National Economic Development and Labour Council

Final Research on Operation Phakisa and Citation:

- Unlocking the Economic Potential of the Ocean Economy through aquaculture. A study on inclusive economic growth through aquaculture, S. Mkhize, and T Mbhele 2017.

Table of Content

Prepared by:

Youth Development Consultants

Mr. Sibusiso Mkhize	**: Director**
E-mail	**: info@intselelocydi.co.za**
Other E-Mail	**: sibusisom@intselelocydi.co.za**
Office Contact	**: +27 (0) 12 771 4235**
Cellphone contact	**: +27 (0) 83 344 0609**
Mr. Themba Mbhele	**: Director**
E-mail	**: info@intselelocydi.co.za**
Other E-Mail	**: thembam@intselelocydi.co.za**
Cellphone Contact	**: +27 (0) 79 960 6322**
	: +27 (0) 011 053 6090

Prepared for:

National Economic Development Council

Development Chamber

Contact Person	**: Ms. Nozipho Ngema/ Ms. Priscilla Mashabane**
	: Development Chamber Coordinator
Contact Number	**: +27 (0) 11 328 4200**
E-Mail	**: nozipho@nedlac.org.za**

1. Context and Objectives of the Desktop study

1.1. In its founding statement NEDLAC identified the following challenges to be addressed by its mandate:

a) Sustainable economic growth - to facilitate wealth creation; as means of financing social programmes, as spur to attracting investment; and as the key way of absorbing many more people into well-paying jobs.

b) Greater social equity - both at the workplace and in the communities - to ensure that the large-scale inequalities are adequately addressed, and that society provides, at least, for all the basic needs of its people.

c) Increased participation - by all major stakeholders, in economic decision-making, at national, company and shop floor level to foster cooperation in production of wealth, and its equitable distribution.

1.2. **Objectives of the study in the terms of reference and rectified in the workshop on the 17th January 2017**

1.2.1. To make inputs and advice the Chamber on certain policy Social Dialogue on the aquaculture sector especially because the Chamber is reviewing draft Aquaculture Bill

1.2.2. Economic and job creation opportunities for communities. To look at opportunities for inclusion of communities living on coastlines or near dams in where aquaculture is taking place or there is potential for new initiatives.

1.2.3. To produce a document that members of the chamber can use as reference to acquaint themselves on the sector.

1.2.4. To identify skills development needs and look at how other countries are dealing with training and capacitation of youth and communities in the aquaculture sector and make recommendations for the South African Context.

2. Executive Summary

Global aquaculture production has grown at a rate of 9% per annum over the last 20 years, and is expected to continue to grow at a rate of 4.5% over the next two decades - if per capita consumption of fish is to be maintained. While South Africa possesses suitable environmental conditions for aquaculture, and opportunities for the commercial culture of various species, the local aquaculture sector has performed below its potential and remains a minor contributor to national fishery production. This is due to a number of constraints including access to water and land, access to technology, high transaction costs, and a lack of supporting policy and legislation, and barriers to entering certain markets. Total production has been fairly stable in recent years with 3,907 tons of products worth R211 million being produced in 2006, compared to approximately 500,000 tons from South Africa's harvest fishery worth R1.8 billion. Due to aquaculture's relatively high production costs, commercially cultured species are mainly high value species which include: abalone,

trout, mussels, oysters, catfish, tilapia, kob, seaweed, and freshwater crayfish. Species on the threshold of commercial production include prawns, yellowtail, sole, spotted grunter and scallops.

The increasing short supply of traditional fish products on the local market (e.g. hake and line fish) has resulted in a sharp rise in prices making aquaculture an increasingly viable production option. In the short to medium term it is unlikely that aquaculture will meet the deficit in supply in the local market. This is due to the relatively long lead time required to establish new operations (3-5 years), and therefore the current levels of imports of fishery products are likely to rise. There are thus opportunities for growing aquaculture production to substitute imports. A growing shortage in the global supply of high value fish products is expected to push up real prices over the next two decades, and opportunities for the export of high quality, fresh fish to the European Union exist.
These markets are readily accessible as the South African fishing industry is a well-established exporter. South African aquaculture is however not expected to be competitive in the production of frozen, white fish fillets as large volumes of cheap tilapia fillets (as low as $1.50/kg) from China and Vietnamese catfish currently dominate the market.

Generally, South Africa possesses a very conducive infrastructure and set of supporting institutions for the development of large scale commercial aquaculture. This includes strong R&D capacity, state aquaculture facilities, aquaculture support staff in certain government departments, financial institutions, fishery export capacity (including SABS certification), and most of the general industrial services required to develop the sector. The main constraints to aquaculture development are a lack of sector level institutional coordination and strategy, and certain specific infrastructure and capacity requirements that individual firms cannot overcome. The state veterinary service needs to develop aquaculture health management capacity, aquaculture investors have difficulty accessing the development finance institutions, information and technology is not easily accessible to prospective investors, and sector level strategies to overcome constraints are lacking. Good progress has been made by certain government departments in addressing the needs of the aquaculture sector, for example, draft national policies for fresh and marine aquaculture have been published, aquaculture staff appointed within several departments, sector working groups established, development projects promoted (including aquaculture SMEs), and aquaculture development strategies drafted at provincial levels. What is lacking is a comprehensive set of national strategies and Key Action Plans (KAPs) to address the potential of the sector as well as the constraints that need to be removed.

If the aquaculture sector is to grow to its potential, an urgent investment in human resources is required as a lack of aquaculture skills both within the private and public sector is a significant constraint to development. As the existing commercial sector is largely white owned and managed, the growth potential of the industry provides an opportunity to achieve a racially representative sector. But an upfront investment in the necessary skills at all levels is required. Currently, no tertiary level technical courses in aquaculture exist, nor are there SETA accredited in-service training courses for the development of aquaculture technical skills. While University level courses in aquaculture exist, targeted bursary funding is required to attract black students.

Global experience and the current diagnostic analysis shows that since aquaculture is a new production sector based on novel technology, state intervention is required to create an enabling environment for investment. South Africa's National Industrial Policy Framework (NIPF) provides guidance in this regard and suggests that for high growth potential sectors such as aquaculture, an equivalent set of support measures to competing nations should be provided. The industrial policy support measures available to the aquaculture sector in South Africa were compared with those of Australia and Chile, two countries with analogous geographic, environmental and economic conditions which have very successfully promoted the development of their aquaculture industries. In Chile, a country with a relatively undeveloped local market and R&D base, state-facilitated technology transfer, capital grants, aquaculture water concessions, and export marketing assistance have helped the sector to take advantage of Chile's exceptional environmental endowment, and become a leading global producer of products such as salmon and scallops. Australia's extensive set of industrial incentives reflect policies which emphasise local technology development, extensive support and promotion of SMEs, skills development, access to export markets, product innovation in the seafood sector, access to information and technology, and public/private sector level collaboration. While South Africa possesses many equivalent industrial support measures, they have largely not been accessed by the aquaculture sector. While the DTI's SMEDP support measures encouraged some company level investment in aquaculture, support for sector level strategic and industry cooperative actions have been lacking. The aquaculture sector has benefited from state-funded R&D through company and university driven research, but lacks a dedicated R&D strategy (equivalent to Australia's Cooperative Research Centre Model) which comprehensively addresses the technology needs of the sector. In conclusion, the industrial incentives available to the South African aquaculture sector are "patchy" and do not form part of a national strategy to realise the potential of the sector and systematically address constraints to development. Suggestions for an appropriate set of industrial support measures and strategies to promote aquaculture sector development are made.

3. Policy Environment and Recommendations for inputs into current Draft Aquaculture Bill Social Dialogue.

3.1 Draft Aquaculture Bill

South African Policy environment is very progressive and pro-growth, but unfortunately benefits of this growth favours established businesses and does little to encourage and enhance new entrants into various business sectors and as such everything is left to industries to transform themselves and without any recourse for not doing so and incentives for complying.

In the current Draft Aquaculture Bill there are a number of gaps that need to be addressed in order to create an enabling environment for communities and community enterprises.

- **CHAPTER 5 AQUACULTURE ZONES**

  This section missed the opportunity to be prescriptive about targeting communities and community lead enterprises. Considering that the bill recommends that licenses be for 30 years it will be a missed opportunity to leave out a target for black communities in those areas because licenses could easily be taken by big businesses. We recommend that this section pronounce on the allocation to take into consideration black communities living on coastlines and areas around dams that at least 25% of allocation should be given to them and this should be part of the allocation in this chapter.

  This chapter should also look at being biased to provinces particularly coastal that are lagging behind in share of development in this sector. For instance the Western Cape has over 70% of market share in this sector and Provinces like KZN have less than 5%. The Bill should pronounce bias towards these provinces for new government investment

- **CHAPTER 7 LICENSES AND PERMITS**

  This chapter should without compromising current Development. Target black farmers to receive at least 40% of NEW permits. The target should be a skills development led approach, which say that government commit itself to development of black people in particular for the sector and there should be a subsequent significant budget allocated in the APAP for capacity building and training. This should be for a targeted period of time in the bill

- **CHAPTER ELEVEN TRANSFORMATION AND SOCIAL RESPONSIBILITY**

  This section again does not have any specific targets. This should be one of the most important sections of the bill. It seems that the section relied on the BBBEE Act. We believe this chapter should set transformation targets on how this sector should be transformed. The opportunity here is that aquaculture is a lot smaller than it should be in the next 20 years, the sector should be able to multiply four folds. So the strategy should be to look at new developments for transformation.

4. Rapid aquaculture development Job Creation and Enterprise Development

Recent Developments in the Agricultural sector have been extremely encouraging and aquaculture will benefit from gains in the agricultural sector. Recently the government started the implementation of Agriparks as means to support local farmers by building required infrastructure for irrigation, fencing, water provision, pack houses, storage and tunnels for hydroponic and thermal intensive agriculture operations. The consequence of that is that it provide a hub from which communities to organize themselves into cooperatives. It provides for primary agriculture operations where communities can produce without having to raise their own funds to develop infrastructure. This also means that a community can mass produce through hundreds of farmers working together but it also provide space where training and development particularly experiential learning can take place.

Aquaculture is not far behind from this model. The Gariep Dam Aquaculture Centre is a very good place to start. The centre is providing a similar type of service to communities that Agriparks provide to plant production farmers. The issue is that the centre is purported as a demonstration centre. Government should consider implementing a Gariep Dam model across the country and invest substantial amount of funds into getting this model across all communities. This will deal with two issues in the Aquaculture sector. The first will be to spread aquaculture development across the country and attract cooperatives and community enterprises into the sector. The second will be to create centres of learning in the aquaculture sector, the speed of this should be dictated upon by training and development in the sector. Investment by government in this regards is extremely important in the Agriculture, Government is investing R2bil for creation of Agripark, similar type of investment is import to stimulate growth in this sector, just by setting up a centre similar Gariep could bring create hundreds of community based enterprises and each enterprise have a potential to create hundreds of jobs. The main focus in the short term though should be the training at community Level. Training at NQF level 2 and NQF 4.

5. Global overview of the Aquaculture sector and species in the South African Waters

5.1 Marine Protection Service and Ocean Governance

The Marine Protection Services and Ocean Governance focus area looked at South Africa's jurisdiction over a very large exclusive economic zone, with an extent of one and a half million square kilometres. With such a large ocean jurisdiction, effective governance is critical but will be challenging given the size and complexity of our oceans. This work stream undertook the task of developing an overarching, integrated ocean governance framework for the sustainable growth of the ocean economy. The work stream identified initiatives to be implemented by 2019. These include the development and implementation of an overarching governance plan by March 2015.
The plan entails the protection of the ocean environment from all illegal activities and to promote its multiple socio-economic benefits with results by 2017. It also proposes the delivery of a National Marine Spatial Planning Framework in order to enable a sustainable ocean economy by December. In the spirit of Operation Phakisa and getting things done as quickly as possible, there is already progress on working towards an Oceans Act. It is envisaged that a draft Oceans Bill will soon be ready promulgation
The Oceans Act will provide a clear foundation for marine spatial planning. Going forward, Delivery Units have been established in the lead departments that will drive the implementation of the detailed delivery plans.
The progress will be monitored on a weekly basis by the responsible departments together with relevant teams in The Presidency. Regular feedback will be provided so that all involved can also track progress.

5.2 Aquaculture

The Aquaculture work stream has underlined the high growth potential of South Africa's aquaculture sector due to increasing demand for fish. While aquaculture contributes to almost half of the global fish supply, it contributes less than 1% of South Africa's fish supply. The sector offers significant potential for rural development, especially for marginalised coastal communities. This work stream has identified eight initiatives to spur the growth of the sector. One initiative will address the selection and implementation of 24 projects across South Africa by 2019.
These projects are expected to grow the aquaculture sector's revenue from about half a billion rand today, to almost R1.4billion in 2019. Three further aquaculture initiatives relate to the creation of an enabling regulatory environment, including the establishment of an Inter-Departmental Authorisations Committee. The committee will co-ordinate aquaculture applications and approvals. The intention is to reduce processing time from the current periods of about 890 days to 240 days in future. Other initiatives focus on funding support, increasing the skills pool and awareness and improving access to markets.
The stream has identified some initial targets as well. They recommend implementing nine projects in the Eastern Cape, North West, KwaZulu-Natal and Western Cape provinces. The work stream also proposes the establishment of the Aquaculture Development Fund, consolidating approximately R500 000 000 of government's funds from five departments into

one pot.

The teams also propose the creation of a South African industry body that will establish seventy to eighty buyer relationships such as local retailers and food service companies. This will create a comprehensive market database covering one hundred % of South African aquaculture production,

5.3 What is Aquaculture

Aquaculture, also known as aqua farming is the farming of fish, crustaceans, molluscs, aquatic plants, algae, and other aquatic organisms. Aquaculture involves cultivating freshwater and saltwater populations under controlled conditions, and can be contrasted with commercial fishing, which is the harvesting of wild fish.

Aquaculture Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. The reported output from global aquaculture operations in 2014 supplied over one half of the fish and shellfish that is directly consumed by humans; however, there are issues about the reliability of the reported figures.

Further, in current aquaculture practice, products from several pounds of wild fish are used to produce one pound of a piscivorous fish like salmon.

Particular kinds of aquaculture include fish farming, shrimp farming, oyster farming, Mari culture, alga culture (such as seaweed farming), and the cultivation of ornamental fish. Particular methods include aquaponics and integrated multi-trophic aquaculture, both of which integrate fish farming and plant farming.

Harvest stagnation in wild fisheries and overexploitation of popular marine species, combined with a growing demand for high-quality protein, encouraged aqua culturists to domesticate other marine species. At the outset of modern aquaculture, many were optimistic that a "Blue Revolution" could take place in aquaculture, just as the Green Revolution of the 20th century had revolutionized agriculture. Although land animals had long been domesticated, most seafood species are still caught from the wild. Concerned about the impact of growing demand for seafood on the world's oceans, prominent ocean explorer *Jacques Cousteau wrote in 1973:*

"With earth's burgeoning human populations to feed, we must turn to the sea with new understanding and new technology.

About 430 (97%) of the species cultured as of 2007 were domesticated during the 20th and 21st centuries, of which an estimated 106 came in the decade to 2007. Given the long-term importance of agriculture, to date, only 0.08% of known land plant species and 0.0002% of known land animal species have been domesticated, compared with 0.17% of known marine plant species and 0.13% of known marine animal species. Domestication typically involves about a decade of scientific research. Domesticating aquatic species involves fewer risks to humans than do land animals, which took a large toll in human lives. Most major human diseases originated in domesticated animals, including diseases such as smallpox and diphtheria that like most infectious diseases move to humans from animals. No human pathogens of comparable virulence have yet emerged from marine species

Biological control methods to manage parasites are already being used, such as cleaner fish (e.g. lump suckers and wrasse) to control sea lice populations in salmon farming. Models are being used to help with spatial planning and sitting of fish farms in order to minimize impact.

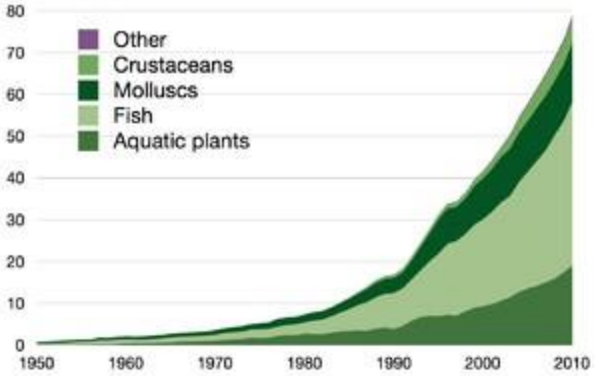
The decline in wild fish stocks has increased the demand for farmed fish. However, finding alternative sources of protein and oil for fish feed is necessary so the aquaculture industry can grow sustainably; otherwise, it represents a great risk for the over-exploitation of forage fish.

Another recent issue following the banning in 2008 of organotin by the International Maritime Organization is the need to find environmentally friendly, but still effective, compounds with antifouling effects.

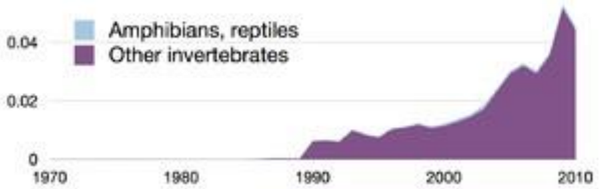
Many new natural compounds are discovered every year, but producing them on a large enough scale for commercial purposes is almost impossible.

It is highly probable that future developments in this field will rely on microorganisms, but greater funding and further research is needed to overcome the lack of knowledge in this field.

Species Groups
Global aquaculture production in million tonnes, 1950–2010, as reported by the FAO.



Main species groups



Aquatic Plants

Cultivating emergent aquatic plants in floating containers

Microalgae, also referred to as phytoplankton, microphysics, or planktonic algae, constitute the majority of cultivated algae. Macroalgae commonly known as seaweed also have many commercial and industrial uses, but due to their size and specific requirements, they are not easily cultivated on a large scale and are most often taken in the wild.

5.4 History of the sector in South Africa

According to the Department of Agriculture, Forestry and Fisheries, "Aquaculture in South Africa is divided into freshwater aquaculture and marine aquaculture. Freshwater fish culture is severely limited by the supply of suitable water. The most important areas for the production of freshwater species are the Limpopo, Mpumalanga Lowveld and Northern Kwazulu–Natal. Trout is farmed along the high mountain in Lydenburg area, Kwazulu-Natal Drakensberg and the Western Cape. Other freshwater species cultivated on a small scale include catfish, freshwater crayfish and tilapia species. Marine aquaculture is a fast developing sector, with a focus on mussels, oysters, abalone, seaweeds and prawns. Of these, mussel farming is the best established. Abalone culture is now well established, centred in the Hermanus area on the Cape south coast. There is also an experimental offshore farm (cage culture) off Gansbaai for salmon.
Export data from the Department of Agriculture, Forestry and Fisheries indicate that the South African industry is dominated by the Western Cape Province, which accounts for more than 80% of all South African aquaculture produce, followed by the Eastern Cape at a distant 12.75%.

The Department of Trade and Industry states in its sector diagnostic study, that national aquaculture production data (2003–2006) in 2003 was 3,485 tons and in 2006 was 3,564 tons which had a value of R210. Abalone accounted for the biggest increase with production increasing by 61% from 515 tons in 2003, to 833 tons in 2006. Declines in production were experienced by the following sub-sectors: oyster, mussel and trout with reductions in production of 19.2%, 39.5% and 18.4% respectively.

“In a fiercely competitive global economy, South Africa cannot be complacent. It must be more aggressive and effective than the intense competition it faces as it advances its domestic commercial interests in key global markets. Nine Point Plan, particularly on the ocean economy represents a sea change in the way South African diplomatic assets are deployed around the world, and in so doing, South Africa can ensure that the commercial success of South African firms and investors is entrenched as one of our core foreign policy objectives”

South African Ambassador to the United States of America.
22 February 2014 “A response to SONA”

By 2003, the sector accounted for 3,485 tons of production and increased slightly to 3,564 tons valued at R210 million in 2006. The greatest increase in production was attributed to the abalone sub-sector where production increased by 61% - from 515 tons in 2003, to 833 tons in 2006. The oyster, mussel and trout sub-sectors reported declines in production of 19.2%, 39.5% and 18.4% respectively, and prawn production ceased. Aquaculture has shown growth in five years, with production from 2014 up fivefold to 20 000 tons. Year on year growth between 2013 and 2014 was 25%, which exceeds the average global growth rate of 7%. Aquaculture has contributed as much as R3 billion to the economy

5.5 Types of aquaculture species in South Africa

5.1.1 Trout
Trout farming is the oldest aquaculture sub-sector in South Africa, and is by volume the largest. The first trout ova were imported in 1896, and the first dry pelleted feeds produced in 1956 (Hecht and Britz, 1990). The development of pelletized feeds
Stimulated growth in production: by 1989, 1,023 tons were being produced. In recent years, production has been relatively stable, and in 2006, approximately 1,100 tons were produced, slightly down from the 1,600 tons produced in 2005 due to high temperature and low flows. The

majority of production is split between the Western Cape and Mpumalanga. In 2006, the Western Cape farmers produced approximately 500 tons of trout that was destined for human consumption.

In contrast, of the 600 tons of trout produced in Mpumalanga, approximately half was sold as fingerlings to the recreational fly-fishing industry. In addition to the production of fish for the table and fly fishing markets, there is also a small market to export disease free ova to the European producers – this is a relatively small (in 2006, 4 million ova), but high value seasonal market that ships ova into Europe during the European summer months when some farmers are unable to produce ova. The technology required for culture is now well developed and typified by raceway, pond and cage culture. Increasingly, recirculation technology is being employed by the industry, which in combination with thermal regulation is preventing the historical losses that were attributed to seasonal fluctuations in water levels and temperature spikes. Nevertheless, many areas in which trout are produced remain to some extent marginal.

5.5.2 Environment for Trout

Trout culture in South Africa is restricted by the high ambient temperatures that are prevalent throughout much of the country, and the lack of suitable water for culture. In order to culture the species successfully, the culture temperature should remain below 18ºC – although the fish can withstand elevated temperatures above 18ºC for short periods. This restricts sites to the smaller streams in the higher altitude catchments where cool clear waters predominate, and as a result, much of the country's trout culture is focused around the foot of the Drakensberg and Midlands areas of KwaZulu-Natal, and the higher regions in Mpumalanga and the Eastern and Western Cape Provinces. A major new trout farm is under development at the Katse Dam in the Lesotho highlands.

5.5.3 Tilapia

Tilapia production in South Africa increased from 70 tons per annum in 1998, to 175 tons in 2003 (Brink, 2003). Current estimates suggest that in 2006, between 50-80 tons of product were produced. Potential culture techniques are varied, and include high density intensive cage and raceway culture - in which the entire nutritional requirements of the animals must be met using formulated feeds - to extensive pond and dam culture, in which formulated feeds are either absent or used as supplements to naturally occurring feed stuffs. In recent years, tilapia culture has received renewed interest in South Africa, stimulated in part by the need for alternatives sources of fish to replace the traditional white ground fish stocks that have historically been supplied by the world's capture fisheries. With many of the traditional fisheries in decline, there is a clear marketing opportunity to develop whitefish replacements. Specifically, many potential farmers view the combination of the recent reductions in the South African hake capture fishery and the rise in local fish prices as an ideal opportunity to move into the tilapia industry. Globally, the potential for tilapia to act as a ground fish replacement species is well documented (Section 2.1.2.1), and thermally controlled, intensive tilapia farming in South Africa is increasingly becoming viewed as a viable business option that, if developed appropriately, can deliver sustainable returns on investment.

Business case for Tilapia

Currently, there are no large scale intensive farms operating in South Africa. Thus, at present the industry comprises a number of small private operators employing traditional pond and cage culture. The centres for the current industry are the Western Cape and further north in Limpopo, North West province, and Northern KwaZulu Natal.

In 2004, there were 10 small scale development initiatives in the Limpopo province (Rouhani and Britz, 2004). The projects are primarily funded by the Department of Agriculture, and in some cases, local government. To date, the projects have been designed to promote food security and develop sustainable livelihood options for local communities, and are not focused on large scale commercial production. While the sector remains small, there are indications that there is considerable potential for growth. For example, the Eastern Cape Development Corporation (ECDC) in collaboration with a private partner – has recently secured EU funding to develop a satellite growers programme in the Eastern Cape. It is anticipated that the project will produce 300 tons of tilapia per annum using intensive culture techniques.

Environment for Tilapia

Applying current technology, tilapia culture is generally possible throughout most lowland areas of South Africa. However, as the optimal temperature for the culture of *Oreochromis mossambicus* is in the region of 28 - 30ºC, the most thermally efficient areas to culture the species would be in the warmer areas of the country that experience warm summers and relatively warm winters - such as the Northern Province, Limpopo, Mpumalanga and Northern KwaZulu Natal. It should however be noted that as water temperatures fall below 28ºC, reduced metabolic activity results in a rapid decline in growth rates. Reduced growth rates result in longer grow-out periods and lower levels of farm production. It is for this reason that many tilapia farms are located in tropical regions where the high ambient temperatures promote optimal year round production. Under the sub-tropical and temperate temperature regimes that prevail in South Africa, tilapia farming is either restricted to seasonal production (during the warmer summer months), or alternatively, can be undertaken under thermally controlled conditions in highly intensive production systems that allow production throughout the cooler winter months. Taking the temperature and associated production issues into consideration, it is realistic to suggest that any future expansion of the sector in South Africa will be based on thermally controlled intensive production systems utilising faster growing strains such as *Oreochromis niloticus* or genetically selected/ modified *Oreochromis mossambicus.*

5.5.4 Catfish

The catfish industry was initiated during the late 1980s - largely as a result of research and development that was initiated by local research institutions with support from the Foundation for Research Development's "Aquaculture National Programme". In 1987, the first 10 tons of *C. gariepinus* was produced commercially. By 1988, production had increased to 137 tons which rose rapidly to over 1000 tons (Hecht and Britz, 1990).
Sadly by 1993, the production figures started to slip into reverse (Uys, 1993) and by 1998, only 40 tons were being produced. While feed, and hence production costs may have played a role in the decline in production (Hoffman *et al*, 1996), it was generally accepted that the major problem was a lack of proper market research and product development (Hecht, 1993; Uys, 1993). A second wave of investment in catfish farming occurred from 2000 onwards driven by companies selling high density turnkey culture systems and the promise of an export market in Thailand. The market evaporated with a strengthening rand and catfish farmers were once again left with fish that

they could not sell. While the culture technology for catfish farming is clearly well developed, and technically, catfish could become a major success story in the South African aquaculture industry, the marketing issues are more problematic.

5.5.5 Carp and Koi Carp

Carp production as a food fish is a marginal activity practised by small scale producers for food security. In contrast, there is a well-established koi carp production industry that is based on the production of low and high value fish for the ornamental fish trade.
The Koi Carp industry is characterised by a large number of small "back yard" producers, and a small number of major producers that produce the majority of the domestic market's requirement. The South African Koi Trade Association (SAKTA) lists sixteen producers, of which only eight can be considered major suppliers. The major producers each farm in the region of 2-3 million fish a year. Of these fish, each farmer only retains 15-20% for sale and the remaining fish with poor colouration patterns are culled. Of the saleable fish 10% are premium fish sought by collectors, and the rest sold for the "pond market". Prices range from R1 for the cheapest pond fish to as much as R100,000 for show champions.

5.5.5 Ornamental fish

The culture of ornamental fish and aquatic plants for the aquarium trade has a long history in South Africa. For many years the industry was dominated by hobbyists and backyard operators. However, recent years have seen a shift in focus to more established commercial farms that specialise in bulk production. The production technologies that are currently employed vary between semi-intensive flow-through systems using tunnel and pond grow-out, to super-intensive recirculating systems employing glass tank / tunnel and pond grow-out. Generally, as the super-intensive systems are costly to install and maintain, they are used to cultivate the higher value species.

The international market for ornamental fish is worth about US $4.5bn per annum, and growing at a rate of about 10-15% per annum. Europe, the USA and Japan are the main markets for ornamental fish. In most countries, the industry operates via importers that derive product from across the world. Generally, wholesalers buy from the importers and distribute to the retailers. The bulk of the world's wild caught fish originate from the tropical regions of South America, Africa and Asia. In many areas the supply of wild caught fish is dwindling or threatened – principally this is due to habitat change or over-fishing. The major areas where ornamental fish are reared commercially include South Eastern Asia, Florida and Eastern Europe. Florida is the hub for the trade on the North American continent - there are over 300 ornamental fish farms in Florida alone and many more fish are imported. A large proportion of the retail fish outlets are dedicated solely to selling ornamental fish.
The South African ornamental fish industry represents less than 1% of the international trade. Concomitant with the koi carp sector, the ornamental sector comprises a large number of small "backyard" or "hobbyist" producers and a small number of large scale commercial producers, At present, the majority of the fish that are sold on the domestic market are imported, and the larger producers typically supplement their production with imported product, and are in effect market wholesalers. It is difficult to assess the numbers of fish that are imported, however it is estimated that approximately 300 boxes are imported a week (15,600 per annum) worth R1000 - R1200 each (R17 million per annum

5.5.6 Business case for *Ornamental fish*

Existing production infrastructure is primarily owned by the private sector; however a number of government-funded demonstration fish farms and seed supply facilities exist that could be converted to ornamental fish production. At present, many of these facilities are no longer operational (Section 1.3.2). The Amalinda Fish Station in East London, formerly a Nature Conservation breeding station, has been converted into a Koi farm by the East Cape Development Corporation and is operated by ex-MK veterans. Research infrastructure supporting ornamental fish research exists at Stellenbosch, Rhodes and Limpopo Universities.

Spread

Using current technology, ornamental fish farming can, and is, undertaken in all provinces in South Africa.

5.5.7 Freshwater crayfish

Freshwater crayfish (Marron - *Cherax tenuimanus*) was first imported into South Africa from Australia in 1984. The initial translocation to South Africa was a contentious issue as freshwater crayfish are not found on the African continent, and there are serious concerns over the potential ecological impacts of the species. Notwithstanding the conservation concerns, the initial production trials failed to live up to expectations, and many of the pioneer farmers ceased production. Principal among the problems associated with the culture of the species was a poor understanding of the culture requirements, untested technologies, and the combination of the territorial and cannibalistic nature of the species with a low reproductive output. DTI Aquaculture Products Study – Volume 1: Industry Stakeholder and Diagnostic Report In recent years a number of farmers have significantly improved the culture technology, and are now producing crayfish. Most notably, improvements in the breeding technology and advances in predator control have stimulated production which now stands at 30-40 tons per annum. While production techniques vary, they are primarily based around tank culture for the juvenile phase of production, and semi-intensive pond culture for the grow-out phase of the operation.

Business case for freshwater crayfish

It is difficult to ascertain the true extent of the South African freshwater crayfish industry as a growers association has not been established, and many farmers are unwilling to divulge their production volumes. Nevertheless, it is reported (A. Piers, *pers comm*.) That there are in the region of 20 crayfish farmers operating in South Africa. While the majority of these farmers are small scale or "backyard" producers, a number of the larger operators produce in the region of 10 tons per annum. The product is sold to the high end markets in the urban centres were prices for live animals are currently in the region of R180-190 / kg (A. Piers. *pers. Comm.*). With respect to the international markets, there is a lucrative European market for live product (most notably France) where prices in the region of R400 / kg can be attained. To date, the sector has failed to penetrate these international markets. The failure to access these markets is associated with the requirement to supply high volumes of product at regular intervals. In its current configuration, the industry is incapable of producing the required volumes to penetrate the markets.

Spread freshwater crayfish

"Marron" is a cold water crayfish species, and so the industry is primarily based in the Western Cape. However, suitable conditions also exist in the Eastern Cape and Free State where there are a small number of farms in operation.

Marine species

5.5.8 Abalone

Abalone (*Haliotis midae*) farming was initiated in South Africa in the early 1990s, and by 1996, a number of small operators had entered the industry. The first 10 tons were produced in 1997, and production has grown steadily to 833 tons in 2006. At present, there are 15 active commercial farms in operation. The industry continues to grow, and during the 2003/4 period, MCM issued 19 permits to culture the species, and one permit to ranch. By 2007, permit numbers had increased to 24 indicating further growth of the sector. While most of the farms are located in the Western Cape - most notably along the South coast between Hermanus and Danger Point, and around Saldanha Bay / St Helena Bay area on the West coast; farms are also located as far north as Port Nolloth in the Northern Cape, and as far east as Haga-Haga in the Eastern Cape.

To date, abalone culture in South Africa has been developed as a land based activity that employs pump ashore technology combined with intensive flow-through or recirculation culture systems. Over the past 15 years, considerable efforts have been made to develop appropriate culture technologies for the species. Most notably, research efforts have focused on issues pertaining to system design, reproduction, nutrition and the development of artificial feeds, and disease control. The reproductive cycle of the animals has been closed, and the technology for the artificial spawning of the animals has been developed. As such, spat are hatchery reared and grown out in tank systems.

Spat are initially reared on algal films, and once large enough, they are weaned onto a macro algal or formulated diet (or a combination of the two). Typically, DTI Aquaculture Products Study – Volume 1: Industry Stakeholder and Diagnostic Report the abalone are harvested at a cocktail size (± 80 – 90 mm shell length), with grow-out periods ranging between 3-4 years. The majority of the farms have developed their own hatchery operations, and by 2000, eleven of the twelve farms that were in operation had their own hatchery. Experimental abalone ranching, which involves the release of hatchery reared juvenile abalone into the wild, has been initiated at three sites on the Namaqualand coast (Port Nolloth), the Southern Cape (Rein's nature reserve) and in the Eastern Cape (Cape Receife). The abalone are left to fend for them, and harvested once they reach a marketable size. While ranching remains at the research and experimental stage of development, MCM is now considering the deployment of commercial permits to ranch in response to the catastrophic poaching of the resource. A commercial ranching licence has been applied for in the Cape Receife area in the Eastern Cape.

5.5.9 Business case for Abalone

The abalone culture industry has obtained a "critical mass" of production and benefits from a well-developed supporting infrastructure of services. This includes:

HACCP certified processing facilities
A pelleted feed for abalone produced by a dedicated abalone feed factory
An air route for the live transport of abalone to Japan
An abalone health management programme which employs a full time

Veterinarian
Significant production infrastructure on 14 established farms
Manufacturers of purpose built tanks, baskets etc. for abalone farming
Engineering and other services specialising in abalone farming
A South African Molluscan Shellfish Monitoring Programme through Marine and Coastal Management's laboratories
Significant research support via the Universities as well as on-farm
A well-established producer association AFASA (Abalone Farmers Association of Southern Africa) which represents farmers' collective interests.

Abalone Spread

The natural range of the abalone is between the Mbashe River (Eastern Cape) and St. Helena Bay (Western Cape). Employing current technologies, the farms can be sited along the entire Northern and Western Cape coasts, and along the Eastern Cape coast as far as the Mbashe River in the former Transkei. The Mbashe River represents the most easterly limit of the species range, and beyond this limit, water temperatures are too high for abalone culture.

5.5.17 Marine Finfish

The culture technology and pilot infrastructure for the production of South African marine finfish species has been established by two companies and commercial production is set to take off. Three species, namely dusky kob (*Argyrosomus japonicus*), silver kob (*Argyrosomus inodorous*) and yellowtail (*Seriola lalandii*) are now produced in two hatcheries and pilot commercial growout is underway both in sea cages and recirculating shore based systems. In 1998/9, research into the culture of Dusky Kob (*A. japonicus*) requirements of the species was initiated at Rhodes University, and following successful preliminary research results, other laboratories and companies have joined the research efforts. To date, laboratory findings have been tested on a pilot scale, and since 2004, the technology has been commercialised. Crucially, the protocols for spawning, larval DTI Aquaculture Products Study – Volume 1: Industry Stakeholder and Diagnostic Report rearing, fingerling production, and the live transportation of fingerlings have been developed by Espadon Marine Ltd. and Irvin and Johnson (Pty) Ltd., and are now fully established. Grow-out studies under experimental culture conditions have been undertaken at Rhodes University, the results of which have spurred the development of the sector.

Research on the nutritional requirements of kob that was initiated in 2002 by Hecht and Daniel (in press) is ongoing at Rhodes University. At this stage a generic 42% protein pellet is used by Espadon Marine Ltd, though indications are that 38% crude protein will suffice, and this would affect significant savings on feed costs, and reduce nitrogenous waste production. Aqua-nutro (Pty) Ltd – a leading aqua-feed manufacturer - has expressed interest in manufacturing a Kob diet, and the research at Rhodes University is being undertaken to develop a kob diet for Marifeed (Pty) Ltd.
Parallel work on the silver kob (*Argyrosomus inodorus*) has also been successfully concluded at I&J abalone hatchery in the Western Cape, and they are now in the process of commercialising the technology.

The company has also independently developed spawning and rearing technology for dusky kob, and can now also easily produce in excess of their requirements. In 2005, the first commercial scale grow-out facility was established by Espadon Marine Ltd. in Johannesburg, and by early June 2006, the company had marketed the first 8 tons of product. While the company is currently the only commercial producer, a number of abalone farms, consortia and private individuals are now seriously considering entering the sub-sector – which is widely viewed within the aquaculture community as the next major prospect for aquaculture sector development in South Africa.

Business case for Marine Finfish

There are currently two commercial kob production facilities in the country. Both are located in the Western Cape - Espadon Marine (Pty) Ltd. operates a dusky kob facility in Hermanus and I&J operate a Silver Kob facility at Danger point, Gansbaai. While Espadon Marine (Pty) Ltd. has developed a land-based grow-out facility in Johannesburg, and is in the process of expanding this operation to a new site (G.Musson, *pers. com*); I&J have elected to develop cage culture operations. I&J are in the process of developing a pilot-scale cage culture operation (50t/ annum) in Algoa Bay (Eastern Cape) with the view that if the technology proves commercially viable, they will develop a full scale production facility (>1000t/annum) off Mossel Bay in the Western Cape.

Geographical Spread for Marine Finfish

The Dusky Kob occurs on the east coast of South Africa from Cape Point to Mozambique, and is especially abundant between Cape Agulhas and KwaZulu Natal (Griffiths, 1996). Using current technology, it would be possible to grow the species along the entire South African coastline, and in inland areas using artificial seawater systems. However, recent research has indicated that the optimal culture temperature for the grow-out of the species is 25ºC, and therefore it is likely that most cost effective areas for grow-out would be along the KwaZulu Natal coast.

Growth in Marine Finfish Production

South African line fish species are well received in both local and overseas markets. Fishing companies such as Irvin and Johnson (Pty) Ltd. and Sea Harvest Corporation have over the years exported various fish products (frozen and fresh) and established recognised South African brands. The emerging marine linefish culture industry is poised to capitalise on this. To be a player in these markets, a volume of thousands of product is required, therefore marine finfish production is really the "next big thing" in South African aquaculture. Currently planned production capacity is for between one and two thousand tons within five years. If the current pilot projects are successful, and sufficient water for offshore cage culture of marine fish is granted to government, the way will be open for production to grow to the order of tens of thousands of tons within 5-10 years.

5.5.9 Oysters

Oyster farming represents the earliest recorded mariculture activity in the country. While the first attempts to culture indigenous species were made between 1673 and 1676, it was only in 1948 with the establishment of the Knysna Oyster Company that commercial operations proved successful. Due to problems associated with the culture of the country's indigenous species, the industry has focused on the culture of the Pacific oyster (*Crassostrea gigas*). Oyster production has been fairly stable despite a reduction in production from 250 tons in 2003 (Brink 2003), to 202 tons in 2006 (MCM statistics). There is renewed interest in the sector due to high market demand, and a degree of consolidation amongst the existing farms. One operator is currently developing a large sea-based culture operation in Algoa Bay in the Eastern Cape. During 2003/4, Marine and Coastal Management issued 13 permits to cultivate *C.*

gigas, and an additional 9 permits to cultivate indigenous oyster species. By 2007, the number of permits to cultivate *C.gigas* had increased to 18, while the number of permits to culture indigenous species had reduced to 6. Oyster production is limited to the Northern, Western and Eastern Cape provinces. Oyster production in South Africa is undertaken in both estuarine and marine environments.

Oysters are excellent culture animals, attaching to almost any hard surface in sheltered waters (estuaries or bays) in the inter-tidal and shallow sub-tidal zones, to a depth of about three meters. The species has a high rate of growth and reproduction, and tolerates a wide range of environmental conditions. It is highly valued by the seafood industry, and as long as it has access to flowing seawater, it feeds itself on the suspended organisms and nutrients in the water column around it.
With respect to the indigenous species, there are no farmers actively spawning these species, however, their permits are often used to enable the farmers to handle and in some case grow-on, and sell wild caught animals.
The majority of producers import their spat from Chile, France or the United Kingdom. Spat production is currently limited to just one producer. A number of grow out technologies have been adopted; these include rack culture, Japanese long-line technology, ponds culture (on trays) and onshore tank systems.

Oysters Business case

The existing farmers in South Africa primarily use rack culture techniques in estuarine environments or decommissioned mining pits. The high energy nature of the marine environment makes it difficult to deploy structures in the intertidal areas. Nevertheless, it has been possible to develop longline operations in sheltered bay areas such as Port Elizabeth and Saldanha Bay. In addition to the grow-out operations, many producers operate small land based purging and holding facilities (tank facilities) that are used to hold and condition the animals prior to transportation to market.

Oysters Spread

Oyster culture is possible throughout the Northern and Western Cape provinces. In the Eastern Cape, the most westerly farm that is currently in operation is at Hamburg in the former Ciskei. Rouhani (2002) surveyed the former Transkei coast and indicated that there was limited potential to farm oysters in the region. While the high energy nature of the coastline precludes the development of sea based culture, some of the estuarine environments were deemed to possess potential, and these included Nqabara and Xora estuaries. It should however be noted that farming oysters in this region can at best be considered marginal – the increased levels of precipitation that are recorded along the East Coast can negatively affect juvenile production. Finally, the higher sea surface temperatures (particularly towards KwaZulu Natal) inhibit production further north.

5.5.10 Mussels

Mussel production in South Africa is a relatively recent innovation that was initiated in the mid-1980s. The industry is located at Saldanha Bay in the Western Cape Province, where the authorities have allocated three hundred hectares of the bay to mussel culture. Initially, the industry expanded rapidly, and in 1989, approximately 1,800 tons were produced (Hecht and Britz, 1990) but low market demand resulted in unsold stock.

Subsequent years has seen a drop in production and by 2003, reported production had dropped to 900 tons (Brink 2003), and by 2006, production had fallen again to 542 tons. During the early years, production focused on three species – the exotic Spanish mussel (*Mytilus galloprovincialis*), and the indigenous black and brown mussels (*Choromytilus meridionalis* and *Perna perna*). Recently, production has shifted towards *M. galloprovincialis,* and the contribution from the local species to annual production has declined to insignificant levels. In 2003/4, MCM issued 4 permits to culture *M. galloprovincialis,* 4 permits to culture *C. meridionalis*, and 2 permits to culture *P.perna*. By 2007, a further three permits were issued for the culture of *M.galloprovincialis,* while the number of permits issued for the indigenous species remained static. Mussel production in South Africa is based on the Spanish raft system. The system comprises a series of off-shore floating rafts beneath which ropes are suspended.

Natural settlement onto the ropes provides the seed-stock that is then sorted during the harvesting process. Harvesting is undertaken once the animals reach a marketable size of 55 – 100mm shell length.

Mussels Environment

A well-established mussel farming infrastructure exists at Saldanha Bay. Water inside the breakwater has been zoned for aquaculture by Portnet, service barges and wharfage are available, a HACCP compliant processing factory exists at Veldrif, and a good transport and service infrastructure is in place for the supply of fresh and processed mussels to the major urban centres.

Mussels Spread

Over recent years the distribution of the cultured European mussel (*M.galloprovincialis*) has changed. The species was first recorded in 1984 in Saldanha Bay, and has since moved up the west coast as far as Luderitz in Namibia and south, down to Cape Point. By the early 1990s, it had expanded its range along the coast as far as Port Alfred in the Eastern Cape (SANBI, 2004), and has subsequently moved further east along the former Transkei coast. With respect to the potential to culture the species, it would theoretically be possible to culture it throughout its range. However, the high energy nature of the South African coastline suggests that it can only be viably cultured in the more sheltered areas of the coastline. Thus, it is likely that farms would be limited to the larger bay areas such as Saldanha Bay, St Helena Bay, and Port Elizabeth.

5.5.10 Prawns

Prawn culture operations were first initiated on the Amatikulu River estuary in 1991.
Initial attempts to culture the tiger prawn (*Penaeus monodon*) proved unsuccessful, and production was switched to the indigenous white prawn (*Penaeus indicus*). Due to the high ambient water temperatures required for prawn culture, the industry was restricted to the Northern Coast of Kwa-Zulu Natal. Until recently, the sub-sector was restricted to a single producer (Amatikulu Holdings (Pty) Ltd) who developed a hatchery and two grow-out sites at Amatikulu and Mtunzini. Production figures reveal that in 2003, the operation produced 130 tons of products. Unfortunately in 2004, the farms ceased operations. There were a number of factors that attributed to the closure of the operations. Primary amongst these were the strength of the Rand, and the poor price of shrimp on the local and international markets. In addition, the profitability of the farms (and hence their ability to absorb global price and currency fluctuations) was directly affected by the size of the operations and the production technology that was in use. It is probable that improvements in production

technology and the development of production based economies of scale could resurrect the operation, and once more, ensure the economic viability of the venture.

Prawns Environment

The former prawn farms at Mtunzini and Amatikulu are no longer operational, and the original hatchery and 24ha of ponds remain underutilised. Nevertheless, over the past couple of years there have been proposals to develop both sites using new high density culture technologies. While there is certainly scope for these developments, to date, these projects have as yet failed to yield results. In contrast, at the Coega IDZ in the Eastern Cape, a pilot prawn farm based on the Pacific White Prawn (*Litopenaeus vannamei*) is currently undergoing production trials. Production is based on bio-secure high density raceway culture under thermally controlled conditions. To date, unconfirmed reports suggest that the pilot project has proved a success, and that the developers (SeaArk Africa (Pty) Ltd) are initiating the Environmental Impact Assessment for the up-scaling of the project. Initial reports suggest that should the full project be implemented, the development's footprint will cover 663 ha, and lead to the creation of 7-10,000 employment opportunities.

Prawns geographical spread

While ambient temperatures restrict traditional semi-intensive open pond prawn culture to the northern coast of KwaZulu Natal, there have in recent years been technological breakthroughs in high density bio-secure production.

High density culture using active and passive thermal regulation systems enables farms to be located beyond the natural distribution of the species, and thus theoretically, the application of this technology opens all coastal regions to this type of activity. In addition, in combination with novel technologies that use saline ground waters as the water source, the activity need no longer be restricted to the coastal zone.

5.5.11 Seaweed *Gracilaria* and *Ulva*

Seaweed (*Gracilaria* and *Ulva* species) is cultured on abalone farms in South Africa as abalone food. Pilot scale of *Gracilaria* cultivation for agar extraction, which was attempted in Saldanha Bay and St Helena Bay employing simple rope and raft culture, was stopped by 2006 due to environmental and permitting problems. Three abalone farms culture *Gracilaria* and *Ulva* as abalone feed in their nutrient rich farm effluent waters and reported production of 664 wet tons in 2006. These systems have the advantage that they strip nutrients from the farm effluent waters, and provide an additional food source for the abalone. The nutritional quality of the cultured seaweed is superior to that of wild harvested kelp and supplementation with it boosts abalone growth rates (Troell, et al 2005).

Seaweed *Gracilaria* and *Ulva* geographical spread

Gracilaria verrucosa is naturally occurring seaweed that is found along the entire Western Cape coastline and east along the Southern Cape coastline as far as East London. Technically, it would be possible to culture the species throughout its natural distribution. However, due to the high energy nature of the coast and the difficulties associated in placing production structures in the water, it can only be commercially grown in sheltered bay areas (e.g. Saldanha Bay, St Helena Bay, and Port Elizabeth) and in shore based operations – using waste water from other aquaculture activities, for example, the waste waters from abalone farms. *Ulva* is a widespread species along the entire coast.

Other Aquaculture species

5.5.12 Salmon

For the past 14 years, Salmo Salar Sea Farmers (Pty) Ltd. have been attempting to initiate cage farming of Atlantic salmon in Gansbaai. The project was privately funded by a Norwegian investor with experience in cage aquaculture. Salmo Salar Sea Farms (Pty) Ltd planned to import standard salmonid culture technology, and market their product locally. In 2005, the company estimated a local demand for fresh salmon to be approximately 700 tons p.a. This was expected to grow to 7000 tons in the future as the eating culture of South Africans changes.

It was anticipated that the salmon would be marketed directly to the retailers. The company estimated a production cost of R20/kg. Furthermore, they predicted that due to the high regional sea temperatures salmon farming in South Africa will have a significant competitive advantage over other areas of production - growth rates of 4kg/year could be achieved locally as opposed to 3kg/year in Norway. Ideal conditions for salmon farming exist from Cape Town to Mossel Bay. Harmful algal blooms present an excessive risk on the West coast. According to the company, the factors limiting salmon production in South Africa will be: fresh water facilities for smolting juveniles and the poor quality of locally manufactured feed and fishmeal. Unfortunately, in 2006, the farm ceased operations due to technical problems with their sea cages and the future of the enterprise is currently uncertain.

5.5.13 Tuna

In recent years, significant advances in tuna mariculture in Australia (Tasmania) and the Mediterranean have made the sub-sector an economic reality. At present, Stellenbosch University is pioneering a project that combines several internationally established technologies for utilizing our indigenous tuna stocks more effectively – the local long-line tuna fishery is struggling as a result of the strong rand, international price fluctuations and unsustainable fishing practices.

Much of the tuna captured locally is either frozen or canned, and as such, receives a poor price at the marketplace.
Tuna farming is essentially a short-term value adding process. Schools of big-eye (*Tunnus obesus*) and yellowfin (*Tunnus albacares*) tuna are sighted by airplane.

The tuna are purse seined or caught with rod and line and transferred to floating cages.
The cages are towed to offshore sites within serviceable distances from the shore, and are either moored to the substrate or maintained in position with boats. The fish are maintained in captivity so that they can be harvested at periods of high market demand. During the captivity period, the fish are fed high-fat diets to improve their fat content. Once optimal market conditions prevail, the fish are delivered to the Japanese sashimi / sushi markets. An alternative technology involves the use of floating platforms from which net cages are suspended. The platforms are self-propelled, allowing them to escape poor weather conditions. The concept is that tuna caught on rod and lines (from the platforms) are stocked into the cages.

5.6 Fish farming

The farming of fish is the most common form of aquaculture. It involves raising fish commercially in tanks, ponds, or ocean enclosures, usually for food. A facility that releases juvenile fish into the wild for recreational fishing or to supplement a species' natural numbers is called a fish hatchery. Worldwide, the most important fish species used in fish farming are, in order, carp, salmon, tilapia, and catfish.

In the Mediterranean, young blue fin tuna are netted at sea and towed slowly towards the shore. They are then interned in offshore pens where they are further grown for the market. In 2009, researchers in Australia managed for the first time to coax southern blue fin tuna to breed in landlocked tanks. Southern blue fin tuna are also caught in the wild and fattened in grow-out sea cages.

A similar process is used in the salmon-farming section of this industry; juveniles are taken from hatcheries and a variety of methods are used to aid them in their maturation. For example, as stated above, some of the most important fish species in the industry, salmon can be grown using a cage system. This is done by having netted cages, preferably in open water that has a strong flow, and feeding the salmon a special food mixture that aids their growth. This process allows for year-round growth of the fish, thus a higher harvest during the correct seasons.

Commercial shrimp farming began in the 1970s, and production grew steeply thereafter. Global production reached more than 1.6 million tonnes in 2003, worth about R1 billion. About 75% of farmed shrimp is produced in Asia, in particular in China and Thailand. The other 25% is produced mainly in Latin America, where Brazil is the largest producer. Thailand is the largest exporter.

Shrimp farming has changed from its traditional, small-scale form in Southeast Asia into a global industry. Technological advances have led to ever higher densities per unit area, and brood stock is shipped worldwide. Virtually all farmed shrimp are penaeids (i.e., shrimp of the family Penaeidae), and just two species of shrimp, the Pacific white shrimp and the giant tiger prawn, account for about 80% of all farmed shrimp.

These industrial monocultures are very susceptible to disease, which has decimated shrimp populations across entire regions. Increasing ecological problems, repeated disease outbreaks, and pressure and criticism from both nongovernmental organizations and consumer countries led to changes in the industry in the late 1990s and generally stronger regulations. In 1999, governments, industry representatives, and environmental organizations initiated a program aimed at developing and promoting more sustainable farming practices through the *Seafood Watch program*.

Freshwater prawn farming shares many characteristics with, including many problems with, marine shrimp farming. Unique problems are introduced by the developmental lifecycle of the main species, the giant river prawn.

The global annual production of freshwater prawns (excluding crayfish and crabs) in 2003 was about 280,000 tonnes, of which China produced 180,000 tonnes followed by India and Thailand with 35,000 tonnes each. Additionally, China produced about 370,000 tonnes of Chinese river crab.

Abalone farm

Aquaculture shellfish include various oyster, mussel, and clam species. These bivalves are filter and/or deposit feeders, which rely on ambient primary production rather than inputs of fish or other feed. As such, shellfish aquaculture is generally perceived as benign or even beneficial.
Depending on the species and local conditions, bivalve molluscs are either grown on the beach, on longlines, or suspended from rafts and harvested by hand or by dredging.

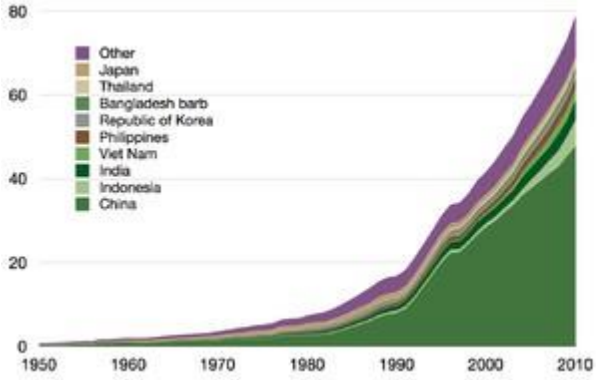
Abalone farming began in the late 1950s and early 1960s in Japan and China. Since the mid-1990s, this industry has become increasingly successful. Overfishing and poaching have reduced wild populations to the extent that farmed abalone now supplies most abalone meat. Sustainably farmed molluscs can be certified by Seafood Watch and other organizations, including the World Wildlife Fund (WWF). WWF initiated the "Aquaculture Dialogues" in 2004 to develop measurable and performance-based standards for responsibly farmed seafood. In 2009, WWF co-founded the *Aquaculture Stewardship Council* with the Dutch Sustainable Trade Initiative to manage the global standards and certification programs.
After trials in 2012, a commercial "sea ranch" was set up in Flinders Bay, Western Australia, to raise abalone. The ranch is based on an artificial reef made up of 5000 (As of April 2016) separate concrete units called ***'abitats'*** (abalone habitats). The 900-kg ***abitats*** can host 400abalone each. The reef is seeded with young abalone from an onshore hatchery. The abalone feed on seaweed that has grown naturally on the ***abitats***, with the ecosystem enrichment of the bay also resulting in growing numbers of dhufish, pink snapper, wrasse, and Samson fish, among other species.

Other groups

Other groups include aquatic reptiles, amphibians, and miscellaneous invertebrates, such as echinoderms and jellyfish. They are separately graphed at the top right of this section, since they do not contribute enough volume to show clearly on the main graph.
Commercially harvested echinoderms include sea cucumbers and sea urchins. In China, sea cucumbers are farmed in artificial ponds as large as 1,000 acres (400 ha).

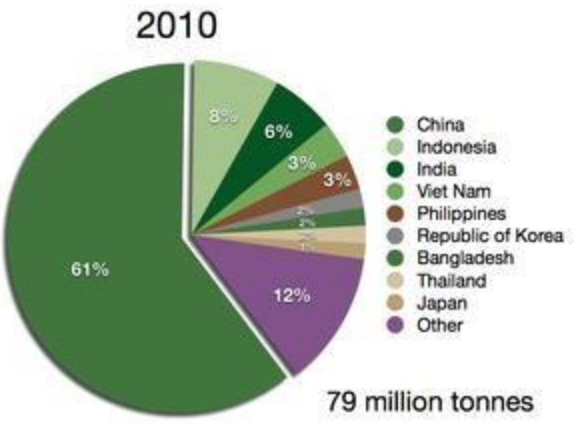
Global Aquaculture scenario

Global aquaculture production in million tonnes, 1950–2010, as reported by the FAO



A United Nations report titled; *The State of the World Fisheries and Aquaculture* released in May 2014 maintained fisheries and aquaculture support the livelihoods of some 60 million people in Asia and ***Africa.*** No sufficient data is available to substantiate the point particularly with reference to Africa.

Main aquaculture countries, 1950–2010



5.7 Main aquaculture countries by 2010

In 2012, the total world production of fisheries was 158 million tonnes, of which aquaculture contributed 66.6 million tonnes, about 42%. The growth rate of worldwide aquaculture has been sustained and rapid, averaging about 8% per year for over 30 years, while the take from wild fisheries has been essentially flat for the last decade. *The aquaculture market globally reached R860 billion in 2009.*

Aquaculture Economic Contribution to Chines GDP
Aquaculture is an especially important economic activity in China. Between 1980 and 1997, the Chinese Bureau of Fisheries reports, aquaculture harvests grew at an annual rate of 16.7%, jumping from 1.9 million tonnes to nearly 23 million tonnes. In 2005, China *accounted for 70% of world production.*

China and responsible aquaculture farming.
The growth of the aquaculture farming business and its contribution to the Chines GDP is arguably the largest but most controversial in the farming environment to date. Data posted by various Non-governmental organizations suggests less compliance with the international standards as well as best practises.

Best Aquaculture Practices (BAP) is a set of farm-raised seafood certification standards developed by Global Aquaculture Alliance (GAA). GAA is the world's leading standards-setting organization for aquaculture seafood. The BAP program is the world’s most comprehensive third-party certification system for aquaculture facilities, addressing every key element of responsible aquaculture, including environmental responsibility, social responsibility, food safety, animal welfare, traceability and more. BAP standards encompassing the entire aquaculture production chain, including farms, processing plants, hatcheries and feed mills. The BAP program is organized as a tiered ranking system certified; companies with four-star ratings are considered the most strictly compliant. The seafood processing plant standards are benchmarked against the latest Global Food Safety Initiative (GFSI) food-safety requirements. BAP’s market development team actively promotes the BAP program to retailers and foodservice operators on behalf of BAP-certified facilities.

5.8 Aquaculture; National laws, regulations, and management

Laws governing aquaculture practices vary greatly by country and are often not closely regulated or easily traceable. In the United States, land-based and near shore aquaculture is regulated at the federal and state levels; however, no national laws govern *offshore aquaculture* in U.S. *exclusive economic zone waters. In June 2011, the Department of Commerce and National Oceanic and Atmospheric Administration released national aquaculture policies to address this issue and "to meet the growing demand for healthy seafood, to create jobs in coastal communities, and restore vital ecosystems*. At some point in the US around 2011 a National Legislation was tabled at Congress tittled; *the National Sustainable Offshore Aquaculture Act of 2011* to establish a regulatory system and research program for sustainable offshore aquaculture in the United States exclusive economic zone. We right this point to illustrate the global legislative vacuum in the industry.

Aquaculture methods Mariculture

Mariculture off High Island, Hong Kong

Carp are the dominant fish in aquaculture

The adaptable tilapia is another commonly farmed fish

Mariculture may consist of raising the organisms on or in artificial enclosures such as in floating netted enclosures for salmon and on racks for oysters. In the case of enclosed salmon, they are fed by the operators; oysters on racks filter feed on naturally available food. Abalone has been farmed on artificial reef consuming seaweed which grows naturally on the reef units.

5.9 Integrated multi-trophic aquaculture

Integrated multi-trophic aquaculture (IMTA) is a practice in which the by-products (wastes) from one species are recycled to become inputs (fertilizers, food) for another. Fed aquaculture (for example, fish, shrimp) is combined with inorganic extractive and organic extractive (for example, shellfish) aquaculture to create balanced systems for environmental sustainability (bio-mitigation), economic stability (product diversification and risk reduction) and social acceptability (better management practices).

"Multi-trophic" refers to the incorporation of species from different trophic or nutritional levels in the same system. This is one potential distinction from the age-old practice of aquatic polyculture, which could simply be the co-culture of different fish species from the same trophic level. In this case, these organisms may all share the same biological and chemical processes, with few synergistic benefits, which could potentially lead to significant shifts in the ecosystem. Some traditional polyculture systems may, in fact, incorporate a greater diversity of species, occupying several niches, as extensive cultures (low intensity, low management) within the same pond. The term "integrated" refers to the more intensive cultivation of the different species in proximity of each other, connected by nutrient and energy transfer through water.

Ideally, the biological and chemical processes in an IMTA system should balance. This is achieved through the appropriate selection and proportions of different species providing different ecosystem functions. The co-cultured species are typically more than just bio-filters; they are harvestable crops of commercial value. A working IMTA system can result in greater total production based on mutual benefits to the co-cultured species and improved ecosystem health, even if the production of individual species is lower than in a monoculture over a short term period.
Sometimes the term "integrated aquaculture" is used to describe the integration of monocultures through water transfer. For all intents and purposes, however, the terms "IMTA" and "integrated aquaculture" differ only in their degree of descriptiveness. Aquaponics, fractionated aquaculture, integrated agriculture-aquaculture systems, integrated peri-urban-aquaculture systems, and integrated fisheries-aquaculture systems are other variations of the IMTA concept.

Salmon aquaculture

If performed without consideration for potential local environmental impacts, aquaculture in inland waters can result in more environmental damaging than wild fisheries, though with less waste produced on a per kg on a global scale. Local concerns with aquaculture in inland waters may include waste handling, side-effects of antibiotics, competition between farmed and wild animals, and the potential introduction of invasive plant and animal species, or foreign pathogens, particularly if unprocessed fish are used to feed more marketable carnivorous fish. If non-local live feeds are used, aquaculture may introduce plant of animal. Improvements in methods resulting from advances in research and the availability of commercial feeds reduced some of these concerns since their greater prevalence in 1990s and 2000s.

Fish waste is organic and composed of nutrients necessary in all components of aquatic food webs. In-ocean aquaculture often produces much higher than normal fish waste concentrations. The waste collects on the ocean bottom, damaging or eliminating bottom-dwelling life. Waste can also decrease dissolved oxygen levels in the water column, putting further pressure on wild animals. An alternative model to food being added to the ecosystem is the installation of artificial reef structures to increase the habitat niches available, without the need to add any more than ambient feed and nutrient. This has been used in the "ranching" of abalone in Western Australia.

5.10 Impacts on wild fish

Some carnivorous and omnivorous farmed fish species are fed wild forage fish. Although carnivorous farmed fish represented only 13 percent of aquaculture production by weight in 2000, they represented 34 percent of aquaculture production by value.
Farming of carnivorous species like salmon and shrimp leads to a high demand for forage fish to match the nutrition they get in the wild. Fish do not actually produce omega-3 fatty acids, but instead accumulate them from either consuming microalgae that produce these fatty acids, as is the case with forage fish like herring and sardines, or, as is the case with fatty predatory fish, like salmon, by eating prey fish that have accumulated omega-3 fatty acids from microalgae. To satisfy this requirement, more than 50 percent of the world fish oil production is fed to farmed salmon.
Farmed salmon consume more wild fish than they generate as a final product, although the efficiency of production is improving. To produce one pound of farmed salmon, products from several pounds of wild fish are fed to them - this can be described as the "fish-in-fish-out" (FIFO) ratio. In 1995, salmon had a FIFO ratio of 7.5 (meaning 7.5 pounds of wild fish feed were required to produce 1 pound of salmon); by 2006 the ratio had fallen to 4.9. Additionally, a growing share of fish oil and fishmeal come from residues (by-products of fish processing), rather than dedicated whole fish. In 2012, 34 percent of fish oil and 28 percent of fishmeal came from residues. However, fishmeal and oil from residues instead of whole fish have a different composition with more ash and less protein, which may limit its potential use for aquaculture.

As the salmon farming industry expands, it requires more wild forage fish for feed, at a time when seventy five percent of the world's monitored fisheries are already near to or have exceeded their maximum sustainable yield. The industrial scale extraction of wild forage fish for salmon farming then impacts the survivability of the wild predator fish who rely on them for food. An important step in reducing the impact of aquaculture on wild fish is shifting carnivorous species to plant-based feeds. Salmon feeds, for example, have gone from containing only fishmeal and oil to containing 40 percent plant protein. The USDA has also experimented with using grain-based feeds for farmed trout. When properly formulated (and often mixed with fishmeal or oil), plant-based feeds can provide proper nutrition and similar growth rates in carnivorous farmed fish.
Another impact aquaculture production can have on wild fish is the risk of fish escaping from coastal pens, where they can interbreed with their wild counterparts, diluting wild genetic stocks. Escaped fish can become invasive, out-competing native species.

5.11 Coastal ecosystems and the impact of irresponsible aqua-farming

Aquaculture is becoming a significant threat to coastal ecosystems. About 20 percent of mangrove forests have been destroyed since 1980, partly due to shrimp farming. An extended cost–benefit analysis of the total economic value of shrimp aquaculture built on mangrove ecosystems found that the external costs were much higher than the external benefits. Over four decades, 269,000 hectares (660,000 acres) of Indonesian mangroves have been converted to shrimp farms. Most of these farms are abandoned within a decade because of the toxin build-up and nutrient loss.

5.12 Pollution from sea cage aquaculture

Salmon farms are typically sited in pristine coastal ecosystems which they then pollute. A farm with 200,000 salmon discharges more fecal waste than a city of 60,000 people. This waste is discharged directly into the surrounding aquatic environment, untreated, often containing antibiotics and pesticides. There is also an accumulation of heavy metals on the benthos (seafloor) near the salmon farms, particularly copper and zinc.
Sea cage aquaculture is responsible for nutrient enrichment of the waters in which they are established. This results from fish wastes and uneaten feed inputs. Elements of most concern are nitrogen and phosphorus which can promote algal growth, including harmful algal blooms which can be toxic to fish. Flushing times, current speeds, distance from the shore and water depth are important considerations when locating sea cages in order to minimize the impacts of nutrient enrichment on coastal ecosystems.

The extent of the effects of pollution from sea-cage aquaculture varies depending on where the cages are located, which species are kept, how densely cages are stocked and what the fish are fed. Important species-specific variables include the species' food conversion ratio (FCR) and nitrogen retention. Studies prior to 2001 determined that the amount of nitrogen introduced as feed which is lost to the water column and seafloor as waste varies from 52 to 95%.

5.13 Genetic modification

A type of salmon called the AquAdvantage salmon has been genetically modified for faster growth, although it has not been approved for commercial use, due to controversy. The altered salmon incorporates a growth hormone from a Chinook salmon that allows it to reach full size in 16–28 months, instead of the normal 36 months for Atlantic salmon, and while consuming 25 percent less feed. The U.S. Food and Drug Administration reviewed the AquAdvantage salmon in a draft environmental assessment and determined that it "would not have a significant impact (FONSI) on the U.S. environment.

5.14 Prospects

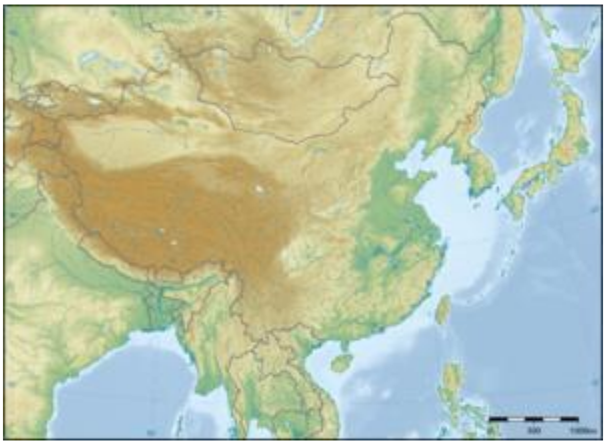
Global wild fisheries are in decline, with valuable habitat such as estuaries in critical condition.[114] The aquaculture or farming of piscivorous fish, like salmon, does not help the problem because they need to eat products from other fish, such as fish meal and fish oil. Studies have shown that salmon farming has major negative impacts on wild salmon, as well as the forage fish that need to be caught to feed them. Fish that are higher on the food chain are less efficient sources of food energy.
Apart from fish and shrimp, some aquaculture undertakings, such as seaweed and filter-feeding bivalve mollusks like oysters, clams, mussels and scallops, are relatively benign and even environmentally restorative. Filter-feeders filter pollutants as well as nutrients from the water, improving water quality. Seaweeds extract nutrients such as inorganic nitrogen and phosphorus directly from the water, and filter-feeding mollusks can extract nutrients as they feed on particulates, such as phytoplankton and detritus.
Some profitable aquaculture cooperatives promote sustainable practices. New methods lessen the risk of biological and chemical pollution through minimizing fish stress, fallowing netpens, and applying Integrated Pest Management. Vaccines are being used more and more to reduce antibiotic use for disease control.

Onshore recirculating aquaculture systems, facilities using polyculture techniques, and properly sited facilities (for example, offshore areas with strong currents) are examples of ways to manage negative environmental effects.
Recirculating aquaculture systems (RAS) recycle water by circulating it through filters to remove fish waste and food and then recirculating it back into the tanks. This saves water and the waste gathered can be used in compost or, in some cases, could even be treated and used on land. While RAS was developed with freshwater fish in mind, scientist associated with the Agricultural Research Service have found a way to rear saltwater fish using RAS in low-salinity waters.[121] Although saltwater fish are raised in off-shore cages or caught with nets in water that typically has a salinity of 35 parts per thousand (ppt), scientists were able to produce healthy pompano, a saltwater fish, in tanks with a salinity of only 5 ppt. Commercializing low-salinity RAS are predicted to have positive environmental and economic effects.

Unwanted nutrients from the fish food would not be added to the ocean and the risk of transmitting diseases between wild and farm-raised fish would greatly be reduced. The price of expensive saltwater fish, such as the pompano and combia used in the experiments, would be reduced.
However, before any of this can be done researchers must study every aspect of the fish's lifecycle, including the amount of ammonia and nitrate the fish will tolerate in the water, what to feed the fish during each stage of its lifecycle, the stocking rate that will produce the healthiest fish, etc.
Some 16 countries now use geothermal energy for aquaculture, including China, Israel, and the United States. In California, for example, 15 fish farms produce tilapia, bass, and catfish with warm water from underground. This warmer water enables fish to grow all year round and mature more quickly. Collectively these California farms produce 4.5 million kilograms of fish each year.

6 Aquaculture the Chinese Model

Aquaculture in China



Intensive mariculture occurs along China's 14,500 km (9,000 mi) coastline

General characteristics (2004 unless otherwise stated)

Lake area	196,000 km^2 (76,000 sq mi) (incl reservoirs)
River area	74,550 km^2 (28,780 sq mi)
Land area	9,326,410 km^2 (3,600,950 sq mi)
Employment	7.9 million persons (2004)
Consumption	25.8 kg (57 lb) fish per capita (2003)

Harvest (2004 unless otherwise stated)

Wild total	19.9 million tonnes (21,900,000 tons)
Aquaculture total	32.4 million tonnes (35,700,000 tons) (2005)
Fish total	49.5 million tonnes (54,600,000 tons) (2005)

China, with one-fifth of the world's population, accounts for two-thirds of the worlds reported aquaculture production.

Aquaculture is the farming of fish and other aquatic life in enclosures, such as ponds, lakes and tanks, or cages in rivers and coastal waters. China's 2005 reported harvest was 32.4 million tonnes, more than 10 times that of the second-ranked nation, India, which reported 2.8 million tons.

China's 2005 reported catch of wild fish, caught in rivers, lakes, and the sea, was 17.1 million tons. This means that aquaculture accounts for nearly two-thirds of China's reported total output.

The principal aquaculture-producing regions are close to urban markets in middle and lower Yangtze valley and the Zhu Jiang delta.

From 1978, China's economic policies moved from central planning towards a market economy, opening new markets for aquaculture products. The effect of this, together with further technological advances, has been to move Chinese aquaculture towards industrial scale levels of production. In the 1980s, many species other than carp, such as other species of fish, crustaceans, molluscs and seaweeds, have been brought into production. However, in the late 1990s, CAFS scientists developed a new variant of the common carp called the Jian carp. This succulent fish grows rapidly and has a high feed conversion rate. Over 50% of the total aquaculture production of carp in China has now converted to Jian carp. By 2004, the induced breeding of carps had been so effective that the carp industry amounted to 46 percent of the total aquaculture output.

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A common carp on a Ming porcelain pot.

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Fishing in a fish pond system at Daye Lake.

Statistics

Dayu Bay, Cangnan County, Zhejiang

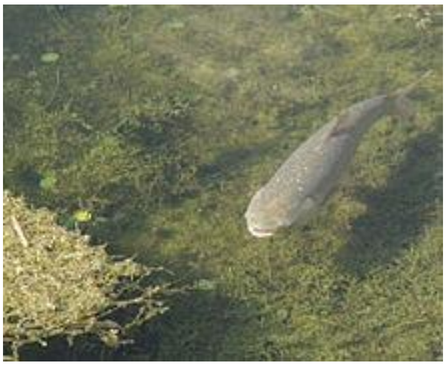
Since 2002, China has been the world largest exporter of fish and fish products. In 2005, exports, including aquatic plants, were valued at R77.7 billion, with Japan, the United States and the Republic of Korea as the main markets. In 2005, China was sixth largest importer of fish and fish products in the world, with imports totaling R40. Billion

In 2003, the global per capita consumption of fish was estimated at 16.5 kg, with Chinese consumption, based on her reported returns, at 25.8 kg.

The common carp is still the number one fish of aquaculture. The annual tonnage of common carp, not to mention the other cyprinids, produced in China exceeds the weight of all other fish, such as trout and salmon, produced by aquaculture worldwide.

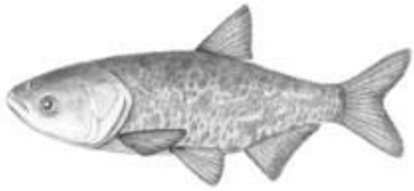
Since the 1970s, the reform policies have resulted considerable development of China's aquaculture, both marine and inland. The total used for aquaculture went from 2.86 million hectares in 1979 to 5.68 million hectares in 1996. Over the same time span, production increased from 1.23 million tons to 15.31 million tons.

In 2005, worldwide aquaculture production including aquatic plants was worth US$78.4 billion. Of this, the Chinese production was worth US$39.8 billion. In the same year there were about 12 million fish farmers worldwide. Of these, China reported 4.5 million employed full-time in aquaculture.



Grass carp

Silver carp



Bighead carp

Top 10 species grown in China in 2005	
Species	**Tonnes**
Japanese kelp	4 314 000
Grass carp	3 857 000
Pacific cupped oyster	3 826 000
Silver carp	3 525 000
Japanese carpet shell	2 857 000
Common carp	2 475 000
Wakame	2 395 000
Bighead carp	2 182 000
Crucian carp	2 083 000
Yesso scallop	1 036 000

Production, area and yield: 2003

	Total production (tons)	**Area used (ha)**	**Yield (kg/ha)**
Overall total	30,275,795	7,103,648	4,260
Marine culture	12,533,061	1,532,152	8,180
Inland culture	17,742,734	5,571,496	3,180
Pond	12,515,093	2,398,740	5,220
Lake	1,051,930	936,262	1,120
Reservoirs	1,841,245	1,660,027	1,110
Rivers	738,459	382,170	1,930
Rice paddies	1,023,611	1,558,042	660
Other	572,396	194,297	2,950

6. Inland aquaculture in china

In 1979, inland aquaculture occupied 237.8 million hectares and produced 813,000 tons. In 1996, they occupied 485.8 million hectares and produced 10.938 million tons. In that year, 17 provinces produced 100,000 tons from inland aquaculture.

Pond culture is the most common method of inland aquaculture (73.9% in 1996). These ponds are mostly found around the Pearl River basin and along the Yangtze River. They cover seven provinces: Anhui, Guangdong, Hubei, Hunan, Jiangsu, Jiangxi and Shandong. The government has also supported developments in rural areas to get rid of poverty. The sector is significant from a

nutrition and food security point of view, because it brings seafood to areas inland away from the sea where consumption of seafood has traditionally been low. Even the arid Xinjiang produced 58,835 tons of fish in 2000, 85% of it from aquaculture.
In recent times, China has extended its skills in culturing pond system to open waters such as lakes, rivers, reservoirs and channels, by incorporating cages, nets and pens.
Fish farming in paddy fields is also developing. In 1996, paddy fish farming occupied 12.05 million hectares producing 376,800 tons. A further 16 million hectares of paddy fields are available for development.

7 Aquaculture Industry the Nigerian Model

In the last five decades Nigeria has witnessed a rapid increase in the number of fish farms largely privately owned and privately driven.
The industry has seen the establishment of four Fish Seed Production Centres
African Regional Aquaculture Centre was established which provided research support and training for aquaculture development in Africa South of the Sahara.
Government of Nigeria upgraded a fish farm facility which integrated poultry-fish farming techniques. All these attempts opened up the awareness of the potentials for aquaculture development but did not translate into much output

50 fish farm facilities
20 000 to 25 000 tons per year of fish supplies in the 1990s
5–6% of domestic production

Management
A different strategy was adopted, which focused on the *private sector*
Government at all levels is divesting its traditional holdings setting up structures to encourage and support private sector producers technical assistance in all aspects of hatchery and grow-out technology is rendered on a sustained basis to private fish farmers Fish feed supply remains problematic by2005, the Federal Government of Nigeria constituted a *Presidential Committee on Fisheries and Aquaculture Development in Nigeria*
Nigerian Federal Government produced a blue-print for accelerated development of the subsector for the next five years. The proposed development was underpinned by Public Private-sector Partnership (PPP). All these efforts have seen aquaculture industry in Nigeria maintaining a steady contribution to total GDP which translates into about 5% of agricultural GDP nationally. Fisheries are an important subsector in the Nigerian agricultural economy. Larger-scale fish farms are vertically integrating, to the advantage of the entire industry. Other role players are working on higher-grade species in response to the demands of more sophisticated markets

8 Comparison Australia, Chile and South Africa models

8.1 Aquaculture Sectors of Australia, Chile and South Africa

Aquaculture is globally a young sector which has emerged as the major contributor to the growth in fishery production since the 1980s. Typically, successful aquaculture industries are based on the development of new technologies to farm species whose harvest fisheries have collapsed or can no longer supply market demand. It usually takes 5-10 years to develop a new aquaculture species to full commercial production.

The growth of emerging national aquaculture sectors is often constrained by the "new kid on the block" syndrome, as supporting policy, legislation and institutions are usually lacking. Global experience shows that without state intervention to provide an enabling for investment into aquaculture, organic industrial growth is slow due to constraints that are difficult for individual firms to overcome. The South African aquaculture sector is a good example of this where growth has been constrained by permitting issues, access to land and water, access to technology, a lack of skilled people and barriers to entering markets such as the EU health standards.

In countries where a national strategy to facilitate the establishment of the aquaculture sector has been put in place, sectoral growth has been more rapid. State led interventions to promote aquaculture sector development in Chile and Australia; - two countries with analogous geographic, economic and environmental conditions to South Africa - have been highly successful, resulting in their aquaculture sectors attaining a "critical mass" of production, infrastructure and services.

Concomitant with this has been a reduction in transaction costs, and the establishment of internationally competitive production. South Africa's National Industrial Policy Framework (NIPF), suggests that in respect of industrial finance "in certain strategic areas it will be important to at least match what is available elsewhere". In this section the industrial incentives available to the aquaculture sectors of Australia, Chile and South Africa are compared, and diagnostic comments provided on what incentives could be provided to stimulate aquaculture sector development in South Africa. Cognisance is paid to principles for industrial financing outlined in the NIPF.

Industrial incentives and support for aquaculture may take various forms including:

- Aquaculture Production grants
- Imports/ exports, quarantine grants and advice
- Innovation, research and development grants
- Business and taxation assistance
- Employment and training grants and facilities
- Environmental management assistance
- Key information sources
- Key contact points

Australia produces 240,000 tonnes of fish a year with aquaculture contributing a third to this. Over the decade to 2006–07 aquaculture production has almost doubled from 29,300 tonnes to 57,800 tonnes. The gross value of aquaculture production in Australia continued to rise in 2007–08 by R662.7 million to R868 million. In 2008 the Aquaculture industry directly employed more than 7000 people and indirectly contributed 20,000 and was the fastest growing primary industry in Australia.

Australia has the National Aquaculture Council

The National Aquaculture Council (NAC) it is the peak industry body representing aquaculture in Australia. NAC provides the industry with a credible voice at the political level, and strives for greater influence of issues of national significance for Australia's aquaculture industry. Since its establishment in 2001, NAC has developed a reputation amongst key Australian Government Ministers and agencies with an interest in aquaculture, primarily the Department of Agriculture, Fisheries and Forestry. The NAC is governed by a Board of Directors, which is responsible for determining the strategic direction of the NAC's work program. In addition to these industry members, are other NAC members including a variety of aquaculture organisations and groups.

Synoptic Comparison of Support Measures

A review of available support measures reveals that South Africa, Australia and Chile possess substantively equivalent sets of industrial incentives and institutions to promote the establishment of new, technology based industries, but specific differences exist reflecting varying policy approaches to development. While aquaculture has benefited substantially from available industrial incentives in Australia and Chile, South Africa's aquaculture industry has only accessed a small range of industrial support measures and significant constraints to industry development remain.

A comprehensive strategic approach to identifying instruments that could unlock key growth opportunities and overcome constraints has been lacking. Public sector institutions that have attempted to support aquaculture sector development have done so in isolated "pockets" of activity, and have ultimately been constrained in their effectiveness by the lack of a comprehensive vision and set of supporting institutions. South Africa's recently published National Industrial Policy Framework provides a means to address the potential of the aquaculture sector in a more rational and systematic way.

The aquaculture sector in Chile has benefited from a very comprehensive, and quite generous, set of industrial support measures, particularly for regions where economic growth is a high priority.

Chile's incentives work both at a sectoral level to set up infrastructure and services, and at a company level to promote investment, innovation and competitiveness. Chile is still in the process of developing its R&D base and hence has placed strong emphasis on instruments which facilitate technology transfer. The experience of Chilean aquaculture producers reveals that a reasonably high level of technical competence is required to write the various grant application documents, and that the application process requires a major time investment.

Grant applications have a high chance of approval if the submitted document is well written; the company conforms to the legal requirements and has a good background in the subject. The evaluation process is regarded as fair and clear. On average, it takes about 3 months for an applicant to formulate a project, and then another 4 to 6 months for the result to be made known by CORFO. Our research revealed that a South African aquaculture company that invested in production in Chile was successful in obtaining a grant for a canning plant. They reported that the application process was relatively straight forward and efficient, and that they were awarded a no-strings-attached upfront capital grant on the basis of their application.

While Australia does not offer the generous capital grants available in Chile, it provides a comprehensive set of industrial incentives that emphasize technology innovation, product development, skills development, export capacity, and access to information and markets. There is good support for collaborative industry actions to development technology and services to support the growth and competitiveness of Australian aquaculture.
Although South Africa possesses a number of instruments which could potentially be used to support the aquaculture sector, consideration has not yet been given to a customised or comprehensive system of industrial finance and support measures. Our research revealed some evidence that the SMEDP grant encouraged individual investments in aquaculture, but that industry development remains fundamentally constrained by some sector level constraints that individual companies cannot overcome by themselves. In the absence of a well targeted and comprehensive state led intervention to remove these constraints, development of the aquaculture sector has been patchy and its growth rate below the international average.

Recommendations for Support Measures required for South Africa to achieve parity with Chile and Australia

Based on the comparison of support measures available in Chile, Australia and South Africa below, a series of brief suggestions on required support measures for South Africa is made below.

Joint Industry Actions

Chile and Australia both have useful sector level grants for joint industry actions.
Equivalent grant support and facilitation of joint industry actions would greatly enhance the growth trajectory of the South African aquaculture sector by encouraging development of critical infrastructure and services.

Research and Development

South Africa possesses a R&D base with great depth and some capacity in aquaculture, but lacks a comprehensive or sector level system of research grant finance. While company level facilities such as THRIP, the Innovation Fund and the

150% research tax deduction are useful, a programme managed, sector level facility, equivalent to the Australian Cooperative Research Centre system, is required if technology development for specific species or technologies is to be developed in a systematic and efficient way.

9 Skills Development in the Aquaculture Industry

The current Aquaculture Bill tabled by the Department of Agriculture, Forestry and Fisheries proposes a creation of Aquaculture Research Facility or Institute under the directive of government. A major gap exists in aquaculture skills development. While University level aquaculture courses are well catered for, there are no technical courses for in-service or tertiary level training equivalent to those offered in Australia and Chile. A particular “special need” is to support skills training of individuals from disadvantaged backgrounds participating in aquaculture SMEs. Experience shows that while these individuals are usually competent in production skills, a lack of business management and planning skills often cause their ventures to fail.
University level aquaculture courses are well established at the Universities of Limpopo, Rhodes and Stellenbosch and graduates from these institutions supply the high level human resource requirements of the public and private sectors. Interestingly, graduates from Limpopo (who are mainly black) tend to be appointed to the public sector positions, and those from Rhodes and Stellenbosch (who are mainly white) to the private sector posts.

A shortage of bursaries is seen as the main constraint to attracting more black students into aquaculture, particularly at Stellenbosch and Rhodes Universities. Actively recruiting and funding black students at all institutions is seen as a critical intervention to achieve racial representivity as the sector grows.
There are no tertiary aquaculture technical courses offered by any of the South African Technikons which is a major gap in terms of the supply of skills for the growing aquaculture sector. There is no local equivalent to the Australian TAFE, or the Chilean "Aquaculture engineer' courses which train aquaculture technicians.
The Tompi Seleka Agricultural College used to offer aquaculture training, from which many current agriculture officials benefited, however the course has not been offered for several years due to a perceived lack of opportunity in aquaculture.

Similarly, there are no SETA unit standards and accredited courses for in-service training which address aquaculture production skills. ABET and similar general skills courses are however available through the AgriSETA (Botes, 2007).
The transport-SETA (TETA) has taken on a role to support marine aquaculture and is funding the training of members of the Port Nolloth community in abalone culture through the Fishing and Mariculture Development Association (FAMDA), to prepare them for employment at the Namaqualand Aquaculture Park. Stellenbosch University regularly comes to Port Nolloth to offer the theoretical and practical training. A limited offering of ad hoc aquaculture short courses is available through Rhodes, Stellenbosch and a few private service providers; however, the skills training needs of the aquaculture sector need to be comprehensively addressed.

10 Technology Transfer

Industry is hungry for information and technology and support for technology transfer and company level skilling in new technology – equivalent to the support measures in Australia and Chile - would be readily taken up by local aquaculture firms.

11 SME Development

Where South Africa is performing relatively well is in the extension of aquaculture technology to create SMEs for previously disadvantaged individuals through the Department of Science and Technology's "Technology for Sustainable Livelihoods" programme. The South African aquaculture sector requires more examples of state led "engineered" approaches to aquaculture development in high priority localities. Experience to date makes it clear that local firms will generally not promote SME development on their own initiative, but are quite willing to participate in facilitated schemes where capital grant support, risk sharing and some leadership by the state supported agencies is provided.

12 Regional Development

Both Australia and Chile have successfully used aquaculture as a means to bring development to economically depressed regions. The concept of promoting regional development through the establishment of "aquaculture development nodes" is a key opportunity to unlock South Africa's aquaculture production potential. An "aquaculture infrastructure fund", as well as staff capacity within the national and provincial government agencies to plan and promote development nodes, is required.

13 Exports

Chile and Australia have a well organised and efficient system of support for encouraging exports – including assistance with health monitoring and certification of products, export training, marketing, electronic documentation, and export advice help lines. In South Africa bureaucracy and a lack of capacity in state institutions constrain the ability of local aquaculture producers to penetrate export markets and raise transaction costs. Serious attention is required to remove this constraint to industrial competitiveness and good examples are available from Chile and Australia on how to achieve this. A lack of aquaculture capacity in the state veterinary services to certify the health of fresh and live products is a particular constraint to exports.

14 Seafood Industry Promotion

Both Chile and Australia have industrial strategies to develop their seafood industries. Comparison of support measures reveals this is an area of distinct neglect in South Africa both in respect of our fishing and aquaculture industries.
In contrast to the emphasis that has been placed on redistributing fishing rights to smaller and medium size enterprises, there have been no programmes or initiatives to build the competitiveness of our seafood sector – which has great potential due to our natural resource endowment. There has been an implicit reliance on the established, larger fishing companies – with their inhouse R&D and marketing capacity – to maintain the competitiveness of South Africa's seafood industry. It is suggested that a national approach to developing an internationally competitive SME sector in the seafood industry (both in aquaculture and fishery production sub-sectors) is required.

15 Assistance with Environmental Management and Legislation

Australia, Chile and South Africa have all promulgated recent legislation and regulations to ensure that the utilisation of the natural resources is sustainable. South African Government has table bills for public comment namely; Aquaculture Bill and the Draft Marine Special Planning Bill. South Africa is currently guided in this regard by the Marine Living Resources Act of 1998.

Australia and Chile have ensured that support measures are in place to ensure that aquaculture farmers are able to comply with environmental legislation without unduly increasing their transaction costs. In South Africa, compliance with recently promulgated environmental legislation and regulations has become increasingly difficult for the aquaculture sector, and producers now complain that this has become the single biggest constraint to industry development, a red tape.
This is exacerbated by fragmented, bureaucratic and inefficient permitting processes. Very little has been done to assist producers to comply with legislation, for example, by means of streamlined permitting and EIA processes, strategic environmental assessments to zone certain areas of land and water for aquaculture guidelines, and implementation of self-regulation by means of best practice protocols.

16 Access to Information

Australia in particular has very effective measures to promote access to information required by industry by means of information resources, advisory services and contact points. Available information for aquaculture in South Africa is very patchy – especially for prospective new entrants into the sector.

Established industry tends to be rather closed, guarding proprietary information, and beyond permitting and regulatory requirements, only rudimentary and very general information on aquaculture is available from government sources, for example;- the MCM and Department of Agriculture websites. South African Government has realised that this industry has the economic potential and spin-offs as well as some real dangers to environment The Aquaculture Association of Southern Africa and Aquaculture Institute of South Africa provide general information on aquaculture, but these sources are at best a starting point for anyone seriously interested in investing in aquaculture.

17 ***Recommendations***

- Strengthen the current trade promotion plan utilizing state resources and services to optimize the commercial interests of South Africa in key markets abroad successfully;
- Endorse the proposed National and Provincial Aquaculture Development Fund to facilitate transformation and inclusive growth. Transformation must be statutory mandatory to the Aquaculture Bill to facilitate inclusion of disadvantaged groups and locals.
- Encourage collaborations between private sector industry players, local communities and government at all spheres.
- Cut Red Tape to facilitate new entrance in the industry through initiatives like business mentoring, dedicate business mentors in the Development Fund to help local communities and new black entrants with funding, compliance and development.
- National Industry Forum must be funded through tax incentives and its core mandate must be to help government achieve; equity targets, inclusive economic growth of the industry, BBBEE compliance, good labour practises, social responsibility and social cohesion.
- Proposed Aquaculture Development Zone to have a dedicated zones that can mirror the concept of Agri-Parks.
- Maintain Environmental integrity through water quality management, protection of the aquatic environment, and prohibition of release of aquaculture organism.
- Review the licensing proposals in the proposed Aquaculture Bill rather streamline the industry to the existing agricultural statutory framework.
- ensuring that South African trade policy tools are prioritized toward initiatives that will yield the maximum economic benefits to South African Aquaculture industry workers and businesses;
- constantly promoting South African position to access the world's two largest markets—the European Union and the United States with total customers-base of more than 800 million, and well over half of the entire global marketplace; and
- Unlock the potential of SMMEs, cooperatives, townships and rural enterprises;

18 Research Institutions on Aquaculture

- Andalusian Center for Marine Science and Technology
- Bedford Institute of Oceanography
- Bureau of Fisheries and Aquatic Resource
- Caribbean Research and Management of Biodiversity Foundation
- Central Institute of Brackish Water Aquaculture
- Central Institute of Fisheries Education
- Central Institute of Fisheries Nautical and Engineering Training
- Central Institute of Fisheries Technology
- Central Marine Fisheries Research Institute
- Centre of Marine Resource Management
- Chinese Academy of Fishery Sciences
- Cronulla Fisheries Research Centre
- Deep Bay Marine Field Station
- Fish research institutions in the Maharashtra
- Fisheries and Illinois Aquaculture Center
- Fisheries College and Research Institute
- Fisheries Research and Development Corporation
- Fisheries Research Services
- Fisheries Research Services Marine Laboratory
- Geoduck aquaculture
- GEOMAR Helmholtz Centre for Ocean Research Kiel
- Global Ocean Ecosystem Dynamics
- Grimsby Institute of Further & Higher Education
- ICAR CIFE Rohtak centre
- Ichthyological Society of Hong Kong
- Institute of Ocean Sciences
- Instituto Nacional dos Recursos Biológicos
- International Council for the Exploration of the Sea
- Karnataka Veterinary, Animal and Fisheries Sciences University
- Kerala University of Fisheries and Ocean Studies
- Korea Institute of Maritime and Fisheries Technology
- Korea Maritime Institute
- Leigh Marine Laboratory
- Maharashtra Animal and Fishery Sciences University
- Marine Institute Ireland
- Maurice Lamontagne Institute
- Ministry of Land, Infrastructure and Transport (South Korea)
- National Fisheries Research & Development Institute
- National Hydrology Research Centre
- Nereus Program
- North Pacific Marine Science Organization
- Northwest Atlantic Fisheries Centre
- Norwegian College of Fishery Science

- Norwegian Institute of Marine Research
- Pacific Biological Station
- Research Institute for Aquaculture No 1
- Royal University of Agriculture, Cambodia
- Runde Environmental Centre
- School of Fisheries and Ocean Sciences
- Sea Around Us (organization)
- Sea Fish Industry Authority
- Shanghai Ocean University
- Skretting Aquaculture Research Centre
- Southeast Asian Fisheries Development Center
- St. Andrews Biological Station
- Tamil Nadu Fisheries University
- UBC Fisheries Centre
- UBC Institute for the Oceans and Fisheries
- West Bengal University of Animal and Fishery Sciences
- World Fish

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