estimates of discards can be made in a variety of ways, including samples from observers and logbook records. Fish (or parts of fish) can be discarded for a variety of reasons such as having physical damage, being a non-target species for the trip, and compliance with management regulations like minimum size limits or quotas.

Forage fish
Fish species that as adults are small enough to be prey of larger species, often nongame fish. (http://cancerweb.ncl.ac.uk/cgi-bin/omd?forage+fish). Also defined as any fish eaten by large predatory fish, seabirds or marine mammals. They are usually abundant and often swim in large schools. (http://www.absc.usgs.gov/research/seabird_foragefish/foragefish/index.html)

Formulated feeds
Two or more feed ingredients proportioned, mixed and processed according to certain specifications.

Growth overfishing[3]
Occurs when too many small fish are being harvested too early, through excessive fishing effort and poor selectivity, and the fish are not given enough time to grow to the size at which the maximum yield-per-recruit from the stock would be obtained. A reduction of fishing mortality on juveniles, or their outright protection, would lead to an increase in yield from the fishery. Growth overfishing occurs when fishing mortality is above Fmax (in a yield-per-recruit model). This means that individual fish are caught before they have a chance to reach their maximum growth potential.

Non target species
Species for which the fishing gear is not specifically set, although they may have immediate commercial value (byproduct) and be a desirable component of the catch (bycatch).
(http://uinen.nrm.se/glossary/Glossary.cfm?TermEnglish=non-target%20species)

Overfishing
A generic term used to refer to the state of a stock subject to a level of fishing effort or fishing mortality such that a reduction of effort would, in the medium term, lead to an increase in the total catch. Often equated to biological overfishing, it results from a combination of growth overfishing and recruitment overfishing and occurs often together with ecosystem overfishing and economic overfishing.

Recruitment overfishing
A situation in which the rate of fishing is (or has been) such that annual recruitment to the exploitable stock has become significantly reduced. The situation is characterized by a greatly reduced spawning stock, a decreasing proportion of older fish in the catch and generally very low recruitment year after year. If prolonged, recruitment overfishing can lead to stock collapse, particularly under unfavourable environmental conditions.

Reduction fishery
Generally regarded as a fishery that is geared towards the reduction of the catch to fishmeal and/or fish oil.

Subsistence fishery
A fishery where the fish caught are shared and consumed directly by the families and kin of the fishers rather than being bought by middle-(wo)men and sold at the next larger market.

Trash fish/low-value fish
Fish that have a low commercial value by virtue of their low quality, small size or low consumer preference – they are either used for human consumption (often processed or preserved) or used for livestock/fish, either directly or through reduction to fishmeal/oil.[4]

[3] Growth overfishing, by itself, does not affect the ability of a fish population to replace itself.
[4] Funge-Smith, S., Lindebo, E. and Staples, D. 2005. Asian fisheries today*: The production and use of low value/trash fish from marine fisheries in the Asia-Pacific Region.* FAORAP, Bangkok, Thailand, RAP Publication 2005/16.

APPENDIX IV

Opening and closing remarks

Welcome
B. Vishnu Bhat
Director, MPEDA, Kochi, India

On behalf of the Marine Products Export Development Authority (MPEDA) and the fishery sector of India, Mr Vishnu Bhat welcomed the participants to Kochi (the "Fish Capital of India") in India to attend the FAO Expert Workshop on the Use of Wild Fish and/or Other Aquatic Species as Feed in Aquaculture and its Implications to Food Security and Poverty Alleviation. Mr Bhat explained the function of MPEDA, emphasizing that it also works in aquaculture development as well as aquaculture promotion.

Opening remarks and brief about the Workshop
Mohammad R. Hasan
Fishery Resources Officer, FAO, Rome, Italy

Dr Mohammad R. Hasan, Fishery Resources Officer (Aquaculture) of FAO in Rome, expressed his gratitude to be able to host this important FAO expert workshop. He commenced by thanking Mr Vishnu Bhat for his introduction and then went on to thank authors of the case studies and workshop hosts. He particularly noted that regional reviewers and case study authors have completed an enormous task and showed an equally enormous patience in the editing process. Dr Hasan commented that this workshop represented a key stage in one of five key thematic areas and was centered on the basic inefficacity of using fish for feeds. Essentially the workshop would need to test this premise and recommend appropriate technical guidelines for sustainable utilization of feed fisheries.

Inauguration of the Workshop
G. Mohan Kumar, IAS
Chairman, MPEDA, Kochi, India

Mr G. Mohan Kumar, Chairman of MPEDA, welcomed all the participants to the workshop. He then went on to explain the background to Kochi's fisheries and it's supporting institutes. He explained the degree of use of fishmeal in aquaculture in India, and in particular the low use in the freshwater aquaculture of carp. He emphasized the importance of diversifying feed sourcing and the importance to break down technical barriers. He considered that sanitary and phytosanitary problems, particularly in respect of shrimp aquaculture, are the main barriers to progress, although there was progress currently being made in this area. He stated that India has been "shrimp centric", but needs to diversify its aquaculture product basis. He considered that exports are important for increasing income and employment, especially in the processing sector and emphasized that India has a large domestic market that is increasingly taking processed product that once was destined to the export markets. Against this background is the importance of sustainable production and he recognized the emerging role of the new National Centre for Sustainability of Aquaculture, a recent NACA initiative.

Mr Kumar specifically highlighted the issue of trash and discarded fish and the need to balance between production, sustainability, food security and poverty. In particular he emphasized the need to reduce future dependence on fishmeal and fish oil. He recognized that there are many new opportunities for this, such as polychaete farming, but considerable international debate will be required.

Address by the Guest of Honor
Mohan Joseph Modayil
Director, CMFRI, Kochi, India

Dr Mohan Joseph Modayil, Director of the Central Marine Fisheries Research Institute (CMFRI), added his welcome to those of his colleagues speaking earlier. He explained that the issue of feed fish use in aquaculture was an important issue with considerable uncertainty. He emphasized the need to

balance environmental, economic and social issues, both within and between different Asian countries and therefore the need to work in partnership.

Wrap up and closure

The workshop was wrapped up by Mohammad R. Hasan of FAO, who indicated that he was satisfied that the objectives of the workshop had been achieved and thanked all participants, all organizers, the chairman of MPEDA and the secretariat who helped make the event the success that it was. The closing remarks were made by G. Mohan Kumar, Chairman of MPEDA. In particular he thanked FAO for choosing Kochi as the venue for the workshop and wished everybody a safe trip home.

APPENDIX V

Summaries of technical presentations

Use of wild fish and other aquatic organisms as feed in aquaculture – a review of practices and implications in Africa and the Near East: key issues to be addressed

Thomas Hecht, Rhodes University, Grahamstown, South Africa

This review presents an overview of aquaculture in Africa and the Near East and attempts to summarize the available information on the use of wild fish as feed in aquaculture. Except for isolated instances, the entire region is extremely data poor with respect to the reduction of fish and the use of fishmeal and fish oil in aquafeeds.

Annual landings of small-pelagic fish in the region amount to some 2.3 million tonnes and approximately 200 000 tonnes of fishmeal is produced. At an average reduction rate of 24 percent, approximately 835 000 tonnes of fish (~36 percent of total landings) are reduced to fishmeal and fish oil. South Africa is the only country in the region that has a dedicated reduction fishery. Total fish production through aquaculture in 2004 amounted to some 709 226 tonnes, of which 88 percent was comprised of non-carnivorous species. It was estimated that aquaculture in Africa and the Near East uses between 25 000 and 76 000 tonnes of fishmeal per annum. The animal feed industry in the most important aquaculture-producing countries in Africa uses an estimated 425 000 tonnes of fishmeal per annum, of which aquaculture uses around 16 percent. Therefore aquaculture in Africa and the Near East is a minor consumer of fishmeal. Small-pelagic fish are an important component of the diet of lakeside and coastal communities in Africa. In several countries for which examples could be found, the increasing demand for pelagic fish by the animal feed industry is reducing the availability of fresh fish for poor communities, and this has a negative impact on food security. It has also been shown that reduction fisheries and downstream animal production activities can lead to improved living standards and food security. However this is only the case if the fishmeal is used in the country where it is produced. Recommendations are: (i) to improve monitoring and reporting of fishmeal and fish oil production; (ii) to foster a greater awareness of the potential benefits of small-pelagic fisheries with respect to poverty reduction and access to fish as food; and (iii) to reduce post-harvest fishery losses.

Use of wild fish and other aquatic organisms as feed in aquaculture – a review of practices and implications in the Asia-Pacific: key issues to be addressed

Sena De Silva, Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand

In order to consider the use of fish, directly and indirectly, as feed ingredients in aquaculture in the Asia-Pacific Region, a few of the major past trends in aquaculture development in the region were taken into consideration. In the period 1980 to 2004, the relative percent contribution of each of the cultured major commodities remained almost unchanged and/or changed only by small proportions. Such factors have dictated, in one way or another, trends in the use of fish as a feed source for cultured aquatic animals. The growth in the sector has gone hand in hand with an increasing dependence on fish, either directly and or indirectly, as a feed source.

The use of fish as a feed source can be through direct utilization of whole or chopped raw fish in wet form, through fishmeal (and fish oil) in formulated feeds, and as live fish. The latter is not common and the overall amounts used are relatively small. In the first two categories, the fish used are considered to be trash fish/low-value fish. Attempts to define the latter involve a certain degree of ambiguity and/or subjectivity, suggesting that an accepted definition will remove ambiguity and bring about uniformity in the treatment of the data.

In this synthesis, use of fish as feed sources based on the above three criteria was estimated primarily by using production data supported by assumptions on the inclusion levels of fishmeal in formulated feeds and observed feed conversion efficiencies for aquatic animals fed directly with trash fish/low-value fish. Predictions were based on the assumption of an increase of 10, 15 and 20 percent in production of the relevant cultured organisms from the current level.

The synthesis also dealt with the production of fishmeal using trash fish/low-value fish in the Asia-Pacific Region. The overall fishmeal production in the region is relatively low, amounting to approximately 950 000 tonnes per year. However, there is a trend to increase the use of fish food

industry waste, such as from the tuna canning industry, as in Thailand. The fishmeal produced in the region is low priced compared to globally traded fishmeal, but the quality is also poorer, and there is a need to assess the latter more intensively.

It was estimated that the Asia-Pacific aquaculture sector directly uses 2 388 000 tonnes of fishmeal (equivalent to approximately 10 271 000 tonnes of raw material) and 1 603 000 to 2 770 000 tonnes of trash fish/low-value fish as a feed source The low and high predictions for year 2010 respectively, and in order are 2 000 000 and 2 191 000 tonnes of fishmeal (equivalent to 8 386 000 and 12 829 000 and/or 7 338 000 and 11 225 000 tonnes of raw material, based on efficiency of raw material to fishmeal conversion rates of 4 and 3.5, respectively) and 2 166 000 to 3 862 000 tonnes of trash fish/low-value fish as direct feed inputs. The estimates indicate that there would be a likely reduction in the use of fish as feed sources in the Asia-Pacific aquaculture sector in the ensuing years, even though the overall production will be higher. These reductions are likely to be brought about through better conversion efficiencies in the reduction industry processes, better feed management and because a significant proportion of marine finfish farming will start to rely on formulated feeds.

Available information indicates that a significant quantity of trash fish/low-value fish (conservatively estimated at 2.3 million tonnes per year) is being used by the pet food industry. Although the use of such raw material in the aquaculture sector has been repeatedly seen as a non-sustainable practice, its use in pet feeds has gone unnoticed. Increasingly the pet feeds are using more of relatively high quality raw materials, contrary to the aquaculture sector, which is attempting to reduce its overall usage through better management practices, better feed formulations, etc. The aquaculture sector needs to bring these facts to the forefront in relation to the suggested use of this raw material for direct human consumption to reduce malnourishment and increase animal protein intake.

The study also suggests a "way forward" in addressing the issue of fish as feed in aquaculture in the Asia-Pacific Region. There needs to be a concerted regional research thrust to alleviate the problem of obtaining significant reductions in the use of fish as feed sources in aquaculture, as had been achieved in the animal husbandry sector over the years. In this context some of the underlying difficulties, particularly in comparison to the animal husbandry sector are highlighted. The study also suggests the need for increasing farmer "awareness" in the use of trash fish, not a daunting or an unachievable task considering equivalent progress that has been made in respect of shrimp farming in the region that almost exclusively involves small-scale practitioners that are often clustered in a given locality.

The analysis indicates that the use of trash fish/low-value fish in aquaculture is likely to be more beneficial from the viewpoints of food security and poverty alleviation. These raw materials are mostly landed in areas where there are other suitable fish commodities for human consumption, and their direct use would involve some degree of value adding and transportation costs, which are most unlikely to be commensurate to an acceptable and affordable price to the consumer, particularly in remote rural areas. In such a scenario the channeling of this perishable resource directly and or indirectly as a feed source to produce a consumable commodity makes sense, economically and otherwise, and appears to be the most logical use of a biological resource for overall human benefit.

Use of wild fish and other aquatic organisms as feed in aquaculture– a review of practices and implications in Europe: key issues to be addressed

Tim Huntington, Poseidon Aquatic Resource Management Ltd., United Kingdom

European aquaculture differs from that in other parts of the world in that it is a maturing industry focusing on a limited number of high-value, mainly carnivorous species. As such, the dynamic growth seen over the 1980s and 1990s has slowed, and European aquaculture is now going through a period of consolidation. This said, while growth in salmon and trout farming has slowed, the farming of seabass and seabream – as well as temperate marine species such as cod and turbot – has expanded to take advantage of the strong market as technological barriers are broken. This study considers that, based on recent trends, a cautious growth in production of around 2–5 percent per annum is likely, mainly in the production of these "new" marine species.

Feed fisheries capture and processing only provide a small contribution towards European fisheries-related employment (0.5 percent) and value added (2.8 percent). However they help support an important aquaculture industry that has been dependent upon regional fishmeal and fish oil

production to sustain its growth. Although the relative contribution of regional feed-fish stocks is likely to fall as alternative protein products become increasingly used, it is considered that they will have a continued role to play in the production of European aquafeeds as part of a balanced strategy of sustainable and responsible use. This presentation focused on a number of issues that are considered to be of particular regional significance. These, together with the recommendations, are summarized briefly below:

- *Improving management of European feed fisheries* through a combination of greater political will and cooperation, as well as the gradual adoption of the ecosystem approach as implementation mechanisms evolve;
- *Providing technical and other assistance to feed fisheries outside European waters*, in particular South American and Antarctic resources, through greater cooperation and the strengthening of relevant regional fisheries management organizations;
- *Piloting of innovative management approaches* such as the certification of responsibly managed feed fisheries to provide a market incentive to influence raw material purchasing;
- *Addressing barriers to the sourcing and use of sustainable fishmeal and fish oils* by: (i) adopting well-structured feed-fisheries sustainability criteria to guide buyers; (ii) improving traceability of materials, especially when blending occurs during manufacture or distribution; (iii) encouraging sustainable purchasing strategies through the use of formal environmental management systems; and (iv) premium branding of aquafeeds and aquaculture products produced using sustainable raw materials;
- *Investigating markets for European feed fish and their by-products in Eastern European and Far Eastern markets.* These markets currently absorb between 60 000–100 000 tonnes of Icelandic capelin per annum (60–85 percent of the total), which might be increased. An investigation might focus particularly on emerging markets (e.g. Russia, Romania, Poland and Ukraine) that are traditionally keen markets for small pelagic products. Such an investigation would determine why import levels have remained static over the past five years and determine the sensitivity of price, stock availability and other key factors in constraining trade. The study should also recognize the recent falls in capelin availability and the likely impact on investor confidence;
- *Developing food products for direct human consumption from species that are currently reduced to fishmeal and oils*. These products should be economically competitive, appeal to European and export markets and be resistant to the cyclical nature of fishmeal and fish oil commodity pricing; and
- *Further developing plant-based substitutes for fishmeal and fish oil inclusion in aquafeeds*. These must be able to provide cost-effective alternative to fish-based products, be acceptable to consumers and not raise sustainability issues in their own right. Much of the required research has already been completed to effect significant levels of substitution, but various commercial and consumer issues also need to be addressed.

Use of wild fish and other aquatic organisms as feed in aquaculture – a review of practices and implications in the Americas: key issues to be addressed

Albert G.J. Tacon, Aquatic Farms Ltd., United States of America

Capture fisheries production within the region has a long tradition and in 2004 was estimated at 26.25 million tonnes and represented 27.2 percent of total global capture fisheries production for that year; the region being home to three of the top four nations in the world in terms of total capture fisheries landings. Following the People's Republic of China, these include Peru at 9.6 million tonnes, Chile at 5.3 million tonnes and the United States of America at 5.0 million tonnes. In marked contrast, commercial aquaculture production is of recent origin within the region, commencing in the United States of America with the culture of oysters and channel catfish in the 1950s and 1960s, respectively. Moreover, whereas capture fisheries production within the region has been stagnant over the past decade (landings decreasing by 6 percent since 1995), regional aquaculture production has grown over two-fold since 1995 to 2 093 003 tonnes in 2004 (valued at US$ 6.55 billion), with production increasing at an average compound rate of 8.9 percent per year.

At present over 9.9 million tonnes or 47.2 percent of the total fishery catch within the region is destined for reduction and non-food uses (global average 36.6 percent), with values for the top fisheries producers within the region ranging from 9.0 percent (Brazil), 17.2 percent (Canada), 18.9 percent (Mexico), 21.9 percent (United States of America), 25.0 percent (Ecuador), to 76.4 percent (Chile) and 87.8 percent (Peru). Small pelagic fish species form the bulk of capture fisheries landings destined for reduction within the region, with anchovies, herrings, pilchards, sprats, sardines and menhaden totalling 13.19 million tonnes or 50.2 percent of the total reported capture fisheries landings (26.25 million tonnes in 2004), followed by miscellaneous pelagic fishes (2.68 million tonnes, includes mackerels and capelin), and squids, cuttlefishes and octopuses (0.78 million tonnes).

Total fishmeal and fish oil production within the region from 1995 to 2004 has fluctuated from 2.0 to 3.7 million tonnes (mean of 3.3 million tonnes) and from 0.37 to 0.90 million tonnes (mean of 0.68 million tonnes), respectively. According to the latest fishing industry estimates, the region produced 3.37 million tonnes of fishmeal and 0.55 million tonnes of fish oil in 2005, or 57.3 percent and 57.1 percent of the total reported global fishmeal and fish oil production for that year, respectively. Globally, the region contributed 68.5 percent of total world fishmeal exports and 55.1 percent of total world fish oil exports in 2005, primarily to Asia and Europe, respectively. The domestic aquaculture sector within the region consumed 469 500 tonnes of fishmeal (13.3 percent of total fishmeal production within the region) and 237 910 tonnes of fish oil (35.1 percent of total fish oil production within the region) in 2004; the largest consumers of fishmeal and fish oil being salmonids and marine shrimp (these species accounting for 89.4 percent and 96.1 percent of the total fishmeal and fish oil consumed by the aquaculture sector within the region in 2004). However, there is an urgent need to reduce the dependence of the region's aquaculture sector upon fishmeal and fish oil via alternative, locally available feed ingredients whose production can keep pace with the growth and specific requirements of the sector.

The use of low-value (in marketing terms) whole feed fish species (usually termed as "trash fish") by the aquaculture sector within the region is small and currently restricted to the on-growing and fattening of tuna in Mexico using locally caught sardines, with total consumption estimated at about 70 000 tonnes in 2006. However the use of feed fish as baitfish for commercial and recreational fisheries within the region (primarily the United States of America and Canada) is believed to be greater than that used by the aquaculture sector and is conservatively estimated to be about 100 000 tonnes per annum. The introduction of stricter legislative and environmental controls by member governments within the major fishing nations, including the introduction and implementation of fishing quotas and closed fishing seasons, has given renewed impetus for the fishing industry to process more of the traditional feed-fish species catch for direct human consumption so as to improve profitability. It is anticipated that this trend will increase in the long run as feed-fish supplies remain tight and fishmeal and fish oil prices continue to rise. It is therefore believed that an ever-increasing proportion of the marine fish catch will be processed for direct human consumption within the region, primarily in the form of easy-to-use and ready-to-eat affordable processed fish products such as canned marinates and stabilized surimi-based fish products. Recommendations are provided concerning suggested strategic approaches and future collaborations within the region to increase the proportion of the fish catch processed and used for direct human consumption.

Global production of fishmeal and fish oil

Andrew Jackson, International Fishmeal and Fish Oil Organization, United Kingdom

The International Fishmeal and Fish Oil Organisation (IFFO) is the global trade association representing fishmeal and fish oil producers and related trades. It represents two thirds of world production of fishmeal and fish oil and around 90 percent of exports. It has producer members in almost all production areas, particularly in Europe and the Americas, as well as South Africa.

World reduction fisheries have remained at between 20 and 30 million tonnes for the last 30 years, and this has yielded 5–7 million tonnes of meal and around 1 million tonnes of oil. The major producing area is South America, with Peru and Chile producing around 40 percent of world production, although their output is occasionally severely affected by the development of El Niño conditions. Fishing for the last two years has not been good in the South Pacific due to weak El Niño conditions, but this has now changed and prospects are looking better for next year.

However, there are no major new raw material sources available, and precautionary fisheries management means that fishmeal and oil production is not expected to rise. Indeed, in some areas increasing volumes of raw material are going for direct human consumption.
With the growth of world aquaculture, an increasing amount of fishmeal is destined for use in aquaculture diets, with the percentage rising from 45 percent in 2002 to 57 percent in 2006. This has come from the land-animal sector, particularly from the poultry sector, which is continuously reducing its use of fishmeal as the price has risen. Also around 87 percent of the oil is now destined for aquaculture, with over 50 percent going into salmonid diets.

China is the single largest market for fishmeal, and its usage reached a peak in 2005 of nearly 2.0 million tonnes, with 1.5 million tonnes being imported and the remainder coming from domestic production. Since then, China's usage has decreased sharply, and it is predicted to be only around 1.2 million tonnes in 2007. This sharp reduction is as a result of two factors: one is the sharp price rise in 2006 that resulted in a reduction in fishmeal inclusion in most diets; while the other is the severe outbreak of "blue-ear" disease in pigs, which drastically reduced the number of animals being reared. The subsequent price reduction and the slow recovery of the pig sector means that volumes are expected to increase next year, but meanwhile this year the volume of fishmeal used in China will be the lowest since 1998, at around 1.2 million tonnes.

The recent fall in fishmeal prices and the rise in other raw material prices mean that fishmeal is now cheaper than at any time since 2005 compared to other raw materials, most notably soybean meal. Equally fish oil, despite having risen recently, is still cheaper than for a number of years when compared to other oils.

However, with the growth of global aquaculture and the fixed supply of fishmeal and fish oil, it seems likely that the future trend for prices will be upwards and aquaculture will have to increase its use of other raw materials. Fishmeal and fish oil, once commodities, will increasingly become strategic ingredients used for specialist diets such as starter feeds, broodstock diets and finisher diets.

The issue of sustainability is becoming increasingly important as feed fisheries come under the focus of attention with the growth of aquaculture. For example, there is concern over the rapid growth of fishmeal production in China, which increased from 100 000 tonnes in 1995 to peak at 700 000 tonnes in 1999 (however, it has since declined rapidly and is likely to be only around 200 000 tonnes in 2007).

It is important that any fishing for feed fish is managed within sustainable levels, and IFFO members are committed to this and it is in their own long-term interests. Most of the fisheries used by IFFO members are well managed by governments adhering to the FAO Code of Conduct for Responsible Fisheries, and the evidence is that they are capable of maintaining the present levels of productivity.

IFFO has recently decided to develop a Code of Responsible Practice for the production of fishmeal and fish oil that will cover areas such as responsible procurement of raw material and product safety and purity during production. This is a business to business assurance that the products have been produced in a responsible manner.

Status and trends on the use of small pelagic species for reduction fisheries and for human consumption in South American countries: key issues to be addressed

Aliro Bórquez Ramírez and Adrián J. Hernández, Catholic University of Temuco/Agro-aquaculture Nutritional Genomic Centre, Temuco, Chile

This presentation reviewed three case studies about the use of small pelagic species as fish feed and for human consumption. Two of the case studies concerned the status and trends of small pelagic fish species in Chile and Peru; the third reported on use of the South American anchovy (*Engraulis anchoita*) as raw material for human food.

It is important to review some socio-economic and cultural aspects of Chile and Peru before considering the use of wild fish and its implications for food security and poverty alleviation. Chile is the leading economy of the region. Urbanization has increased during the last 20 years as Chile has become part of a global economy and the average per capita income has grown significantly. This meant that only 18.2 percent of the population lived below the poverty line in 2005. During the past year unemployment levels have fallen and stood at 7.7 percent at the end of 2007. In Peru, on the

other hand, about 53 percent of the population live below the poverty line and unemployment remains high.

Chile and Peru are world-leading producers of fishmeal and land more marine fish than do other South American countries. In spite of its abundant fish stocks, annual consumption of fish is low in Chile, at about 7 kg per person. This has been so during the last 30 years, irrespective of whether fish is expensive or not. Chileans prefer red meats, the annual consumption of which is of the order of 75 kg per person. The situation is similar in neighbouring Argentina, Brazil and Uruguay. In Peru, it is different. Fish consumption is above the world average at about 22 kg per person per year.

As aquaculture has grown rapidly, Chilean fishmeal has been finding a growing domestic market, particularly for the cage culture of salmon, which has become a major force in the Chilean economy. There are those who see the growing use of fishmeal by the Chilean aquaculture industry as worrisome, in particular for the stocks of jack mackerel.

In Chile, the most important landing centers for pelagic species (including jack mackerel) are in the "Bio-bio" region. A case study done there shows that what has been a national trend the last two years also occurs in Bio-bio – that a growing portion of the pelagic catch is channelled into products destined for the human market and that these products are generally more valuable than fishmeal and oil. The use of jack mackerel for human food instead of as aquaculture feed is a scenario that might have positive effects in terms of food security and poverty alleviation. However it is difficult to assert that this would be the case in Chile today. The reason is that there is little local demand for the fish, while it is in demand overseas. However, a reduction in Chilean fishmeal production would not have immediate effects on Chilean salmon aquaculture, as given present rates of fishmeal inclusion in feeds, Chile still exports significant quantities of fishmeal. More fish processing plants would, of course, mean increased employment. In southern Chile, where most of the salmon farming is located, this industry is the dominant source of employment in what was a poor area, so the industry's importance in terms of food security and poverty alleviation is recognized.

In Peru the situation is different. The aquaculture sector is small, almost insignificant in comparison to capture fisheries. However there is a steady increase in the use of small pelagic species as human food. However the fish processing technologies used to convert small pelagics into human food need to be improved, and such an effort appears fundamental in order that the fishing industry can help alleviate the food shortages confronted by the Peruvian population.

The study of the South American anchovy (*Engraulis anchoita*) compared the effects in terms of food security of (i) continuing use of the anchovy as raw material for fishmeal and (ii) converting the fish into dehydrated products of a risotto-type or into a soup formulated with hydrolyzed proteins. The comparison showed that the latter products would have a greater impact on food security than does the production of fishmeal. Assuming products could be sold, production of protein-rich foods from anchovy would have a significant direct impact on food security and consequently, on poverty reduction.

Trends in the use of trash fish/low-value fish in three Asian countries: the primary feed source in marine finfish farming

Sih Yang Sim, Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand

The feed types currently used in Asia for carnivorous marine finfish aquaculture are mainly trash fish/low-value fish and commercial pelleted feed. A series of surveys was carried out in Indonesia, Malaysia and Viet Nam to investigate the practices and trends in the use of trash fish/low-value fish in these countries.

In Malaysia marine finfish farming areas are commonly developed around fishing ports or fish landing sites. In these areas cultured marine finfish tend to be fed with bycatches of trash fish that have little alternative use and would be wasted if not used as fish feed. However trash fish quality is generally poor. Farmers in Malaysia (Kukup, Johor) farmed a variety of marine finfish such as pompano, threadfin, trevally, snappers, etc. Although many farmers have gradually replaced trash fish with commercial feed, grouper farmers still find it difficult to wean their stock to commercial feed. This difficulty is frequently thought to derive from the fact that the cultured stocks originate predominantly from wild-caught fingerlings. Feed cost accounts for about 60 percent of the total operational costs, while trash fish make up about 20–30 percent of this component.

In Viet Nam, many fish farmers are also fishers. Low-value fishery bycatches or unsold catches tend to be used for growing fish. The quality of the trash fish used is relatively good, particularly for the farming of high-value species such as groupers. There are at least 15 species of trash fish used as feed in mariculture in Viet Nam. Commercial feeds are limited. In central Viet Nam, 31 of the 62 farms surveyed produced marine finfish, and all used trash fish as feed. Feed costs averaged around 31–60 percent of the total production cost for most farms but some reached as high as 70 percent. In northern Viet Nam, 53 of the 68 farms surveyed used trash fish/low-value fish as the main food source. For the majority of the farms using trash fish, feed cost was about 41–60 percent of the total operating cost.

In Indonesia four locations were surveyed: Batam, Belitung Island, Situbondo and Lampung. It was found that trash fish/low-value fish are still the main food source for carnivorous species. The quality of trash fish used is very good. Although commercial feeds have been developed for grouper species, they only deliver good results at the nursery stage for about three months. Thus a majority of farmers still used trash fish at the grow-out stage. Feed cost for trash fish averaged about 40 percent of the total operating cost.

Several issues were identified for commercial feeds, including feed quality, use of generic feeds and hardness of the feed. In addition, farmers perceive that trash fish is cheaper that commercial feeds, is easy to obtain, and that cultured fish perform better when fed trash fish as opposed to commercial feeds.

The food conversion ratio (FCR) for commercial feed in grouper farming is relatively high at about 2.64 (Sim, 2006)[1], with some FCRs being even greater than 3. Economic analysis on feed by Sim (2006) showed that trash fish is still cheaper for grouper farming. The equilibrium feed cost level for trash fish versus commercial pelleted feed using FCRs of 13 and 2.6, respectively, is reached at a cost of US$ 0.20/kg for trash fish and US$1.00/kg for commercial pelleted feed. For most small-scale fish farmers, trash fish still appeared to be more attractive, even though the saving was minimal.

It is possible to induce farmers to adapt to commercial feeds provided the feeds deliver good results at a reasonable cost/price. However, small-scale farmers are also fishers and typically live in rural/remote locations where commercial feeds are not cost effective, and they are also commonly associated with traditional cultural practices. Also farmed carnivorous marine finfish species in Asia are diverse, making it difficult for commercial feed companies to sell a generic feed; it is probably not cost effective for them to produce a large variety of feeds aiming to comply with the nutritional requirements of all the cultured species.

Global study on the existing and projected competition between humans and aquaculture for pelagic forage fish species: approach and preliminary findings

Albert G.J. Tacon, Aquatic Farms Ltd, United States of America

The approach of the study is divided into four parts, namely: (i) the market demand and use of fishmeal and fish oil within aquafeeds; (ii) the current demand and projected future demand for small pelagic forage fish as aquaculture feed; (iii) the current and future competition between small pelagic forage-fish fisheries and forage fish for human consumption; and (iv) policy recommendations concerning the management and use of small pelagic fishery resources for food and non-food uses.

A questionnaire concerning the current market demand and use of fishmeal and fish oil within compound aquafeeds and the use of forage fish as aquaculture feed was prepared and sent to over 800 researchers, feed manufacturers, farmers, fishery specialists and other possible interested stakeholders in over 50 countries covering all continents. Preliminary results obtained to date were discussed.

Key issues discussed included the (i) increasing price and competition for fishmeal and fish oil, and effect of price increases on speed of substitution; (ii) increasing competition/demand for energy and the trend toward increased energy, transportation and feed production costs; (iii) competition between humans and animal feed and biofuels sector for use of potential food-grade feed ingredient sources for animal feeding and/or biofuel production; (iv) state of our oceans and rivers and concern for the environment, including the growing importance of feed and food safety issues, and occurrence of environmental contaminants within fishery products including trash fish; (v) the important

[1] Sim, S.Y. 2006. *Grouper aquaculture in three Asian countries: farming and economic aspects*. Ph.D. Dissertation, Deakin University, Victoria, Australia, 254 pp.

contribution of China to total global aquaculture production and lack of understanding and reliable information concerning aquafeed production and use, including use of pelagics and competition with humans and the fishmeal and fish oil manufacturing sector; and (vi) lack of information and understanding concerning the importance and role played by lower-value fish species and small pelagics in the nutrition and food supply of the rural poor within developing countries, including both marine and freshwater species in lakes and rivers.

Use of wild fish and/or other aquatic species as feed in aquaculture and its implications to food security and poverty alleviation – a global synthesis

Tim Huntington, Poseidon Aquatic Resource Management Ltd., United Kingdom

With around three quarters of the world's capture fisheries fully or over-exploited, aquaculture is seen to be the main source for future growth of fish production. Given this finite state of affairs, this paper examines the role of "feed" fisheries in fish and animal farming and asks whether their direct consumption might be preferable on environmental, food security and livelihood grounds. This is a synthesis of four regional analyses and a number of country case studies (e.g., Argentina, Brazil, China, Chile, Peru, Uruguay, Viet Nam) on the subject.

There is a marked difference between the global regions regarding the sourcing and use of fish-based protein for feeds. South America and Europe utilize high performance compounded feeds derived from target feed stocks, although they are increasingly substituting fishmeal with plant-based alternatives due to supply competition with Asia. Asian aquaculture – apart from the intensive culture of marine shrimp – still largely depends upon trash fish and farm-made diets due to their availability and low cost, which is considered to outweigh their poor growth and environmental performance.

There is considerable scope to increase the proportion of some key feed fisheries used for human consumption to address food security concerns, particularly in South America. However this switch depends upon the development of low-cost, easily conserved products that are accessible by poor, inland rural areas. In Asia there is some scope for greater use of low-value fish for human consumption, but again affordability and product preservation are potential limitations.

In terms of food security and livelihood maintenance, such a switch would be beneficial to South American populations in particular. However the situation in Asia is less clear cut, as cheap and seemingly abundant trash fish allows small-scale aquaculture development and the livelihood opportunities that accompany this. In summary, there is no single "answer" as to whether more use of "feed" fish should be made for human consumption. This requires a regional approach that examines all the consequences – economic, social and environmental – of policy change to ensure that inappropriate solutions are not rushed through on the back of simplistic assertions.

Assessing performance of ingredients and diets through understanding nutritional physiology of fish

Chris G. Carter, University of Tasmania, Tasmania, Australia

Traditional methods of diet and ingredient assessment include feed intake, digestibility, nutrient utilization and growth performance. These provide the most direct information about the performance of diets and allow comparisons between ingredients. Integrating these methods into a strategy that considers ingredient characteristics, including digestibility, maximum inclusion, ingredient functionality, additivity between ingredients and effects of processing, and relates fish performance to models of protein and energy utilization provides a powerful tool for developing and refining experimental and commercial diets. Complementary to this can be the inclusion of research on broader aspects of nutritional and health physiology, including the interaction with environmental factors. Furthermore, rapid advances in molecular biology are introducing approaches and techniques that have the potential to provide further information. It should be noted that fish are often grown in changing and sub-optimal conditions, whereas experiments have previously focused on ingredient use under optimal conditions. This paper uses examples to consider the range of approaches and methods being used to gain an in-depth understanding of nutritional physiology and the processes underlying differences in performance of diets and of ingredients. Protein nitrogen turnover, the balance between protein synthesis and breakdown, provides considerable information about relationships between diet, nutrient utilization, physiology and growth performance. Information can be fundamental but also practical in the types of assessments that can be made. In the case of Asian seabass, elevated

temperature caused a decrease in protein intake and protein synthesis that lead to an expected decrease in protein growth performance. There was a significant increase, of approximately three-fold, in gene expression in one but not other, degradation pathways. This suggested both increased recycling of muscle amino acids for energy metabolism and a specific mechanism for this. The importance of following a direct approach to ingredient and feed assessment is recommended. The selective use of nutritional physiology and molecular biology methods provides additional information for assessment and development of ingredient potential for a wide variety of aquaculture species.

Economic themes of the use of fish in aquafeeds

Cécilè Brugère, FAO, Rome, Italy

The objective of this presentation was to place issues of wild fish use raised in presentations and discussions in an economic context. Economic elements that had arisen from the use of low-value/trash fish to feed cultured species and its implications for food security and poverty alleviation related broadly to: (a) the functioning of markets, demand and prices variations; (b) allocation of wild fish in competing uses, also called optimal allocation; and (c) the role of policies, government interventions and institutions.

Market and demand issues, including the high price elasticity of demand for fish feed (example of China and Indonesia), indicate that when the price of fish feed increases, aquaculture operators quickly shift to cheaper alternatives. Declining marginal returns for low-value fish were also exemplified in the case of the Asian trawling industry where, beyond a certain quantity caught, it becomes more economically efficient to sell lower-value species at a lower price for feed instead of preserving them onboard of trawlers for consumption markets. Market forces at work regarding the allocation of wild feed for human consumption or as input into other activities, however, do not preclude government interventions when markets are inadequately functioning, when the interests of the poor have to be preserved, for example through the establishment of safety nets, or on environmental grounds.

If allocation is not left to the markets, decisions have to be made regarding optimal allocation when uses of wild fish resources are competing. Such decisions can be assisted by the use of linear programming to solve the problem of allocating resources among conflicting uses. Linear programming, often used in agricultural – and to some extent aquaculture – farm studies, is a basic tool to model resource allocation by maximizing a linear function (e.g. profits) of variables (e.g. activities such as aquaculture, livestock) subject to linear inequalities or constraints (e.g. feed fisheries maximum sustainable yield (MSY), requirements for home consumption, local job creation, investment capacity, etc.). An example of an allocation matrix was shown.

Policies and economic or legal instruments can then be used to direct allocation, but their use has to be context specific. For example the ban on the use of jack mackerel for production of fishmeal and fish oil in Peru can be seen as a positive intervention, while the provision of fuel subsidies to fishers in Asia has been damaging to fisheries management in the region. This therefore calls for flexible policy and legal frameworks adapted to the state of the resource, comprehending clear objectives and coherent sets of actions/interventions.

The FAO Expert Workshop on the Use of Wild Fish and/or Other Aquatic Species as Feed in Aquaculture and its Implications to Food Security and Poverty Alleviation was convened in Kochi, India, from 16 to 18 November 2007. The workshop consisted of technical presentations and working group discussions. The technical presentations included regional reviews, case studies, a global synthesis and a number of invited presentations. The workshop served to address the following thematic areas and other issues of significance emerging from the regional reviews and case studies: a) fisheries management; b) policy development; c) food security; d) poverty alleviation; e) social and ethical issues; and f) aquaculture technology and development. Following several working group deliberations, the workshop agreed on a series of principles and guidelines on the use of wild fish as feed in aquaculture and concluded that such use should be governed by the above guiding principles.

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