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A review of aquaculture in the Western Cape: History, status and future potential

South Africa's aquaculture sector has shown remarkable resilience to ecological, social and policy changes over its existence. This review traces the origin of freshwater and marine aquaculture in the Western Cape Province – one of the country's four coastal provinces. Starting with oyster farming attempts as early as the 17th century, farming operations have since evolved into a multimillion-rand sector with a wide range of stakeholders as well as lucrative overseas and local markets. Commercial oyster cultivation was first established in the late 1940s, with mussel farming following 30 years later. Abalone farming was pioneered in the late 1980s, emerging against a backdrop of severe overfishing and growing exponentially since. Concurrently, freshwater aquaculture found its origins in colonial-era sport fishing, with trout farming originating in the late 19th century and the Jonkershoek hatchery (founded 1893) underpinning its development. While tilapia culture, introduced in the 1930s, and the ornamental fish sector exist, they remain limited in the Western Cape because of climatic and economic factors. Currently defined by dominant marine production and niche freshwater operations, the sector, despite enduring challenges ranging from climate constraints, illegal harvesting and local market resistance to freshwater-farmed fish, has evolved into a domestically significant sector with established international markets, demonstrating remarkable resilience while retaining substantial potential for sustainable expansion.

Significance:

This review provides a deeper understanding of the Western Cape's aquaculture sector, its historical development and the complex forces that continue to shape its trajectory against the backdrop of unprecedented climate change.

Introduction

On 6 April 1652¹, Jan Van Riebeeck arrived at the Cape of Good Hope with a contingent of European settlers to establish a refreshment station for the Dutch East India Company (Vereenigde Oostindische Compagnie or VOC) (Figure 1).¹ This arrival marked the beginning of a colonial enterprise that would fundamentally alter the landscape, its resources and the lives of the Indigenous peoples – including the Khoikhoi – who had populated the region for centuries.² Driven by the imperialistic ideologies of that era, the world (or in this case, the Cape) was their oyster. The subsequent history of aquaculture's origins, while documented in specialist works, largely escapes mainstream texts. Notably, the colonial lens governing these extant records means this review is subject to a historical bias, as the documentation likely omits the pre-existing knowledge, labour and market participation of local Indigenous communities.³

At present, the Western Cape Province is the dominant producer of marine aquaculture in South Africa, contributing up to 95% of total production in 2021 (6382.9 t) and housing the majority (77%) of farms (Tables 1 and 2).⁴ Marine aquaculture is concentrated along the West and Southern Cape Coasts, with slightly different uses in technology. Mussel

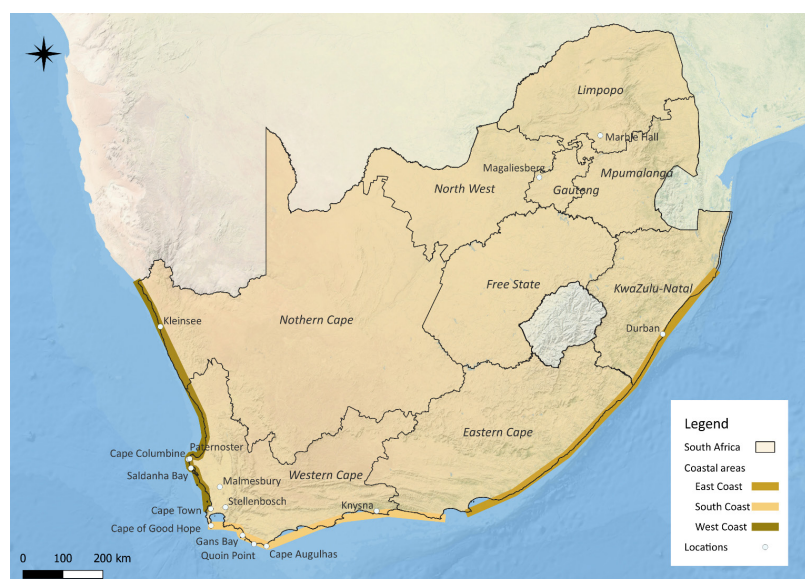


Figure 1: Map of South Africa showing provincial boundaries and all geographic locations referenced in this review. Coastal regions of the Western Cape Province are the primary aquacultural production sites in the country, with cultivation activities dating back to the 17th century near Cape Town. Map produced by the authors using QGIS.

Table 1: Operational farms per aquaculture species by province in 2021

Species	EC	FS	GP	KZN	LP	MP	NC	NW	WC	TOTAL
Abalone (<i>Haliotis midae</i>)	2	0	0	0	0	0	3	0	9	14
Finfish (<i>Argyrosomus japonicus</i> , <i>Salmo salar</i>)	2	0	0	1	0	0	0	0	1	4
Mussels (<i>Mytilus galloprovincialis</i> , <i>Choromytilus meridionalis</i>)	0	0	0	0	0	0	0	0	20	20
Oysters (<i>Crassostrea gigas</i>)	1	0	0	0	0	0	1	0	4 (7)*	6 (9)*
Total marine farms	5	0	0	1	0	0	4	0	34 (37)	44 (47)
Catfish (<i>Clarias gariepinus</i>)	1	4	1	2	7	1	0	3	0	19
Common carp (<i>Cyprinus carpio</i>)	0	0	1	0	1	0	2	0	1	4
Marron crayfish (<i>Cherax cainii</i> , <i>Cherax tenuimanus</i>)	2	0	0	0	0	0	0	0	0	2
Ornamentals (various species)	2	0	5	7	1	3	0	0	2	20
Tilapia (<i>Oreochromis niloticus</i> , <i>O. mossambicus</i>)	3	0	16	5	21	12	1	12	1	71
Trout (<i>Oncorhynchus mykiss</i> , <i>Salmo trutta</i>)	1	0	3	5	0	10	0	0	15	34
Total freshwater farms	9	4	26	19	30	26	3	15	19	151
Total national aquaculture farms	14	4	26	20	30	26	7	15	53	195

Source: Adapted from the South African Department of Forestry, Fisheries and the Environment.⁴

*Three farms cultured both oysters and mussels. These farms were captured under the primary species cultured. Seaweed farms are excluded.

Provinces: EC, Eastern Cape; FS, Free State; GP, Gauteng; KZN, KwaZulu-Natal; LP, Limpopo; MP, Mpumalanga; NC, Northern Cape; NW, North West; WC, Western Cape

Table 2: Total production in tons by province and subsector in 2021

Subsector	EC	FS	GP	KZN	LP	MP	NC	NW	WC	Total
Abalone (<i>Haliotis midae</i>)	163.37	0	0	0	0	0	54.26	0	2245.66	2463.29
Finfish (<i>Argyrosomus japonicus</i> , <i>Salmo salar</i>)	0	0	0	0	0	0	0	0	13.00	13.00
Mussels (<i>Mytilus galloprovincialis</i> , <i>Choromytilus meridionalis</i>)	0	0	0	0	0	0	0	0	3420.88	3420.88
Oysters (<i>Crassostrea gigas</i>)	82.13	0	0	0	0	0	0	0	308.36	390.49
Total marine production	245.50	0	0	0	0	0	54.26	0	5987.9	6287.66
Catfish (<i>Clarias gariepinus</i>)	42	0.8	0	8	2	0	1.3	0	3.50	57.60
Common carp (<i>Cyprinus carpio</i>)	2	0	1.6	0	2.5	0	2.5	0	3.70	12.30
Marron crayfish (<i>Cherax cainii</i> , <i>Cherax tenuimanus</i>)	1	0	0	0	0	0	0	0	2.00	3.00
Ornamentals (various species)	3	0	4.5	4.5	0.8	1.9	1.0	0	1.80	17.50
Tilapia (<i>Oreochromis niloticus</i> , <i>O. mossambicus</i>)	55.60	0	7.0	7.0	78.0	45.0	4.0	50	0.00	246.60
Trout (<i>Oncorhynchus mykiss</i> , <i>Salmo trutta</i>)	11.20	0	84.0	403.8	0	250.2	12.1	0	384.00	1145.30
Total freshwater production	114.80	0.8	97.1	423.3	83.3	297.1	20.9	50	395.00	1482.30
Total aquaculture production	360.30	0.8	97.1	423.3	83.3	297.1	75.16	50	6382.90	7769.96

Source: Adapted from the South African Department of Forestry, Fisheries and the Environment.⁴

Total production in tons is shown for each province and sector.

Provinces: EC, Eastern Cape; FS, Free State; GP, Gauteng; KZN, KwaZulu-Natal; LP, Limpopo; MP, Mpumalanga; NC, Northern Cape; NW, North West; WC, Western Cape

and oyster farms are concentrated in Saldanha Bay on the West Coast and rely on rafts and longlines. Abalone farms are primarily located along the South Coast, utilising pump-ashore land-based facilities (Figure 1). Freshwater aquaculture is comparatively smaller, with only 19 farms in the province, mostly situated in the Southwestern Cape. This includes rainbow

trout (*Oncorhynchus mykiss*), a key species, cultivated in dams or with flow-through systems⁵ as well as other freshwater operations including ornamental fish farms, aquaponics systems and tilapia farms. These farms contributed approximately 27% (395 t) to the total freshwater production in South Africa in 2021.⁴ During the decade between 2011 and 2021,

aquaculture production in the Western Cape increased from 1614 t to 6382.9 t, representing a total increase of 295.5% with a compound annual growth rate of 14.7%.^{4,6} This growth, together with growing pressure on wild fisheries, suggests that an understanding of the sector's history and a forward-looking view focusing on sustainable expansion are increasingly priorities. This review aims to show the environmental, socio-political and market pressures shaping the sector's trajectory, demonstrating its remarkable resilience and adaptability despite operating at a fraction of global production scales. Understanding these historical forces is essential to realising the sector's sustainable expansion potential, and it is with this historical overview that the review begins.

Marine aquaculture

Oysters

The first saltwater species cultivated in South Africa was oysters, roughly 350 years ago, only two decades after the first European settlers arrived. In 1673 and again in 1676, Isbrand Gosker, the second Governor of the Dutch Cape Colony, attempted oyster farming in Table Bay.⁷ He arranged transportation of oysters from the South Coast to Table Bay for the purpose of cultivation. The experiment failed on both occasions. Other documented attempts would ensue between the 1870s and 1890s. Futile attempts curbed the enthusiasm of the early pioneers to such an extent that oyster farming along the South African coastline was deemed unfeasible at the time.^{1,7} It would be almost 60 years later before farming attempts resurfaced.

Commercial marine aquaculture started in 1948 with the establishment of the Knysna Oyster Company.⁷ Growing local demand and a dwindling supply of Indigenous oysters had fuelled interest in the cultivation of *Striostrea margaritacea*, a local oyster species. Initial farming attempts

proved ineffective, as limited technical knowledge for commercial cultivation existed at the time.² Trial-and-error attempts saw the importation of various exotic oysters, and in 1973, the company finally settled on *Crassostrea gigas*, the non-native Pacific oyster.⁸ Its faster growth rates (9–11 months to reach market size) and reduced production losses compared to the local *Striostrea margaritacea* oysters (approximately 36 months to reach market size) were fundamental to its success, as was market acceptance.² To this day, *Crassostrea gigas* is the only oyster species cultivated in South Africa.⁴

Production system and value chain of oysters

In 2021, the Western Cape produced 308.36 t of oysters, equalling 79% of South Africa's total production.⁴ All, save two of the oyster farms, are situated in the Western Cape, predominantly in Saldanha Bay, which is the powerhouse of oyster and mussel cultivation in South Africa (Table 1 and Figure 1).

South African oyster cultivators depend almost solely on imported seed, mainly from Chile, Guernsey and Namibia.⁹ There are only two nurseries in South Africa: one in the Northern Cape at Kleinsee and one in the Western Cape at Paternoster (Figure 1). These nurseries produce oysters from larval stages growing spat to roughly 4 mm. In the Western Cape, all oyster farms, except for the one in Paternoster, are grow-out facilities, meaning that farmers obtain spat they grow to harvest (market) sizes.⁹

Oyster production in the Western Cape is represented by four longline systems and one raft system.⁴ The oysters are categorised into different market sizes – such as cocktail (40–49 g), champagne (50–59 g), medium (60–79 g), large (80–99 g) and extra-large (100–120 g) – and typically reach harvest size after approximately 7 months. They are commonly consumed live or raw but are also available in various processed forms (Table 3).^{9,10}

Table 3: Possible systems for cultivation of species and product ranges in the Western Cape

Species produced	Systems used	Product range	Sizes sold	Period (months)
Rainbow trout	RAS	Fertilised trout ova		
<i>Oncorhynchus mykiss</i>	Cage	Live fish	750 g	12–18
	Pond	Processed: smoked, fillet	1.25 kg	18–36
	Raceway	Whole: fresh, frozen		
Tilapia	RAS	Live fish		
<i>Oreochromis niloticus</i>	Aquaponics	Whole: fresh, chilled	500 g	9
<i>Oreochromis mossambicus</i>	Pons	Frozen: whole, filleted	475 g	14
	Cage culture			
Mussels	Longline culture	Live		
<i>Mytilus galloprovincialis</i>	Raft culture	Half shell: fresh, chilled, frozen	55–100 mm	6–7
<i>Choromytilus meridionalis</i>		Full shell: fresh, frozen	>60 g	
Oysters	Longline culture	Live		
<i>Crassostrea gigas</i>	Raft culture	Half-shelled	40–105 mm	6–7
		Freshly shucked	>70–80 g	
		Processed: canned, frozen, vacuum-packed		
Abalone	RAS	Live	80–100 mm+	36–52
<i>Haliotis midae</i>	Flow-through systems	Processed: canned, dried	50–200 g	
	Cage culture ranching			

Sources: Compiled from Kaiser EDP and Enviro-Fish Africa¹⁰, South African Department of Agriculture, Fisheries and Forestry^{5,9,11,12} and South African Department of Forestry, Fisheries and the Environment¹³.

The local oyster market in South Africa is well established, with relatively high domestic demand. In 2020, roughly 70% of oysters produced were consumed by the local market, with 30% earmarked for international export, approximately 237 t, primarily to China and Hong Kong.¹³

Mussels

Compared with oysters, mussel cultivation is a more recent endeavour. In 1972, the Fisheries Development Corporation (FDC), known in Afrikaans as the Visnywerheidsontwikkelingskorporasie (VISKOR), conducted experimental farming trials with the indigenous black mussel (*Choromytilus meridionalis*) and sought to identify optimal cultivation sites in Saldanha Bay (Figure 1).^{8,14} This naturally sheltered embayment on the west coast of South Africa provides a productive and adequately sheltered environment conducive to shellfish cultivation. The bay is divided into a smaller, inner bay and a larger, outer bay by a 4 km-long iron ore-loading jetty, constructed in 1975.^{15,16} While historically mussels were often used as bait for catching saltwater fish and have been consumed by Indigenous people for thousands of years, their utilisation in the mainstream sector was limited at that time.^{2,17,18}

Andre Du Plessis, a pioneer in mussel and abalone farming, led the 1972 Fisheries Development Corporation research programme. Du Plessis reflected on the findings from the 1972 study, noting that the market at that time was reluctant to accept the native mussel and that it was only from 1976 to 1978 that the Mediterranean mussel (*Mytilus galloprovincialis*), cultured at large scale in countries like France and Spain, appeared in the bay. Anecdotal evidence suggests the initial settlement occurred when spat was introduced via the ballast water of ships docking from the north. The appearance of this invasive species renewed interest in mussel cultivation (Du Plessis A, 2023, written communication, November 11).

In 1981, engineer Philip Steyn initiated his idea of starting a mussel farm. In 1984, he was granted a lease for a 10 ha tidal pool, located adjacent to Saldanha Bay's iron ore jetty.^{2,15} Available space was limited, and despite the mussel rafts being protected from waves, the conditions for water supply and circulation were suboptimal. Consequently, the production output was limited, leading to Steyn's discontinuation of the venture shortly thereafter.

The commercial sector was formally established in 1985, when the Sea Harvest Group, a seafood, aquaculture, agri-processing and branded fast-moving consumer goods business, opened a mussel farm. In 1987, they leased 37 ha, located in the outer portion of Small Bay, from the Port Authorities (SA Transport Services), and in September 1987, their first raft was set afloat. Within the next few years, they had over 40 large rafts, and between 1991 and 1992, they were able to produce over 1000 metric tons of mussels (Du Plessis A, 2023, written communication, November 11; Pienaar V, 2023, written communication, November 11). These early pioneers were inspired by methods observed in Spain, including the use of rope and raft culture technologies.⁷

In 1986, Atlas Sea Farms embarked on an ambitious project, securing a lease for 1550 ha beyond the harbour wall in Saldanha Bay – a notably exposed expanse, also referred to as the “outer bay area”. The project failed as the rafts could not cope with the challenging sea conditions characteristic of the Cape, leading to farm closure shortly after a major storm. In fact, a few companies came and went between 1987 and 1992. In Spain, mussels are grown out in fjords with calm, deep waters. By comparison, the waters of the Cape presented formidable challenges. Therefore, many crucial refinements followed, adapting mussel farming techniques and equipment to withstand South Africa's relatively harsh coastal conditions (Du Plessis A, 2023, written communication, November 11; Pienaar V, 2023, written communication, November 11).

Production systems and value chain of mussels

Currently, all mussel farms in South Africa are situated within the Western Cape Province, with production exclusive to Saldanha Bay (Figure 1).⁴ The bay is unique as one of the only naturally protected embayments in South Africa. Located in an area of frequent upwelling, it offers an ideal environment for phytoplankton, which forms the primary diet of mussels and oysters.^{16,19}

Two species of mussels are cultured, namely the indigenous black mussel (*Choromytilus meridionalis*) and the exotic Mediterranean mussel (*Mytilus galloprovincialis*). Of these, the favourite species is *Mytilus galloprovincialis*, owing to its superior growth rates and adaptability to changing environmental sea conditions.^{4,9} For example, it provides a considerably higher average flesh yield, with a 65-mm mussel yielding 2.1 g of dry flesh compared to 1.4 g from *Choromytilus meridionalis*.²⁰

In terms of biomass, the mussel subsector ranked first among South Africa's aquaculture contributors, producing roughly 3421 t in 2021⁴ (Table 2). Also in 2021, there were 20 operational farms in Saldanha Bay, employing 3 raft culture operations and 17 longline culture operations.⁴

Mussels are typically harvested after a 6–7-month period, when they are more than 60 g in weight. Product forms include fresh (live) mussels supplied mainly to restaurants or frozen (half- or full-shelled) mussels supplied to supermarkets, restaurants and the catering industry (Table 3).⁹

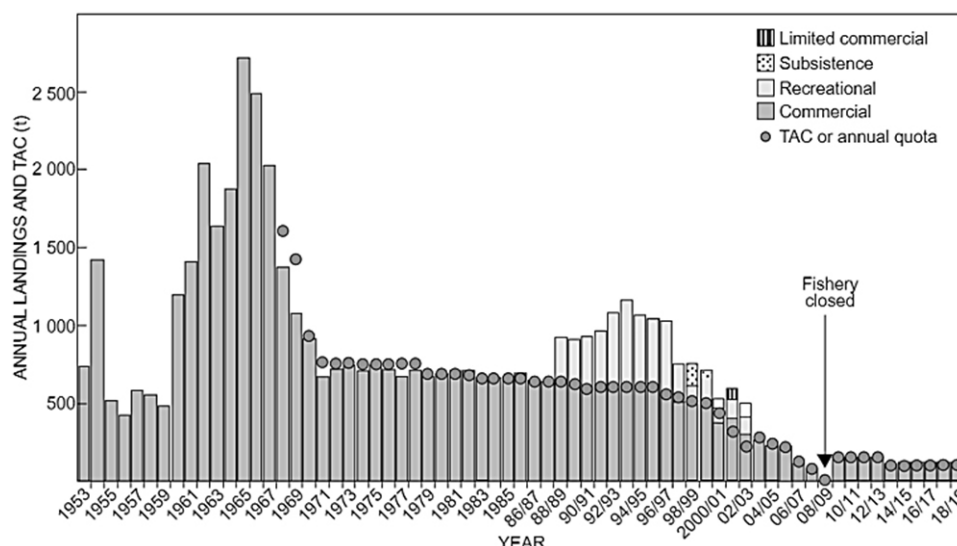
Abalone

While there are six species of abalone endemic to South Africa, only one species, *Haliotis midae*, is commercially cultured.^{4,11} The rise of abalone farming was driven by a collapsing abalone fishery industry, as a result of a complex interplay of social, economic and environmental factors.

In 1949, the discovery of extensive natural beds of abalone, coupled with a growing international demand, led to the establishment of the commercial abalone fishery in South Africa.^{21,22} Throughout the 1970s to the mid-1990s, the fishery was characterised as stable.²³ But in the 1990s, with the end of the apartheid era, borders opened, and opportunities for trade grew. At this same time, in an effort towards equity and equality in a post-apartheid South Africa, complex reform took place, reallocating some rights from corporate entities to individual divers and historically marginalised traditional fishers.^{21,24} However well-intentioned, it saw many traditional fishers excluded. For those relying on marine resources for sustenance and income, the act of fishing was considered a legitimate right, irrespective of possessing a formal permit. Many who were denied these fishing rights continued to fish, selling their harvest to a rapidly growing illicit market.²⁴ Concurrently, rock lobster populations shifted from the west to the southwest coast during the late 1980s and early 1990s. This movement was likely a response to a combination of climate-driven environmental pressures, particularly the increased frequency of low-oxygen events, exacerbated by historical over-exploitation.^{24,25} This change reduced abalone recruitment, as young abalone typically shelter under sea urchin spines for protection, and increased rock lobster predation on sea urchins reduced this refuge.^{25,26} Amidst this biological pressure on the wild stock, the market value of abalone, particularly in the thriving Far East market, increased from USD10 to USD55 per kilogram between 1990 and 2007 (exchange rate of 2.58 and 7.06 at the time), further fuelling illegal harvesting.²¹ Ultimately, rising demand, a growing black market, increased resource access and reduced abalone recruitment resulted in an 88% reduction in the total allowable catch from 615 t to 75 t between 1995 and 2008, leading to the recreational fishery's indefinite closure in 2003 and complete commercial closure between 2008 and 2010.²⁷ The commercial fishery has since reopened with a total allowable catch of 96 t since 2013 and 50.5 t since 2019.^{28,29} This collapse, combined with persistent high demand, catalysed the development of abalone aquaculture as an alternative supply source.

In 1984, at Hermanus, a popular coastal town 120 km east of Cape Town, veterinarian Dr Pierre Hugo began experiments on spawning abalone in captivity.³¹ Using small fish tanks at home and testing different feeds, he was among the early pioneers of abalone farming in South Africa. In 1995, Hugo founded Abagold, currently one of the largest abalone farms in the country.^{32,33} At around the same time, in 1988, Genade et al.³⁴ published an article demonstrating the successful culture of the abalone species, *Haliotis midae*, under controlled and semi-controlled conditions.

Abalone farming took off in the early 1990s, and by 1997, the first 10 t were produced.^{35,36} Since then, it has grown exponentially, seeing an increase in production of 110% between 2000 and 2020.¹³ Unfortunately, global imports of *Haliotis midae* go beyond the legal production levels, suggesting consumption of abalone from illegal sources.³⁷ This illegal poaching poses a threat to abalone farmers, threatening the economic sustainability and



Source: Reproduced from the South African Department of Forestry, Fisheries and the Environment.³⁰

Figure 2: Documented (legal) annual landings and total allowable catch (TAC) for the abalone fishery, for the period 1953 to 2018/2019. Data on recreational sector landings are only accessible from 1988/1989 onwards. Notably, illegal catches are not included in the data.³⁰

integrity of the abalone value chain, as it is unregulated, supplies the market with low-quality products and competes with the livelihood of legitimate farmers – all while degrading and disrupting the natural ecosystem and depleting wild populations.¹¹ Notwithstanding the complex environment that gave birth to the abalone sector, South African farmers have risen to prominence as global leaders in abalone culture, currently being the third-largest international cohort of producers in the world.³⁸ However, in the last decade, China has seen a notable increase in abalone production, with up-scaling, improved farming methods and advanced breeding techniques³⁹, posing a new competitive threat to South African farmers.

Production system and value chain of abalone

Abalone meat is highly valued in Asian countries, where it is believed not only to be rich in nutritional benefits but also to be claimed as an aphrodisiac, and traditionally used for the treatment of certain blood diseases.^{35,40} In 2020, the abalone subsector accounted for 32% of South Africa's overall animal aquaculture production and contributed 74% of the country's aquaculture revenue.¹³ It is the most prolific in terms of revenue generated.

There are 14 abalone farms in the country (Table 1). Nine farms situated in the Western Cape are responsible for more than 90% of the total abalone production (Table 2).⁴ In the Western Cape, all the farms use flow-through operations. Farms are located near the shoreline, and land-based tanked systems are used whereby seawater is pumped ashore, filtered and then fed into commercial abalone tanks. Characteristically, all farms include a hatchery area, either under cover or indoors, and an outdoor 'grow-out' area, making up the bulk of the farm. All farms use formulated feed, although some farms integrate seaweeds such as *Ulva*, kelp and algae, into their nutritional regimes.

Abalone typically takes between 32 and 56 months to complete the grow-out process, harvested around 80–100 mm, which is commonly referred to as cocktail abalone. Products sold include live or processed (canned, dried) abalone, and prices vary according to the product sold (Table 3).^{4,10,11}

Freshwater aquaculture

Trout

Freshwater aquaculture originated around 150 years ago, as early European settlers endeavoured to acclimate the region into a familiar semblance of their homeland.⁴¹ Driven by a longing for their native fruit, fish, flocks and game, they started introducing these into the area. Freshwater aquaculture thus found its colonial origins in sport fishing.^{7,42,43}

In 1867, the "Bill for encouraging the introduction into the waters of this Colony of fishes not native to such waters" was passed. This bill allowed

for the possibility of establishing and acclimatising trout, including brown (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*), currently used in the recreational and commercial sectors, respectively.⁷ Over the following years, various attempts were made to import and stock trout in the rivers around what is now the Western Cape, Eastern Cape and KwaZulu-Natal Provinces.

Trout eggs require flowing water, ideally kept between 7 and 14 °C, for successful hatching within 5–6 weeks.⁴⁴ Around the 19th to early 20th century, a typical journey from Europe would take at least 5 weeks.⁴⁵ Developing ova underwent most of their development on board a ship in ice-packed trays.⁴⁶ Simply keeping the eggs frozen on this journey would have been logistically challenging. To complicate matters, containers in those days were either made of zinc or zinc-lined, which is toxic to freshwater fish. This fact was unknown at the time.^{44,47} Additionally, in the Northern Hemisphere, trout spawn in winter, and eggs sent to the South would have had to travel into a much warmer climate. These factors resulted in high mortality rates of trout ova.⁴⁴

In 1890, John Parker, after numerous failed attempts, managed to successfully hatch 2000 brown (*Salmo trutta*) and brook (*Salvelinus fontinalis*) trout on a farm in KwaZulu-Natal.^{41,44} Two months later, Parker successfully introduced trout fry into the Bushman's and Umgeni Rivers.⁴⁸ At about the same time, parallel experiments saw the successful hatching and introduction of trout into the rivers of the Cape Colony.⁴¹

In 1892, Lachlan Maclean and his associates, with backing from the Cape government, obtained permission to utilise a cool, well-ventilated basement room at the Anneberg Brewery in Newlands, Cape Town. The brewery provided a reliable, consistently cool water supply from the famous Newlands Spring.⁴⁹ During that year, three shipments with a total of 100 000 trout (*Loch level* and *brown trout*) ova were sent to the Cape. Eighty percent of the fry perished because of water quality issues, inefficient hatching troughs and delayed funding. Nonetheless, around 20 000 fry were successfully transferred into the Eerste, Breede, Lourens, and Berg rivers.^{7,43,49} In 1893, recognising the need for proper hatching facilities, the government at the time secured an ideal site lease from Fredrik Godfried Watermeyer at Jonkershoek, near Stellenbosch, outside Cape Town, and transferred the hatchery there (Figure 1). The Jonkershoek hatchery was a success, and by 1895, the first ova were obtained from brown trout (*Salmo trutta*) that were bred from imported eggs.⁷ The following year, the first rainbow trout (*Oncorhynchus mykiss*) ova were imported, and successful production of this species commenced from 1899 onwards.⁴²

In the 1940s, R. Charter from Magaliesberg in Transvaal (today Gauteng) requested trout ova from the Jonkershoek hatchery (Figure 1). He would

continue to start the very first trout farm in South Africa. Other trout farms soon followed, and the subsequent years saw significant developments, including the establishment of the first pelleted feed company in 1959 and the formation of the South African Trout Farmers Association in 1974.⁷ At present, the trout farming sector is firmly established with rainbow trout (*Oncorhynchus mykiss*) serving the commercial aquaculture sector and brown trout (*Salmo trutta*) used for recreational fishing.⁵⁰ The Jonkershoek hatchery, foundational to the development of freshwater aquaculture in the Western Cape, has since closed, with limited availability of locally produced fry subsequently identified as a key constraint for small-scale producers.

Production system and value chain of trout

In the Western Cape, the trout sector is the largest freshwater aquaculture sector, with about 44% of all trout farms located in this province. As of 2021, there were 15 trout farms⁴, though by 2023, this had reduced to 10 active farms, including four aquaponic projects, co-cultivating fish and plants (Stander H. 2023, written communication, September 2). Farm closures have been attributed to the impact of the COVID-19 pandemic on tourism, market challenges like limited fry access and load shedding (Stander H. 2023, written communication, September 2; Weaver R. 2023, written communication, November 10).

Trout are cultivated using technologies, including raceways, recirculating aquaculture systems (RAS), cage culture and pond culture (Table 3). In the Western Cape, raceways, pond flow-through systems and RASs can be employed throughout the year, although water cooling or heating is often needed depending on the season.⁵ Cage culture on dams is limited to higher elevation areas where cool, clear water predominates, with grow-out periods restricted to the colder months of the year. In 2021, trout production in the Western Cape was estimated to be 384 t, contributing 34% to the total trout production nationally (see Tables 1 and 2).⁴

Typically, cultivation periods span between 12 and 36 months, with trout products coming in a variety of offerings, including fertilised trout eggs for production, trout egg caviar, fry (0.5–5 g) and fingerlings (5–75 g) and fish for consumption (Table 3). This encompasses live and previously frozen options, as well as value-added products like smoked filleted trout.^{5,10,50} In the Western Cape, trout are mainly sold in various sizes, including plate size (250–350 g), braai trout (600–800 g) and larger kilo-trout (1.2–1.5 kg). Additionally, value-added products such as smoked trout also cater to the retail and food service industries.⁵¹

Tilapia

In South Africa, two species of tilapia are cultured, including the African indigenous Mozambique tilapia (*Oreochromis mossambicus*) and the Nile tilapia (*Oreochromis niloticus*). Mozambique tilapia, also called “largemouth kurper” or “mud bream”, are indigenous to East Africa, initially recorded in rivers as far north as Tanzania down to the Chulumna River, which empties into the Indian Ocean.⁴² The species has since been introduced for aquaculture, recreational fishing, as bait for bass and for biological control of macrophytes and chironomids.^{42,52}

In 1936, a farmer in Malmesbury, Western Cape, obtained Mozambique tilapia from the then-Transvaal (present-day Gauteng) and placed them in some farm dams on his property (Figure 1). He found that they bred well in small farm dams, and subsequently, some of these fish were sent to the Jonkershoek hatchery in 1940, where they were successfully bred and used as fingerlings to feed predatory fish.⁵² In 1959, several exotic tilapia species, including the Nile tilapia (*Oreochromis niloticus*), Mango tilapia (*Sarotherodon galilaeus*) and the Redbelly tilapia (*Tilapia zillii*), were obtained from Israel, and 15 dams across the Western Cape were stocked with offspring from these species in 1960.^{52,53} That same year, the Cape Nature Conservation Department, the provincial conservation authority for the Western Cape, introduced *Mozambique tilapia* into various Western Cape dams. Despite these efforts, aquacultural production in the Western Cape never quite took off, even though a few populations established themselves in some of those water bodies.⁵⁴ It was at Marble Hall, in the mid to late 1950s, where tilapia farming was eventually mastered.⁷

Currently, tilapia is mainly cultured in the Limpopo, North West and Gauteng Provinces, mostly on a small scale (Figure 1). There is no

formal definition of small-scale aquaculture in South Africa; however, it often refers to operations of low input and low output, characterised by modest size and localised scope.⁵⁵ In this study, “small scale” is defined as farms producing less than 10 t annually and having a turnover of less than ZAR500 000 annually. The favoured species for aquaculture purposes in South Africa is the Nile tilapia, because it has enhanced growth and shorter production cycle compared to other species; however, its status as an alien invasive species means producers require permits for production, which may be challenging to obtain.^{12,13}

Currently, the Western Cape is not ideal for culture, mainly because the species’ preference for warm waters is at odds with the cool winters experienced here. Moreover, the year-round heating of water is economically unfeasible, especially in a market that must compete with cheaply imported Chinese tilapia.^{56,57}

Production system and value chain of tilapia

Production of tilapia predominantly occurs on a small scale, with farmers mostly using recirculation and pond culture systems.¹²

Currently, there is only one operational tilapia farm recorded in the Western Cape, producing just below 1 ton per year using an RAS. This farm reportedly plans to switch to *Pangasius* species to mitigate the high heating costs required for year-round tilapia culture (optimal temperature: 25–30 °C).^{12,58} However, the introduction of this exotic species, even within a closed RAS, may face regulatory and environmental scrutiny. Nevertheless, an estimated 17 aquaponic farms in the Western Cape also culture tilapia (Stander H. 2023, written communication, September 2).

Nile tilapia is an invasive species that requires a permit for culture, which often poses a significant hindrance to farmers due to the complex, uncoordinated process of securing permits from multiple regulatory bodies.^{12,56} Furthermore, market access is challenging for many small-scale farmers, who struggle to compete with cheaper imported tilapia despite potential retailer interest in local produce.

Tilapia typically takes between 9 and 14 months to grow out and is harvested at roughly 500 g. Product forms include live, fresh, chilled and frozen, both as whole fish and filleted portions (Table 3).

Ornamental fish

The ornamental subsector stands as one of the oldest subsectors in South Africa. In 1726, François Valentyn documented seeing a Japanese goldfish (*Carassius auratus*) in a tank at Groot Constantia, at the residence of the Governor of the Cape.^{7,42} More than a century and a half later, in 1867, Chas. A. Fairbridge introduced Dace and Golden Carp from England into his garden pond at Sea Point, in Cape Town.⁴² These decorative fish were used not only for ornamental purposes but were also valued as they fed on mosquito larvae. During the Second World War in 1941, historical records show that the demand for goldfish and other ornamentals increased, as the supply from Europe and the Far East was being choked. This caused the Jonkershoek hatchery to increase its culture.⁴²

Backyard hobbyists were the pioneers of this sector, and in the 1970s, one of the first aquarium fish farms was started in the Orange Free State (present-day Free State) by M. Kimbel. In 1981, great strides were made with the registration of a company called Amatikulu Hatchery (Pty) Ltd in KwaZulu-Natal, which became the first to intensively culture ornamental fish.⁶ Although voluntarily liquidated in 2001 in order to switch to prawn culture in the late 1980s, it produced between 70 and 80 different varieties, with a market distribution of some 1.5 million fish, 20% of which was exported to Germany.^{7,59}

Production system and value chain of ornamentals

At present in South Africa, the ornamental fish sector is small and underdeveloped. Production is limited to a select group of breeders cultivating various species: Lake Malawi cichlids, different goldfish (*Carassius auratus*) varieties, diverse killifish species, various discus fish and koi (*Cyprinus carpio*).

In the Western Cape, only two farms operated in 2021. The sector, although considered high value, faces challenges due to the specialised

requirements for maintaining diverse species, precise environmental conditions and the need for sophisticated breeding and care practices, all contributing to elevated operational expenses. Additionally, the ornamental fish market is often erratic, influenced by seasonal demand, hobby trends, consumer preferences and competition with imported varieties.⁵¹

Conclusion

Significant strides have been made in establishing the Western Cape aquaculture sector, which is the highest producer amongst South Africa's nine provinces. While the province's production is impressive domestically, it pales in comparison to major international producers. For instance, South Africa's total aquaculture production in 2021 was 7769.96 t, while Egypt produced over 1.55 million t that same year.^{4,60} This shows that the aquaculture sector is still maturing on the African stage.

South Africa's marine and freshwater aquaculture sectors' development has been defined by a continuous process of adaptation and resilience, from early cultivation failures and reliance on imported genetics, to navigating contemporary challenges such as limited market access for small-scale farmers, climatic hurdles, infrastructural constraints like load shedding, and the pervasive impact of illegal abalone poaching. Key findings of this review suggest that freshwater aquaculture remains constrained by climate limitations, market access barriers and regulatory complexity, while marine aquaculture's dominance in the Western Cape is underpinned by favourable ecological conditions, internationally established markets and strong market demand.

From a policy perspective, streamlining permit processes for tilapia producers, strengthening enforcement against illegal abalone harvesting, providing targeted support for small-scale freshwater operators and addressing the limited availability of locally produced fry and fingerlings for freshwater producers represent priority areas for intervention. Reducing dependence on internationally sourced oyster and mussel seed through investment in domestic broodstock development would further strengthen supply chain resilience for the shellfish subsector. At a national level, Operation Phakisa, introduced in 2014 as part of South Africa's National Development Plan, encompasses multiple development priorities, with the Oceans' Economy representing one key focus area for developing and expanding the aquaculture sector.⁴ The proposed Aquaculture Development Bill, currently under development by the Department of Forestry, Fisheries and the Environment, further seeks to integrate fragmented regulatory frameworks across provincial and national authorities into a cohesive legislative framework for the sector.⁴ Together, these initiatives signal growing governmental commitment to expanding the sector, although their long-term effectiveness warrants continued evaluation. Future research should focus on climate adaptation strategies for vulnerable subsectors, the socioeconomic dimensions of small-scale aquaculture development and the long-term sustainability of marine production under increasing environmental pressure. As the sector continues to grow and adapt, there is an opportunity for sustainability, inclusivity, climate adaptability and resilience to be built into this foundation.

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Data availability

This article is based on research conducted between 2023 and 2024. At that time, the most recent data available in terms of production figures were from the Department of Forestry, Fisheries and the Environment Aquaculture yearbook 2022.⁴

Declarations

We have no competing interests to declare. After writing the first draft, Gemini version 2.5, Google⁶¹, was used to shorten lengthy sentences and rephrase content to improve the clarity of the manuscript. The text was then reviewed and edited for accuracy before submission. This article is based on work completed as part of a master's thesis by J-M.S. entitled The effects of climate change on aquaculture in the Western Cape of

South Africa (Stellenbosch University, 2024), with content adapted and restructured for publication.

Authors' contributions

J-M.S.: Conceptualisation, investigation, writing – original draft, writing – review and editing. K.S.: Supervision, writing – review and editing. R.R.M.: Supervision, writing – review and editing. All authors read and approved the final manuscript.

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