Land-Based RAS production of Atlantic salmon near Vredenburg on the West Cape Coast, Western Cape, South Africa

October, 2024

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INTRODUCTION

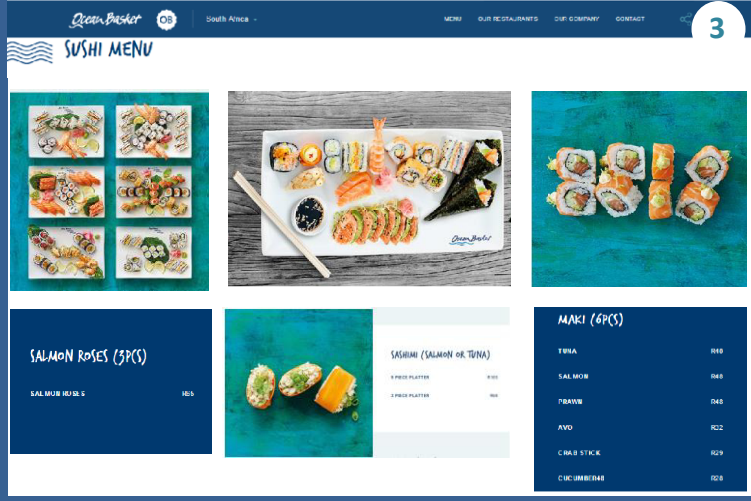
South Africa currently imports over 5,000 tonnes/year of Atlantic salmon (*Salmo salar*) a high-value marine salmonid fish species at a premium for air freighted fresh product, required for the local sushi market, adding around US$1.80/kg in air freight and related charges supplied mostly by Norway.

Norway alone exported around 4,200 tonnes to South Africa in 2014 attributed to the rise in domestic consumption of sushi-sashimi in the country's many sushi bars and seafood restaurant chains. Imports have since climbed to over 5,000 tonnes worth over R1 Bn [for 5-6kg Head-on-Gutted (HoG) farmed Atlantic salmon from Norway [See the following link to the *NASDAQ Salmon Index* for latest pricing < https://salmonprice.nasdaqomxtrader.com/public/report;jsessionid=F3FB4F51AAE2445A22DAB264EED3DD15?0 >] attributed to the widespread popularity and availability of salmon based sushi meals.

Salmon is the main feature in sushi across all seafood restaurant chains, over 250 restaurants in South Africa

Ocean Basket, John Dory's, Cape Town Fish market and many, many more...

"Up to 80 per cent of all seafood used in sushi in South Africa is salmon, so we can safely say that salmon has a very strong position in sushi," say Nofima researchers Geir Sogn-Grundvåg and Morten Heide of Nofima one of the largest institutes for applied research within the fields of fisheries, aquaculture and food research in Europe (Seafarmingexpert, 2015).



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Salmon for in-store sushi, or as frozen fillets and steaks, or processed gravlax, smoked and thinly sliced, and other added value portions has become popular across many supermarket multiples in South Africa....

WOOLWORTHS

Pick n Pay

Inspired by you

SPAR

better and better

Checkers

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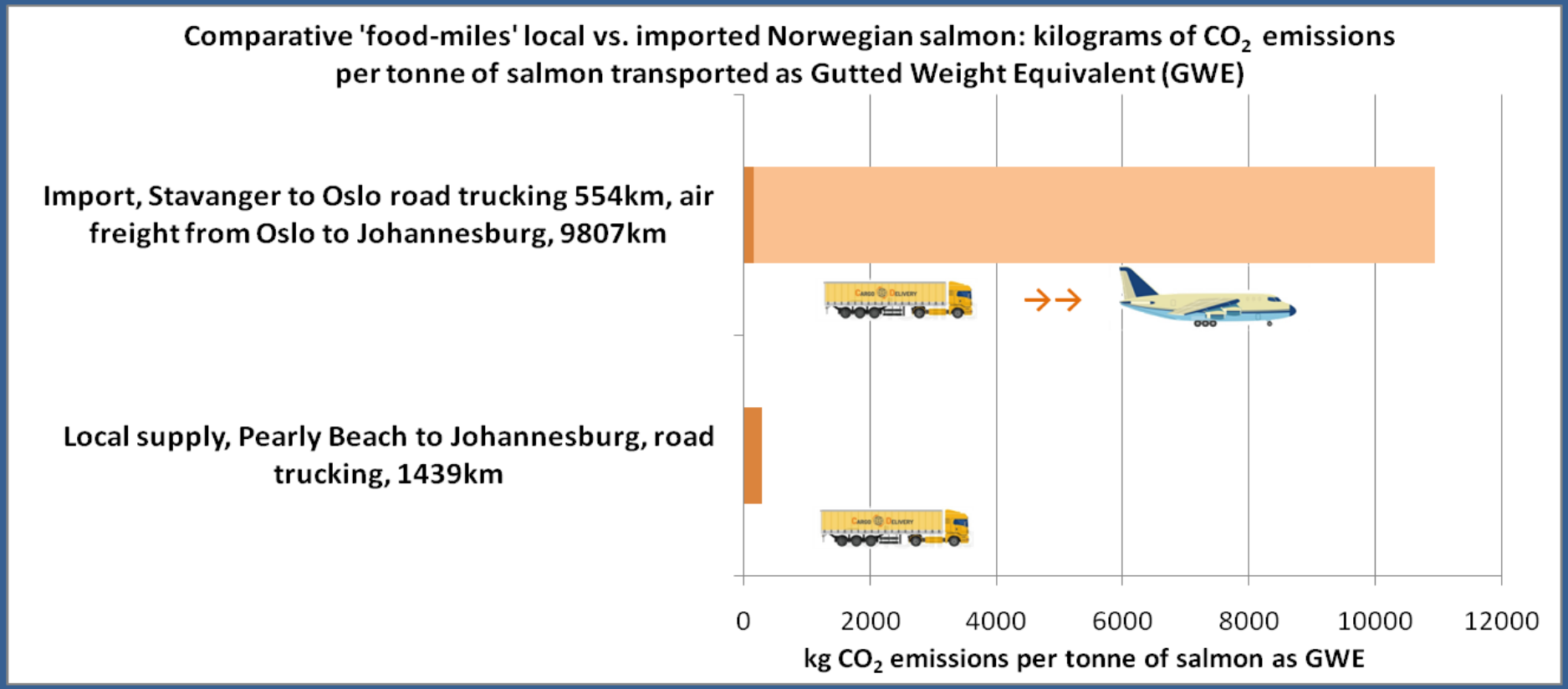
Freshness for sushi is key....

By the time Norwegian salmon arrives at OR Tambo Airport from Oslo, Norway, with a very high carbon footprint, already more than 48 hours have elapsed since the time of harvest...not fresh enough for sushi...



Salmon is an established market in South Africa for import replacement. Then it follows that locally farmed would offer a fresher product by around 18 hours or more (12 hour delivery anywhere in South Africa from the west Cape coast) produced to the highest standards. Atlantic salmon, then, is a prime aquaculture business opportunity in South Africa at this time.....a myriad of product forms.....particularly when locally farmed and more affordable fresh Atlantic salmon become available year-round and on tap...

A troubling development: Air freight emissions increase beyond post pandemic economy

< https://www.theguardian.com/environment/article/2024/jun/26/air-freight-greenhouse-gas-emissions-increase-post-pandemic-economy >

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No competition..barriers to entry, this follows based upon the unsuccessful short history of salmon farming in South Africa

- → Safriel and Bruton (1984) mention Atlantic salmon (*Salmo salar* L) as a potential candidate aquaculture species in South Africa, and again Hecht and Britz (1990) again mention Atlantic salmon (*Salmo salar* L) as a potential candidate aquaculture species in South Africa;
- → Kourie (1994) authored the first dedicated report entitled, "*Potential for Atlantic salmon (Salmo salar L) farming in South Africa*". The report introduces a second generation land-based pump ashore tank farming technology for prototyping ahead of any serious investment into sizable salmon farming operations as a more sustainable and biosecure approach when gauged against typical net pen salmon farming. No investment into the pilot plant occurred at the time, and the whole program to establish land-based salmon farming went dormant.
- → 2005 sees the first pilot scale net pen Atlantic salmon farm established by *Salmo Salar Sea Farming* (Pty) Ltd just 1km from Kleinbaai (Gansbaai). Several incidents brought about the closure of the net pen farm among them, storm damage to cage structures and repeated losses of salmon stocks to escapes apart from pressure from local lobbyists and negative press [see articles below].
- → In June 2015 after seven months into an Atlantic salmon cage culture trail near Saldanha Bay Three Streams Holdings (Pty) Ltd deems marine salmon farming as 'not viable,' quoting Gregory Stubbs, the CEO, who believes a land-based approach may be a better option.
- → A third cage culture production trial is underway in Saldanha Bay owned by Viking Fishing which has received allot of negative public opinion (Carte Blanche, a few months ago) – the same technical challenges remain unconquered.

Salmon Farming in SA? *Farmers Weekly*, 16 September 1994 issue

Mr Kourie holds a model of a single R-ended tank, showing the overhead walkway for easy access, and a copy of his book.

SALMON FARMING IN SA?

Research shows there's good potential along the Cape's West Coast

by Stephen McVeigh

SALMON are not being produced commercially in South Africa. Nor have they ever been farmed successfully, even on a small scale.

But there is reason to believe that with modern technology salmon farming could become a reality for SA, says Ramon Kourie of Intensive Fish Farming, Somerset West, in his recently released publication, *Potential For Atlantic Salmon Farming in South Africa.*

Atlantic salmon are being produced successfully in the Southern Hemisphere, notably in Chile, the Falkland Islands, New Zealand and Tasmania.

So why not SA? "The potential for Atlantic salmon farming in SA ...is well recognised and was recently documented by Hecht and Britz (1990) in their first report on the status of aquaculture in South Africa," says Mr Kourie.

It seems SA has a history (albeit a short one) of unsuccessful sea water fish culture, according to Mr Kourie's work.

Two sea water trout farms along the West Cape Coast were unsuccessful for technical reasons. A third is still operating, but its financial and production status is unknown to Mr Kourie.

Despite this lack of success in growing on of salmonids in sea water, Mr Kourie says developments over the past decade or so make it necessary to take a new look at sea water salmonid on-growing.

Trout and salmon production in sea water systems is essentially the same, both species sharing nearly identical environmental requirements during the growing out in sea water production systems, says Mr Kourie.

"The reason for the earlier failure of the two marine rainbow trout on-growing facilities on the West Cape Coast has been attributed to engineering problems associated with the sites selected," says Mr Kourie.

The sea water systems used could be classified as first generation technology, he says. Nowhere in the world have such systems been successful. The farming of trout using appropriate second generation marine pump ashore tank farms is potentially viable.

The ability to satisfy the environmental requirements of rainbow trout at the succesfully operating sea water growing-on farm near Saldanha Bay implies production of salmonids under local conditions can succeed.

Production of Atlantic salmon can be commercially successful given:

- The lower mortality of Atlantic salmon compared to that of rainbow trout at sea transfer (that is, when the fresh water-raised smolts are introduced to sea water growing-on conditions) and greater resilience to pathogens in the marine environment;
- The growth of Atlantic salmon is nearly three times faster than most strains of rainbow trout in sea water at salinities of 30-35 parts per thousand on dry feed;
- That Atlantic salmon exceeding 3 kg command a higher selling price at several market centres, including Billingsgate (UK) and Fulton Fish Market (USA), than portion sized trout (250-500g) or larger trout (less than 3 kg).

WATER TEMPERATURE

Possibly the greatest advantage for future local salmon producers is the application of a technically superior version of second generation, land based tank farms which are being used in Norway and Scotland – the traditional world leaders in salmon production.

Equally as important are the highly favourable sea temperatures off the south west and West Cape Coast lines.

Atlantic salmon grow at a faster rate in water temperature of about 16 C than at any other water temperature, says Mr Kourie. Optimum temperature range for farming Atlantic salmon in the marine on-growing phase is 14-18 C.

So the sea water temperature of the location selected for salmon production is important. The longer the sea water temperature remains within or near the optimum, the more successful and profitable the venture is likely to be because the fish grow more quickly and a multiple stocking and harvesting schedule can be more efficiently applied.

A comparison of mean, monthly sea water temperatures of the more important salmon farming locations of the world shows the South West Cape Coast from Cape Hangklip to Danger Point (especially Gansbaai) followed closely by the West Coast from Blouberg Strand to Port Nolloth and into Namibia (excluding the bays) are, in terms of sea water temperature, the two best locations in the world for farming salmon, says Mr Kourie.

"The South West Cape Coast appears to have a year round mean temperature of 15,3 C, which is closest to the optimum of 16 C (optimum range 14-18 C) for rearing salmon," says Mr Kourie.

Atlantic salmon would grow a faster rate on the South West Cape Coast, (followed closely by the West Cape Coast) than at any other destination.

Fish could be grown to almost 5 kg in just over 10 months using the Sunndalsora salmon strain.

Conditions off the West and South West Cape Coasts are rough and exposed, maximum wave heights potentially reaching or exceeding 10 m (from trough to crest). The few sheltered bays potentially available for cage farming, including False and Saldanha Bays, are either generally too polluted or have too high sea temperatures during summer (False Bay) or too great winter-summer variations (Saldanha Bay) to be suitable for high -efficiency salmon farming.

There are only two alternative approaches towards salmon farming in SA, says Mr Kourie:

- Floating off-shore or submerged off-shore cage culture or;
- On-shore tank farming using sea water pumped ashore.

Although off-shore cage farming of salmon seems a potentially viable option, Mr

SALMON FARMING

Kourie is reluctant to recommend this because of the high risks of red tide, stock escapes, storm damage and the high economic penalties due to loss of quality and management control.

"Some of Norway's most prominent researchers have expressed their backing of the development of highly controllable and manageable on-shore tank farms," says Mr Kourie.

He, too, supports the idea of land based, pump-ashore tank farms using high-performance R-ended advanced second generation tanks for production.

The system is suitable for salmon, trout, red tilapia, sea bream, sea bass, eels and other high value fish where both fish quality and profitability are paramount.

There are several design advantages to the high-performance tanks, says Mr Kourie. These include:

- Improved oxygen usage by the fish due to higher overall oxygen tension throughout the tank, this being attributed to the improved water mixing performance of the design.

This results in an almost homogeneous oxygen environment and lengthy in-tank water retention time;

- High stocking densities as a result of uniform in-tank physical and chemical water quality environment resulting also in near uniform fish distribution. This is due to the nearly complete mixing of old and new water, creating an almost complete homogeneous environment;
- In-tank velocity control to affect higher fillet yields, improved growth rates, improved muscle tone and texture to give a higher flesh quality and lower mortalities;
- Maximum use of floor/building space; pipelines, service and drainage channels; water supplies and common pond walls to effect a reduction in building material requirements;
- Single but maximum use of water before re-use (after being reconditioned) or discharge to produce regular and sustainable batches of high quality fish that have low mortality, equal feed conversions and growth rates;
- Simplified bath and flush medication procedures;
- Efficient mechanical feed distribution systems (more applicable on large farms using more than 100 t yearly) and low feed conversions due to frequent daily feedings, good feed spreading and excellent control possible over feeding in general;
- Efficient aeration inducing controllable in-tank curent velocities and the capability of full stock support. At an average in-tank current speed of 0,4 body lengths per second (BL/sec) farmed salmon will cover 5 700-6 300 km over a 10-12 month on-growing period.

This approximates the distance a salmon travels during wild migration. The aim of this process is to produce a fish that has the firmness and quality of the edible flesh of a wild salmon and is an improvement over farmed salmon in general.

- Fully self-cleaning systems which efficiently eliminate the settlement of faecal solids and improves their efficient removal.

The following is a simplified description of the tank system recommended by Mr Kourie.

"The configuration is rectangular, having rounded ends and a central dividing baffle around which a water current is induced, the overall effect being that of a continuous raceway offering the many husbandry and design advantages mentioned above.

VARIATIONS

"This configuration has many variations and has received various descriptive names. Intensive Fish Farming has termed this tank system 'rounded-ended' or abbreviated 'R-ended'.

The impact of rapid sea water temperature changes, caused by cold water upwelling, can result in unusually high stock losses in off-shore cage culture.

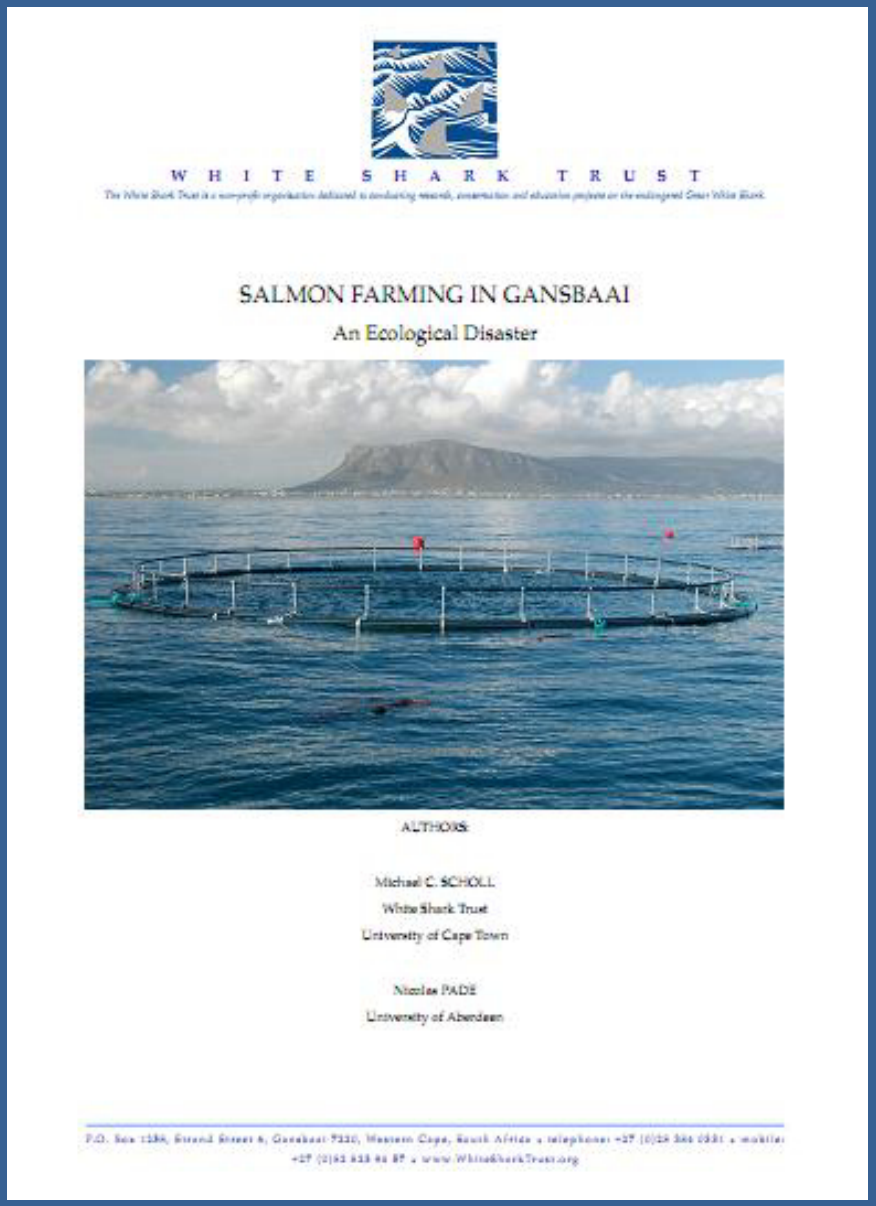
With a land-based pump-ashore tank farm, a "lengthy" retention time of sea water in the tanks will tend to buffer the rate of in-tank water temperature change, dramatically reducing the impact of rapid changes in temperature in the source water.

Possibly the greatest single threat to marine fish farms on the South West and West Cape Coasts is that of red tides formed by toxin producing marine algae.

The potentially shorter sea water rearing period of farm raised Atlantic salmon on both the West and South West Cape Coasts, compared to other salmon farming destinations of the world, could result in many advantages and few disadvantages, says Mr Kourie.

Despite ample availability of fresh water reared, large rainbow trout, true salmon are still being imported into SA, at least by two processors.

Negative perceptions and press coverage of the Gansbaai net pen salmon farm



WHITE SHARK TRUST

SALMON FARMING IN GANSBAAI

An Ecological Disaster

AUTHORS:

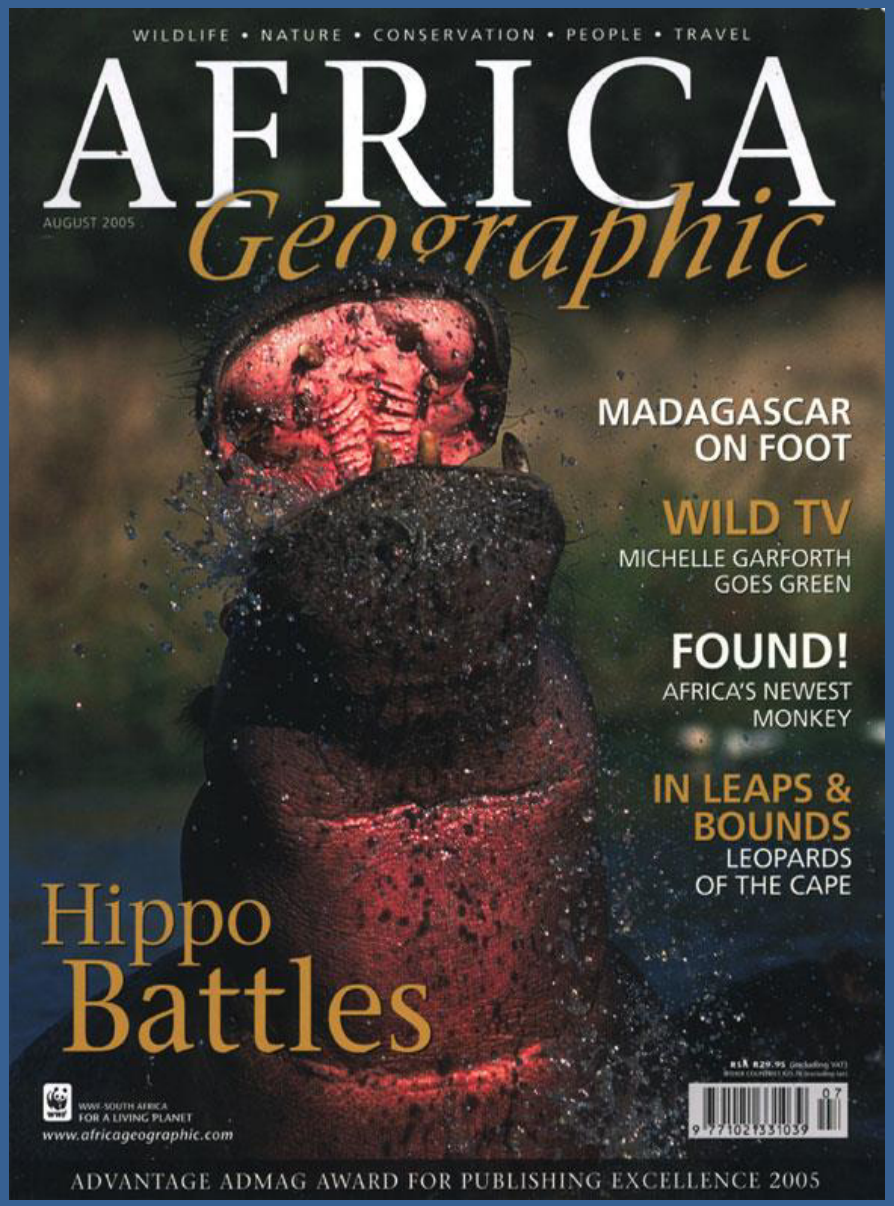
Michael C. SCHOLL
White Shark Trust
University of Cape Town

Nicolas PADE
University of Aberdeen

Main concerns

- Location of the fish farm;
- Choice of farmed fish;
- Direct and indirect adverse impact upon listed threatened species, listed protected species and listed migratory species (*e.g. great white sharks, cape fur seals, southern right whales, etc*);
- Chemical, medical and biological pollution;
- Salmon is a carnivorous species that require fish feed from other fisheries that are unsustainable;
- Risk for the local line fishery – The main industry in Gansbaai is fishing;
- Risk for the local tourism industry - Great white shark cage diving, shore- and boat-based whale watching companies, and associated tourism businesses (*accommodation and restaurants*);
- No business plan or EIA (*Environmental Impact Assessment*) documents available from the Overstrand Municipality, Dyer Island Fisheries or from Marine and Coastal Management;

Cage or net pen culture is viewed negatively in South Africa



around africa

dire straits *for Dyer Island*

'They want to do what, where?' was the first question that came to Thomas P. Peschak's mind when he heard about a salmon farm operating a stone's throw from Dyer Island Nature Reserve. He had to investigate...

50 000 invasive salmon are being reared in this pen – the first to become operational at a fish farm near Dyer Island Nature Reserve.

Dyer Island lies about nine kilometres offshore from the coastal town of Gansbaai in the Western Cape and is one of South Africa's great natural history wonders. It is packed with African penguins, cormorants and rare terns, while adjacent Geyser Rock is home to a large colony of Cape fur seals. The island's star attractions, however, live in the seas that surround it: probably the largest population of transient great white sharks in the world and important concentrations of southern right whales that come here to mate and calve during the winter months.

Who would permit fish farming in such an environmentally sensitive location, especially of an invasive alien fish? I was certain that a few phone calls would reveal this to be a misunderstanding. Sadly, I was wrong. In 2002 the Department of Environmental Affairs issued the company Salmon Salar a licence to farm salmon and by early 2005 the first pen stocked with over 50 000 fish became operational.

Great white sharks are a protected species in South Africa and are listed as Vulnerable on CITES's Appendix II. They are also Gansbaai's biggest tourist attraction and bring in millions of rands in tourism revenue. Equipped as they are with a superlative array of senses, the sharks will quickly become aware of the presence of tens of thousands of salmon and will surely make attempts to feed on them. International studies have shown that sharks, whales, seals and seabirds frequently become entangled in the nets of open-water pens and many die as a result of such encounters. In Australia over a five-year period, nine great white sharks became entangled in fish-farming installations and in eight cases this resulted in the death of the animal.

Dr Deon Nel of WWF-SA would like the greater Dyer Island area to be reserved primarily for nature-based tourism and says that any activity which could potentially prejudice this industry should be treated with extreme caution. He believes that operating a salmon farm in such close proximity to Dyer Island will result in heightened conflict among the users of the coastal resources and is entirely contrary to the principles of the White Paper on Sustainable Coastal Development. The head of the Overstrand Municipality's nature conservation department, Craig Spencer, agrees and fears that it will place the entire marine ecosystem under further pressure.

Unavoidably, many salmon will escape from captivity and could potentially out-compete the wild native fish populations and transfer alien diseases and parasites to them. What is more, farming practices dictate that concentrated fish faeces and uneaten food laced with chemicals and antibiotics will be released directly into the water. Not only will these pollutants be assimilated by marine mammals, birds and fish, they will also sink to the seabed where they will threaten biodiversity and potentially lead to habitat loss for commercially important species such as rock lobster and abalone.

This fish-farming venture does provide much-needed employment in a very impoverished area, but the choice of location and species could lead to a *loss* of jobs by threatening the tourism and fishing sectors – key employers in the region at present. If job creation is so desirable, why not farm an indigenous species of fish at an environmentally less sensitive location? ■

Thomas P. Peschak is a researcher at the Marine Biology Research Institute at the University of Cape Town.

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A checkered past and an troubled future for cage farming in the oceans in South Africa

Past experience, namely two production trials raising Atlantic salmon smolts in net pens in Gansbaai and Saldanha Bay present intrepid cage farmers with hurdles that are difficult to surmount including;

→ Extreme biofouling and the high risks of storm damage and stock escapes.

→ Risks to great white sharks becoming entangled in predator proof nets as well as whales and other marine fauna.

→ High risks of toxic algal blooms such as *Gymnodinium spp*.

→ Lack of biosecurity (impossible in net pens in the open ocean) and disease risks both forwards from wild fish to farmed salmon and backwards from farmed salmon to wild fish posses additional risks.

→ And by far the biggest hurdle - strong community opposition to cage/net pen farming in the two regions, namely the south west Cape coast (Cape Hangklip to Cape Agulhas) and west Cape coast (Saldanha Bay).

2nd generation land-based pump ashore tank culture proposed by Kourie (1994) seemed to offer a technically plausible, economically viable and environmentally more palatable approach. While, developments in land-based Recirculation Aquaculture Systems (RAS) offers the answers to practically all the challenges posed by the marine grow-out phase of Atlantic salmon including far less concerns by local residents!!!

RAS technology know-how and experience exists both from within South Africa – and from abroad within the EU, USA, Israel, Denmark, Norway etc.

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The solution = Land-Based Zero-Discharge Recirculation Aquaculture System (RAS) built into an *Integrated Multi-Trophic Aquaculture* (IMTA) system

The obvious question then...

Is RAS technology viable for the marine grow-out phase of Atlantic salmon in South Africa?

Most scientists all over the world would agree that RAS is the ultimate objective in fish farming; zero pollution to recipient waters, offers unmatched biosecurity, the opportunity to produce chemically free farmed fish - eco-friendly and organic certification - the culture non-ambient genotypes, allows for the placement of farms in any climate of the world (some RAS) and removes concerns about site water availability.

Close-up of Guilthead sea bream in a SAFF-marine RAS in Tartous, Syria in 2009.

The SAFF-marine RAS producing the Guilthead sea bream (*Sparus aurata*) in Tartous, Syria in 2009.

RAS also permits far more control over husbandry, feeding practices, and inventories often enabling producers to supply fish in response to market triggers or enables year-round production in marginal or otherwise unsuitable climates for the species being reared.

The main drawback to the successful widespread use of RAS, both in the developed and developing world, has been cost on the one hand and complexity on the other – where current RAS operations have not yet demonstrated economic competitiveness both repeatedly and conclusively.

Traditional forms of fish farming or aquaculture such as cage culture, earth pond based farming and the use of flow-through raceway systems have been shown to produce fish at lower costs compared to most RAS, although some of which result in nutrient pollution to recipient waters viz. cage culture in public waters, flow-through raceway tank culture and all of which are classified as "open-systems" vulnerable to the elements and infectious disease agents (non-biosecure) etc.

> ***Ramon Kourie an Aquaculture Expert with 38 years of international experience introduced a new generation of RAS technology to the world in the year 2000 which was reported upon in 2004 in the Famers Weekly magazine article by Steve McVeigh [see overleaf]. The technology involves a bespoke and highly integrated design of RAS based upon an efficient and practicable husbandry and stock management philosophy, feeding practices founded on the principles of bioenergetics and sensible engineering economics, all air operated under very low head-losses [< 0.1m, height water is lifted for conveyance and treatment].***
>
> ***Two more SAFF-RAS farms were developed, the second a larger scale tilapia 25 tonne per annum RAS in Malawi (2006) and the third a 50 tonne per annum marine RAS in Tartous, Syria (2009) raising Sea bream (Sparus aurata).***

The answer to the question posed, "*Is RAS technology viable for the marine grow-out phase of Atlantic salmon in South Africa?*" is a very definitive yes…read on below for more details.

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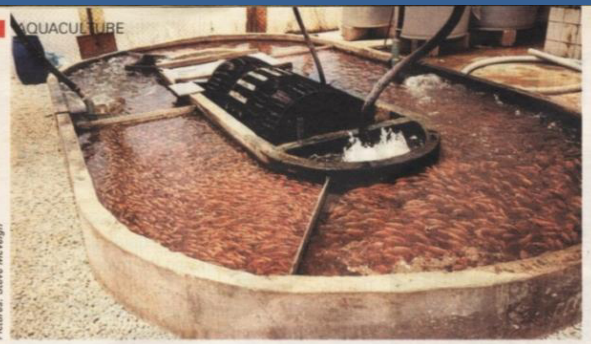
The first prototype SAFF–RAS... year 2000...24 years ago.



Pictures: Steve McVeigh

LEFT: An IFF recirculation aquaculture system, heavily stocked with fish.

A breakthrough in recirculation aquaculture in Lebanon has been designed by a South African fish-farming specialist. Aquaculture journalist **Steve McVeigh** spoke to **Ramon Kourie**, the research and development force behind the new IFF one-tank fish-farming system.

Super-efficient fish tank

RECIRCULATION aquaculture is vital in land-based fish-farming, where water is a limiting factor. Take the harsh conditions of the Middle East, for instance. Here fish-farming specialist, Ramon Kourie, CEO of Intensive Fish Farming (IFF), an SA-based aquaculture development concern, has put his designs to the test at the Hadath Tilapia Farm near Beirut in Lebanon. He has shown that water recirculation can be effectively applied to produce a wide range of finfish species.

Ramon's IFF one-tank system is a very competitive space- and energy-efficient recirculating aquaculture system. Visually impressive, the prototype is now in its third year of operation at Hadath, where it is used to produce red tilapia fish. The Hadath Tilapia Farm was established to demonstrate how efficiently the system works, says Ramon. There's also a farmer developing a 50 tons-per-year system in which he grows tilapia, also in Lebanon, and one with a 50 tons-per-year multi-species marine finfish on-growing farm in Syria. These enterprises use much larger tank systems than those used at the Hadath Tilapia Farm, but they retain the concept first explored and prototyped by IFF in South Africa for land-based salmon production.

"The goal during the development of the one-tank system was to come up with a water-, labour- and energy-efficient fish-production system that would be practical and inexpensive," Ramon says. "It had to be compact so it could be placed close to the market and not some distance away. I believe we have achieved this, making it possible to place our fish-farming units strategically either near or in metropolitan areas. Farmers using the system can retail freshly slaughtered fish directly to the consumer and the local catering industry on demand. Airfreight, trucking, handling and middleman costs and commissions – the so-called 'value chain' – are eliminated. This means more profit for the producer."

Low energy input

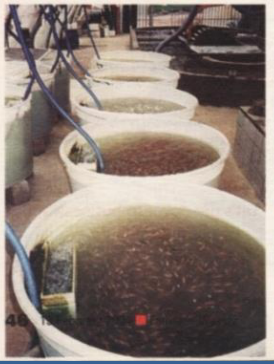
The new system allows a huge reduction in energy use for water movement, treatment and aeration. Most recirculated aquaculture systems are multiple tank systems and make use of external water treatment units. They require an elaborate system of water pumps and piping for treating and moving the water, and can use as much as 4 to 6 kilowatt hours to raise a kilogram of fish, according to Ramon.

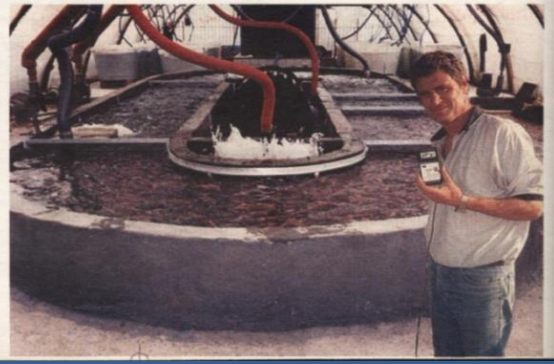
Not so at the Hadath Tilapia Farm. The system is extremely energy efficient. The whole system is entirely driven by low-pressure air – a single high-speed centrifugal blower is used. Biological filtration is achieved by means of rotating biological filters in the inside area of the D-ended raceway tank. The system includes a lamella separator – for large solids capture – and a floating foam fractionator to remove fine solids. The blower also drives in-tank airlift aerators and airlift pods to pull water through the water treatment system. A peripheral side-stream treatment is recommended if top-up water is limited. UV sterilisation and/or ozonation further improves the quality of the water.

The farm can produce 10 tons of tilapia annually from one 30m³ IFF one-tank system. In addition, some 300 000 4g fingerlings are produced each year from 10 small circular breeding tanks and one primary rearing 6,5m³ tank housed in the same tunnel, and they all run on the same air-supply system.

BELOW LEFT: The hatchery and nursery set-up employs transparent plastic photo-bioreactors.

BELOW: Ramon Kourie in front of the 30m³ IFF one-tank prototype system.





Optimum use of rearing volume

The tank system is designed so that the farmer can insert screened partitions all along its length, enabling several cohorts – age and/or size classes – to be reared simultaneously. Each cohort of tilapia is only two or three weeks older than the next, and is kept separate from others by means of in-tank screens. The screens, designed to maximise horizontal water movement, are lifted and the fish ushered into the next rearing compartment every two or three weeks as they develop.

Keeping the cohorts separate, rather than mixing a whole variety of age and size classes in one tank, eliminates the need to grade the fish, except at the end of the production cycle of five to six months when the fish should have reached the ideal harvest weight of 500g to 700g, depending on the strain or breed and its growth potential. Not having to net, handle and grade the fish means they are not exposed to this stress, and there is no hiccup in their growth and development.

The size and number of compartments is carefully calculated to maximise the use of the rearing volume. This is achieved by providing just sufficient space for a two- or three-week growth period and by adopting a stocking density, based on fish size, that capitalises on tilapia's ability to grow faster when reared at high stocking densities. Annual yields have been impressive at the Hadath Tilapia Farm, proving that even at average operating stocking densities of around 45kg/m³, harvest yields of over 300kg/m³ per year are achievable.

"With the best breeds of tilapia in the world today, such as the Nile tilapia *(Oreochromis niloticus)* from Fishgen in the UK, production-to-capacity ratios of nearly 8:1 are possible due to the shorter cycle length and faster production," explains Ramon.

IFF has developed a special feed formulation for use in recirculation systems. It's highly digestible, and makes for improved feed conversion and low solids and ammonia production.

"Premium A-grade tilapia, free of off-flavours, don't have to cost more to produce," says Ramon. With cost savings in production, such as those achieved at Hadath, farmers can afford to take additional care to maintain total organic carbon (TOC) at really low levels.

The results are encouraging

The lessons learned at the Hadath Tilapia Farm indicate that either sufficient "make-up" water needs to be introduced, at least 10% to 15% of the recycled volume, or additional water treatment systems have to be used, such as ozonation and foam fractionation, to remove fine suspended solids and excess bacteria.

"The fillet yields and firmness of fillet flesh we have achieved have been particularly encouraging," says Ramon. He believes that tilapia raised in moving water, as they are at Hadath, have improved white-muscle hypertrophy (muscle enlargement), resulting in improved fillet yields and firmer meat texture.

The combination of faster growth rates, improved feed conversions, lower mortalities, improved productivities and high annualised yields per cubic meter, and low power consumption coupled with the year-round availability of premium-quality tilapia are some of the reasons why Ramon believes the IFF system can out-compete traditional cage-, raceway- and earth-pond-type tilapia production systems.

More to come

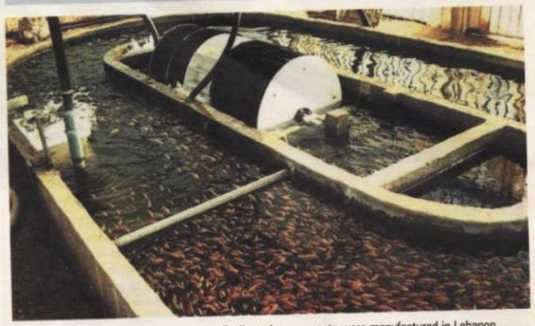
The use of organic tilapia feed and the addition of a hydroponic unit grafted onto the fish production unit to effectively use the nutrients generated by the fish are some of the tasks which lie ahead for IFF. The technology used at the Hadath Tilapia Farm offers some interesting applications, including inland marine-fish farming, production of tropical species in temperate climates, meeting GMO-free labelling requirements, eco-labelling and certified organic production.

• *Call Bryce Fleming on (011) 447 4611 or 072 210 0277, or e-mail fleminghome@mweb.co.za. Ramon Kourie can be e-mailed at highwayk@cyberia.net.lb.* FW

Manufacturing the IFF one-tank system

ALL THE dedicated components of the IFF system were made in Lebanon by Ramon Kourie. "A manufacturing base is being set up in South Africa. Its weak currency favours exports, and thanks to its broad-based economy that includes sophisticated mining, manufacturing and agricultural sectors, raw materials and labour are cheap," says Ramon.

"Cell phones are no longer manufactured in Europe or the US, but in the East. Likewise, South Africa is an excellent country to set up a high-quality and low-cost aquaculture-equipment manufacturing business. Items such as UV sterilisers and ozone generators are already being manufactured very competitively in South Africa."



The IFF one-tank primary rearing system. Dedicated components were manufactured in Lebanon.

Highly space efficient **Integrated design** **A high degree of locally sourced inputs**

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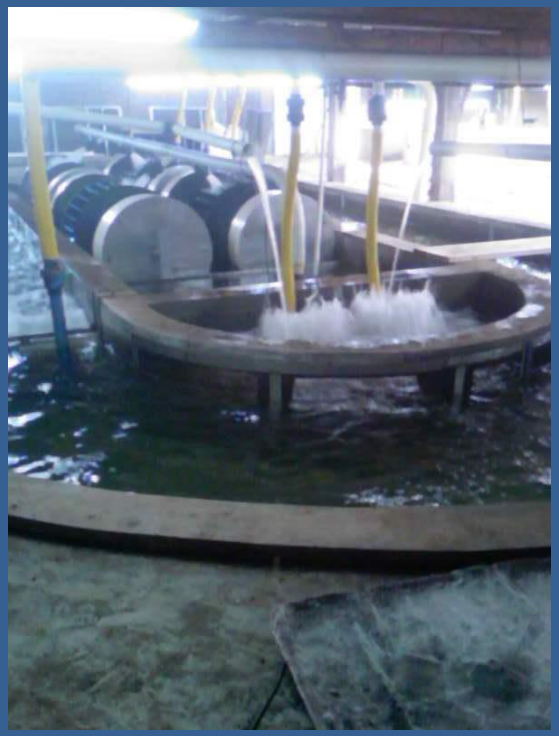
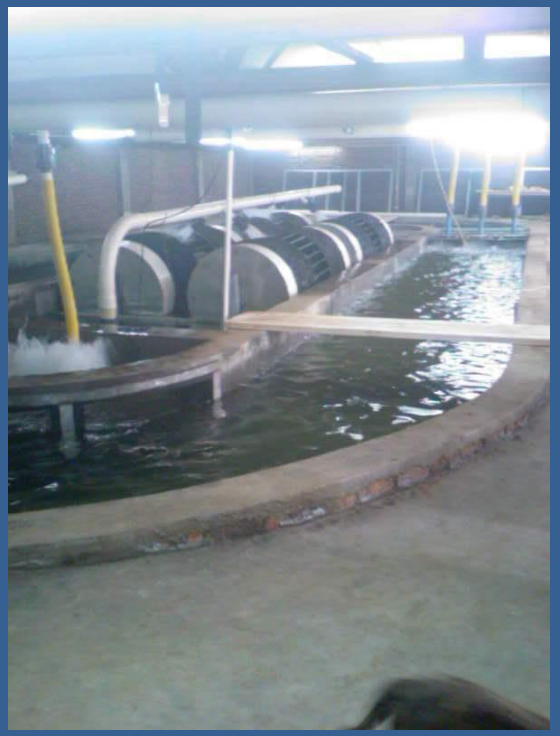
The second larger scale 25 tonne per annum freshwater tilapia SAFF-RAS in Malawi in the year 2006 some 18 years ago.



Superior rearing environment

Reduced energy input

High degree of uniformity of highly beneficial horizontal water velocities



The use of three major reduced head loss water treatment processes integrated into the RAS tank system

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A third , a marine finfish SAFF-RAS capable of producing 50 tonnes per annum of Sea bream in the year 2009 some 15 years ago.

The SAFF-RAS a winning combination of simple but highly efficient technology developed for the Global South resulting in a least-cost approach to fish production based upon tried and tested practical husbandry and stock management practices, the principles of bioenergetics applied to feeding regimes and a sensible approach to design integration and engineering economics, in addition to being the most energy efficient RAS system on the world market.

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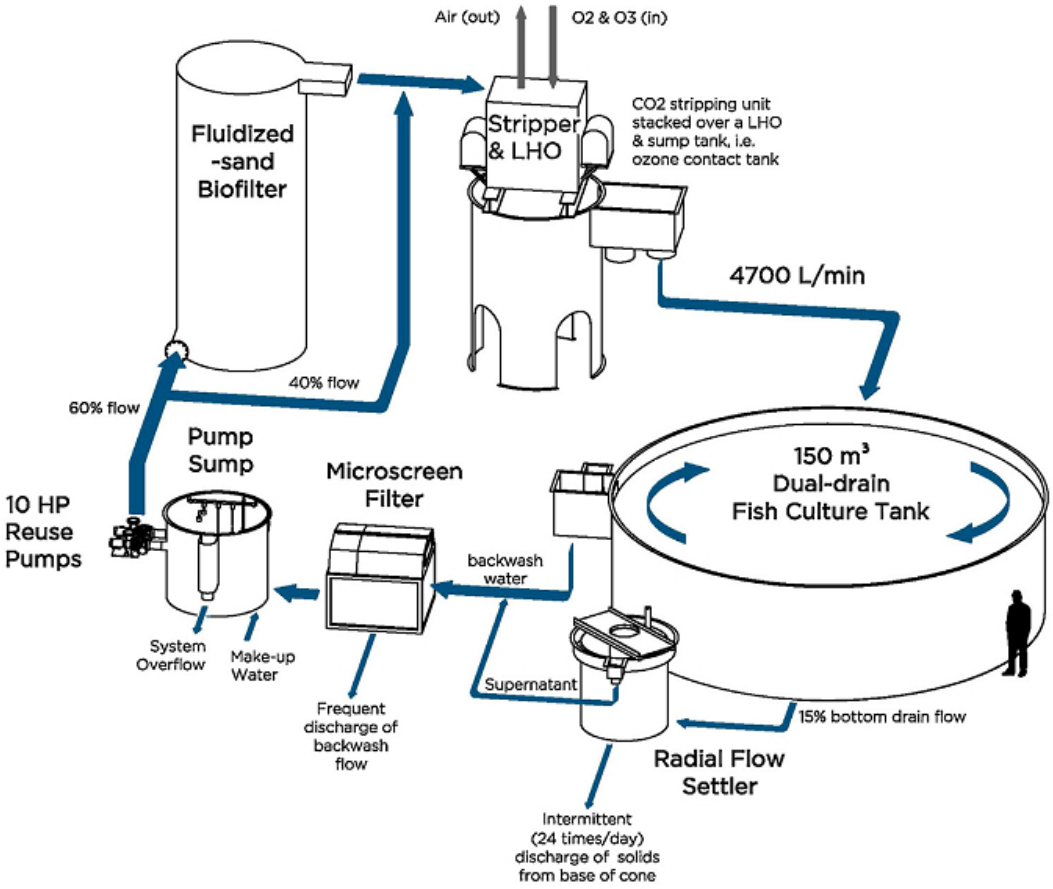
The Freshwater Institute along with collaborating Cornell University in the US have very much set the trend as far as developing standard practice RAS technology for the global industry including Atlantic salmon aquaculture (Summerfelt *et al*., 2009; Davidson *et al*, 2016) displaying a highly compartmentalized and non-integrated approach which by virtue of the design philosophy is also highly energy demanding, and is also a resource use wasteful approach to the design of RAS, including the building footprint.



Process flow drawing of the commercial scale Recirculation Aquaculture System (RAS) used to culture post-smolt Atlantic salmon to market-size at the Conservation Fund's Freshwater Institute, Shepherdstown, West Virginia, US (source; Davidson *et al*, 2016).

The design is energy demanding operated at high head losses (>1m), operates at high carbon dioxide levels (>15mg/L), and demonstrates a high building footprint which greatly reduces the usefulness of this RAS technology for research purposes, non-commercial applications, nursery farms or for the commercial grow-out of very high value species.

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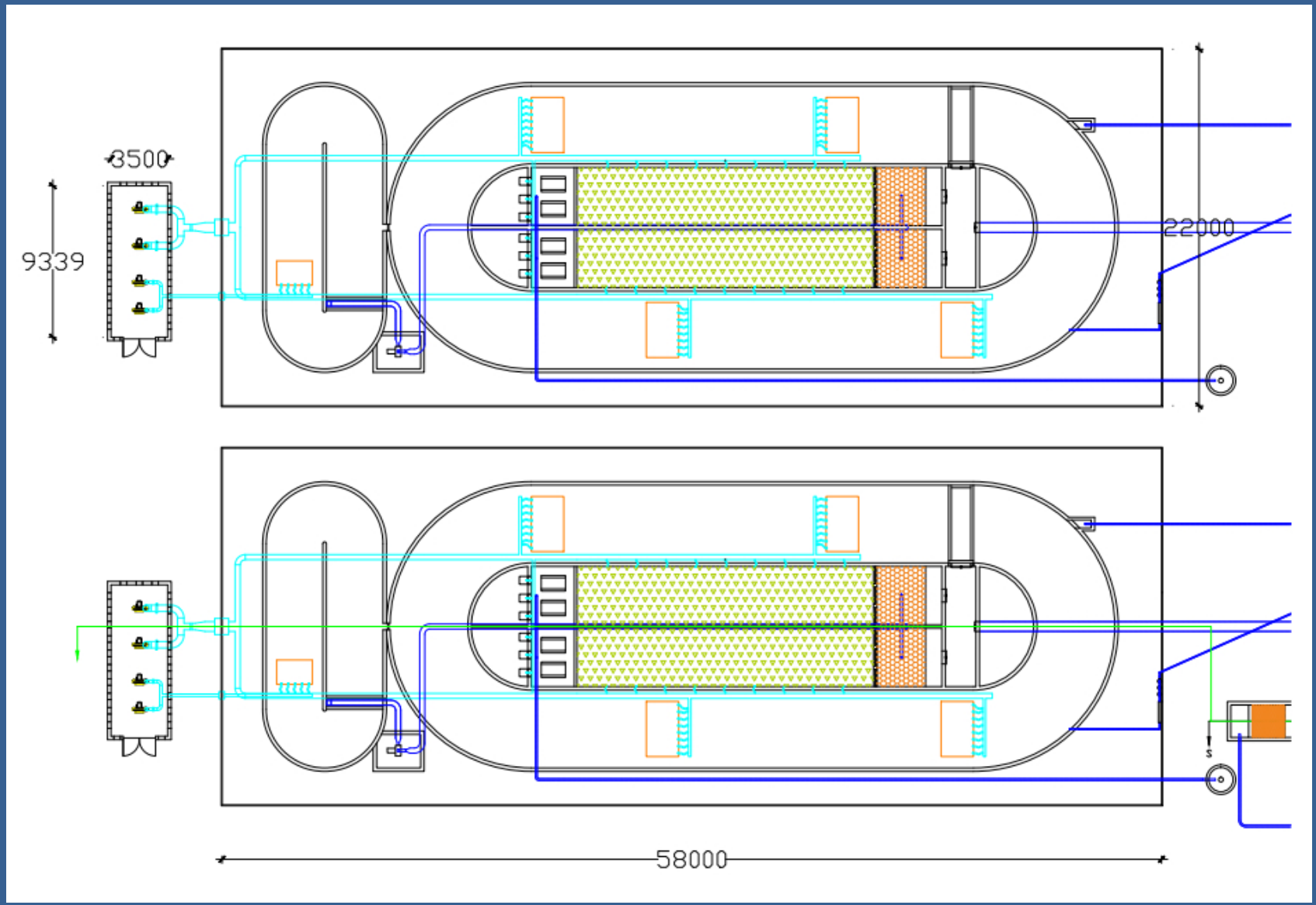
Limited detail Plan View layout of the highly integrated, low-energy input, all low-pressure air driven SAFF 2nd generation RAS for Atlantic salmon consisting of two grow-out SAFF-RAS, two by 200 tonne per annum units, showing linked purging tank, decoupled from the sludge handling, concentration and de-watering system and the IMTA components (for the sake of the exploded view)



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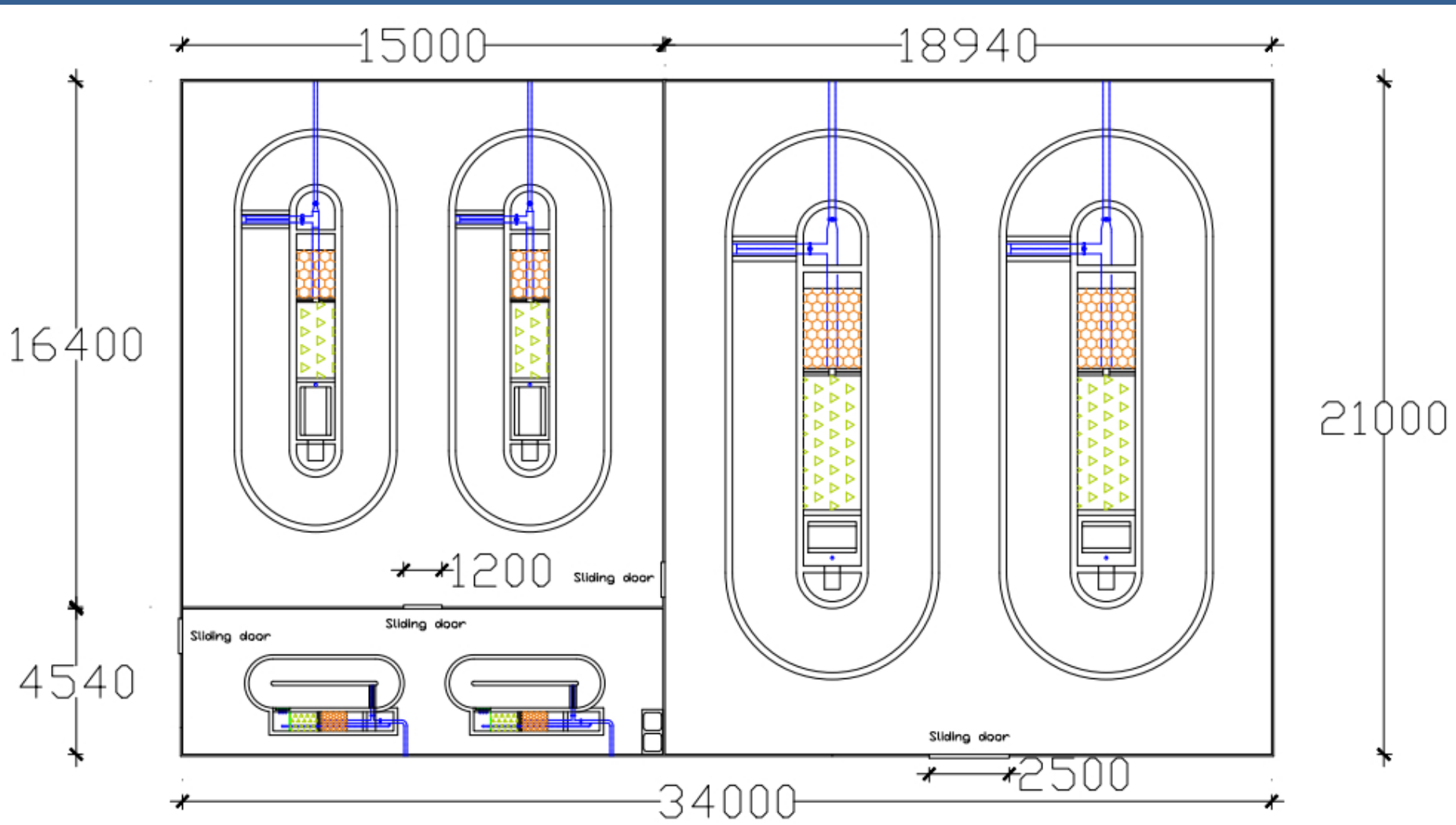
Limited detail Plan View layout of the Atlantic salmon smolt plant design tuned to output around 24,000 smolts at 42 day intervals adequate to produce 1,000 tonnes per annum (5 by 200tpa RAS grow-out units) including major internal dimensions in millimeters (mm)



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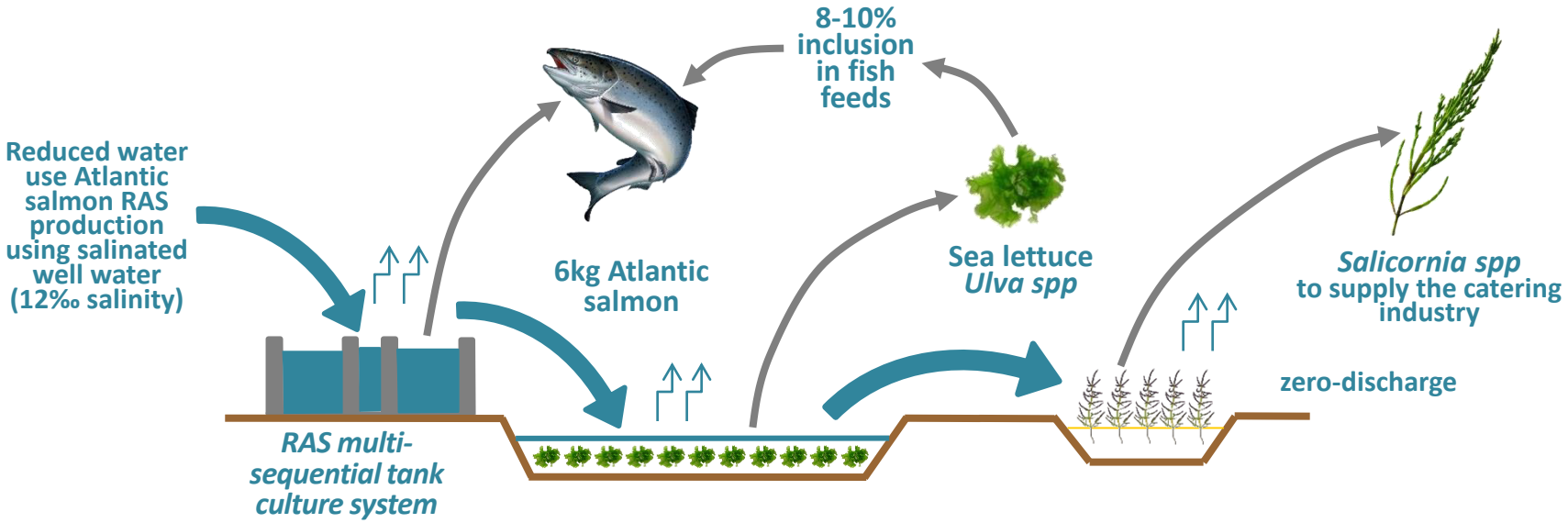
Integrated Multi-Trophic Aquaculture (IMTA): Land-based SAFF-RAS (2nd generation) Atlantic salmon farm showing integrated decoupled sequential water/waste stream use for zero-discharge



Definition of "Integrated Multi-Trophic Aquaculture (IMTA)"

IMTA provides the by-products, including waste, from one aquatic species as inputs (fertilizers, food) for another. Farmers combine fed aquaculture (e.g., fish) with organic extractive (e.g., sea cucumber, shellfish, shrimp) and inorganic extractive (e.g., seaweed, micro- or macro algae, halophytes) aquaculture to create balanced systems for environment remediation (bio-mitigation), economic stability (improved output, lower cost, product diversification and risk reduction) and social acceptability (better management practices).

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Where will the Atlantic salmon RAS pilot fish farming operation be located ?

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Closer Google Earth view of the location of the Future Fish™ Industry Pilot Operation (FFIPO) at the Big Green Organic Fish Farm, Vredenburg, West Cape coast, Western Cape, South Africa and the demarcation of the adjacent site for the Atlantic salmon land-based RAS pilot operation. CAPEX investment savings would be possible should the FFIPO and Phase 2 FFII be developed in tandem with the Atlantic salmon RAS allowing for shared supporting infrastructure.

Zoomed-in Google Earth birds-eye view of the location of the Future Fish™ Industry Pilot Operation (FFIPO) at the Big Green Organic Fish Farm, Vredenburg, West Cape coast, Western Cape, South Africa and the demarcation of the adjacent site for the Atlantic salmon land-based RAS pilot operation

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Existing facilities at the Big Green Organic Fish Farm adjacent to the site earmarked for the Atlantic salmon RAS pilot operation

Entrance to the Big Green Organic Fish Farm

New fingerling 6.5m³ BFT tank

Operational Fingerling 12m³ BFT tank

New multi-cohort sequential 80m³ BFT grow-out tank (visible from the Google Earth birds-eye view)

Operational multi-purpose 5.4m³ BFT round tanks at the Big Green Organic Fish Farm

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10 year projected financials summary for a pilot scale Atlantic salmon SAFF-RAS farm under baseline conditions assuming 100% borrowed capital at an interest rate of 10% per annum in January 2024.

Note that Atlantic salmon RAS farms are seldom viable under production volumes under 5,000 tonnes in the US and Europe.

While due to the novel and innovative design of the SAFF-RAS, a highly CAPEX and energy-use sparing approach to RAS designed for the Global South, it would be possible to realize a reasonable return on investment when operating under a pilot scale producing just 200 tonnes per annum.

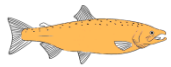
Increasing the scale of output to 1,000 tonnes per annum, or 5 by 200 tonne per annum SAFF-R-ended grow-out RAS tank systems, at today's input costs would likely result in a farm-gate production cost falling to less than R75.00/kg [Euro 4.37/kg HoG some 16.4% lower than Norwegian net pen salmon farming production costs] in round figures and a selling price of around R160.00/kg generating profits of over 50%.

R 50 m
Development capital

R 7 m
Operating capital

100 %
Total capital R 57m

Production output
83.3 tonnes LW year 2
200 tonnes LW year 3



Income
R 13.3 m year 2
R 32 m year 3

Selling price
R 160.00/kg as LW

Average cost/kg
R 87.68/kg as LW

Profit 45.2%
R 72.32/kg

10 year economic performance indicators (after-tax)

27.3 %
Return on Investment (ROI)

17.2 %
Internal Rate of Return (IRR)

R 14,819,621.43
Salvage Value at end year 10

72 months
Pay-back Period after-tax

5.0 %
Labour-Capital Ratio

R 5,555,555.56
Cost per job

R 32,632,312.19
Net Present value (NPV)

Norwegian producer costs were Euro 5.23/kg HoG equal to R89.67/kg LW [=(5.23 * 20.41) * 0.84].
The pilot land-based RAS then would produce Atlantic salmon 2.2% more cost efficiently than the Norwegian average industry rate for 2022 [see slide 27].

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Why is Atlantic salmon such a prime aquaculture business opportunity in South Africa at this time?

- → Established local markets for fresh product (sushi and sashimi in particular) for a high value commodity, with decent profit margins on the farm gate production cost.
- → Import replacement potential exists for around 5,000 tonnes per annum into South Africa (could be more in 2024) worth over ZAR 1Bn.
- → Improvement in South Africa's trade balance by over ZAR 1Bn to buy imported salmon for all product forms.
- → The creation of over 250 direct on-farm jobs [to produce 5000 tonnes per annum] excluding linkages; feed raw material commodity farming, processing and feed manufacture, secondary salmon value-added processing, distribution sales, marketing, retailing etc.
- → Fresher and improved product particularly firmer meat texture attributed to raising salmon in circulating R-ended tank systems in moving water (30-35cm/sec) and a high degree of water velocity uniformity [Totland *et al.* 1987 study in Norway].
- → Regional export potential into Sub-Sahara Africa, S.E Asia and Indian Ocean Islands.
- → Scale and scope economies will aid to reduce consumer prices making salmon more affordable as a competitive meat protein [< ZAR 150.00/kg] against red meats [lamb and beef] in South Africa
- → Production cost advantages attributed to the use of novel and innovative low cost RAS production technology, thrice proven at various production scales, in Lebanon, Syria and Malawi by Ramon Kourie, a South African Aquaculture Expert. *The Food Security Research Institute* (FSRI) will develop the blueprints furnished by Ramon Kourie to seed and catalyze this new industry in South Africa.
- → Salmon farming initiatives in South Africa would be supportive of governments initiatives to develop an Oceans Economy and in support of local job creation initiatives. Continuing to import Atlantic salmon then "exports" job opportunities to Norway the main source country of farmed salmon in South Africa.

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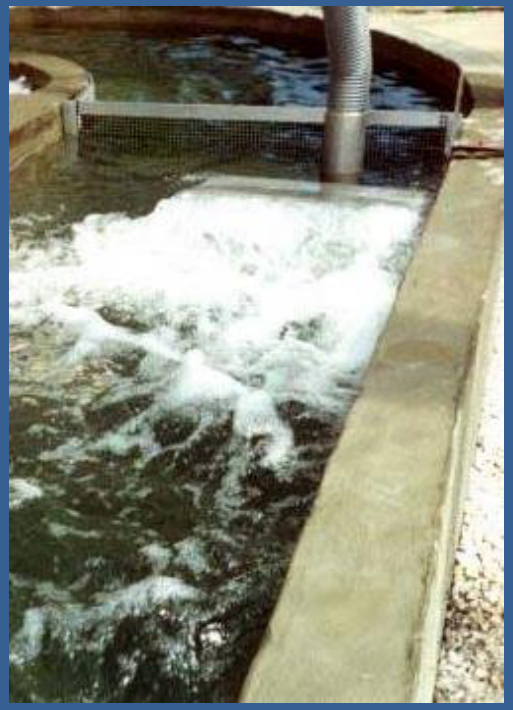
Thrice proven indigenous South African technology in Lebanon, Syria and Malawi.

Is it not time to put the Proudly South African label on salmon grown for the local sushi market?

The SAFF-13 floating foam fractionator at the Syrian Asmak Company, Tartous Syria installed in a marine RAS producing Gilthead sea bream (*Sparus aurata*).

Two SAFF-38Lps multiple-tube airlift water pumps installed in a marine RAS producing Gilthead sea bream (*Sparus aurata*) in Tartous, Syria.



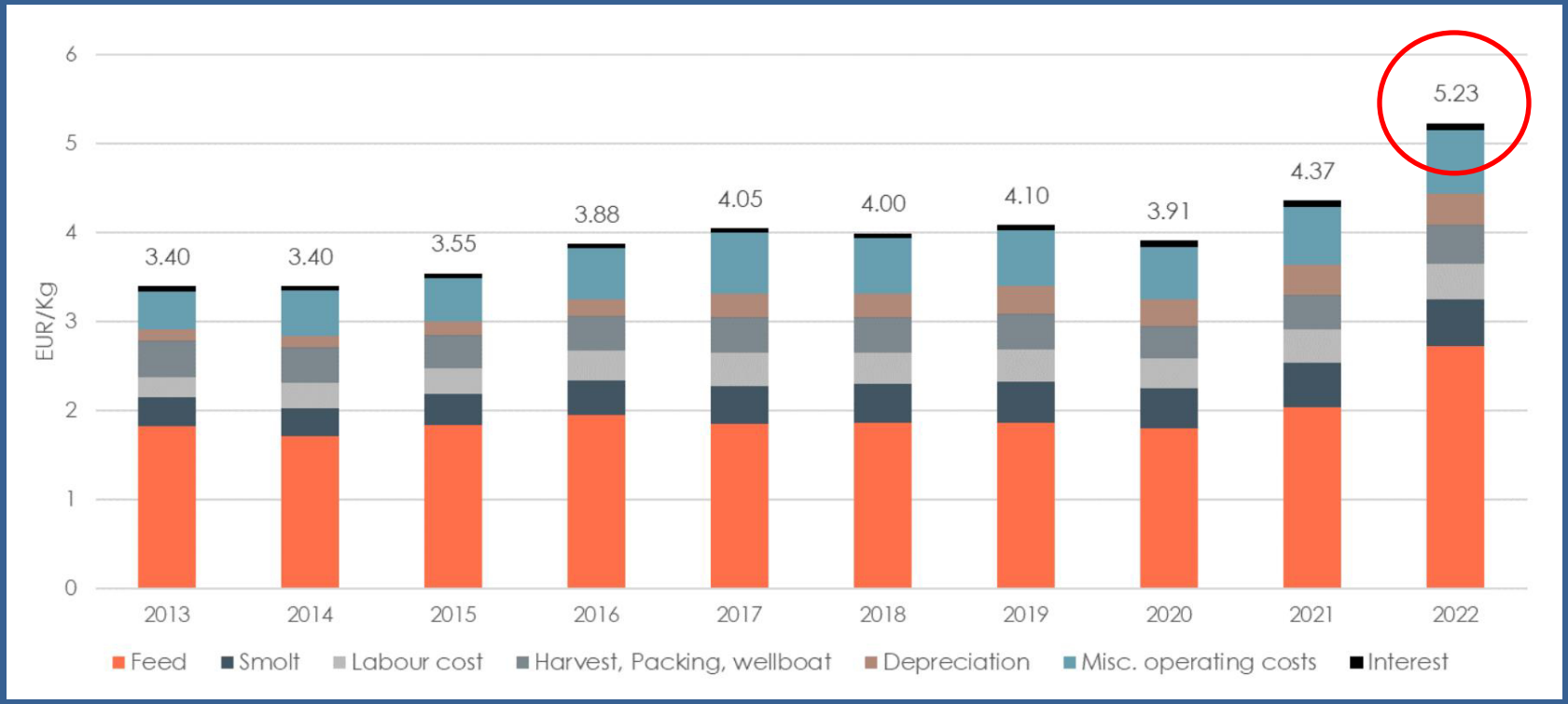
The SAFF-120 (MK1) medium-bubble airlift aerator operational at the Hadath Tilapia Farm, Lebonon (year 2000) and a side elevation of the aerator.

FSRI

Cost competitive production of Atlantic salmon using RAS technology, against typical ocean net pen farming, would be a game-changer opening up massive growth opportunities for land-based RAS technology integrated into an IMTA approach where markets will exist in every developed economy of the world, for new farms built on this competitive RAS technology, and in some developing economies dependent on fresh salmon imports.

Our projections indicate that a 5,000 tonne Land-Based, Zero-Discharge, SAFF-RAS (2nd generation) farm built into an IMTA would produce Atlantic salmon at a cost just under Euro 3.43/kg LW = Euro 4.08/kg HoG (R70.00/kg LW or R83.33/kg HoG in January 2024) which would render land-based salmon farming a lower cost production technology when compared to current ocean net pen farming in Norway, the worlds leading producer. Producer prices in Norway in 2022 were Euro 5.23/kg HoG [see bar graph below].

Cost structure of the Atlantic salmon industry in Norway 2013-2022 (source, Mowi, 2023)



Initially published 2024-01-31 15:07 CET

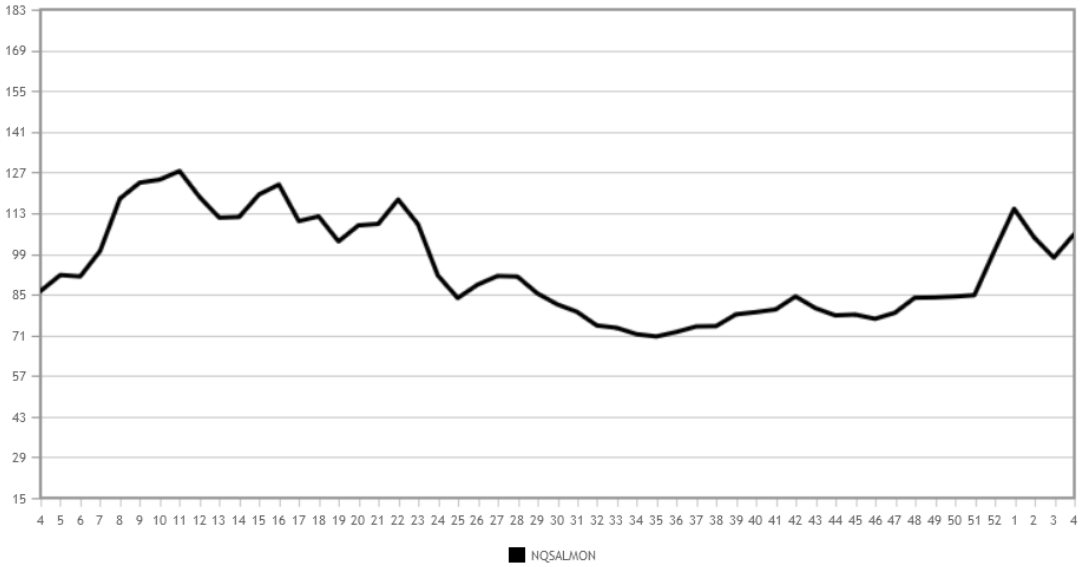
The NASDAQ Salmon Index (NQSALMON) is the weighted average of weekly reported sales prices and corresponding volumes in fresh Atlantic Superior Salmon, head on gutted (HOG), reported to Nasdaq Copenhagen, BMR Administrator by a panel of Norwegian salmon exporters and salmon producers with export license. The panel is representative for the total export out of Norway.

NASDAQ Salmon Index		
NQSALMON (NOK/kg)	105.42	
1 Week Change	▲7.89	+8.09%
4 Week Change	▲5.68	+5.69%
12 Week Change	▲27.77	+35.76%

NASDAQ Salmon Index - Prices Per Weight Class

Weight Class (kg)	Price (NOK/kg)	1 Week Change	Distribution %	St.dev.
1-2	67.79	1.00	0.83	3.53
2-3	81.17	1.01	12.30	1.50
3-4	93.65	4.52	20.63	1.05
4-5	100.78	4.73	30.92	2.34
5-6	118.59	3.44	19.67	3.93
6-7	132.60	1.72	8.67	6.99
7-8	136.22	1.94	5.02	3.45
8-9	139.32	3.97	1.84	2.67
9+	137.20	4.45	0.14	1.16
NQSALMON	105.42	7.89		

NASDAQ Salmon Index - Historical Prices



Notes:

1) Exchange rate during week 4/2024 was ZAR 1.78 = NOK 1.0
2) Prices are for Head-on-Gutted Atlantic salmon or LW/0.84.

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South African markets have been paying a premium for 2 day old fresh salmon for too long costing about R1bn (in January 2024) for some 5,000 tonnes per annum (assuming all 3-4kg HoG salmon at a landed cost of ZAR 200.00/kg – see below) while a west Cape coast salmon farm can produce this quantity of Atlantic salmon at a farm gate cost of R350m (in January 2024) which translates into < ZAR 70.00/kg LW at the farm gate (NOK 39.33/kg LW) or ZAR 83.33/kg HoG equal to NOK 46.82/kg HoG.

Anybody ready for premium quality fresher salmon (12-18 hr from harvest) available year-round produced by a west Cape coast RAS salmon farm targeting the local market for import replacement at more affordable prices?

NASDAQ Salmon Index - Prices Per Weight Class for the 4th week of 2024

Weight Class (kg)	Price, NOK/kg HoG before freight	Price, ZAR/kg HoG before freight	Price, ZAR/kg HoG including air-freight
1 -2	67.79	120.67	153.97
2 - 3	81.17	144.48	177.78
3 - 4	93.65	166.70	200.00
4 - 5	100.78	179.39	212.69
5 - 6	118.59	211.09	244.39
6 - 7	132.60	236.03	269.33
7 - 8	136.22	242.47	275.77
8 - 9	139.32	247.99	281.29
9+	137.20	244.22	277.52
NQSALMON	105.42	187.65	220.95

Notes: Source data < https://salmonprice.nasdaqomxtrader.com/public/report;jsessionid=F3FB4F51AAE2445A22DAB264EED3DD15?0 >

Air freight based upon US$1.80/kg HoG weight at an exchange rate of R18.50=US$1.00.

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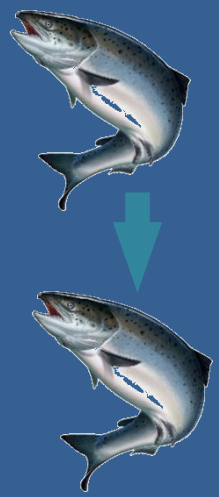
Competitive pricing of locally farmed premium quality fresh Atlantic salmon at a scale of 1,000 tonnes per annum of 5-6kg LW fish to undercut the landed costs of 5 - 6kg Norwegian salmon based upon the average week 4/2024 NASDAQ Salmon Index pricing plus air freighted delivery costs reported by Nofima (exchange rate for February 2024 was ZAR 1.78 = NOK 1.00)



IMPORTED NORWEGIAN SALMON

Cost of Norwegian salmon before air freight costs, Atlantic salmon duty free as HoG (=LW / 0.84)

NOK 118.59/kg as HoG	ZAR 211.09/kg as HoG

Landed cost of air freighted Norwegian Atlantic salmon duty free as HoG in Johannesburg, South Africa

NOK 137.30/kg as HoG	ZAR 244.39/kg as HoG
NOK 115.33/kg as LW	ZAR 205.29/kg as LW

LOCALLY PRODUCED SALMON FARM GATE BREAK-EVEN PRICE and SELLING PRICE

Farmed gate production cost of Atlantic salmon as LW (= HoG X 0.84)

NOK 42.13/kg as LW	ZAR 75.00/kg as LW
NOK 50.16/kg as HoG	ZAR 89.29/kg as HoG

Competitive selling price of locally farmed Atlantic salmon as HoG (=LW/ 0.84)

Competitive pricing = ZAR 160.00/kg LW or ZAR 190.47/kg HoG

Cost advantage of locally farmed over imported Norwegian salmon = ZAR 84.39/kg as HoG for 5 – 6kg fish and R40.00/kg HoG against 3-4kg imported Norwegian salmon !!!

Join us on this mission to bring one of the worlds most highly sought after fish species into local production for the competitive supply of fresher Atlantic salmon for the South African market to replace imports mostly from Norway.

Atlantic salmon in the wild , one of the worlds most valuable and sought after fish species, for the white tablecloth industry

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