The use of wild fish as aquaculture feed and its effects on income and food for the poor and the undernourished

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SUMMARY

This report concerns the effects that the use of wild fish as feed for fish and crustaceans have on the poor and the undernourished worldwide. However, little information is available about the social and economic impacts of the use of fish as feed. Therefore, the analysis focuses on the direct effects on employment/income for the poor and the supply of fish as food for the food insecure. No attempt has been made to assess the long-term effects of changes in income or consumption of fish.

Most of today's shrimp culture and much of finfish culture make use of wild fish as feed in one form or another. Wild fish is obtained from feed fisheries, from bycatch and from artisanal feed fisheries. Most of it is supplied by feed fisheries in South America and northwestern Europe. While bycatch is a worldwide phenomenon, it is only in East Asia that bycatch provides significant quantities of fish for aquaculture. Artisanal feed fisheries (supplying fish to fishers's fish farms) occur in Asia and the Pacific region.

The poor in Europe, North America and sub-Saharan Africa do not obtain more or less cheap fish or more or less work because wild fish is used as aquaculture feed. In Africa, the reason is that feed fisheries are an exception and aquaculture is nascent and not much dependent on fish as feed. In Europe and North America, the practice has no direct consequences because of the low number of poor and undernourished in these two regions.

In Asia, the situation is different; the use of fish as feed benefits some of the poor and undernourished while the practice harms others. On the one hand, Asian shrimp and fish farmers, whose farms provide employment and income to large numbers of poor inhabitants, need more fishmeal (and fish oil) than local producers can supply. The difference is imported from producers mainly in South America and northwestern Europe. On the other hand, the practice of using Asian bycatch as raw material for fishmeal reduces local employment in fish processing and the amount of cheap fish available, particularly in China, Indonesia and Viet Nam.

Feed Fisheries

Wild fish, processed into fishmeal and fish oil and then incorporated into shrimp and fish feed, contributes substantially to employment. The high-quality fishmeal produced in South America and Europe is frequently used in Asian and South American shrimp culture. Employment in marine shrimp culture worldwide is probably equal to between 2.5 and 3 million man-years, and most of this employment is within reach of the poor, and not only for those from coastal areas. Fishmeal is an essential ingredient in shrimp feeds, and in the absence of high-quality fishmeal, the industry would be much reduced, with negative consequences also for the poor and undernourished.

Wild fish, in the form of fishmeal and fish oil, is present – albeit sometimes in very small amounts – in most manufactured fish feeds. For some species, like salmon and trout, fish protein is a prerequisite, while for others, such as carps and tilapias, it is a positive factor but not irreplaceable. Employment is substantial in the farming of finfish, worldwide probably of the order of 4 to 5 million man-years equivalent. Most of these workers earn an income on farms where fish as feed is not absolutely essential. However, on some farms – e.g. those raising salmonids or *Pangasius* – fish protein is essential, and employment for the poor and undernourished is provided on such farms in Chile (salmon) and Viet Nam (*Pangasius*) and on various marine finfish farms in China and other parts of Asia and the world.

By definition, feed fisheries do not contribute cheap fish used directly as human food. However, this does not imply that feed fisheries pre-empt the access of the poor to cheap fish. This does not occur, as feed fisheries obtain a price for their products that even the poor can afford. It is technically and economically feasible to treat species constituting feedfish as foodfish and market them to the poor, but this is seldom done at a significant scale. The obstacles that confront whoever attempts to do this on a large

scale in any of the major feed fisheries are economic; the need to preserve the fish and transport it sometimes long distances (e.g. from northern Europe or South America to Africa or Asia) make the resulting food too costly for the poor. It seems *a priori* that any large-scale attempt to provide feedfish as food to the poor and malnourished would need an international agreement that would make the required subsidies compatible with various international agreements concluded in the World Trade Organization (WTO).

However, for many feed-fish species that are acceptable also as food (herring, sardines, anchoveta) there has been a noticeable, albeit often slow, increase in the quantities used as food. This has come about as the food markets have been able to pay more than the fishmeal/oil manufacturers. Fisheries supplying feed to the capture-based culture of bluefin tuna may be the exception to this rule, given the very high prices paid by the Japanese market for the end product.

While most feed fisheries in South America and northern Europe have existed for several decades, some – particularly in northern Europe – by the early twenty-first century have been exploited beyond what the exploited feed-fish stocks can sustain in the long run. If continued mismanagement were to permanently reduce the level of production in these feed fisheries, it cannot be excluded that the poor in developing countries, particularly in Asia, would also suffer in terms of reduced employment possibilities in shrimp and fish farming.

The onshore employment generated by the fishmeal and fish oil industry is minimal. A modern fishmeal and fish oil plant is capital intensive. In comparison, a modern fish canning plant or shrimp processing facility is labour intensive. The work provided per tonne of fish handled in a fishmeal plant may generate only 1 to 2 percent of the work the same tonne of fish generates in modern food processing. This means that countries that have feed fisheries and the associated shore-based industries, but do not have shrimp or fish farming that consumes the fishmeal, have an interest in promoting local food industries and using part of the feedfish to do so. In poor regions, reducing/abolishing feed fisheries and associated shore-based facilities and replacing them with food fisheries (but maintaining the fishing level on the same species) and associated land-based industries could result in a real boost to local well-being.

Bycatch

In East Asia, there are clear indications that the use of bycatch as aquaculture feed has reduced the access of the poor to cheap fish. This report estimates (Huntington and Hasan, 2009) that the quantities of bycatch involved are of the order of 4 to 5 million tonnes per year. A large part of these quantities is landed in the coastal regions of China, Thailand and Viet Nam. Although it is unlikely that the entire quantity of bycatch used as fish feed would have been available as food for the poor, in the absence of its use in aquaculture, the local supplies of fish within economic reach of the local poor would have been substantially higher.

Shore-based handling of bycatch is labour intensive in East Asia, and this is so irrespective of whether the bycatch is used for food or for feed. However, the same groups of individuals may not be employed when the bycatch is used as food as when it is used as feed. In addition, the care needed to transform and maintain the fish as food is more than that needed to supply the bycatch as feed, and it seems likely that this is reflected in much higher levels of employment if bycatch is used as food.

Fisheries that generate bycatch are harmful to commercial fisheries. Most bycatch contains large amounts of immature commercial fish, and observers agree that fisheries for commercial species are impacted negatively. As this impact also occurs if the bycatch is discarded – and not brought to shore – trying to deal with this issue by prohibiting/limiting the use of bycatch once it is landed will be ineffective. The issue is

best tackled as a fishery management problem, i.e. by modifying gear/fishing methods and/or by imposing time or area limitations on fishing.

There are several drawbacks associated with the use of wild fish as direct feed (e.g. pollution, risks of disease transmission, high feed conversion ratios). Government policy in China is, therefore, to encourage farmers to use pelleted feed instead of wild fish mixed in farm-made feeds. It is likely that this policy will be effective and the practice will subside, and not only in China.

Conclusions

Most feed fisheries do not subtract large amounts of cheap fish for the poor. Although aquaculture, by the use of feedfish, may reduce the supply of foodfish in the world, it creates employment opportunities for the poor and undernourished, particularly in Asia. However, a combination of intense fishing and environmental variability means that the sustainability of some feed fisheries continues to be under threat.

Seen from the perspective of the poor and the undernourished, the use of bycatch as aquaculture feed is a much more dubious practice. In regions adjacent to large fishing harbours, particularly in China, Thailand and Viet Nam, the practice does reduce the supply of cheap fish for the poor, and aquaculture does not compensate for this by generating more employment than what would have been available if the fish had been used for food. In fact, employment and income opportunities for the poor would increase considerably if the bycatch now used as feed could be used as food.

There is a concern that the use of fish as feed leads to less food and at times also to smaller incomes for the poor and undernourished. To date, governments have not effectively limited the practice of using fish as feed in order to safeguard a supply of cheap fish – either by limiting the use of small pelagic fish for the production of fishmeal and fish oil or by restricting the use of bycatch as animal feed and thereby increasing the supply of cheap fish as food.

One explanation for this lack of action may be that public policies aiming to alleviate poverty and improve the nutritional status of the poor give priority to creating employment for the poor. Employment (whether self-employed or salaried) has proven to be the best way to ensure poverty alleviation, which in turn leads to improved nutritional status. Providing cheap food (including fish) to people is more often part of schemes meant to support victims of natural or man-made disasters (including crop failures) than part of long-term strategies aiming to lift the poor out of poverty.

Also attempts to create employment are faced with obstacles. Governments that want to establish food industries based on feed fisheries have very limited possibilities to do so. One reason is international trade law; the international trade in fish and fish products means that economic and fiscal policies directed towards fish processing industries must respect both international agreements on international trade and the parameters guiding national economic and fiscal policies vis-à-vis national food industries.

1. THE ISSUE

During the last three decades, aquaculture has grown rapidly, expanding faster than most other food sectors. However, it was already apparent in the early 1990s that aquaculture faced a number of constraints. In particular, there was a concern and an international debate about the use of fish as feed[1] in aquaculture. There were those who argued that although not all cultured aquatic animals require substantial amounts of animal proteins in their feed, aquaculture growth may be slowed significantly as fish become a limiting resource.

In recent years, the focus of this discussion has widened to include the effects that the use of fish as feed has outside the aquaculture industry. In particular, the world-wide effort to reduce undernutrition and poverty has naturally brought aquaculture and its impacts on poverty and nutrition into focus. As a consequence, there is a wide-spread concern, both within governments and in civil society, that the use of fish as aquaculture feed has more negative than positive outcomes for the poor.

Also, some of those debating these issues maintain that irrespective of the amount of fish available, it is not ethically correct to use fish as feed for other fish or crustaceans if the fish used as feed can be sold as human food. This is particularly the case if carnivorous fish are exported from developing to developed countries; i.e. when wild fish that could have fed the poor are used as ingredients for "luxury" farmed fish.

Others are primarily concerned that a growing demand for fish as animal feed will lead to an increase in fishing effort on the wild fish stocks that are used as raw material in fishmeal production. In their view, such pressure would lead to an even higher overexploitation of the world's marine fish stocks, which could have far-reaching and negative consequences for the total supply of fish from the oceans and exacerbate a situation in which the marine global resources base seems to be shrinking.

In this paper, the debate is narrowed to reviewing the practice of using fish as aquaculture feed from the point of view of the poor and the undernourished. From that perspective, the principal arguments advanced against the use of wild fish as aquaculture feed are that the practice reduces either the income earning opportunities of the poor or their access to cheap fish now and possibly also in the future. There are four main arguments; three concern the supply of cheap fish and one concerns income earning possibilities:

(i) when fish are obtained through reduction fisheries and then converted into fishmeal, less fish are being provided as human food – and particularly for the poor – than would be the case if fish were not converted into fishmeal and then incorporated into industrially-made fish feeds used to grow fish and/or shrimp;

(ii) when fish are obtained from the bycatch of commercial fisheries or from surplus landings of small pelagic fisheries and then fed to cultured fish either directly or as fishmeal, the quantities of cheap fish normally accessible to the poor in port markets is reduced;

(iii) the growing use of fishmeal in fish feed contributes to unsustainable increases in fishing pressure in reduction fisheries and, in the end, to the demise of some wild fish resources, and, therefore, eventually to less fish being available for human consumption, which will affect the poor in particular;

[1] In this text, the expression "fish as food" refers to all fish that is destined for human consumption in fresh or processed form. "Fish as feed" refers to all fish used as feed for animals. Such fish may be provided to aquatic animals whole, minced, as one of the ingredients of farm-made fish/shrimp feeds (this feeding method is sometimes described as fish being provided as "direct feed") or in the form of fishmeal/fish oil used as an ingredient in industrially made fish/shrimp feeds (sometimes referred to by stating that the fish is used as "indirect feed"). "Industrial fisheries" or "reduction fisheries" are those fisheries that are specialized in providing fish to the fishmeal and fish oil industries.

(iv) when fish are obtained through reduction fisheries and converted into fishmeal, employment onshore is much below what it would be if the fish were destined for human consumption, and this affects the poor in particular, as much of the work to be done in preparing fish as food demands only low-skilled labour.

Three aspects of these arguments should be noted.

First, the focus of three of the four arguments is on the supply of cheap fish, and this is surprising, as it is generally recognized by those involved in public programmes pursuing poverty alleviation – and this will be discussed later in this paper – that poverty alleviation is achieved primarily when the poor obtain the opportunity to earn an income. Provision of cheap food is a less effective strategy, and one that poor societies have difficulties financing in the long run.

The second aspect to be noted is that the arguments do not take issue with the notion that aquaculture is beneficial for those who undertake it (they earn an income, especially important for the poor who need to buy food) and for those who eat fish or shellfish, the nutritional benefits of which are recognized universally. Rather, the argument against the use of fish as feed is that it is harmful for others than those directly involved or that harm appears with delay and then possibly also for those active in aquaculture.

The problem is that the market does not by itself correct the negative impacts experienced by third parties and they, most of the time, do not have the economic power to modify prevailing market forces in their favour. Therefore, they need to call on public authorities to intervene on their behalf. However, frequently, calls for redress are made not by those who suffer the negative outcomes of the market, who are often poor and lacking the know-how and access to media needed to make such calls, but by others.

The third aspect to note is that the first three arguments take as a given that more fish equals a better world, and a better world also for the poor. However, if it is agreed that for the poor a higher steady income is more important than cheap fish, then it is worth finding out if the use of fish as aquaculture feed leads to more and sustained income for the poor than any alternative use of the concerned fish. If this is so, actions that maintain such a source of income can be seen as poverty prevention and must be given due consideration.

2. INTRODUCTION

2.1 Purpose, limitations and method

This paper is intended to assist professionals working with poverty prevention and undernutrition to understand the potential that aquaculture provides for achieving sustainable solutions to poverty and malnutrition, while focusing on the role that aquaculture operations that use fish as feed may have in this context. Its purpose is not to provide standard solutions, but rather to indicate strategies that may be used to undertake the analysis needed to identify and formulate equitable and sustainable solutions to issues created by the use of wild fish as aquaculture feed.

The paper also identifies, and where possible, quantifies the issues involved. Although there are lacunae in the knowledge of the amount of fish used as feed, the order of magnitude is now known (Huntington and Hasan, 2009). Paradoxically, there is less information available about the number of individuals directly affected by the use of fish as feed. In order to develop a quantitative estimate, the paper resorts to extrapolations using available data to provide some initial estimates of the numbers of people involved. These estimates need to be verified by surveys in randomly selected relevant locations.

The paper reviews alternatives for dealing with negative outcomes of using fish and feed. As most economies today rely on some form of market economy, the negative

outcomes occur in spite of or because of the way the market economy works. Remedies are thus possible only if it is accepted that some kind of interference with the market forces is necessary. In the text, an attempt is made to be explicit about the nature of such interventions.

Aquaculture that uses fish as feed may cause pollution or transmit illnesses. Such effects will also affect the poor and undernourished. No attempt is made to estimate these consequences in this paper.

Neither does the paper attempt to provide any information on "second round" effects. An example of a positive second round effect would be increased schooling for children of the poor who earn a living in aquaculture and its consequences. Conversely, however, the negative outcomes of second round effects can be dramatic. The long-term consequences of child undernurished are dramatic and tragic at the level of the individual and also affect economic growth. It is recognized that it is unrealistic to decide in principle about how to deal with fish as feed without including second-round effects in the information base for such a decision.

It is important to understand not only the current extent and nature of the problem, but to identify how it is has come about and formulate best possible projections of future trends. What are the forces that maintain today's situation? These forces should preferably be co-opted into any future solution of the problem. They must, therefore, be known and are a required part of the problem description. Although this paper is not intended to identify and prescribe solutions to the "negative outcomes" associated with the use of wild fish as aquaculture feed, most likely it will be useful for later research if the outlines of possible solutions could orient the problem description.

"Negative outcomes" are experienced over time by the poor and food insecure. They either see an already difficult situation degenerate or experience that they have missed an opportunity to improve their situation. In both cases, the "negative outcome" is defined by a comparison of what has actually happened with what is believed could have happened. The study of this kind of problem thus involves comparing actual facts with an expectation of what could have happened – an imagined situation.

The first task is to establish a sequence of facts that documents the use of wild fish as aquaculture feed today and provides salient information on how this practice had developed and spread. To this information should be added information about the situation of those poor and food insecure who might be or might have been affected by the practice of using fish as feed.

Once that is done, the second task in this problem identification is to attempt to establish what most likely would have happened had not the practice of using wild fish as aquaculture feed developed and become common. This involves speculation, preferably drawing on information about locations where wild fish have not been used as aquaculture feed.

This speculation starts by providing a tentative answer to the question "what would have been the situation for the "target group of poor" if aquaculture had not used wild fish as feed?" By comparing this situation with the situation as it actually developed, an idea can be generated about the magnitude and the nature of what would have happened if fish had not been used as feed in aquaculture. In particular, one can then ask "how do the benefits (in terms of more cheap fish) stemming from a "no fish as feed aquaculture" for the poor and undernourished compare with a possible loss of income (and associated effects) for those poor who obtain a living through shrimp or finfish culture?"[2]

[2] But the analytical problems do not end here. Assuming that yes indeed, there would be benefits for the poor (likely some immediate and some long term) from stopping the use of wild fish as feed, is there a linear relationship between cause and effect? Put simply: does a little use of fish as feed cause a small problem and a large use of fish as feed cause a correspondingly large problem? Or is some level of use of fish as feed without harm? (Does the harm only appear after some level of use?)

Other papers in this fisheries technical paper provide ample information on the nature and extent of the use of wild fish as feed in aquaculture worldwide. Data on culture technologies, on the status of fish stocks and on environmental impacts dominate. However, there is little data available about the human dimensions in the use of wild fish as feed. This makes an analysis of the impact on the poor and food insecure extremely difficult.

Given the shortage of data worldwide – particularly that needed to identify social consequences – this report is limited to attempting to develop global quantitative estimates in two areas; the first concerns the "food impact" and the second, the "income impact".

The paper will develop an idea of the "food impact" by estimating the number of food insecure who might have benefited if fish had been used as food instead of as feed. This will be done simply by considering the potential supply per caput (live-weight equivalent) that fish used as feed could have provided if supplied as food. It will also develop an idea of the "income impact" by estimating the number of poor who earn an income under the present practice and comparing it with what the number could have been had fish not been used as aquaculture feed.

2.2 The report

As the focus of this analysis is on the poor and the food insecure, the report starts with a brief section about them and about the nature of the strategies used to ameliorate their situation. This is followed by a brief and general review of the impacts of aquaculture on food production and poverty. An analysis of the impacts on the poor and undernourished of the use of fish as feed in aquaculture then follows. The analysis is divided into two parts. The first concerns the use of fish obtained in reduction fisheries, while the second looks at the food and income impacts of using fish obtained from bycatches and/or from excess landings of small pelagic species.

The paper ends with a discussion of policies that might be able to address the negative consequences of using wild fish as aquaculture feed while, simultaneously, not harming the poor and undernourished.

3. POVERTY AND FOOD SECURITY

Following the Second World War, the number of sovereign states grew as colonies became independent. The international community soon realized that several of the newly formed nations needed technical and economic aid if their populations were to escape poverty and food insecurity. However, progress was uneven during the following decades and in 1996, the international community, assembled at the FAO headquarters in Rome, agreed to increase and improve these efforts with the aim of halving the number of the world's hungry by 2015[3].

[3] The World Food Summit (WFS) held in Rome in November 1996 at which Heads of State and Government, or their representatives, adopted the Rome Declaration on World Food Security and the WFS Plan of Action and pledged their political will and their common and national commitment to achieving food security for all and to an ongoing effort to eradicate hunger in all countries, with an immediate view to reducing the number of undernourished people to half their level no later than 2015. (Declaration of the World Food Summit: 5 years later).

3.1 The poor and the food insecure

The world's poor[4] outnumber[5] the food insecure[6] and undernourished. In 2004–2005, there were about 1.4 billion poor (World Bank and Collins, 2009) and about 830 million (FAO, 2008a) undernourished. With the exception of a few countries in North Africa and the Near East, most countries report that their poor are more numerous than their undernourished. It seems to be the case generally that the undernourished are also poor.

In sub-Saharan Africa about 50 percent of the total population is poor; in South Asia, this is true for about one-third of the population; in East Asia and the Pacific, the proportion of poor has now fallen to below 20 percent; while in Latin America and the Caribbean, it is about 8 percent for the region as a whole.

During the period from 2003 to 2005, more than 35 percent of the population in 17 countries was undernourished. Sixteen of these countries were in sub-Saharan Africa, Haiti being the only country not from that region. The populations of oil-producing countries in Africa were better fed. In Asia, India reported to have about 21 percent of its population underfed; Pakistan, 23 percent; Bangladesh, 27 percent; and China, about 10 percent.

According to the United Nations Hunger Task Force, about half of the world's hungry are smallholders[7]; a fifth are landless; and a tenth are agropastoralists, fisherfolk and forest users; the remaining fifth live in urban areas (World Bank, 2007). The agropastoralists, fisherfolk and forest users would thus number about 80 to 85 million individuals. Full-time and half-time fishers and aquaculturists were believed to number about 43.5 million in 2006 (FAO, 2009a). Providing that each fisher sustains at least two more individuals (children and old), the number of individuals directly supported by fishing and aquaculture would be in the order of 100 million. These figures indicate that, in fact, not all fisherfolk (including aquaculturists) and their families belong to the category of the poor.

3.2 Combating poverty and food insecurity

Combating poverty means not only helping the poor out of their condition of poverty (poverty reduction), but also preventing poverty from spreading to new population groups or worsening for those who already are poor (poverty prevention). Poverty is reduced when the poor generate income and wealth in the form of capital[8]. Preventing poverty is usually achieved by reducing the risks facing the poor and/or by improving safety net[9] functions.

A large portion of the rural poor are smallholders[10], but all smallholders are not poor. Those people concerned with poverty reduction in rural areas generally agree

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[4] There are several definitions of poverty. It is generally accepted that poverty consists not only of low income and little wealth, but also a lack of the material requirements needed to meet essential human needs such as health and education.

[5] The most common measuring rod for poverty seems to the World Bank's estimate that affirms that those who have an income below US$1.25/day (Purchasing Power Parity) live in poverty. That definition is used in this paper.

[6] The commonly accepted definition of food security is: "When all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 2002).

[7] Defined as farms of 2 ha or less.

[8] Those concerned with poverty reduction often distinguish between several different types of capital, all important for those who experience poverty. Among these forms are human, social, natural, physical and financial capital (ADB, 2005).

[9] "Safety net" is an umbrella term for various types of programmes aimed at assisting vulnerable population groups. Safety nets include food distribution programmes, cash transfer schemes, various feeding programmes and employment schemes (FAO, 2008a).

[10] About two-thirds of the 3 billion rural people in the world live off the income generated by farmers managing some 500 million small farms of less than 2 ha each (FAO, 2008a).

that improved production and productivity of smallholders is essential, and studies of poverty reduction have revealed that agricultural growth is up to four times more effective in reducing poverty than is economic growth in other sectors of the economy (FAO, 2008a).

Although this finding is not reported as directly applicable to aquaculture, there is reason to believe that aquaculture growth also is effective in reducing poverty. There are two reasons: on the one hand, and as further described below, rural, small-scale aquaculture operations usually generate cash for their owners, which is indispensable for the poor as they buy food both in rural and urban areas, and on the other hand, the economic similarities between rural aquaculture and agriculture are such that the World Bank, in its analysis of the rural economy, classifies aquaculture as part of agriculture (World Bank, 2007).

Given that most of the food insecure are also poor, the actions meant to deal with the problems of poverty will also, in all likelihood, help deal with the problems of malnutrition and food insecurity. However, malnutrition is debilitating and, therefore, reduces the income earning possibilities of those who are undernourished. Thus, any action that leads to better nutrition in the end also combats poverty.

Most of the food insecure live in rural areas where most of the food is produced, yet they are net food buyers rather than sellers. Poverty constrains their access to food in the marketplace.

Therefore, agriculture's ability to generate income for the poor, particularly women, is more important for food security than its ability to increase local food supplies (World Bank, 2007).

This means that the fight against malnutrition is tightly linked to the fight against poverty: if poverty is reduced – or its spread prevented – this generally leads also to a concurrent improvement in nutrition for the poor.

3.3 Food insecurity, malnutrition and fish

Food insecurity has many different forms. The chronically food insecure never have enough to eat. Those who are seasonally food insecure fall below adequate consumption levels in the lean season, while the transitory food insecure fall below the adequate consumption threshold as a result of an economic or natural shock such as a drought, sometimes with long-lasting consequences (World Bank, 2007).

While fish is a good source of minerals, vitamins, fatty acids and animal proteins, it generally does not provide calories in sufficient quantities for those who regularly carry out heavy manual labour. It has been long recognized that those living in prosperous fishing communities must trade – fish does not provide them with sufficient supplies of all essential nutrients (Kurien, 2005).

Fish, however, are important for the micronutrients they contain. Some essential nutrients are not found or are found in very small quantities in many of the staples consumed in low-income countries. These nutrients – iron, iodine, zinc, calcium, vitamin A and vitamin C – are found in fish or vegetables. Marine fish also contribute fatty acids that are necessary for the development of the brain and the body (Bené, Macfadyen and Allison, 2007). The consumption of small fish is of particular importance, as these are often consumed whole, which means that nutrients available in the eyes, viscera and skeleton are used. Whereas big and small fish of the same species contain the same amount of protein per unit weight, small fish provide relatively higher amounts of minerals in diets because they are consumed whole, including the bones (Bené, Macfadyen and Allison, 2007). Fatty fish, in particular, are an extremely rich source of essential fatty acids, including omega-3 polyunsaturated fatty acids (PUFAs), so important for normal growth and mental development, especially during pregnancy and early childhood (FAO, 2003).

Fish are important as a source of animal protein, especially where other sources of such protein are scarce. Fish protein accounts for about 18 percent of the animal protein intake in developing countries (Laurenti, 2007). However, the differences among countries and among regions within countries are large. In many communities in small island states, in Africa south of the Sahara and in Asia, the contribution of fish to nutrition is essential. Fish proteins can provide up to 50 percent and more of the total supply of animal proteins.

Increasing the availability of fish in the diet increases palatability and leads to increased consumption of a range of foods, thereby improving overall food and nutrient intakes (FAO, 2003).

4. AQUACULTURE: THE CREATION OF INCOME AND FOOD

4.1 Introduction

Is aquaculture good or bad for the poor and the food insecure? Although most fishery and aquaculture professionals would probably answer "good" to this question, there is no one answer. There are too many different forms of aquaculture and too much variation in the situation of the poor and food insecure for a single answer to be possible. In fact, even if the question is narrowed down to a particular industry (e.g. tilapia farming in Central America, shrimp farming in Thailand), observers will differ about effects.

On the one hand, there are several effects of aquaculture that are positive for the poor and the food insecure. The industry generates income and produces nutritious food. On the other hand, the pursuit of aquaculture also creates externalities (usually effective through alterations of the environment) and undesirable market outcomes. In this paper "undesirable outcomes" are those that cause either reduced incomes for the poor or a reduced supply of fish or cheap foods containing animal proteins.

However, there seems to be a consensus among those familiar with the poor and food insecure in Southeast Asia where family operated aquaculture activities are common and well-established that their contribution to household income and food security overshadows the negative outcomes that this type of aquaculture may generate (see Edwards, 1999; Tung, 2000; Prowse and Admos, 2007). This section of the paper will consider those features of aquaculture that are positive for the poor and the food insecure. Negative aspects will be reviewed later.

Worldwide aquaculture production (not including plants) at the producer level was estimated to have had a value of about US$85.9 billion in 2006 (FAO, 2009a). A significant share of this accrued to small-scale producers and their employees in Asian aquaculture. As aquaculture continues to expand, it may become a stronger force for lifting rural households out of poverty than small-scale fisheries[11].

Commercial, large-scale, aquaculture of shrimp, salmon, tilapia, catfish, grouper, carps, etc, also generates employment (in production, processing and marketing) and provides income in rural and urban areas. Tax revenues from commercial aquaculture enterprises and foreign exchange earnings allow governments to invest in sectors that may add to the achievement of food security (FAO, 2003).

Aquaculture is now providing about half of the fish consumed by the human population worldwide (FAO, 2009a). As consumers in developed countries account for only about 30 percent of the total world fish consumption (Laurenti, 2007), it is evident that aquaculture supplies a very important part of the fish consumed in the developing world, but almost exclusively in Asia.

[11] As capture fishery production stagnates, the role of small-scale fisheries in poverty alleviation will probably take the shape of poverty prevention (Bené, Macfadyen and Allison, 2007) rather than poverty reduction, at least as long as substantive numbers of alternative employment opportunities do not develop for capture fishers.

4.2 Aquaculture and income for the poor

In Asia, rural aquaculture – managed as household activities or as enterprises – can contribute significantly to income for the rural poor[12]. Worldwide, fish – whether produced through capture fisheries[13] or aquaculture – are frequently seen as cash crop, even in the poorest of households. Studies in various developing countries (e.g. China and Viet Nam) have shown that 80–100 percent of the aquaculture products from rural farm households are marketed (FAO, 2003). This suggests that aquaculture is an activity that generates not only food for rural households but above all, cash and thus is an important direct and indirect source of food security.

In many countries, the average market prices of fish are lower than those of other animal products such as chicken, pork and red meat. Especially in Asia, the low prices of aquaculture commodities such as carps and tilapias make fish highly accessible to even the poorest segments of the population. Poor people in land-locked countries such as Nepal and Laos largely depend on freshwater aquaculture for their fish (FAO, 2003).

The average annual per capita income of people employed full-time in the fisheries sector (including aquaculture) in China was about US$540 in 1999, which was more than double that of rural terrestrial farmers. In Southeast Asian countries such as Cambodia, Thailand and Indonesia, a similar situation can be found; farmers engaged in aquaculture generally generate higher household incomes than those who are not. In Viet Nam, 50 percent of the farmers involved in aquaculture consider it as their main source of income and derive on average 75 percent of their households' income from it. Catfish and shrimp culture specifically have, in recent years, provided an average annual household income of over US$1 000, which is significantly more than that generated by comparable agricultural practices (FAO, 2003).

Suitable technology, know-how and inputs must be available for rural aquaculture to be a reality. However, aquaculture is able to function as an activity that generates cash only if aquaculturists find ways of marketing their produce. Thus, efficient markets are essential. Unless such markets exist or are developed, fishers and aquaculturists will not be able to rely on sales of fish as a source of livelihood.

4.3 Aquaculture and nutrition for the poor and food insecure

In many countries, fish is an important component of the diet and in some, rural aquaculture is an important source of supply. The main factor behind the high demand for staple foodfish (in particular, inexpensive farmed freshwater fish species feeding low on the aquatic food chain) within most developing countries is their greater affordability to the poorer segments of the community (FAO, 2003).

A consumption survey in Bangladesh confirmed that fish is an important part of the diet for most people in rural areas. Fish were eaten in small amounts and with great frequency in nearly all households. Changes in fish supply available for consumption therefore, affect the diets of most people in the country, including the poor households (Roos, Thilsted and Islam, 2003).

Aquaculture producers have, through various technological interventions, achieved important productivity gains and cost reductions. Over time this has led to a decrease in prices, despite short-term intervals of significant price swings. The prices of fishery products did not increase as a result of the growing international demand, instead they showed a decreasing trend (FAO, 2003). Studies seem to indicate two important

[12] "Small-scale aquaculture is a very positive poverty reduction technology if it can be developed and integrated with participatory planning approaches, institutional and credit supports" (Tung, 2000).

[13] Research in the Lake Chad area has shown that the poorest households around the lake consume a lower proportion of their catch than the better-off households and instead sell most of their fish in order to be able to purchase cheaper foodstuffs – in the region, mainly millets (Bené, Macfadyen and Allison, 2007).

characteristics. First, that indeed aquaculture is usually an effective rural activity as a source of income. As income is such a key factor in elimination of poverty, this seems to be extremely important. The second fact is that rural fish farming, where it is a long established tradition, has been and continues to be a source of food that even the lower income groups can afford to buy.

5. USE OF WILD FISH AS FEED: EFFECTS ON FOOD AND INCOME

Up to this point, the paper has provided a brief review of poverty, food insecurity, the interdependence of these conditions and the extent to which aquaculture alleviates poverty and improves food security. The effects of aquaculture on poverty and food security are sometimes large, like those reported for freshwater fish culture in many parts of Asia, sometimes smaller, as is the case in Africa and the Americas. However, there is little doubt that when undertaken in areas where a large part of the population is poor and food insecure, aquaculture will have positive effects on food security and help individuals exit poverty. In economically well-off regions, aquaculture contributes to economic growth. Nevertheless, climatic and economic conditions are not favourable everywhere, and in some regions the initiation and growth of aquaculture has been dependent on provision of public subsidies.

This section reports on investigations of the effects that might stem from the practice of using wild fish (and other aquatic animals) as feed for cultured fish and crustaceans. When these practices reduce income for the poor or decrease their food supplies, then aquaculture activities that employ wild fish as feed can be said to cause negative or undesirable outcomes.

5.1 Use of bycatch as aquaculture feed: impacts on food and income of the poor

Globally, the use of wild fish as direct feed is not common. It occurs mainly in Asia, but is only infrequently practiced elsewhere[14] and with the exception of fattening of bluefin tuna, it is virtually absent from aquaculture as practiced in Africa, Europe and the Americas.

In Asia, the practice is common mostly in East Asia. It has hardly spread to India, Pakistan, Sri Lanka or the Pacific Islands. For countries in which freshwater fisheries predominate, the picture is mixed. There seems to be relatively little feeding with fish in Bangladesh and Laos, while the practice is widespread in Cambodia (Nam *et al.*, 2005), where aquaculture production reached 34 000 tonnes in 2006 (FAO, 2008b).

In East Asia, virtually all of the fish given as feed to fish and crustaceans originates in bycatch. However, bycatch has many uses. Some of it is sold directly as food, some is cured and some is used as raw material for surimi and other modern, ready-to-eat products. Also, some of the bycatch is used as raw material for fishmeal production.

There are reports (De Silva and Turchini, 2009) that fish farmers in Asia go fishing to provide feeds to their aquaculture activities. However, although in some areas large number of farmers are involved, if measured in terms of volumes of fish caught and supplied as feed, this practice is not significant in the Asian context.

In East and Southeast Asia, most of the fish used directly[15] as aquaculture feed has its origin in bycatch, often from trawl fisheries. In the context of this analysis, this fact raises four questions:

[14] E.g. small-scale fattening of crabs in Africa.

[15] In this paper, the term "directly as feed", or "direct feed" when applied to wild fish, refers to all practices, with one exception, that result in the fish being used as feed for cultured aquatic animals. The exception is the practice of converting fish to fishmeal that is then incorporated, in an industrial process, in the manufacture of fish or shrimp feed, a practice referred to as using wild fish as "indirect feed" for aquaculture.

(i) Does the fact that bycatch is used as aquaculture feed cause a decline in the availability of fish and possibly, food security for a section of the population in the region where landings occur?
(ii) Does the practice lead to less work and, therefore, less income for the poor and food insecure?
(iii) Does the practice lead to unsustainable fishing pressures that in the end may threaten fish supplies from wild fisheries?
(iv) Does the practice cause pollution and/or threaten human health?

A priori, it is most unlikely that the answer to any one of these questions will be the same for all of East and Southeast Asia. The situation will vary from region to region.

5.1.1 Employment impact: global aspects

Handling of bycatch generates employment on board vessels. Once landed, the catch will again be sorted, preserved, transported and marketed. At sea, crew sort and store the catch into various categories of catch and bycatch. This must be done irrespective of the final use of the bycatch, so the amount of work involved is not much influenced by whether the bycatch is used as aquaculture feed or not.

On land the situation is different; but almost irrespective of the final destination of the bycatch, much employment is generated. Fishmeal manufacturing is the exception, as it provides little employment[16]. Even if many fishmeal plants in East Asia are not the most modern (and do not separate meal from oil[17]), the labour intensity is comparatively low. But, as mentioned, fishmeal is only one of the uses of bycatch in Asia[18], and aquaculture feed is not the principal use for the low-quality meal produced (often used for livestock and poultry). As a result, relatively few workers find employment in fishmeal plants that produce fishmeal from bycatch that is later incorporated into aquaculture feed.

It is fairly recent that the volume of bycatch and its use has drawn attention in Asia. While some countries have detailed reports, others have close to no data. As comprehensive data are lacking, discussions of the Asian situation rely on estimates[19]. This report affirms that the annual amount of fish used as direct aquaculture feed in the Asia -Pacific region in 2004 was in the range of 2.47 to 3.88 million tonnes (De Silva and Turchini, 2009). This feed was used primarily in the culture of marine finfish, freshwater catfish and for crab fattening. Although not quantified, a small amount of trash fish is used for lobster fattening and some for mollusc culture. The total output was in the order of 1.54 million tonnes[20] of fish, which may have generated an

[16] In Peru, for each man-year of labour about 310 tonnes of fishmeal are produced (Sánchez Durand and Gallo Seminario, 2009). This can also be expressed by saying that each 1 000 tonnes of fish (in the Peruvian case – anchoveta) provide only 0.77 man-years of employment in the reduction industry proper.

[17] Edwards, Le and Allan (2004) reported that in Viet Nam few fishmeal plants separate fish oil from fishmeal. Of the 119 fishmeal plants found in Thailand in 2003, only 13 separated fish oil from fishmeal (Thongrod, 2005).

[18] But there are exceptions. In Thailand, almost all "trash fish" becomes fishmeal and about one-quarter of "low-value foodfish" is used as raw material for fishmeal and one quarter as direct aquaculture feed (Khemakorn *et al.*, 2005).

[19] While the historical information for Thailand is comprehensive (Thongrod, 2005), information about bycatches in India is "a matter of individual opinion rather then a verifiable fact" (Salagrama, 1998). Similarly, information on bycatches in Bangladesh is not detailed, and only global estimates are available (Ahamad, 2005).

[20] Finfish production was 1.02 million tonnes in 2004; 0.4 million tonnes of freshwater catfish and 0.12 million tonnes of crabs were produced (De Silva and Turchini, 2009).

employment of 0.27 million man-years (0.175 man-years/tonne[21]), out of which the low-skilled would be a majority, presumably in the order of 80 percent or more. To this employment should be added that of individuals not employed on fish farms but who are employed in bringing fish to farms, in manufacturing farm-made feeds or in bringing the product to export markets. No information is available on how much labour is used in these activities. A liberal assumption would seem to be that it equals the work on the farm. If so, the total employment generated would be on the order of 0.5 million man-years.

If not used in fish farming, the bycatch could, at best, have been used for production of food. Such activities are labour intensive. The employment generated in post-harvest activities (wet market, cured products and modern surimi type production) averages 1.5 man-years per tonne of fish (landed weight)[22]. This means that hypothetically between 8.1 and 10.2 million individuals, mostly unskilled, could have been employed by the fish processing industry. Even if a large degree of uncertainty surrounds these numbers, it seems clear that in Asia the use of fish as aquaculture feed, although creating substantive employment (above all, in the culture of marine fish), would generate a much larger employment had it been possible to sell the bycatch as food.

5.1.2 Food impacts, global aspects

The potential food impact of 5.4 to 6.8 million tonnes of bycatch used as aquaculture feed would have been large in 2004. It would have been sufficient to provide 540 to 680 million people with an additional 10 kg of fish per person per year or, in the latter case, it would have been sufficient to augment world annual per capita fish consumption by between 6 and 7 percent[23]. Such an increase would have made a

[21] There seem to be few published references to the labour intensity on shrimp farms or in aquaculture generally. It is reported for Madagascar (N. Hishamunda, FAO, personal communication, 2009) that the shrimp culture industry has generated employment for about 4 000 to 5 000 persons. With an output of 6 000 to 8 000 tonnes of shrimp per year, this gives an employment "generation" per tonne produced of between 0.500 and 0.833. Given the low living standards in Madagascar and the modernity of the shrimp culture plants, the mechanization is higher on these farms than in most small shrimp farms in India, for example. Thus using an "employment" multiplier of 0.75 is probably an underestimate of the employment generated in Asian marine shrimp culture. Given the work involved in transporting, handling and distributing feed based on bycatch, it would seem, *a priori,* that the employment generation in marine finfish culture is at least as high, and probably higher, than that reported for shrimp culture. However, global statistics do not support this thesis. In 2006, about 8.1 million aquaculturists in Asia (FAO, 2009a) produced 46.3 million tonnes of aquaculture output, not including algae (Lymer *et al.*, 2008), which gives an "employment multiplier" of 0.175. An Asian Development Bank (ADB) review of aquaculture projects arrived at similar multipliers for tilapia farming in Bangladesh and the Philippines, 0.23 and 0.17 for the pond and cage cultures in the Philippines and 0.23 for pond culture in Bangladesh (ADB, 2005).

[22] Scientific studies of employment in artisanal fish processing and marketing in artisanal communities seem to be lacking (Ward *et al.,* 2004; Kébé, 2008). However, it is common in the fisheries literature to find affirmations to the effect that each fisher provides work for two to four individuals further down the line in post-harvest activities. Are these full-time or part-time activities? In Asia, the average fisher may be producing an average of 2 to 3 tonnes per year. This would imply an employment generation of between 0.66 and 2.0 man-years in these post-harvest activities per tonne of fish landed. In Asia, the productivity of the average fisher is low. FAO (Lymer *et al.*, 2008) reports it to have been on the order of 1.3 tonnes per fisher per year in 2006. *A priori,* it seems unlikely that this amount could provide employment for up to four individuals in post-harvest activities. Given the economic growth that has taken place in South and East Asia during the last decades, productivity also in post-harvest activities is likely to have improved. This analysis is based on the assumption that 1.3 tonnes of fish landed provides 2 man-years of work in post-harvest activities. This means that each tonne of fish will generate on average 1.5 man-years of work.

[23] Such an increase would have been ideal from the nutritional point of view. However, it should be recognized that it would be judged as ideal from an overall perspective. It is mostly the case that bycatch contains a large proportion of juveniles of commercial species (or specimens of endangered species). Therefore, public policies will, probably irrespective of the use of bycatch, continue to aim for a reduction of bycatch. In addition, it should be pointed out that although most bycatch is edible, local preferences may preclude some of it being demanded as food.

dramatic improvement in the nutritional status of the poor if the fish could have been channelled to them. In Asia and the Pacific, the number of undernourished in 2003–2005 was estimated to have been 542 million. If the bycatch could have reached them, they would each have had about 8.3 kg of extra fish annually.

Will aquaculture production, in part through the use of feed produced from the use of 5.4 to 6.8 million tonnes of bycatch, somehow compensate for this loss? The species (groupers, snappers, cobia, etc.) that are fed directly with this bycatch are generally priced at levels that preclude their regular purchase by the poor. Neither does it seem reasonable to argue that the production of these fish – generally sold in overseas markets – will somehow cause other species to become cheaper in the localities where the poor and undernourished in Asia do their food purchases, and that they, therefore, somewhat benefit nutritionally from this form of aquaculture. Thus, it is probably not reasonable to argue that the aquaculture production achieved by using bycatch as feed somehow offsets the food "loss" that use of fish as direct aquaculture feed can be said to cause in Asia.

However, the bycatch that is now used as aquaculture feed is brought to shore only in some regions of Asia. Most of the bycatch used for aquaculture feed is landed in China, Thailand and Viet Nam. Together these countries accounted for at least 90 percent of the bycatch used as direct aquaculture feed in 2002 (Stobutzki *et al*., 2005). Although bycatches in India are substantial, only very small amounts are used for aquaculture feed. In Bangladesh, most bycatch seems to be discarded at sea. In Malaysia, the absolute quantities of bycatch used are relatively small, 43 000 tonnes in 2002, but they are large on a per capita basis. In Indonesia, the Philippines and Thailand, the amounts used are small on a per capita basis.

In the regions where bycatches are landed, they represent an opportunity for the local poor and undernourished to obtain cheap fish when the bycatch is offered for sale in wet fish markets. But as soon as preservation and/or transport is needed to bring the fish to the poor, the price of the fish increases, and soon the very poor will not have the means to purchase it. It does not seem reasonable to argue that alternative food-fish markets for bycatch that is now used as aquaculture feed could realistically be found outside the countries where these bycatches are landed. In fact, landings are not economically available as food outside the regions surrounding landing centres[24]. However, it should be recognized that in those regions the nutritional difference could be very significant. Additionally, some of them could cover quite vast territories in densely populated a coastal regions (e.g. in China, India, Viet Nam), given the use of long-established, low-cost curing methods and means of transport. On the one hand, where the volumes are relatively small in comparison with the market, which is the case in several countries (i.e. Bangladesh, Indonesia, India and the Philippines), local demand probably exists for the quantities of bycatch that could be made available, and the difference in food supplies could be considerable in the coastal regions concerned. On the other hand, in China, Thailand and Viet Nam, the quantities of bycatch used as aquaculture feed are probably too large, in relation to markets, to find a market among the poor within the regions surrounding those landing centres where the bycatches are landed. While a difference would be achieved within the coastal regions of these countries, it is not evident that all the present bycatch could be disposed of as food.

[24] However, it should be recognized that the availability of bycatch as food for the poor is not only threatened by its use in aquaculture. Already in 1998 Salagrama (1998) wrote about the use of bycatch in India, where only a very small part of it is used as aquaculture feed: "The growing market demand for all varieties of fish appears to affect poorer segments of the society – petty fish traders, processors and lower-end consumers – negatively and requires careful and urgent attention".

5.1.3 Bycatches: a source of fisheries decline that will impact the poor?

All reports seem to show[25] that often a very large part of the bycatch – be it quantified as trash fish or as low-value foodfish – contains a large share of juveniles of commercial species. This will negatively impact commercial fisheries, and beyond a certain point, may even threaten the sustainability of the species. However, in respect of the question "does the use of bycatch as aquaculture feed lead to unsustainable fisheries?", the answer is probably "no" in most situations. There are two reasons.

First, although fishers in Asia have come to see more of an economic role for bycatch and have modified their fishing practices accordingly, bycatch is still a secondary motivation. Fishers will add something to their earnings by landing and selling bycatch, but most income comes from the sale of the fish at which the fishery was aimed (e.g. shrimp in trawl fisheries for shrimp). So if fishers were prohibited from landing and selling bycatch (thus being obliged to discard all of it), such a rule would somewhat reduce the fishing effort, but probably not for long. Therefore, in the wider context of sustainable fisheries, the use of bycatch as aquaculture feed seems to be a non-issue, and it is unlikely that fishery managers in the future will be able to count on a "bycatch for aquaculture prohibition" as an effective tool in the struggle against unsustainable fisheries[26].

The second reason is that with the exception of China, Thailand and Viet Nam, aquaculture feed, direct or indirect, is not a dominating use for bycatch. In the rest of Asia and elsewhere, bycatch is mostly used either as human food, as feed for livestock and poultry or discarded.

Again, to be clear, fisheries that are characterized by large volumes of bycatch are also mostly unsustainable; and unless remedied, this may cause a decline of the aquatic resource base, which most likely in the end will impact negatively on society, including the poor and undernourished. But, this scenario is not caused by aquaculture, and, therefore, modifications of aquaculture practices will not contribute to a brighter future for world marine fisheries in the sense that they would result in sustainable management of bycatches.

5.1.4 Country notes

China

China reports that large quantities of low-value/trash fish are used in aquaculture. The practice had been growing in parallel with the growth in aquaculture, and lately some 2.8 to 2.9 million tonnes were reportedly fed annually, mostly to marine finfish. During this period, market prices for low-value fresh fish increased and poor sections of the community had seen a fall in their possibilities to consume fish (De Silva and Turchini, 2009).

The proportion of undernourished in the Chinese population has fallen and was recorded at 9 percent in the period 2003–2005 (FAO, 2008a). This means, however, that there were still about 125 million undernourished in the country. In the same period, per capita supplies of fish[27] reached 25.8 kg, providing some 6 g of animal protein per person per day. However, the Chinese diet is relatively rich in animal proteins (21 percent of energy comes from animal proteins), and the contribution of fish to animal protein supply has fallen and was below 20 percent in 2003 (Laurenti, 2007). If fish used as aquaculture feed in China had been supplied locally as human food, annual

[25] For examples, see Salagrama (1998) and Ahamad (2005).

[26] Management of bycatch will probably continue to focus on the "supply", i.e. the volume of bycatch caught, accepting that the costs associated with any management of the use of bycatch are prohibitive. Therefore, efforts will continue to develop technological inventions in the design and use of fishing gear, but there will also be increasing use of economic incentives and various command and control strategies.

[27] Live-weight equivalent.

supplies would have increased by about 2.2 to 2.3 kg (about 9 percent increase) for all the inhabitants.

Fishery and aquaculture authorities in China are reported to be supporting increased use of industrially manufactured, pelleted aquaculture feeds. There are several reasons for the shift, but a major reason is apparently the difficulty in coming to grips with the pollution and negative effects on human health that are linked to the widespread use of wild fish as feed (De Silva and Turchini, 2009).

Recently, the production of surimi-based products has expanded in China. These products also use low-value fish as raw material. So, even if the use of low-value fish as fish feed were to decline (as farmers follow the policy of using pelleted feeds instead of raw fish), it is not evident that the availability of low-value/trash fish for human consumption would increase. Also, it seems plausible that at least a portion of the bycatch will be channelled into production of pelleted feeds.

India

It has been estimated (Chandrapal, 2005) that landed bycatches in India are around 1.3 million tonnes yearly[28]. A large part is sold directly for food, in fresh or cured form, and most of the rest is converted into fishmeal[29]. However, the quality is low, generally unsuitable as feed for marine shrimp, and the product is used primarily as poultry and livestock feed. The exception is feed for freshwater shrimp[30].

Thus, in India the use of bycatch for aquaculture feed has been limited (although fluctuating), and at present its use does not seem to interfere noticeably with the food and income situation of the poor and undernourished. However, this situation can change, if it has not already done so. Increases in the world price for fishmeal will increase the incentive to establish modern fishmeal factories in India, factories that can supply meal and oil of a quality essential for shrimp feeds. Such developments would, of course, also encourage fishing vessels to retain, possibly even capture, larger quantities of fish suitable to be sold as raw material for fishmeal.

Viet Nam

In Viet Nam, the rapidly expanding aquaculture industry is dominated by marine shrimp and freshwater fish production. In 2006, *Pangasius* culture provided almost 40 percent of the finfish culture. The industry uses large and growing volumes of fish as feed. It has been estimated that in 2002 the industry used 0.9 million tonnes of trash fish as direct feed (Stobutzki *et al*., 2005). Given the rapid expansion in catfish culture and the practice of feeding with feeds that include fish, this amount has most likely have increased considerably.

There are no data about the employment in the Vietnamese shrimp culture industry. If the productivity is similar to that in Bangladeshi marine shrimp culture in industry[31] (ten individuals per tonne produced), then the employment in Viet Nam's shrimp culture industry ought to be on the order of magnitude of 3.5 million people. However, if the technology used were similar to that of the modern, large-scale farms of Madagascar, then employment[32] would number about 290 000. This figure is probably closer to the correct number, as Viet Nam reports a total aquaculture employment of about 670 000 people.

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[28] Equivalent to about 1.3 kg/inhabitant/year (live-weight equivalent). In absolute terms the figure is low, but it amounts to a potential increase in consumption (if all bycatch can be consumed as food – which is not likely) of about 20 percent.

[29] Twenty-seven fishmeal plants are established in South India (Andhra Pradesh, Tamil Nadu, Kerala and Karnataka).

[30] About 30 000 tonnes of freshwater shrimp produced per year (2002, 2003).

[31] FAO data (N. Hishamunda, FAO, personal communication, 2009).

[32] Expressed as the equivalent of full man-years of employment.

The use of wild fish as direct feed is common in the culture of *Pangasius* as well as in grouper and spiny lobster culture. It has been estimated that some 160 000 individuals are employed in the *Pangasius* industry.

If the 0.9 million tonnes of bycatch were not used as direct aquaculture feed, this quantity of fish might give rise to some 1.35 million man-years of employment (see footnote 21) in processing, storage and trade of food-fish products. This is a significant number in a country whose population was 80 million in 2002, and it is twice the employment generated in the aquaculture industry as a whole.

If the bycatch now used as feed, either because it is made into fishmeal for aquaculture (a small portion) or because it is fed directly (generally as an ingredient in farm-made feeds), could be supplied as food, the volumes available would be considerable. The order of magnitude is 0.9 million tonnes[33]. This is equivalent to a supply of 10 kg per person per year, which at the time of writing would be equal to an increase of more than 50 percent of fish supplies. In a country where one in four children is underweight or stunted (FAO, 2008a) but (food) energy supplies are close to normal, additional nutrients are important. If the fish could be channelled to those most in need, then the difference could be considerable.

5.1.5 Conclusions

In summary, it would seem that the use of bycatch as aquaculture feed is beneficial for those of the poor and undernourished in East Asia who are gainfully employed in aquaculture activities. They gain considerable income from this activity.

However, they are outnumbered by those who (at least in theory) could benefit if the bycatch were not used as aquaculture feed. They would benefit both in terms of access to cheaper fish and in terms of employment and, therefore, income. This group is several times larger than the group within the aquaculture industries that benefit. In terms of gaining paid employment, the group not having such opportunities might be three to five times larger than those who are employed in aquaculture activities where fish are used as feed. These "adverse outcomes" of using fish as aquaculture feed seem particularly pronounced in China, Thailand and Viet Nam. However, as pointed out earlier, the benefits for the poor and undernourished that might flow from a cessation of the use of fish as feed in these three countries will come about only if the bycatch can reach their local markets and be sold at prices they can afford.

It is true, of course, that food is produced by the concerned aquaculture units; but the fish and shrimp produced are generally destined to "up-market" consumers, frequently in other countries or on other continents. Thus, the positive effects on local fish markets in Asia and sub-Saharan Africa – the two regions with most of the poor and undernourished – in the sense of more fish being made available, are an unlikely effect[34] of present aquaculture practices.

5.1.6 Outlook

In several Asian countries, the demand for bycatch has increased. It has become a source for making fishmeal and a starting point for making surimi and other easy-to-eat foods. In East Asian countries, the demand for bycatch as aquaculture feed has increased rapidly during the last decades *pari passu* with the growth in aquaculture. The use of bycatch as fish feed has been particularly conspicuous in China, Thailand and Viet Nam.

[33] The effects associated with imported fishmeals are not included in the calculation.

[34] Globally, it is clear that the supply of fish, crustaceans and molluscs from culture has kept world fish prices at a level below what they would have been in the absence of aquaculture. True, the supply of cheap foodfish originating in bycatch or of small pelagic species would have been higher than currently, and this would have kept average prices down, but it is not certain that fishmeal production would have been much smaller than it is, as the meal would have been used as feed in the livestock industry.

Will these trends continue? It is doubtful – on the one hand, there are several forces that work against an increase in using wild fish obtained as bycatch as aquaculture feed. They include the negative effects on commercial fish stocks of the catch of juveniles, the risk of spreading disease to fish and humans, the loss of employment/income for the poor and less nutritious food being available for the undernourished.

On the other hand, rapid increases in prices of internationally traded commodities such as fishmeal and fish oil will stimulate Asian and African entrepreneurs to convert more of the locally available fish – whether bycatch or target catch – into fishmeal and oil, both for local and export markets.

5.2 The practice of fishing for aquaculture feeds and its impacts on the poor and undernourished

With almost no exceptions[35], the fish that are captured explicitly for the purpose of becoming animal feed – and thus also aquaculture feed – are converted into fishmeal and oil before being converted into shrimp and fish feed. Such dedicated reduction fisheries supply the fishmeal industries in most of the Americas and in Europe, where the fishmeal plants are also obtaining a growing volume of viscera, heads and bones from the fish processing industries. In Africa, there are reduction fisheries in Morocco and South Africa, while in the Asia-Pacific region the main such fishery takes place in Japan.

These reduction fisheries affect people who participate in them, as well as those who subsequently use the fish landed. They include those working in fishmeal and fish-feed factories, fish and shrimp farms and those who provide inputs to these facilities and ensure transport of the various raw materials and products. Given the intercontinental trade of fishmeal, these groups of people will find themselves on different continents. Many of those who catch the fish and turn it into fishmeal work and live in the Americas or Europe, while many of those who produce fish feeds and subsequently grow fish and shrimps are in Asia[36].

5.2.1 Employment impacts: global aspects

Modern factories that each day turn hundreds of tonnes of fish (and offal) into fishmeal and fish oil have relatively few employees. The factories that produced the 1.78 million tonnes[37] of fishmeal needed for marine shrimp culture (3.26 million tonnes) and culture of marine finfish (1.1 million tonnes) in 2004 are likely to have created some 1 370 man-years of employment[38] in fishmeal plants. The associated fisheries could have generated some 78 000 man-years of employment for fishers[39].

[35] However, in remote areas, fishers who keep marine fish in cages may not have access to pelleted feeds and, therefore, bycatch is their only option. This means that at times when bycatches are low, fishers have to embark on fisheries for low-value fish explicitly to feed their cultured stock of fish (De Silva and Turchini, 2009).

[36] This study estimates that the total aquaculture use of fishmeal in Asia was on the order of 2.4 million tonnes in 2004. The Asian production of fishmeal in that year was on the order of 1.7 million tonnes (FAO, 2008b). As in many countries, a large share of this meal was not used for fish feed; it is clear that much of the fishmeal used in Asia is produced outside the region.

[37] A global survey by Tacon and Metian (2008) indicates that the food conversion ratio (FCR) for marine shrimp feeds averages 1.7 and the average fishmeal inclusion in 2006 was 20 percent. Thus 1.11 million tonnes of fishmeal were required. The corresponding figures for marine fish are a FCR of 1.9 and fishmeal inclusion of 32 percent. Thus 0.67 million tonnes of fishmeal were needed.

[38] The Peruvian Case Study (Sánchez Durand and Gallo Seminario, 2009) in this technical paper states that 1 000 tonnes of feedfish generate 0.77 man-years of employment in the fishmeal and fish oil industries (not including seagoing personnel), while 1 000 tonnes of the same fish – but then well preserved on landing – would generate 65.6 man-years of work if the fish were taken to a cannery and preserved as food.

[39] Total capture fishery landings in 2006 in Peru reached 7.0 million tonnes. This was done by about 68 000 fishers, an average productivity of 102 tonnes per fisher per year (FAO, 2009a). While the Peruvian fisheries are exceptionally productive, this productivity may be on the high side for other fisheries. Assuming a 23 percent recovery, the total amount of fish required is about 7.74 million tonnes.

The employment on shrimp and fish farms using the fishmeal will be on the order of 2.64 million people[40], more than 90 percent of whom are in shrimp culture, mainly in Asia. Most of this employment is of unskilled labour and is thus a possible source of income for the poor. To this figure should be added some additional employment in independent feed mills and transport services. Thus, most employment is generated where the fishmeal is used, not where it is manufactured.

Could it be otherwise? Could more employment be generated in the regions where the fish are caught and landed and, if so, would the poor benefit? If fish were not landed, and therefore no fishmeal produced, of course all would be worse off. A large section of the South American fishing fleet would stay in port and the shrimp farming in India, Indonesia and Viet Nam would probably close, as they depend almost entirely on imported high-quality fishmeal. Large unemployment would follow. Some of the farms in China and Thailand would survive on local fishmeal. After some years, fish species that prey on the reduction species might flourish. It is unclear if increased landings of such species would impact positively or negatively on the incomes of the poor.

One conceivable scenario is that the fish are landed and instead of being turned into fishmeal, they are processed, preserved and marketed as food. Such a scenario would have very dramatic employment effects, but they will be analysed only if such a scenario is realistic. This will be done in the next section, where in fact, it will be shown not to be realistic.

5.2.2 Food impacts: global aspects

One of the alleged undesirable outcomes associated with the use of fishmeal and fish oil is a reduced supply of fish, particularly for the poor and food insecure. There are two scenarios for reduction in supplies: (i) the situation in which an existing market for fresh fish has seen supplies of fish reduced because fishmeal factories have bought the fish and turned the fish into fishmeal, and (ii) the situation in which the food processing industry has not managed to use drastically increased supplies of fish as food but instead turned the fish into fishmeal, that is, the increased supplies of fish have been used to make fishmeal instead of supplied as food. The first argument applies more to the bycatch situation, the second situation concerns reduction fisheries. This is the situation that will be analysed now.

Only if fish are cheap is there a reasonable chance that the poor can afford to buy them and improve their nutrition. This paper has already argued that bycatch is of nutritional or food benefit to the poor only if they can access it at, or close to, landing centres and soon after off-loading. Once the fish have to be processed in modern fish processing plants, costs are added and the likelihood that the product will be bought by the poor recedes. Where local landings are far in excess of what the nearby markets can absorb – which is the case for some of the fisheries in South America, northwest Africa and Northern Europe – such processing is the only realistic alternative. Traditional processing, relying on wind and sun, will not do.

The same argument applies to the poor and reduction fisheries. The species supplied to fishmeal plants are all edible and more[41] or less in demand as food where they are caught. Why then have reduction fisheries developed? Essentially because the species exploited under reduction fisheries are usually seasonal fisheries of pelagic species with large quantities of fish landed during relatively brief periods, the quantities far exceeding what local markets reasonably can consume in fresh form or what fish

[40] Conversion factors: 0.75 man-years of employment per tonne of shrimp produced, 0.175 man-years of employment per tonne of marine fish produced. See footnote 21 for explanations.

[41] But not all. While there are other uses for menhaden, the species is hardly consumed as food. The same applies to a group of feedfish known as sand eels that are caught in the North Sea.

processing plants can convert into processed fish products. Often this means that the fishmeal plants obtain their raw material cheaply. Until a few years ago, the price hardly ever exceeded US$100 per tonne. This is a price that local consumers, even the poor, often can afford. Thus, the reason that larger quantities of fish are not consumed as food is not that the fish are too expensive for the consumer; it is rather that at the low prevailing prices demand for the fish as food is met, and if the surplus is not used as animal feed, it could at best be used as fertilizer or pet food. In such situations, fishers would soon reduce the volumes they bring ashore. At present, they make ends meet by bringing to fishmeal plants the large volumes of feedfish that they are able to catch. Thus, as a general rule the argument that existence of feed fisheries has reduced consumption of cheap fish by the poor does not hold.

The idea of landing large quantities of anchoveta, or sand eel, or most of the other species used in feed fisheries, and using them to provide food for the poor is a laudable objective, but unrealistic. By the time the poor can afford to purchase the resulting canned or cured fish products, they no longer will find themselves referred to as poor. Also, in the long run the market affects changes. In the middle of the last century most of the herring landed in Norway was converted into fishmeal; however, by the beginning of the twenty-first century the proportion had fallen to under 10 percent.

Nevertheless, there is a recurring argument that making fishmeal – and feeding it to fish – is wrong if the purpose is to maximize food production, as the practice leads to less food being available[42]. In theory, this is correct and would be of relevance for the poor, if they would have access to the fish supplied as feed (in the form of fishmeal and fish oil); but, as they do not have that access, the argument is misleading. In addition, one fish does not equal another. In the eyes of the consumer, they are not identical, some are strongly preferred (for reasons of taste, smell, appearance, ease of eating, etc.). So the argument does not give any weight to the economic realities or food preferences that govern the use of fish. The consequence is that the argument is seldom followed up by specific recommendations as to what should be done to alter the prevailing use of fish.

The argument is sometimes expressed as follows: as it takes at least 3 kg of fish (converted into fishmeal and then incorporated into fish feeds) to produce 2 kg of fish, the culture of carnivorous fish is self-defeating, as it reduces the supply of fish as an item of food[43]. The argument assumes that the fish that are about to be converted into fishmeal could in fact be sold to a waiting consumer. In virtually all reduction fisheries, and particularly in South America, this is not true. Only minute fractions of the large quantities of fish landed could be sold as food; and, as argued above, if the fish are to be preserved and transported – especially from one continent to another – they will end up being sold to the relatively better off – not to the poor.

Any attempt to modify this use of feedfish at a much faster pace than that imposed by the market will need public intervention to modify existing market forces. In most situations, such policies will involve a transfer of public funds or access to the benefits of using public funds, to entrepreneurs – and thus be classified as "subsidies" by those who prefer a status quo. Given the prevalence of international trade in fish, the use of subsidies will be scrutinized by competitors (especially by those countries where the fishing industry exports food products based on low-value pelagics) to see that any subsidies accorded to convert feed fisheries to food fisheries are WTO-compatible.

[42] In the 1970s, a third argument held sway: fishmeal should be produced to such a quality that it can be used, if not as a food in its own right, at least as an additive in other foods. FAO and various national governments (Norway and Peru being two) worked without success to establish such an industry.

[43] See http://endoftheline.com/

It would seem likely that any large-scale attempt to make food fisheries out of feed fisheries ought to take place under the umbrella of an international agreement among concerned countries.

Another possibility is to leave the fish in the water. As small pelagic species generally are prey for larger carnivorous fish, the volumes of predators will increase and the supply of fish from these fisheries will increase. As markets for such fish are often better – that is, the price per kg of fish is higher – this could be a better alternative. Yes, but not really. If the objective is to maximize the volume of fish as food, the argument must take into account that for an adult predator to grow in size by 1 kg, it will need to eat somewhere between 5 and 15 kg (most often about 10 kg) of prey. In that light, the conversion ratios obtained by aquaculture seem to be favourable: at least 1 kg of cultured carnivorous fish for 1.5 kg of fish (as converted into fishmeal)[44].

5.2.3 Unsustainable feed fisheries: an externality harming the poor?

Where feed fisheries are not managed sustainably, aquaculture today constitutes an important threat to world fish stocks because of aquaculture's reliance on fishmeal and thus on reduction fisheries. The recent increases in the world market price for fishmeal exacerbate overfishing in unmanaged feed fisheries, and aquaculture no doubt has contributed to the growing price of fishmeal and fish oil. Overfishing of reduction fisheries could lead to a long-term decline in the amounts of fish that can be extracted from the world´s oceans, as the species concerned are forage for fish at higher trophic levels. If a long-term decline were to occur, it would turn out that the farming of shrimp and carnivorous fish has not been paying the full costs of its use of fishmeal and fish oil (as it is incorporated into industrially manufactured fish feeds).

Several of the reduction fisheries in South America are currently producing at levels below historical highs. While the yields of Peruvian anchoveta, after a dip in landings following the occurrence of El Niño in 1997–1998, have recovered, and oscillate around 7 million tonnes per year, they have not reached the 10 million tonnes or more recorded in the 1970s.

During the 10 year period 1995 to 2004, the landings of Chilean jack mackerel fell. Landings in 1995 were about 5 million tonnes; three years later they were 2 million tonnes and have since oscillated around this figure. While the Chilean jack mackerel is believed to be fully or overexploited, the Peruvian anchoveta stock is qualified by FAO (2005) as fully exploited and recovering. The management of these fisheries follows modern principles that should, if adhered to, make the fisheries sustainable.

Given this situation, there does not seem to be any foundation for the argument that aquaculture threatens the sustainability of South American reduction fisheries and, therefore, endangers the food security of those who are already undernourished or the income levels of the poor in Chile, Peru or anywhere else. There are two reasons for this: on the one hand, management of the feed fisheries, even if not perfect, assures continuity of these fisheries, and on the other hand, those who want to buy and eat or commercialize fish normally destined for feed as food can do so as long as they are prepared to pay the price paid by the reduction industry, which usually is low in comparison with prices for foodfish.

The fishmeal industry in the United States of America[45] is based on menhaden, a type of fish that is not much liked as food, and whose only other main use is as bait (Tacon, 2009). There are two stocks of menhaden, both fully exploited. The fishery is

[44] The main reason for this difference is that fish and shrimp feed contain other feedstuffs in addition to fishmeal and fish oil. With the exception of salmon feeds and feeds for special phases of the culture cycle for other species, ingredients other than fishmeal and fish oil make up the larger share of the feed.

[45] In Alaska, more than half the weight of the marine fish catch, mostly in the form of heads, viscera and frames obtained from the fish processing industries, is converted to fishmeal (Tacon, 2009).

a rather small one and does not significantly affect American society or the poor and undernourished in other parts of the world.

Feed fisheries in Europe are not well managed. The stocks of blue whiting and capelin have been exploited beyond the recommended catch limits. This may have future negative consequences for fishmeal production in Northern Europe, which in turn will worsen the feed situation, particularly for Norwegian cage-culture of salmon, trout and – in a possible future – cod. There may be negative consequences also for shrimp and fish farmers outside Europe that could threaten employment possibilities on fish and shrimp farms for the unskilled and poor in those regions.

In summary, available data and information do not support the thesis that feed fisheries create an externality (demise of these and other marine fisheries) that will significantly harm the world's poor and that, therefore, concerned public authorities need to correct. So, there does not seem to be a factual basis for holding fish and/or shrimp farmers responsible – at least not more responsible than any other user of fishmeal and fish oil (e.g. livestock producers, pet food manufacturers).

5.2.4 Country and regional notes

Chile and Peru

The west coast of South America is home to the world's largest capture fisheries. Chile and Peru together regularly account for between 12 and 15 percent of the world landing from capture fisheries. These two countries have a combined population of about 47 million, or about 0.7 percent of the world population. It is not surprising that they export a large part of their catch. Even if their populations consumed fish at the rate of the most fish-consuming populations (60 kg/capita/year, live, weight equivalent), they would still only consume about 2.8 million tonnes, or 20 to 25 percent of landings.

The governments of the two countries promote fish as food, and consumption is above the world average, reaching about 20 kg per person per year in both countries. However, populations in both countries prefer red meat, fish supplying between 15 and 20 percent of animal proteins in Chile and about 25 percent in Peru. However, in 2003, 15 percent of the population in Peru was undernourished and one quarter of the children were stunted.

In Chile and Peru, most of the landings from capture fisheries originate in reduction fisheries supplying pelagic fish to local fishmeal factories. The main reduction species are also consumed as food. For the anchoveta, the proportion of the total landings is increasing but small, still less than 1 percent of the volume landed in Peru. Of the Chilean horse mackerel landed in Chile, the proportion used as food is larger, and an important and growing volume is being exported. A large share of these exports is going to better-off consumers in West African countries and China.

In Chile and Peru, reduction fisheries do not mean a reduced access to fish as food, they mean employment and income for the poor. In these countries, the reduction fleets generate employment for the unskilled, and in Chile the salmon industry creates employment in the poorer regions of the country.

Elsewhere in South America

The reduction industries have relatively little influence in the rest of South America. The possible exceptions are Brazil and Ecuador, both of which have significant shrimp culture industries. While Ecuador produces enough fishmeal for its needs and is a net exporter, Brazil depends on imports of fishmeal for its expanding shrimp culture industry (65 000 tonnes in 2006). The poor in both countries can be said to be beneficiaries in terms of employment and income.

Africa

In Africa, fish is food. In many countries south of the Sahara, fish protein provides a large part of the animal protein in everybody's diet. Fisheries have a double function, providing a livelihood for many and nutrition for more. Thus, fisheries for purposes other than providing food have been exceptions and are likely to remain so for some time in most parts of the continent.

Nevertheless, some 15 percent of the continent's catches are reported (Laurenti, 2007) as destined for non-food uses. Morocco, Namibia, Senegal and South Africa account for more than 85 percent of this fish.The first three of these are countries with large fishery resources but relatively small population densities, no doubt a part of the explanation of why not all fish are used as food. In fact, the vast majority of African countries report no catches as destined for other than food purposes.

Fishmeal is produced at an industrial scale in South Africa and Morocco. In South Africa, there is a dedicated fishmeal fishery, while in Morocco fishmeal factories are supplied by vessels that fish not only for the reduction industry.

With a few exceptions, there is little culture of marine shrimp (the exception being Madagascar) and carnivorous marine finfish in Africa. Thus, little locally produced fishmeal becomes part of fish feed. Most of the fishmeal produced is used as feed for livestock and poultry or exported.

Madagascar

This country is interesting; although it is among the world's poorest nations, it can be argued that its poor benefit from reduction fisheries. This happens because the Malagasy shrimp culture industry employs unskilled manpower.

In Madagascar, culture of marine shrimp is well established, reaching a volume of 6 000 to 8 000 tonnes per year. From a poverty and food security perspective, the industry has direct impacts, in that it provides employment. For the industry as a whole, the employment is reported to be on the order of 4 000 to 5 000 individuals in shrimp farming proper. A majority of those employed are low-skilled, manual workers. Employment, income and fish supplies are important, as more than one-third of the country's population is undernourished and the consumption of proteins is below recommended levels (FAO, 2008a).

The industry employs modern semi-intensive methods, and the feed is industrially manufactured dry feed incorporating fishmeal and fish oil. Tacon and Metian (2009) estimate that the industry used between 18 000 and 20 000 tonnes of feed in 2006. The industry relies on imported fishmeal, as the quantity of fish destined for non-food uses in Madagascar is low. During the period from 2001 to 2003, the average amount of fishmeal produced per year was about 1 000 tonnes (Laurenti, 2007).

In summary, the use of fishmeal in shrimp feeds seems to benefit the poor and food insecure in Madagascar, in the sense that some of them are able to obtain an income that might not otherwise be available.

South Africa

It is mostly pelagic fish that are used for fishmeal in South Africa. The quantities supplied to fishmeal factories declined drastically during the 1970s, stabilizing during the 1980s at about 0.5 million tonnes per year only to fall drastically during the 1990s. During the first few years of the last decade, quantities rose again to reach 380 000 tonnes in 2003 (Laurenti, 2007). If South Africans had eaten the fish used for fishmeal in 2003, it would have meant a per capita apparent consumption of 15.5 kg[46], more than double the amount recorded for the year.

[46] Live-weight equivalent.

Are these fisheries sustainable? "South African anchovy and pilchard are both managed in South Africa through total allowable catches (TACs) set each year on the basis of estimated biomass of stocks. Catches of South African anchovy have increased steadily since falling to a minimum of 42 000 tonnes in 1996, reaching 289 000 tonnes in 2001 and decreasing to 255 000 tonnes in 2002. Catches of South African pilchard were 265 000 tonnes in 2002, the highest on record since 1976" (FAO, 2005). As South Africa is reported to have well-developed management systems for its pelagic fisheries, there is a possibility that these fisheries will remain sustainable.

From a food security point of view, the fishmeal production does not appear to have removed fish from the poor. There are two reasons for this. First, supplies of fish for human consumption have been rather stable in South Africa but have never been high. The level of fish consumption in the country increased to about 10 kg per capita in the late 1980s to fall back to about 7 kg 10 to 15 years later. Simultaneously, there have been dramatic fluctuations in the quantities of fish used for non-food purposes, reflecting fluctuations in capture fisheries landings. This would seem to indicate that the food market has been satisfied and surplus landings have been used in fishmeal factories. Thus, fishmeal manufacture has not pre-empted the access of the South African population to fish. The second reason for not considering this outcome as undesirable is that contrary to the situation in most other countries south of the Sahara, fish proteins provide only a very small part – less than 10 percent – of the animal proteins of the average South African diet. Also, as fish consumption has fallen, other animal proteins have taken the place of fish, and the overall supply of animal proteins per person has remained stable at between 24 and 28 g per capita per day (Laurenti, 2005).

In addition, it should be pointed out that aquaculture production in South Africa is modest. Total aquaculture production (not including plants) reached about 3 500 tonnes in 2006. The bulk of the fishmeal produced in the country is used for purposes other than aquaculture or is exported. In 2006, compound fish-feed production in South Africa is reported to have reached about 1 500 to 2 000 tonnes (Tacon and Metian, 2008).

In summary, fishmeal production in the country does not seem to have generated negative consequences for the poor and undernourished in South Africa or elsewhere in the region (through shifts in fish supplies) or seems likely to do so in the future (through externalities in the form of overexploited pelagic resources).

Morocco

The situation in Morocco has similarities with that in South Africa. The fishmeal industries are supplied by the pelagic fisheries. The quantities of fish reported to be used for purposes other than food increased slowly to the middle of the 1990s and fluctuated around 350 000 tonnes between 1994 and 2003. Morocco exports almost all the fishmeal it produces. Some is used locally as animal feed; however, as freshwater fish completely dominates the small Moroccan aquaculture sector, virtually no fishmeal is used by local aquaculture.

A survey of stocks of small pelagic fish off the northwest coast of Africa has concluded that the combined catch of small pelagic fish should not be higher than the average landings for the period 1998–2003 (FAO, 2005). Management of these fisheries is complicated by the presence of fishing fleets from non-coastal countries, some of them fishing in the Moroccan Exclusive Economic Zone (EEZ). Thus, the future of these stocks is uncertain; whether or not a collapse can be avoided remains to be seen.

Morocco regularly exports more fish (300 000 to 350 000 tonnes[47]) than is consumed locally per year (230 000 to 270 000 tonnes). This rate of consumption works out to an

[47] Live-weight equivalent.

apparent consumption of about 8 kg per person per year. If all the fish now used for non-food purposes were eaten, it would mean that each inhabitant would consume an additional 11 kg per year.

The population of Morocco is relatively well off nutritionally; less than 5 percent of the population is undernourished (FAO, 2008a), although between 10 and 20 percent of children are reported to be underweight or stunted. Animal protein consumption in Morocco is low, some 16 g per capita per day, but fish contribute no more than 15 to 17 percent of this amount. Consumption of proteins is within the recommended amounts (FAO, 2008a). Fish consumption has increased over the last few decades but seems to have stabilized at about 7 to 8 kg (live-weight equivalent) per person during a 15-year period ending in 2003.

Morocco has a long-established and modern fish canning industry based on small pelagics. It exports high-quality canned products worldwide. Thus, Moroccans have access to cheap fresh fish and high-quality canned and processed products at competitive prices. These has been made available because of the pelagic fisheries, not in spite of them. Just as in South Africa, in Morocco fishmeal industries cannot be seen as having had a negative influence on food availability for the poor.

Europe

The poor and undernourished are few in Europe and found mainly in the eastern parts. Although some carp culture is carried out in those regions, and modern farms include some fishmeal in the fish feeds used, feed fisheries cannot be said to have any measurable impact on the poor and food insecure of Eastern Europe. Neither will fishmeal plants have significant impacts in the areas of Western Europe where they are located.

Asia

Most fishmeal production in Asia makes use of bycatch, or of "surplus" catches in food fisheries of small pelagics and, increasingly, of heads, guts and viscera from industrial fish processing. However, in Japan the large-scale culture of Japanese amberjack (*Seriola quinqueradiata)* of about 150 000 tonnes became possible as large volumes of low-value fish (sardines and sandlance) were landed and used as direct feed. In recent years, fishmeal, as part of pelleted feeds, has replaced a considerable part of the direct feed as landings of sardine fell.

China

The country is a large net importer of fishmeal and fish oil. In 2006, imports amounted to just under 1 million tonnes, having been substantially higher in 2004 and 2005 (FAO, 2008b). At the same time, exports amounted to only a few thousand tonnes. Fishmeal use in shrimp and fish feed is reported to have been about 526 000 tonnes in China in 2006 (Tacon and Metian, 2009). This was 41 percent of all fishmeal used for livestock. The shrimp culture and fish culture industries are large employers of poor and unskilled staff. Without access to imported fishmeal, employment in these industries would have been substantially lower.

India

The country has no feed fisheries of its own. Fishmeal is produced from bycatch and from excess landings of small pelagic species. However, the standards of the fishmeal industry are comparatively low. Few plants separate out the fish oil and at the time of writing, the shrimp culture industry imports the fishmeal it needs in feeds.

Non-food uses have traditionally been low in India and are of little consequence for country wide nutrition (quantities have generally been below 0.1 kg per capita per year). Nevertheless, an expanding poultry industry and a boom in marine shrimp

culture in the 1990s led to an increase in fishmeal production and, therefore, use of bycatch and small pelagics as raw material.

The total volume of fish used for non-food purposes expanded to over 0.4 million tonnes in the 1990s but has since fallen and was about 0.35 million tonnes in 2003. However, most of the fish used for non-food purposes is of pelagic origin, the shrimp-trawler bycatch accounting for about 20 percent of the total.

In the coastal areas of southern India, some of the poor benefit through employment and income from feed fisheries conducted outside the subcontinent. They do so because these foreign fisheries provide the fishmeal that is included in the industrially manufactured shrimp feeds used in Indian shrimp culture.

There do not seem to be any figures on the employment in Indian shrimp farming. If labour productivity is similar to that in Madagascar, employment may be in the order of 0.1 million; however, as much shrimp farming in India is of the smallholder kind, employment productivity is not likely to be as high as in Madagscar, and, therefore, total employment in the shrimp culture industry is considerably above 0.1 million (man-year equivalent), with a large share of those employed being unskilled and unorganized.

Any national or international policy originating in a desire to lessen the use of fishmeal as an ingredient in shrimp feed that leads to a fall in the production of cultured shrimp in India would initially lead to increased poverty in some coastal areas of the country, and, therefore, a worsened food security situation of concerned households. Naturally, with time, pond owners will attempt to culture species not dependent on fishmeal and fish oil, or will find uses for their ponds that are outside aquaculture (although the increased soil salinity will reduce the possibilities).

Japan

The country regularly uses more than 0.5 million tonnes of fishmeal a year, but produces only about 0.2 million tonnes. The difference is imported. The fishmeal ingredients used in the farming of Japanese amberjack and red seabream should not exceed 0.1 million tonnes per year (or 1.2–1.3 percent of food-fish supply). Given that most fishmeal made in Japan is also used within the country, the Japanese feed fisheries and manufacture of fishmeal have no direct implications for the poor and undernourished elsewhere.

Viet Nam and Indonesia

The shrimp culture industries in Indonesia and Viet Nam are in almost the same situation as that just described for India. Although both countries have local fishmeal factories, their supplies are not based in feed fisheries, and as they do not produce enough fishmeal for their respective needs, imports are needed. Also in these countries, the employment of coastal poor in shrimp culture is tied to imports of fishmeal, which almost always is high-quality fishmeal based on feed fisheries and complemented with fish offal. It seems that in both countries, if the only source of raw material is bycatch, then local fishmeal plants have difficulties in competing with other sectors. The volumes are small at any one point[48] and the competition from other uses and the fresh fish market, are too severe.

5.2.5 Fattening of Bluefin Tuna

Beyond the Asia-Pacific region, the direct use of wild fish as aquaculture feed is uncommon. It is only in recent years, with the advent of an industry based on the

[48] Edwards *et al.*(2004) reported that a fishmeal plant in Viet Nam would need daily supplies of about 120 tonnes of raw material to keep the plant operating economically.

fattening of bluefin tuna, that the practice is employed in a modern and expanding industry. However, it is not clear to what extent the provision of feed, often pelagic species, is obtained through specialized fisheries.

Apart from in Australia, fattening of bluefin tuna is now carried out in the eastern Central Pacific (Mexico) and in several countries bordering the Mediterranean Sea. Virtually all of the cultured bluefin tuna is shipped to Japan, where it enters the sashimi market.

Overall, the amount of wild fish used annually as feed in this industry is probably about 0.2 million tonnes. Most of this total is made up of small pelagic species (Huntington and Hasan, 2009). Local fisheries generally provide this fish, while it is reported that northwest African pelagic fisheries have been providing feeds to bluefin tuna kept for fatting in the Mediterranean Sea. In most regions, the quantities so far used are small in relation to pelagic fisheries in total[49].

Where supplies are removed from fish that normally would have been processed into fishmeal, the effects on food supplies can generally be considered as small. The effects on employment and income in the region where the fisheries take place could be positive (value added in freezing, storing and transport of whole fish – probably higher than the value added linked to fishmeal production), but overall the value is likely to be small.

5.2.6 Conclusions

Feed fisheries, through aquaculture, generate employment and income for poor in many coastal areas of the world. At the same time, they provide employment at sea and in fishmeal factories for unskilled workers, particularly in South America and in a few African countries.

Also, as a rule, these fisheries do not limit the access of the poor and undernourished to fish as food. The exception to this rule may be fisheries that supply feed to capture-based culture of tunas. Given the extraordinarily high prices paid for such tunas in the Japanese markets, those who raise bluefin tuna in captivity can afford to pay more for sardines and other pelagic species than do those who prepare this fish for the food market (Zertuche-González *et al.*, 2008).

Feed fisheries, in common with most marine fisheries, experience management difficulties because fishers often exceed established catch limits. In many of these fisheries difficulties are exacerbated by oscillations in the biomass of the species concerned, oscillations that are linked to a fluctuating and changing marine environment. Nevertheless, as these fluctuations follow varying rhythms, the fluctuations for the sector as a whole will be less dramatic than that of any individual fishery, and overall it seems plausible that the feed fisheries will continue to provide raw material to fishmeal plants according to a pattern that will not differ much from the recent past. The exception at present seems to be the North Atlantic feed fisheries. However, if appropriate management action is taken in the North Atlantic fisheries, the world's feed fisheries are unlikely to be exploited by such high levels of fishing effort that these fisheries will threaten overall yields of marine fisheries.

The above discussion of the use of fishmeal and fish oil in aquaculture feeds seems to support the affirmation of Willmann (2005) that "Globally, evidence is weak, if any, that expanding aquaculture has significantly contributed to increased fishing pressure on reduction fish species. The primary reason for over-exploitation is the absence of effective fisheries management and increase in the demand and price of food fish."

[49] However, the share can also be significant at the local level. It is reported that in 2006 about half of the Pacific sardines (*Sardinops sagax caerulea*) landed in Ensenada on the west coast of Mexico was used as feed in local capture-based culture of the northern bluefin tuna (*Thunnus orientalis*) (Zertuche-González *et al.*, 2008).

5.2.7 Outlook

The data used above include some information for 2006. They do not, therefore, reflect the convulsions that the fishmeal and fish oil industry and associated markets have experienced as prices sky-rocketed for fishmeal and fish oil in 2007 and 2008. The immediate effects were reduced demand, but also an increased ability by fishmeal manufacturers to pay for raw material. Simultaneously, however, the least proficient aquaculture enterprises may have experienced difficulties in affording the increase in feed prices. Simultaneously, they would have had difficulties in passing on cost increases to consumers, as several of the more important markets experienced stagnation and/or recession.

The increase that has taken place in the real prices of fishmeal and fish oil, on the one hand, will speed up the gradual replacement of fishmeal and fish oil in aquaculture feeds by plant proteins and vegetable oils[50] and, on the other hand, lead to reduced inclusion of fish proteins in feeds for omnivorous species. In addition, it will lead to increased efforts to include offal obtained when foodfish are processed industrially, which may reach 50 percent of the live weight. Eventually these developments will help the aquaculture industry to grow and the poor to keep their employment in and income from shrimp and fish culture.

Until the middle of the first decade in the present century, the aquaculture industry's use of fishmeal and fish oil grew rapidly. This has not led to any real increase in the volumes of fishmeal and fish oil produced, but to a shift in the use of what has been produced – instead other users of these products have reduced their share. However, this trend has now come close to its natural end – there is little output left to shift to aquaculture.

While the recent price increase leads to increased supply of fishmeal and oil, it simultaneously reduces demand and spurs the development of alternative feeds. This will help the aquaculture industry expand; but how will it affect the poor and undernourished? For them, the employment/income effect will be the sum of two divergent trends. On the one hand, employment in aquaculture will be maintained and possibly expand, but on the other hand, employment will fall in fish processing as the share of a stagnant world marine fisheries output that is dedicated to feed fisheries expands. Simultaneously, a growing population will face a contracting supply of (comparatively) cheap fish that is instead used for feed. This is a possible future negative outcome.

Finally, with time, weak states will become stronger. Corruption will decline and managers will have a better chance to manage fisheries effectively. This ought to improve sustainability in feed fisheries and reduce fluctuations in supply of fishmeal and fish oil also to aquaculture feed manufacturers.

6. DISCUSSION OF PUBLIC POLICIES FOR MODIFYING NEGATIVE OUTCOMES FOR THE POOR AND UNDERNOURISHED DERIVING FROM THE PRACTICE OF USING WILD FISH AS AQUACULTURE FEED

So far this paper has looked at the issues surrounding the use of fish as aquaculture feed from a global perspective. It has found that on the whole feed fisheries provide considerable benefits to many. Nevertheless, governments hosting export-oriented reduction industries may want to shift the use of fish away from feed to food. Apart from improving the nutritional status of local populations, such policies may also lead to more local employment and, therefore, contribute to economic growth.

With regard to the use of bycatch as aquaculture feed, the situation is much less favourable. It is evident that such usage has reduced the availability of cheap fish in

[50] Feed producers and academic research institutions are making an enormous effort in this field, which is likely to produce results in the near future (see Naylor *et al.,* 2009).

communities adjacent to fishing centres and that the bycatch often contains such a high percentage of juveniles that negative externalities are created, i.e. that other fisheries suffer serious negative consequences. Governments are struggling to control bycatch fisheries and may also want to promote food-use of sustainable bycatch.

What could and should governments do if they want to promote a modification in the use of feedfish or a different usage of sustainable bycatch? A number of possible actions come to mind. They are likely to be a combination of economic incentives/disincentives and straight-out regulations. Before adopting any measure, governments will want to (i) investigate the effectiveness of the proposed measure and (ii) make certain that it is compatible with the economic policies that it applies nationally and must adhere to internationally.

Entrepreneurs in the fisheries field very often trade their products in the international market[51], and they will not want to contravene international trade agreements. National governments will not want to be seen as enacting economic policies towards the fisheries and aquaculture sector that differ in their basic principles from those applied to the economies generally.

6.1 Undesirable outcomes of economic growth

Today most countries organize their economies as market economies. However, the "invisible hand" at work in market economies does not direct economic activities so that the poor and food insecure automatically benefit. Neither, as has become painfully obvious during the last decades, will the market economy ensure sustainable use of land and water. In rural areas of straggling economies, the market may act so that the poor and food insecure are disadvantaged, i.e. that their income and/or wealth shrinks or their access to food is impaired in the short and/or long run. The fundamental reason for this is that a market economy is organized (and supported by a legal regime) to generate wealth in the economy, but does not automatically ensure that the wealth is distributed in line with what might appear appropriate to many. A market economy generates economic growth, not an equitable distribution of the resulting income or wealth.

When the income of the poor falls or their access to food is curtailed, the reasons are usually related to market swings and/or externalities. The problem is that in most situations market forces will not automatically counteract externalities and market swings. Those economic actors who benefit from market swings or externalities will argue that the negative outcomes they cause are not very important; those who suffer them will argue the contrary. Thus, it is up to those concerned to call the situation to the attention of public authorities so that these can assess whether to intervene or not, and subsequently take appropriate legal or regulatory actions.

Those who participate in debates about negative outcomes intend to persuade public authorities that they need to intervene to nullify or defend, as the case may be, the negative outcomes. In such discussions, the rural poor in struggling economies often start with a handicap. They may be illiterate and they may be ignorant of their legal rights.

6.1.1 Market swings

A market swing[52] is a situation that occurs when a commodity or service appears or disappears in a market. When the swing peters out and trade stabilizes, a market shift has occurred. Such changes can occur at different scales, at different speeds and in regional, national or world markets. They can be seen as positive or negative.

[51] FAO has estimated that in 2006, some 38 percent of all fish products (capture fisheries and aquaculture) entered international trade in one form or another (S. Vanuccini, FAO, personal communication, 2009).

[52] In the traditional macroeconomic literature, such changes in the market are often described as "shifts" in the supply or demand curves.

Market swings appear not only for finished goods and services, but also for factors of production.

Market shifts are common in market economies. In fact, they are an inherent part of economic growth: slide rules are replaced by computers, mechanical typewriters by electric keyboards, telegrams by emails, etc. This "destructive growth"[53] generally is seen as something positive in the long run.

As long as the rate of change is not faster than that it permits a redeployment of those who become unemployed and does not cause sustained harm to consumers, the market shift is normally permitted to proceed. In these situations, public authorities mostly limit their interventions to making it easier for the unemployed to find employment. However, those who suffer the changes of market swings will argue that the market shift has had such strong negative consequences that the authorities need to intervene to modify them or roll them back entirely.

Rapid market swings for food products are, in fact, prone to quick and sometimes drastic interventions by public authorities. The rapid increases in world food prices that occurred in 2007 and 2008 illustrate this. Demand for biofuels led to higher maize prices, which in turn caused higher prices for substitutes, among them rice. This led a large number of governments to restrict exports of rice, and the world price of rice rose drastically in the course of a matter of months (FAO, 2009b).

Market swings that are modest but long lasting and affect low-priced products receive less attention. The use of wild fish as aquaculture feed is one such change in supply. As discussed earlier, in East Asia, where it is common to use wild fish as aquaculture feed, this practice has led to a decrease in supplies of cheap fish. There are those who argue that this practice should not be permitted to continue. However, it seems that few authorities have intervened to redress this situation.

Both in North America and in Europe, imports of cultured fish and shellfish (catfish, Atlantic salmon and marine shrimp) have generated protests from producers in importing markets who have seen their livelihoods threatened (Norman-López and Asche, 2006). North American salmon fishers and catfish producers have protested successfully. There are probably several reasons for the success of these protests. In respect of salmon, it may have to do with the "up-market", luxury nature of the salmon (definitely not food for the poor when aquaculture was started), and, therefore, it was difficult for importers to argue that imports of cultured salmon were needed for reasons of food security. The second reason for the success is probably most salmon fishers were – and are – North American, while those who culture salmon are found principally in Norway and Chile. The North American fishers used to dominate the world market for salmon with wild species caught in the North Pacific. Where fishers and aquaculturists are of the same nationality (as in the culture of seabass in the Mediterranean Sea), the rise of aquaculture has been easier to accept for both those involved and public authorities.

Some argue that in a certain situation a market swing ought to have taken place, and the fact that it has not is harmful to sections of the community. These situations can be seen as "unrealized market swings". The following argument is an illustration of the concept "unrealized market swing": if Peruvian anchoveta was not turned into fishmeal – and then incorporated into aquaculture feed – the world (and the poor in particular) would have more fish available as food, and, therefore, aquaculture using fishmeal should not be permitted to continue to turn perfectly good food into animal feeds.

[53] In 1942, the Austrian economist Joseph Schumpeter in his book Capitalism, Socialism and Democracy used the term to describe the process of transformation that accompanies radical innovation.

6.1.2 Negative externalities: income for some – costs for others

When shrimp farming started on the east coast of India, it was common to convert rice fields to shrimp ponds. However, as shrimp farmers flushed shrimp ponds with brackish water, they eventually caused a build up of salt in the soil and also in the surrounding lands. This made these lands less suitable for growing rice or other crops, and the farming households who where not part of the shrimp culture activities would see their income fall. This is an example of an externality[54] created by aquaculture.

In a growing and functioning economy, the availability of factors of production fluctuates following modification of existing technologies and/or access to new markets. This means that enterprises have more or less difficulty in making ends meet as needed labour or raw materials may increase in price or the demand for the finished product may fall. The beneficial side of these shifts in availability is that factors of production are used where they produce the most value. Therefore (and sometimes in spite of much protest), governments are generally reluctant to interfere in the market to redirect the use of factors of production.

However, when an enterprise causes externalities, those who suffer them have a better chance of obtaining public redress than do those who protest about market swings. The individual who suffers the consequences of an externality can point to a "failure" in the market: the fact that the entrepreneur does not compensate those who suffer economically (or otherwise) because of his/her enterprise[55].

Dealing with undesirable outcomes in most economies is a political process. The issue for public authorities, who should act in this process, is one of deciding how to deal with market swings and negative externalities. A decision on their part must include information on the extent and nature of the externalities. How many individuals are concerned and how are they affected? In poor economies, effects on income and nutrition are fundamental knowledge.

However, given international agreements on trade and national practice in respect of economic and fiscal policies, most governments have limited freedom to effectively use pro-poor policies to mitigate negative outcomes originating in the practice of using fish as feed in aquaculture.

6.2 Pro-poor, national policies for feed fisheries

The previous discussion of feed fisheries has shown that governments may want to intervene in feed fisheries in order to improve the situation of the poor and undernourished. Their situation may be improved as measured by: food supplies, employment and income generation, and sustainability of marine fisheries.

6.2.1 Food supplies

Governments could buy small pelagics on the open market and provide them at a subsidized cost in institutional feeding programmes (hospitals, schools, military, etc.). However, given the public expenditures involved, it would seem unlikely that in poor economies such schemes could be maintained for any length of time or cover a

[54] An economic side-effect. Externalities are costs or benefits arising from an economic activity that affects someone other than the people engaged in the economic activity and are not reflected fully in prices. For instance, smoke pumped out by a factory may impose clean-up costs on nearby residents; bees kept to produce honey may pollinate plants belonging to a nearby farmer, thus boosting his crop. Because these costs and benefits do not form part of the calculations of the people deciding whether to go ahead with the economic activity, they are a form of market failure, because the amount of the activity carried out if left to the free market would be an inefficient use of resources. If the externality is beneficial, the market would provide too little; if it is a cost, the market would supply too much. (http://www.economist.com/research/Economics/alphabetic.cfm?LETTER=E)

[55] A few decades ago, many aquaculture activities were rightly blamed for causing pollution, an externality, in many ecosystems. At present, there exists a considerable body of knowledge about how to deal with pollution caused by aquaculture, and the industry has done much to reduce it.

significant share of the landings in feed fisheries. Thus, impacts on fishmeal and fish oil users, including aquaculture farms, would be marginal.

6.2.2 Employment and income generation

In countries like Chile and Peru, the employment generated ashore by the huge reduction fisheries is probably experienced as small and insufficient. One avenue for modifying the situation is simply to prohibit the use of fish – which is also sold as food – as raw material for fishmeal and fish oil. Obviously, such a policy would have to be introduced gradually and slowly, if it is meant to roll back an existing industry. If applied pre-emptively, it is of course much easier to achieve. This was done successfully in Argentina for the anchovy fishery out of Mar-del-Plata. The measure has been in force for several decades, and a shore-based food processing industry exists. Only in the case of a significant roll-back of existing feed fisheries could these policies affect aquaculture based on fish as feed, and if so, negatively. It would then be a matter of weighing the loss of employment in aquaculture (and possibly in the livestock sector)– most of which is likely to be undertaken in countries that import fishmeal and fish oil – against the expected increase in employment in shore-based industries.

It may be tempting to provide economic incentives (referring to an "infant industry argument") in order to establish a local fish processing industry using feedfish as raw material. Given the international trade that occurs in tinned fish products, such a policy is likely to run into complaints about unfair competition and eventual referral to the WTO. Thus, it is not a likely avenue for most countries.

6.2.3 Sustainability

Managing feed fisheries sustainably is difficult. The problem in these fisheries is a traditional fisheries management problem that they share with many other fisheries. How to control fishing effort so that established catch quotas are not exceeded? This is much debated in the fisheries management literature and will not be discussed further here.

Instead, it should be stated that appealing to consumers of aquaculture products not to buy certain species in the hope that this will reduce the fishing pressure in feed fisheries is a very blunt instrument. It is a blunt instrument because fishmeal has many uses and what is not incorporated into fish and shrimp feeds may well be used to produce feed for poultry and/or livestock or incorporated into pet foods. Furthermore, a consumer boycott is also a strategy that is wasteful from the economic point of view, as it attempts to direct fishmeal to uses other than those that the market considers the most profitable.

If such policies are successful against fishmeal produced in Northern Europe, the consequence for the poor and undernourished in tropical countries is loss of employment and income, and to achieve international support such policies should probably be accompanied with support for development of alternative livelihoods in areas where shrimp and marine fish farming are common.

6.3 Pro-poor national policies for bycatch fisheries

Bycatch fisheries and the use of bycatch for aquaculture feed also impacts the poor's (i) access to food, and (ii) possibilities to find paid employment either directly or in the long term, as a consequence of crumbling fish stocks.

Food supplies

There is no easy method available to alter the allocation of bycatch in the market so that the access of the poor is favoured. One possibility is to prohibit the use of bycatch for aquaculture feed. However, in most locations such a prohibition would be difficult and costly to enforce. In theory, rich governments could purchase those parts

of the bycatch that they would like to reserve as food – by paying a price higher than aquaculturists could afford – and then put them on the wet fish market at subsidized prices. In any such scheme, the transactions costs that would need to be incurred to prevent subsidized fish from finding their way back to aquaculturists may turn out to be substantial.

6.3.2 Employment and income generation

If effective, a prohibition to use bycatch as feed would lead to more bycatch being used for other purposes such as raw material for cured products, fresh sales, etc. This would, in turn increase employment. An effective stop to the landing of bycatches would of course, lead to loss of employment in several post-harvest sectors. This creates a dilemma for those who have to deal with the sustainability issues related to bycatch, as the loss of the "bycatch" could run into stiff opposition in local communities, whose needs for income and food associated with the bycatch are immediate and pressing.

6.3.3 Sustainability

The bycatch issue is a classic and well-known fisheries management problem. Various technical measures have been developed to deal with it, but if they are not enforced, and this is frequently the case in countries where bycatch is used as aquaculture feed, then the bycatch problem remains. Also, bycatch is not easy to deal with by applying consumer pressure (through labels of various kinds), as some parts of the bycatch are composed of non-commercial species or of damaged commercial species, for which animal feed is probably the best possible use. The transaction costs involved in monitoring the flow of bycatch could be very high indeed.

It is quite evident that in many fisheries, and not only in Asia and Africa, bycatch is a big and in some cases growing issue, and no matter how it is dealt with the poor will be affected.

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This technical paper provides a comprehensive review of the use of wild fish as feed inputs for aquaculture covering existing practices and their sustainability as well as implications of various feed-fish fisheries scenarios. It comprises four regional reviews (Africa and the Near East, Asia and the Pacific, Europe, and Latin America and North America) and three case studies from Latin America (Chile, Peru and the study on the use of the Argentine anchoita in Argentina, Uruguay and Brazil). The four regional reviews specifically address the sustainable use of finite wild fish resources and the role that feed-fish fisheries may play for food security and poverty alleviation in these four regions and elsewhere. With additional information from case studies in China and Viet Nam, a global synthesis provides a perspective on the status and trends in the use of fish as feed and the issues and challenges confronting feed-fish fisheries. Based on the information presented in the global synthesis, regional reviews and three case studies, and through the fresh analysis of information presented elsewhere, an exploratory paper examines the use of wild fish as aquaculture feed from the perspective of poverty alleviation and food security.

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