CLIMATE CHANGE AND OTHER CHALLENGES IN THE DEVELOPMENT OF A SUSTAINABLE AND VIBRANT AQUACULTURE INDUSTRY IN SOUTH AFRICA

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ABSTRACT

In 2009 global aquaculture contributed 45% of all aquatically derived food products consumed. In all probability aquaculture production will eclipse capture fisheries in the not too distant future. Unlike in other parts of the world aquaculture development has been slow in South Africa. Possible reasons for this will be discussed. As well as, appropriate governmental interventions to fast track aquaculture development. Key to theses strategies are the creation of an enabling institutional environment. Globally most capture fisheries are fully exploited or in some cases over exploited. Certain fishing stocks have shifted their geographic range because of changes in oceanic temperatures. This has brought economic hardship to coastal communities traditionally reliant on these fishing resources though direct employment and ancillary service industries. Other fish stocks have been fished to commercial extinction. On the West Coast of South Africa the pilchard stock has shifted to the South Coast which means that fish has to be landed in Mosselbay and transported by road to canning plants in St. Helena Bay. Aquaculture enterprise development can definitely play a role, in part, in reviving economic prosperity in impoverished coastal communities. However, other appropriate economic interventions should be sought to expand the economic opportunities in specific coastal areas.

1. INTRODUCTION

The total landed catch of South African fisheries oscillates between 500 000 and 800 000 tonnes whole wet weight per annum (Hutchings et al., 2009). In 2005 this constituted a fishery worth in the region of R4.5 billion. The demersal (bottom trawl) fishery, which is principally constituted of hake, constitutes 60–80% of the landed catch by value. The second most valuable resource and the largest amount caught by weight is made up of the small pelagic purse seine fishery (sardines, anchovy and redeye). Human consumption constitutes a small portion of the resource catch use, with fish meal being a primary processed product of the fishery.

Most global fisheries are currently at Maximum Sustainable Yield (MSY) or are in decline (Pauly et al. 2002). There have been predictions that by 2048 all finfish fisheries will be commercially extinct, i.e. the density of the stocks will be so low that the Catch Per Unit Effort (CPUE) would make it uneconomical to fish the remaining resources. Global Aquaculture currently produces 45% of all aquatic derived food products (Nomura, 2009). The balance comes from the harvesting of wild stocks. Fisheries and aquaculture, both in freshwater, brackish and marine environments, will both be impacted by climate change. In certain instances climate change would have positive impacts for culture of certain species and in other case may impact aquaculture and fisheries negatively.

The South African aquaculture industry was worth R 327 million and produced 3,654 metric ton of product in 2008 (Britz et al. 2009). Of this production the Western Cape Province produced, both freshwater and marine species, 61% of the tonnage and 83% by value. The primary component to this figure is the export based abalone (*Haliotis midae*) industry, the balance is made up of rainbow trout (*Onchorynchus mykiss*), oysters (*Crassostrea gigas*) *and* mussels (*Mytilus galloprovincialus* and *Choromytilus meridionalis*). The Eastern Cape made up 18% by tonnage and 7% by value through mostly marine based operations. Mpumalanga accounted for 8.7% of the national tonnage tally (mainly rainbow trout) which was valued at 3.4% of the national total. The other provinces made up a combined 200 ton of product or 5.5% by weight. The South African abalone industry is the success story of aquaculture in the country. This industry is vertically integrated with relatively stable long term clients and markets. There is a

sense amongst current industry members that there is a relatively finite market segment for farmed abalone and as such a number of abalone operations are hedging their bets in developing aquaculture projects in fin fish as well as shellfish. Some of these businesses, as well as new entrants, are branching out into the boarder SADEC region into Mozambique and Namibia for marine species and Mozambique and Zambia for freshwater species. The abalone industry is in a sense driving aquaculture development, as a lot of the entrepreneurs that are branching out into other species and venture have “cut their teeth” so to speak in the abalone and to a lesser extent in the trout industry.

In 2009 the president of the republic of South Africa restructured a number of government departments. For aquaculture a far reaching decision was made in that a new primary production department was formed. The Department of Agriculture, Fisheries and Forestry (DAFF) is in the process of being integrated. This will have an immediate effect in that the fresh water aquaculture (under the old Department of Agriculture) and marine aquaculture (under the Department of Environmental Affairs and Tourism’s directorate of Marine and Coastal Management) policies which were separately developed and promulgated and will now be integrated into a single policy. The formation of DAFF should strengthen governmental efforts and align development initiatives in aquaculture. A common development vision will hopefully be the developed between government officials tasked with developing aquaculture.

2. MATERIALS AND METHODS

A literature review of the most current and pertinent sources were done. Coupled with this the author has been active in the commercial aquaculture industry for at least 10 years. As such additional comment will be made to augment the review results that are collated in this communication. The effect of stock movement in two fisheries will also be discussed in relation to socio economic impact on coastal communities.

3. RESULTS

In their report the FAO (2008) predicted that climate change would impact on ecosystems, livelihoods and food security in the following ways:

Ecosystem impacts:

1. Modification the distribution (geographically and possibly spatially in the water column) of marine and freshwater species. As a general rule species will be displaced towards the poles and will experience changes in habitat size and productivity. There could be both positive and negative repercussions to this trend.
2. In warmed water bodies, ecosystem productivity is likely to be reduced in most tropical and subtropical oceans, seas and lakes and increased in high latitudes. Increased temperatures will affect fish, shellfish and aquatic plants’ physiological processes resulting in both positive and negative effects on fisheries and aquaculture systems.
3. Climate change is affecting and will possibly affect to a greater extent the seasonality of particular biological processes, altering marine and freshwater food webs. The consequences of these seasonal modifications for fish production are uncertain in some cases. Increased risks of species invasions and spreading of vector-borne diseases are similar to those found in terrestrial habitats.
4. Differential warming between land and oceans and between polar and tropical regions will affect the intensity, frequency and seasonality of climate patterns (e.g. El Niño). Extreme meteorological events (e.g. floods, droughts, storms) will affect the stability of marine and freshwater resources and organism populations adapted to or affected by these phenomena.
5. Sea level rises, glacier melting, ocean acidification and changes in precipitation, groundwater and river flows will significantly affect and modify coral reefs, wetlands, rivers, lakes and estuaries. This will require the adoption of measures to exploit positive opportunities and minimize negative impacts on fisheries and aquaculture systems.

Livelihoods will be impacted in the following ways:

1. Changes in distribution, species composition and habitats will necessitate changes in the way fishers and aquaculturists do business. Changes in fishing practices and aquaculture operations, as well as in the sighting of landing, farming and processing facilities will be required to stay competitive.

2. Extreme weather events will probably impact on infrastructure negatively. These impacts could affect landing and farming sites, post-harvest facilities and transport routes. Safety at sea and coastal settlements, with communities living in low-lying areas, will be at greater risk.
3. Water stress and competition for water resources will affect aquaculture operations and inland fisheries production, and are likely to increase conflicts among water-dependent activities. Freshwater aquaculture ventures will experience greater competition form terrestrial water resource users.
4. Livelihood strategies will have to be modified. An example of this would be changes in fishers' migration patterns due to changes in timing of fishing activities.
5. Livelihood options inside and outside the fishery sector will be reduced or possibly modified. This will probably force occupational changes and could increase social pressures. Livelihood diversification is an established means of risk transfer and reduction in the face of shocks, but reduced options for diversification will negatively affect livelihood outcomes.
6. Gender dimensions will come into play. Including competition for resource access, risk from extreme events and occupational change in areas such as markets, distribution and processing, in which women currently play a significant role.

Food security will be impacted in the following ways:

1. Availability of aquatic foods will vary, positively and negatively, through changes in habitats, stocks and species distribution. These changes will occur at local and regional levels in inland, coastal and marine systems, due to aquatic ecosystem shifts and impacts on aquaculture.
2. Stability of supply will be impacted by changes in seasonality, increased variance of ecosystem productivity, increased supply risks and reduced supply predictability. Possible impacts supply chain costs and retail prices are likely.
3. Access to aquatic foods will be affected by changes in livelihoods and catching or aquaculture opportunities. This will be combined with transferred impacts from other sectors (i.e. increased prices of substitute foods), competition for supply, and information asymmetries. Rigid management measures, that control temporal and spatial access to resources, may impact access negatively.
4. Utilization of aquatic products and the nutritional benefits produced will be impacted by: changes in range and quality of supply; market chain disruptions; greater food safety issues; and reduced opportunities to consume preferred products. This is particularly critical for countries with high per capita fish consumption.
5. Food security will be affected positively by increasing the percentage of fish used for direct human consumption (versus fish used for animal feed) and reducing post-harvest losses through spoilage and waste.
6. Climate change will add to the complexity of addressing the above mentioned issues and climatic events may have a direct negative impact on the control of spoilage and waste of aquatic products.

Britz et al. (2009) ranked the following constraints to aquaculture enterprise development in South Africa as follows, with this author's comments in parentheses:

1. Environmental regulatory requirements (It is my opinion that South Africa is in all probability over regulated in the aquaculture sector and that prohibitive regulations and legislation in some cases do not warrant the perceived potential environmental risks.)
2. Site selection and availability (This is a mayor constraint in especially coastal areas as aquaculture invariably competes with property development for land, NIMBY "Not In My Back Yard" principle has also stifled aquaculture projects in the past where overzealous coastal communities have fought aquaculture projects for purely aesthetic reasons, in the respect the proposed pre-zoning of acceptable aquaculture development zones by government will probably be of great assistance to aquaculture entrepreneurs.)
3. Processing (In coastal areas there a number of FPE's (Fish Processing Establishments) that are underutilised because of dwindling fish stocks, in land FPE's for freshwater fish product processing may be required.)
4. Permitting (The concept of aquaculture zoning should in the medium term speed up the process of obtaining aquaculture rights and permits.)

5. Access to finance (This is a significant problem as most financial institutions are unfamiliar with aquaculture projects and therefore the amount of risk involved in granting loans. However, on the other side potential investors are sometimes not rigorous enough in their business planning and due diligence on markets. Producers should be market driven and not production driven.)
6. Access to research and development (There is a need for extension services to package research findings to potential farmers in a “digestible” format. As well as to feed back to researchers what industry really needs.)

These authors also ranked the following interventions to promote aquaculture in South Africa:

1. National policy, strategic plan and implementation plan for the sector (In the Western Cape these interventions have been planned for and could be rolled out to other provinces)
2. Facilitation of access to finance (The Department of Trade and Industry should be tasked into looking into the feasibility of an incentives package for the stimulation of investment into this sector.)
3. Promotion of aquaculture education, training, and skills development (Especially necessary at middle management level, the provision of extension services in the marine aquaculture sector is lacking at this stage. Training at small farmer level is some times in excess of what is required. It will be necessary to develop extension capacity in small scale fisheries.)
4. Capacity to monitor and guarantee the safety of the aquaculture product (Especially important if it is hoped to capture export markets.)
5. Monitoring of water quality to ensure export of aquaculture product (The same as for no. 4 above.)
6. Veterinary services for aquaculture (State sponsored veterinary services are currently lacking for this sector and there is a severe lack of aquatic organism veterinary expertise.)
7. Identification and zoning of areas for aquaculture development (This is receiving attention but these processes need to be sped up. Also the cost of marine lease fees needs to be reduced to align it with global trends. Currently South African marine lease water fees are up to a thousand percent higher when compared to our neighbour Namibia for instance)
8. Research, technology development and transfer (Industry driven research is required and competent extension transfer. Funding agencies should also try to speed up the publication of research findings from research service providers in both the scientific and popular press. Currently new research results are taking too long to reach the industry.)
9. Promotion of South African Aquaculture
10. Promotion of best management practices
11. Promotion of trade in aquaculture products.

4. DISCUSSION

Coastal fishing communities on the West Coast of South Africa are all ready experiencing the effects of climate change on their traditionally fished resources. These changes into how the stocks are reacting to climate change are having far reaching socio economic effects. The experiences of two fisheries namely the West Coast Rock Lobster and the small pelagic fishery will be discussed.

West Coast Rock Lobster (*Jasus lalandii*) stocks have in recent years experienced a decline in growth rate and a southward shift in distribution as low oxygen waters on the West Coast increased (Hutchings et al., 2009). The fishery is managed over a number of fishing zones. Traditionally the commercial fishery stretched from Port Nolloth in the North to Cape Hangklip in the South East of its distribution range. With the southward shift a new fishery zone was opened east of Cape Hangklip into the Walker Bay area. This has had the effect of reducing the size of the exploitable stock in the northern fishing zones. This has had the effect of FPE’s in these areas being closed as they are no longer financially viable. This has led to retrenchments of the fisher folk that fished for lobster, using small row boats locally named “bakkies” and worked as packers in the factories. In some of the coastal towns the lobster fishery was a primary if not only form of employment. Today towns such as Doring Bay are experiencing unemployment figures to the number of 95%. Towns like Lamberts Bay, Elands Bay, Paternoster and Saldanha are experiencing similar trends but maybe just not as acute as in the case of Doring Bay. Interestingly enough the Doring Bay community has turned to developing business plans and projects around abalone and fin fish farming, with the help of provincial government departments. It has been a long difficult road to secure land and leases. Recently the government has made available a sum of money for the initial development of project. Their abalone farm will require more funding if it is to become sustainable. In the south of the rock

lobster fishery range fishers have benefitted from the south and east ward shift of the stock. Consequently these communities in the coastal towns of Walker Bay are now exploiting a resource that it did not have access to previously, to the same extent that it has to today.

The small pelagic fishery for anchovy (*Engraulis encrasicolus*) and sardine (*Sardinops sagax*) constitutes a significant fishery and job creator on the West Coast. Anchovy and sardine have alternated as the dominant component of the fishery, although in recent years landings of the two species have been similar (Hutchings et al., 2009). Anchovy and sardine stocks show a high degree of inter-annual variability in recruitment strength, due to life history traights and the timing of spawning and blooms of unicellular algae to feed the larval fish, which results in high variability in population size (Hutchings et al., 2009). The anchovy catch is taken off the west coast and comprises young fish (70%) migrating from the west coast nursery grounds to the south coast spawning grounds. Sardine is caught off the west, southwest and south coasts during different periods of the fishery. Inter annual variability in population size is also observed, especially for sardine. This phenomenon may be linked to long-term environmental forcing. Anchovy and sardine appear to have increased their distribution ranges significantly between mid- to late 1980s and the 1990's and, since 1997, the average location of sardine catches has shifted further eastwards each year. In real terms this gradual range shift has brought variability in where and how much of the catch is landed. Most of the pelagic fishery's processing capacity has evolved in the St Helena Bay area and yet now larger and larger proportions of the catch is being landed further south and east. This has led to fish being landed in Mossel Bay for instance and being trucked on flake ice to St. Helena Bay. The strengthening of processing capability in the south has created employment in those areas but has lead to a reduction of job security and shift time in the northern areas. In 2009 this trend was some what reversed but the variability in where the stock will be most economically does not bode well for product price, job security and industry stability.

There are certain appropriate aquaculture interventions that could be employed on the West Coast. One of the great opportunities lies in bivalve shellfish (mussels and oysters) aquaculture in Saldanha Bay. Currently the bay is producing at 5% of the theoretical carrying capacity. There are opportunities in market development in that South Africa is an importer of mussels. For each single job created on a mussel farm between 3 and 4 jobs are created in processing. The cost of creating a similar amount of jobs in abalone farming is significantly higher. The income generation cycle of mussel farming is also quicker when compared with abalone farming, 7 months versus 3.5-5 years. Mussel farming lends itself to small farmer, franchise and cooperative farming models when compared to large economy of scale and high investment farming ventures such as abalone farming. Not all environments along the South African coast lend themselves to mussel farming but neither does abalone farming. There are small farmer opportunities in oyster seed growing in the Inner Bay of Saldanha. The outer bay area is rougher and a prospective farmer will need to make larger investment in culture infrastructure such as boats and long lines to cope with the prevailing conditions. However, small farmers (with smaller boats and lighter line systems) can grow small 10–25mm (1-4g) seed onto 20-30 g large seed for selling onto larger ongrowers. There is steady market for oysters coupled to the expanded tourism industry. An export market could be developed. Product range could also be diversified to capture new markets. If government is to invest in this industry it should be done at a pace that the market can absorb.

Abalone farming has high capital and technical input requirements. The economy of scale required to farm profitably has also increased over the last 10-15 years. Where a farm with its own hatchery could be scaled at a 50 ton per annum production unit the latest estimates suggest a 120-150 ton production unit is appropriate. Currently this will set an investor back in the region of between R45-50 million. Such a production unit could generate 80-100 full time jobs. Production and hatchery management staff would need to have graduate and/or post graduate qualifications. The reason for the high development cost is because of the slow growth of abalone which negates carrying staff and plant costs for between 3 and 5 years before the business gets into positive cash flow. Abalone farming is definitely a long term investment option. The market is developed but international competition is driving profit margins down. The global recession has also slowed the demand for abalone products down.

All though this paper has dealt predominantly with marine aquaculture opportunities it is appropriate to mention some aspects to be born in mind when planning freshwater aquaculture ventures. It is the authors' opinion that trout farming in the Western Cape, especially small and emergent farmers, need access to larger state owned dams to improve the economies of scale of production units. Larger water bodies also have a greater buffering capacity with regard to sudden changes in water quality parameters when compared to small dams. The impact of these trout production units can be modelled and production limits can be set, and monitored, as not to unduly threaten an increase the water treatment costs especially for human use.

The production African Sharptooth Catfish or Barbel (*Clarias gariepinus*) in the South Africa is technically feasible. Temperate environments are not conducive to farming this species in ponds and would require the use of intensive, enclosed heated recirculation systems as the fish show the best growth performance and feed conversion ratios at temperatures between 28 and 30^{o}C. Currently catfish production is not viable, because of the following reasons: a.) No market willing to pay the price needed for a farmer to profitably farm these fish, b.) Fish processors do not like the fillet characteristics as there are relatively large blood flecks next to the spinal column. The fillet also has a greyish tinge and finally c.) The more affluent potential market segment that maybe able to pay the price needed to commercially farm the species has a perception that the fish flesh tastes like mud. Therefore, low market acceptance in this market segment.

Decision makers should not see aquaculture as a panacea for the solving of all the job creation ills in poor rural and/or coastal communities. Rather it should be seen as part of suite of interventions to improve the standard of living of rural and coastal communities.

REFERENCES

Britz, P.J., Lee, B. & Botes, L., 2009. AISA 2009 aquaculture benchmarking survey: primary production and markets. AISA report produced by Enviro-Fish Africa (Pty) Ltd. 117p.

FAO, 2008. Report of the FAO expert workshop on climate change implications for fisheries and aquaculture, 7-9 April 2008, Rome. FAO Fisheries Report 870. 41p, Rome.

Hutchings, L., Augustyn,C.J., Cockroft, A., Van Der Lingen, C., Coetzee, J., Leslie, R.W, Tarr, R.J., Oosthuizen, H., Lipinski, M.R., Roberts, M.R., Wilke, C., Crawford, R., Shannon L.J. & Mayekiso, M., 2009. Marine fisheries monitoring programmes in South Africa. *South African Journal of Science 105: 182-192.*

Nomura, I., 2009. The role of responsible aquaculture for socioeconomic advancement in developing countries, Book of Abstracts: World Aquaculture 2009 Conference, Vera Cruz Mexico, 25 -29 September 2009, *World Aquaculture Society*.

Pauly, D., Christensen, V., Guenette, S., Pitcher, T.J., Sumaila, U.R., Walters, C.J., Watson, R. & Zeller, D., 2002. Towards sustainability in world fisheries. *Nature 418: 689-695.*