AQUACULTURE YEARBOOK 2022

STATUS OF THE SECTOR

SOUTH AFRICA

forestry, fisheries & the environment
Department:
Forestry, Fisheries and the Environment
REPUBLIC OF SOUTH AFRICA

AQUACULTURE YEARBOOK 2022

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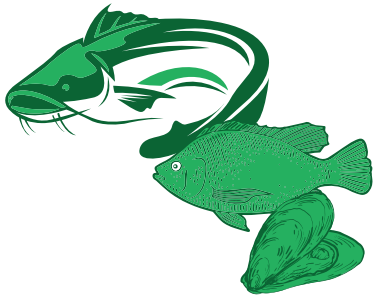
ISBN: 978-0-621-5099-6

Department of Forestry, Fisheries and the Environment

Cape Town, 2022



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Publication: November 2023

ACKNOWLEDGEMENTS

The Department of Forestry, Fisheries and the Environment (DFFE), as the lead department on aquaculture sector development, acknowledges a collective effort made by government, its entities, the private sector, and other stakeholders, for their contribution towards the publication of South Africa's Aquaculture Yearbook 2022.

The close working relationship between government and the industry has enabled the DFFE to track the status of aquaculture in South Africa through data collected from various contributors. This data made it possible to publish sector performance information on South Africa's Aquaculture Yearbook 2022. Special acknowledgement is dedicated to the Aquaculture line functions who compiled and packaged information from their various areas of expertise to ensure its publication through South Africa's Aquaculture Yearbook 2022.

The leadership and valuable contributions received from, among many individuals who made efforts to contribute towards the compilation of this edition of South Africa's Yearbook 2022, Mr Belemane Semoli (Chief Director: Aquaculture and Economic Development), Ms Khumo Morake-Makhalemele (Director: Aquaculture Technical Services), Mr Asanda Njobeni (Director: Sustainable Aquaculture Management), and Ms Andrea Bernatzeder (Director: Aquaculture Research and Development) in ensuring that all the subunits within the Chief Directorate: Aquaculture and Economic Development played a key role, are hereby acknowledged with appreciation.

EXECUTIVE SUMMARY

To monitor the performance of the aquaculture industry in South Africa, the Department of Forestry, Fisheries and the Environment (DFFE) collects, analyses and interprets aquaculture production data annually. The data collection process takes into account freshwater and marine sectors, food safety programme, environmental and aquatic aspects, research advances and the economic performance of the entire aquaculture industry.

The current publication is the 14th edition of *South Africa's Aquaculture Yearbook 2022*. Aquaculture functions within the DFFE are a responsibility of the Chief Directorate: Aquaculture and Economic Development (CD: AED). The CD: AED is responsible for ensuring sustainable growth, responsible management and development of the aquaculture sector. To ensure implementation, the CD: AED is supported by three directorates, namely the Directorate: Aquaculture Technical Services (D: ATS), the Directorate: Sustainable Aquaculture Management (D: SAM) and the Directorate: Aquaculture Research and Development (D: ARD).

The Operation Phakisa Aquaculture Delivery Unit (OPADU) is responsible for a support role by overseeing the implementation of the development and management of initiatives. To meet the demands and expectations of the aquaculture industry, the CD: AED engaged with public and private aquaculture stakeholders through various forums, including, but not limited to the National Aquaculture Inter-Governmental Forum (NAIF), the Marine Aquaculture Working Group (MAWG), Aquaculture Industry Liaison (AIL), the Aquaculture Value Chain Round Table (AVCRT) and the Interdepartmental Authorisations Committee (IAC).

Aquaculture in South Africa is practised in all nine (9) provinces with freshwater production prevalent in inland provinces, while marine production is practised predominantly from four (4) coastal provinces. A total of 195 operational farms were recorded in 2021 for marine and freshwater aquaculture. This included 151 freshwater farms and 44 marine farms. This is a slight decline of six (6) farms compared to 201 farms recorded in 2020.

The total aquaculture production in 2021 was 7 769,96 tons, with total freshwater production recorded at 1 482,30 tons, which is a 19% contribution to the total aquaculture production. The total marine production was recorded at 6 287,66 tons which is an 81% contribution to the total aquaculture production. The total aquaculture production in 2021 increased by 1 723,99 tons from the 6 045,97 tons that was recorded in 2020, which demonstrates an 28% increase. The total freshwater production increased by 1,08 tons, which is a 0.07% increase from the 1 481,22 tons recorded in 2020. The total marine production increased by 1 722,91 tons from the 4 564,75 tons that was recorded in 2020, demonstrating a 38% increase. Seaweed total production recorded in 2021 was 2 595,03 tons. However, seaweed production data was excluded in the 2021 total production data due to inconsistent reporting of this subsector.

The Western Cape province recorded the highest aquaculture contribution with 6 382,90 tons (83%) from 44 farms. This was followed by the KwaZulu-Natal province with a contribution of 423,30 tons (29%) from 20 farms. The total aquaculture production in the Eastern Cape province (EC) with 360,30 (3,8%) from 14 farms Mpumalanga province recorded the fourth highest contribution with 297,10 tons (3,3%) from 26 farms, Gauteng province with 97,10 tons (1,3%) from 26 farms and Limpopo province with 83,30 tons (1,1%) from 30 farms. The last three contributions were recorded from the Northern Cape province with 75,16 tons (0,98%) from seven (7) farms, North-West province with 50,00 tons from fifteen (15) farms and Free State province with 0,80 tons (0,0005%) from four (4) farms.

The freshwater aquaculture production during 2021 was 1 482,30 tons from various subsectors which include trout, marron crayfish, tilapia, catfish, ornamentals and common carp. The trout subsector was the leading subsector, having recorded 1 145,30 tons and having contributed 15% towards the sector. This was followed by the tilapia subsector recorded 246,60 tons and contributed 3% towards the sector. The African Sharptooth Catfish subsector recorded 57,6 tons, contributing 1% towards the sector. The ornamental and common carp subsectors recorded 57,6 tons and 17,50 tons, respectively. The Marron Crayfish subsector recorded 3 tons and contributed 0,04% towards the sector.

The marine aquaculture production during 2021 was 6 287,66 tons from various subsectors which include mussels, abalone, oysters, and marine finfish. The mussel subsector led with 3 420,88 tons and contributed 44,65% towards the sector. This was followed by the abalone subsector, which recorded 2 463,29 tons, contributing 30,73% towards the sector. The oyster subsector recorded 390,45 tons and contributed 5,1% towards the sector. The finfish subsector recorded 13,00 tons and contributed 0,17% towards the sector.

Furthermore, some species were trialled in several farms for the purposes of research studies. These included the white stumpnose (*Rhabdosargus globiceps*), south coast sea urchin (*Tripneustes gratilla*), South African scallop (*Pecten sulcicostatus*) and Mozambique tilapia (*Oreochromis mossambicus*). There were also a few aquaculture species on farms for the purposes of further research and pilot studies. These species included ocean reared rainbow trout (*Oncorhynchus mykiss*) and Atlantic salmon (*Salmo salar*).

Aquaculture in South Africa is practiced in all nine (9) provinces with freshwater production prevalent in inland provinces while marine production is practiced predominantly from four (4) coastal provinces. The total aquaculture production for all nine (9) provinces for 2021 was recorded as 7 769,96 tons from a total of 195 operational farms. The Western Cape province recorded the highest aquaculture contribution with 6 382,90 tons (83%) from 44 farms. This was followed by the KwaZulu-Natal province with a contribution of 423,30 tons (29%) from 20 farms. The Mpumalanga province recorded the third highest contribution with

297,10 tons (3,8%) from 26 farms. Other contributors to the total aquaculture production included the EC with 360,30 (3,3%) from 14 farms, Gauteng province with 97,10 tons (1,3%) from twenty-six (26) farms and Limpopo province with 83,30 tons (1,1%) from 30 farms. The last three provinces' contributions were recorded from the Northern Cape province with 75,16 tons (0,98%) from seven (7) farms, North-West province with 50.00 tons from 15 farms and the Free State province with 0,80 tons (0,0005%) from four (4) farms.

The value of various aquaculture services (in other words, marine and freshwater) was R2 241 342 813 in 2021 (two billion two hundred and forty-one million three hundred and forty-two thousand eight hundred and thirteen Rands). The abalone subsector continues to be the largest contributor. In 2021, abalone subsector contributed approximately R717 000 000 (seven hundred and seventeen million Rands) contributing 86%, followed by oysters (6%), tilapia (3%) and mussels (2%) in the total value of the sector.

The DFFE continues to lead the Oceans Economy Aquaculture focus area since the launch of Operation Phakisa government initiative in July 2014 to help implement the National Development Plan, with the ultimate goal of boosting economic growth and creating jobs. This will be addressed through nine (9) key initiatives. One (1) initiative addresses the selection and implementation of catalyst projects, improving both the number and productivity of the new farms. Three (3) initiatives relate to the creation of an enabling regulatory environment and others focus on funding support, increasing the skills pool and awareness; and improving access to markets. The initiative nine "Develop and Implement Aquaculture Development Zones (ADZs)" seeks to promote investment into the sector and create an enabling environment. The targets over five years (2019-2024), seeks to grow sector revenue from R0,67 billion to R3 billion; production by 27 020 additional tons; jobs by 6 560 direct jobs and to ensure increased participation to support transformation in the sector.

The DFFE continues to be the managing and regulatory authority for aquaculture activities and operations that include farming, harvesting and transportation of aquaculture species for wholesale trading as stipulated in permit conditions that are issued in terms of the Marine Living Resources Act, 1998 (Act No. 18 of 1998) (MLRA) and associated regulations. A total of 54 shellfish and finfish farms were monitored for food safety and security, including seventeen (17) abalone farms, twenty-five (25) mussel farms, ten (10) oyster farms and two (2) finfish farms.

The monitoring of fish farms was conducted for human health hazards including heavy metals, pesticides, polychlorinated biphenyls (PCBs), dioxins, dyes, veterinary drug residues and radionuclides during the production phase. Furthermore, monitored for biotoxins and microbiological contamination. The implementation of contingency measures were for mussel farms located west of the Cape Point due to biotoxins (PST and LST), *E. coli* and cadmium concentrations that exceeded regulatory limits and one (1) oyster farm located in

Algoa Bay for LST and *E. coli*. Therefore, no closure notices were issued to either finfish, abalone or lobster farms.

The DFFE continued to provide support to the Aquaculture Technology Demonstration Centre (ATDC). To assist freshwater aquaculture sector in South Africa by serving as a training, technology demonstration, breeding techniques, culture systems, research and development facility for youth and elderly participating in new and existing aquaculture activities and operations. The DFFE has an initiative to extend the services of ATDC to benefit South African and Southern African Developing Communities (SADC). The development of aquaculture continues to reveal new challenges to aquatic animal health requiring varying degrees of responses. Diseases can introduce significant disturbances to the aquaculture sector from international trade to food safety and security. However, impacts are more extensive and include socio-economic consequences. Data from the Aquatic health programme within the DFFE indicates that the South African molluscan shellfish aquaculture industry is historically free from the diseases listed by the OIE. To ensure this relative high health status with regards to these OIE-listed diseases, continuous investment by both industry and government is being made to demonstrate that the basic biosecurity conditions are continually being met.

Currently, the freshwater sector is legislated through provincial ordinances in the absence of an overarching legislation to enable the DFFE to authorise the sector. The DFFE is in the process of developing the Aquaculture Development Bill which seeks to promote sustainable development of the aquaculture sector in South Africa, inclusive of both marine and freshwater subsectors to ensure that the sector contributes to government priorities such as food security, job creation, economic growth and addressing historical imbalances in accessing aquaculture opportunities. Bilateral engagements to finalise the Bill are still ongoing and all comments received from the industry stakeholders are being carefully considered by the DFFE's Bill drafting team with further intergovernmental consultations planned for 2023.

The former Department of Agriculture, Forestry and Fisheries (DAFF) acquired funding from the National Skills Fund (NSF) for training, capacity building and mentorship of smallholder/small scale producers and placement of graduates in commercial farms. During 2021, approximately 11 aquaculture graduates remained placed in eight (8) farms that are located in the Western Cape, Free State, EC and Gauteng provinces, respectively, from the fifteen (15) graduates that were placed in 2020. There were four (4) resignations from farms in the EC and the Western Cape, respectively, owing to new opportunities and the relocation of one (1) intern from a farm to the DFFE office in the Western Cape province. Various training programmes were also convened with potential and existing farmers in Gauteng, Mpumalanga, Western Cape, EC and KwaZulu-Natal provinces. A total number of 257 people were trained on various courses during 2021 which include courses in Business

and Entrepreneurship (accredited), Aquaculture Farm Management and Governance and Management of Co-operatives which non-credit were bearing.

The DFFE currently engages aquaculture stakeholders in various platforms to improve knowledge, understanding and response to needs of the aquaculture sector. The national aquaculture stakeholder engagements involved the National Aquaculture Intergovernmental Forum (NAIF), which has an objective to improve management through joint planning, facilitation, coordination, resource mobilisations, evaluations and oversight for an aligned implementation and reporting of all key government programmes to achieve sustainable aquaculture development in South Africa.

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ABBREVIATIONS

AM	Aquaculture Management
AAH	Aquatic animal health
AAM	Aquaculture Africa Magazine
ADB	African Development Bank
ADEP	Aquaculture Development and Enhancement Programme
ADU	Aquaculture Delivery Unit
ADZ	Aquaculture Development Zone
AED	Aquaculture and Economic Development
AGRISETA	Agricultural Sector Education Training Authority
AIL	Aquaculture Industry Liaison
ARC-OVI	Agricultural Research Council-Onderstepoort Veterinary Institute
AST	Amnesic Shellfish Toxins
ASTRAL	All Atlantic Ocean Sustainable, Profitable and Resilient Aquaculture
ATDC	Aquaculture Technology Demonstration Centre
ATM	Abalone tubercle mycosis
ATS	Aquaculture Technical Services
AVCRT	Aquaculture Value Chain Round Table
AZA	Azaspiracid
BSFM	Black soldier fly meal
CAGR	Compound Annual Growth Rate
CLAR	Central Laboratory for Aquaculture Research
CMM	Crocodile meat meal
CPUT	Cape Town University of Technology
CSIR	Council for Scientific and Industrial Research
COP	Community of Practice
Covid-19	Coronavirus disease 2019
CDA	Cellular Domoic Acid
DAFF	Department of Agriculture, Forestry and Fisheries
D: ARD	Directorate: Aquaculture Research and Development
DCS	Department of Correctional Services
DEAT	Department of Environment and Tourism
DHA	Docosahexaenoic acid
DRDAR	Department of Rural Development and Agrarian Reform
DEFF	Department of Environment, Forestry and Fisheries
DFFE	Department of Forestry, Fisheries and the Environment

DFI	Department Funding Institution
DHET	Department of Higher Education and Training
DoH	Department of Health
DPWI	Department of Public Works and Infrastructure
D: SAM	Directorate: Sustainable Aquaculture Management
DTIC	Department of Trade, Industry and Competition
EA	Environmental Assessment
EC	Eastern Cape province
EIA	Environmental impact Assessment
ENV	Environment
EOP	Environmental Officer Production
EOSP	Environmental Officer Specialised Production
EPA	Eicosapentaenoic acid
ETQA	Education and Training Quality Assurance
EU	European Union
EUS	Epizootic Ulcerative Syndrome
FA	Fatty Acids
FAO	Food and Agriculture Organisation
FCO	Fisheries Compliance Office
FCR	Feed Conversion Ratio
FM	Fishmeal
FOB	Free on Board
FPE	Fish Processing Establishment
FS	Free State province
FSDARD	Free State Department of Agriculture and Rural Development
FSO	Food Safety Office
GCI	Gonado-somatic Index
GDA	General Discharge Application
GEOHAB	Global Ecology and Oceanography of Harmful Algal Blooms
GnRHa	Gonadotropin-releasing hormone agonist
GO$_2$NE	Global Ocean Oxygen Network
GP	Gauteng province
HAB	Harmful Algal Bloom
HAEDAT	Harmful Algal Event Database
HAP	Hamburg Aquaculture Project
HPLC	High-performance liquid chromatography
HUFA	Highly unsaturated fatty acids

IAC	Inter-Departmental Authorisations Committee
IAEA	International Atomic Energy Agency
ICMA	Integrated Coastal Management Act
IDC	Industrial Development Cooperation
IMTA	Integrated Multi-Trophic Aquaculture
IPAP	Industrial Policy Action Plan
IOC	International oceanographic Commission
IOCCG	International Ocean-Colour Coordinating Group
KHV	Koi Herpes Virus
KZN	KwaZulu-Natal
LC-FLD	Liquid Chromatography–Fluorescence Detector
LC-MS/MS	Liquid chromatography mass spectrophotometer
LP	Limpopo province
LST	Lipophilic shellfish toxins
MAFISA	Micro Agricultural Financial Institute for South Africa
MLRA	Marine Living Resources Act
MAWG	Marine Aquaculture Working Group
MCS	Monitoring, Control and Surveillance
MÉRIEUX	Mérieux NutriSciences
MOU	Memorandum of Understanding
MP	Mpumalanga province
MSc	Master of Science
NAIF	National Aquaculture Intergovernmental Forum
NASF	National Aquaculture Strategic Framework
NC	Northern Cape province
NDP	National Development Plan
NRCP	National Residue Control Programme
NRF	National Research Fund
NECSA	Nuclear Energy Corporation of South Africa
NEMA	National Environmental Management Act
NEM: BA	National Environmental Management: Biodiversity Act
NSF	National Skills Fund
NOK	Norwegian Krone
NOSA	National Occupational Safety Association
NRCS	National Regulator for Compulsory Specification
NRCP	National Residue Control Programme
NW	North-West province

NWDARD	North-West Provincial Department of Agriculture and Rural Development
NWU	North-West University
OA	Okadiac Acid
OBIS	Ocean Biodiversity Information System
OIE	World Organisation for Animal Health
OsHV-1	Ostreid Herpesvirus 1 microvariants
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
PCR	Polymerase Chain Reaction
PER	Protein efficiency ratio
PI	Primary Investigator
POGO	Partnership for Observation of the Global Oceans
PST	Paralytic Shellfish Toxins
PXT	Pectenotoxins
PUFA	Polyunsaturated fatty acids
QCTO	Quality Control for Trades and Occupations
RAS	Recirculating Aquaculture System
RU	Rhodes University
SADC	South African Development Community
SAAMFM&CP	South African Aquaculture Marine Fish Monitoring and Control Programs
SABS	South African Bureau of Standards
SAIAB	The South African Institute for Aquatic Biodiversity
SAM	Sustainable Aquaculture Management
SANAS	South African National Accreditation System
SAQA	South African Qualifications Authority
SASM&CP	South African Shellfish Monitoring and Control Programme
SCOR	Scientific Committee of Research
SEA	Strategic Environmental Assessment
SEDA	Small Business Development Agency
SEFA	Small Enterprise Finance Agency
SGR	Specific growth rate
SLA	Service Level Agreement
SMME	Small, Medium and Micro-sized Enterprise
SOP	Standard Operating Procedures
STX	Saxtoxin
SU	Stellenbosch University

TAP	Total Aquaculture Production
TCBS	Thiosulfate Citrate Blue Sucrose Agar
TIA	Technology Innovation Agency
TIKZN	Trade and Investment KwaZulu-Natal
TFF	Total Freshwater Farms
TFP	Total Freshwater Production
TMF	Total Marine Farms
TMP	Total Marine Production
TNAF	Total National Aquaculture Farms
TNPA	TransNational Ports Authority
TSA	Tryptone Soy Agar
TOR	Terms of Reference
UAE	United Arab Emirates
UCT	University of Cape Town
UFH	University of Fort Hare
UKZN	University of KwaZulu-Natal
UMP	University of Mpumalanga
UPS	Uninterrupted power supply
UWC	University of Western Cape
WAS	World Aquaculture Society
WC	Western Cape province
Wesgro	Western Cape Trade and Investment Agency
WOAH	World Organisation for Animal Health
WRC	Water Research Commission
YTX	Yessotoxins
ZAR	South African Rand

NOTES

CHAPTER 1

AN OVERVIEW OF AQUACULTURE YEARBOOKS

1 . AN OVERVIEW OF AQUACULTURE YEARBOOKS

1.1 History of Aquaculture Yearbooks

The first publication of the South Africa's Aquaculture yearbook was in 2009 and the current publication is the 14th edition. The South Africa's Aquaculture yearbooks changed over the years. These changes have led to several developments over a period. Different names and government departments have contributed towards the publications. The first publication only focused on marine aquaculture under the then Department of Environmental Affairs and Tourism (DEAT) and the publication called *South Africa's Marine Aquaculture Industry Annual Report 2009*.

In 2010, the second publication was the *Marine Aquaculture Annual Report 2010* under the then Department of Agriculture, Forestry and Fisheries (DAFF). Owing to the restructuring of government and formation of the then DAFF, the scope of the publication was broadened to cover developmental aspects of aquaculture. The impact of government restructuring also manifested in 2011 publication that required the inclusion of freshwater aquaculture. This resulted in further name change to *South Africa's Aquaculture Annual Report 2011*, still under the auspices of the then DAFF. The last revision of the publication name occurred in 2012 under the then DAFF. The name changed to *South Africa's Aquaculture Yearbook* and retained until this publication.

In 2019, there was further restructuring of government. The aquaculture functions, among others, moved to form part of the Department of Environment, Forestry and Fisheries (DEFF). Publications for 2017 and 2018 were published under the DEFF. In April 2021, the name of the department revised to Department of Forestry, Fisheries and the Environment, therefore, the current publication compiled under the auspices of DFFE. The previous publications include:

- South Africa's Marine Aquaculture Industry Annual Report 2009, published in 2009 under the then DEAT
- Marine Aquaculture Annual Report 2010, published in 2010 under the then DAFF
- South Africa's Aquaculture Annual Report 2011, published in 2011 under the then DAFF
- South Africa's Aquaculture Yearbook 2012, published in 2012 under the then DAFF
- South Africa's Aquaculture Yearbook 2013, published in 2014 under the then DAFF
- South Africa's Aquaculture Yearbook 2014, published in 2015 under the then DAFF
- South Africa's Aquaculture Yearbook 2015, published in 2016 under the then DAFF
- South Africa's Aquaculture Yearbook 2016, published in 2017 under the then DAFF
- South Africa's Aquaculture Yearbook 2017, published in 2020 under the DEFF
- South Africa's Aquaculture Yearbook 2018, published in 2020 under the DEFF
- South Africa's Aquaculture Yearbook 2019, published in 2020 under the DEFF
- South Africa's Aquaculture Yearbook 2020, published in 2022 under the DFFE
- South Africa's Aquaculture Yearbook 2021, will be published in 2022 under the DFFE
- South Africa's Aquaculture Yearbook 2022, will be published in 2022 under the DFFE

1.2 The Purpose of Aquaculture Yearbooks

Similar to previous publications, the main purpose of the South Africa's Aquaculture Yearbook 2022 is to provide access to information and ensure transparency related to the status of aquaculture sector in South Africa. Its aim is to –

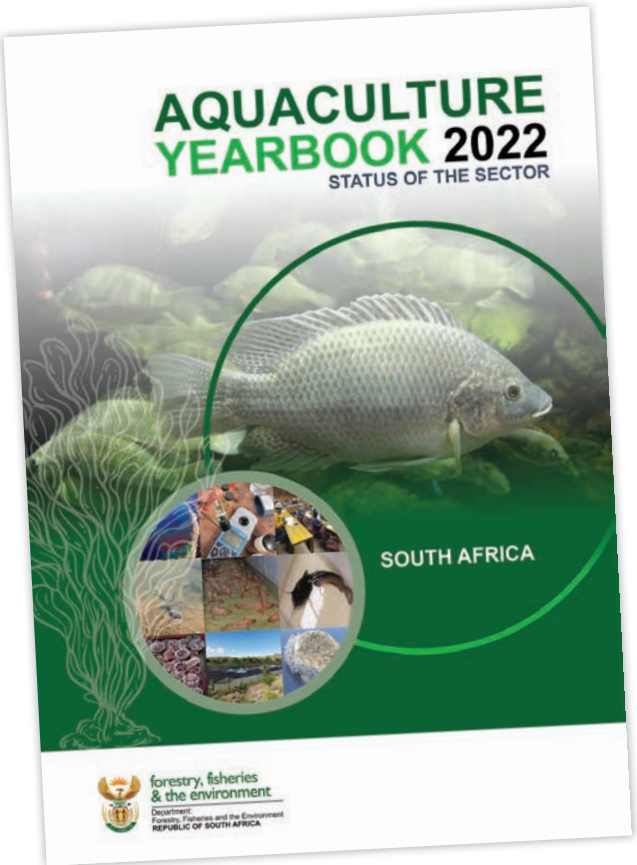
- create awareness;
- promote the sector; and
- provide information to decision makers, potential investors and public.

The objective of the *South Africa's Aquaculture Yearbook 2021* includes, but not limited to –

- recording and monitoring progress of the sector;
- to ensure availability of official aquaculture statistics and information to stakeholders;
- facilitate public awareness;
- identify deficiencies in development and management systems; and
- makes a business case for future developmental initiatives of the sector.

1.3 Compilation Process of the 2022 Aquaculture Yearbook

A consistent approach was taken towards the compilation of previous editions of the South Africa's Aquaculture Yearbooks and was used to compile the South Africa's Aquaculture Yearbook 2022. The compilation of the publication was based on the information collected from different aspects of the sector ranging from research, production statistics, to existing publications, socio-economic and economic information. Key component of this publication is the production data and socio-economic data.



It was compiled based on data collected during 2021, from both freshwater and marine aquaculture farmers. Data collected from the marine aquaculture sector were from legislated and legally operating farmers, importers and exporters as per the Marine Living Resources Act, 1998 (Act No.18 of 1998) (MLRA). The submission of such data was guided by 2020 permits conditions of several subsectors and permits issued under several sections of the MLRA.

Collection of the freshwater aquaculture data continues to pose a challenge for the DFFE as it is currently voluntary for industry to submit information. It was collected through questionnaires, telephonic interviews and through industry associations. The data in this report for freshwater aquaculture may not be a true reflection due to limitations resulting from gaps in legislation governing this process. This aspect demonstrates the importance of having an overarching legislative tool to incorporate both freshwater and marine aquaculture sectors.

NOTES

CHAPTER 2

STATUS OF AQUACULTURE IN SOUTH AFRICA

2. STATUS OF AQUACULTURE IN SOUTH AFRICA

2.1 Overview of Aquaculture in South Africa

Aquaculture continues to be a growing industry in South Africa with 195 farms recorded in 2021 for both marine and freshwater aquaculture (Table 2.1). This included 151 freshwater farms and 44 marine farms. This is a slight decline of six (6) farms compared to 201 farms recorded in 2020. Freshwater farms Recirculating Aquaculture Systems (RAS), ponds, aquaponics and earth ponds to culture several species. Marine farms utilize rafts, longlines, ponds, cages and Integrated Multi-Trophic Aquaculture Systems (IMTAs). The national aquaculture farms have been fluctuating over the years with 229 farms recorded in 2018, 225 farms in 2019 and 201 farms in 2020.

Table 2.1: Total number of aquaculture farms in 2021

Operational Farms per Species and Province (2021)										
Species	**EC**	**FS**	**GP**	**KZN**	**LP**	**MP**	**NC**	**NW**	**WC**	**TOTAL**
Abalone	2	0	0	0	0	0	3	0	9	14
Finfish	2	0	0	1	0	0	0	0	1	4
Mussels	0	0	0	0	0	0	0	0	20	20
Oysters	1	0	0	0	0	0	1	0	4 (7) *	6 (9) *
Total marine farms (TMF)	**5**	**0**	**0**	**1**	**0**	**0**	**4**	**0**	**34 (37)**	**44(47)**
Catfish	1	4	1	2	7	1	0	3	0	19
Common carp	0	0	1	0	1	0	2	0	1	4
Marron crayfish	2	0	0	0	0	0	0	0	0	2
Ornamentals	2	0	5	7	1	3	0	0	2	20
Tilapia	3	0	16	5	21	12	1	12	1	71
Trout	1	0	3	5	0	10	0	0	15	34
Total freshwater farms (TFF)	**9**	**4**	**26**	**19**	**30**	**26**	**3**	**15**	**19**	**151**
Total national aquaculture farms (TNAF)	**14**	**4**	**26**	**20**	**30**	**26**	**7**	**15**	**53**	**195**

*(3) three farms cultured both mussels and oysters; however, the farms have been captured under the primary species cultured. Data based on information that submitted to the department. Seaweed farms were not included.

In 2021, ten (10) species were cultured which included six (6) freshwater and four (4) marine species for various purposes. Freshwater aquaculture operates in all nine (9) provinces across South Africa. However, production areas for freshwater species were highest in the Limpopo province, followed by the Gauteng and Mpumalanga provinces; KwaZulu-Natal (KZN) and the Western Cape (WC) provinces. The freshwater species cultured in 2021 included African sharptooth catfish (*Clarias gariepinus*); rainbow trout (*Oncorynchus mykiss*); brown trout (*Salmo trutta*); common carp (*Cyprinus carpio*); Koi carp (*Cyprinus rubrofuscus*); Marron crayfish (*Cherax tenuimanus*); Mozambique tilapia (*Oreochromis mossambicus*) and Nile tilapia (*Oreochromis niloticus*).

Marine aquaculture operates in four (4) provinces across South Africa. The total number of marine farms were highest in Western Cape province, followed by the EC. The least number of farms are in Northern Cape and KwaZulu-Natal respectively. The marine species cultured in 2021 included abalone (*Haliotis midae*), pacific oyster (*Crassostrea gigas*), mussels (*Mytilus galloprovincialis* and *Choromytilus meridionalis),* dusky kob (*Argyrosomus japonicas*), East Coast Rock Lobster (*Panulirus homarus*) and seaweed (*Ulva* spp. And *Gracilaria* spp.).

The total aquaculture production in 2021 was 7 769,96 tons, with total freshwater production recorded at 1 482,30 tons, which is a 19% contribution to the total aquaculture production. The total marine production was 6 287,66 tons, which is an 81% contribution to the total aquaculture production. The total aquaculture production in 2021 increased by 1 723,99 tons from the 6 045,97 tons that was recorded in 2020, which demonstrates an 28% increase. The total freshwater production increased by 1,08 tons, which is a 0.07% increase from the 1 481,22 tons recorded in 2020. The total marine production increased by 1 722,91 tons from the 4 564,75 tons recorded in 2020, demonstrating a 37% increase.

The leading subsectors based on the total freshwater production were trout with 1 145,30 tons followed by tilapia with 246,60 tons and catfish at 57,6 tons. The leading subsectors based on the total marine production were mussels with 3 420,88 tons followed by abalone with 2 463,29 tons and then oysters with 390,49 tons (Table 2.2).

Table 2.2: Total production per province and subsector in 2021

Subsector	EC	FS	GP	KZN	LP	MP	NC	NW	WC	TOTAL
Catfish	42,00	0,80	0,00	8,00	2,00	0,00	1,30	0,00	3,50	57,60
Common carp	2,00	0,00	1,60	0,00	2,50	0,00	2,50	0,00	3,70	12,30
Marron crayfish	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2,00	3,00
Ornamentals	3,00	0,00	4,50	4,50	0,80	1,90	1,00	0,00	1,80	17,50
Tilapia	55,60	0,00	7,00	7,00	78,00	45,00	4,00	50,00	0,00	246,60
Trout	11,20	0,00	84,00	403,80	0,00	250,20	12,10	0,00	384,00	1 145,30
Total Freshwater Production (TFP)	**114,80**	**0,80**	**97,10**	**423,30**	**83,30**	**297,10**	**20,90**	**50,00**	**395,00**	**1 482,30**
Abalone	163,37	0,00	0,00	0,00	0,00	0,00	54,26	0,00	2 245,66	2 463,29
Finfish	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	13,00	13,00
Mussels	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3 420,88	3 420,88
Oysters	82,13	0,00	0,00	0,00	0,00	0,00	0,00	0,00	308,36	390,49
Total Marine Production (TMP)	**245,50**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**54,26**	**0,00**	**5 987,90**	**6 287,66**
Total Aquaculture Production (TAP)	**360,30**	**0,80**	**97,10**	**423,30**	**83,30**	**297,10**	**75,16**	**50,00**	**6 382,90**	**7 769,96**

2.2 Overview of Aquaculture Sector Activities and Interventions since 2006

In the past 16 years, the aquaculture sector had shown the potential to grow despite the fragmented legislative that challenges the sector. There have been multiple factors and interventions that have contributed to this growth. Yearly interventions made from various units of the former Departments of Environmental Affairs and Tourism; Department of Environmental Affairs; Department of Agriculture, Forestry and Fisheries were observed since 2006. The following government interventions were made and not limited to:

During 2006 and 2009, the sector received some interventions to improve its potential growth rate, which included the following:

- During the five (5) year period between 2010 and 2015, the sector continued to gradually grow further. The following interventions were received:
  - Formulation of the Chief Directorate: Aquaculture and Economic Development to oversee aquaculture sector (Marine and Freshwater aquaculture);
  - Inclusion of aquaculture in the Customised Sector Strategies Programme and the Industrial Policy Action Plan (IPAP);
  - National Aquaculture Strategic Framework for South Africa, 2012;
  - National Aquaculture Policy Framework for South Africa, 2013;
  - Review of legislation and institutional arrangements governing aquaculture in South Africa (detailed in Chapter 4);
  - Aquaculture Development and Enhancement Programme (ADEP) approved and launched by the then Department of Trade and Industry in 2012; and
  - Operation Phakisa – Oceans Economy (Aquaculture Lab) launched in 2014
- For the last six (6) years, since 2015 to 2021, the sector had improved performance, and the interventions received were:
  - Aquaculture Development Bill concept document (gazetted)
  - ADEP reviewed
  - Draft Aquaculture Development Bill
- Sector investment promotion initiatives are outlined below:
  - The first international conference and exposition of the World Aquaculture Society (WAS) held on the African continent at the Cape Town International Convention Centre 26-30 June 2017.
  - Projects profiled at investment conferences nationally and internationally this includes the China Outward Investment Mission in Fujian and Hangzhou and the Sweden Blue Economy Business Seminar in Gothenburg, Sweden.
- New markets have been explored and interest was received from:
  - Iran for tilapia
  - China (Taiwan) for farmed oysters
  - Europe for finfish and abalone
- Investment readiness consultations were held with Wesgro (Western Cape Trade and Investment Agency); and business plan support was provided to African Olive Trading and Aquafoods through SEDA.

- Projects that required investment were presented and profiled at investment conferences nationally and internationally as outlined below:
    - The dti and DAFF United Arab Emirates and Saudi Arabia Investment Mission (UAE and Saudi, March 2018).
    - Chile Scoping Mission with DAFF Deputy Minister: AquaSur International Conference (Puerto Montt, October 2018).
    - Operation Phakisa: Oceans Economy Italy Webinar (Pretoria, September 2018).
    - The Presidential Investment Conference (Sandton, October 2018).
    - United Arab Emirates Agriscape Conference and Investment Mission (Abu Dhabi, October 2018).
- The first Aquaculture Finance and Investment Seminar held in Durban during 2018 and virtually during 2021.
- The Public Awareness and Marketing Strategy for Aquaculture Products and the Sector in South Africa was completed (this also informs investment promotions internationally)
- The Value Proposition for the Aquaculture Sector completed with the Department of Trade, Industry and Competition (DTIC). The value proposition provides an overview of why and how to invest into the sector which is a valuable tool for targeting new investors.
- Transformation strategy development, 2019
- Approval of the small-scale aquaculture programme, 2020
- Approval of the implementation plan for small scale producers, 2021

2.3 Overview of Aquaculture Production Scales over 15 years (2006-2021)

The aquaculture sector has shown significant growth over the past fifteen (15) years with a total aquaculture production of 76 748,90 tons recorded from 2006 to 2021 (Table 2.3). This is an increase from the 68 176,31 tons that was recorded in 2020. An improved growth in production was observed over every five-year period, from 2006 to 2010, a volume of 14 128,75 tons, the following five (5) years of 2011 to 2015 recording a volume of 22 965,17 tons and the last five (5) years recording a total volume of 31 079,32 tons.

Table 2.3: Total production per subsector over 15 years (2006-2021)

Subsector	2006	2007	2008	2009	2010	2011	2012	2013	Total Production (Tons) 2006-2021
Abalone	833,36	783,25	1 037,11	913,58	1 015,43	1 036,01	1 111,41	1 469,78	**21 571,43**
Catfish	180,00	180,00	180,00	180,00	180,00	160,00	0,00	0,00	**1 249,60**
Common carp	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**35,91**
Finfish	0,00	0,00	2,71	22,75	0,00	7,98	48,45	122,54	**791,68**
Marron crayfish	0,20	0,40	0,40	0,40	0,80	0,80	3,50	5,00	**39,50**
Mussels	542,00	466,00	736,74	682,40	700,14	859,77	859,77	1 116,13	**24 380,39**
Ornamentals	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**101,80**
Oysters	279,87	157,86	226,62	223,53	276,57	269,34	241,58	277,23	**4 843,52**
Tilapia	0,00	0,00	0,00	10,00	10,00	100,00	234,20	289,70	**3 535,56**
Trout	807,00	658,00	943,00	948,62	950,00	1 199,00	1 428,00	1 497,30	**19 407,83**
TOTAL	**2 642,43**	**2 245,51**	**3 126,58**	**2 981,28**	**3 132,94**	**3 632,90**	**3 926,91**	**4 777,68**	**76 748,90**

Table 2.3: Total production per subsector over 15 years (2006-2021) (Continued)

Species	2014	2015	2016	2017	2018	2019	2020	2021	Total Production (Tons) 2006-2021
Abalone	1 306,80	1 479,22	1 703,32	1 276,06	1 522,21	1 656,53	1 963,80	2 463,29	**21 571,43**
Catfish	0,00	0,00	3,30	3,30	20,00	59,90	45,50	57,60	**1 249,60**
Common carp	0,00	0,00	0,00	5,30	7,10	6,10	5,11	12,30	**35,91**
Finfish	161,86	77,30	118,60	115,56	73,81	20,10	7,02	13,00	**791,68**
Marron crayfish	5,00	4,00	4,00	4,00	4,00	4,00	0,00	3,00	**39,50**
Mussels	1 682,47	1 758,50	1 960,90	2 083,52	2 182,13	3 053,46	2 275,58	3 420,88	**24 380,39**
Ornamentals	0,00	0,00	16,00	16,00	16,00	16,00	20,30	17,50	**101,80**
Oysters	266,40	276,80	357,30	432,66	466,23	382,69	318,35	390,49	**4 843,52**
Tilapia	289,70	325,30	340,80	402,30	571,30	303,86	411,80	246,60	**3 535,56**
Trout	1 497,30	1 497,00	1 503,00	1 249,80	1 503,00	1 583,00	998,51	1 145,30	**19 407,83**
TOTAL	**5 209,53**	**5 418,12**	**6 007,22**	**5 588,50**	**6 365,78**	**7 085,64**	**6 045,97**	**7 769,96**	**76 748,90**

Figures 2.1 and 2.2 demonstrate continuous sector growth since 2006 to 2021 with a significantly decreased production experienced during 2020 due to delays in imports and exports as the result of the impact of Covid-19 pandemic that occurred around the world.

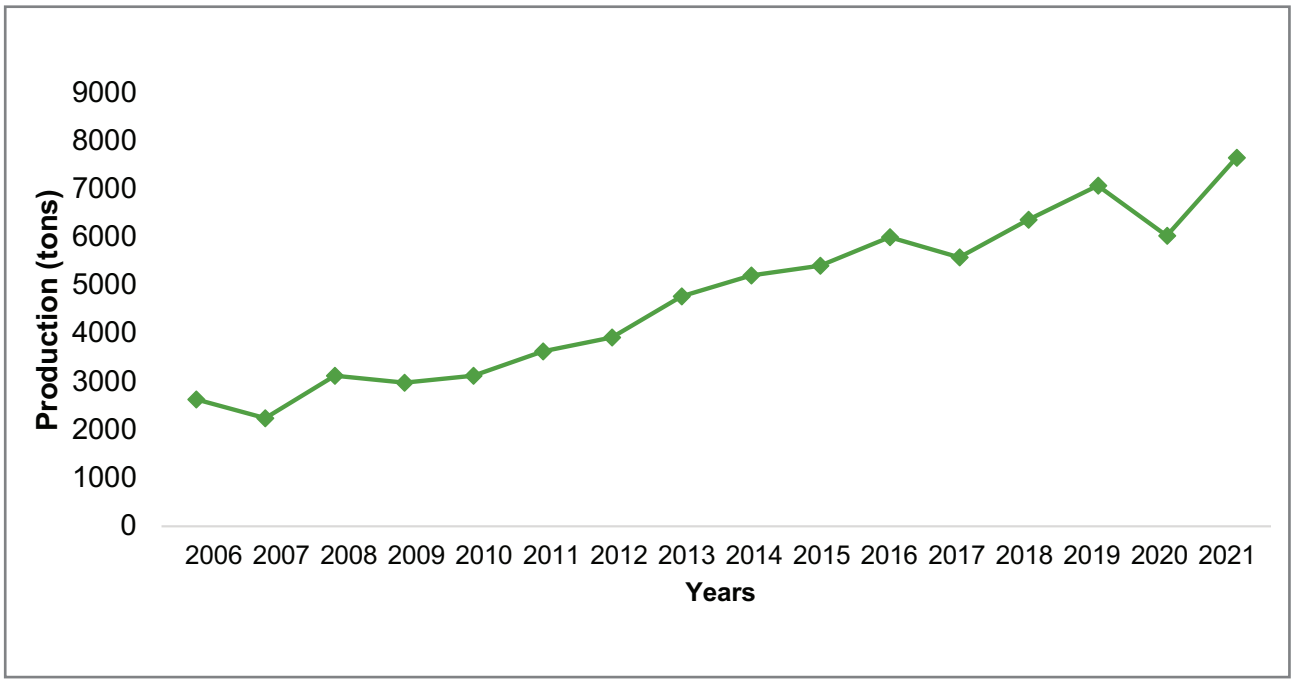


Figure 2.1: South Africa's aquaculture production growth over a 15-year period (2006-2021)

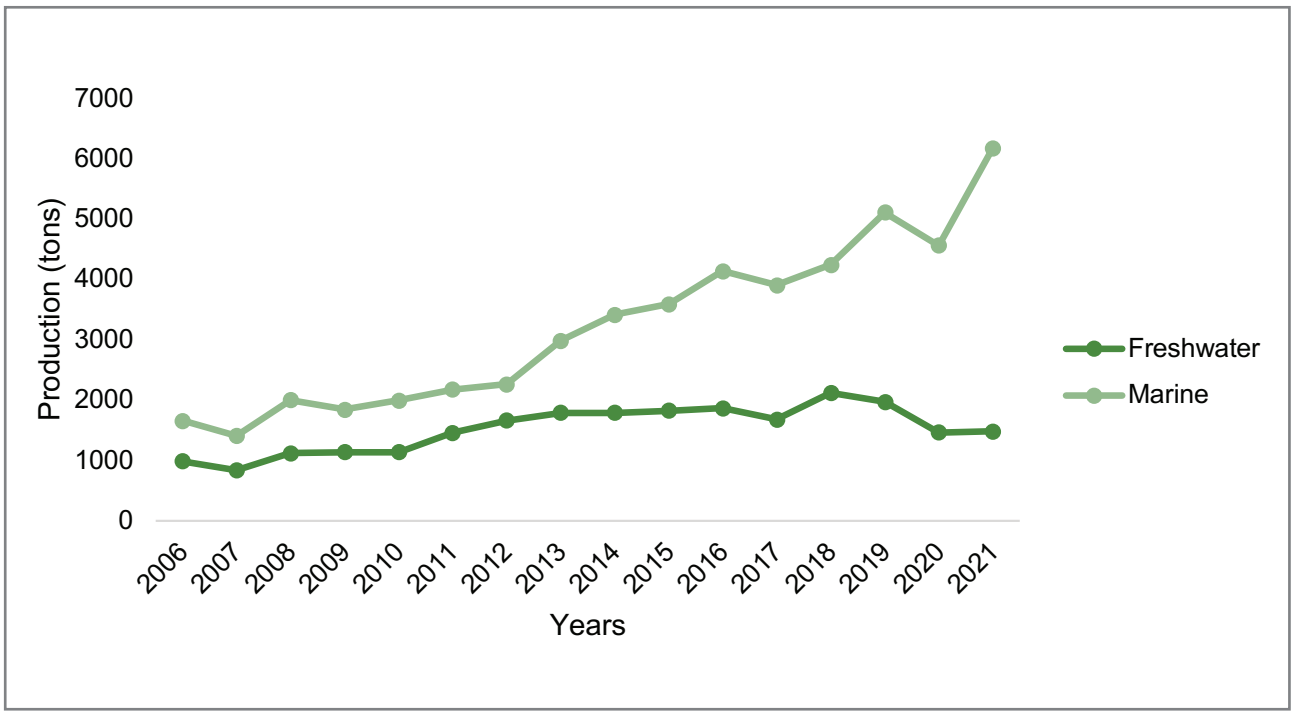


Figure 2.2: South Africa's aquaculture production growth for the marine and freshwater sector from 2006 to 2021

CHAPTER 3

STATUS OF MARINE AQUACULTURE

3. STATUS OF MARINE AQUACULTURE

3.1 Operational Marine Aquaculture Farms

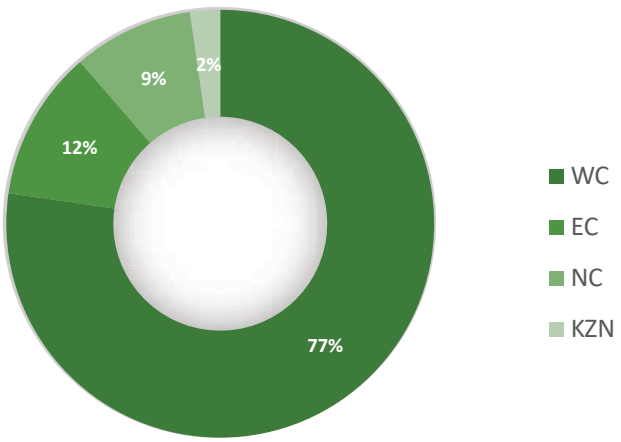
In 2021, there were 44 operational marine aquaculture farms in South Africa, as represented in Table 3.1 below. There were 34 operational marine aquaculture farms in the Western Cape province (WC). The WC had the highest number of marine farms operating in 2021, comprising of four (4) subsectors; abalone represented by nine (9) farms, marine finfish represented by one (1) farm, oysters represented by seven (7) farms and mussel represented by 15 farms. There were five (5) marine aquaculture farms operating in the EC in 2021. The EC had the second highest number of operating marine farms, comprising of three (3) subsectors; abalone (2) and oyster (1) and finish (2). The Northern Cape province (NC) had four (4) marine aquaculture farm operating in 2021, comprising of two (2) subsectors; abalone (3) and oyster (1). The KwaZulu-Natal province (KZN) had the one (1) finfish farm operating in 2021. The total number of farms operating in the EC and Northern Cape provinces include abalone ranching operations, two (2) farms in the NC and one (1) farm in the EC. The Western Cape province has most of the marine aquaculture farms accounting for 77% of South African marine farms, followed by the EC accounting for 12%, the Northern Cape accounting for 9% and KZN accounting for 2% (Figure 3.1).

Table 3.1: Total number of operational marine aquaculture farms in 2021 per province and subsector

Operational Farms per Province and Subsector (2021)					
Subsector	**WC**	**EC**	**NC**	**KZN**	**TOTAL**
Abalone	9	2	3	0	14
Finfish	1	2	0	1	4
Mussels	20	0	0	0	20
Oysters	4 (7) *	1	1	0	6 (9) *
TOTAL	**34 (37)**	**5**	**4**	**1**	**44 (47)**

*Three (3) farms cultured both mussels and oysters; however, the farms have been captured under the primary species cultured, in other words, mussels. Data are based on the information submitted to the DFFE and excludes seaweed farms.

Figure 3.1 Percentage of marine aquaculture farms per province



3.2 Marine Aquaculture Species Farmed

In 2021, various marine species were cultured at different scales as outlined in Table 3.2 below. Marine aquaculture species cultured at commercial scale included abalone (*Haliotis midae*), pacific oyster (*Crassostrea gigas*), mussels (*Mytilus galloprovincialis* and *Choromytilus meridionalis),* dusky kob (*Argyrosomus japonicas*), East Coast Rock Lobster (*Panulirus homarus*) and seaweed (*Ulva* spp and *Gracilaria* spp). The DFFE conducted research on potential species during 2021; these species were kept at the Aquaculture Research Facility in Sea Point (Cape Town) and included the following species, white stumpnose (*Rhabdosargus globiceps*), south coast sea urchin (*Tripneustes gratilla*) and the South African scallop (*Pecten sulcicostatus*). A few aquaculture species were kept on farm premises for pilot and research purposes. These species included ocean-reared rainbow trout (*Oncorhynchus mykiss*) and salmon (*Salmo salar*).

Table 3.2: Total number of operational marine aquaculture farms in 2021 per province and subsector

Marine Aquaculture Species in South Africa 2021		
Common Name	**Scientific Name**	**Operational Scale**
Abalone	*Haliotis midae*	Commercial
Pacific oyster	*Crassostrea gigas*	Commercial
Mediterranean mussel	*Mytilus galloprovincialis*	Commercial
Black mussel	*Choromytilus meridionalis*	Commercial
Seaweed	*Ulva spp*	Commercial
Seaweed	*Gracilaria spp*	Commercial
Dusky kob	*Argyrosomus japonicus*	Commercial
East Coast Rock Lobster	*Panulirus homarus*	Commercial
Ocean Trout/Steelhead Trout	*Oncorhynchus mykiss*	Pilot
Salmon	*Salmo salar*	Pilot
White stumpnose	*Rhabdosargus globiceps*	Research
Spotted Grutter	*Pomadasys commersonii*	Research
South Coast Sea Urchin	*Tripneustes gratilla*	Research
South African scallop	*Pecten sulcicostatus*	Research
Clams	*Venerupis corrugatus*	Research

3.3 Marine Aquaculture Production Scales (Tons)

3.3.1 Marine Aquaculture Production in 2021

This analysis of marine aquaculture production excludes seaweed used as abalone feed in South Africa. South Africa's total marine aquaculture production in 2021 was 6287.75 tons. Table 3.3 below illustrates the total production per subsector in each province. In 2021, the Western Cape province recorded a production of 5 987,90 tons and was the main contributor of South Africa's total marine aquaculture production followed by the EC and Northern Cape provinces with a production of 245,50 and 54,26 tons, respectively. KZN was the lowest contributor, recording a production of 0,0 tons.

Table 3.3: Total marine production per province and subsector

Subsector	WC	EC	NC	KZN	TOTAL
Abalone	2 245,66	163,37	54,26	0,00	2 463,29
Finfish	13,00	0,00	0,00	0,00	13,00
Mussels	3 420,88	0,00	0,00	0,00	3 420,88
Oysters	308,36	82,13	0,00	0,00	390,49
TOTAL MARINE PRODUCTION (TMP)	**5 987,90**	**245.50**	**54,26**	**0,00**	**6 287,66**

South Africa's total marine aquaculture production increased by 1 722,91 tons from 4 564,75 tons recorded in 2020. The marine sector contributed 81% to the overall aquaculture production of 7 769,96 tons. The abalone subsector contributed 31,70% towards the overall aquaculture sector and contributed 39% towards the marine aquaculture sector in 2021. This demonstrates an increase of 499,49 tons (25,43%) in the abalone subsector from 2020.

The finfish subsector contributed 0,17% towards the overall aquaculture sector and contributed 0,21% towards the marine aquaculture sector in 2021, demonstrating an increase of 5,98 tons (85,19%) from 2020. The mussel subsector contributed 45% towards the overall aquaculture sector and contributed 55% towards the marine aquaculture sector in 2021, demonstrating an increase of 1 145,30 tons (50%) from 2020. The oyster subsector contributed 5% towards the overall aquaculture sector and contributed 6% towards the marine aquaculture sector, demonstrating a decrease of 72,13 tons (23%) from 2020 (Figures 3.2 and 3.3).

Seaweed total production recorded in 2021 was 2 595,03 tons. However, seaweed production data was excluded in the 2021 total production data due to inconsistent reporting of this subsector.

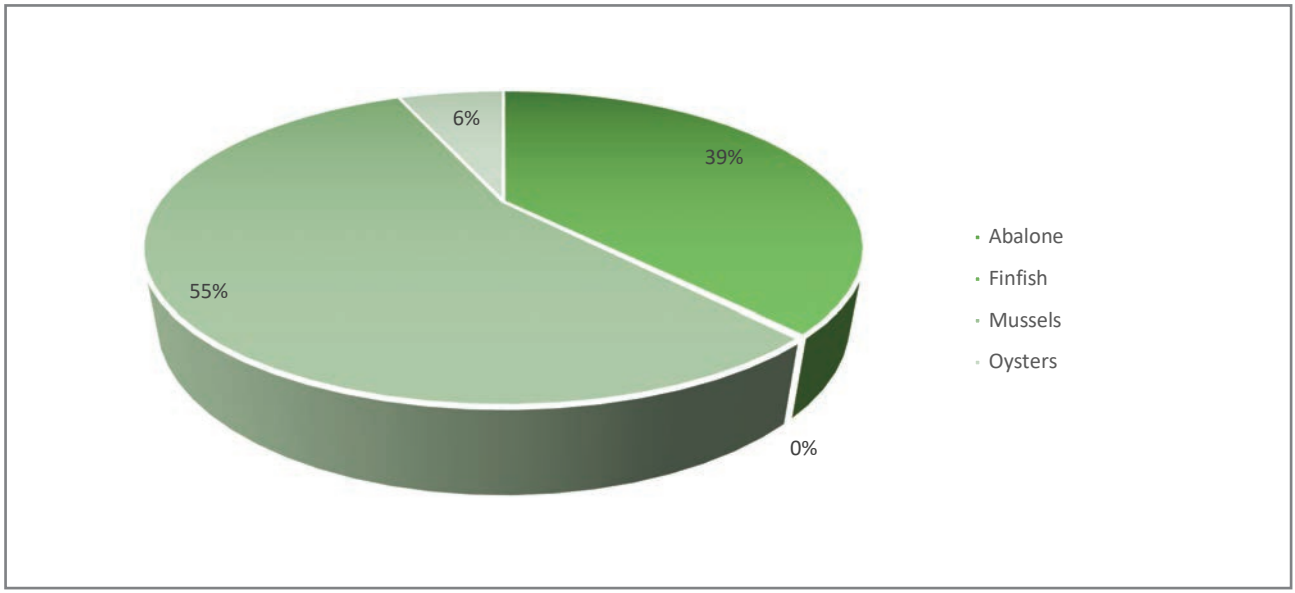


Figure 3.2: Contribution of each marine aquaculture subsector to total marine aquaculture production in 2021

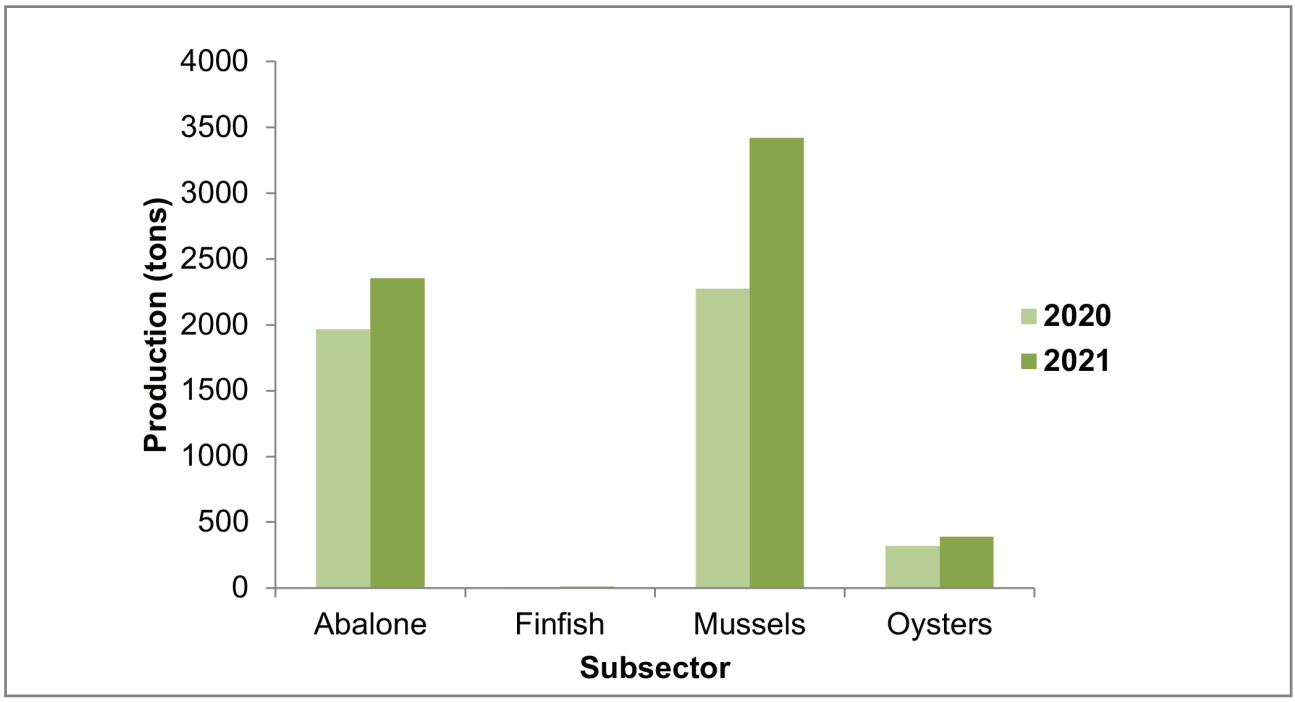


Figure 3.3: Production of marine aquaculture species for 2020 and 2021

3.3.2 Marine Aquaculture Production Trends (2001-2021)

The production from 2001 to 2021 increased significantly, however an increase in production was experienced during 2021 (Figure 3.4). The marine aquaculture sector recorded an overall total production of 57 563,30 tons from 2001 to 2021 as per Table 3.4 below. The marine aquaculture sector is represented by the abalone, mussel, oyster and finfish subsectors; with abalone and mussel subsectors contributing the largest production over the past 20 years. The production of mussel subsector was significantly high in 2021 and recorded 3 420,38 tons. Over the past five (5) years, the mussel subsector displayed growth in production and has been the lead contributor in the sector. The abalone subsector is the

second highest contributor, with the highest production recorded in 2021, with a production of 2 463,29. The oyster subsector production increased significantly from 2011 to 2021, with the highest production of 466,23 tons recorded in 2018. The finfish subsector has been fluctuating over the years and recorded its highest production in 2014 with 161,86 tons. The finfish subsector experienced a drastic decrease in 2020, with a production of 7,02 (Figures 3.5-3.8).

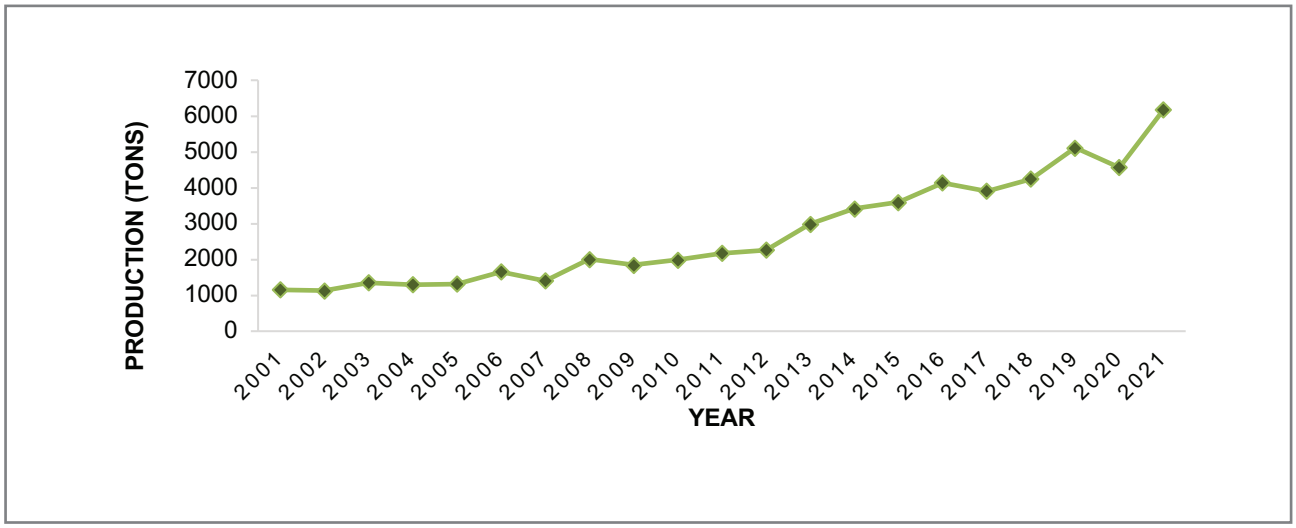


Figure 3.4: Marine aquaculture production over 20 years (2001-2021)

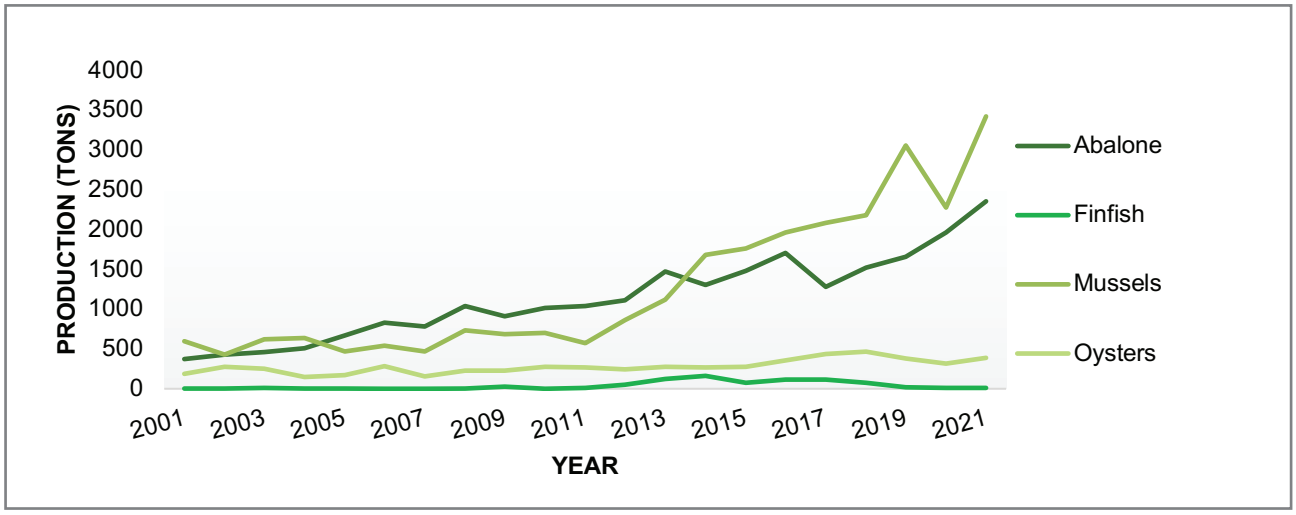


Figure 3.5: Marine aquaculture production trends over 20 years per subsector

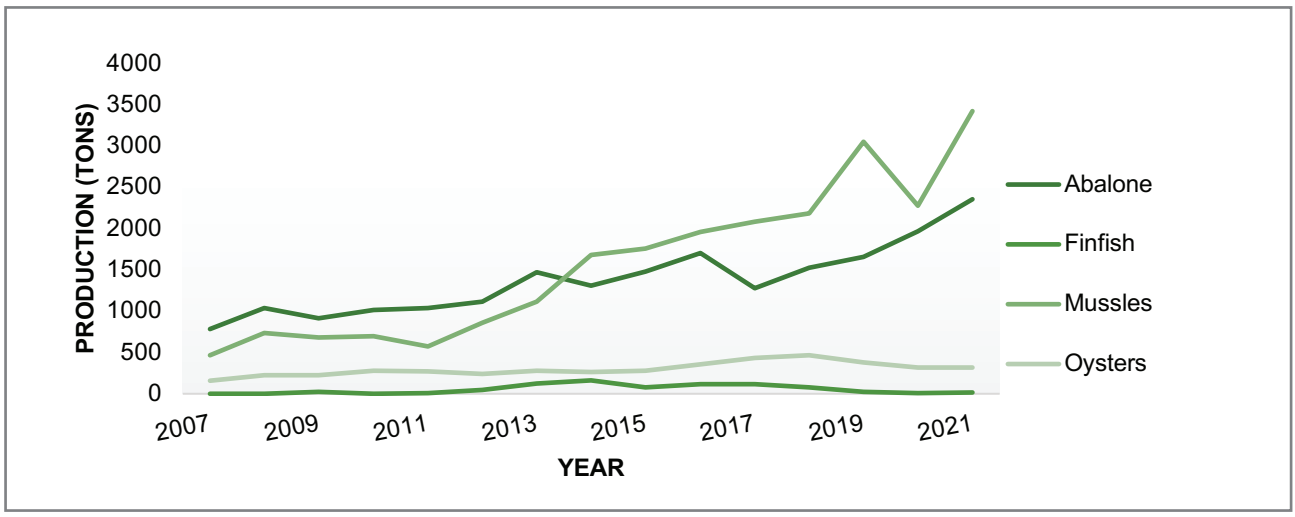


Figure 3.6: Marine aquaculture production trends over 15 years per subsector

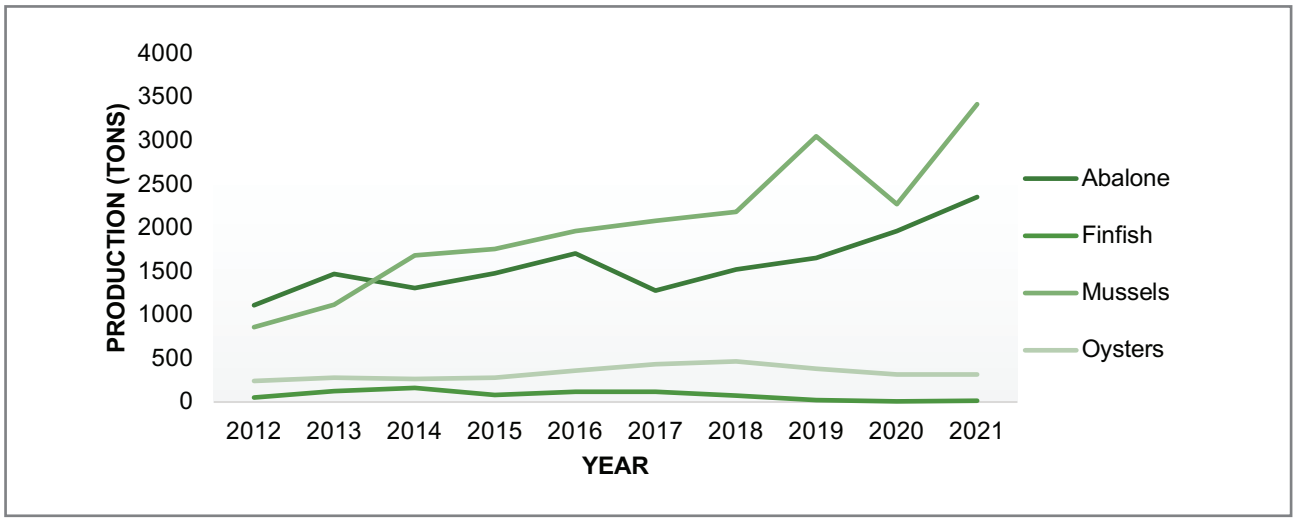


Figure 3.7: Marine aquaculture production trends over 10 years per subsector

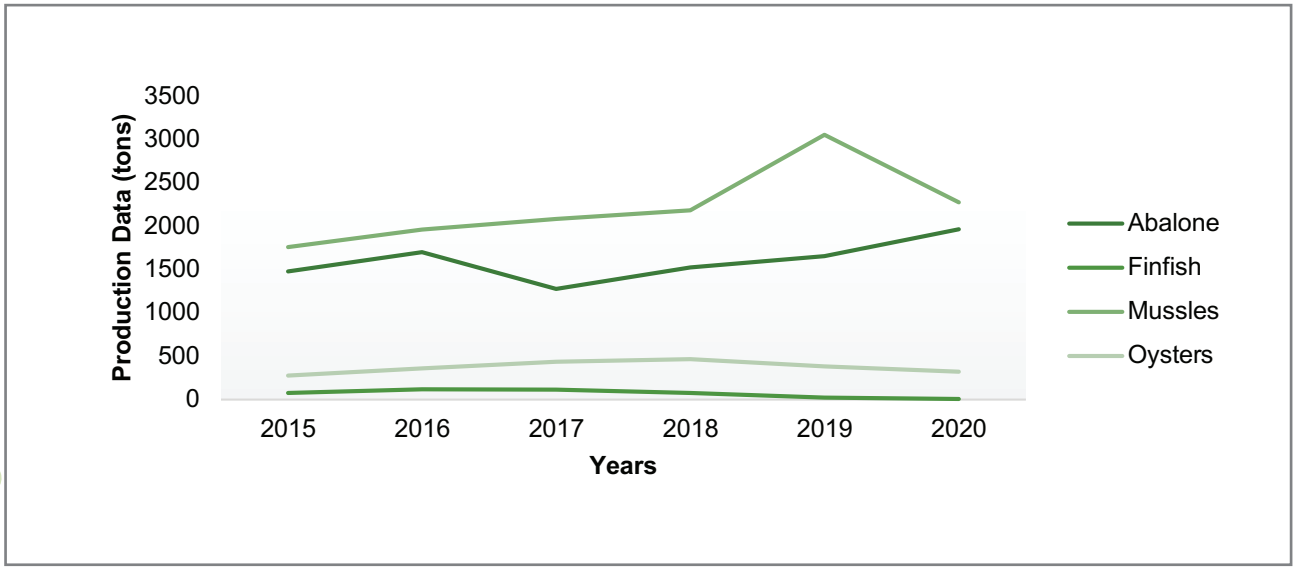


Figure 3.8: Marine aquaculture production trends over five years per subsector

Table 3.4: Total marine production over 20 years per subsector

Subsector	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Abalone	372,88	429,42	462,02	509,20	670,80	833,36	783,25	1 037,11	913,58	1 015,43	1 036,01
Finfish	0,30	2,38	14,00	1,81	1,68	0,00	0,00	2,71	22,75	0,00	7,98
Mussels	600,00	429,11	623,00	640,00	472,00	542,00	466,00	736,74	682,40	700,14	570,16
Oysters	187,53	272,10	255,24	147,66	174,91	279,87	157,86	226,62	223,53	276,57	269,34
Seaweed	0,00	0,00	0,00	0,00	0,00	664,00	0,00	1 833,49	1 900,18	2 015,01	2 884,61
TOTAL	**1 160,71**	**1 133,01**	**1 354,26**	**1 298,67**	**1 319,39**	**1 655,23**	**1 407,11**	**3 836,67**	**3 742,44**	**4 007,15**	**1 883,49**

Table 3.4: Total marine production over 20 years per subsector (continued)

Subsector	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total Production (Tons) 2001-2021
Abalone	1 111,41	1 469,78	1 306,80	1 479,22	1 703,32	1 276,06	1 522,21	1 656,53	1 963,80	2 463,29	**24 015,51**
Finfish	48,45	122,54	161,86	77,30	118,60	115,56	73,81	20,10	7,02	13,00	**811,88**
Mussels	859,77	1 116,13	1 682,47	1 758,50	1 960,90	2 083,52	2 182,13	3 053,46	2 275,58	3 420,88	**26 854,91**
Oysters	241,58	277,23	266,40	276,80	357,30	432,66	466,23	382,69	318,36	390,49	**5 880,98**
Seaweed	2 000,00	0,00	1 643,60	0,00	1 114,40	862,07	1 687,07	2 154,54	2 718,10	2 595,03	**24 072,10**
TOTAL	**2 261,22**	**2 985,69**	**3 417,54**	**3 591,82**	**4 140,12**	**3 907,80**	**4 244,39**	**5 112,80**	**4 564,75**	**6 287,66**	**57 563,30**

*Totals exclude seaweed

3.4 Marine Aquaculture Analysis per Subsector

3.4.1 Abalone Subsector

The abalone species currently being cultivated in South Africa is *Haliotis midae*. In 2021, the abalone subsector has increased by 499,49 tons (25%), recording a total of 2 463,29 tons (39%) to the total marine aquaculture production (Figure 3.9). Favorable environmental conditions, research and development and the well-established infrastructure have contributed to the continuous growth of this sector. The abalone subsector comprised of fourteen (14) farms in 2021. The abalone subsector has a distribution range that stretches from the Northern Cape and Western Cape to the EC.

Three (3) farms were operating in the Northern Cape province, two (2) in the EC and nine (9) in the Western Cape province. The production systems utilised within this sector include a flow-through, semi-recirculating aquaculture system, cage culture and ranching. In the Western Cape province, abalone farming all the farms are operating as flow-through operations. In the Northern Cape province, one (1) farm is operating using as a flow-through system, and two (2) farms operating as a ranching operation. In the EC, abalone farming represented by one (1) farm operating as a flow-through operation and one (1) ranching operation.

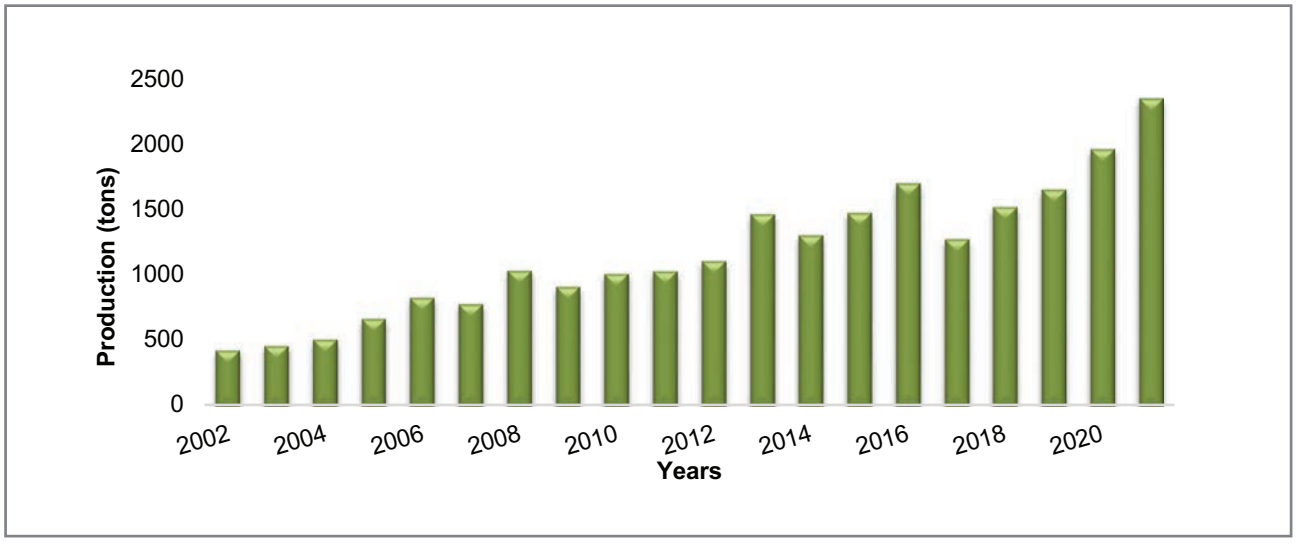


Figure 3.9: Abalone subsector production over 20 years (2001-2021)

3.4.2 Finfish Subsector

The finfish subsector in South Africa is an emerging industry and it shows great potential in terms of production; however, several operations have not been feasible due to the lack of market, technology and their location. In 2021, the subsector contributed a production total of 13,00 tons (0,21%) to the total marine aquaculture production (Figure 3.9). Compared to 2020, the finfish subsector has increased by 5,98 tons (85%).

Four finfish aquaculture farms were operational in 2021. One cage culture operation situated in Saldanha Bay and one pond culture operation in KwaZulu-Natal and two farming culturing finfish using the Recirculating Aquaculture System in the EC (Figure 3.10) represent finfish farming in the Western Cape province.

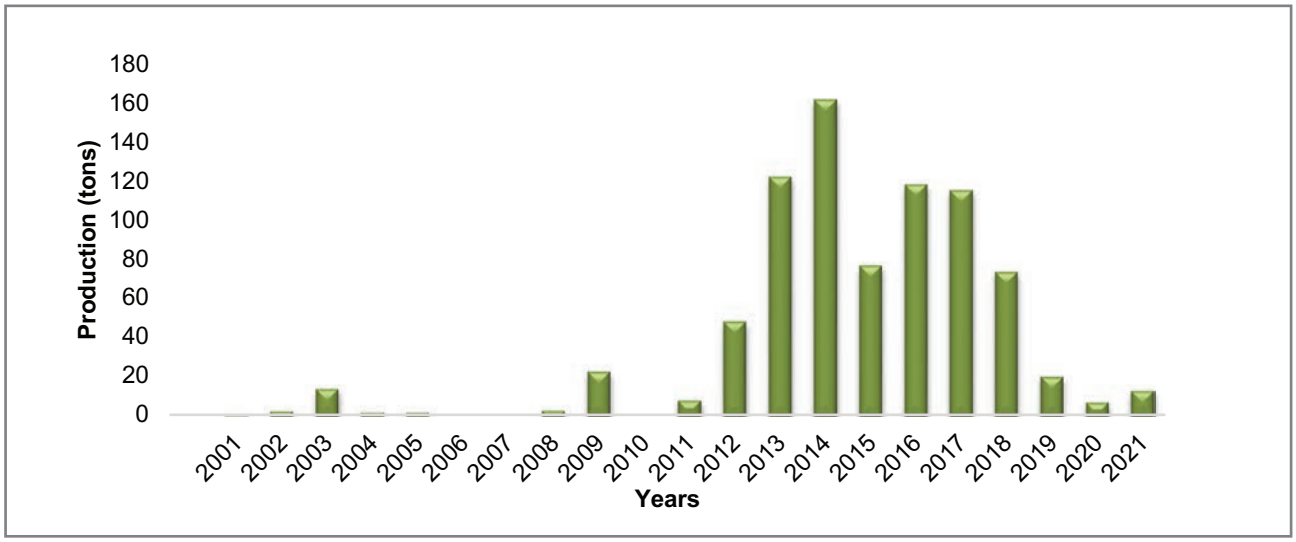


Figure 3.10: Finfish subsector production over 20 years (2001-2021)

3.4.3 Mussel Subsector

In 2021, there were 20 mussel farms operational. The species cultured in South Africa are the exotic Mediterranean mussel (*Mytilus galloprovincialis*) and the indigenous black mussel (*Choromytilus meridionalis*). The mussel's subsector recorded an increase of 1 145,30 tons (50%) thereby contributing a total production of 3 420,88 tons (55%) to the total marine aquaculture sector, as compared to the 2 275,58 tons of mussels produced in 2020 (Figure 3.11). The mussel subsector is the highest contributor in term of biomass to aquaculture in South Africa. The mussel subsector represented by the Western Cape province with 17 longline culture operations and three raft culture operations.

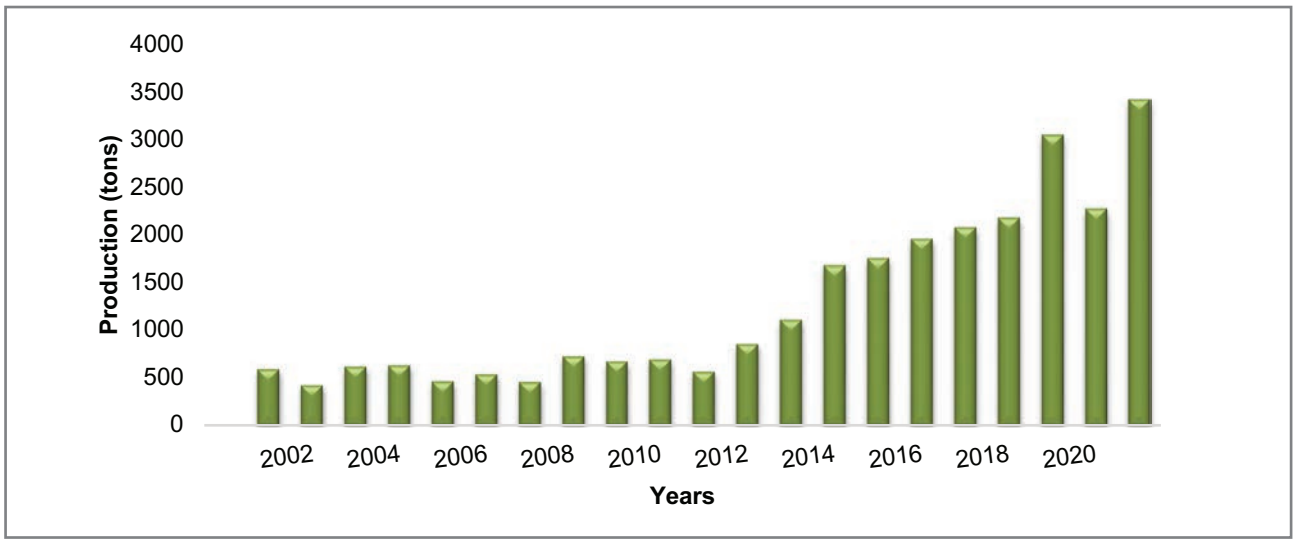


Figure 3.11: Mussel subsector production over 20 years (2001-2021)

3.4.4 Oyster Subsector

The species cultivated in South Africa is the exotic Pacific oyster (*Crassostrea gigas*). In 2021, the subsector recorded a production of 390,45 tons (5%) (Figure 3.12) towards the overall marine aquaculture production, therefore, demonstrating an increase of 72,13 tons (23%). Seven (7) oyster aquaculture farms were operational in 2021. The production systems utilized in this sector include longlines and rafts. Oyster production in the Western Cape province is represented by four (4) longline systems and one (1) raft system. In the Northern Cape province, oysters were cultivated using longline systems, with the EC being represented by one (1) longline system.

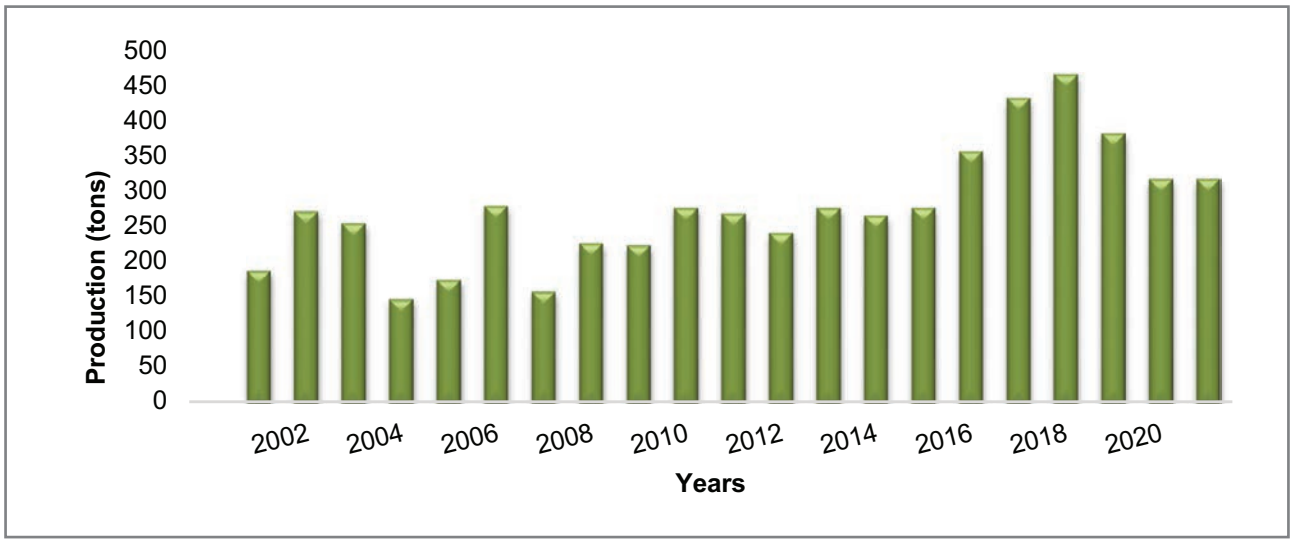


Figure 3.12: Oyster subsector production over 20 years (2001-2021)

3.5 Marine Aquaculture Authorisations

The marine aquaculture sector is regulated under the MLRA. The MLRA provides a regulatory framework for the conservation of ecosystems, the sustainable utilisation, and protection of marine living resources. Even though marine aquaculture is more developmental focused, it forms part of activities that are regulated in terms of the MLRA due to its utilisation of the marine living resources. It continues to be regulated in the form of issuing of Rights, Permits and Exemptions where necessary in terms of the MLRA. The previous Department of Agriculture, Forestry and Fisheries (DAFF) had embarked on a process of drafting new legislation for the aquaculture sector. The process of the development of the Aquaculture Development Bill will create an enabling environment and integrated regulatory framework for both marine and freshwater aquaculture sectors in South Africa.

(a) Marine Aquaculture Rights

Marine Aquaculture Rights are granted in terms of section 18 (1) of the MLRA, which states the following:

"No person shall undertake commercial fishing or subsistence fishing, engage in mariculture or operate a fish processing establishment unless a right to undertake or engage in such an activity or to operate such an establishment has been granted to such a person by the Minister".

The Marine Aquaculture Policy, gazetted in September 2007, provides for the Department to grant marine aquaculture long-term Rights which are valid for a period not exceeding 15 years. On 27 March 2009, the Minister gazetted a General Notice No. 313 of 2009 inviting applications for long term Rights.

Exemptions are granted in terms of section 81 of the MLRA, which states that:
"If in the opinion of the Minister there are sound reasons for doing so, he or she may, subject to the conditions that he or she may determine, in writing exempt any person or group of persons or organ of state from a provision of this Act."

Most marine aquaculture Fish Processing Establishments (FPEs) operate under an Exemption due to institutional delays in the granting of Fish Processing Establishment (FPE) Rights for the marine aquaculture sector. The Department granted a sector-wide Exemption for "South African wholesalers, retailers, restaurants, hotels and other legitimate entities (farmed abalone sellers) to sell undersized, farmed abalone (*Haliotis midae*) without a permit that is issued in terms of Section 13 of the MRLA" (herein referred to as "local sales permits") since 2020. This Exemption was granted to allow for the local sale of undersized cultured products. The Exemption was granted in an effort to lift sales of farmed abalone in the face of Covid-19 impacts on the industry and succeeded in doing so. The Exemption allowed farms to begin the process of growing local markets for their abalone, notwithstanding the fact that they were going to attempt to do so in local consumer, tourism and hospitality sectors that were themselves facing huge disruptions caused by Covid-19 impacts.

The DFFE also issued two exemptions to all fishing sectors and other sectors" to allow for continued business and efficient service delivery in all sectors due to the effects of the Covid-19, the preventative restrictions; office outbreaks and rotational work schedules which caused delays in the issuing of permits. These exemptions were applicable to all operational permits, imports and exports.

In 2021, one new Marine Aquaculture Right was granted in the Western Cape province (Table 3.6). Applications for a Marine Aquaculture Right can be submitted to the DFFE on a continuous basis. The application process is open to any individual with a registered business entity that has shown an interest in undertaking an aquaculture activity. The applicant must meet the criteria set out in the application process and provide the relevant supporting documentation, as required. The completed application, together with all supporting documentation, is assessed by the Marine Aquaculture Working Group (MAWG), which will recommend approval to the Delegated Authority or request any outstanding requirements. Once approval is granted, the applicant is issued with a Marine Aquaculture Right and proceeds to apply for a permit to engage in marine aquaculture.

Table 3.5: Rights to engage in marine aquaculture in 2021.

Company Name	Operational Area	Subsector	Species	Duration of Right
Pearly Beach Sea Farms (Pty) Ltd	Farm Pearly Beach no 385. Western Cape	**Abalone**	*Haliotis midae*	13/12/2021 – 12/12/2036

(b) Permits

To legally use a Right or exemption, a permit is issued in terms of section 13(1) of the MLRA, which states the following:

(1) "No person shall exercise any right granted in terms of section 18 or perform any other activity in terms of this Act unless a permit has been issued by the Minster to such a person to exercise that Right or perform that activity:

(2) Any permit contemplated in subsection (1) shall-be

(a) be issued for specific period not exceeding one year.

(b) be issued subject to the conditions determined by the Minister in the permit; and

(c) be issued against payment of any fees determined by the Minister in terms of section 25(1).

(3) The holder of a permit shall always have that permit available for inspection at the location where the right or activity in respect of which the permit has been issued, is exercised.

(4) A permit to exercise an existing right in terms of the Act may be refused if the conditions of a previously issued permit had not been adhered to."

In 2021, 227 marine aquaculture permits issued in South Africa to Marine Aquaculture Right Holders, agencies, importers, exporters, Fish Processing Establishments (FPEs) and transportation companies (Table 3.2). The total number of issued import permits was 60 which was higher than the total number of permits issued for exports which was 58. There have been lower volumes of imports and exports when compared to the previous years because of the market related challenges associated with the Covid-19 pandemic and the exemptions granted. The abalone sector dominated exports. The exemptions issued to all fishing sector including marine aquaculture also decreased permit volumes.

Table 3.6: Permits issued for 2021 in the marine aquaculture sector, as per section 13 of the Marine Living Resources Act, 1998 (Act No. 18 of 1998)

No.	Permit Type	No. of Permits issued
1	Import marine species and products	60
2	Export cultured marine species and products	58
3	Transport cultured marine species and products	16
4	Engage in marine aquaculture activities	43
5	Possess broodstock and operate a hatchery	13
6	Possess and sell undersized cultured abalone obtained from a right holder	3
7	Engage in abalone ranching and stock enhancement pilot project: Seeding	2
8	Engage in abalone ranching and stock enhancement pilot project: Harvesting	3
9	Operate a Fish Processing Establishment (FPE)	15
10	Conduct scientific investigations and practical experiments	5
11	Dive in banned areas according to *Government Gazette* No. 30716	9
TOTAL		**227**

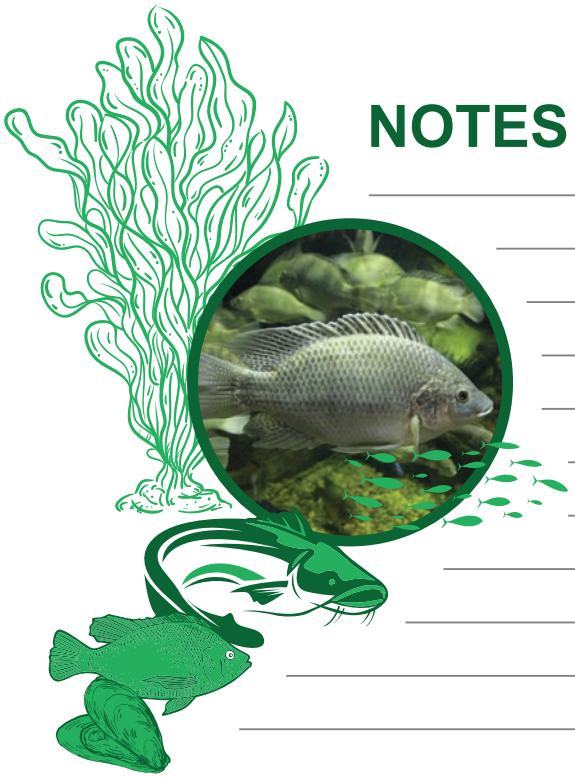
3.6 Site Surveillances of Marine Aquaculture in 2021

The Directorate conducts site visits annually: Sustainable Aquaculture Management (SAM) to marine aquaculture farms when required and on ad hoc basis. These site visits have played a vital role since 2008 in updating information on growth and development in the sector by ensuring compliance with the Department's marine aquaculture permitting frameworks and regulations promulgated under the MLRA. The purpose of the site visits is to ensure compliance with permit conditions on animal health, food safety (for example, annual EU food safety audit), environmental, and reporting requirements.

The site visits are also important to obtain information on any changes in shareholding, culture techniques, and expansion activities in the marine aquaculture sector. This has been essential in ensuring that non-compliant operations are communicated through proper channels such that the Chief Directorate: Monitoring, Control and Surveillance (MCS) performs its role responsibly in protecting the wellbeing of the industry. This has also ensured open channels of communication between the DFFE and the marine aquaculture industry in the development of permit conditions for the sector. The majority of fully established marine aquaculture operations have fish processing establishments (FPEs) on site or supply their product to an FPE for processing, which are also required to comply with the necessary permit conditions.

In 2021, the Department conducted site surveillance of the marine aquaculture abalone, finfish, and bivalve sectors to existing operations situated in the EC and Western Cape. In the Western Cape, 14 oyster/mussel marine aquaculture right holders and six marine aquaculture FPEs were visited. This included one oyster hatchery situated in Paternoster, Western Cape. In the EC, one abalone, two oyster and two finfish marine aquaculture right holders were visited, including two onsite marine aquaculture FPEs.

The Department would like to ensure the continuous open channel for communication from the marine aquaculture sector through the continued support provided in implementing site surveillance. The Directorate: SAM is working closely with other units in the Chief Directorate: Aquaculture and Economic Development (AED) (for example, Operation Phakisa Delivery Unit and Directorate: Aquaculture Technical Services (ATS) when updating information on the status.



NOTES

CHAPTER 4

STATUS OF FRESHWATER AQUACULTURE

4. STATUS OF FRESHWATER AQUACULTURE

4.1 Operational Freshwater Aquaculture Farms

Aquaculture in South Africa is still in its infancy and small-scale aquaculture farmers dominate the freshwater sector. The current aquaculture legislation does not cater to the freshwater sector, which makes submission of sector related information from farmers difficult to enforce. Therefore, it is important to note that the information presented in this chapter based on reported data only and may not be a true reflection of the entire freshwater aquaculture sector.

There was a decline in the number of freshwater farms operating in 2021 from the 163 farms recorded in 2020 to 151 recorded in 2021. These can be attributed to the number of farms that closed down due to challenges associated with the Covid-19 pandemic.

Table 4.1: Total number of freshwater aquaculture farms operating in South Africa by subsector and province in 2021

Species	EC	FS	GP	KZN	LP	MP	NC	NW	WC	TOTAL
Catfish	1	4	1	2	7	1	0	3	0	19
Common carp	0	0	1	0	1	0	2	0	1	5
Marron crayfish	2	0	0	0	0	0	0	0	0	2
Ornamentals	2	0	5	7	1	3	0	0	2	20
Tilapia	3	0	16	5	21	12	1	12	1	71
Trout	1	0	3	5	0	10	0	0	15	34
TOTAL	**9**	**4**	**26**	**19**	**30**	**26**	**3**	**15**	**19**	**151**

The total number and percentage contributions (Table 4.1 and Figure 4.1) towards freshwater aquaculture per province were as follows:

- Limpopo province (LP, 30 farms, 19%);
- Gauteng province (GP, 26 farms, 17%);
- Mpumalanga province (MP, 26 farms, 17%);
- KwaZulu-Natal province (KZN, 19 farms, 13%);
- Western Cape province (WC, 19 farms, 13%);
- North-West province (NW, 15 farms, 10%);
- Eastern Cape province (EC, 9 farms, 6%);
- Free State province (FS, 4 farms, 3%); and
- Northern Cape province (NC, 3 farms, 2%).

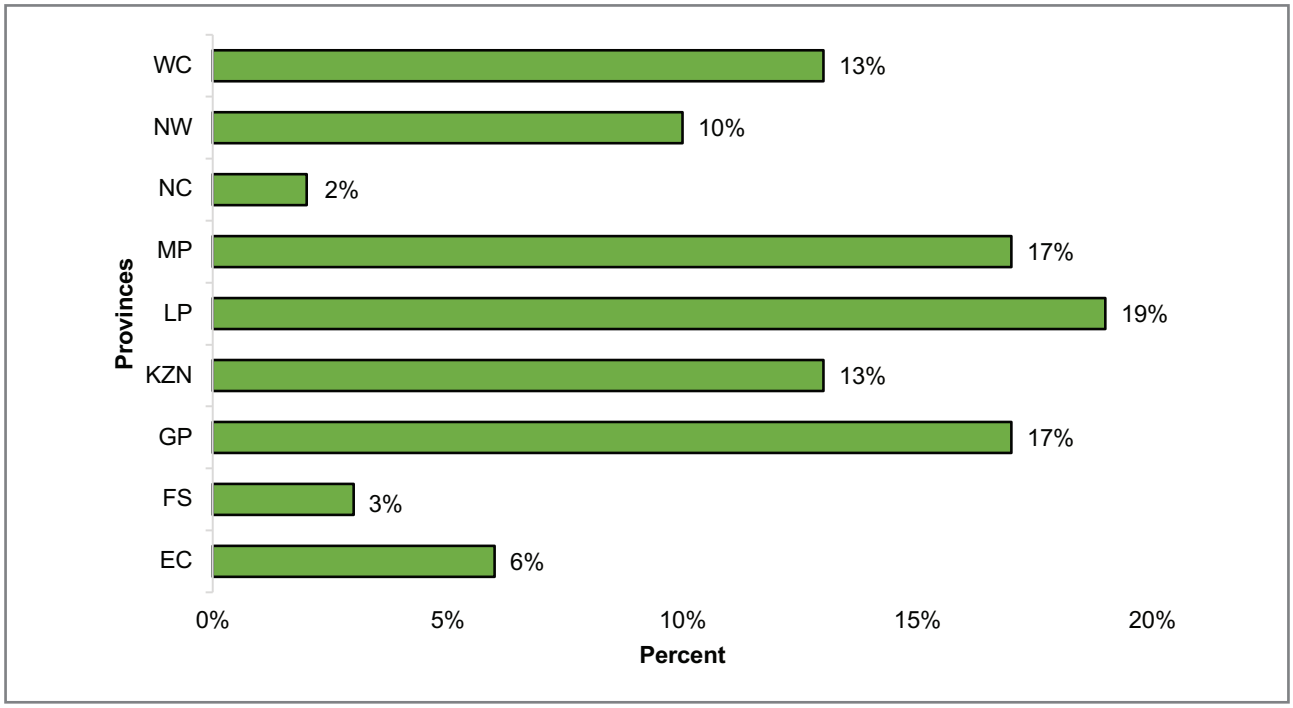


Figure 4.1: Freshwater aquaculture farms per province

4.2 Freshwater Aquaculture Species Farmed

The freshwater aquaculture species cultured during 2021 included African sharptooth catfish (*Clarias gariepinus*), rainbow trout (*Oncorynchus mykiss*), brown trout (*Salmo trutta*), common carp (*Cyprinus carpio*), Koi carp (*Cyprinus rubrofuscus*), marron crayfish (*Cherax tenuimanus*), Mozambique tilapia (*Oreochromis mossambicus*) and Nile tilapia (*Oreochromis niloticus*). The aquaculture operations for the culturing of the above species include small-scale (<20 tons as an annual production scale), research and commercial farms (Table 4.2).

Table 4.2: Freshwater aquaculture species cultured in South Africa in 2021 and their operational scale

Freshwater Aquaculture Species in South Africa (2021)		
Common name	**Scientific name**	**Production scale**
African sharptooth catfish	*Clarias gariepinus*	Commercial and small scale
Brown trout	*Salmo trutta*	Commercial
Common carp	*Cyprinus carpio*	Small scale
Koi carp	*Cyprinus rubrofuscus*	Small scale
Marron crayfish	*Cherax tenuimanus*	Small scale
Mozambique tilapia	*Oreochromis mossambicus*	Small scale and research
Nile tilapia	*Oreochromis niloticus*	Commercial
Rainbow trout	*Oncorynchus mykiss*	Commercial

4.3 Freshwater Aquaculture Production Scales (Tons)

4.3.1 Freshwater Aquaculture Production in 2021

The freshwater aquaculture small-scale production during 2021 was 1 482,30 tons, which is a slight increase from the 1 481,22 tons, recorded in 2020, suggesting a 1,08 ton, 0,07% increase. The total number and percentage contributions (Table 4.2 and Figure 4.2) towards freshwater aquaculture production per province were as follows:

- KwaZulu-Natal province (KZN, 423,30 tons, 29%);
- Western Cape province (WC, 395,00 tons, 26%);
- Mpumalanga province (MP, 297,10 tons, 20%);
- Eastern Cape province (EC, 114,80 tons, 8%);
- Gauteng province (GP, 97,10 tons, 7%);
- Limpopo province (LP, 83,30 tons, 6%);
- North-West province (NW, 50,00 tons, 3%);
- Northern Cape province (NC, 20,90 tons, 1%); and
- Free State province (FS, 0,80 tons, 0%).

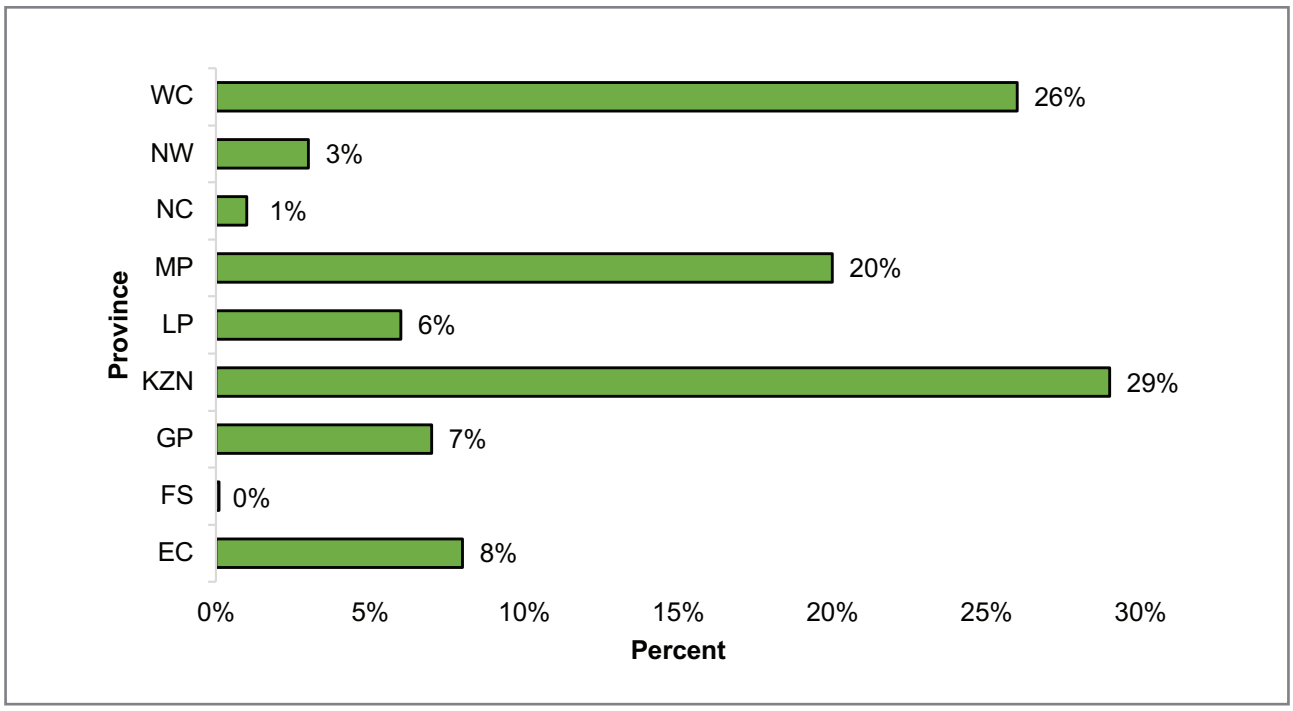


Figure 4.2: Freshwater aquaculture production per province

Table 4.3: Freshwater aquaculture total production per subsector in each province in 2021

Subsector	EC	FS	GP	KZN	LP	MP	NC	NW	WC	TOTAL
Catfish	42,00	0,80	0,00	8,00	2,00	0,00	1,30	0,00	3,50	57,60
Common carp	2,00	0,00	1,60	0,00	2,50	0,00	2,50	0,00	3,70	12,30
Marron crayfish	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2,00	3,00
Ornamentals	3,00	0,00	4,50	4,50	0,80	1,90	1,00	0,00	1,80	17,50
Tilapia	55,60	0,00	7,00	7,00	78,00	45,00	4,00	50,00	0,00	246,60
Trout	11,20	0,00	84,00	403,80	0,00	250,20	12,10	0,00	384,00	1 145,30
TOTAL	**114,80**	**0,80**	**97,10**	**423,30**	**83,30**	**297,10**	**20,90**	**50,00**	**395,00**	**1 482,30**

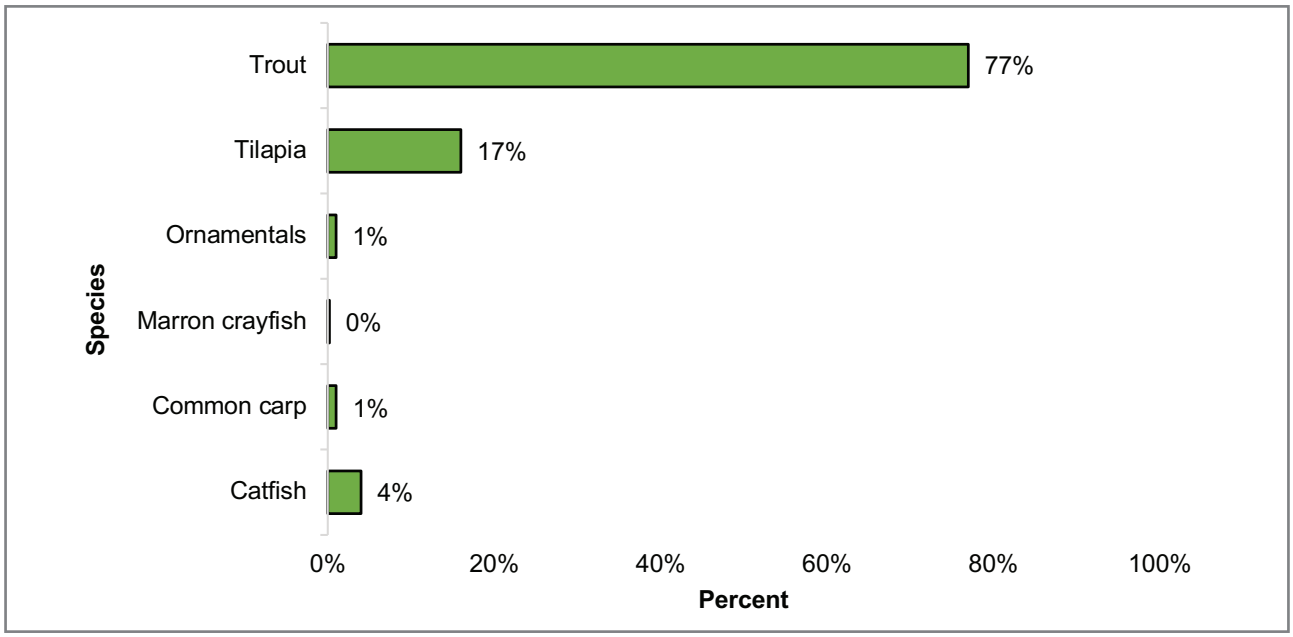


Figure 4.3: Contribution of each freshwater aquaculture subsector to the total production in 2021

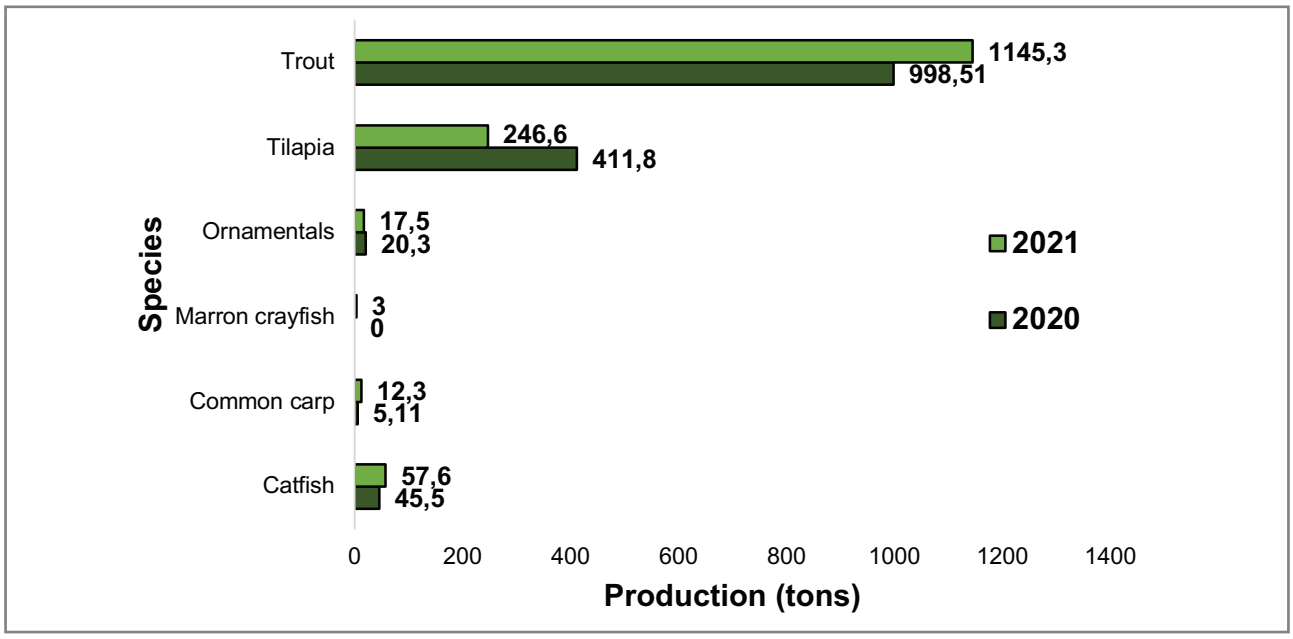


Figure 4.4: Comparison of 2020 and 2021 production per species

4.3.2 Freshwater Aquaculture Production (2006-2021)

The freshwater aquaculture production during 2021 was 1 482,30 tons compared to 2020 at 1 481,22 tons and 2019 at 1 972,9 tons. The trout subsector remains the highest contributor to the freshwater aquaculture production, contributing 77% with 1 145,30 tons. This is a 15% increase from the 998,51 tons recorded in 2020. Marron crayfish remains the least contributor with 0% from the 3 tons contribution recorded in 2021 to the total freshwater production, which is an increase from the 0 tons recorded in 2020.

The tilapia subsector demonstrated a decrease in production with 246,60 tons recorded in 2021 from the 411,80 tons that during 2020, thereby contributing 17% to the total freshwater production. The ornamentals and common carp subsectors both contributed 1% to the total freshwater production. Ornamentals contributed 17,50 tons and common carp contributing 12,30 tons. The catfish subsector recorded a 27% increase of 57,6 tons in 2021 from 45,50 tons in 2020, which is a 4% contribution to the total freshwater production.

4.4 Freshwater Production Trends over 15 years (2006-2021)

The freshwater aquaculture production has been increasing steadily since a production volume of 987,20 tons recorded in 2006. However, in 2007, the production volume dropped by 15% to 838,40 tons. From 2008, the sector recorded an increase in production volume of 1 123,40 tons, which continued to increase until 2016 where a decrease in production experienced from 1 867,10 to 1 680,70 in 2017.The highest production volume was in 2018 at 2 121,40 tons, which was a 26% increase from the previous year in 2017. Another decrease in production volume was in 2019 and 2020 where 1 972,86 and 1 481,22 tons. In 2021, 1 482,30 tons was recorded, which is a 0,07% increase from 2020.

NOTES

Table 4.4: Total freshwater production over 15 years per subsector (2006-2021)

Subsector	2006	2007	2008	2009	2010	2011	2012	2013	2014
Catfish	180,00	180,00	180,00	180,00	180,00	160,00	0,00	0,00	0,00
Common carp	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Marron crayfish	0,20	0,40	0,40	0,40	0,80	0,80	3,50	5,00	5,00
Ornamentals	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Tilapia	0,00	0,00	0,00	10,00	10,00	100,00	234,20	289,70	289,70
Trout	807,00	658,00	943,00	948,62	950,00	1 199,00	1 428,00	1 497,30	1 497,30
TOTAL	**987,20**	**838,40**	**1 123,40**	**1 139,02**	**1 140,80**	**1 459,80**	**1 665,70**	**1 792,00**	**1 792,00**

Table 4.4: Freshwater aquaculture production per subsector (2006-2021) (Continued)

Subsector	2015	2016	2017	2018	2019	2020	2021	Total Production (Tons) 2006-2021
Catfish	0,00	3,30	3,30	20,00	59,90	45,50	57,60	1 249,60
Common carp	0,00	0,00	5,30	7,10	6,10	5,11	12,30	35,91
Marron crayfish	4,00	4,00	4,00	4,00	4,00	0,00	3,00	39,50
Ornamentals	0,00	16,00	16,00	16,00	16,00	20,30	17,50	101,80
Tilapia	325,30	340,80	402,30	571,30	303,86	411,80	246,60	3 535,56
Trout	1 497,00	1 503,00	1 249,80	1 503,00	1 583,00	998,51	1 145,30	19 407,83
TOTAL	**1 826,30**	**1 867,10**	**1 680,70**	**2 121,40**	**1 972,86**	**1 481,22**	**1 482,30**	**24 370,20**

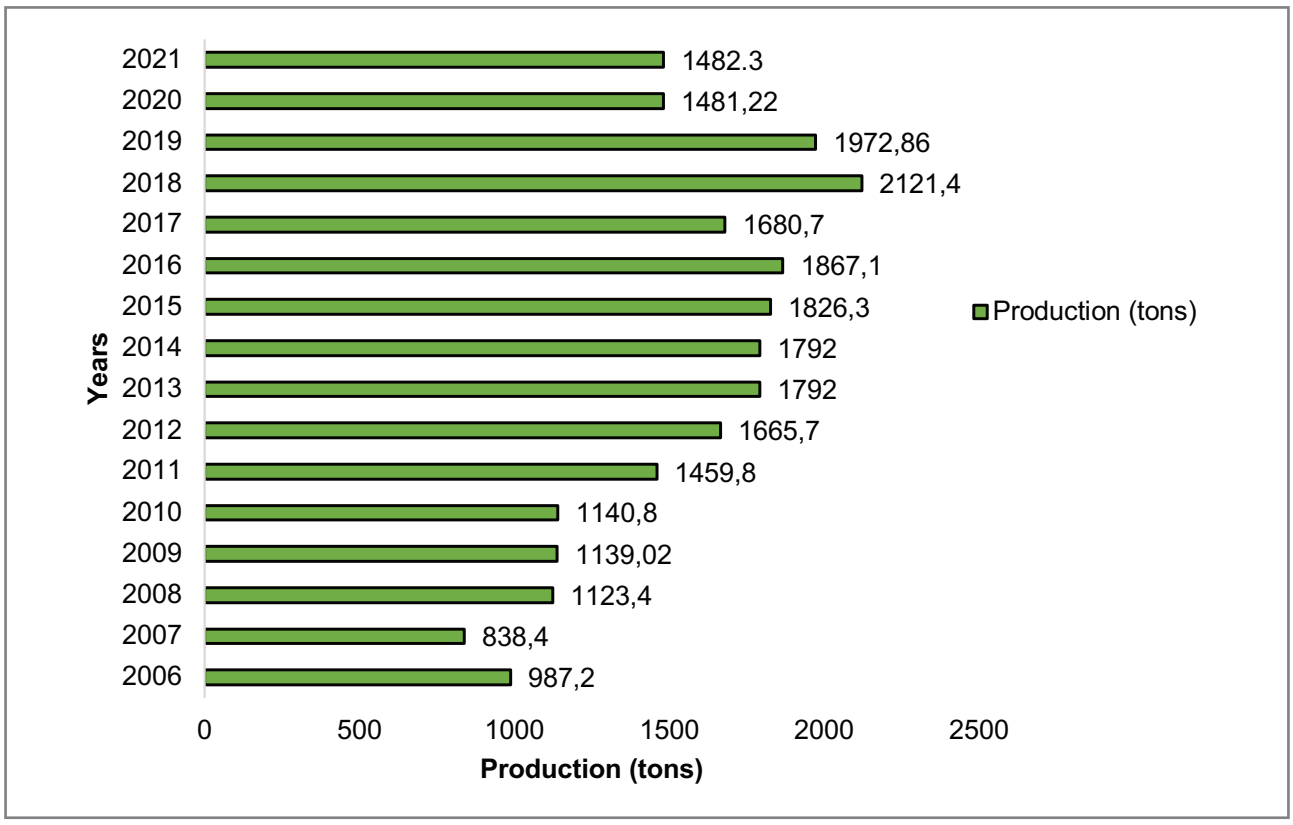


Figure 4.5: South Africa's freshwater production from 2006 to 2021

4.5 Freshwater Analysis per Subsector

4.5.1 Catfish Subsector

Producers within the catfish subsector are predominantly small scale with only one known commercial farm situated in the EC. Farming of the species is through RAS and ponds culture systems in Mpumalanga, Limpopo, KZN, Gauteng, North-West and EC provinces. The subsector has experienced fluctuating production volumes over the years with 180,00 tons recorded from 2006 to 2009. There was no production recorded from 2012 to 2015 and production volumes recovered from 3,30 tons recorded in 2016 and 2017 to 20,00 tons in 2018. The subsector recorded the highest production volume in 2020 with 59,90 tons. Total production volume for catfish in 2021 was 57,6 tons, which is a 26% increase from the 2020 production volume of 45,50 tons. The catfish subsector contributed 4% towards the freshwater aquaculture sector and 1% to the overall national aquaculture sector.

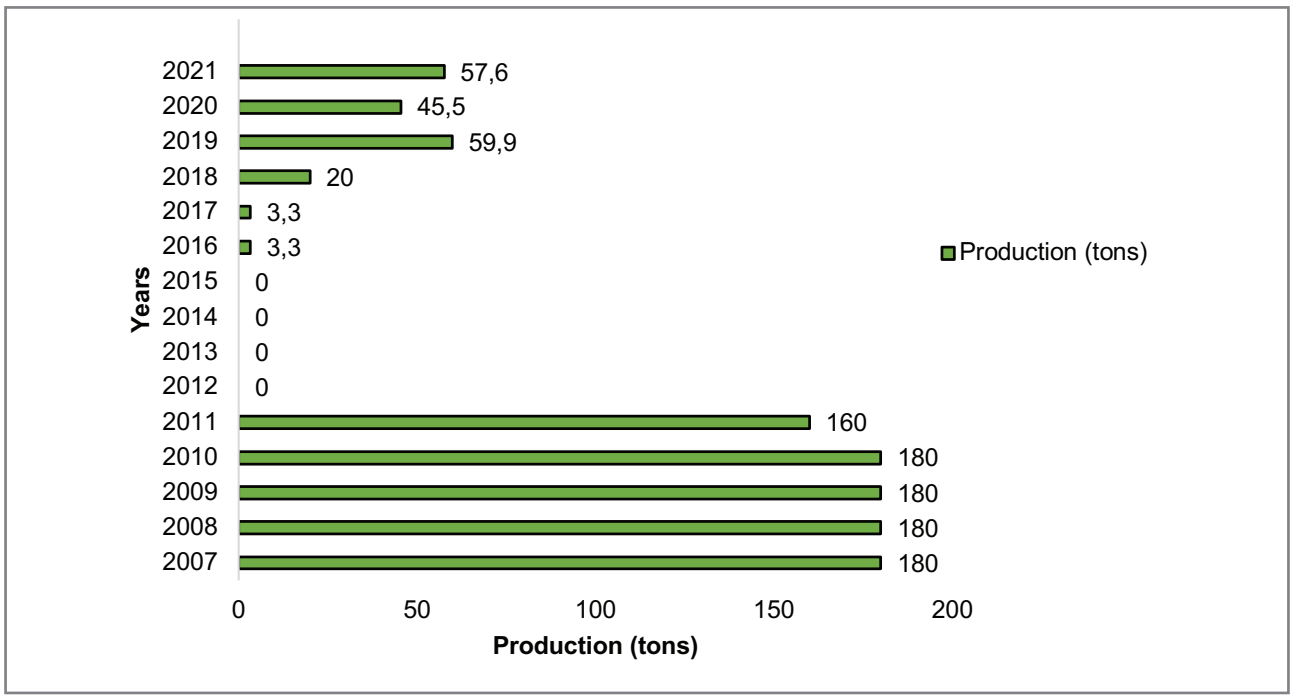


Figure 4.6: Catfish production in South Africa from 2007 to 2021

4.5.2 Common Carp Subsector

The common carp subsector has the second lowest production volumes within the freshwater sector with 12,3 tons recorded in 2021. Species were farmed in Gauteng, Limpopo, Northern Cape and Western Cape provinces, respectively. There was no production recorded in the subsector from 2006 to 2016. In 2017, 5,30 tons was recorded, 7,10 tons was recorded in 2018, while in 2019, and 6,10 tons was recorded. Production volumes for 2021 increased by 142% from 5,11 tons recorded in 2020 to 12,3 tons in 2021. The percentage contribution towards the freshwater aquaculture sector was 1% and 0,16% to the national aquaculture sector.

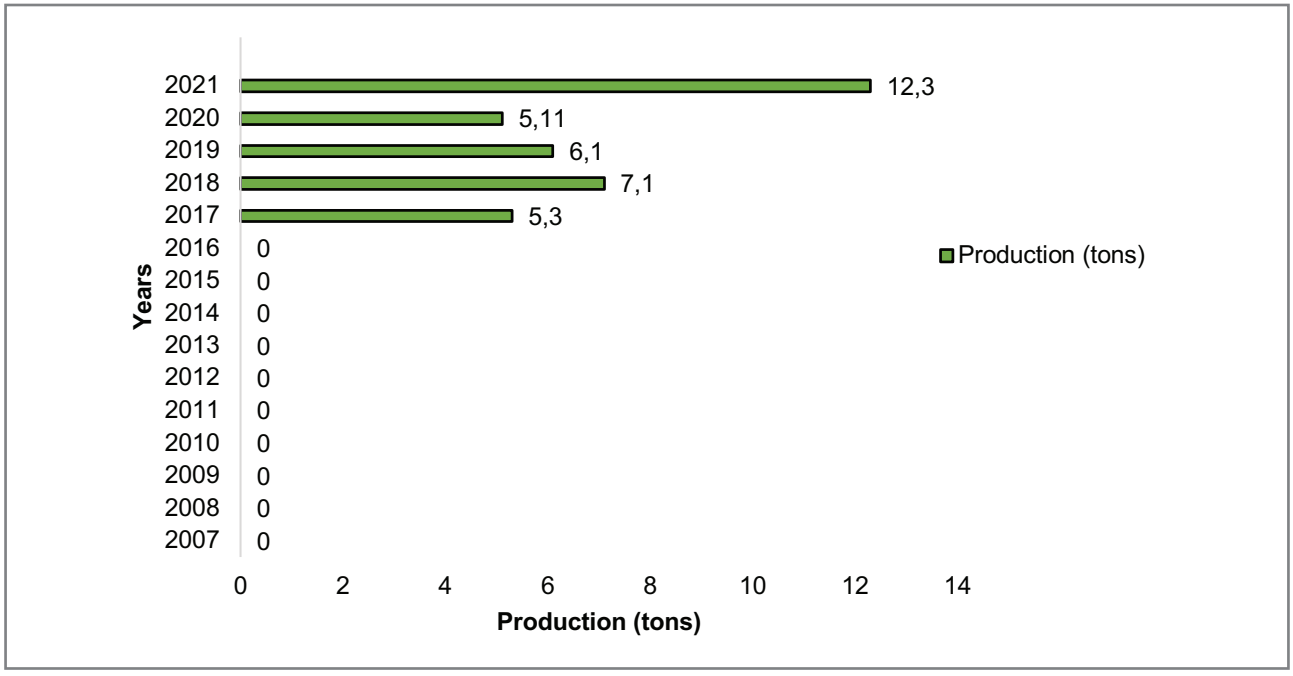


Figure 4.7: Common carp production in South Africa from 2007 to 2021

4.5.3 Marron Crayfish Subsector

This is the smallest subsector within the freshwater sector in terms of production volumes with 3,00 tons recorded in 2021 compared to the 0,00 tons in 2020. The species are farmed only in the EC and contributes 0% towards the freshwater sector and 0,04% to the national aquaculture sector. The subsector increased from 0,00 tons in 2020 to 3,00 tons in 2021, which is a 100% increase with a 0,04% contribution towards the national aquaculture sector.

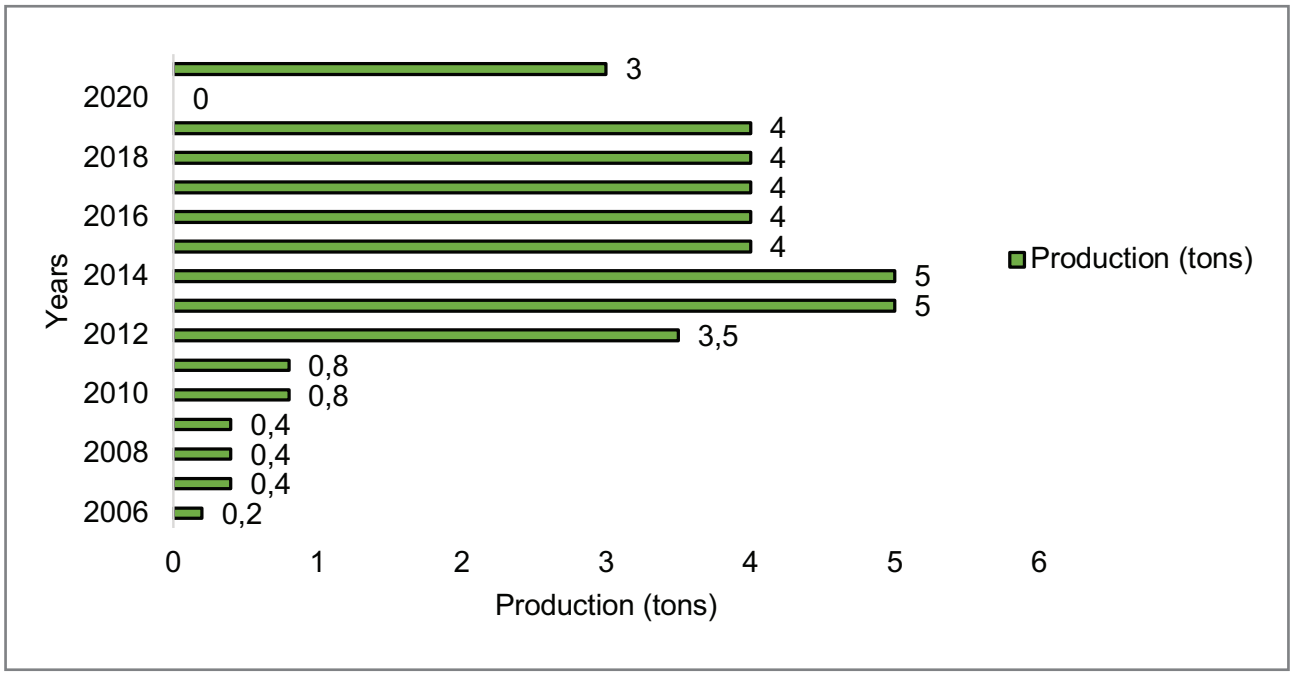


Figure 4.8: Marron crayfish production in South Africa from 2006 to 2021

4.5.4 Ornamental Subsector

The ornamental subsector is relatively small and dominated by small scale operations that are situated in seven of the nine provinces, with the exception of Free State and North-West provinces where farms were not recorded. In 2020, a production volume of 20,30 tons was recorded and this value decreased by 14% to 17,50 in 2021. The subsector contributed 1% towards the freshwater aquaculture sector and 0,26% towards the national sector.

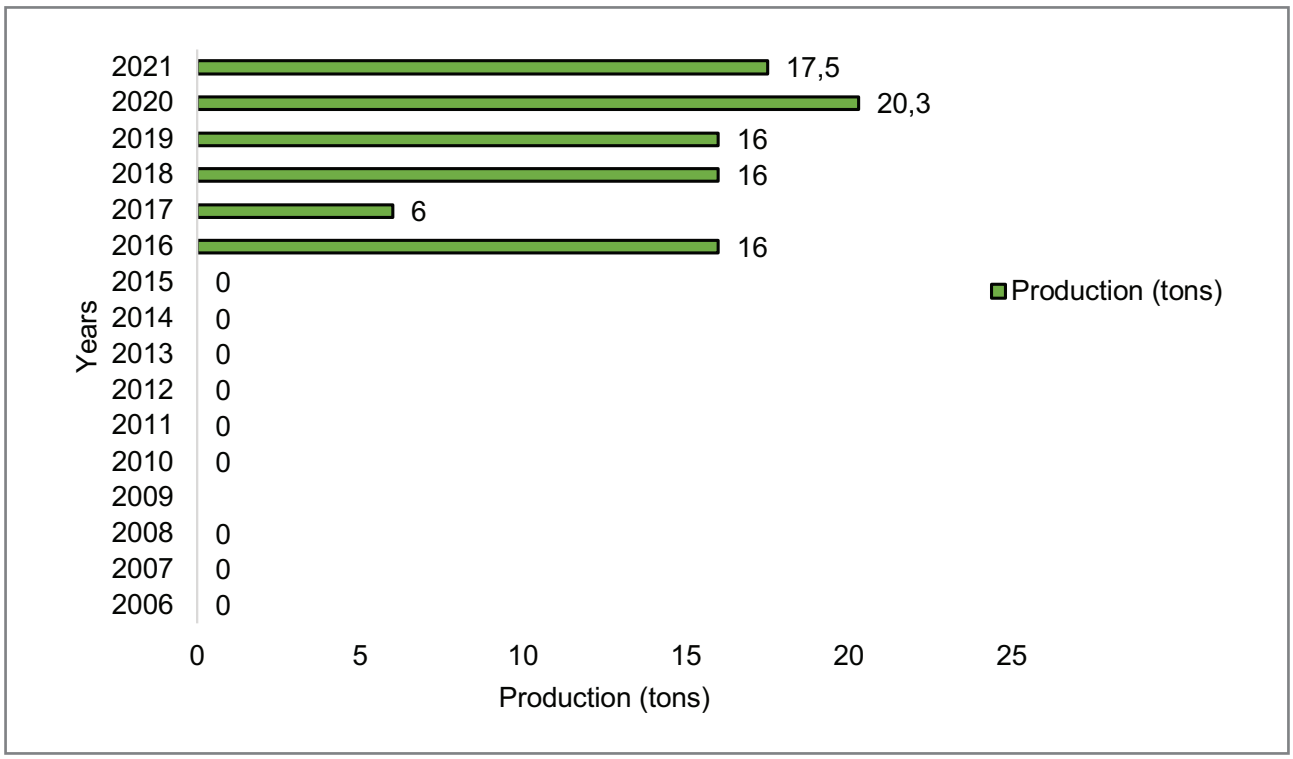


Figure 4.9: Ornamentals production in South Africa from 2006 to 2021

4.5.5 Tilapia Subsector

The tilapia subsector consists of Nile and Mozambique tilapia farmers who are situated in eight (8) of the nine (9) provinces, with the exception of Free State province. In the past 16 years from 2006 to 2021, the subsector recorded zero (0) production volume from 2006 to 2008 when production of 10 tons was recorded and remained the same until 2010 production. The subsector breached the 100 tons mark in 2011 and increased steadily until 2019 when a significant decrease in production volume of 303,86 was recorded from 571,30, which remains the highest production volume recorded since 2006. In 2020, the subsector recorded 411,80 tons and the production volume dropped by 40% to 246,60 tons in 2021. The tilapia subsector contributed 17% towards the freshwater aquaculture sector and 3% towards the national aquaculture sector.

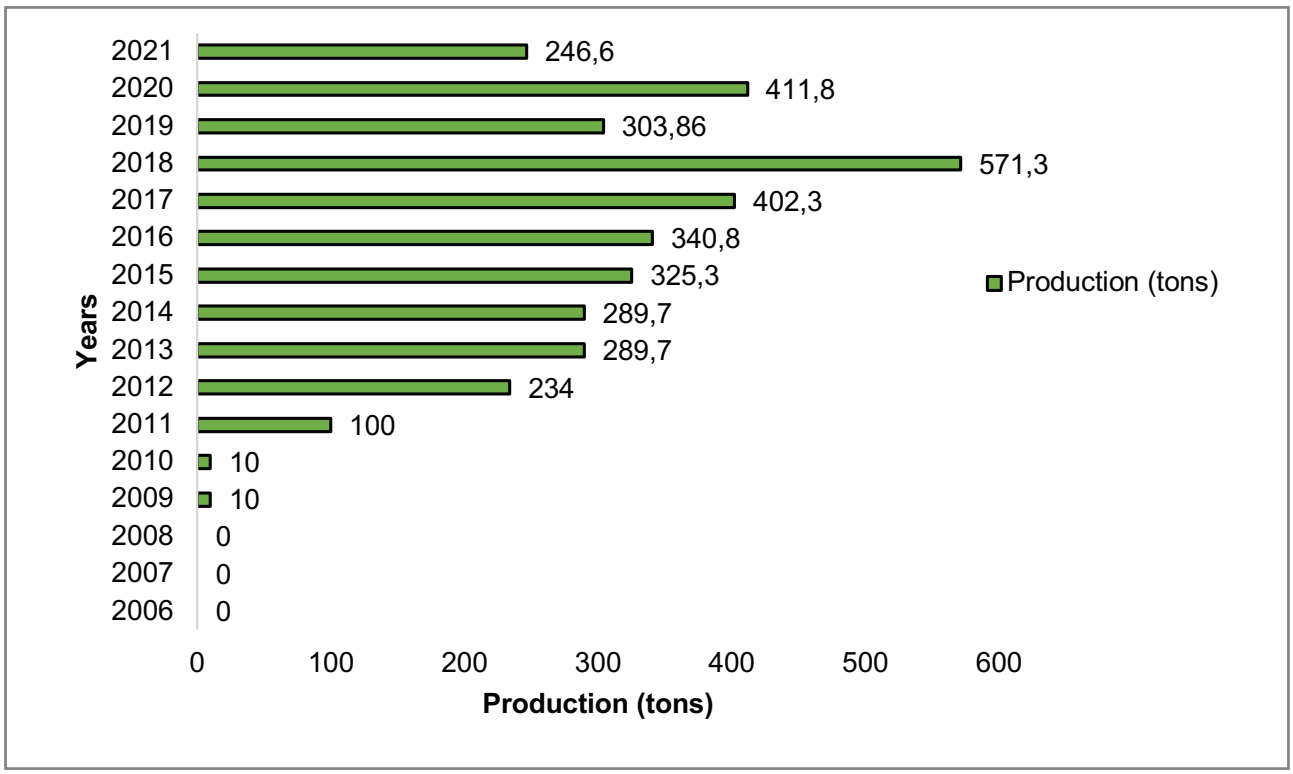


Figure 4.10: Tilapia production in South Africa from 2006 to 2021

4.5.6 Trout Subsector

The trout subsector remains the highest contributor to the freshwater aquaculture production, contributing 77% with 1 145,30 tons. This is an increase of 15% from 2020 from 998,51 tons. The subsector has been growing consistently from 2006, where 807,00 tons was recorded and breached the 1 000 tons mark in 2011 when 1 199,00 tons were recorded. The highest production volume recorded in the subsector is 1 583,00 tons in 2019, which has decreased by 28% to the 1 145,30 tons recorded in 2021. The subsector contributes 15% to the national aquaculture sector.

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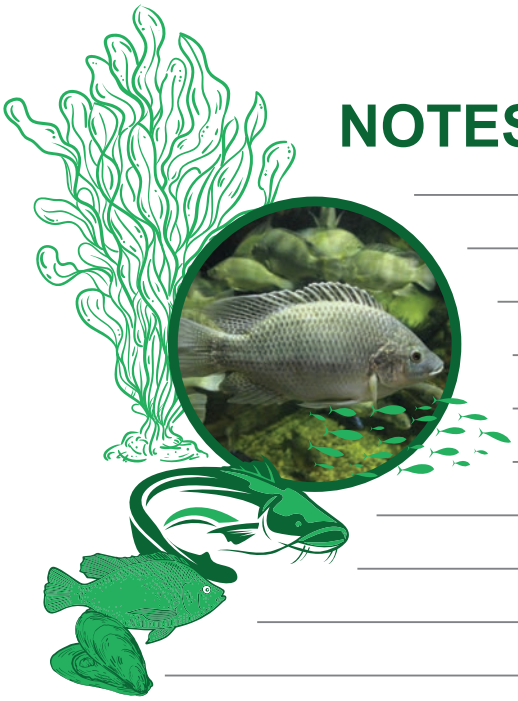

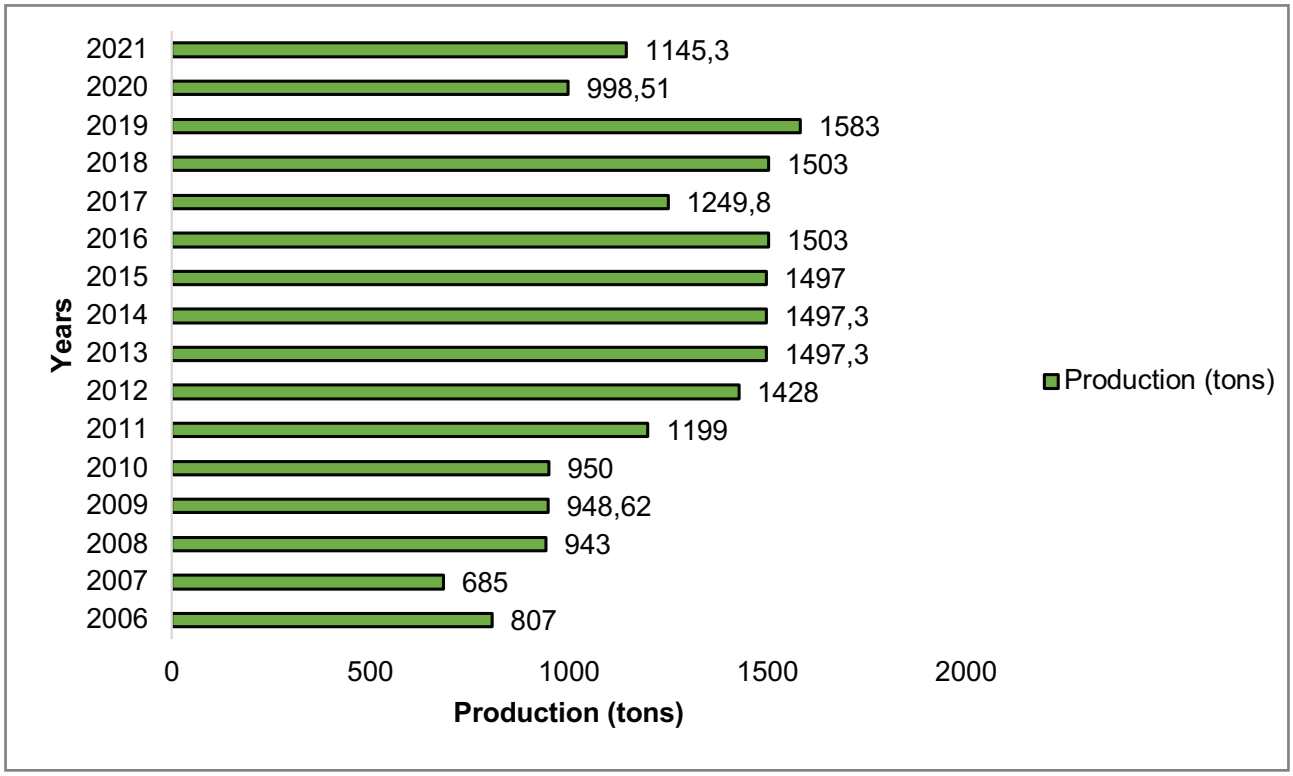

Figure 4.11: Trout production in South Africa from 2006 to 2021

4.6 Freshwater Aquaculture Authorisations

The freshwater sector is currently being legislated through provincial ordinances, as there is no overarching legislation, which enables the DFFE to authorise the sector. The DFFE is addressing this challenge through the development of an Aquaculture Development Bill.

4.7 Site Surveillances of Freshwater Aquaculture in 2021

No site surveillances were undertaken in 2021 due to limitations associated with legislation. Some farms were visited as part of the ADEP and these are accounted for in Chapter 7 of this report.

NOTES

CHAPTER 5

PROVINCIAL ANALYSIS OF THE AQUACULTURE SECTOR

5. PROVINCIAL ANALYSIS OF THE AQUACULTURE SECTOR

5.1 Eastern Cape Province

The EC is the second-largest province in South Africa by surface area and has major potential for agricultural activities. The province is located on the east coast of South Africa between the Western Cape and KwaZulu-Natal provinces. Marine and freshwater aquaculture activities operate in the province.

Figure 5.1: South Africa's map showing the Eastern Cape province

Number of farms and species farmed: In 2021, the EC recorded 14 farms that include five marine farms and nine freshwater farms. This is an increase from the 13 farms that were recorded in 2020. These comprised of two abalone, two finfish, one oyster, one catfish, two marron crayfish, two ornamental, one trout and three tilapia farms.

Production: The abalone subsector recorded the highest production volume in 2021 with 163,37 tons, followed by the oyster subsector with 82,13 tons. The subsector with the lowest production volume was marron crayfish with 1 ton. The EC has a total contribution of 360,30 tons from both marine and freshwater sectors, contributing 4,6% to the national aquaculture production. The total contribution for the EC increased by 41% from the 255,08 tons recorded in 2020. Marine aquaculture in the province produced 245,50 tons in 2021 accounting for 3,9% of the national marine aquaculture production and 3,1% towards the national aquaculture production. Freshwater aquaculture produced 114,80 tons in 2021 in the EC, accounting for 7,7% to the freshwater aquaculture production and 1,5% to the national aquaculture production.

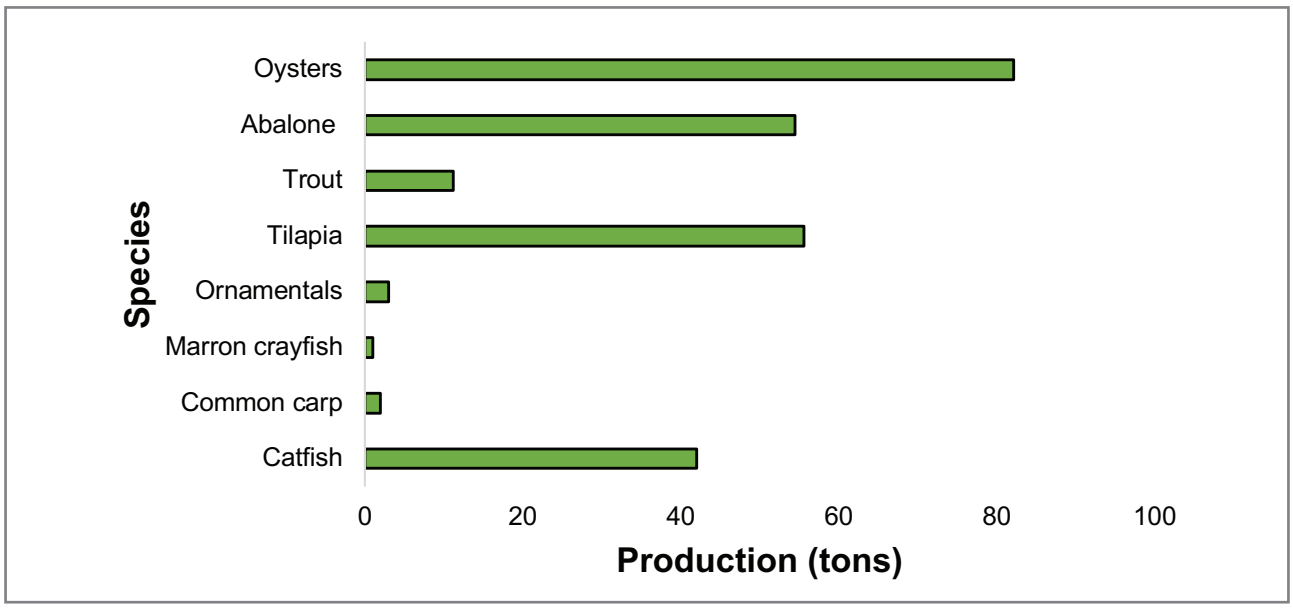

Figure 5.2: Aquaculture production in the Eastern Cape province

5.2 Free State Province

Free State is the third-largest province in South Africa and is located in the geographical centre of South Africa. The province has a facility (Aquaculture Technology Demonstration Centre) which is located in the Xhariep District, whose primary functions are to demonstrate breeding techniques; technology demonstration of culture systems; research studies, development studies; and training, capacity building and promotion. Only freshwater aquaculture activities recorded as the province is land-locked and does not practice any marine aquaculture activities.

Figure 5.3: South Africa's map showing the Free State province

Number of farms and species farmed: The Free State province recorded a total number of four (4) freshwater farms. All recorded farms were from the catfish subsector. This is a decrease from the nine (9) farms recorded in 2020.

Production: The total production volume recorded for Free State province is 0,80 tons from the catfish subsector. This significant decrease from the twelve (12) tons recorded in 2020. There was no production volume recorded for the other subsectors, except for catfish. The total production volume for the province contributed 0,0005% to the national freshwater production and 0,0001% to the national aquaculture production.

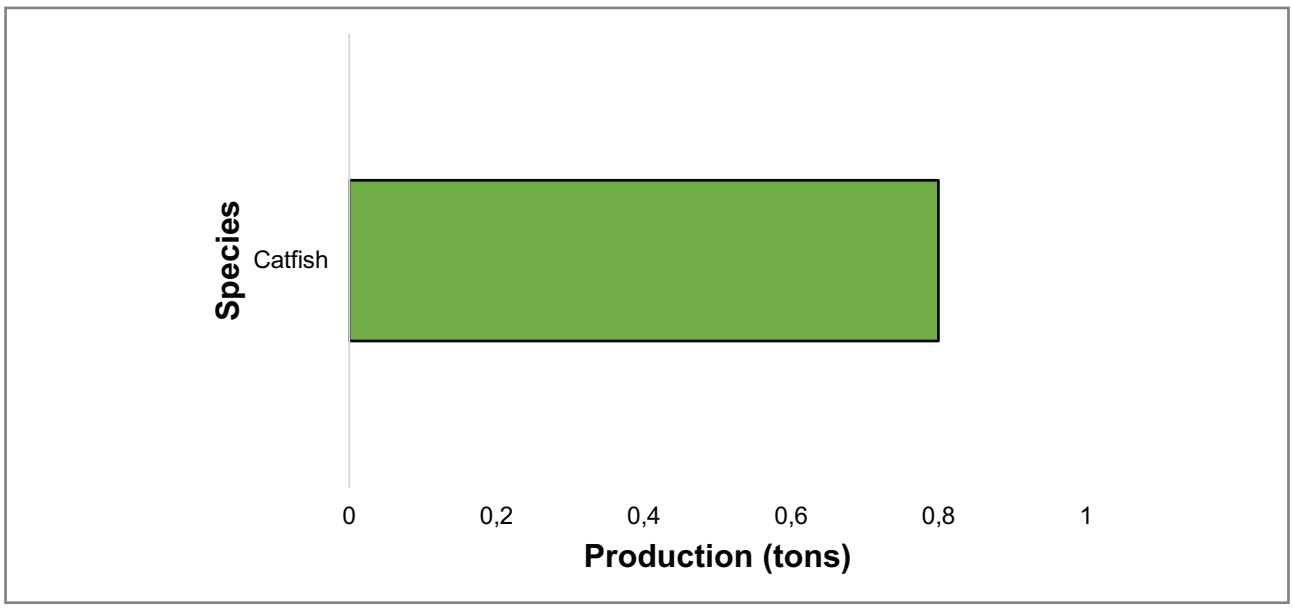

Figure 5.4: Aquaculture production in the Free State province

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5.3 Gauteng Province

Gauteng is the smallest of South Africa's provinces, but the province serves as an economic hub of the country and the subcontinent due to availability of key sectors and relevant logistical resources. The province accounts for production of freshwater species.

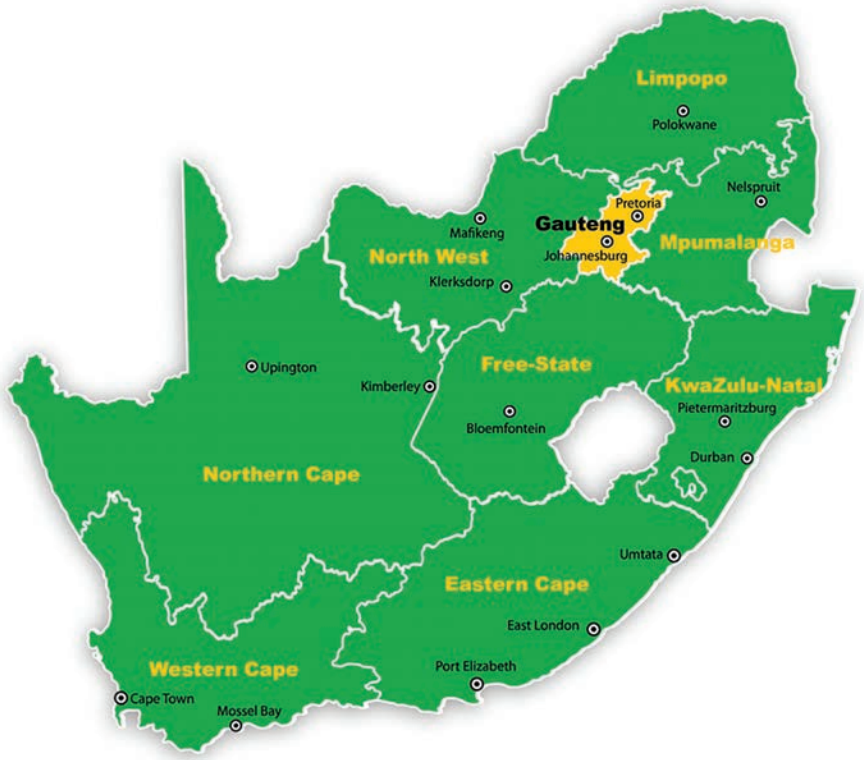

Figure 5.5: South Africa's map showing the Gauteng province

Number of farms and species farmed: In 2021, 26 farms were recorded in the Gauteng province, which is a decrease from the 37 farms that were recorded in 2020. The farms comprised one catfish, one common carp, five ornamental, three trout and 16 tilapia farms.

Production: The trout subsector recorded the highest production volume with 84 tons, followed by the tilapia subsector with 7 tons. The ornamental and common carp subsectors recorded 4,5 tons and 1,6 tons, respectively. The total production volume for the province was 97,10 tons, which is a 51% decrease from the 197,8 tons that recorded in 2020. The production volume for Gauteng province contributes 6,6% to the total freshwater aquaculture production and 1,3% to the national aquaculture production.

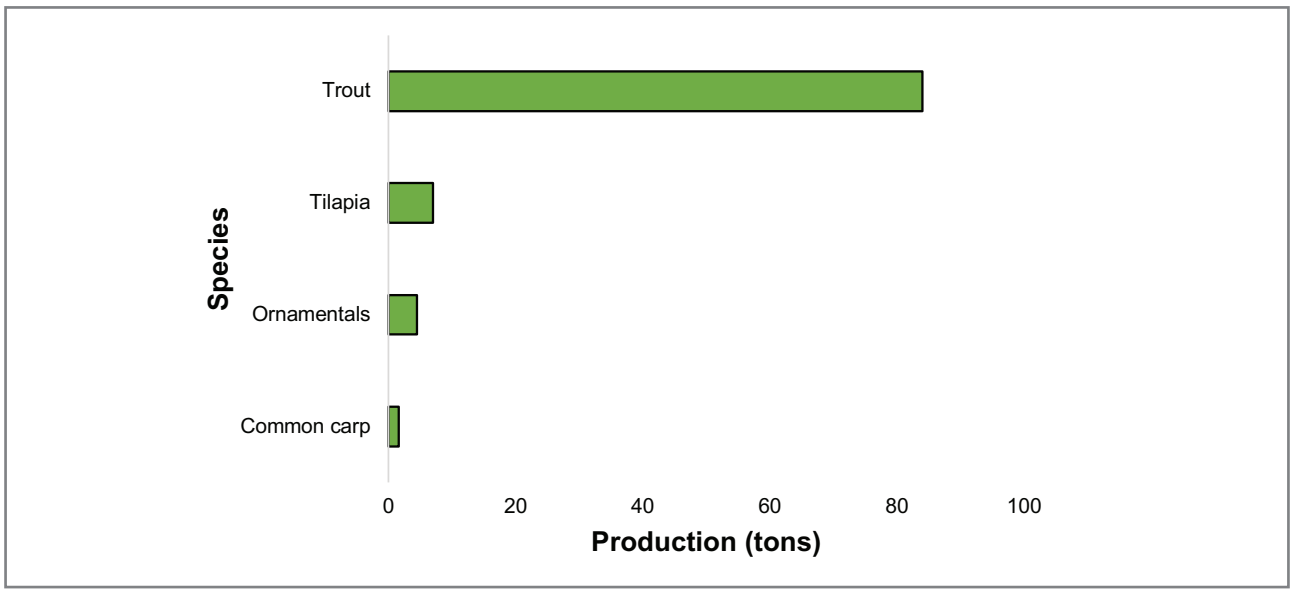

Figure 5.6: Aquaculture production in the Gauteng province

5.4 KwaZulu-Natal Province

KwaZulu-Natal is the third smallest province in the country, situated in the southeast of South Africa bordering the Indian Ocean. The province is one of four coastal provinces that account for both marine and freshwater aquaculture activities.

Figure 5.7: South Africa's map showing the KwaZulu-Natal province

Farms and species farmed: In 2021, the province recorded twenty (20) farms, which is an increase from the thirteen (13) farms recorded in 2020. There were nineteen (19) freshwater farms and one (1) marine farm comprising one (1) marine finfish, two (2) catfish, five (5) trout, five (5) tilapia and seven (7) ornamental farms.

Production: The trout subsector contributed the highest production volume with 403,80 tons, followed by the catfish subsector with 8,00 tons. The tilapia and ornamental subsectors contributed 7,00 and 4,50 tons, respectively. The marine finfish subsector recorded zero (0) production in 2021. The total production recorded for KZN in 2021 was 423,30 tons which is a 3% decrease from the 436,80 tons that was recorded in 2020. The total production volume for the province contributes 29% to the national freshwater production and 5,5% to the national aquaculture production.

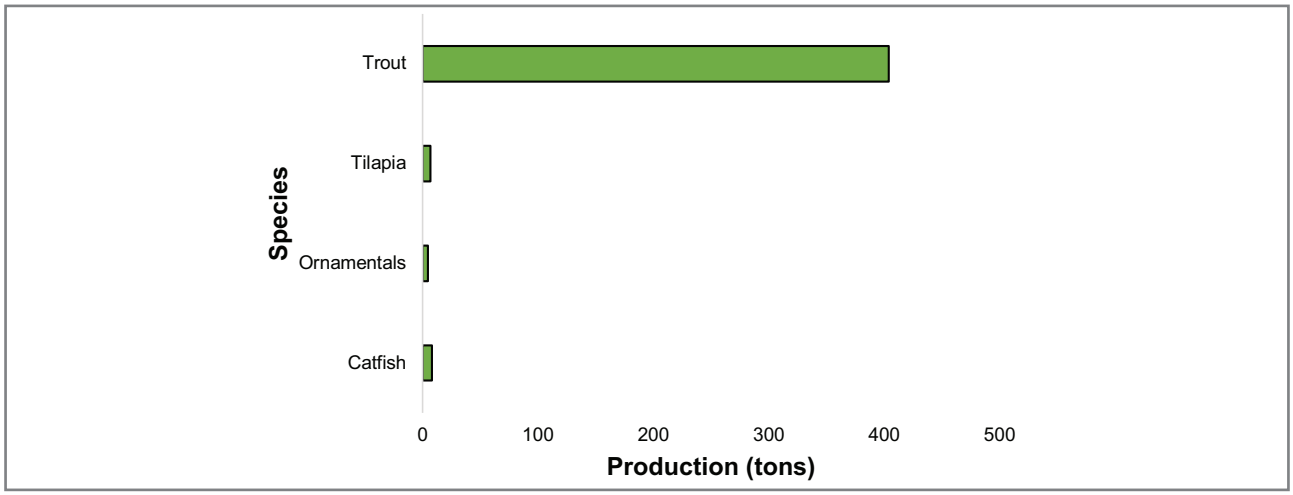

Figure 5.8: Aquaculture production in the KwaZulu-Natal province

5.5 Limpopo Province

Limpopo province is the fifth largest province in the country and supported by the Turfloop state-owned hatchery while the University of Limpopo undertakes research and development activities. The province accounts for production of freshwater species.

Figure 5.9: South Africa's map showing the Limpopo province

Farms and species farmed: In 2021, the province recorded thirty (30) farms, which is an increase from the twenty-seven (27) farms recorded in 2020. The farms comprised of one (1) common carp, one (1) ornamental, seven (7) catfish, and twenty-one (21) tilapia farms.

Production: The tilapia subsector recorded the highest production volume with 78,00 tons, followed by the common carp subsector with 2,50 tons. The catfish and ornamental subsectors contributed 2,00 and 0,80 tons, respectively. The total production volume recorded for the Limpopo province in 2021 was 83,30 tons, which is a 6% increase from the 78,30 tons recorded in 2020. The total production volume contributes 5,6% to the total freshwater production and 1,1% to the national production.

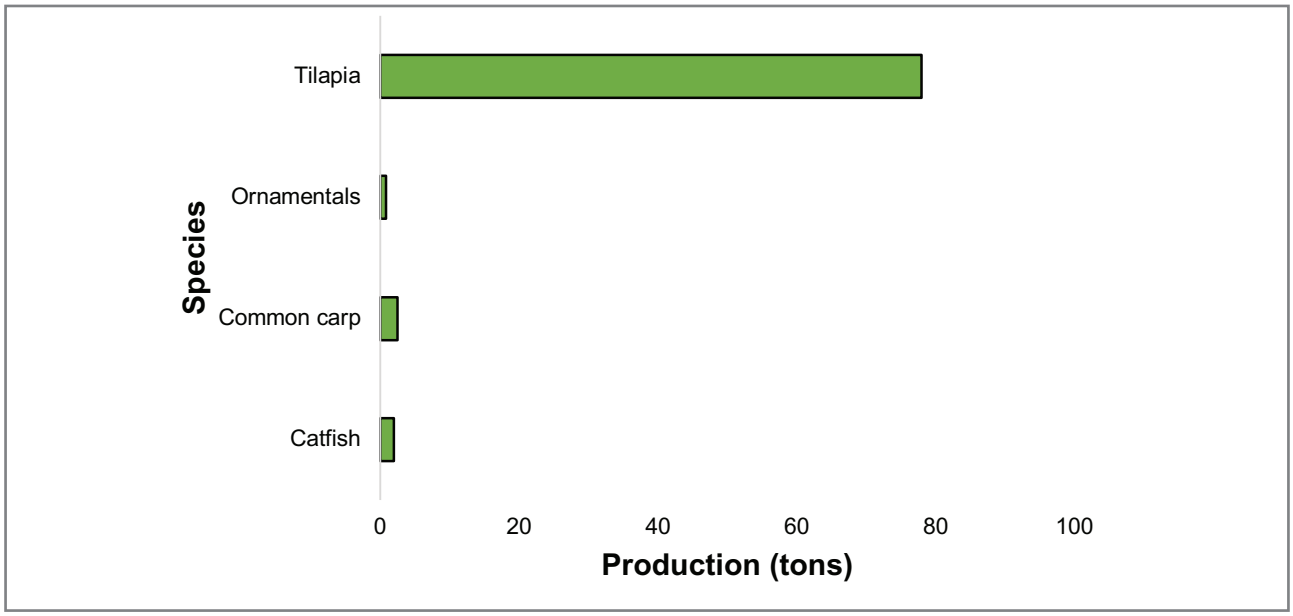

Figure 5.10: Aquaculture production in the Limpopo province

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5.6 Mpumalanga Province

Mpumalanga, the second-smallest province in South Africa after Gauteng and is located in the northeast part of the country. The province only accounts for freshwater production.

Figure 5.11: South Africa's map showing the Mpumalanga province

Farms and species farmed: In 2021, twenty-six (26) freshwater farms recorded in Mpumalanga province, which a decrease from the twenty-seven (27) farms recorded in 2020. The farms comprised of one (1) catfish, three (3) ornamental, ten (10) trout and twelve (12) tilapia farms.

Production: The subsector with the highest production volume recorded in the Mpumalanga province was trout with 250,20 tons, followed by the tilapia subsector with 45,00 tons, while the ornamental subsector recorded 1,90 tons. The total production volume recorded for the Mpumalanga province in 2021 was 297,10 tons, which is a 0,3% decrease from the 298,10 tons recorded in 2020. The total production volume contributes 20,04% to the total freshwater production and 3,8% to the national aquaculture production.

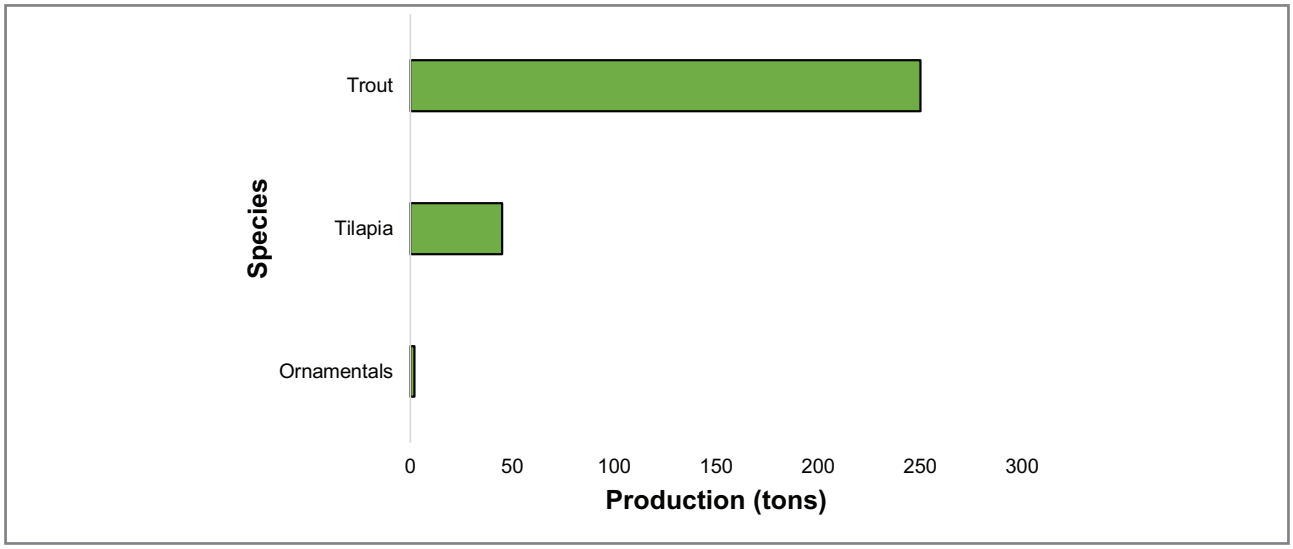

Figure 5.12: Aquaculture production in the Mpumalanga province

5.7 North-West Province

North-West lies in the north of South Africa on the Botswana border and the province only accounts for freshwater production.

Figure 5.13: South Africa's map showing the North-West province

Farms and species farmed: In 2021, the North-West province recorded fifteen (15) freshwater farms, which is an increase from the thirteen (13) farms recorded in 2020. The farms comprised of three (3) catfish and twelve (12) tilapia farms.

Production: The only contribution in terms of production volume in the North-West province recorded from the tilapia subsector with 50,00 tons, which was a 117% increase from the 23,00 tons recorded in 2020 for the tilapia subsector. The total production volume recorded for the province was 50,00 tons, which contributes 3,4% to the national freshwater production and 0,7% to the national aquaculture production.

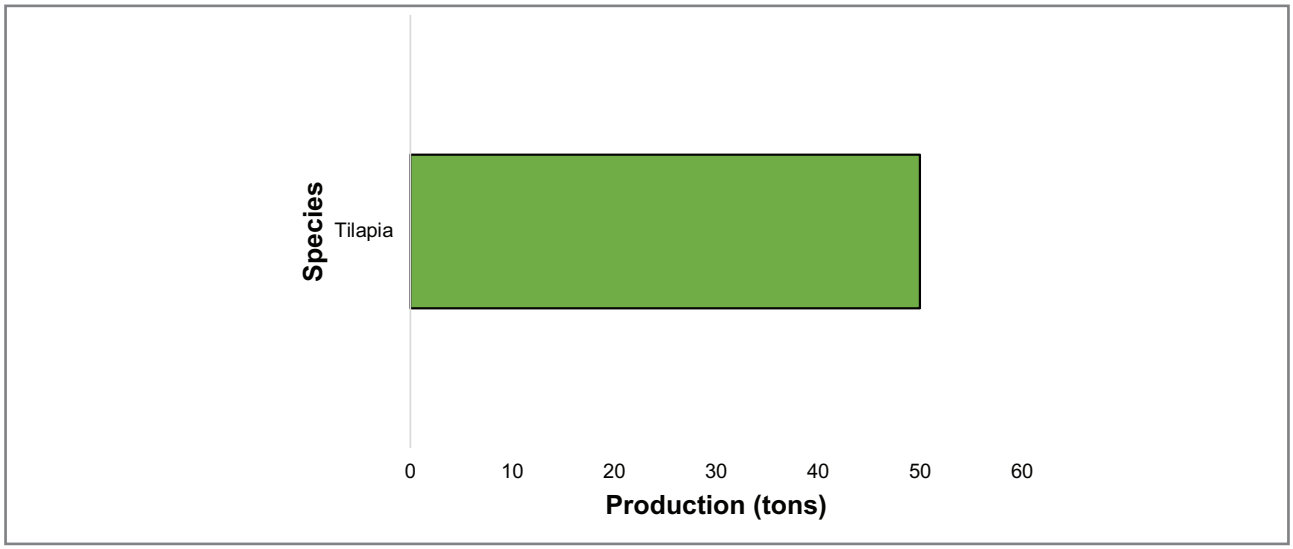

Figure 5.14: Aquaculture production in the North-West province

5.8 Northern Cape Province

Northern Cape is the largest province in South Africa and as in other coastal provinces, it accounts for both marine and freshwater aquaculture production.

Figure 5.15: South Africa's map showing the Northern Cape province.

Farms and species farmed: In 2021, the Northern Cape province recorded seven (7) farms comprising of three (3) freshwater and four (4) marine farms. This is the same number recorded in 2020.

Production: The highest performing subsector in terms of production volume in the Northern Cape was abalone with 54,26 tons. Followed by the trout subsector with 12,10 tons and the tilapia subsector with 4,00 tons. The common carp and catfish subsectors recorded 2,50 tons and 1,30 tons, respectively. The total production volume recorded for the province was 75,16 tons, which includes 54,26 tons for marine and 20,90 tons for freshwater. This 16% is an increase from the 65,01 tons recorded in 2020. The total production volume contributes 5% to the national freshwater production and 0,98% to the national aquaculture production.

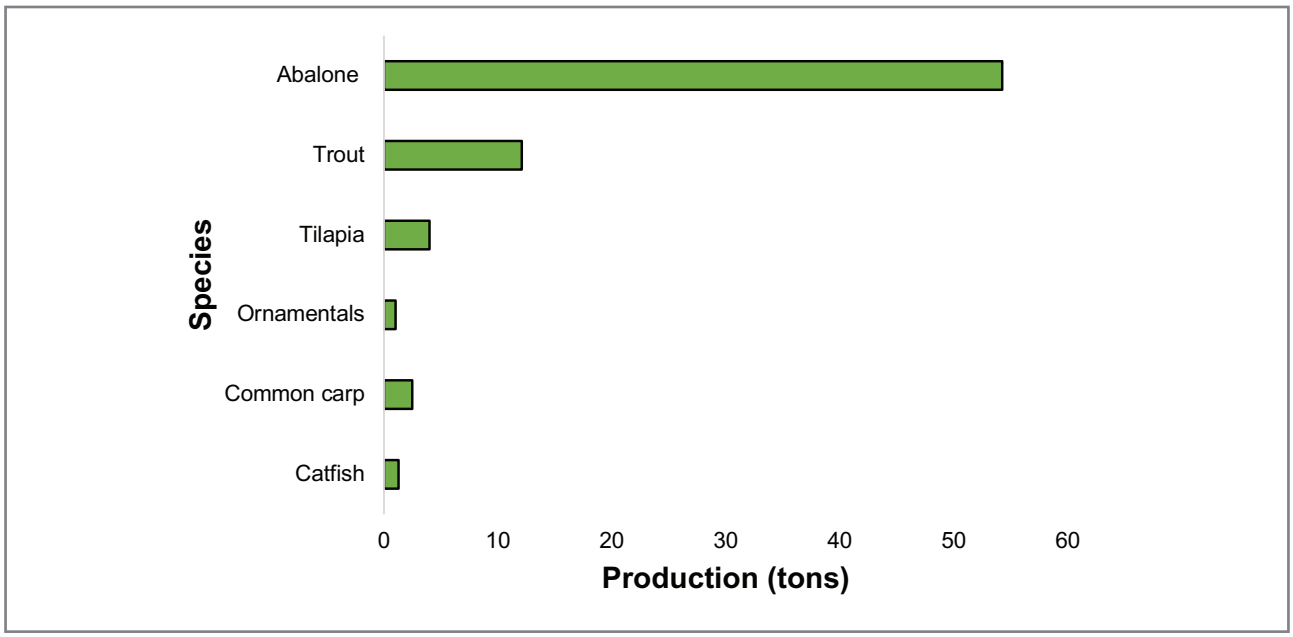

Figure 5.16: Aquaculture production in the Northern Cape province

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5.9 Western Cape Province

The Western Cape is located on the southern tip of the African continent between the Indian and Atlantic Oceans. The province remains the largest contributor in terms of production value and number of farms. As a coastal province, it also accounts for both freshwater and marine species.

Figure 5.17: South Africa's map showing the Western Cape province

Farms and species farmed: In 2021, the Western Cape province recorded sixty-three (63) farms, which include forty-four (44) marine farms and nineteen (19) freshwater farms. This is an increase from the fifty-five (55) farms recorded in 2020.

Production: The mussels subsector had the highest production volume with 3 420,88 tons recorded in 2021, followed by the abalone subsector with 2 245,66 tons. Furthermore, the trout subsector recorded 384,00 tons, while the oysters subsector recorded 308,36 tons. The marine finfish subsector recorded 13,00 tons, while the lowest subsector in the province was ornamental with 1,80 tons recorded.

The total production volume recorded for the province was 6 382,90 tons, which includes 395,00 tons for freshwater and 5 987,90 tons for marine. This is an 77% contribution towards the national aquaculture production and a 37% increase from the 4 660,58 tons recorded in 2020. The marine aquaculture production contributes 95% towards the national marine

aquaculture production and 77% towards the national aquaculture production. Freshwater aquaculture produced 395,00 tons, accounting for 26% of the national freshwater aquaculture production and 5,1% towards the national aquaculture production.

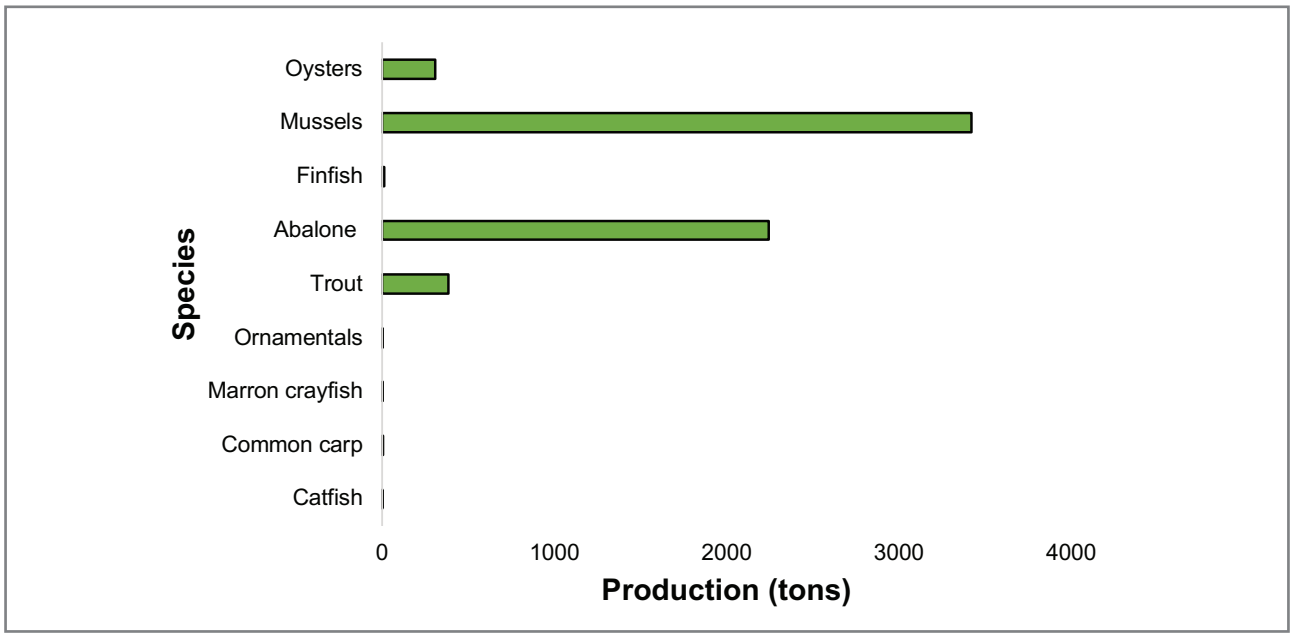

Figure 5.18: Aquaculture production in the Western Cape province

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CHAPTER 6

AQUACULTURE FOOD SAFETY

6. AQUACULTURE FOOD SAFETY

6.1 Introduction

The DFFE continues to be the managing and regulatory authority for the undertaking of aquaculture activities that include farming, harvesting and transporting of fish for wholesale trading stipulated in the permit conditions issued in terms of the Marine Living Resources Act, 1998 (Act No. 18 of 1998) and associated regulations. The Directorate: Sustainable Aquaculture Management (D: SAM) of the Fisheries Management Branch of the DFFE is responsible for the development, management and regulation of a sustainable aquaculture industry that contributes towards job creation, food security, rural development and economic growth. D: SAM aims to achieve the above-mentioned strategic objectives through the development and implementation of relevant enabling legislation, policies and programmes as well as be responsive and compliant to international obligations and agreed standards.

The Food Safety Office (FSO) within D: SAM is responsible for the development and management of food safety programmes stipulated in the permit conditions issued in terms of the Marine Living Resources Act, 1998 (Act No. 18 of 1998). Including the South African Shellfish Monitoring and Control Programme (SASM&CP), South African Aquaculture Marine Fish Monitoring and Control Programme (SAMFM&CP) and the National Residue Control Programme (NRCP). The objectives of the food safety programmes include providing guarantees to domestic and international markets and consumers that South African cultured marine fish products are safe for human consumption.

The food safety risks associated with cultured marine fish include environmental and veterinary medicine residues and the accumulation of biotoxins and pathogenic microbiological organisms in shellfish. The aquaculture industry monitored and controlled in terms of the Marine Living Resources Act, 1998 (Act No. 18 of 1998) include the shellfish and finfish farms. Shellfish species farmed in South Africa include *Haliotis midae* (abalone), *Crassostrea gigas* (oyster), *Mytilus galloprovincialis* (Mediterranean Mussel) and *Choromytilus meridionalis* (Black Mussel) and the crustacean *Panulirus homarus* (East Coast Rock Lobster). Farmed finfish include *Argyrosomus japonicus* (Kob), *Seriola lalandi* (Cape Yellowtail) and *Onchorhynchus mykiss* (Rainbow Trout).

The majority of the abalone farms are located in the Walker Bay and Buffeljags region on the south-west coast and to a lesser extent along the West Coast and Northern Cape and one (1) farm is situated near East London (Figure 6.1). Oyster and mussel farms are predominantly located in Saldanha Bay and one (1) oyster farm is situated in Algoa Bay. The finfish farms are located in Saldanha Bay and in the East London Industrial Development Zone and the rock lobster farm situated on the abalone farm near East London.

6.2 Farm Status

There were 54 shellfish and finfish farms monitored for food safety during 2021. The farms included 17 abalone farms, 25 mussel farms, 10 oyster farms and 2 finfish farms (Figure 6.1). All the abalone farms monitored were land – based. The abalone were grown in land-based systems where the water is pumped ashore and flows through the tanks with varying levels of recirculation. The oyster and mussel farms were sea-based. The oysters were cultivated in cages suspended from buoys and the mussels grown on ropes suspended from floating rafts or long-lines. The finfish farming was conducted in sea cages and land-based systems.

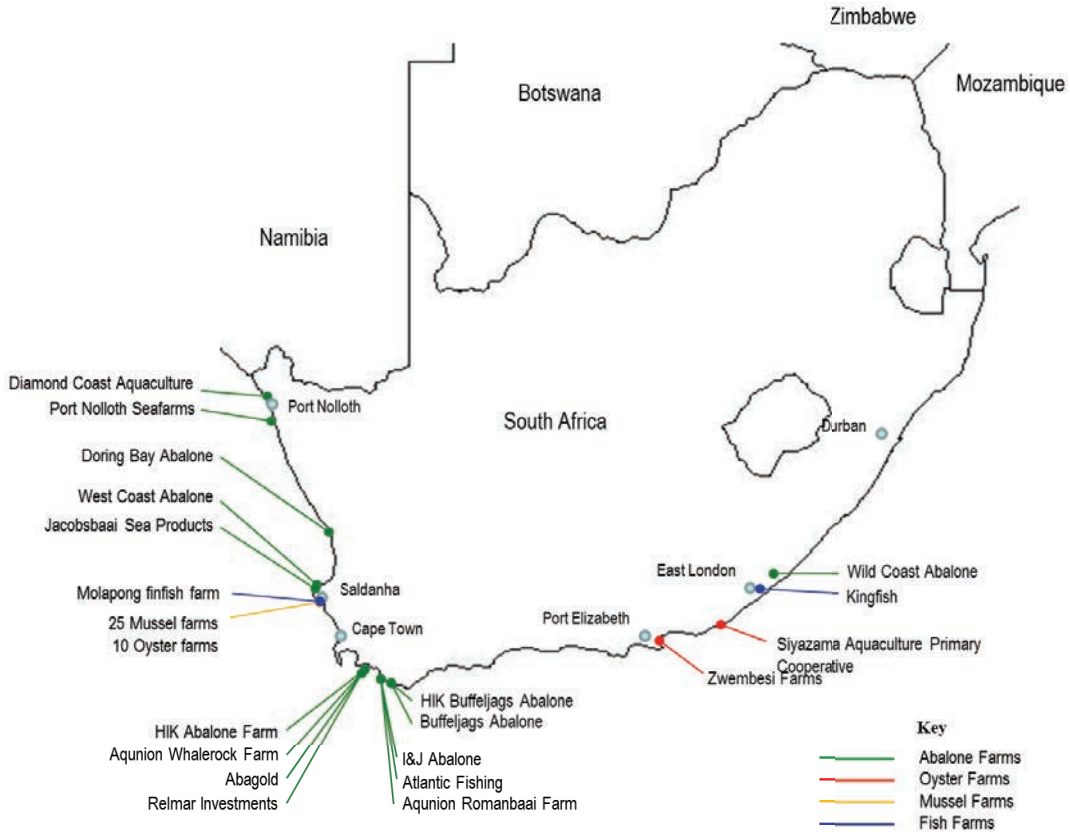

Figure 6.1: Distribution of marine fish farms along the South African coast

6.3 Monitoring of Haz rdous Substances

Sanitary assessments have established that the farms that are near the industrialised or urban areas are at most risk of pollution. Most of the farms in South Africa, however, are situated in areas that are relatively free of pollution. Natural contaminants also pose a risk to food safety. Generally, the farms to the west of Cape Point, particularly shellfish farms are more at risk of biotoxin contamination than the farms to the east of Cape Point.

The fish farms were monitored for human health hazards such as heavy metals, pesticides, polychlorinated biphenyls (PCBs), dioxins, dyes, veterinary medicine residues and radionuclides during the production phase. In addition, shellfish farms were furthermore monitored for biotoxins and microbiological contamination.

Products harvested for human consumption are required to comply with the regulatory requirements. In instances where the regulatory limit for any of the hazardous substances in the fish exceeded the regulatory limits, farms were temporarily closed for harvesting until the contaminant reached acceptable limits.

The test methods used are stipulated in the food safety programmes and are South African National Accreditation System (SANAS) accredited and the international laboratories are affiliated with International Laboratory Accreditation Cooperation (ILAC). The laboratories are required to inform the FSO in the form of a red alert, should a test result exceed the regulatory limit. The red alert requires that the laboratory emails the FSO staff responsible for farm closures, indicating the test result. The FSO then warns the farm not to harvest until the test result has been confirmed. If the result is confirmed to exceed the regulatory limit, the farm is temporarily closed and the relevant stakeholders are informed accordingly. A farm is also temporarily closed if fish are not tested in accordance with the food safety programmes.

When any of the hazardous substances or microbiological organism concentrations exceeds the regulatory limit the criterion for reopening a farm depends on the contaminant that is present on that particular farm. As an example, when a farm is temporarily closed due to biotoxins, the biotoxin concentration in two consecutive samples taken over a period of not less than three (3) days is required to be below the regulatory limit and show a declining trend. When the farm is closed due to other contaminants, the farm is reopened when the contaminant is below the regulatory limit indicated in Table 6.1.

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Table 6.1: Regulatory limit for contaminants monitored

Haz rdous Substances	Regulatory Limit
Biotoxins	
Paralytic shellfish toxins	≤ 0.8 mg STX equiv./kg edible flesh
Okadaic acid (OA) group toxins: OA, Dinophysis toxins (DTX) 1, DTX 2 & DTX 3 and Pectenotoxins (PTX) group toxins: PTX 1 & PTX 2	≤ 0.16 mg okadaic acid equivalents / kg edible flesh
Yessotoxins (YTX) group toxins: YTX, 45 OH YTX, homo YTX, and 45 OH homo YTX	≤ 8 mg yessotoxin equivalents / kg edible flesh
Az spiracids (AZA) group toxins: AZA1, AZA2 and AZA3.	≤ 0.16 mg azaspiracid equivalents / kg edible flesh
Amnesic shellfish toxins	< 20 mg DA/kg edible flesh
Microbiological Contamination	
E. coli	≤230/100g edible flesh
Environmental and Veterinary Drug Residues	
Heavy Metals (Lead, mercury cadmium, arsenic)	Various concentrations
Pesticides	< 0.01 mg/kg
Non-dioxin-like-PCB	< 75 µg/kg
Dioxin-like PCB & Dioxin	< 6.5 µg/kg
Dioxins	< 3.5 µg/kg
PAH 4	< 35 µg/kg
Radionuclides	< 600 Bq/kg
Malachite Green & Crystal Violet	Not detected
Nitrofurans	Not detected
Aflatoxins	Not detected
Nitroimidaz les	Not detected
Stilbenes & Hormones	Not detected
Anthelmintics	Not detected
Antibiotics	Various concentrations

6.4 Microbial Monitoring

Microbiological contamination poses a risk to consumers. The sources of contamination include sewage, wild animals and livestock. *E. coli* is used as an indicator of pathogenic enteric viruses as it has a better survival rate than other microbiological organisms. *E. coli* is also used for the classification of shellfish production areas.

Mérieux NutriSciences laboratories situated in Claremont, Cape Town, tested the microbiological samples. Mérieux NutriSciences is the only laboratory in South Africa that is SANAS accredited for the required *E. coli* test method.

Bivalves filter feed and, therefore, accumulate pathogenic microbiological organisms that are present in the marine environment. The *E. coli* concentrations in the cultured mussels and oysters were generally low, reaching 230 CU/100g in 2% of the samples and reaching a maximum of 1300 CFU/100g in one oyster sample on the east coast (Figure 6.2). Bivalve farms were closed on two (2) occasions due to microbiological contamination in 2021. Abalone have a lower risk of accumulating pathogenic microbiological organisms, and no contingency measures were implemented.

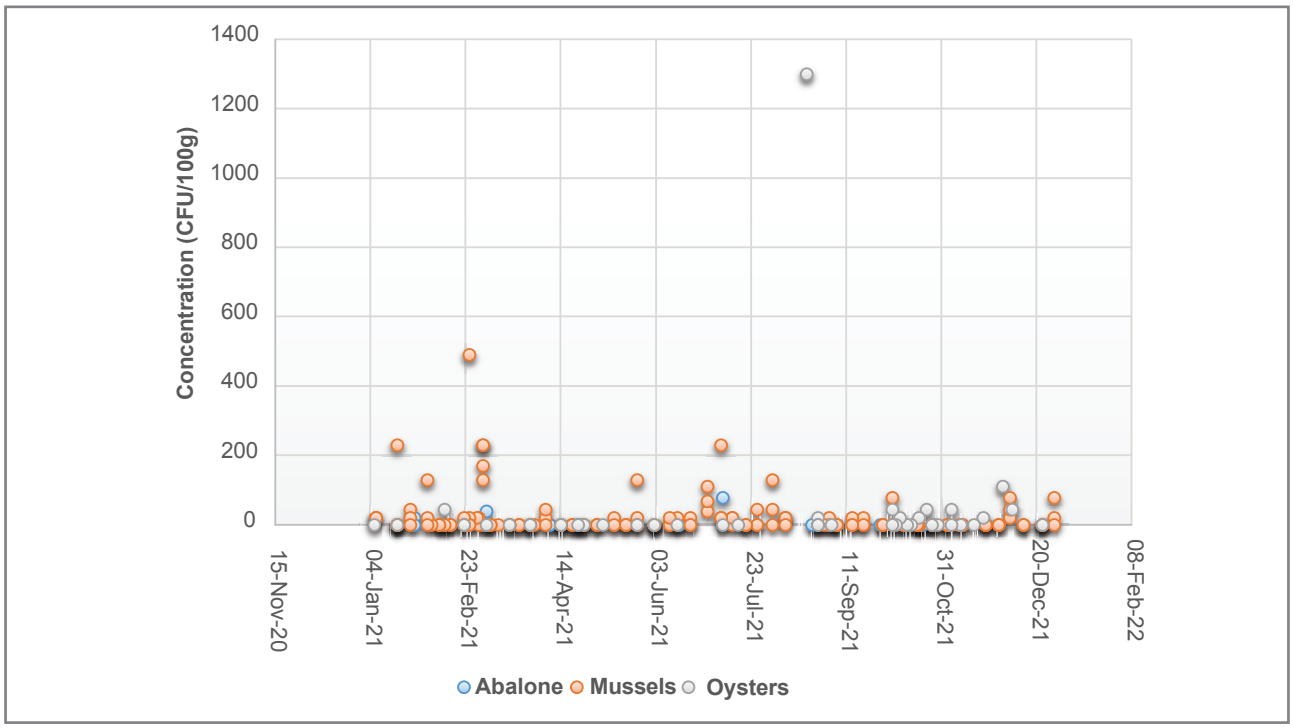


Figure 6.2: *E. coli* concentrations in cultured molluscan shellfish in 2021

The farms were all classified as “Approved Class A” based on the data received. The abalone production facilities continued to be classified as Approved Class A and are exempted from routine *E. coli* monitoring. The *E. coli* in abalone is tested during official surveillance of end-of-line product by the NRCS.

6.5 Biotoxin Monitoring

Biotoxins are produced by toxic phytoplankton and accumulate in shellfish. Contaminated shellfish may result in poisoning of consumers if present in significant concentrations. The routine monitoring frequency of farms and the location of sampling were based on the potential risk of contamination (Table 6.2). There tends to be substantially more upwelling systems to the west of Cape Point resulting in higher incidences and concentrations of Harmful Algal Blooms (HABs) and concomitant biotoxin accumulation in the shellfish.

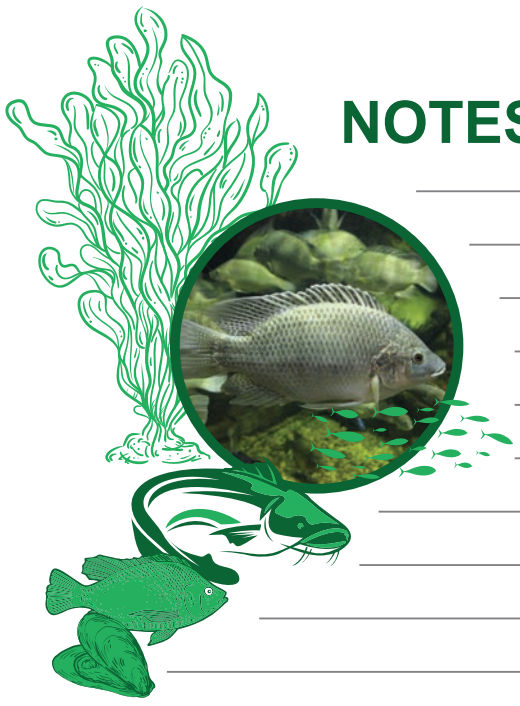
Table 6.2: Schedule for the testing of biotoxins

Biotoxins	West of Cape Point		East of Cape Point	
	Filter Feeder	Non-filter Feeder	Filter Feeder	Non-filter Feeder
Paralytic Shellfish Toxin	48 hours or twice a week for multiple harvesting	biweekly	Monthly	Monthly
Lipophilic Shellfish Toxins	Weekly	Monthly	biweekly	Monthly
Amnesic Shellfish Toxin	Monthly	Monthly	Monthly	Monthly

The biotoxins monitored by conducting testing of samples at Assure Cloud in Paarden Eiland, Cape Town. The biotoxins monitored include Paralytic Shellfish Toxins (PST), Lipophilic Shellfish Toxins (LST) and Amnesic Shellfish Toxins (AST) and were tested using the Liquid Chromatography–Fluorescence Detector (LC-FLD), Liquid Chromatography–Mass Spectrometry (LC-MS/MS) and the High-performance liquid chromatography–Ultraviolet Detector (HPLC-UV) instruments respectively.

Bivalves along the South African coast have historically accumulated PST and LST. The LST included okadaic acid and low concentrations of yessotoxin (≤6.2 mg/kg). The okadaic acid reached concentrations of 0.24 mg OA equiv./kg in mussels and 0.32 OA equiv./kg in oysters in March 2021 (Figure 6.3), exceeding the regulatory limit of 0.16 mg/kg. Low concentrations of AST were also detected in mussels (≤3.1 mg/kg) in Saldanha Bay (Figure 6.3).

The abalone to the west of Cape Point are known to accumulate PST and in 2021 the PST was consistently present throughout the year reaching a maximum concentration of 0.8 mg STX equiv./kg (Figure 6.4), which is below the regulatory limit.



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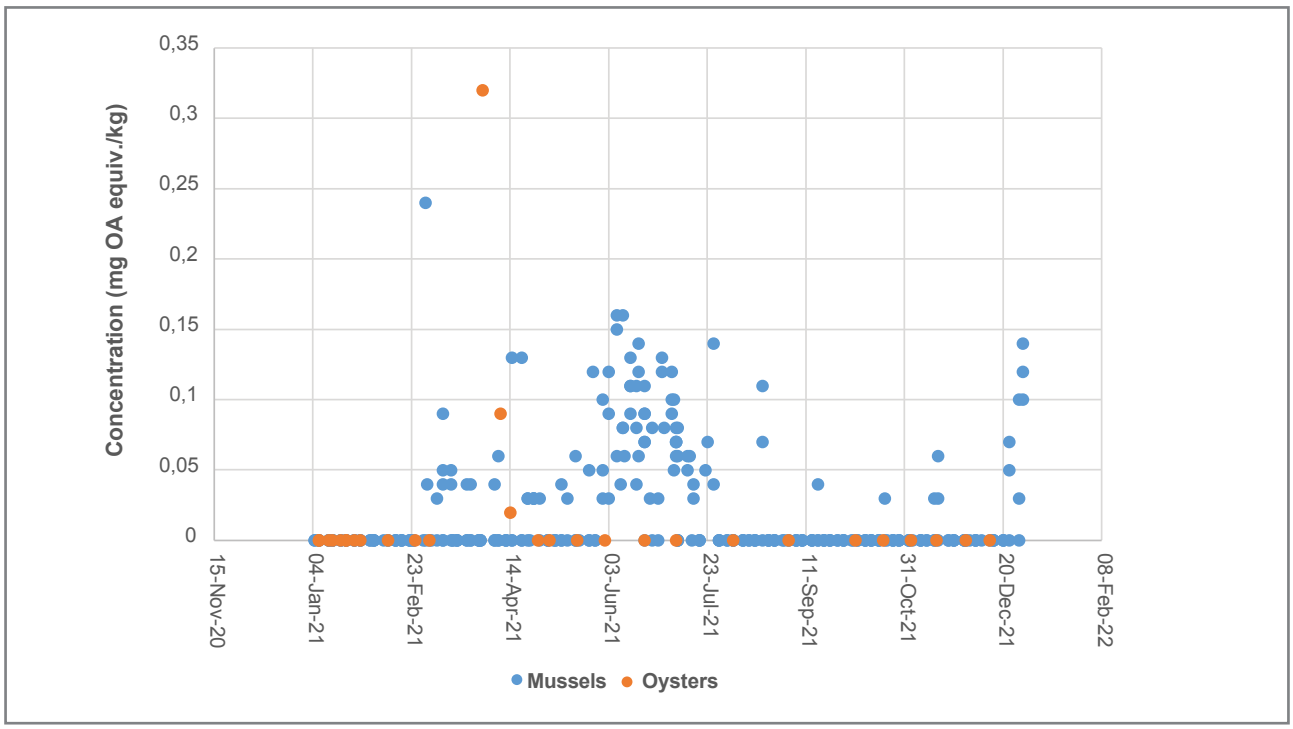


Figure 6.3: Okadaic acid concentrations in cultured bivalves in 2021

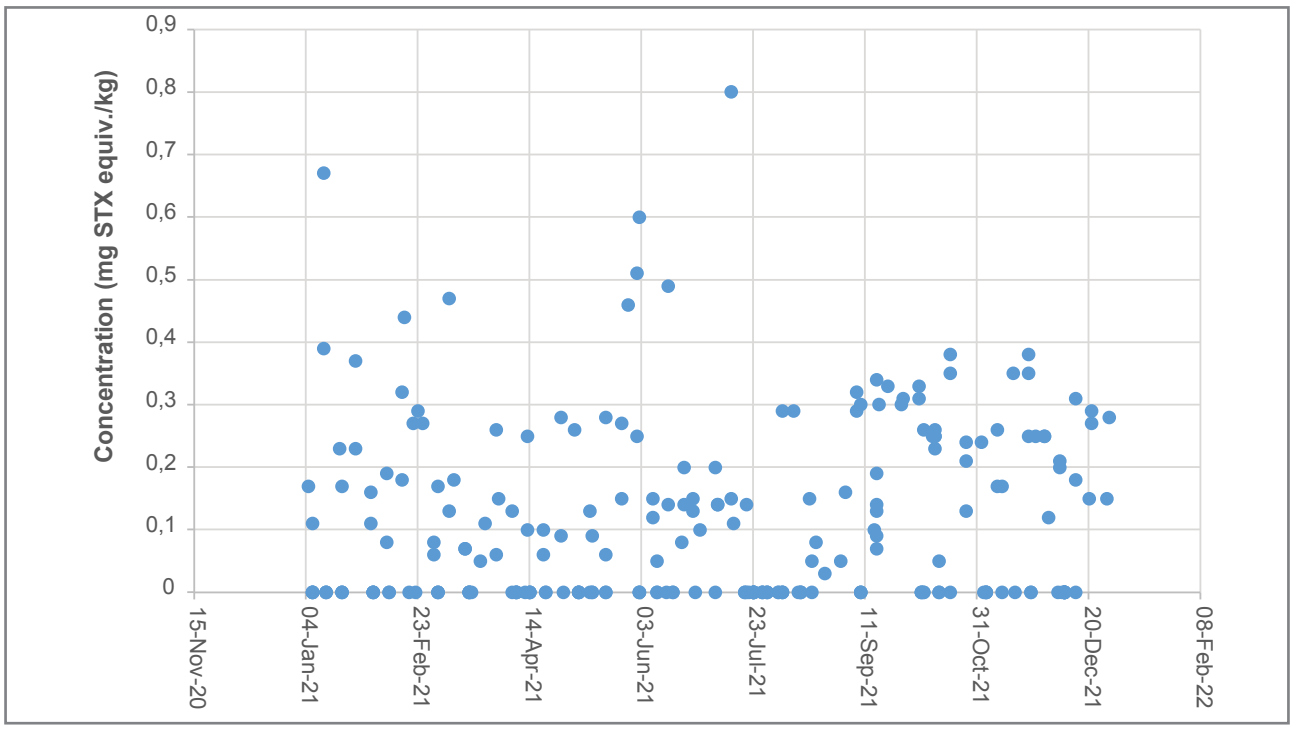


Figure 6.4: Paralytic shellfish toxin concentrations in cultured abalone in 2021

The number of incidences of PST concentrations exceeding the regulatory limit in bivalves were substantially greater in 2021 than in the previous year (Table 6.3), whereas it was substantially less for okadaic acid.

Table 6.3: Count of samples exceeding the biotoxin regulatory limits in shellfish from 2019 to 2021

Year	PST	OA	AZA	YTX	AST
2019	7 (471)	11 (327)	0 (329)	0 (326)	0 (134)
2020	1 (520)	76 (605)	0 (619)	0 (597)	0 (131)
2021	7 (556)	4 (496)	0 (489)	0 (488)	0 (147)

(x) = Number of samples tested; PST – Paralytic Shellfish Toxin, OA – Okadaic Acid, AZA – Azaspiracid, YTX – Yessotoxin, LST – Lipophilic Shellfish Toxins, AST – Amnesic Shellfish Toxins.

During 2021, there were three (3) farm closure notifications issued (Table 6.4) for biotoxins exceeding the regulatory limit. One (1) of the notifications was for an oyster farm and two (2) notifications were for mussel farms. The mussel farms situated on the west coast and the oyster farm on the east coast.

Table 6.4: Farm closure notifications

Species	Number of Notices	Contaminant Exceeding Regulatory Limit
Mussels	2	Lipophilic Shellfish Toxins
Oysters	1	Lipophilic Shellfish Toxins
TOTAL	3	

Each time a closure notification was issued, the farms were temporarily closed for the marketing of shellfish until the product met the food safety requirements indicated in the SASM&CP.

6.6 Toxic Phytoplankton Monitoring

Toxic phytoplankton is responsible for the accumulation of toxins in shellfish. The monitoring of toxic phytoplankton and, therefore, harmful blooms is an early warning system indicating the potential risk of shellfish poisoning. Harmful Algal Blooms (HABs) on the West Coast are usually associated with upwelling systems which are driven by persistent offshore south-easterly winds, typically in the region of 3 to 10 day events (Hill et al. 1998), resulting in upwelling of nutrient rich water into the euphotic zone (Pitcher et al. 2010). The timing of HABs are associated with seasonal wind patterns, particularly during late summer and early autumn (Pitcher et al. 2010). During this period the surface currents tend to be offshore and equator-ward (Pitcher et al. 2010). The HABs develop once there is relaxation of the offshore wind and solar radiation, which leads to stratification of the water column (Pitcher et al. 2010).

The relaxation of the south-easterly wind also results in the pole-ward movement of the longshore current and an on-shore wind drives the bloom towards the shore (Pitcher et al. 2010) into close proximity of the aquaculture farms. Consequently the highest incidence of HABs south of Cape Columbine is during April and May (Pitcher & Calder 2000).

The FSO conducted official phytoplankton monitoring for shellfish farms along the South African coastline. There are two (2) phytoplankton laboratories, namely SeaWise in Saldanha Bay and Amanzi Biosecurity in Hermanus. These two (2) laboratories collect and analyse the phytoplankton samples for all shellfish farms along the South African coast.

The official phytoplankton monitoring for 2021 shows high concentrations of *Pseudo-nitzschia* during the summer months as well as *Dinophysis acuminata* and *Protoceratium reticulatum* during the autumn and winter months (Figure 6.5). The other toxic phytoplankton species, namely *Alexandrium catenella, Dinophysis fortii, Dinophysis rotundata, Dinophysis tripos, Gonyaulax spinifera* and *Lingulodinium polyedrum* were present in low concentrations.

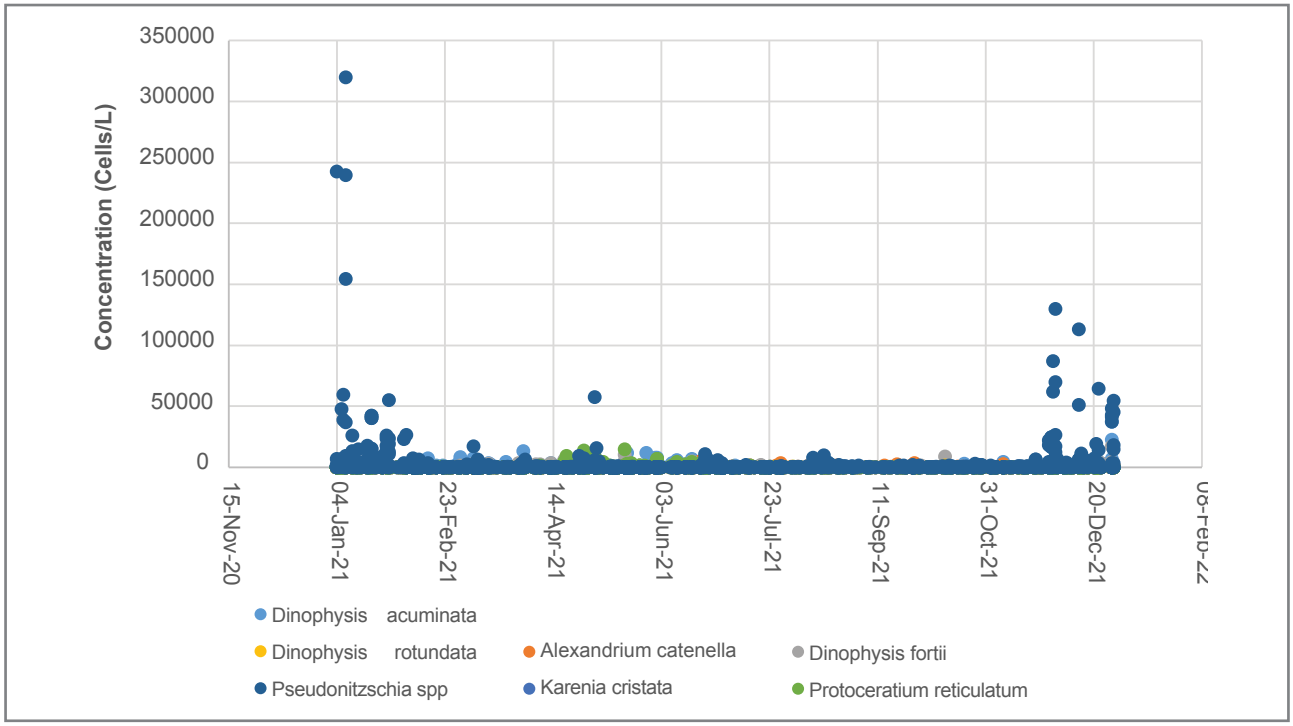


Figure 6.5: Official toxic phytoplankton counts for 2021

Pseudo-nitzschia though ubiquitous along the South African coastline does not appear to cause the accumulation of domoic acid in shellfish and, therefore, currently not considered to be a risk. *Protoceratium reticulatum* is responsible for the production of yessotoxins. Though the species have been present in high numbers, the yessotoxin concentration in shellfish remained low, well below the regulatory limit. *Dinophysis* species cause the accumulation of certain LSTs in bivalves, particularly okadaic acid and triggers intensive testing of LST in bivalves when present in significant numbers.

6.7 Residue Monitoring

Residue contamination includes environmental and veterinary medicine residues and are predominantly from anthropogenic sources. The environmental residues include heavy metals (lead, mercury, cadmium and arsenic), pesticides, polychlorinated biphenyl (PCB),

dioxins, polycyclic aromatic hydrocarbons (PAH) and dyes and whereas the veterinary medicine residues include stilbenes, steroids, antibiotics and anthelmintics. Residue monitoring is required to determine the level of residues in fish that are destined for human consumption. The residues were tested randomly in the fish in accordance with the National Residue Programme. The fish types monitored included finfish, abalone, mussels and oysters. Banned substances are furthermore tested for in formulated fish feed. The tests are randomly undertaken and when required targeted according to their likely use and/or historical presence in the production system. The samples taken were submitted to Mérieux NutriSciences for testing.

There was one (1) contingency measure implemented for cadmium concentrations exceeding United States of America regulatory limit of 4 mg/kg in mussels during 2021. The cadmium concentration on certain farms exceeded the People's Republic of China's regulatory limit of one (1) mg/kg on five (5) incidences, the farms were, however, granted permission to continue harvesting and exporting to countries such as the United States of America that had less stringent regulatory limits for cadmium.

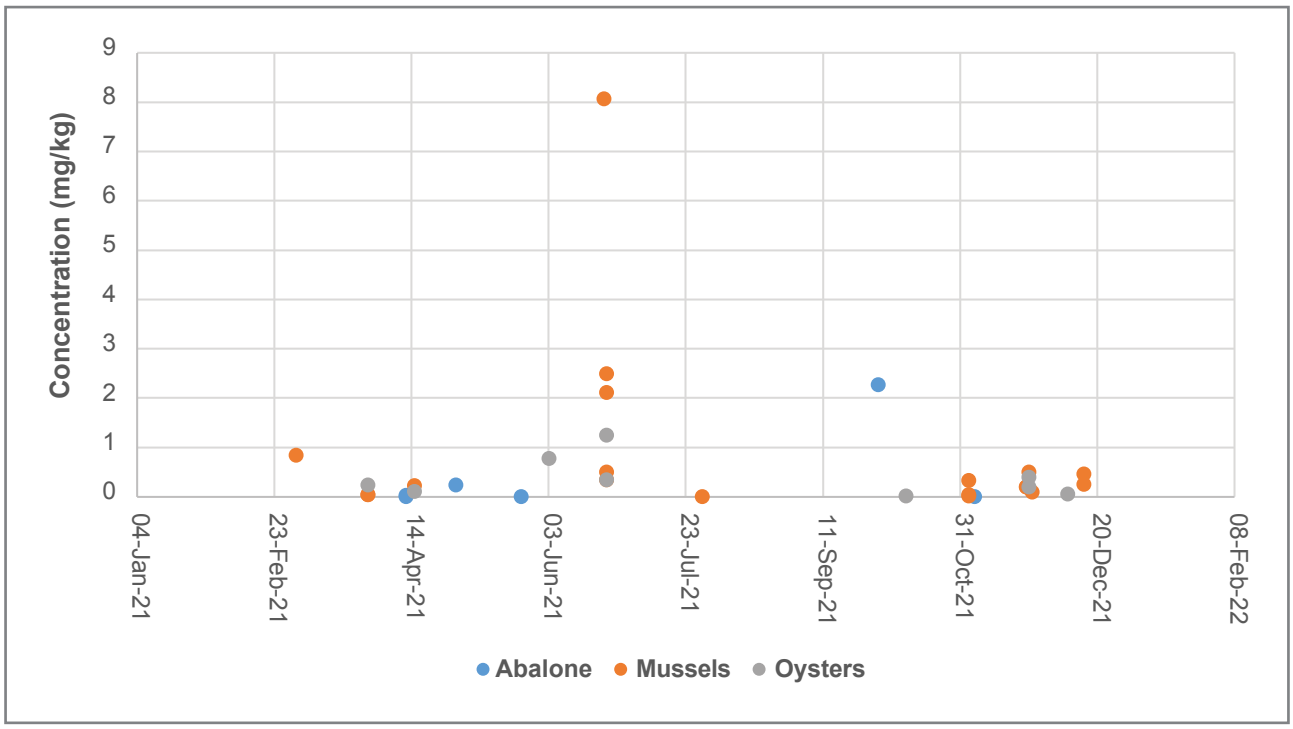


Figure 6.6: Cadmium concentrations in cultured molluscan shellfish in 2021

The environmental residues, namely lead, mercury, total arsenic, PCB, dioxin and PAH were present in the cultured shellfish in very low concentrations well below the regulatory limits (Table 6.5). There were no pesticides or veterinary medicines detected in any of the fish samples taken during 2021.

Table 6.5: Count of samples exceeding the residue regulatory limit in cultured shellfish in 2021

Residue	2021
Heavy Metals	5 (101)
Anthelmintics	0 (41)
Antibiotics	0(98)
Chloramphenicol	0 (12)
Nitrofurans	0 (7)
Nitroimidazoles	0 (4)
Steroids	0 (7)
Stilbenes	0 (7)
PAH	0 (4)
PCBs	0 (14)
Dioxins	0 (7)
Dyes	0 (16)
Radionuclides	0 (10)

(x) = Number of samples tested

6.8 Food Safety Monitoring Programme (Progress)

The FSO continues to improve food safety monitoring of aquaculture farms. In 2021, the office compiled and implemented abalone production area action plans in addition to the Saldanha Bay and Algoa Bay Biotoxin and Microbiological Action. The action plans included the Biotoxin Action for Wild Coast, South-West Coast, West Coast and Northern Cape. The plans were compiled to manage specific production areas in terms of the SASM&CP requirements. The aim of these action plans is to ensure that biotoxin and microbiology monitoring is conducted effectively for both abalone and bivalves farms where relevant, particularly bivalve farms which have a high risk of concentrating pathogenic microbiological organisms and biotoxins.

The food safety programmes (SASM&CP, SAAMFM&CP and National Residue Programme) were reviewed and updated to ensure harmonisation with the relevant South African legislation as well as Codex Alimentarius guidelines, as South Africa is a signatory to Codex Alimentarius. The relevant SOPs have also been aligned with the revised food safety programmes. All the implemented food safety programmes have gone through vetting process by the Departmental legal office to ensure that monitoring of farms is done according to the South African Law.

Food safety monitoring and control is dependent on accredited laboratories to provide accurate and timeous test results. The biotoxin, microbiological, pesticide, PCB and radionuclide tests are undertaken by South African laboratories whereas the veterinary medicine residues, dioxin and PAH tests are being undertaken by international laboratories. The DFFE is in the process of developing capacity within South Africa to undertake veterinary

drug residue testing. Phytoplankton monitoring is required as an early warning system for determining the risk associated with biotoxin accumulation by shellfish. The phytoplankton laboratories continue to sample and analyse the phytoplankton samples on a real-time basis.

The Food Safety Report for 2021 outlines the food safety risks of 54 marine fish farms and the implementation of official food safety programmes. Contingency measures were implemented for mussel farms located to the west of Cape Point due to biotoxin (PST and LST), *E. coli* and cadmium concentrations exceeding the regulatory limits and for one (1) oyster farm in Algoa Bay for LST and *E. coli* concentrations exceeding the regulatory limits. There were no closure notices that were issued to finfish or abalone farms.

NOTES

CHAPTER 7

ECONOMIC OVERVIEW OF AQUACULTURE

7. ECONOMIC OVERVIEW OF AQUACULTURE

7.1 Introduction

Aquaculture is a critical industry in South Africa's economy, making a significant contribution to employment, foreign direct investment, food, and nutrition security. Most notably, the South African government made significant investments in the industry, setting up governance, value chains, determining the sector's viability from an economic standpoint, and deciding on the best market strategies for the growth and sustainability of the sector. The industry has expanded significantly, with output levels rising by almost 75%. The industry's marginal output in 2021 was 7 769,96 tons, an increase of (28%) from the previous year. Part of the industry's underperformance in 2020 can be attributed to the Covid-19 pandemic and other long-standing constraints such as limited skills, limited access to water, and inadequate technology development.

The sector is experiencing exponential growth, and it accounts for a sizable portion in the global market, with abalone accounting for most in the Asian market. Despite the lack of exact data that may be used to simulate consumption trends and efficiency gains in the local market, there are signs that point to a positive trend, primarily in yearly output and exports. Stats SA's 2020 reported that on South African households' purchasing patterns, fish accounts for (3%) percent of all food purchases made by households overall. In terms of trade balance, investment, and business growth in 2021, the industry is evaluated, and its prognostic trends are examined in the section below.

7.2 Value of the Aquaculture Sector

The projected value of various aquaculture services, including marine and freshwater services, in 2021 was approximately R2 241 342 813 in 2021 (Two Billion Two Hundred Forty-One Million Three Hundred Forty-Two Thousand Eight Hundred Thirteen Rands). Abalone continues to be the largest contributor; in 2021, the industry contributed approximately R717 million, accounting for (86%) percent of the total value of the industry, followed by oysters (6%), tilapia (3%), and mussels (2%), respectively.

7.3 Employment Status

Employment is critical for human dignity, long-term economic development, and solidarity (SA National Treasury, 2021). However, unemployment rate in South Africa peaked in 2021, reaching an all-time high of (35%) percent in the fourth quarter (Stats SA, 2021). This is exacerbated further by the lockdown of many businesses across the country, and the abalone subsector, which is the largest employer, had to reduce its labour force.

In 2021, about 0.5% of all employment in agriculture, forestry, and fishing came from the Aquaculture Industry. The industry employed about 4 591 people on a full-time, part-time, occasional, or undetermined basis. And indirectly employs over 100 000 people throughout the value chain or in industries related to the sector.

With increased investments, improved value chains, and strengthened collaborative efforts, on a yearly the industry might employ more than 10,000 people.

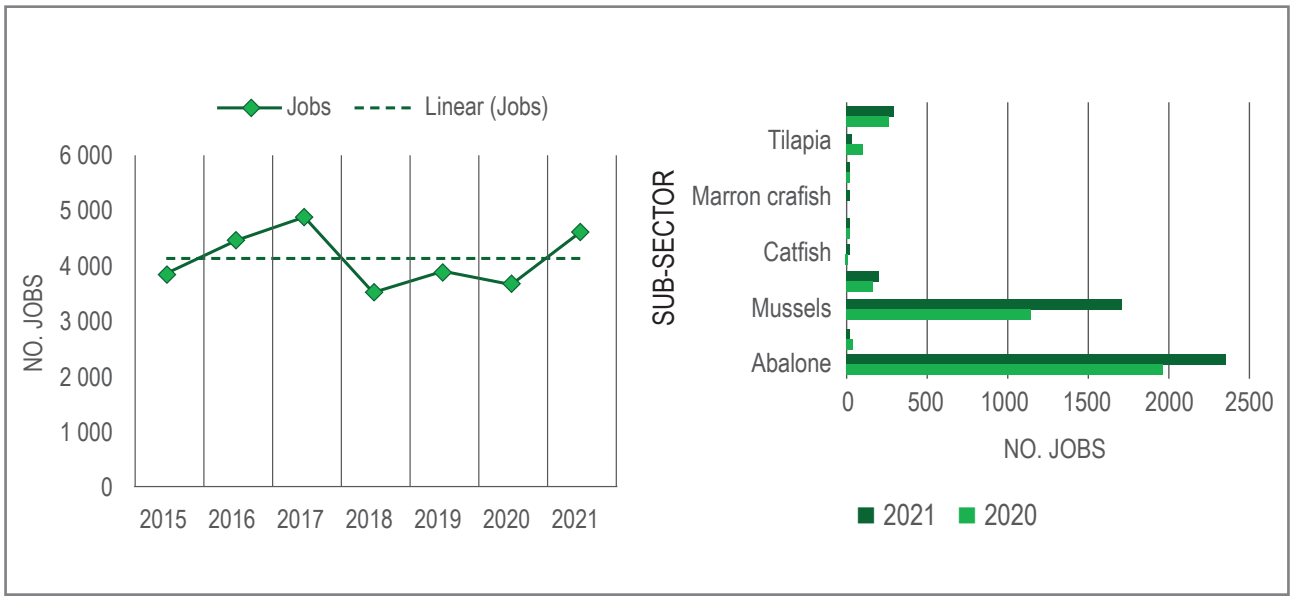


Figure 7.1: Employment in the aquaculture industry

With one job generated per ton of abalone harvested, the abalone subsector remains the largest employer. In 2021, the abalone subsector employed approximately 2 463 people, accounting for 43% of total the employment, followed by the mussel subsector (37%), trout (6%), oysters (4%), tilapia, catfish, and finfish (less than 1%).

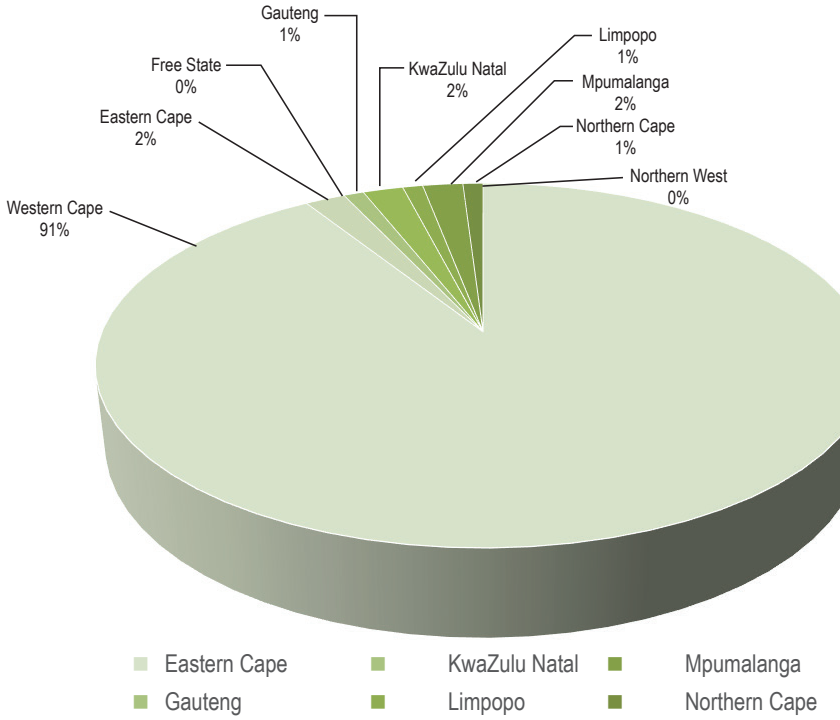


Figure 7.2: Jobs created per province

The production of marine aquaculture products continues to be dominated by the Western Cape. With 3895 employees, the province employs 91% of the sector's workforce, followed

by KwaZulu-Natal (106), the EC (95), Mpumalanga (74), and the Northern Cape (63), all of which have 2% of the workforce.

7.4 Capital Assets and Investment in Aquaculture

Despite multiple production challenges, South Africa's Aquaculture industry's growth and development are hindered by a lack of capital investment. Aquaculture operations are capital intensive and, therefore, require finance for several activities, including operating activities, the purchase of buildings, machinery and marketing arrangements and other relevant technologies. Timely access to financing sources is critical for improving farmer profitability and the sustainability of operations. The South African government established the Aquaculture Development and Enhancement Program, which is an incentive program that contributes up to 50% (capped at R20 million) of qualifying costs for all South African registered entities engaged in aquaculture activities. The development finance institutions and the private sector have always expressed a willingness to support aquaculture initiatives.

South Africa's Development Finance Institutions (DFIs) provide a range of financial solutions to farmers at various stages of the fish farming. Commercial banks and other private associates also offer different financing models in place for investing in Aquaculture operations. Aquaculture Technical Services publishes a comprehensive report containing information about the various programs and products offered by South African financing institutions on a yearly basis. The report outlines the funding criteria, the application process, and the contact information for each financing institution. The Aquaculture Development and Enhancement Program continues to play an important role in the industry's investment growth. In 2020, the incentive invested approximately R111,2 million, which represents a twofold increase in overall spending from 2020.

7.5 Market Analysis of Aquaculture Products 2021

Despite fluctuations in supply and demand caused by the external environment and the Covid-19 epidemic in 2020 and early 2021, the fisheries trade recovered considerably in 2021 (FAO/WTO, 2021). International fish prices were lower on average in 2020, but prices increased by seven (7) percentage points in 2021 in response to increased demand caused by the strong economic recovery. Aquaculture prices are expected to rise by (33%) percent (+1,5% p.a.) in nominal terms beginning in 2023 but remain stable in actual terms.

According to forecasts, the global market is currently worth US$191.3 billion and is expected to grow at a compound annual growth rate (CAGR) of (4,4%) percent to US$232.4 billion by 2026. Population growth, increased demand for animal protein, increased need for food security, and declining wild fisheries resources are all key drivers of this rising demand (OECD/FAO,2021). South Africa's Aquaculture industry is still relatively stable in terms of production; the industry is currently worth more than two billion dollars per year, and is the largest on the African continent, contributing up to (40%) percent of Africa's total production.

7.6 Export Trade Analysis

South Africa's total aquaculture exports are estimated to be 3 887,35 tons worth approximately R830 million in 2021 (Table 7.1). South Africa experienced a 28 % significant drop in export volumes compared to 2020, while export values increased by approximately R246 048 840, indicating a 35% percentage difference. Tilapia accounted for approximately 42% of total exports, followed by abalone (32%), mussels (8%), oysters (7%), and catfish (7%), respectively (Figure 7.1).

Table 7.1: Total export values per sub-sector in 2021

Species	Quantity (Tons)	Value of Quantity Exported (ZAR FOB)
Abalone	1 294,34	R717 721 649
Catfish	268,00	R5 517 499
Carp	3,01	R48 660
Trout	79,027	R6 662 943
Tilapia	1 630,89	R27 348 213
Atlantic Salmon	16,012	R1 750 045
Pacific Salmon	31,59	R4 925 930
Mussels	291	R15 784 943
Oysters	263,405	R50 060 414
Ornamentals	3,335	R699 160
Scallop	7,740	R318 929
TOTAL EXPORTS	**3 887,35**	**R830 838 385**

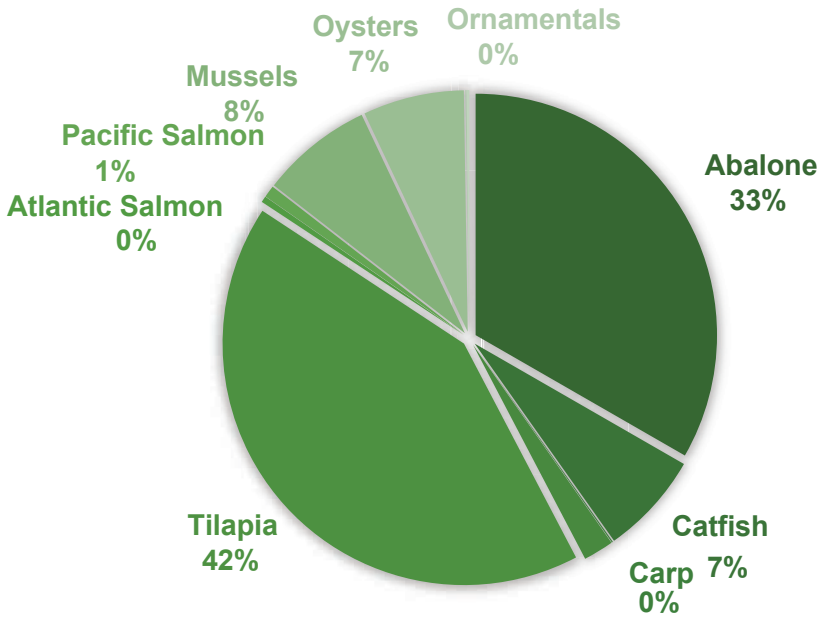


Figure 7.3 Export volumes per subsector

7.7 Top 10 Importing Countries for Aquaculture Products from South Africa

Figure 7.4 depicts the countries that imported aquaculture products from South Africa in 2021, as well as their contribution to total exports during the year. Malawi remains the largest importer of South African aquaculture products, accounting for up to 39%, followed by Hong Kong at 23%, Taiwan and the United States at 10%, and Mozambique, China, Namibia, the Democratic Republic of Congo, Australia, and Zambia each contributing less than 9%.

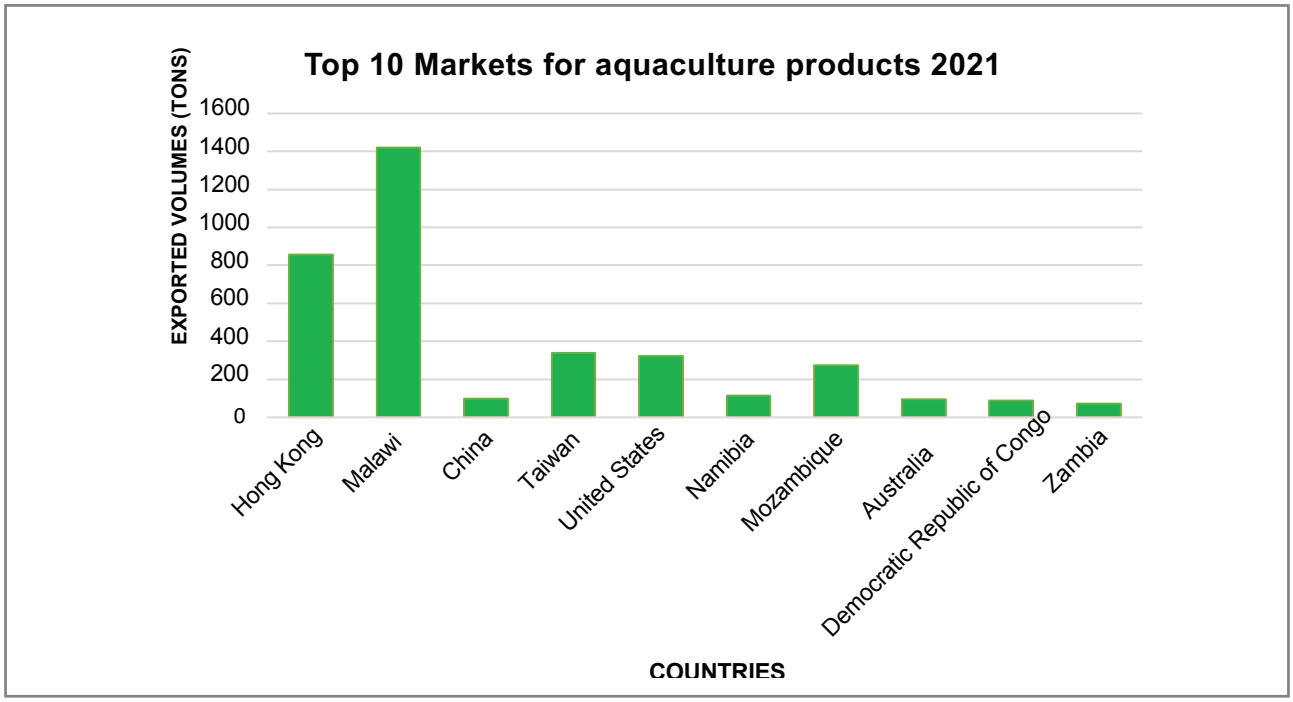


Figure 7.4 Top 10 importing markets for South Africa's aquaculture products

7.7.1 Abalone Exports 2021

South Africa is one of the top three abalone producers in the world, with most farms located in the Western Cape province. Abalone is commonly known as the best shellfish in the market and the best premium product with therapeutic benefits. South Africa supplies a wide range of abalone products, comprising of live, fresh, or chilled (HS: 030781), smoked, frozen, or both (as HS: 030783, 030787, and 030789), canned or preserved (as HS: 0307879). Canned abalone is often more popular in China than fresh abalone, which is preferred by Japanese consumers. Smoked, and dried abalone are the most traded types, particularly in the Hong Kong market. By far the major global markets for abalone are Hong Kong, China mainland, Taiwan, and Australia.

A total of 1 294 tons of abalone, worth R717 million were exported from South Africa in 2021. This represents a (44%) percentage increase over the 901 tons exported in 2020, as well as a significant increase in export revenues of up to (75%) percent from R408 489 765. Hong Kong was the largest importer, accounting for up to 59% percent of total trade, followed by Taiwan (20%) percent, Australia (7%), China (6%), and Singapore respectively.

Table 7. illustrates the value of exports based on the key abalone products traded in international markets. Abalone product sales have grown significantly, increasing from R408 489 765 in 2020 to R717 721 649 in 2021. This equates to an average annual growth rate of (75%) throughout this time.

Table 7.2: Markets for abalone exports in 2021

Species	Country of Destination	Quantity Exported (Tons)	Value of Quantity Exported (ZAR FOB)
Abalone	Canada	0,277	R2 377 053
Abalone	Japan	0,226	R26 676
Abalone	Lesotho	0,0018	R65
Abalone	Thailand	0,212	R57 595
Abalone	Australia	94,319	R1 749 118
Abalone	Democratic Republic of Congo	0,599	R11540
Abalone	China	82,30	R64 845 356
Abalone	Hong Kong	759,64	R55 1683712
Abalone	Namibia	1,5	R1500
Abalone	Malaysia	0,496	R213 964
Abalone	Taiwan	258,248	R88 161390
Abalone	Singapore	5,629	R3 597 735
Abalone	United States	90,893	R4 995 945
TOTAL		**1 294,34**	**R717 721 649**

Source: South African Revenue Service (SARS), 2021

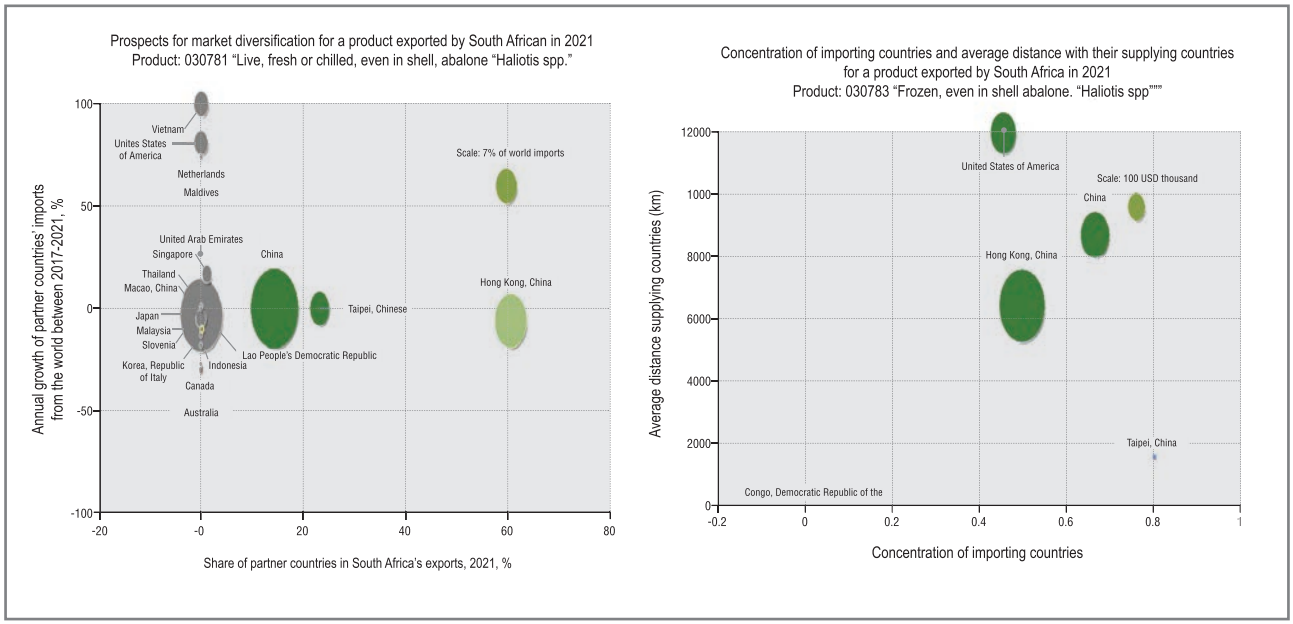


Figure 7.5: Main importing countries of abalone products in 2021

Figure 7.5 shows the major importing countries for each of the main abalone products categories based on the volume of exports. In total, Hong Kong was the biggest importer

of smoked and frozen abalone followed by China, Taiwan is the second largest importer of live abalone after Hong Kong. In terms of other abalone products such as canned, frozen on shell etc. Thailand is the largest importer amounting up to 67% of South's product export. Figure 7.6 below indicates abalone monthly exports.

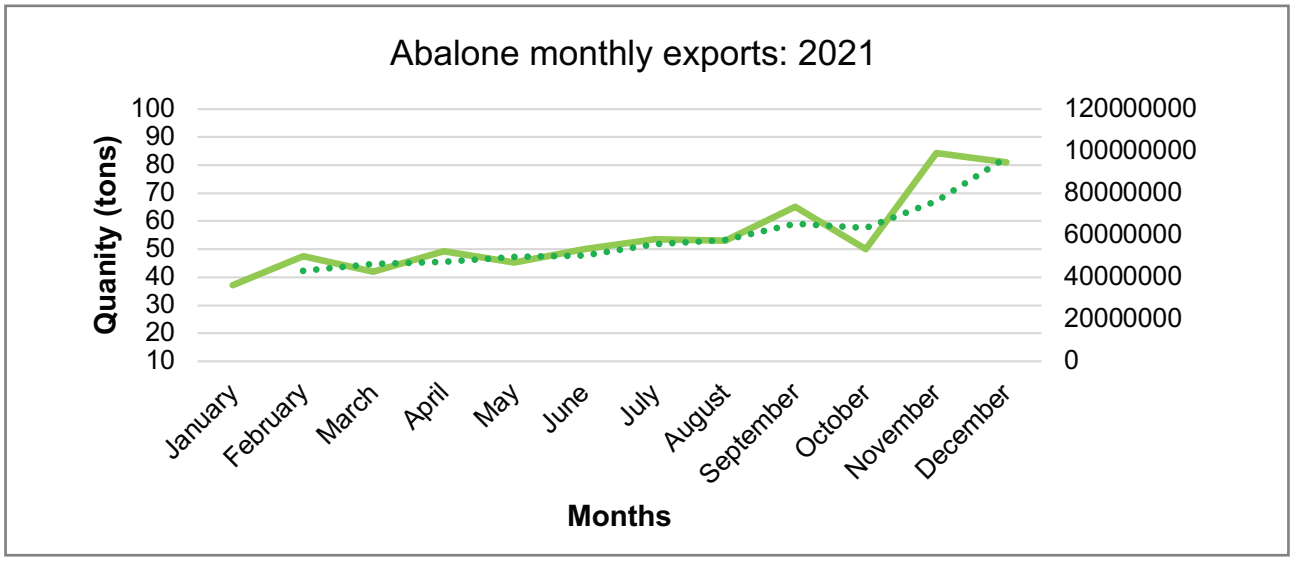


Figure 7.6: Abalone monthly exports

The average monthly abalone exports varied from 30 to 50 tons per month, but the number of sales climbed dramatically during the month and December and went to 80 tons.

Summary of Abalone Export Patterns

Abalone exports have been stable for the past four years, with very little growth momentum; however, abalone exports increased exponentially from 2020 to 2021 (Figure 7.5). However, despite the noted significant increases in illegal trade of abalone, South Africa's farmed abalone production has increased significantly in recent years, for example, abalone production in 2019 totalled 1 656 tons, an 9% increase over the previous year. Furthermore, the abalone subsector increased by 307,27 tons (19%) in 2020, reaching a total of 1 963,80 tons (43%). This exponential trend continued in 2021 abalone production increased to 2 354,38 tons, thereby representing an 20% difference from 2020.

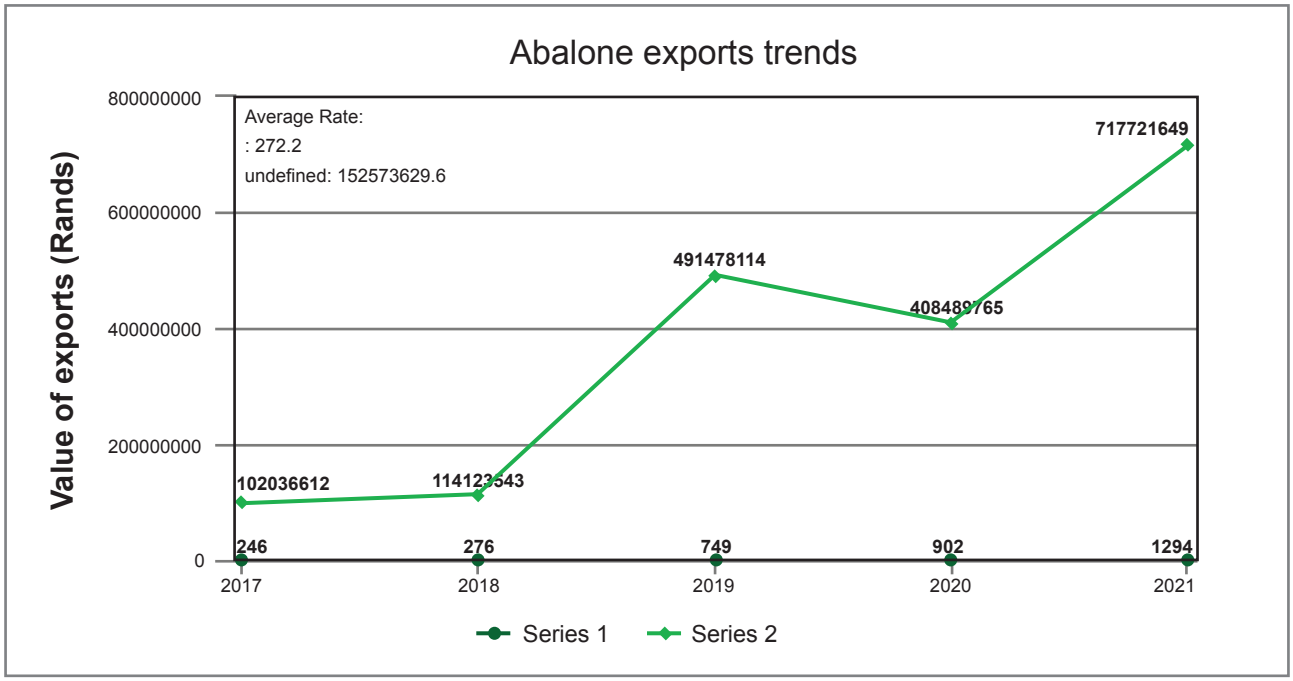


Figure 7.7: Year export trends of abalone

7.7.2 Catfish exports 2021

In 2021, South Africa exported up to 268 tons of catfish with most catfish exported to Mozambique and Namibia. South Africa does not produce many catfish because of consumer resistance, which is exacerbated by religious beliefs and South Africans' perception of catfish as a scavenger. As a result, most catfish consumers are from neighbouring countries. However, due to the rising demand from other African markets, the country sourced approximately 2 084 tons of catfish to supplement the international market, primarily from Mozambique, which imported approximately 91% of the catfish commodity exports.

Table 7.3 Catfish export markets in 2021

Species	Country of Destination	Quantity Exported (Tons)	Value of Quantity Exported (ZAR FOB)
Catfish	Namibia	21,950	R430 455
Catfish	Mozambique	246,115	R5 616 474
Catfish	Lesotho	0,264	R4 182
TOTAL		268,34	R6 051 101

Catfish export sales increased dramatically in October, from 40 tons to 85 tons, before declining steadily by 10% in November (Figure 7.8). In 2021, South Africa exported up to 20 tons per month on average. August and November saw the greatest monthly export volumes.

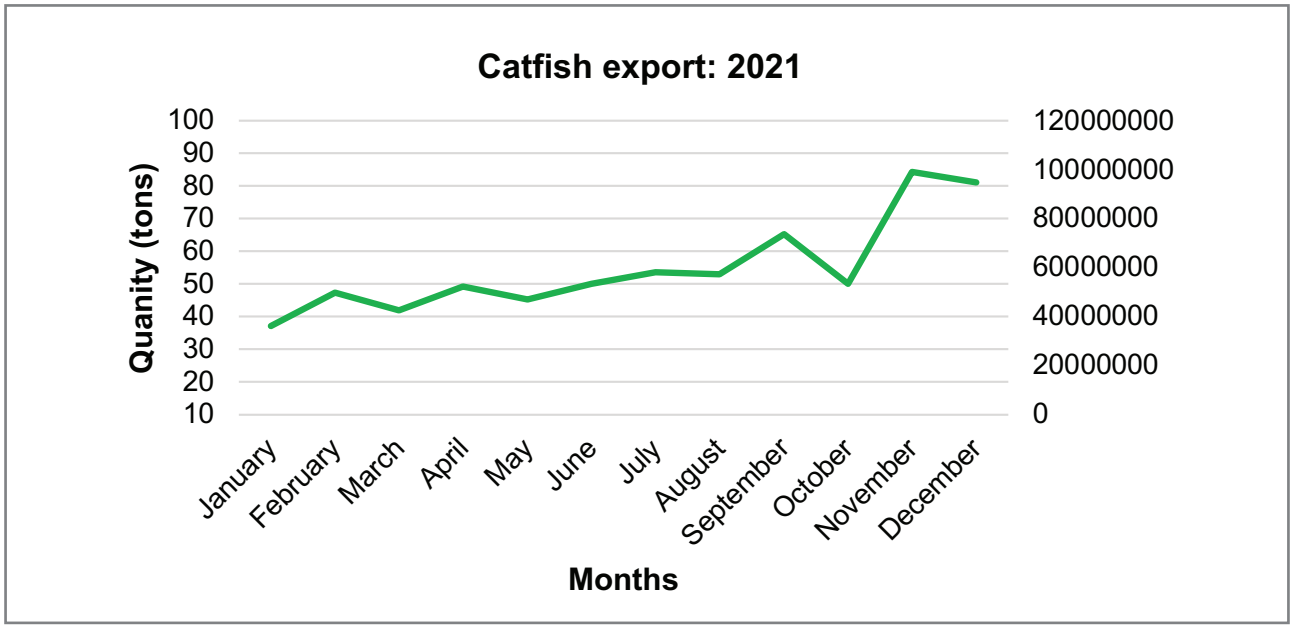


Figure 7.8: Catfish monthly exports

7.7.3 Carp exports 2021

South Africa exported approximately 3 tons of carp valued at R48 660, priced at R162 20 per ton (Table 7.4). Mozambique was the primary importer. Carp production in South Africa has been stagnant since 2018, owing to increased competition from the world's best carp producers.

Table 7.4: Common carp export markets in 2021

Species	Country of Destination	Quantity Exported (Tons)	Value of Quantity Exported (ZAR FOB)
Carp	Mozambique	3,01	R48 660
TOTAL		**3,01**	**R48 660**

7.7.4 Trout exports 2021

Trout and salmon are the backbone of aquaculture in South Africa and around the world. In 2021, South Africa produced 1 583 tons, but exported only 79 tons worth R6 662 943 (Table 7.5). This is due to the high demand for trout in the local market; currently, the industry is experiencing an imbalance since local demand exceeds supply; as a result, the industry relies on imports to meet local demand. To close this gap, more capital investment in the industry is required. In addition to South Africa's target market for trout, Lesotho was the leading importer of trout in 2021, accounting for up to 70% of total imports, followed by Zambia (18%), Spain (5%), Mozambique (3%), and the United States (1%).

Table 7.5: Trout export markets in 2021

Species	Country of Destination	Quantity Exported (Tons)	Value of Quantity Exported (ZAR FOB)
Trout	Zimbabwe	0,372	R22 357
Trout	Zambia	14,103	R460 903
Trout	Unclassified	0,215	R38 670
Trout	United States	1,388	R293 096
Trout	Spain	4,107	R247 165
Trout	Nigeria	0,057	R23 338
Trout	Namibia	0,802	R58 327
Trout	Mozambique	2,133	R338 689
Trout	Malawi	0,464	R18 845
Trout	Iran	0,112	R77 741
Trout	Lesotho	54,715	R5 058 248
Trout	Ethiopia	0,003	R1043
Trout	Botswana	0,424	R2500
Trout	Democratic Republic of Congo	0,001	R400
Trout	Eswatini	0,126	R21 621
TOTAL		**79,027**	**R6 662 943**

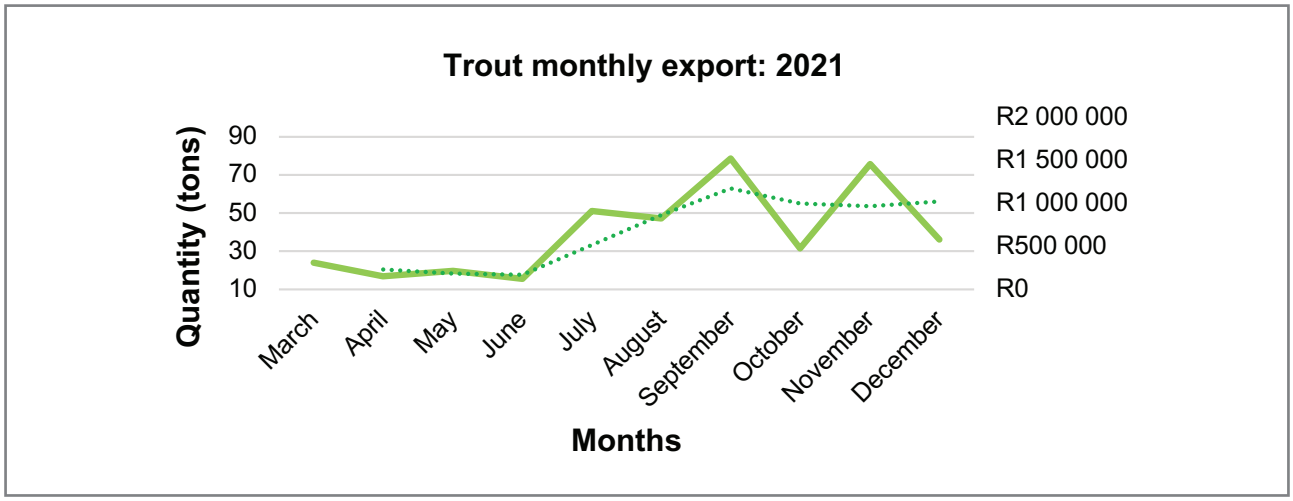


Figure 7.9: Trout volumes of monthly exports

During the first half of 2021, trout exports values were steadily declining from March to June, followed by a fluctuating trend that saw a significant increase in September before declining sharply in December (Figure 7.9).

7.7.5 Tilapia exports 2021

Producers are capitalising on lucrative opportunities in the global tilapia market as governments encourage tilapia production to improve food security. China is the leading tilapia producer, followed by Egypt and Indonesia, which has grown rapidly in terms

of volume over the last few years. In terms of market trends of tilapia, suppliers have seen significant growth in recent years. Tilapia is a well-known seafood in the dietary, pharmaceutical, personal care, and cosmetic industries. The market for tilapia is anticipated to grow from up to US$9.2 billion by 2027.

South Africa exported approximately 1 630 tons with an estimated value of R27 348 213 towards other African markets in 2021. Nevertheless, the tilapia industry saw a drop in export volumes of 1 933 tons from 3 563,88 tons exported in 2020. Malawi procured 86% of the country's tilapia exports in 2021, followed by the Democratic Republic of Congo with 5%, Zambia with 3%, Eswatini with 2%, Namibia with 1%, and Mozambique with less than 1% (Table 7.6).

Table 7.6 Tilapia export markets in 2021

Species	Country of Destination	Quantity Exported (Tons)	Value of Quantity Exported (ZAR FOB)
Tilapia	Zimbabwe	0,6	R14 400
Tilapia	Botswana	8,060	R241 900
Tilapia	Democratic Republic of Congo	77,552	R1 343 318
Tilapia	Eswatini	34,388	R743 633
Tilapia	Italy	1,305	R133 118
Tilapia	Zambia	53,947	R1 070 682
Tilapia	Saint Helena, Ascension, and Tristan da Cunha	0,001	R267
Tilapia	Namibia	21,711	R474 198
Tilapia	Mozambique	10,000	R165 000
Tilapia	Malawi	1 418,271	R23 077 350
Tilapia	Lesotho	5,053	R84 347
TOTAL		**1 630,89**	**R27 348 213**

During the first quarter of 2021, tilapia markets saw increased demand, which was amplified by the exponential rise in trade liberalisation following the Covid-19 pandemic (Figure 7.10). Export volumes fell significantly between May 2021 and August 2021, with quantities and volumes falling by 23% and 35%, respectively.

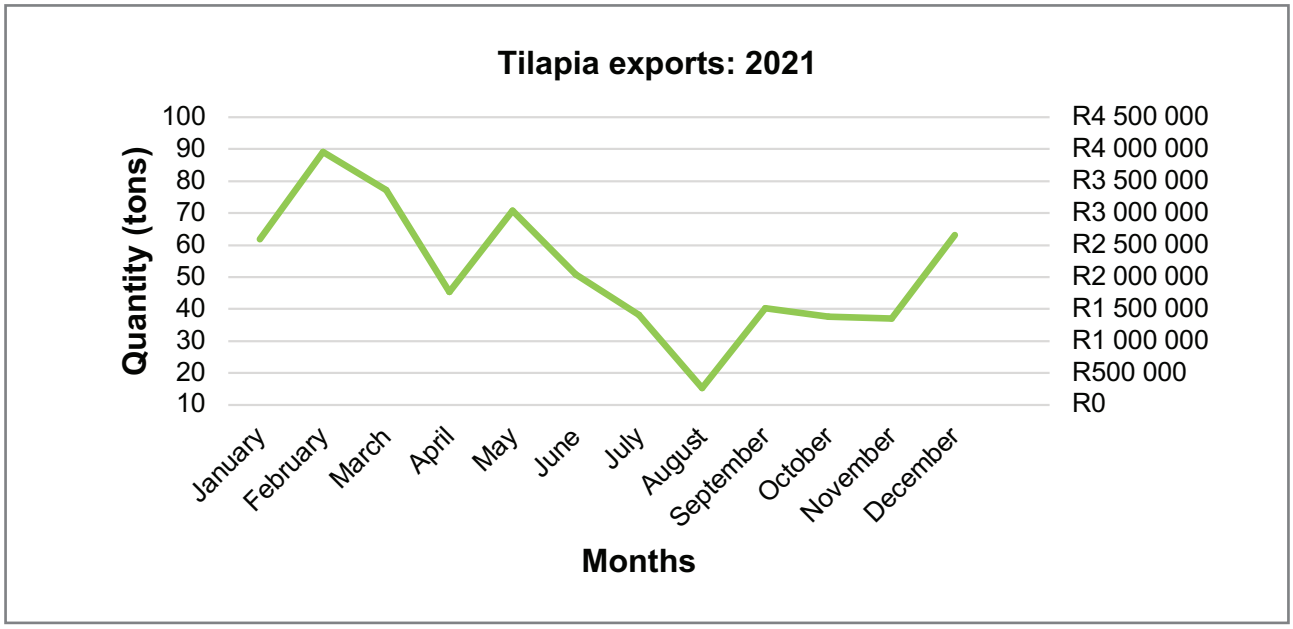


Figure 7.10: Tilapia volumes of monthly exports

7.7.6 Atlantic Salmon exports 2021

Globally, Atlantic salmon is the most cultured species of salmon: and is currently the most widely consumed salmon species. It is high in proteins, vitamins, and omega-3 fatty acids. The Covid-19 outbreak, on the other hand, has had an impact on the global salmon industry at every stage of the supply chain, including production, processing, and logistics. The result was a significant decline in South Africa's export volumes, which fell by 88% from 131,54 tons exported in 2020 to 16,012 tons valued at R1 750 045 in 2021.

Table 7.7: Atlantic salmon export markets in 2021

Species	Country of Destination	Quantity Exported (Tons)	Value of Quantity Exported (ZAR FOB)
Atlantic salmon	Zimbabwe	3,435	R33 520
Atlantic salmon	United States	2,300	R432 739
Atlantic salmon	Ship/Aircraft	0,40	R1 617
Atlantic salmon	Nigeria	0,150	R20 100
Atlantic salmon	Namibia	3,601	R302 272
Atlantic salmon	Mozambique	2,971	R453 313
Atlantic salmon	Botswana	0,680	R76 523
TOTAL		**16,012**	**R1 750 045**

In 2021, South Africa exported an average of 1,4 tons of Atlantic salmon per month. The most was exported in June, ranging from 46%, followed by 17,9 and 19% in August and October, respectively (Figure 7.11).

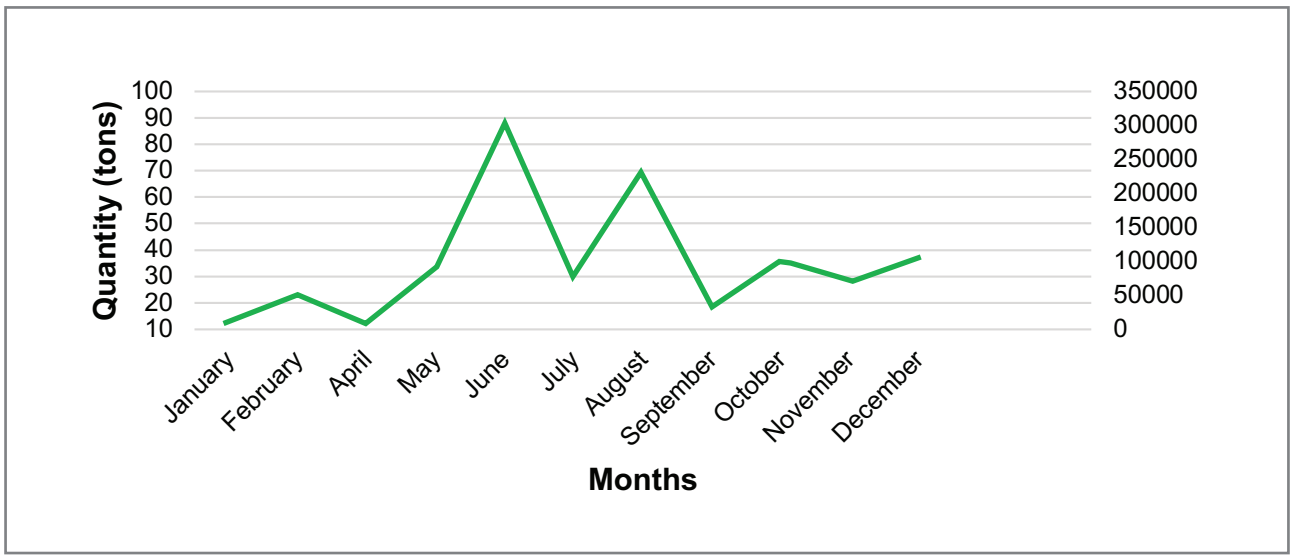


Figure 7.11: Atlantic salmon volumes of monthly exports

7.7.7 Pacific Salmon exports 2021

South Africa exported only 31,59 tons of Pacific salmon worth R4 925 930 in 2021, a significant decrease of up to 57% from export volumes in 2020 (Table 7.8). Namibia was the biggest buyer of Pacific salmon in 2021, importing roughly 74% of the total, followed by Zambia with 13%, Botswana with 9%, Mozambique with 3%, Angola with 3%, and all other nations with imports of less than 1% each.

Table 7.8: Export markets for Pacific Salmon in 2021

Species	Country of destination	Quantity exported (Tons)	Value of Quantity Exported (ZAR FOB)
Pacific salmon	Zimbabwe	0,600	R22 785
Pacific salmon	Angola	1,200	R12 383
Pacific salmon	Antarctica	0,016	R3 415
Pacific salmon	Botswana	3,052	R620 238
Pacific salmon	Democratic Republic of Congo	0,005	R1 677
Pacific salmon	Eswatini	0,100	R12 532
Pacific salmon	Ethiopia	0,001	R538
Pacific salmon	Israel	0,699	R83 458
Pacific salmon	Lesotho	0,33	R14 803
Pacific salmon	Malawi	0,735	R21 519
Pacific salmon	Mozambique	1,025	R32 7400
Pacific salmon	Namibia	23,722	R3 665 585
Pacific salmon	Nigeria	0,016	R5950
Pacific salmon	Ship/Aircraft	0,002	R1002
Pacific salmon	Zambia	4	R132 645
TOTAL		**31,59**	**R4 925 930**

South Africa's Pacific salmon exports were fluctuating in 2021, falling from an average monthly export of 2,6 tons to 1,8 to 1,5 tons. The highest export returns were only recorded in May, amounting to R721 597, while the lowest volumes were exported in September (Figure 7.12).

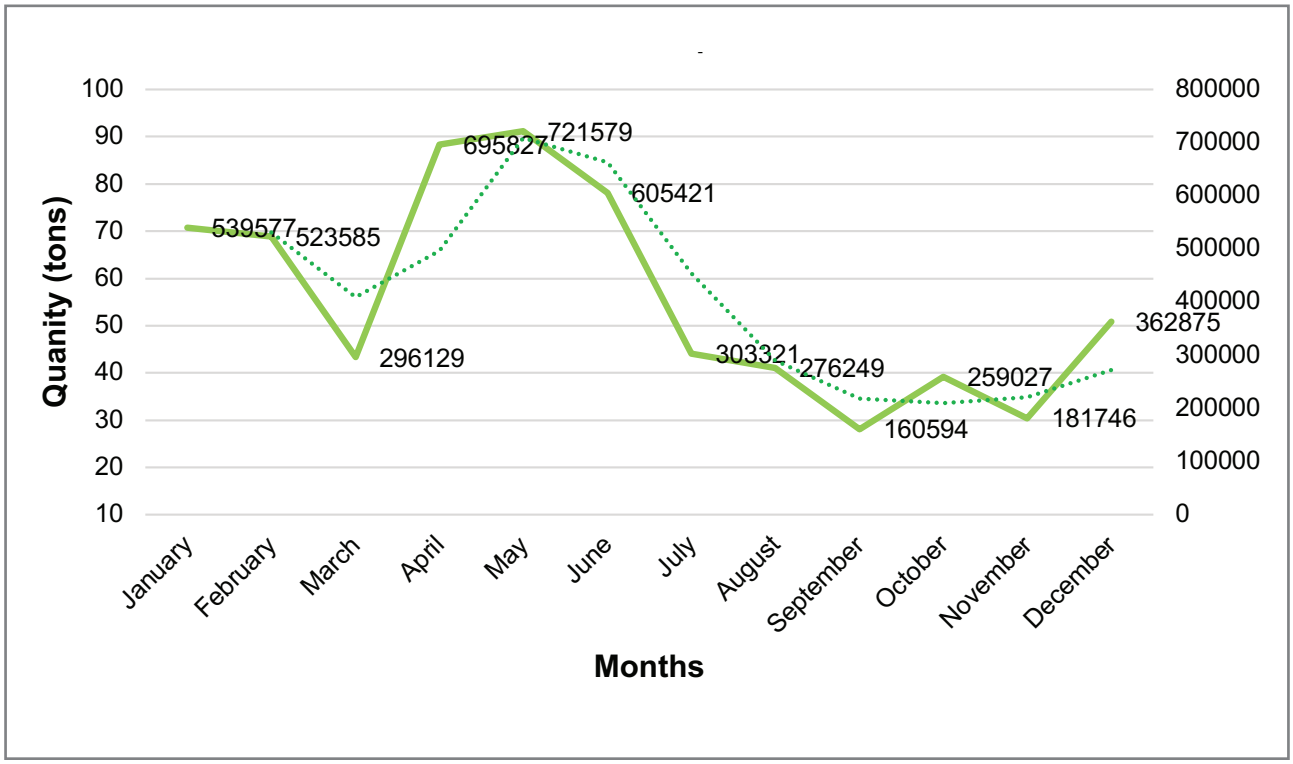


Figure 7.12: Pacific salmon volumes of monthly exports

7.7.8 Mussel exports 2021

The global mussel's market is expected to be worth USD4.1 billion by 2022, growing at a CAGR of 4,6% between 2022 and 2032. In addition, the mussel market has seen exceptional growth in recent years, and this trend is expected to continue in the future. Consumers' growing health concerns, as well as their growing knowledge of the advantages of mussel extracts, have had an impact on this trend. Mussel extract improves nerve cell function while also increasing bone and tissue sensitivity. Mussel extract is found in a wide range of supplement products, including immunity boosters and dietary supplements.

South Africa exported 291 tons of mussel worth up to R15,7 million in 2021, a 174,528% annual rise from the previous year, when the country sold 106,41 tons worth R5,9 million. The United States was the biggest importing market for this subsector, accounting for almost 71% of total trade, followed by Namibia (9%) and Eswatini (6%) (Table 7.9).

Species	Country of Destination	Quantity Exported (Tons)	Value of Quantity Exported (ZAR FOB)
Mussels	Singapore	5,85	R414 274
Mussels	United States	207,10	R12 322 624
Mussels	Tanzania	0,523	R32 193
Mussels	Zimbabwe	2,608	R167 461
Mussels	Zambia	4,3	R197462
Mussels	Seychelles	0,519	R22 618
Mussels	Saint Helena, Ascension, and Tristan da Cunha	0,022	R1 873
Mussels	Nigeria	2,610	R161 601
Mussels	Netherlands	0,050	R9200
Mussels	Namibia	27,347	R1 251 032
Mussels	Mozambique	5,647	R332 113
Mussels	Mauritius	3,744	R354 447
Mussels	Australia	7,678	R131 065
Mussels	Lesotho	0,866	R8 586
Mussels	Malawi	1,05	R73 036
Mussels	Kenya	0,609	R65 837
Mussels	Hong Kong	0,048	R15
Mussels	Botswana	2,252	R126 296
Mussels	Democratic Republic of Congo	0,957	R52 936
Mussels	Eswatini	17,747	R47 927
Mussels	Ghana	0,180	R12 347
TOTAL		**291**	**R15 784 943**

Table 7.9: Mussels export markets in 2021

South Africa's mussels export has fluctuated monthly, but an average of 45 tons worth R1,5 million and R3,7 million were exported from March to May and from May to July and August, respectively, before a steep decline in export appeared in September and December (Figure 7.13).

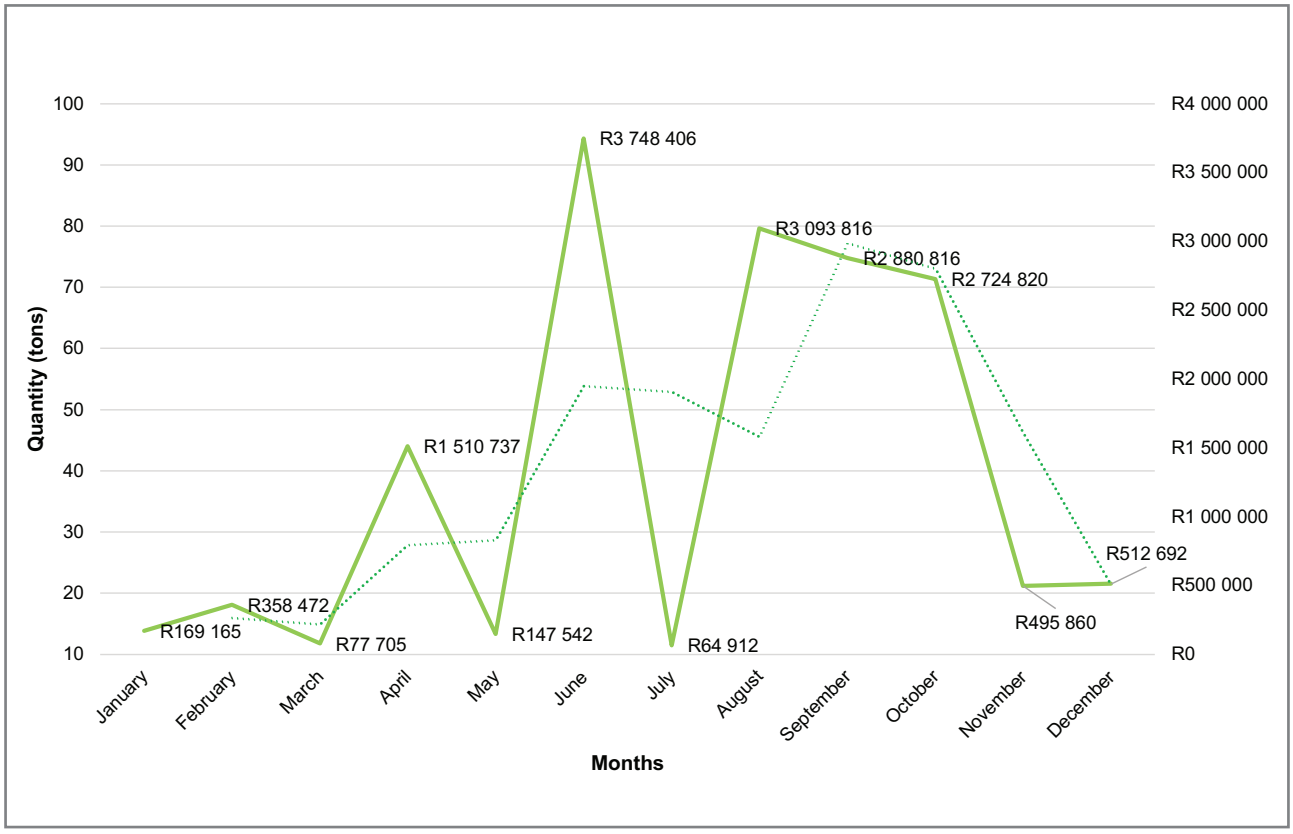


Figure 7.13: Mussel volumes of monthly exports

7.7.9 Oyster exports 2021

The oyster industry was severely impacted by the Covid-19 pandemic in 2020, but it recovered in 2021. Volumes and consumption recovered very strongly in 2021, as a result, South Africa exported 263 tons of oysters valued approximately R50 million. Significant quantities of export proceeded to Hong Kong (41%), Taiwan (31%), Namibia (8%), the United States (7%), and China (6%), in that order (Table 7.10).

Table 7.10: Oyster export markets in 2021

Species	Country of Destination	Quantity Exported (Tons)	Value of Quantity Exported (ZAR FOB)
Oysters	China	15,670	R2 102 052
Oysters	Botswana	3,717	R25 788
Oysters	Democratic Republic of Congo	8,051	R907 820
Oysters	Eswatini	0,501	R78 670
Oysters	Zambia	0,822	R46 655
Oysters	Hong Kong	97,203	R18 406 721
Oysters	Malaysia	0,721	R194 820
Oysters	Lesotho	2,034	R124 610
Oysters	Mozambique	3,288	R76 186
Oysters	Malaysia	0,721	R194 820

Oysters	Namibia	20,658	R1 997 494
Oysters	Saint Helena, Ascension, and Tristan da Cunha	0,409	R9 828
Oysters	Ship/Aircraft	0,008	R1 627
Oysters	Thailand	0,220	R5 8237
Oysters	United Arab Emirates	0,047	R349
Oysters	United States	19,840	R368 426
Oysters	Tanzania	0,817	R65 101
Oysters	Singapore	5,835	R1 063 775
Oysters	Taiwan	82,446	R24 298 237
Oysters	Ghana	0,151	R26 456
Oysters	Zimbabwe	0,242	R12 742
TOTAL		**263,405**	**R50 060 414**

When compared to the same time in 2020, oyster exports grew by more than 15% from January to April 2021, with trade value climbing to R8,3 million (Figure 7.12).

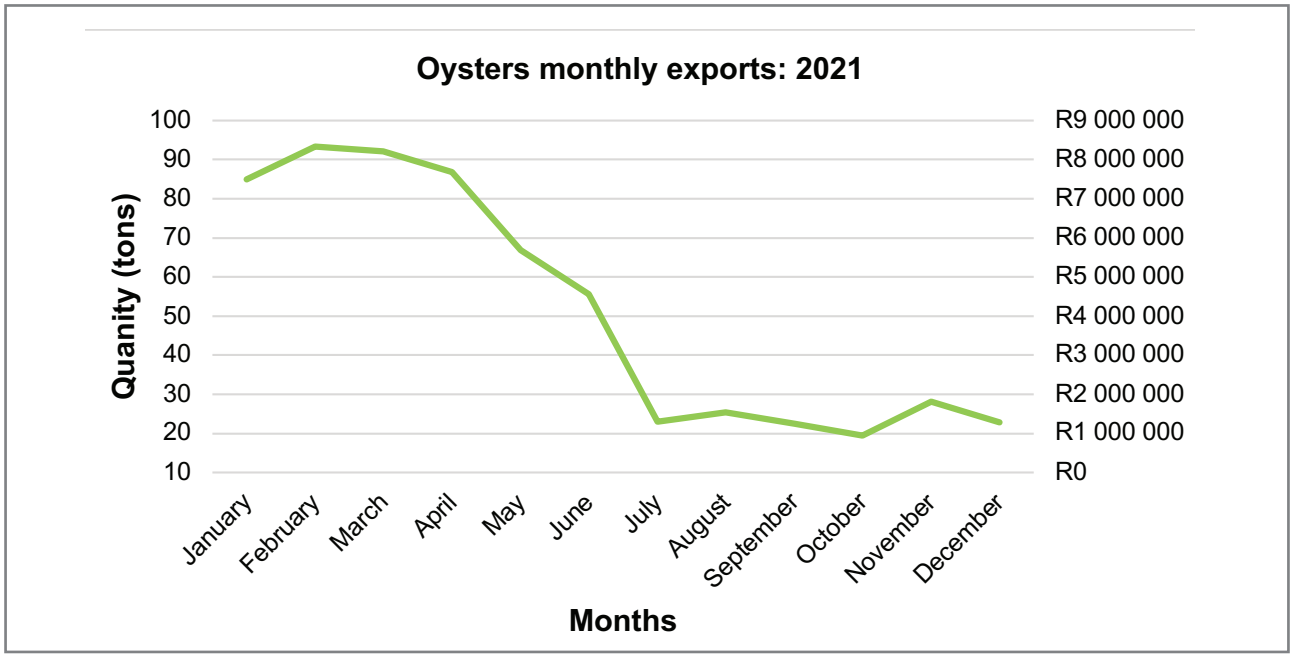


Figure 7.14: Oyster volumes of monthly exports

7.7.10 Ornamentals exports 2021

Aquarium fish keeping has been a popular hobby for millennia, and its growing popularity has resulted in a continuous increase in trade. Currently, the sector is worth between $15 and $30 billion every year. Asia accounts for 55% of global market supplies. In 2021, South Africa exported 3,33 tons of ornamentals to a value of R699 160. The industry saw no substantial change in terms of quantity exported between 2020 and 2021, but the value climbed dramatically by up to 87%. The top five (5) ornamental importing markets are Mauritius (42%) and an unclassified market that imported up (43%), with the remainder going to neighbouring nations. The detailed trade for ornamental is shown on next page.

Table 7.11: Ornamentals export markets in 2021

Species	Country of Destination	Quantity Exported (Tons)	Value of Quantity Exported (ZAR FOB)
Ornamentals	Zambia	0,016	R3 480
Ornamentals	Namibia	0,192	R33 800
Ornamentals	Unclassified	1,380	R323 415
Ornamentals	Mauritius	1,390	R297 394
Ornamentals	Zimbabwe	0,134	R35 668
Ornamentals	Lesotho	0,200	R1 450
Ornamentals	Eswatini	0,9	R978
Ornamentals	Democratic Republic of Congo	0,12	R2 975
TOTAL		**3,335**	**R699 160**

South Africa traded 0,275 tons of ornamentals worth R58 263,33 per month on average, but the monthly exports were flat, with April and October exporting the most. In March and September, the least amount was exported (Figure 7.15).

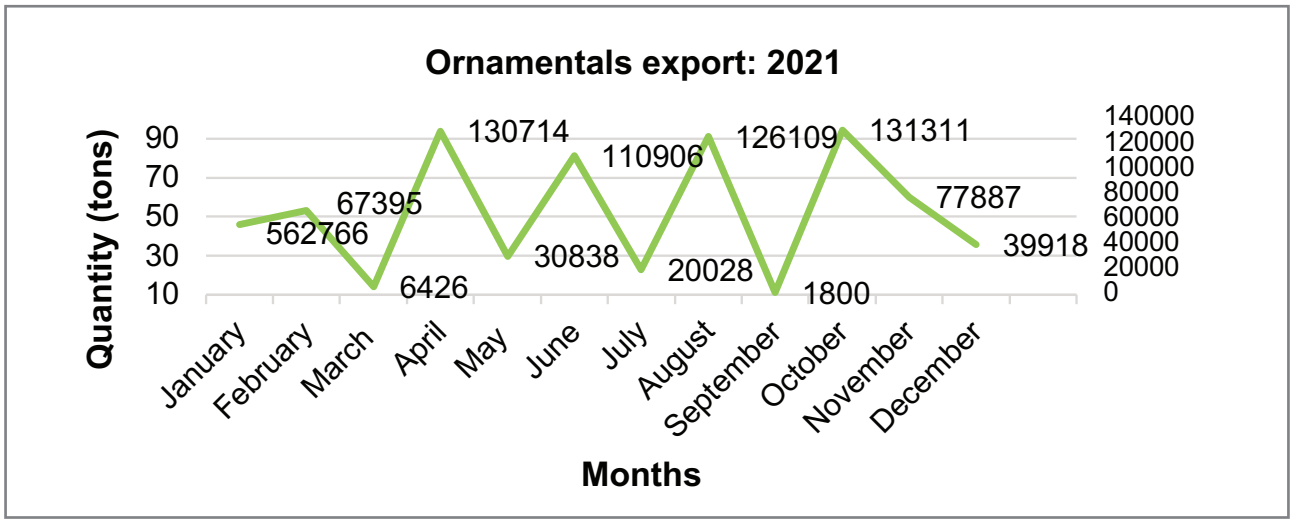


Figure 7.15: Ornamental monthly exports

7.7.11 Scallop exports 2021

Scallops are one of the most traded and consumed seafoods in the world, with aquaculture accounting for the greater part of production. However, during 2021, the scallop industry reported lower volumes with high prices in the market. However, given that scallop production is constrained globally, the situation is anticipated to persist throughout 2023. On the other hand, South Africa exported about 8 tons of scallops for R318 929. Up to 90% more scallops were exported compared to the previous year, and the value of exports increased significantly

by 165%. Zimbabwe (44%), Lesotho (39%) and Democratic Republic of the Congo (12%) were the main markets for scallops, while Malawi and Mozambique both imported (2% and less) (Figure 7.16 and Table 7.12).

Table 7.12: Scallop exports in 2021

Species	Country of Destination	Quantity Exported (Tons)	Value of Quantity Exported (ZAR FOB)
Scallop	Mozambique	0,005	R1 402
Scallop	Malawi	0,005	R482
Scallop	Democratic Republic of Congo	1,027	R149 175
Scallop	Lesotho	3,128	R135 270
Scallop	Zimbabwe	3,575	R32 600
TOTAL		**7,74**	**R318 929**

From January to September 2021, South Africa exported less than one ton on average; however, in September and October, exports increased significantly, approaching values ranging from R17 001 to R139 850 before reaching R24 121 in December (Figure 7.16).

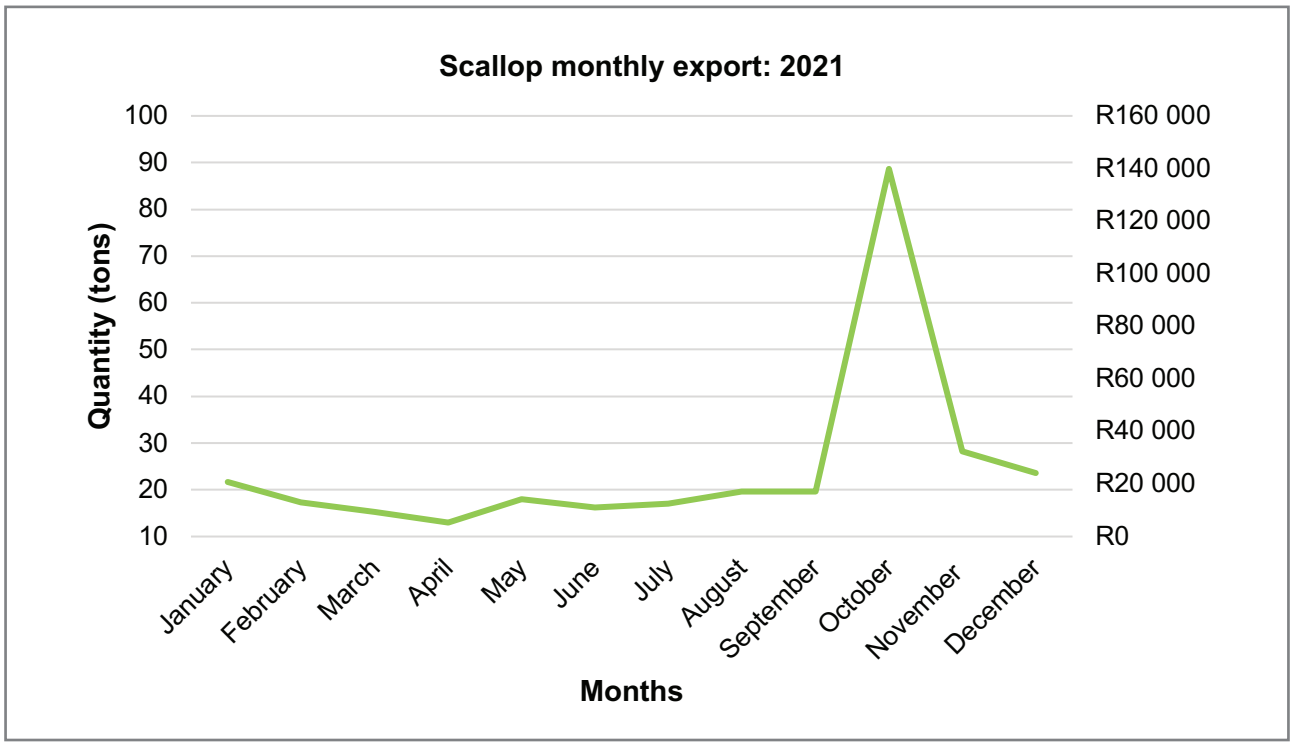


Figure 7.16: Scallop volumes of monthly exports

7.8 Trade Analysis of Fisheries Imports

Table 7,13 shows the total quantity and value of imported aquaculture goods in 2021. South Africa imported 13 933,53 tons of fisheries products in 2021, a 12% decline from the previous year's imports of 15 850,45 tons. In terms of value, the interval range fell from R595 736 130

in 2020 to R345 763 558 in 2021. Imports have typically been flat since peaking in 2019 and then flattening out around 2020 and 2021.

Table 7.13: Total import quantity and the total cost of aquaculture species in 2021

Species	Quantity Imported (Tons)	Value of Quantity Imported (ZAR FOB)
Tilapia	10 922,68	R119 998 931
Trout	1 141,22	R82 361 804
Atlantic Salmon	1 027,22	R101 608 291
Carp	242,37	R3 478 811
Catfish	203,2	R2 084 822
Ornamental	194,79	R27 724 250
Mussels	110,27	R4 255 295
Oysters	51,62	R2 433 568
Pacific Salmon	31,4	R503 374
Scallop	6,37	R1 194 222
Other aquatic invertebrates	2,39	R120 159
TOTAL	**13 933,53**	**R345 763 558**

Tilapia was the most common species imported into South Africa, accounting for 10 922,68 tons. The amount of tilapia imported has grown by 5% from 10 377 tons in 2020. Trout was the second largest species, followed by Atlantic salmon, with 1 141,22 and 1 027,22 tons, respectively.

7.9 South Africa's top 10 Aquaculture exporting Countries in 2021

Figure 7.17 depicts the top ten nations that exported aquaculture goods to South Africa in 2021, along with the relative quantities exported. China continues to be the largest supplier of aquaculture products, accounting for 78% of total imports into South Africa.

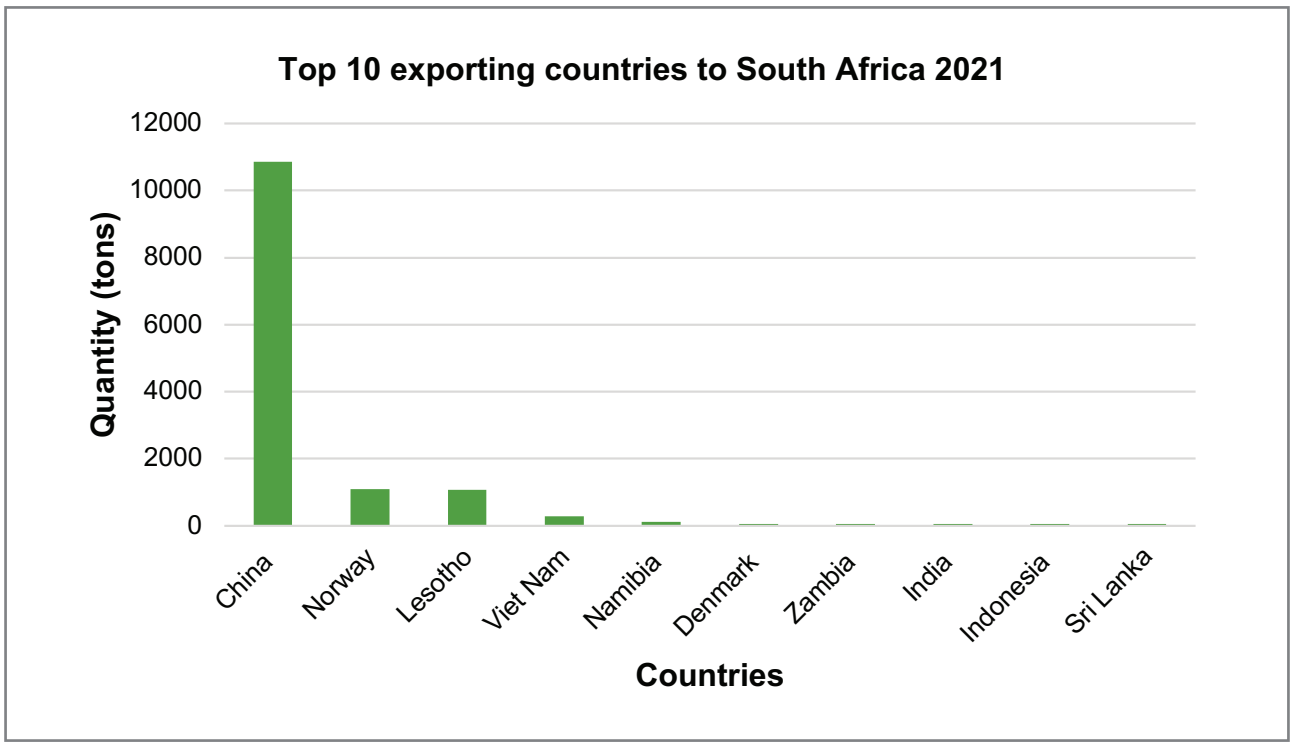


Figure 7.17: Top 10 exporting countries

Considering the significant quantities of tilapia imports reported in 2021, this might be owing to China is by far the greatest producer of tilapia, producing more than 10 922 tons annually. Norway ranked second in terms of exports, contributing about 1 087,91tons. Lesotho accounted for approximately 22 per cent of total imports. Most of the supplies are provided by operations near Katse Dam, an enclave surrounded by South Africa.

Imports by Species 2021

7.9.1 Atlantic Salmon imports 2021

On a monthly basis, South Africa imported an average of 85,6 tons of Atlantic salmon. However, the highest value of Atlantic salmon imported in 2021 in September was R89 767 665, while the lowest quantity was R160 818 in July. Furthermore, in 2021, the monthly average quantity of Atlantic salmon will cost around R8 467 357.

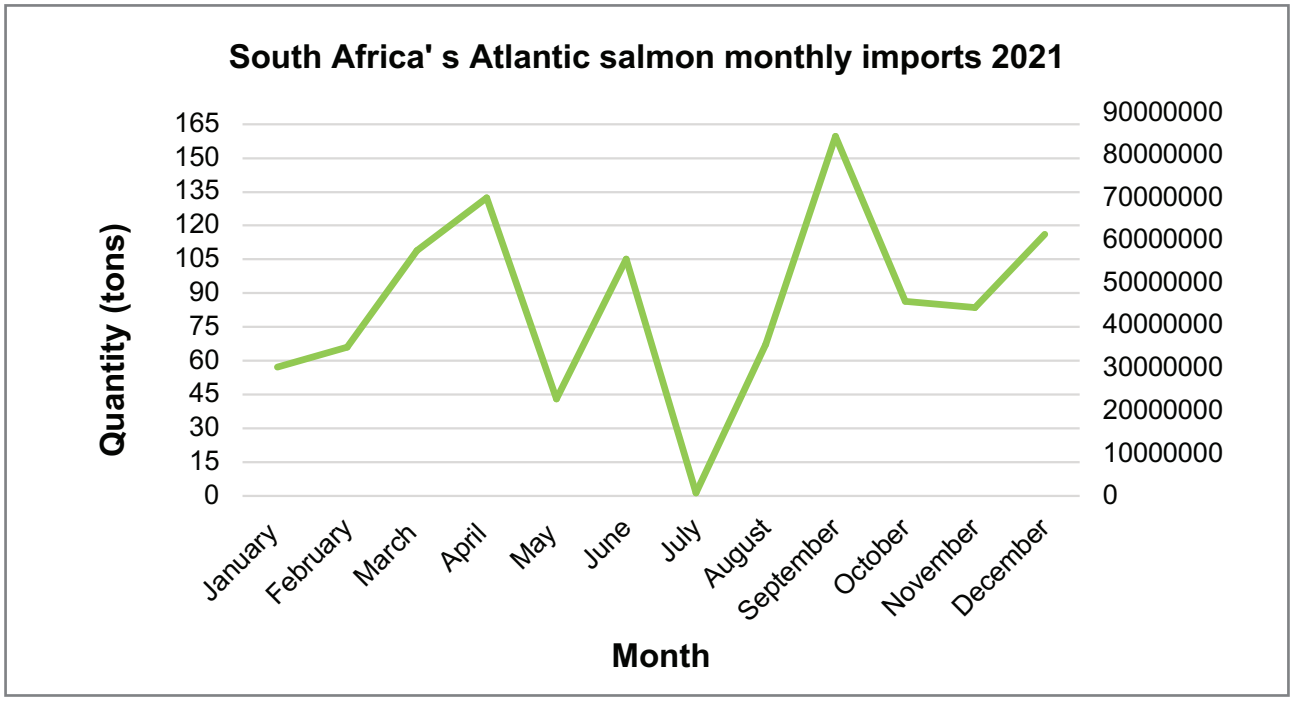


Figure 7.18: South Africa's Atlantic salmon monthly imports in 2021

Table 7.14 shows the total value of imports as well as the quantity of imports. In 2021, roughly 1 027,22 tons of Atlantic salmon were imported at a cost of R101 608 291. According to the data, the total volume of imported Atlantic salmon fell by 2 025,37 tons between 2020 and 2021, for a loss of R201 092 816. Norway was the sole exporter of Atlantic salmon in 2021. The number of Atlantic salmon imported into South Africa in 2021 was 7% less than the previous year.

Table 7.14: Atlantic salmon imports in 2021

Species	Exporting Country	Quantity Imported (Tons)	Value of Quantity Exported (ZAR FOB)
Atlantic Salmon	Norway	1 027,22	R101 608 291
TOTAL		**1 027,22**	**R101 608 291**

7.9.2 Carp imports 2021

South Africa imported carp throughout the year 2021, except for July, August, and December. The months with the highest and lowest imports were June (103,70 tons) and March (0,91 tons) respectively. Carp was imported into South Africa at a monthly average of 20,2 tons. The maximum value of quantity exported for carp was R803 513 in June, and the lowest value of quantity exported was R87 355 in January. The monthly average quantity for carp in 2021 was R289 900,90.

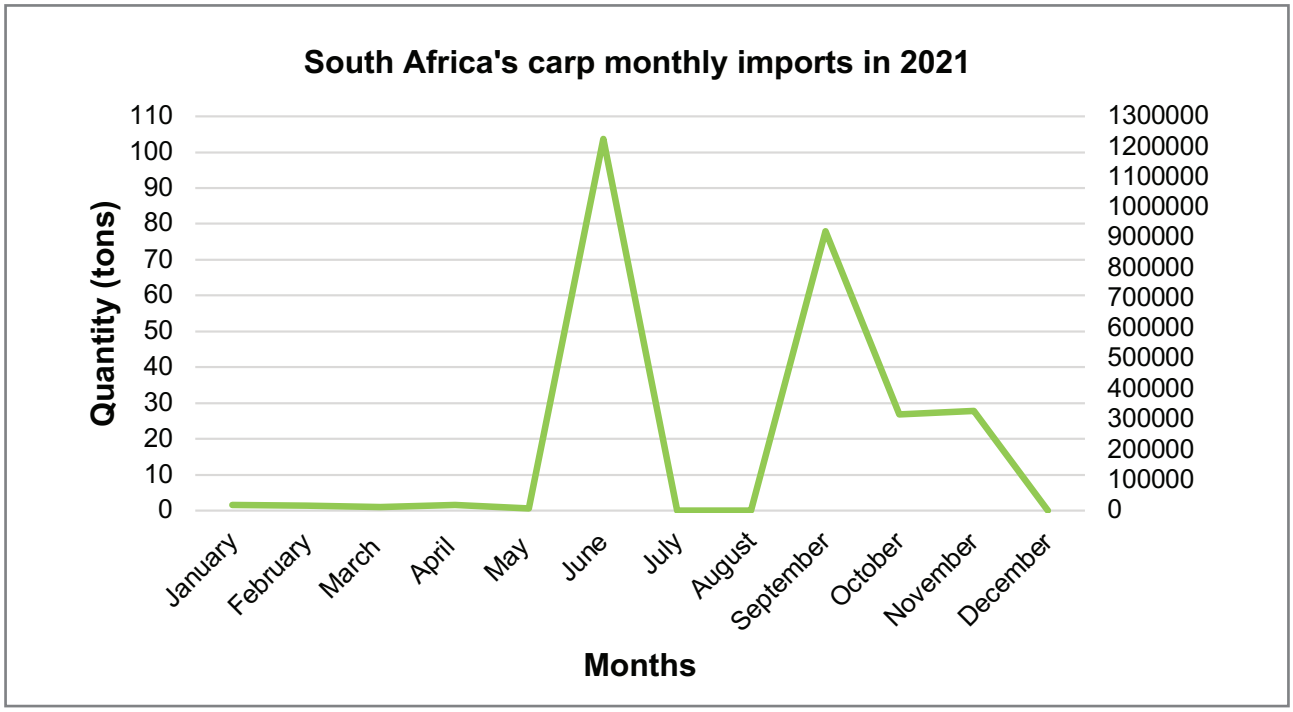


Figure 7.19: South Africa's carp monthly import trends in 2021

The total quantity imported, and the value of carp exported in South Africa in 2021 are shown in Table 7.15. Carp imports totalled 242,37 tonnes, with a total value of R3 478 811. Between 2020 and 2021, the overall volume of carp imports increased by 237,52 tons, with an R3 069 434 price increase.

Carp consumption grew in 2021, resulting in an increase in the total quantity of carp imported into South Africa during the year 2021. China was the top exporter of carp, followed by Japan, with imports of 235,52 and 6,85 tons, respectively. Carp contributed significantly to the total amount of aquaculture goods imported into South Africa in 2021.

Table 7.15: Carp imports in 2021

Species	Exporting Country	Quantity Imported (Tons)	Value of Quantity Exported (ZAR FOB)
Carp	China	235,52	R2 759 831
Carp	Japan	6,85	R718 980
TOTAL		**242,37**	**R3 478 811**

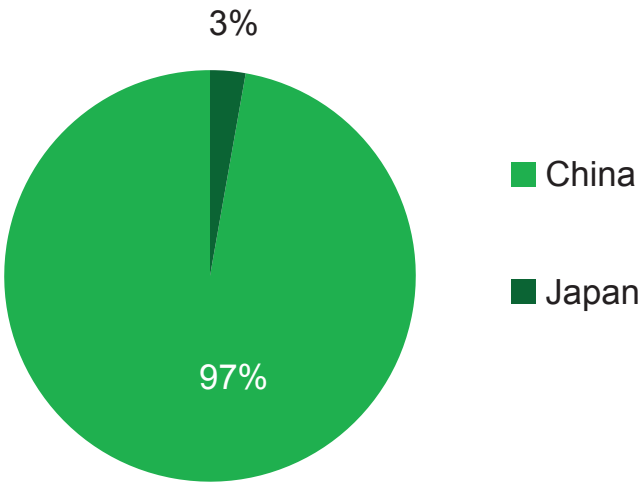


Figure 7.20: South Africa‘s total carp imports in 2021

7.9.3 Catfish imports 2021

Catfish was only imported into South Africa at a monthly average of 16,9 tons in May, July, and August 2021. However, the highest value of catfish exported was reported in August, valued at R1 009 015, while the lowest value was recorded in July, valued at R360 589.

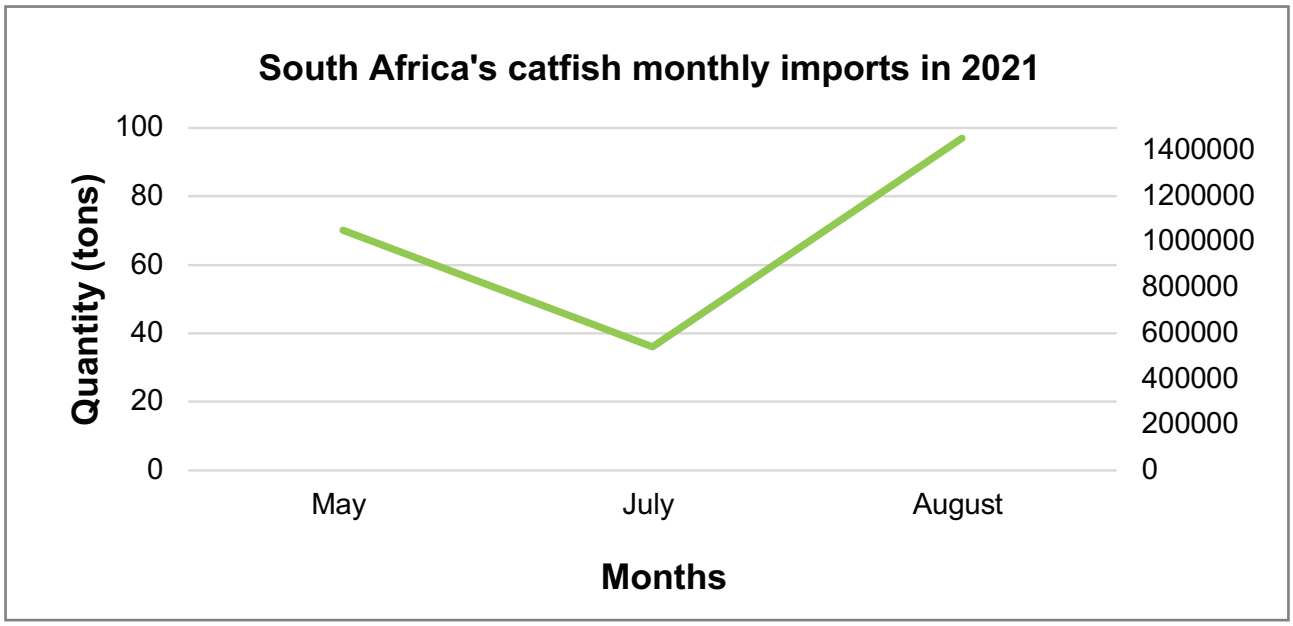


Figure 7.21: South Africa’s catfish imports per month in 2021

The total volume imported, and the value of catfish exported in South Africa are shown in Table 16. Catfish imports totalled 203,2 tons in 2021, with a total value of R2 084 822. South Africa’s demand for catfish declined, resulting in a decrease in the overall number of catfish imported into the country. The myths and branding concerns surrounding catfish influence market demand.

Table 7.16: Catfish imports in 2021

Species	Exporting Country	Quantity Imported (Tons)	Value of Quantity Exported (ZAR FOB)
Catfish	China	203,2	R2 084 822
TOTAL		**203,2**	**R2 084 822**

7.9.4 Mussels imports 2021

In 2021, South Africa imported an average of 20,2 tons of mussels per month. In February 2021, the value of the total amount of mussels supplied was at its highest point – R1 771 222 - and its lowest point - R23 380.

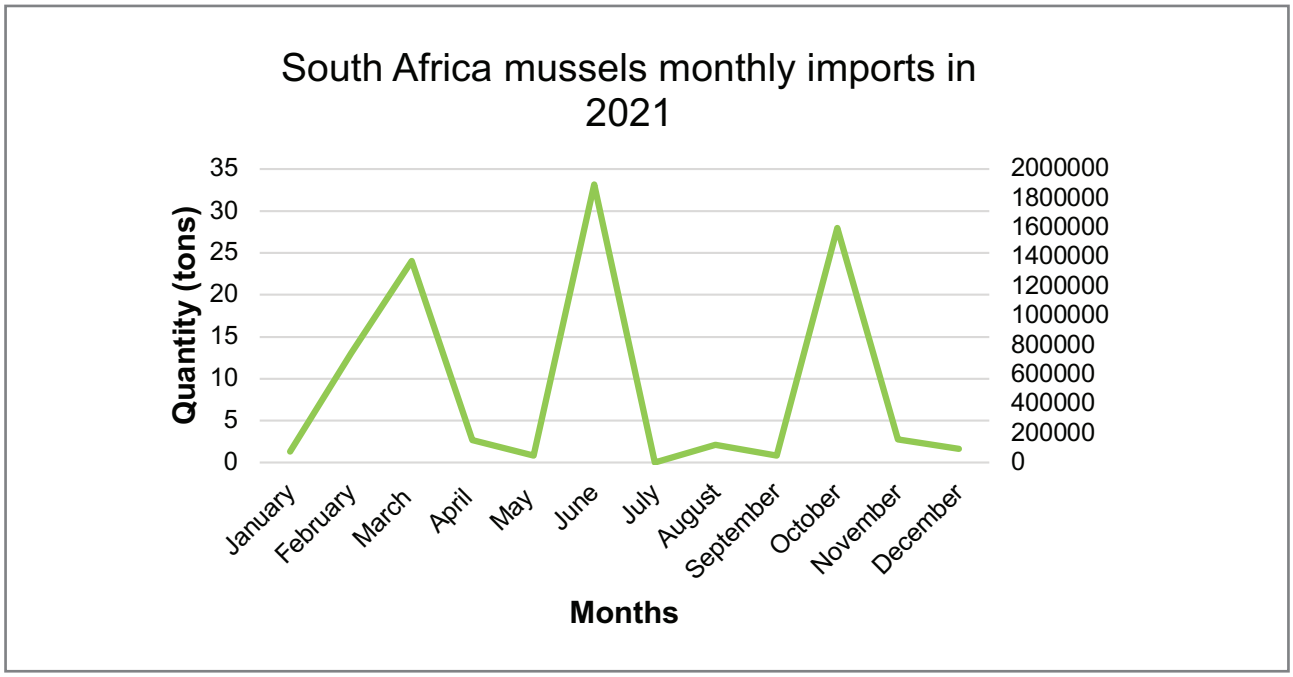


Figure 7.22: South Africa's mussel imports per month in 2021

In 2021, the total quantity imported, and the value of mussel supplied to South Africa are shown in Table 17. The total amount of mussels imported items was 110,27 tons, valued at R4 255 295. Indicating an enormous decrease of approximately 217,17 tons over the previous year. China leads in mussel exports to South Africa, followed by Denmark and New Zealand, with imports totalling 96,86, 10,68, and 1,27 tons, respectively.

Table 7.17: Mussels imports

Species	Exporting Countries	Quantity Imported (Tons)	Value of Quantity Exported (ZAR FOB)
Mussels	China	96,86	R3 153 127
Mussels	Denmark	10,68	R43 438
Mussels	Namibia	0,72	R40 040
Mussels	New Zealand	1,27	R951 813
Mussels	Portugal	0,74	R66 877
TOTAL		**110,27**	**R4 255 295**

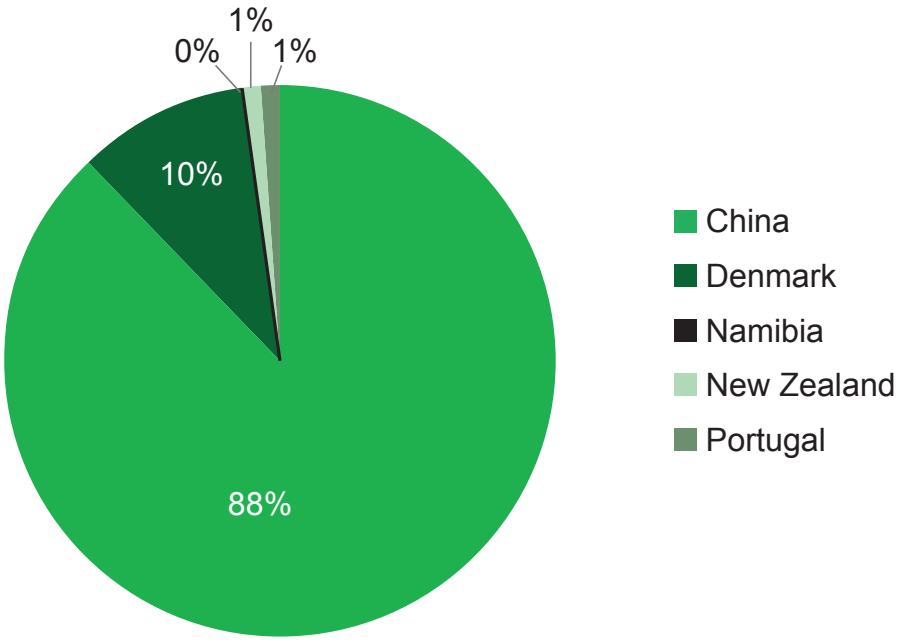


Figure 7.23: South Africa's mussel imports in 2021

NOTES

In 2021, a total of 194,79 tons of ornamentals were imported into South Africa. In terms of value, the highest proportion was recorded in November at R3 131 139, and the lowest quantity was recorded in December at R1 224 459.

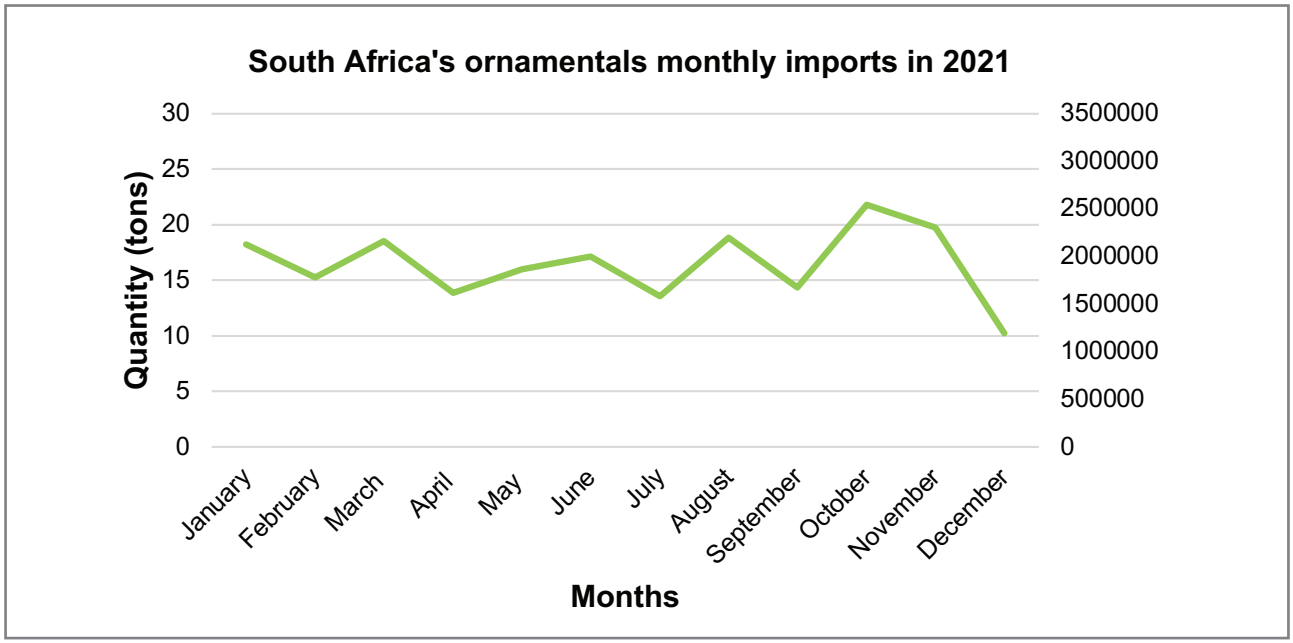
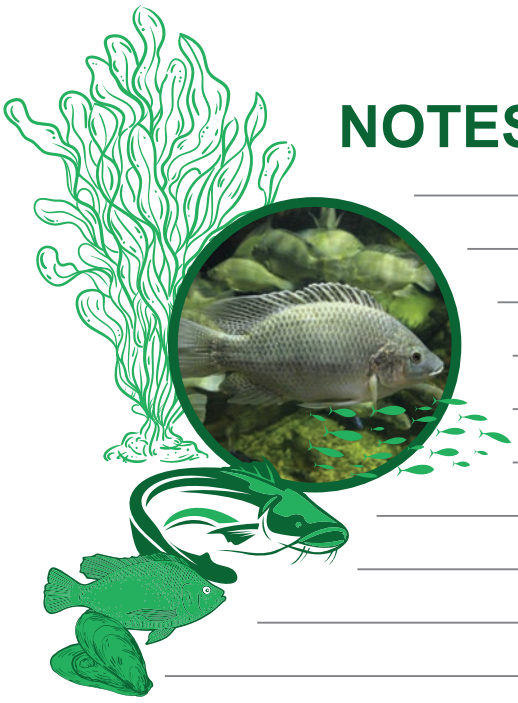


Figure 7.24: South Africa's total monthly imports for ornamentals in 2021

The total amount of ornaments imported in South Africa for the calendar year 2021 are shown in Table 7.18. Approximately 194,79 tons of ornamental imports amounting R27 724 250 in value were imported in total in 2021. When compared to the previous year, import quantities increased by 19,18 tons and increased in value by R4 919 537. Sri Lanka was the leading exporter of ornamentals, followed by Indonesia and Singapore, with 47,01, 29,22, and 28,82 tons, respectively.



NOTES

Table 7.18: Ornamental imports in 2021

Species	Exporting Country	Quantity Imported (Tons)	Value of Quantity Imported (ZAR FOB)
Ornamental	Australia	1,217	R709 968
Ornamental	Colombia	2,43	R216617
Ornamental	DRC	0,31	R41 568
Ornamental	Germany	0,27	R43 307
Ornamental	India	0,15	R14 019
Ornamental	Indonesia	29,22	R3 295 357
Ornamental	Israel	17,99	R4 031 943
Ornamental	Japan	2,92	R327 256
Ornamental	Kenya	16,73	R1 006 777
Ornamental	Malaysia	8,28	R810 450
Ornamental	Martinique	0,45	R28 983
Ornamental	Nigeria	1,06	R177 457
Ornamental	Philippines	2,17	R133 208
Ornamental	Qatar	7	R7 078
Ornamental	Singapore	28,82	R6 996 458
Ornamental	Sri Lanka	47,01	R3 630 882
Ornamental	Taiwan	1,99	R709 832
Ornamental	Thailand	24,08	R4 021 950
Ornamental	Turkey	0,61	R54 215
Ornamental	United Kingdom	0,81	R18 158
Ornamental	United States	0,11	R57 478
Ornamental	Venezuela	0,59	R53 830
Ornamental	Vietnam	6,68	R1 337 459
TOTAL		**194,79**	**R27 724 250**

7.9.6 Oysters imports 2021

In 2021, South Africa imported 4,3 tons of oysters per month. October experienced the highest number of oyster imports to South Africa, with 12,05 tons imported, while August received the lowest number, with 1,9 tons supplied. Oyster imports were valued R529 470 in terms of value, with R64 000 being the lowest value, but the monthly average value for oysters was R202 797,30.

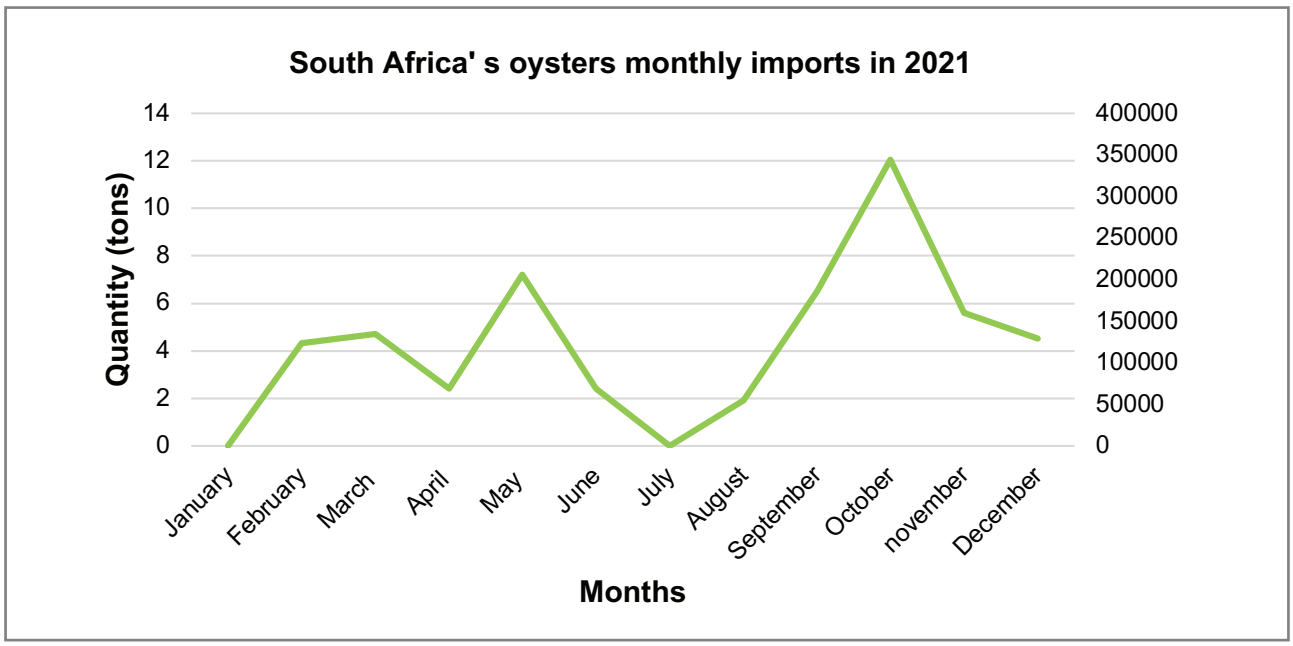


Figure 7.25: Oyster imports per month in South Africa in 2021

Table 7.19 shows the total amount imported and the value of oysters exported in South Africa in 2021. The total amount of oysters imported in 2021 was 51,62 tons, with a total value of R2 433 568. The statistics reveal a reduction in volumes of imports (106,44 tons) and a decrease in value of R10 164 425 in comparison to the previous year. Namibia was the largest exporter of oysters between these two countries, followed by China, with 44,37 and 7,25 tons exported, respectively. Oysters contributed 0,4% of all aquaculture products imported into South Africa by 2021.

Table 7.19: Oyster imports in 2021

Species	Exporting Country	Quantity Imported (Tons)	Value of Quantity Exported (ZAR FOB)
Oysters	China	7,25	R110 167
Oysters	Namibia	44,37	R2 323 401
TOTAL		**51,62**	**R2 433 568**

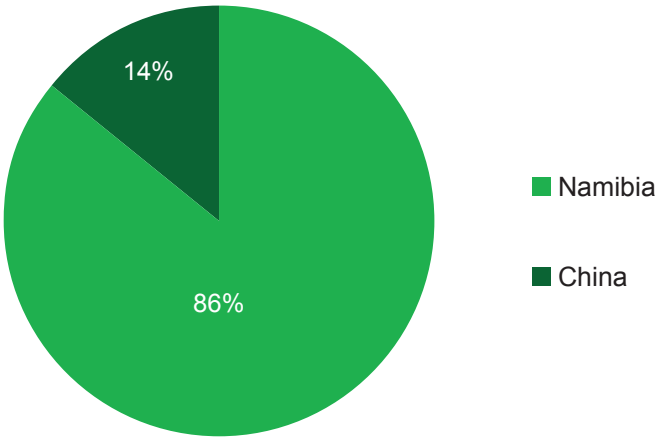


Figure 7.26: South Africa's total quantity of oyster imports in 2021

7.9.7 Pacific Salmon imports 2021

In 2021, South Africa imported an average of 2,6 tons of Pacific salmon per month. Approximately 9.98 tons, were imported in March. The highest value of Pacific salmon exported was reported in October, valued at R167 769, while the lowest value was recorded in November.

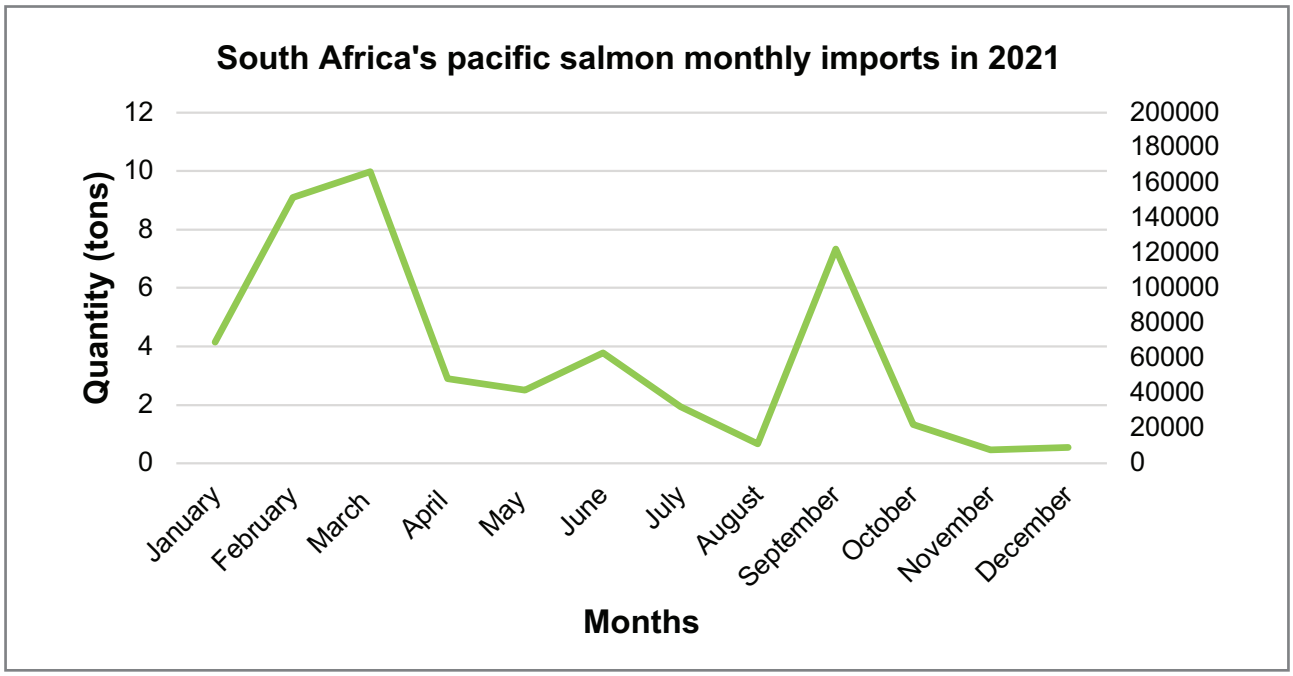


Figure 7.27: South Africa's Pacific salmon imports per month in 2021

Table 7.20 shows the total number and value of imported Pacific salmon into South Africa in 2021. Pacific salmon imports were 31,74 tons, worth R505 374 in total. Malawi was the top exporter of Pacific salmon, followed by Tanzania and Nigeria, with imports ranging from 5.2 to 57 tons. Furthermore, in 2021, Pacific salmon provided 0.2% of total aquaculture goods imported into South Africa.

Table 7.20: Pacific salmon imports in 2021

Species	Exporting Country	Quantity Imported (Tons)	Value of Quantity Exported (ZAR FOB)
Pacific salmon	Egypt	0,0075	R1 932
Pacific salmon	Ghana	0,7	R709
Pacific salmon	Malawi	14,57	R28 892
Pacific salmon	Mozambique	2,7	R13 500
Pacific salmon	Nigeria	5,62	R29 041
Pacific salmon	Tanzania	7	R30 615
Pacific salmon	United Kingdom	0,88	R392 858
Pacific salmon	United States	0,0083	R6 377
Pacific Salmon	Zambia	0,25	R1 450
TOTAL		**31,74**	**R505 374**

Source: South African Revenue Service (SARS), 2021

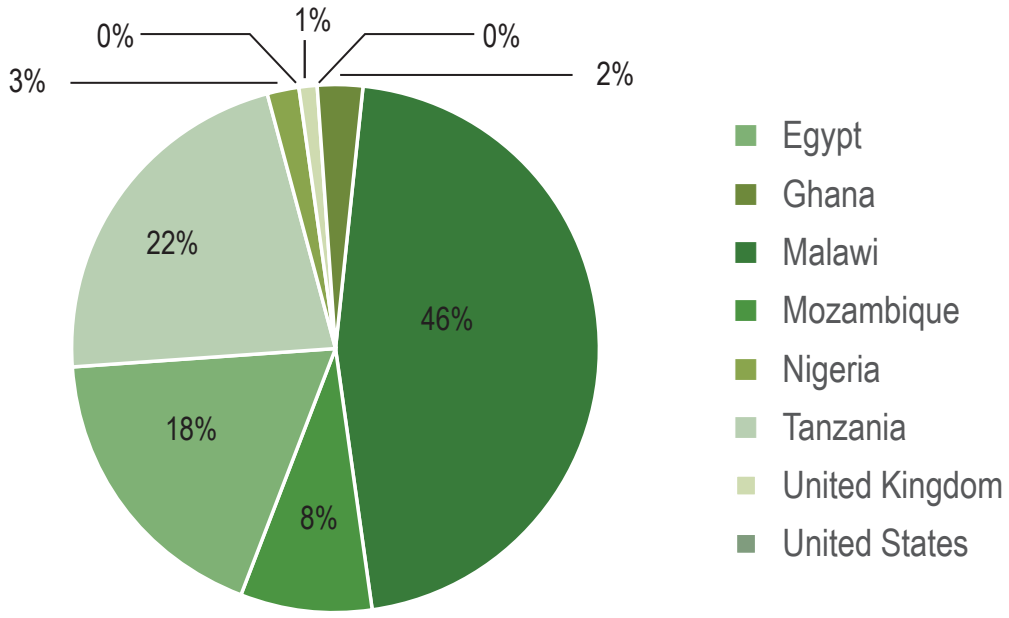


Figure 7.28: South Africa's Pacific salmon imports

7.9.8 Tilapia imports 2021

South Africa imported 910,2 tons of Tilapia each month, valued at R9 999 910,90. The largest amount spent on tilapia imports was R20 366 457 in May, while the lowest amount was R4 058 403 in March.

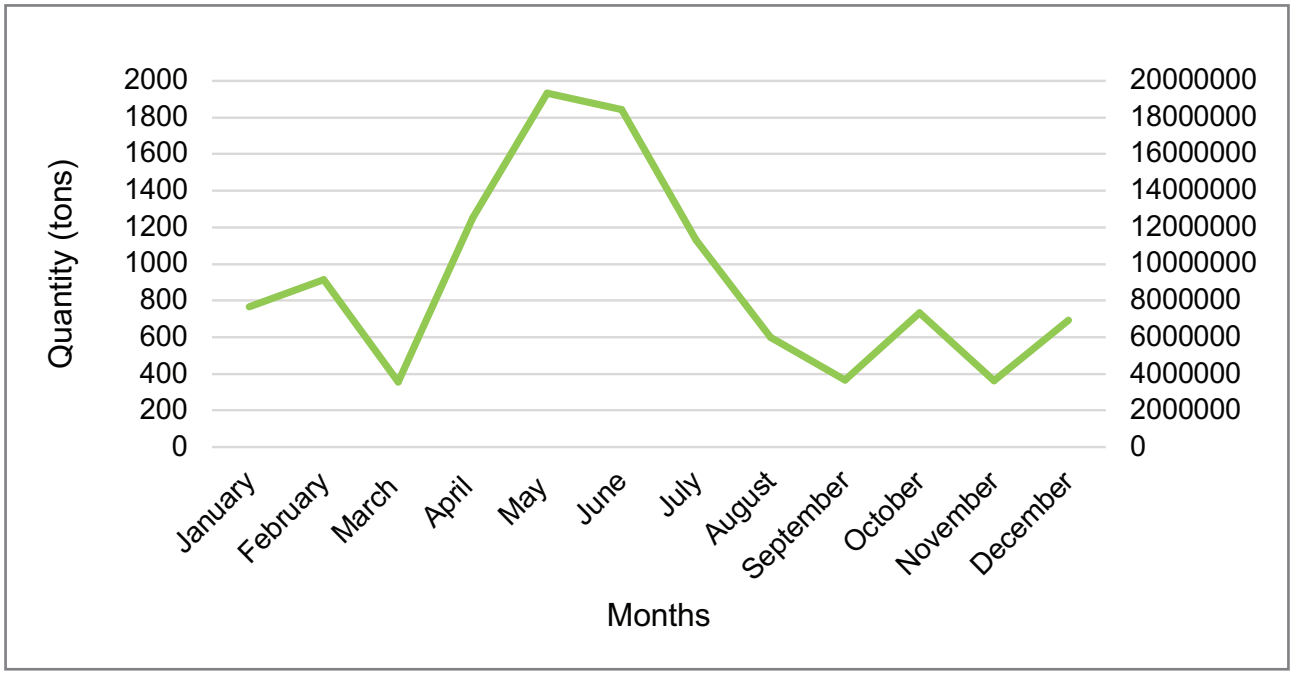


Figure 7.29: South Africa's tilapia imports per month in 2021

Table 22 illustrates the total number and value of tilapia imports into South Africa in 2021. Based on forecasts, South Africa imported approximately 10 922,68 tons worth R110 998 931. The tilapia industry experienced an enormous increase in import quantities of approximately 545,3 tons and an R2 186 344 increase in value. Tilapia imports to South Africa have increased as demand from other African markets continues to rise.

Table 7.21: Tilapia imports in 2021

Species	Exporting Country	Quantity Imported (tons)	Value of Quantity Exported (ZAR FOB)
Tilapia	Canada	0,00019	R13 265
Tilapia	China	10319,96	R109 530 691
Tilapia	Denmark	51	R658 792
Tilapia	India	50,23	R773 795
Tilapia	Indonesia	18	R853 893
Tilapia	Mozambique	20	R772 876
Tilapia	Namibia	78	R1 170 780
Tilapia	Zambia	54,87	R2 048 525
Tilapia	Zimbabwe	30,03	R1 079 049
Tilapia	Vietnam	277,59	R2 711 915
Tilapia	Unclassified	23	R385 250
TOTAL		**10 922,68**	**R119 998 931**

Source: South African Revenue Service (SARS), 2021

China was the leading exporter of tilapia, followed by Vietnam and Zambia, with total shipments ranging from 54,87 to 10 319,96 tons. As a result, tilapia made up 78% of all aquaculture goods imported into South Africa.

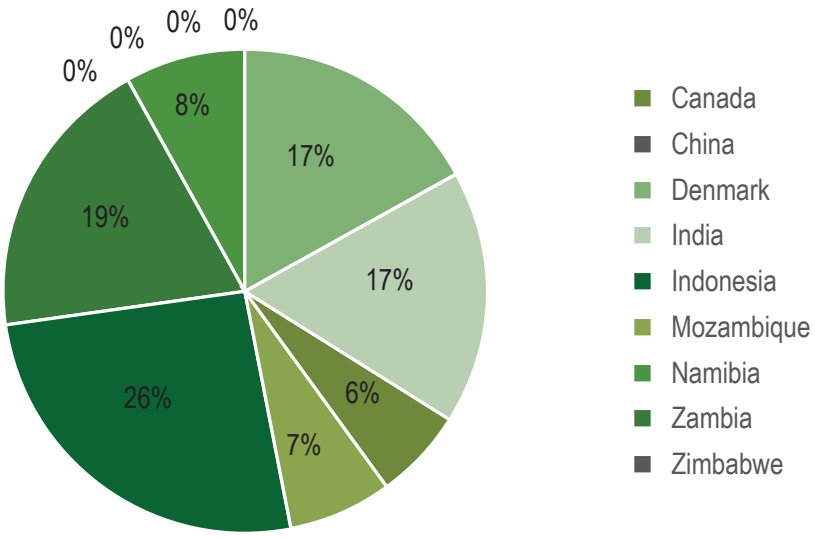


Figure 7.30: South Africa's tilapia imports in 2021

7.9.9 Trout imports 2021

Trout was imported into South Africa at a monthly average of 95,1 tons costing R686 342. The largest amount was imported in December, totalling 295,78 tons, while the lowest amount was imported in April, totalling 14,65 tons. In terms of value, the largest import value was R23 550 986 in December, and the lowest was R3 363 000 in February (Figure 7.31).

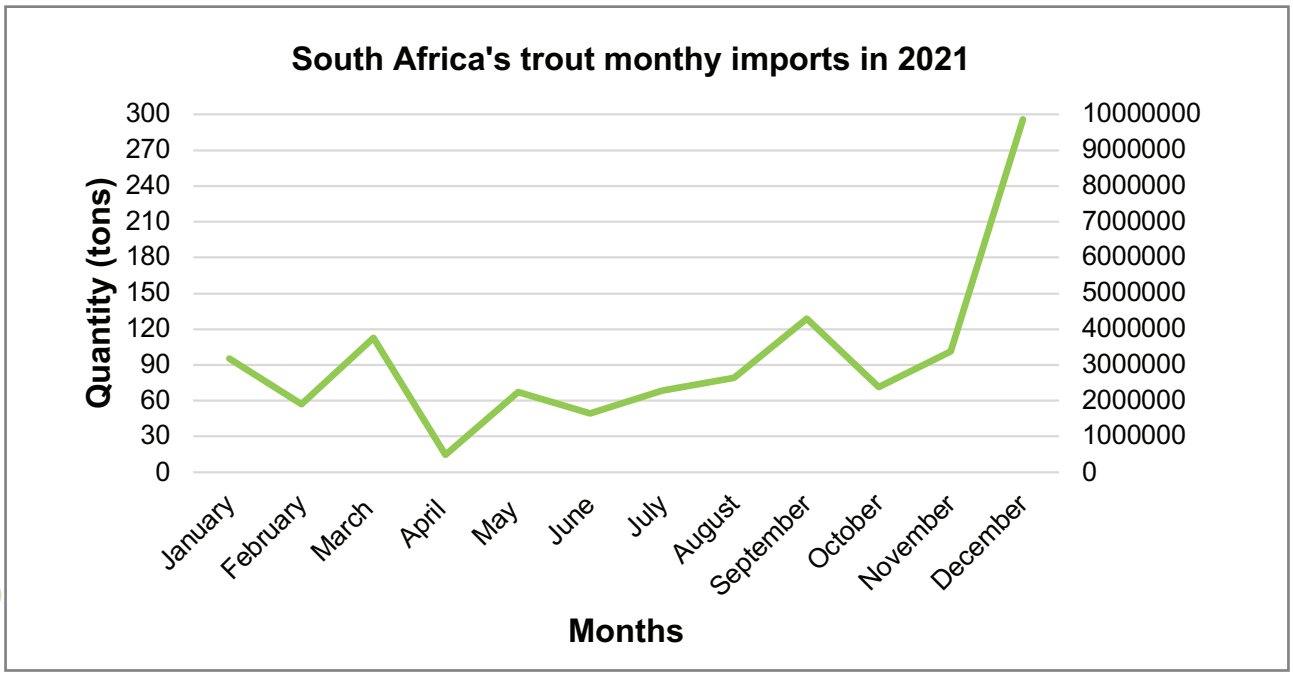


Figure 7.31: South Africa's trout imports per month in 2021

The total amount of trout imports was 1 141,22 tons, valued at R82 361 804. This reflects a decline in both quantity and value of approximately 49,83 tons and R4 423 798, respectively. Lesotho and Norway are the only two countries that export trout to South Africa. In 2021, Lesotho was the leading trout exporter, followed by Norway, with imports of 1 080,53 tons and 60,69 tons, respectively.

Table 7.22: Trout imports in 2021

Species	Exporting Country	Quantity Imported	Value of Quantity Exported (ZAR FOB)
Trout	Lesotho	1 080,53	R78 551 958
Trout	Norway	60,69	R3 809 846
TOTAL		**1 141,22**	**R82 361 804**

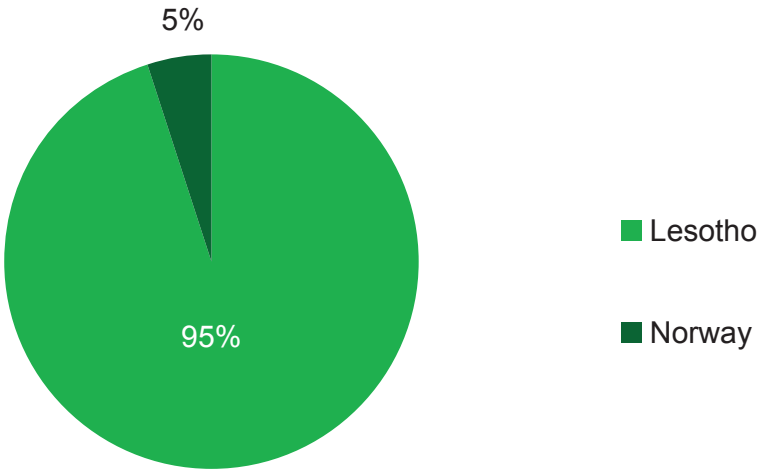


Figure 7.32: South Africa's trout imports in 2021

7.9.10 Scallop imports 2021

Scallop was imported into South Africa at a rate of 0.5% on average in January, June, November, and December of 2021. In November, the largest amount spent on scallop imports was R373 872, while the lowest amount was R7 842 which was spent in January. The average monthly pricing of the quantities imported, on the other hand, was predicted to be R99 518,50.

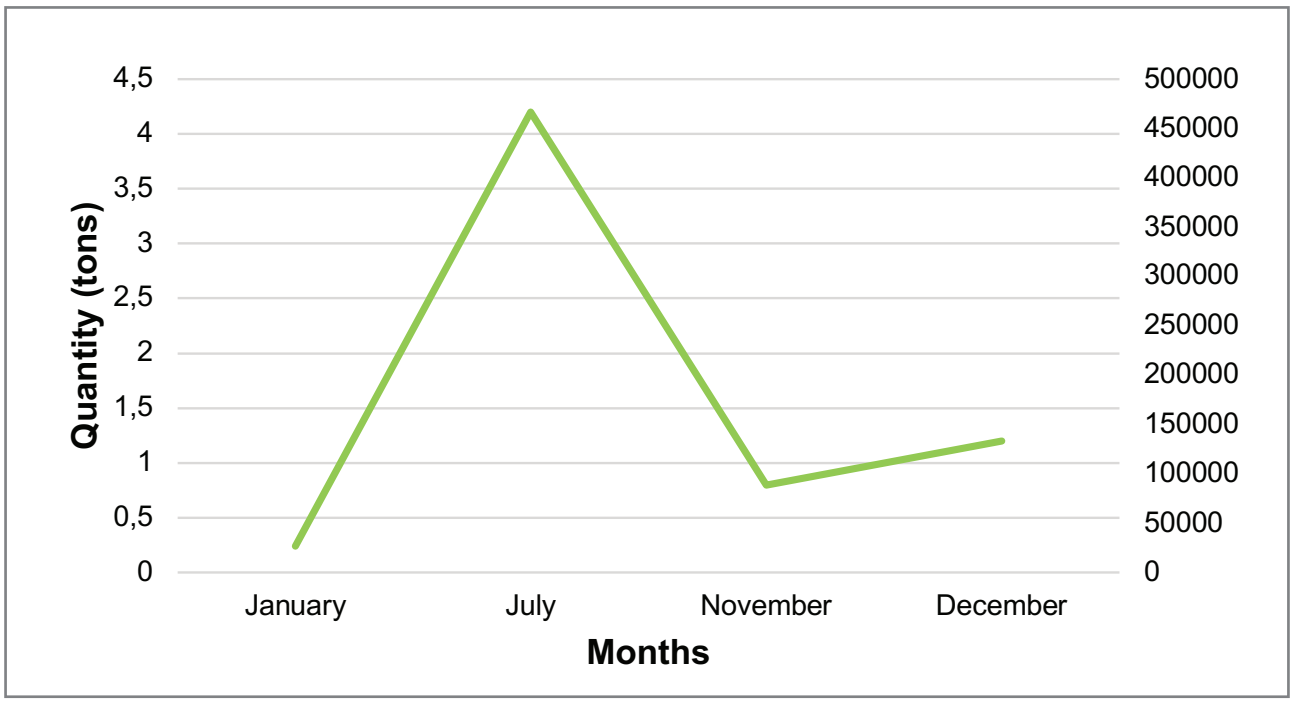


Figure 7.33: South Africa's scallop imports per month in 2021

The total quantity imported, and the value of scallop exported to South Africa in 2021 are shown in Table 7.23 below. In 2021, the overall volume of scallop imports was 6,37 tons, with a total value of R1 194 222. From 2020 to 2021, the total amount of scallop imported declined by 12,28 tons, with a value decrease of R77 695. This could be explained by lower consumption of scallops notably during the restricted period. Additionally, China is the main exporter of scallops followed by the United Kingdom.

Table 7.23: Scallop imports in 2021

Species	Exporting Country	Quantity Imported in (Tons)	Value of Quantity Exporting (ZAR FOB)
Scallop	China	4,52	R323 833
Scallop	Netherlands	1,05	R496 517
Scallop	United States	0,80	R373 872
TOTAL		**6,37**	**R1 194 222**

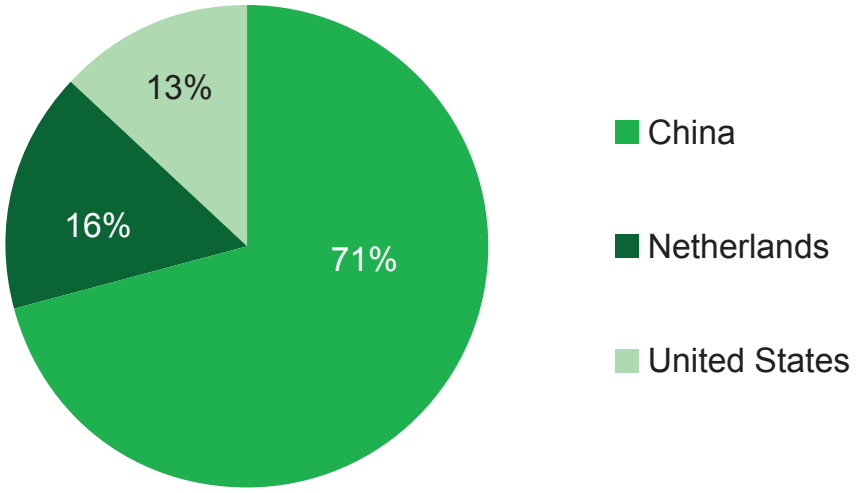


Figure 7.34: South Africa's imports for scallop in 2021

Table 7.24: Other aquatic invertebrates

Species	Exporting Country	Quantity Imported (Tons)	Value of Quantity Imported (ZAR FOB)
Other aquatic invertebrates	Namibia	1,34	R85 519
Other aquatic invertebrates	Vietnam	1,05	R35 000
TOTAL		**2,39**	**R120 519**

7.10 Trade Balance

South Africa exported 3 887,35 tons of aquaculture goods worth R830 838 385 and imported 13 933,53 tons of aquaculture goods worth R345 643 368 in 2021. Even though the country's export volumes were lower, the value of exports exceeded the cost of its imports, resulting in a trade surplus of about R385 191 122. In comparison to the previous year, balance of trade improved significantly, as the country had a trade deficit of approximately -R46 946 585 in 2020.

Table 7.25: Balance of Trade

Species	Value of Quantity Exported (ZAR FOB)	Imports	Trade Balance
Abalone	R717 721 649	0	R717 721 649
Catfish	R5 517 499	R2 084 822	R3 432 677
Carp	R48 660	R3 478 811	-R34 330 151
Trout	6 662 943	R82 361 804	-R75 698 861
Tilapia	27 348 213	R119 998 931	-R92 650 718
Atlantic Salmon	R1 750 045	R101 608 291	-R99 858 246
Pacific Salmon	R4 925 930	R503 374	R4 422 556
Mussels	15 784 943	R4 255 295	R11 529 648
Oysters	R50 060 414	R2 433 568	-R47 626 846
Ornamentals	R699 160	R27 724 250	-R875 293
Scallop	R318 929	R1 194 222	-R875 293
TOTAL	**R830 838 385**	**R345 643 368**	**R385 191 122**

Source: South African Revenue Service (SARS), 2021

Major markets for fish, crustaceans, molluscs, and other aquatic invertebrates produced in South Africa are shown above. Major export destinations for 2021 were Hong Kong, China, Taiwan, the United States of America, Spain, Australia, and other African countries. Malawi remains the largest importer of South African aquatic products, accounting for up to 39%, followed by Hong Kong at 23% Taiwan, and the United States at 10%, and Mozambique, China, Namibia, the Democratic Republic of Congo, Australia, and Zambia each contributing less than 9%.

NOTES

CHAPTER 8

AQUACULTURE ENVIRONMENTAL INTEGRITY

8. AQUACULTURE ENVIRONMENTAL INTEGRITY

8.1 Environmental Integrity

The concept of sustainable development in the context of aquaculture, seeks to optimise the social and economic benefits arising from the use of natural resources, while protecting the biological diversity and maintaining the ecosystem function. The aquaculture industry in South Africa has learnt some important lessons over time through implementation of new ventures; following internationally acceptable practices as well as through aggressive South African-based research, and have, therefore, developed commonly accepted “best management practices” to minimise the impacts associated with these operations.

Owing to the high capital investment of aquaculture, it is in the best interest that operators ensure that they maintain a healthy environment in which they cultivate their fish and shellfish, whether the operation is located on land or in the ocean. Precautionary approaches are advocated for many aquaculture practices, particularly with regards to the use of alien invasive species and special considerations are given to sensitive habitats. The development and application of the Environmental Impact Assessment (EIA) process combined with regular environmental monitoring assists in providing effective management measures targeting individual farms as well as farm clusters such is the case with Aquaculture Development Zones (ADZs).

8.2 How is Government Ensuring the Development of a Sustainable Aquaculture Sector in South Africa?

The Sub directorate: Aquatic Animal Health and Environmental Interactions under the D: SAM renders technical advisory services regarding environmental management and monitoring by reviewing and commenting on EIAs for aquaculture operations as well as providing inputs into developments that may have an adverse impact on existing industry. The DFFE aims to create an enabling environment for the development and growth of South African aquaculture through the establishment of ADZs. The first phase of the development of an ADZ is undertaking the basic assessment process for the proposed project area by meeting environmental legislative requirements. While the second phase includes pursuing funding and managing the process of installation of basic infrastructure such as roads, electricity, security fences, reservoirs, water pumps, water extraction and discharge pipelines which are installed for the land-based ADZs while sea-based ADZs require ongoing management and monitoring of the implementation phase of the ADZ. The purpose of which is to encourage investor and consumer confidence, create incentives for industry development, while providing marine aquaculture services, managing the risks associated with aquaculture as well as providing skills development and employment for coastal communities.

8.3 Aquaculture Development Zones Initiated by the Department of Forestry, Fisheries and the Environment

To promote the growth of the aquaculture sector in a sustainable manner and create and enabling environment, the DFFE has identified land and sea-based sites suitable for aquaculture activities along the South African coastline. These suitable sites are referred to as ADZs, an area that has been earmarked specifically for aquaculture activities. The benefits of ADZs are to encourage investor confidence; create incentives for industry development; provide aquaculture services; manage the risks associated with aquaculture; job creation; skills development; empowerment of rural communities and most importantly benefit from Special Economic Zones incentives.

The goals of the DFFE are to negotiate and obtain consent from the landowners; undertake EIA process where necessary; declare an ADZ; install the required basic infrastructure (roads, electricity, security fence, reservoir, water pump, water extraction and discharge pipeline) and the establish support facilities, for example, processing establishment and laboratories. The establishment of several ADZs have been undertaken by the DFFE over the past few years. Table 1 below outlines details of the various DFFE-led ADZ projects currently being pursued by the DFFE, which are at different stages of implementation:

NOTES

Table 8.1. Summary of the Department of Forestry, Fisheries and the Environment-led aquaculture development zones

1. Qolora ADZ (EC)	**Area** 26,4 ha (land-based zone) **Targeted species** Marine finfish, abalone and seaweed **Potential Production** Possibility of developing two 300 ton abalone/seaweed farms and a combination of fish farms. Total production capacity expected is as follows: • 600 tons of abalone production capacity (integrated abalone/seaweed farming) at 11 m to 12 m above sea level. • 5 500 tons of finfish at 15 m to 25 m above sea level **Year the EIA was initiated** BA undertaken in 2010/11 **Year the EA was issued** EA 1st issue September 2011 1st extension to September 2014 2nd extension to September 2017 3rd extension to September 2023 **Current Status** A request was made by the DFFE on behalf of the applicant, the community trust, to the provincial department in May 2020. The request was granted in October 2020. The EA extension has been granted for a further three years till September 2023, by which time the applicant is to commence with one of the listed activities, as per the EA. All permits are in place for the construction and operation of the ADZ apart from the Coastal Waters Discharge Permit which will be issued to the individual farms during the operation phase.
2. Algoa Bay ADZ (EC)	**Area** 1 146 ha (sea-based zone) **Targeted species** Marine finfish, oysters and mussels **Potential Production** **Algoa 1:** 218 ha of mussel production (approximately 6 mussel farms) and 94 ha of oyster production. A viable mussel operation requires an annual production volume of ±500 tons and approximately 38 ha of space **Algoa 6:** 479 ha (approximately 16 oyster farms) **Algoa 7:** 355 ha – Three finfish operators produced 1 000 tons in the first year of the pilot study and up to 9 000 tons by the third year. **Year the EIA was initiated** 1st BA undertaken in 2010-2014 **Year the EA was issued** 2nd BA undertaken in 2018/19 1st EA issued in July 2014 1st appeal decision issued August 2015 2nd EA issued in February 2020 2nd appeal decision issued in June 2021 **Current Status** One farm is currently operational in the Port Elizabeth Harbor (within Algoa 6). The EA was issued in February 2021 and appeal process was initiated, 34 appeals were received, and the decision was reached in June 2021 by the Minister of Justice and Correctional Services who took the decision to uphold the EA thereby dismissing the appeals. The Branch Fisheries Management proceeded to begin internal discussions around the implementation of the ADZ, the Aquaculture Management Committee nomination letters were sent out to the respective departments who have a mandate over aquaculture to nominate officials to represent their respective departments on the committee.

3. Amatikulu ADZ (KwaZu-lu-Natal)	**Area** Approximately 37 ha to be used for aquaculture (12,6 ha for freshwater production and 24,6 ha for marine production) **Targeted species** Ornamentals, prawns, marine and freshwater finfish, sea cucumbers and crocodiles. **Potential Production** Approximately 300 tons of table fish per annum **Year the EIA was initiated** BA undertaken in 2018/19 **Year the EA was issued** Refusal of the EA July 2019 and appeal decision October 2021 **Current Status** The appeal decision regarding the appeal against the decision to refuse an EA to the Branch Fisheries Management was issued by the Minister of Justice and Constitutional Service in October 2021.
4. Saldanha Bay ADZ (Western Cape)	**Area** A total of 464 ha of currently allocated area exist in the ADZ, of which 151 ha were operational in 2018. With a further 420 ha area for new production. **Targeted species** The following species are considered for farming in the ADZ: **Currently cultivated bivalve species:** • Pacific oyster • Mediterranean and Black mussel **New indigenous shellfish species:** • Abalone • South African scallop **New indigenous finfish species:** • White Stumpnose • Kabeljou • Yellowtail **Alien finfish species:** • Atlantic salmon • Coho salmon • King/Chinook salmon • Rainbow and Brown trout • Seaweed **Potential Production** • Limited to 10 000 tons per annum of shellfish (can increase after two years of monitoring) • Finfish production limited to 1 000 tons per annum • Finfish production can achieve up to 5 000 tons per annum over five years **Future growth:** • Environmental authorisation to increase production to 15 000 tons • Increase in the number of direct jobs to ±2 500 (5-fold increase) • 255 ha of new water space has been issued to 4 existing projects and 14 new entrants (primarily PDIs and SMMEs) **Year the EIA was initiated** BA undertaken in 2016/17 1st Part 1 amendment application May 2019 2nd Part 1 amendment application August 2020 **Year the EA was issued** EA issued in January 2018 Appeal decision issued on June 2018 1st Part 1 amendment appeal decision issued July 2019 2nd Part 1 amendment appeal decision issued in July 2021

4. Saldanha Bay ADZ (Western Cape)	**Current Status** • In 2021, there were twenty-seven (27) aquaculture farmers from Saldanha Bay registered on the Rights Register with only three (3) inactive farms producing approximately 3 600 tons of mussels and oysters in the bay. • One farm producing under 50 tons of trout under a pilot phase. • 754 jobs have been created in the bay (this includes the fish processing facilities). • In 2021, on implementation of the ADZ, the operators were faced with market-related issues due to Covid, as well as other challenges. • The 2nd Part one Amendment application was granted in September 2020 however this entered an appeal process in 2021 and the appeal decision was issued in July 2021 by the Minister of Justice and Correctional Services, all appeals were dismissed. • Ongoing implementation of the ADZ continued, and the AMC and CF meetings continued to report on progress of the ADZ. • Ongoing annual monitoring continued with service maintenance of bottom moored instruments for oceanographic monitoring as well as benthic and chemical surveys taking place in April 2021. • Further monitoring included investigations into biofouling, reef survey methodology for investigations in Big Bay and various research studies initiated by the industry commencing in the latter part of 2021. • Year 2 audit (2020/21) was conducted in February 2021 and the recommendations included in a revised version of the ADZ EMPr (v3). • The Emergency response protocol (v2) as well as the Operational and Management guidelines were endorsed by the AMC in January 2021. • An open day was held in June 2021 informing stakeholders of the progress of the ADZ and outlined the roles and responsibilities of the DFFE.
5. Vanderkloof Trout ADZ (Northern Cape)	**Area** 2nd largest dam in SA **Targeted species** Freshwater finfish (trout) **Potential Production** Approximately 11 518 tons per annum **Year the EIA was initiated** Trial project **Current Status** No farming is currently taking place. The DFFE is in the process of getting an implementing agent to undertake the trout aquaculture trail.
6. Mossel Bay ADZ (Western Cape)	**Area** Undefined **Targeted species** Marine finfish and bivalves **Potential Production** To be identified in the BA process. **Year the EIA was initiated** Still to be undertaken **Current Status** The Basic Assessment process to be undertaken by the DFFE.
7. Richards Bay ADZ (KwaZulu-Natal)	**Area** Undefined **Targeted species** Marine finfish **Potential Production** Approximately 600 tons per annum **Year the EIA was initiated** Still to be undertaken **Current Status** BA process to be undertaken by the DFFE. The DFFE is currently unpacking the results of the feasibility study in consultation with the Transnet National Ports Authority to determine a way forward for aquaculture in the bay. A stakeholder meeting was held in November 2020 to communicate the final outcomes of the feasibility study.

CHAPTER 9

AQUATIC ANIMAL HEALTH PROGRAMMES

9. AQUATIC ANIMAL HEALTH PROGRAMMES

9.1 Introduction

The South African molluscan shellfish aquaculture industry is historically free from the diseases listed by the OIE. To ensure this relative high health status with regards to these OIE-listed diseases, continuous investment by both industry and government is being made to demonstrate that the basic biosecurity conditions are continually being met. The export of aquaculture animals and their products from South Africa requires that assurances of health and disease freedom are provided to importing countries. This has led to the development of sector specific animal health procedures to provide the appropriate evidence of disease freedom upon which health certification is based (Christison 2019). These procedures describe the conditions required to continually demonstrate disease freedom from and ensure adequate disease security for the relevant OIE listed diseases and other significant emerging and production diseases.

9.2 Surveillance and Monitoring

The purpose of aquatic animal disease surveillance is to provide scientifically accurate and cost-effective information for assessing and managing risks of disease transfer associated with the trade of aquatic animals, animal production efficiency, and public health (Subasinghe et al., 2004). The primary objective of the surveillance activities reported here is the provision of evidence of freedom from diseases at the country, zone, or aquaculture establishment level relevant to the domestic and international movement of aquatic animals and products.

9.2.1 Targeted Surveillance

Targeted surveillance comprises the collection of information on a specific disease or condition to provide evidence to substantiate the absence of a disease within a defined population of susceptible hosts (Subasinghe et al., 2004). The targeted surveillance for specified diseases of farmed abalone (*Haliotis midae*) and farmed oysters (*Crassostrea gigas*) defined in the "*Health Management Procedures for South African Abalone Produced for Export"* and the "*Health Management Procedures for South African Bivalves (Oysters and mussels) Produced for Export"* documents respectively. These documents were developed to comply with the basic biosecurity conditions as required by the OIE (OIE, 2018). These procedures describe the conditions required to continually demonstrate disease freedom from and ensure adequate disease security for the diseases currently listed by the OIE for *Haliotis* species and *Crassostrea gigas* respectively.

Abalone

Although parasites and potential pathogens have been reported from farmed H. midae in South Africa (Macey et al., 2011, Mouton & Gummow, 2011, Boonzaaier et al., 2014, Horwitz et al., 2016), there is a high level of confidence that South Africa's farmed population of H.

midae is currently free of all the diseases listed by the OIE for Haliotis species (infections with abalone herpesvirus, Perkinsus olseni and Xenohaliotis californiensis) (OIE, 2018). Although these diseases have been reported from a range of Haliotis species from other parts of the world, H. midae has not been specifically listed as a susceptible host species for any of these diseases (OIE, 2016).

Table 9.1: Number of abalone sampled per zone for the period 1 January 2017 to 31 December 2021, as reported to the Department of Forestry, Fisheries and the Environment in line with the "Health Management Procedures for South African Abalone Produced for Export".

Zone	Infection with:	Diagnostic Test	2017	2018	2019	2020	2021
East Coast Zone (1 Farm)	Abalone Herpesvirus (AbHV)	Histopathology	265	0	2	0	0
		PCR	0	8	0	12	69
	Perkinsus olseni	Histopathology	350	4	0	0	0
		PCR	0	0	0	0	69
	Xenohaliotis californiensis (Whithering Syndrome)	Histopathology	350	4	0	0	0
		PCR	0	0	0	0	69
South Coast Zone (12 Farms)	Abalone Herpesvirus (AbHV)	Histopathology	500	380	73	154	0
		PCR	1	727	701	521	758
	Perkinsus olseni	Histopathology	502	383	364	467	588
		PCR	0	724	390	239	170
	Xenohaliotis californiensis (Whithering Syndrome)	Histopathology	502	383	364	467	588
		PCR	0	724	390	239	170
West Coast Zone (5 Farms)	Abalone Herpesvirus (AbHV)	Histopathology	416	0	0	0	0
		PCR	0	138	285	346	242
	Perkinsus olseni	Histopathology	416	0	34	277	173
		PCR	0	138	251	0	69
	Xenohaliotis californiensis (Whithering Syndrome)	Histopathology	416	0	34	277	173
		PCR	0	138	251	0	69

Table 9.1 presents the number of samples tested by either histopathology or PCR to demonstrate freedom from the three diseases listed by the OIE for *Haliotis* species. These data are presented according to each respective zone as described in Abalone Movement Protocol for South Africa as detailed in the "*Health Management Procedures for South African Abalone produced for Export*". No evidence of infection with abalone herpes virus, *Perkinsus olseni,* and *Xenohaliotis californiensis* found in any of these samples.

Oysters

Table 9.2 presents the number of samples that were tested either by histopathology or by PCR to demonstrate freedom from the two diseases listed by the OIE for *Crassostrea gigas*. These data are presented according to each respective zone as described in Oyster Movement Protocol for South Africa as detailed in the "*Health Management Procedures for South African Bivalves (Oysters and Mussels) Produced for Export*". No evidence of infection with Ostreid herpesvirus or *Perkinsus sp.* Found in any of these samples.

Table 9.2: Number of oysters sampled per zone for the period 1 January 2017 to 31 December 2021, as reported to the Department of Forestry, Fisheries and the Environment in line with the "Health Management Procedures for South African Bivalves (Oysters and Mussels) Produced for Export"

Zone	Infection with:	Diagnostic Test	2017	2018	2019	2020	2021
East Coast Zone (1 Farm)	Ostreid Herpesvirus 1 microvariants (OsHV-1)	Histopathology	165	0	0	0	0
		PCR	0	34*	34*	55	55
	Perkinsus sp.	Histopathology	165	0	0	0	0
		PCR	0	34*	34*	55	55
West Coast Zone (5 Farms)	Ostreid Herpesvirus 1 microvariants (OsHV-1)	Histopathology	165	0	0	0	0
		PCR	0	165	165	161	167
	Perkinsus sp.	Histopathology	165	0	0	0	0
		PCR	0	165	165	161	167
Northern Cape Zone (1 Farm)	Ostreid Herpesvirus 1 microvariants (OsHV-1)	Histopathology	0	0	0	0	0
		PCR	165	165	165	165	165
	Perkinsus sp.	Histopathology	0	0	0	0	0
		PCR	165	165	165	165	165

*Pooled samples (34 pools of 5 animals each)

9.2.2 non-targeted surveillance

The abalone farm stock inspections form part of the active, non-targeted disease surveillance as described in the Approved Official Surveillance Program: Active Component of the "Health Management Procedures for South African Abalone Produced for Export". The stock inspections act as an early disease detection system and entail the assessment of mortality and morbidity in a representative sample of baskets housing abalone. During 2021, all 15 registered South African abalone grow-out farms were inspected by the DFFE, and individual technical reports were generated and circulated to the respective farms.

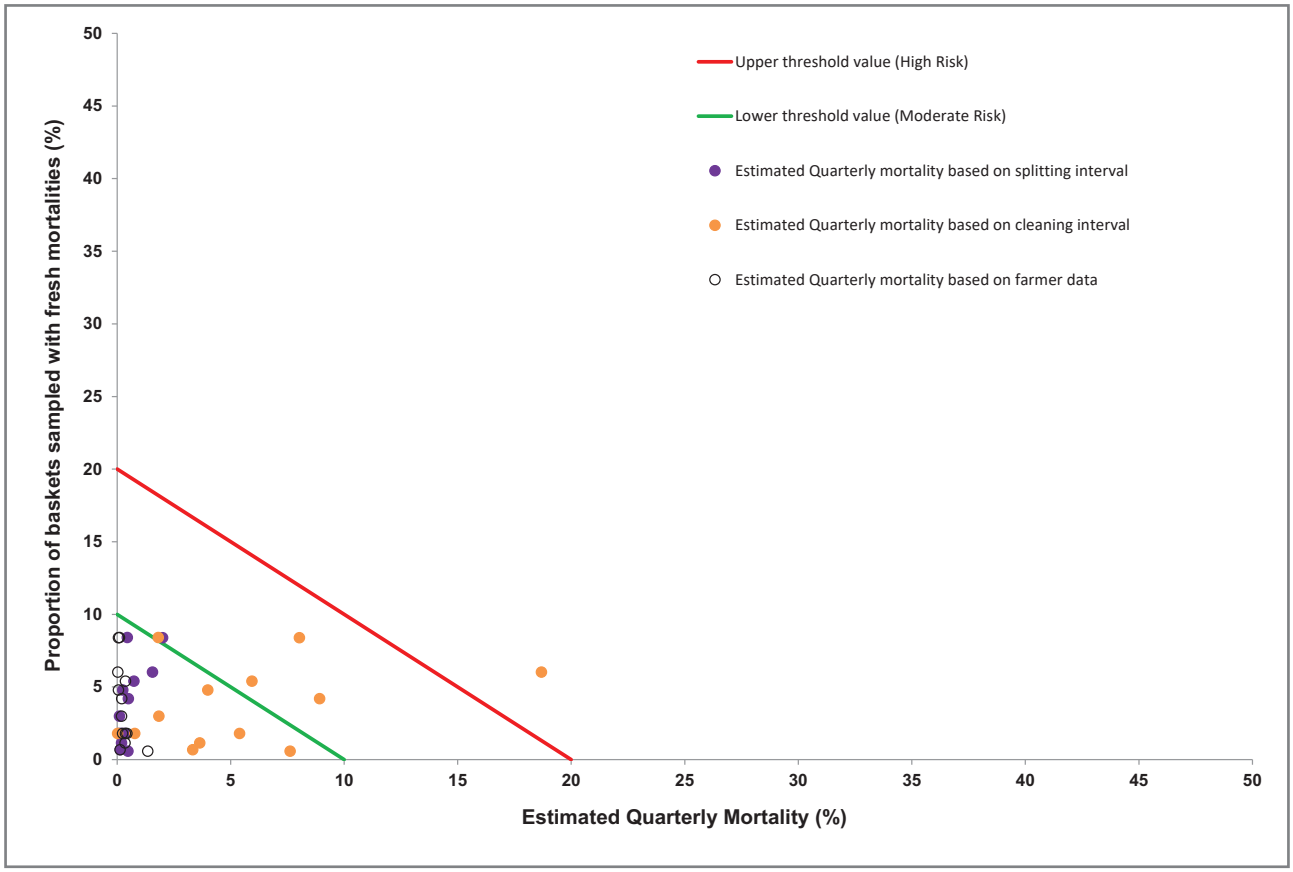


Figure 9.1: Proportion of baskets sampled with fresh mortalities (%) vs estimated quarterly mortality (%). Animal health and welfare risk distribution of South African abalone farms based on assessments from 2021 stock inspections.

NOTES

Figure 9.2 Department of Forestry, Fisheries and the Environment staff, coastal monitors and provincial veterinary services staff carrying out stock inspections in 2021

9.3 Disease Events

9.3.1 Infection with *Halioticida noduliformans* (Abalone Tubercle Mycosis)

Abalone tubercle mycosis (ATM) is a disease caused by the oomycete *Halioticida noduliformans* which was first detected in South Africa in 2006 (Macey et al., 2011; Greeff et al., 2012) and is considered a production disease. In South Africa, this disease has only

been isolated from captive populations of abalone, *Haliotis midae*, and regarded by the DFFE as having the potential to pose a significant threat to the abalone aquaculture industry. During the 2021 cycle, two cases of ATM, from separate farms, reported to the department.

These reports represent isolated cases in weaning and grow-on respectively with no clinical signs observed in any other animals at the time. The responses by the respective farmers and the DFFE as per the *"Abalone Tubercle Mycosis Management Protocol"* was sufficient to contain and reduce the risk of progression of the disease within the respective production units and consequently between farms. Despite the relatively broad geographic distribution of this pathogenic agent in the natural and farming environments, the observation of this disease in farmed abalone remains sporadic thereby presenting more as a production disease and to some degree as an indicator of the overall health status of animals on the farm.

9.3.2 Infection with *Aphanomyces invadans* (Epizootic Ulcerative Syndrome)

Epizootic Ulcerative Syndrome (EUS) is a disease caused by the oomycete *Aphanomyces invadans* to which both farmed and wild, freshwater, and brackish water fish are susceptible. No new cases of infection with *Aphanomyces invadans* reported from South Africa during 2021.

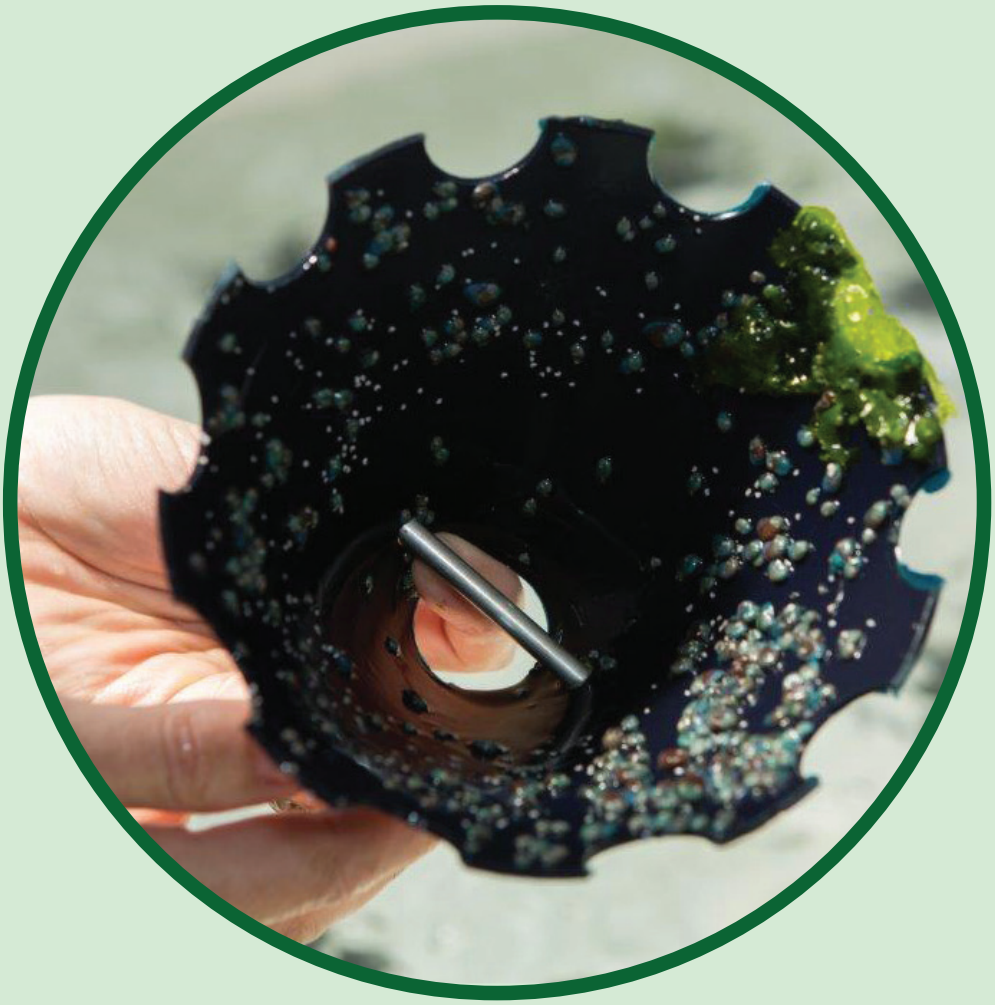
9.3.3 Infection with Koi Herpesvirus

Koi herpesvirus (KHV) is a disease caused by cyprinid herpesvirus-3 following the nomenclature for other cyprinid herpesviruses. Initial outbreaks of infection with Koi herpesvirus in South Africa were in 2001-2003 (Haenen et al., 2004) where the disease caused serious losses in valuable koi collections (Huchzermeyer & Colly, 2015). Although this disease is most commonly associated with the ornamental fish industry, in 2014 KHV was confirmed and reported from a feral population of Cyprinus carpio – Common Carp in Cape Town. No new cases of infection with KHV reported from South Africa in 2021.

NOTES

CHAPTER 10

AQUACULTURE RESEARCH AND DEVELOPMENT



10. AQUACULTURE RESEARCH AND DEVELOPMENT

10.1 Introduction

Aquaculture is a knowledge and technology driven industry, which relies heavily on research to advance sustainable commercial production. The development of aquaculture technology, particularly for indigenous species, has, therefore, been identified within the National Aquaculture Strategic Framework (NASF) as a key strategy for growing the local aquaculture sector. The Directorate: Aquaculture Research and Development (D: ARD) has been established to oversee, facilitate, and conduct research in support of a competitive and sustainable aquaculture sector in South Africa. The focus areas are:

- **Diversification and competitiveness** - Development of the aquaculture sector in South Africa requires diversification, with particular emphasis on indigenous species and the development of appropriate technology. Research that will enhance diversification throughout the value chain is undertaken and improvements to existing aquaculture systems pursued to enhance efficiency. Research, therefore, includes the establishment of new species for culture, breeding and genetics, production systems, pilot/demonstration projects, nutrition and feed development and market and post-harvest technology.

- **Sustainable production**. Sustainability is of key importance for the South African aquaculture sector. This will require information gathering and access to knowledge of the interactions between aquaculture and the environment and of animal health. Environmental sustainability underpinned by the use of appropriate technology and development of sustainable management techniques. The focus area is comprised of the following dedicated research programmes: aquatic animal health and welfare, environmental interactions and food safety.

The D: ARD has three subunits responsible for addressing the above focus areas, namely i) Reproduction, Production and Nutrition, ii) Environmental interactions, and iii) AAH. From January to December 2021, 42 research projects were undertaken, 22 students were co-supervised, and scientists of the D: ARD published 20 papers in collaboration with universities and the industry. Research highlights for each subunit, together with a list of the main projects undertaken as summarised below.

10.2 Reproduction, Production and Nutrition Subunit

Research within this subunit focusses on (i) the development of controlled reproduction methods for selected finfish and shellfish, (ii) the development of production methods for various plankton, finfish and shellfish species, incorporating implementation of IMTA technologies, (iii) the formulation of cheaper diets derived from terrestrial resources with similar or better growth characteristics than obtained with commercial feeds with fishmeal as main protein contributor and (iv) the development of tetraploid broodstock in alien fish species with aquaculture potential to improve performance and reduce environmental risk.

Highlights during 2021 firstly include the development of a novel and efficient method for the oral delivery of bioactive peptides in commercially used finfish that are responsive to GnRHa induced spawning. The first success was achieved after four attempts with different protocols. Further refinement of the method is underway to improve efficiency and cost-effectiveness (ongoing research). Secondly, an article was published on the use of crocodile meat as fishmeal substitute in juvenile dusky kob. Partial fishmeal replacement with crocodile meat was demonstrated but it lacked polyunsaturated fatty acids (PUFA) and highly unsaturated fatty acids (HUFA) constituents (Mdhluvu et al. 2021).

Another highlight includes a published book chapter on the overview on the selected inclusion of medicinal plant constituents in aquaculture feeds as a cheap option to treat disease outbreaks in aquaculture, also reducing the use of antibiotics to which resistance can be developed by pathogens. Medicinal plants contain compounds with immunostimulatory, antibacterial and antifungal properties. Lastly, an MSc student supervised by the DFFE completed their thesis - describing complete developments on programmable broodstock conditioning and hatchery procedures for the spotted grunter (*Pomadasys commersonnii*). However, survival of swimming bladder-inflated larvae remains a challenge, which could be resolved by use of calanoid copepod nauplii as fist larval feed to ensure a commercial level of larval survival to weaning stage. Outcomes of this research in draft stage for review and eventual publication.

10.3 Crocodile Meat Meal as a Fishmeal Substitute in Juvenile Dusky Kob (*Argyrosomus japonicus*) Diets: Feed Utilisation, Growth Performance, Blood Parameters and Tissue Nutrient Composition

Introduction

Fishmeal (FM) and fish oil are major ingredients in diets of many farmed fish (Yones & Metwalli, 2015). In South Africa, these valuable aqua feed components are produced from captured wild forage fish (anchovies, and pilchards) whose other role is to sustain a productive marine ecosystem as a principal food source for bigger fish, seabirds, and marine mammals (Engelhard et al., 2014). However, wild fish stocks have started to decline over the last few years due to climatic changes (Tourre et al., 2007) and overfishing driven by rising demand for FM and fish oil (Olsen Hasan, 2012).

Overfishing depletes targeted and non-targeted fish species, which negatively modifies the structure and function of marine ecosystems (Myers, 2005). To compound matters, FM is also used as a feed ingredient for other food animals adding to its demand and, therefore, higher market prices. High financial and ecological costs of FM have driven the search for alternative protein sources that could improve the sustainability of farmed fish.
Indeed, terrestrial protein sources, such as insect meals (Belforti et al., 2015; Belghit et al.,

2018) and poultry by-products (Karapanagiotidis et al., 2018), have been evaluated as FM alternatives in carnivorous fish diets with mixed results. Crocodile meat meal (CMM), a co-product of the lucrative crocodile skin business, is another novel terrestrial protein that could be used as an alternative to FM in aqua feeds**.** Ingredients (g/kg) and chemical composition (g/kg DM, unless stated otherwise) of black soldier fly meal (BSFM) and experimental diets. In South Africa, local demand for crocodile meat for human consumption is very limited resulting in farmers discarding large quantities (Personal communication: Pit Süssmann, Managing Director, Izintaba Farm Crocodile [Pty] Ltd, 25 November 2011). The meat is a good source of proteins, lipids, minerals, and vitamins (Cernikova et al., 2015) and could be used to replace FM in farmed fish diets.

Apart from a comparative analysis of the proximate composition of Nile crocodile meat and FM by Luthada-Raswiswi et al. (2019), we have not found any published studies that evaluate crocodile meat as a novel dietary ingredient for fish. Using crocodile meat as an alternative source of protein for carnivorous fish such as the dusky kob could be an ingenious strategy to add value to the crocodile farming enterprise while ensuring economically and environmentally sustainable dusky kob aquaculture.

However, in farmed fish, the nutrient composition of fillet is highly dependent on diet composition, among other factors such as species, temperature, and water salinity (Xu et al., 2020). Fish are an irreplaceable source of amino acids, fats, vitamins, and minerals for human nutrition (Bogard et al., 2015). In particular, fish of marine origin have higher levels of *n*-3 long chain polyunsaturated fatty acids (PUFA) compared to terrestrial animal products (Tacon & Metian, 2013). Long chain *n*-3 PUFA such as docosahexaenoic acid (DHA, 22:6*n*-3) and eicosapentaenoic acid (EPA, 20:5*n*-3) have a well-documented role in the prevention of metabolic disorders, cancer, and cardiovascular diseases in humans (Gill et al., 2012).

However, replacing FM with CMM has the potential of altering the nutrient profile of fish fillet, thereby affecting the nutrition and health of fish consumers. This study was designed to determine the effect of complete or partial (50%) replacement of dietary FM with raw or cooked CMM on feed utilisation, growth performance, haematology, serum biochemistry, and tissue nutrient composition in juvenile dusky kob (*Argyrosomus japonicus*, Temminck & Schlegel, 1843), an economically important aquaculture fish in South Africa. The study tested the hypothesis that replacing FM with CMM would not compromise feed utilisation, growth performance, haematology, serum biochemistry, and tissue nutrient composition in juvenile dusky kob.

Summary of objectives, materials, methods, and results

Therefore, this short-term, preliminary study investigated the effect of replacing FM with raw or cooked CMM on feed utilisation, growth performance, haemato-biochemical parameters, and tissue nutrient composition in juvenile dusky kob (*Argyrosomus japonicus*, Temminck and Schlegel, 1843). Diets were formulated (Table 10.1) by replacing FM in a commercial

diet (control) with 1. cooked CMM at 50% (CCR50), 2. raw CMM at 50% (RCR50), 3. raw CMM at 100% (RCR100), and 4. cooked CMM at 100% (CCR100).

Fingerlings (7.55 ± 0.87 g) were offered diets at 2,8% body weight, twice daily, in a recirculating aquaculture system (20 tanks; 110 fish/tank) for 5 weeks. Weight was measured weekly while blood and fillet samples were collected in week 5. Table 10.2 shows that complete replacement of FM with CMM significantly reduced feed intake, weight gain, specific growth rate (SGR), and protein efficiency ratio (PER) while increasing FCR over the 5-week period. The RCR100 and CCR100 diets also resulted in higher levels of urea, alkaline phosphatase, and lower triglycerides in the serum of the fish.

Complete replacement of FM with CMM increased palmitoleic and oleic acids in fish muscle compared to the control. Regardless of level of FM substitution, CMM had an adverse impact on linoleic acid, linoleic acid, eicosapentaenoic acid, and docosahexaenoic acid concentration of the dusky kob fillet. A supplementation strategy using oils rich in *n*-3 fatty acids could mitigate the negative impact of dietary CMM on feed utilisation, growth performance, and polyunsaturated fatty acid levels in dusky kob fillet without raising economic and ecological costs.

Table 10.1. Formulation, proximate composition, and amino acid composition of control and crocodile meat meal-containing treatment diets

	Diets				
	Control	**RCR50**	**CCR50**	**RCR100**	**CCR100**
Ingredients (g/kg)					
Fishmeal	545	272,5	272,5	0	0
Raw crocodile meat	0	272,5	0	545	0
Cooked crocodile meat	0	0	272,5	0	545
Corn starch	280	280	280	280	280
Cellulose	95	95	95	95	95
Premix[2]	80	80	80	80	80
Proximate composition					
Dry matter (g/kg)	939,9	958,1	961,0	976,3	982,2
Ash (g/kg)	86,3	55,7	55,3	25,0	20,3
Crude protein (g/kg)	476,6	478,9	483,8	481,2	481,0
Gross energy (Kcal/kg)	1 986,0	2 002,8	2 005,5	2 019,5	2 025,0
Crude fat (g/kg)	252,4	259,0	248,6	265,6	244,7
Essential amino acids (g/100 g DM)					
Arginine	3,54	4,38	4,08	5,21	4,62
Threonine	1,66	2,02	1,97	2,38	2,27
Methionine	0,71	1,03	1,02	1,35	1,33

Valine	2,47	2,86	2,76	3,25	3,04
Phenylalanine	1,93	2,12	2,05	2,30	2,17
Isoleucine	1,92	2,52	2,44	3,05	2,90
Leucine	3,42	3,73	3,73	4,03	4,03
Histidine	1,34	1,23	1,79	1,11	2,24
Lysine	2,92	4,42	4,16	5,91	5,40
Tryptophan	5,40	5,75	5,70	6,10	5,99
Non-essential amino acids (g/100 g DM)					
Alanine	2,43	2,67	2,49	2,99	2,63
Tyrosine	1,22	1,60	1,70	1,98	2,17
Proline	2,45	2,57	2,35	2,68	2,25
Serine	1,85	2,05	1,99	2,24	2,12
Aspartic acid	3,36	4,09	3,97	4,81	4,57
Glutamic acid	6,17	7,04	6,91	7,91	7,65
Glycine	2,68	3,43	2,83	4,18	2,98

[1]Diets: Formulated by replacing FM in a commercial diet (control) with cooked CMM at 50% (CCR50); raw CMM at 50% (RCR50); raw CMM at 100% (RCR100); and cooked CMM at 100% (CCR100).
[2]Premix: Vitamins/minerals mix composed of procaine HCl (15mg) methylsulphonylmethane (MSM) (300 mg) lecithin (300 mg) alpha-tocopherol (vitamin E) (30 mg) thiamine HCl (vitamin B1, 10 mg) riboflavin (vitamin B2, 3 mg) pyridoxine HCl (vitamin B6, 3 mg), nicotinamide (10 mg), calcium pantothenate (10 mg), choline (40 mg), magnesium (100 µg), chromium (25 µg), zinc amino acid chelate (10 mg), inositol (30 mg), manganese (75 µg) and iron (5 mg).

Table 10.2. Effect of partial or total substitution of dietary fishmeal with raw or cooked crocodile meat meal on feed utilisation and growth performance in juvenile dusky kob

Parameters	Diets[1]					
	Control	**CCR50**	**RCR50**	**CCR100**	**RCR100**	**SEM[2]**
Feed intake (g/fish)	21,14^{c}	18,20^{b}	17,52^{ab}	16,79^{a}	16,57^{a}	0,34
Protein intake (g/fish)	10,08^{c}	8,81^{b}	8,39^{ab}	8,24^{ab}	7,98^{a}	0,16
Weight gain (g)	25,75^{c}	20,02^{b}	20,24^{b}	13,47^{a}	13,63^{a}	0,66
SGR[3] (%)	3,38^{b}	3,08^{b}	3,10^{b}	2,36^{a}	2,36^{a}	0,09
FCR[4]	0,83^{a}	0,91^{a}	0,87^{a}	1,19^{b}	1,22^{b}	0,04
PER[5]	2,55^{b}	2,28^{b}	2,42^{b}	1,71^{a}	1,71^{a}	0,08

[1]Diets: Formulated by replacing FM in a commercial diet (control) with cooked CMM at 50% (CCR50); raw CMM at 50% (RCR50); raw CMM at 100% (RCR100); and cooked CMM at 100% (CCR100).

Research Projects Undertaken by Reproduction, Production and Nutrition [Principle investigator(s) and student indicated in brackets]

1. Feasibility of commercial integrated multi-trophic aquaculture of sea urchin (Tripneustes gratilla) and sea lettuce (Ulva sp.) in South Africa. [PI(s): Brett Macey (DFFE), Mark Cyrus (DFFE), John Bolton (UCT); PhD Student: Sebastian de Vos (UCT)]
2. Identification and characterization of compounds within Ulva which act as feed attractants and settlement cues for Tripneustes gratilla [PI(s): Brett Macey (DFFE), Mark Cyrus (DFFE), John Bolton (UCT), Denzel Beukes (UWC); PhD Student: Lekraj Etwarysing (UCT)]

3. Determining larval settlement, post-settlement and weaning substrates and regimes for the sea urchin Tripneustes gratilla in intensive aquaculture [PI(s): Mark Cyrus (DFFE), Brett Macey (DFFE), John Bolton (UCT); M.Sc. Student: Michael Bennett (UCT)]
4. The effects of salinity, temperature and nutrients on the nutrient content and chemistry of Ulva [PI (s): Mark Cyrus (DFFE), Brett Macey (DFFE), John Bolton (UCT), Gavin Maneveldt (UWC); M.Sc. Student: Dhiren Vanmari (UWC)].
5. The effects of varying salinities on the growth, immunity and physiological response of the cultured sea urchin, *Tripneustes gratilla* [PI (s): Brett Macey (DFFE), Mark Cyrus (DFFE), Rashieda Toefy (CPUT); **M.Sc. Student: Rifaat Aż z (CPUT)**].
6. Qualitative and quantitative analysis of the carotenoid composition of the cultured sea urchin *Tripneustes gratilla* gonads in relation to gonad colour. [PI(s): Mark Cyrus (DFFE), Gavin Maneveldt (UWC), Denzel Beukes (UWC); **Honours Student: Nthabiseng Thibeli (UWC)**].
7. Culturing local marine calanoid copepods as live foods for marine fish larvae. PI(s): Chris Fouche (DFFE), Mark Goodman (DFFE) and Riaan Cedras (UWC). **M.Sc. Student: Ngoepe Maphuti Eva (UWC)**].
8. Development of advanced larval rearing techniques for spotted grunter (*Pomadasys commersonnii*) (family: Haemulidae) until the weaning stage [PI (s): Chris Fouche (DFFE) and Heather Marco (UCT)**: M.Sc. Student: Amos Rakgoale (UCT)**].
9. The effect of dietary acid-fermented chicken silage on growth performance, digestive enzymes and histology in *Oreochromis mossambicus* in South Africa [PI (s): Esau Mbokane (DFFE) and Chris Fouche (DFFE)].
10. Feed utilization, growth performance and blood parameters in juvenile dusky kob (*Argyrosomus japonicus*, Scieaenidae) reared on insect meal-containing diets [PI (s): Molatelo Madibana (DFFE), Brett Lewis (DFFE), Chris Fouche (DFFE) and Victor Mhlambo (UMP)].
11. Description the reproductive cycle of the clam *Venerupis corrugatus* from Langebaan Lagoon [PI (S): Dr Dale Arendse (DFFE); **Adv. DIP** - **Mbona Nobuhle (CPUT)**].
12. Spawning induction and larval rearing of the clam *Venerupis corrugatus* [PI (S): Dr Dale Arendse (DFFE); **M.Sc. Student: Stian Louw (CPUT)**].
13. Development of a novel and efficient method for the oral delivery of spawning induction peptides in the spotted grunter (*Pomadasys commersonnii*) [PI(s) Chris Fouche (DFFE) & Mark Goodman (DFFE)].
14. Growth performance and heath parameter evaluation of graded Black soldier fly meal (BSFM) inclusions as partial fish meal replacement substitute in in the diet of juvenile dusky kob [(PI(s): Molatelo Madibana (DFFE) and Chris Fouche (DFFE)].
15. Development of IMTA controlled larval rearing techniques for spotted grunter (*Pomadasys commersonnii*) [PI(S): Chris Fouche (DFFE), Mark Goodman (DFFE) and Alick Hendricks (DFFE)]

10.4 Environment Interactions Subunit

Aquaculture has often been associated with environmental degradation relating to biological pollution (for example, escapes, aliens and diseases), use of trash fish for fish feeds, organic pollution and associated eutrophication, fauna interactions (for example, whale/shark entanglements, predators, etc.), chemical pollution and habitat modification. Without proper evaluation and mitigation of impacts in terms of an environmental assessment, and implementation of responsible environmental management plans, aquaculture stands to degrade the ecosystems upon which it is dependent.

It is, therefore, important to locate and manage aquaculture activities so that degradation of the environment and biological impacts minimized. An increased understanding and monitoring of the interactions between aquaculture and the environment is, therefore, required for effective management. The environment (ENV) research unit of the Directorate: Aquaculture Research has two focus areas, namely: (i) to address the suitability and assimilative capacity of different environments to various aquaculture practices, and (ii) to address the impacts of aquaculture practices on the environment.

10.4.1 Research Highlights: Environment (2021)

Highlights during 2021 included our contribution to the completion of two (2) major publications as outcomes of our participation in international projects. The first was the report of the International Ocean Colour Coordinating Group on the *Observation of Harmful Algal Blooms with Ocean Colour Radiometry* (Bernard et al. 2021) and the second was a report of GlobalHAB on *Guidelines for the Study of Climate Change Effects on HABs* (Wells et al. 2021). These documents are likely to guide the HAB scientific community for some years to come on both the value of satellite observations in monitoring blooms and in achieving a globally consistent approach in the study of HABs in response to climate change.

Another important paper stemmed from our contribution to the IOC databases on Harmful Algal Blooms: OBIS and HAEDAT. Entitled *Perceived global increase in algal blooms is attributable to intensified monitoring and emerging bloom impacts* the paper published in the journal *Communications Earth and Environment*, is the first product of the analysis of these data sets, and importantly influences global thinking relating to the trend of increasing HABs (Hallegraeff et al. 2021).

A further highlight was publication of the review paper *System controls of coastal and open ocean oxygen depletion* in the journal *Progress in Oceanography* (Pitcher et al. 2021). Our leading role in this publication was the outcome of our participation in the IOC expert group GO_2NE (Global Ocean Oxygen Network) tasked with improving our understanding of ocean deoxygenation. In this regard, impact assessments of shellfish farming on Saldanha Bay continue using oxygen as an ecological indicator of bay health.

Research Projects Undertaken by Environment [Principle investigator(s), collaborators and students indicated in brackets]

1. Investigate threat posed by the toxic diatom *Pseudo-nitzschia* to shellfish farmers in Saldanha Bay [PI: Grant Pitcher (DEFF), Collaborators: Lisa Mansfield and Brett Macey (DFFE), Allan Cembella and Bernd Krock (Alfred-Wegener Institute for Polar- und Meeresforschung, Bremerhaven, Germany)].
2. Investigate Paralytic Shellfish Poisoning [PSP] toxins in farmed abalone [PIs: Grant Pitcher, Brett Macey (DFFE); **PhD student: John Foord (UCT)].**
3. Monitor the threat to abalone farms of yessotoxin-producing dinoflagellate blooms [PI: Grant Pitcher, Collaborators: Andre du Randt and Lisa Mansfield (DFFE), Stewart Bernard (CSIR)].
4. Assessment of the role of satellite derived ocean colour data in the monitoring of harmful algal blooms [Pis: Grant Pitcher, Stewart Bernard (CSIR), Raphael Kudela (University of Southern California, USA), Lisl Robertson Lain (UCT)].
5. Contribute to IOC databases on Harmful Algal Blooms: OBIS and HAEDAT [Pis: Grant Pitcher and Lisa Mansfield (DFFE)].
6. Participate in the international IOC-SCOR programme GlobalHAB through publication of *Best Practice Guidelines on Climate Change and Harmful Algal Bloom Research* [Pis: Grant Pitcher (DFFE), Mark

   Wells (University of Maine USA), Michele Burford (Griffith University, Queensland, Australia), Anke Kremp (Leibniz Institute for Baltic Sea Research Warnemünde, Rostock, Germany), Marina Montresor (Stazione Zoologica Anton Dohrn, Napoli, Italy)].
7. Investigate the risk posed by ocean deoxygenation and acidification through climate change [but also through other drivers at shorter time scales] to aquaculture on the SA coast [PI: Grant Pitcher (DFFE), Collaborators: Andre du Randt, Lisa Mansfield, and Koena Seanego (DFFE)].
8. Participate in International Atomic Energy Agency [IAEA] project RAF/7/014 through maintenance of a coastal O_2 and pH monitoring programme in St Helena Bay [PI: Grant Pitcher (DFFE), Collaborators: Andre du Randt, Lisa Mansfield, and Koena Seanego (DFFE)].
9. Participate in IOC initiative Global Ocean Oxygen Network [GO_2NE] to address the threat of deoxygenation driven by global change (Pis: Grant Pitcher (DFFE) and numerous international experts]. 10. Assessment of the water quality in Vanderkloof dam with regard to the cage culture of rainbow trout (*Oncorhynchus mykiss*) [PI: Koena Seanego, Grant Pitcher (DFFE), Collaborators: Andre du Randt and Lisa Mansfield (DFFE)].
11. Monitor the natural environment of candidate clam species [PI: Dale Arendse (DFFE), Collaborator: Grant Pitcher (DFFE)].
12. Assessment of impact of expanding aquaculture operations on Saldanha Bay through development of an oxygen debt indicator [PI: Grant Pitcher (DFFE), Collaborators: Andre du Randt, Lisa Mansfield, and Koena Seanego (DFFE), **M.Sc. Student: Trevor Coetze (CPUT)**].

13. Assessment of biofouling discarded during the harvesting of shellfish in Saldanha Bay [Pis: Dale Arendse and Grant Pitcher (DFFE), **M.Sc. Student: Lloyd Sassman (CPUT)**].
14. An assessment of impact of rainbow trout (*Oncorhynchus mykiss*) cage culture on water quality of Vanderkloof dam [PI: Koena Seanego, Grant Pitcher (DFFE), Collaborators: Andre du Randt, and Lisa Mansfield (DFFE)].

10.5 Aquatic Animal Health Research Subunit

Aquaculture development continuously brings new challenges to AAH that require varying degrees of governmental response. Diseases can significantly disrupt the aquaculture sector, international trade and ultimately food security, but the impacts are more extensive and have social and financial consequences as well. Surveillance programs that focus on early detection of a pathogen, through the development of improved or novel diagnostic methods, combined with epidemiological research, enable a rapid response to disease epizootics to prevent the spread and establishment of diseases in cultured and wild aquatic animal populations.

Strategies that aim to improve the general health of the host and its ability to tolerate the stressful conditions associated with aquaculture production systems must also be promoted; and include the use of preventative measures such as prebiotics, probiotics, and vaccines, as well as improved feeds and production systems (such as IMTA). Generating scientific information of this nature in support of improved biosecurity is indispensable.

Consequently, the AAH Research Unit of the Directorate: Aquaculture Research has three main focus areas, namely (i) the development of novel methods for the diagnosis of new and emerging pathogens to provide accurate and reliable disease diagnosis for aquatic animals; (ii) collection of epidemiological data for significant aquatic animal diseases in Southern Africa to inform management and contingency interventions; and (iii) the development of effective preventative and treatment strategies for existing and emerging marine aquaculture diseases. The scope of research conducted by the unit spans all aquatic environments, including the freshwater environment in support of inland fisheries and aquaculture development.

10.5.1 Research Highlights: Aquatic Animal Health (2021)

Highlights during 2021 include our contributions towards the European Union Horizon 2020 funded ASTRAL — All Atlantic Ocean Sustainable, Profitable and Resilient Aquaculture — project that focuses on integrative multi-trophic aquaculture (IMTA) farming. ASTRAL aims to develop new, sustainable, profitable, and resilient value chains for IMTA production within the framework of existing, emerging, and potential Atlantic markets, and the project has been funded from September 2020 – August 2024. The project team consists of 17 partner organizations from a wide range of SMEs, aquaculture communities and value chain stakeholders in Norway, Spain, Portugal, Brazil, Argentina, and South Africa, and gathers four IMTA labs.

The labs include an open offshore system (Ireland, Scotland), inshore land-based pump ashore system with partial-recirculating (South Africa), inshore land-based recirculation system (Brazil), and one prospective IMTA lab (Argentina), focusing on a regional challenge-based perspective, including fish, molluscs, echinoderms, crustaceans, and algae species. The ASTRAL, aims to increase circularity by 50-60% compared to monoculture baseline aquaculture. Furthermore, provide a circular business model, boosting revenue diversification for aquaculture producers increasing profitability by at least 30%.

The South African IMTA lab based at two sites: (1) the DFFE Marine Research Aquarium (MRA) and (2) Viking Aquaculture (Buffeljags abalone farm). Species cultivated at these sites include the South African abalone (*Haliotis midae*), sea lettuce (*Ulva lacinulata*), collector sea urchin (*Tripneustes gratilla*) and Cape urchin (*Parechinus angulosus*). The partners involved in the South Africa IMTA lab include the DFFE, University of Cape Town (UCT), Council for Scientific and Industrial Research (CSIR), LEITAT (Spain) and Viking Fishing (Buffeljags Abalone).

The highlights in 2021 include detailed study of the physical and chemical parameters of the abalone-Ulva IMTA systems at Buffeljags Abalone Farm. Where 50% recirculation, including the microbiome (bacterial, fungal and oomycete) which is an initiation of a new study to assess the impacts of increasing water recirculation (50%, 75% & 100% recirculation) in abalone-*Ulva* IMTA systems on potential disease risks (biosecurity), species health and system health/sustainability; an assessment of the gut microbiome of cultured abalone, *Haliotis midae*, fed various diets; an assessment of the potential use of faeces from the Cape sea urchin (*Parechinus angulosus*) as a source of feed/probiotic for juvenile abalone (co-habitation/symbiotic experiments); and the optimization of culture technology for the production of a new high value species, the sea urchin *Tripneustes gratilla*, in IMTA systems, which includes the construction of the first urchin-*Ulva* IMTA system in South Africa at Buffeljags Abalone.

10.5.2 Research Projects Undertaken by Aquatic Animal Health (Principle investigator[s] and student indicated in brackets)

1. Characterisation of the microbiome of a partially recirculated abalone-*Ulva* IMTA system [PI(s): Brett Macey (DFFE), John Bolton (UCT), Marissa Brink-Hull (UCT), Mariska Greeff-Laubscher (NWU), Vernon Coyne (UCT); **PhD Student: Nokofa Bridget Makhahlela (UCT)].**
2. Characterization of *Ulva* (Ulvaceae, Chlorophyta) species cultured in commercial abalone farms in South Africa, and comparison with closely related wild species, using morpho-anatomical and molecular methods [PI(s): John Bolton (UCT), Brett Macey (DFFE), Maggie Reddy (UCT); **M.Sc. Student: Teejaswani (Shikha) Bachoo (UCT)**].
3. Potential for the use of faecal matter from the Cape sea urchin *Parechinus angulosus* as a feed/probiotic for juvenile abalone [PI(s): Marissa Brink-Hull (UCT Postdoctoral Research Fellow), John Bolton (UCT), Brett Macey (DFFE)]**.**

4. Molecular characterization of Flavobacteriaceae isolated from rainbow trout (*Onchorhynchus mykiss*) and the development of a molecular diagnostic tool for differentiating between species in this genus [PI(s): Brett Macey, Leonard Flemming (Wemmershoek Diagnostic Laboratory), Vernon Coyne (UCT); **M.Sc. Student: Godfrey Komane (UCT)].**
5. *Ulva* as a functional feed: A practical investigation into the effects of *Ulva lacinulata* on the growth, consumption, health, and gut microbiota of the farmed abalone *Haliotis midae* [PI (s): John Bolton (UCT); Brett Macey (DFFE), **PhD Student: Morgan J. Brand (UCT)].**
6. The identification of antimicrobial compounds from *Ulva* grown in an integrated aquaculture system [PI (s): Brett Macey (DFFE), Denzel Beukes (UWC), Gavin Maneveldt (UWC), John Bolton (UCT); **M.Sc. Student: Niccole Okkers (UWC)].**
7. Assessment of the risks associated with the use of various macroalgae as aquafeed ingredients and methods for sterilization of seaweeds [PI (s): Cliff Jones (RU), Brett Macey (DFFE), Dirk Weich (Marifeed); **PhD Student: Petronilla Masika Mwanguda (RU)].**
8. Targeted surveillance of local freshwater fish populations for Epizootic Ulcerative Syndrome (EUS) [PI(s): Kevin Christison (DFFE), Brett Macey (DFFE); **Postdoctoral Research Fellow: Dr. Mariska Greeff-Laubscher (NWU)]**
9. Development and validation of a health assessment index for farmed dusky kob in RSA [PI(s): Kevin Christison, Brett Macey, Prof. A. Vosloo (UKZN)]
10. Characterization and diagnosis of *Ichthyophonus hoferi* from Two Oceans Aquarium [PI (s): Kevin Christison (DFFE), Dr. G. Cole (Two Oceans Aquarium); **MSc Students: Nicholas Nicolle (UWC), Bret Wurdeman (UWC)].**
11. Classification and characterization of aquatic animal pathogens [PI (s): Kevin Christison (DFFE), Dr. David Vaughan (CQU); **Postdoctoral Research Fellow: Dr. Mariska Greeff-Laubscher (NWU)]**.

10.6 International Multi-Stakeholder Projects

1. All Atlantic Ocean Sustainable, Profitable and Resilient Aquaculture (ASTRAL) Project 2020 – 2024 – a European Union Horizon 2020 Research and Innovation Programme Project (Grant Agreement No 863034) [Dr BM Macey & Dr MD Cyrus]. **https://www.astral-project.eu/**.
2. International research network (GDRI-Sud) AfriMAQUA 2019 – 2023 – Research Network for Sustainable Marine Aquaculture in Africa (IRD, France) [Dr BM Macey, Dr MD Cyrus, Dr KW Christison, Dr C Fouche]. **https://en.ird.fr/project-afrimaqua-sustainable-marine-aquaculture-africa.**

10.7 Working Groups and Committees

1. *Global Ocean Oxygen Network* – an IOC-UNESCO Expert Group on ocean deoxygenation [Dr GC Pitcher]
2. *GlobalHAB* [an IOC/SCOR programme] working group on the *Establishment of Guidelines for the Study of Climate Change on Harmful Algal Blooms* [Dr GC Pitcher]
3. *Global Ocean Oxygen Decade* [GOOD] – a programme of the UN Decade of Ocean Science for Sustainable Development 2021-2030 [Dr GC Pitcher]
4. International Atomic Energy Agency [IAEA] project RAF/7/014 *Applying nuclear analytical techniques to support harmful algal bloom management in the context of climate and environmental change* [Dr GC Pitcher]
5. International Ocean-Colour Coordinating Group [IOCCG] and the Global Ecology and Oceanography of Harmful Algal Blooms [GEOHAB] Working Group: *Harmful Algal Blooms and Ocean Colour* [Dr GC Pitcher]
6. NANO Global Project: A global study of coastal productivity, deoxygenation and ocean acidification at selected sites – an initiative of POGO – *Partnership for Observation of the Global Oceans* [Dr GC Pitcher]
7. Scientific Committee of *International Conference of Harmful Algae 2021*, La Pas, Mexico [Dr GC Pitcher]
8. Co-convener of the session Drivers and consequences of marine dissolved oxygen depletion: from estuaries to the open ocean at the *Ocean Sciences Meeting* 24 February – 4 March, Hawaii, 2022 [online].
9. Scientific Committee of the *Liege colloquium on ocean dynamics – Low oxygen environments in marine and coastal waters: drivers, consequences and solutions*, Liege, Belgium, 2022 [Dr GC Pitcher]
10. World Organisation for Animal Health (WOAH, Formerly OIE) Aquatic Animals Health Standards Commission [Dr KW Christison]
11. World Organisation for Animal Health (WOAH, Formerly OIE) *Ad Hoc* group on susceptibility of mollusc species to infection with WOAH listed diseases. [Dr KW Christison]
12. World Organisation for Animal Health (WOAH, Formerly OIE) *Ad Hoc* group on Technical References for Aquatic Animals. [KW Christison]
13. Member of WRC reference working group. The latter focuses on evaluating research with respect to various aquaculture related research projects conducted by Universities/ SAIAB and supported by WRC funding [Dr Chris Fouche]
14. Gariep ATDC committee member of training group (aquaculture), aquaculture research group (supervising research) and facility development design and execution (OSC management involvement) [Dr Chris Fouche]

10.8 Capacity Building

Refer to Chapter 12: Training and Capacity Building

10.9 Publications by the Directorate: Aquaculture Research and Development in 2021

1. Bernard S, Kudela R, Robertson Lain L, Pitcher GC. 2021. Observation of Harmful Algal Blooms with Ocean Colour Radiometry. IOCCG Report Series, No. 20, International Ocean Colour Coordinating Group, Dartmouth, Canada. http://dx.doi.org/10.25607/OBP-1042.
2. Christison KW, Vaughan DB, Shinn AP, Hansen H. 2021. Gyrodactylus molweni sp. N. (Gyrodactylidae: Monogenea) from Chelon richardsonii (Smith, 1922). International Journal for Parasitology: Parasites and Wildlife 15: 87-94.
3. Glibert PM, Pitcher GC. 2021. Harmful algal blooms, changing ecosystem dynamics and related conceptual models. In: Bernard S, Kudela R, Robertson Lain L, Pitcher GC. (Eds.), Observation of Harmful Algal Blooms with Ocean Colour Radiometry. IOCCG Report Series, No. 20, International Ocean Colour Coordinating Group, Dartmouth, Canada. Pp 13-24.
4. GlobalHAB. 2021. Guidelines for the Study of Climate Change Effects on HABs. In: Wells M, Burford M, Kremp A, Montresor M, Pitcher GC (Eds), IOC Manuals and Guides No. 88, Paris, UNESCO-IOC/SCOR.
5. Grégoire M, Garçon V, Garcia H, Breitburg D, Isensee K, Oschlies A, Telszewski M, Barth A, Bittig HC, Carstensen J, Carval T, Chai F, Chavez F, Conley D, Coppola L, Crowe S, Currie K, Dai M, Deflandre B, Dewitte B, Diaz R, Garcia-Robledo E, Gilbert D, Giorgetti A, Glud R, Gutierrez D, Hosoda S, Ishii M, Jacinto G, Langdon C, Lauvset SK, Levin LA, Limburg KE, Mehrtens H, Montes I, Naqvi W, Paulmier A, Pfeil B, Pitcher G, Pouliquen S, Rabalais N, Rabouille C, Recape V, Roman M, Rose K, Rudnick D, Rummer J, Schmechtig C, Schmidtko S, Seibel B, Slomp C, Sumalia UR, Tanhua T, Thierry V, Uchida H, Wanninkhof R, Yasuhara M. 2021. A Global Ocean Oxygen Database and Atlas for Assessing and Predicting Deoxygenation and Ocean Health in the Open and Coastal Ocean. Frontiers in Marine Science 8: 724913.
6. Hallegraeff GM, Anderson DM, Belin C, Bottein M-YD, Bresnan E, Chinain M, Enevoldsen H, Iwataki M, Karlson B, McKenzie CH, Sunesen I, Pitcher GC, Provoost P, Richardson A, Schweibold L, Tester PA, Trainer VL, Yñiguez AT, Zingone A. 2021. Perceived global increase in algal blooms is attributable to intensified monitoring and emerging bloom impacts. Communications Earth and Environment 2:117.
7. Hallegraeff GM, Aligizaki K, Amzil Z, Andersen P, Anderson DM, Arneborg L, Azanza RV, Bates SS, Benico G, Bottein M-YD, Bresnan E, Arevalo F, Belin C, Branco MAC, Carbonell DJ, Cembella AD, Chinain M, Clarke D, Correa J, Davidson K, Dhanji-Rapkova M, Dai X, Darius HT, Eikrem, W, Enevoldsen H, Escalera L, Farrell H, Fensin E, Fernandez Lozano R, Fernández-Tejedor M, Gatti CM, Gobler CJ, Guðfinnsson H, Haigh N, Hay B, Hoeglund AE, Howland KL, Hubbard KA, Ismael A, Iwataki M, Jaffrezic E, Jipanin SJ, John U, Karlson B, Klemm K, Kobos J, Kulis DW, Landsberg JH, Laza-

Martinez A, Leaw CP, Lefebvre KA, Llehtinen S, Lemoine M, Lewis AM, Lewis NI, Lim WA, Lim PT, Locke A, Louw DC, Lu D, Lundholm N, Mackenzie L, Mancera-Pineda JE, McKenzie CH, Menendez LM, Martin JL, Maskrey BH, Mazur-Marzec H, McKinney A, Mendez SM, Montresor M, Mozetič P, Naustvoll L, Orlova T, Pazos Y, Peña A, Pitcher GC, Poelman M, Poulin M, Provoost P, De Rijcke M, Quod J-P, Revilla M, Rhodes L, Richlen ML, Rochon A, Rourke WA, Sakamoto S, scarratt MG, Schweibold L, Siano R, Silva A, Smith JL, Solow AR, Soudant D, Suikkanen S, Sunesen I, Swan S, Starr M, Taş S, Totti C, Tester PA, Trainer VL, Turner AD, Wells T, West JJ, Yñiguez AT, Zingone A. 2021. Global HAB Status Report. A Scientific Summary for Policy Makers. In: Hallegraeff GM, Enevoldsen H, Zingone A (Eds), Paris, UNESCO.

8. Hayes PM, Christison KW, Vaughan DB, Boxshall GA. 2021. Sea lice (Copepoda: Caligidae) from South Africa, with descriptions of two new species of Caligus. Systematic Parasitology 98 (4): 369-397.
9. Kudela RM, Smith ME, Pitcher GC, Bernard S. 2021. Application of ocean colour to blooms of the toxic diatom genus Pseudo-nitzschia. In: Bernard S, Kudela R, Robertson Lain L, Pitcher GC (Eds), Observation of Harmful Algal Blooms with Ocean Colour Radiometry. IOCCG Report Series, No. 20, International Ocean Colour Coordinating Group, Dartmouth, Canada. Pp 51-60.
10. Maapea AD, Vine NG, Macey BM. 2021 Bacterial microbiome of dusky kob Argyrosomus japonicus eggs and rearing water and the bacteriostatic effect of selected disinfectants. Aquaculture. Volume 542, 2021, Article 736882. https://doi.org/10.1016/j.aquaculture.2021.736882.
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14. Pitcher GC, Glibert PM, Kudela RM, Smith ME. 2021. Application of ocean colour to harmful high biomass algal blooms. In: Bernard S, Kudela R, Robertson Lain L, Pitcher

GC (Eds), Observation of Harmful Algal Blooms with Ocean Colour Radiometry. IOCCG Report Series, No. 20, International Ocean Colour Coordinating Group, Dartmouth, Canada. Pp 107-121.

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17. Roy S, Pitcher GC, Kudela RM, Smith ME, Bernard S. 2021. Ocean colour remote sensing of dinoflagellate blooms associated with paralytic shellfish poisoning. In: Bernard S, Kudela R, Robertson Lain L, Pitcher GC (Eds), Observation of Harmful Algal Blooms with Ocean Colour Radiometry. IOCCG Report Series, No. 20, International Ocean Colour Coordinating Group, Dartmouth, Canada. Pp 39-50.
18. Vaughan DB, Christison KW, Hansen H. 2021. New monogeneans from the bathydemersal southern African endemic catshark, Holohalaelurus egain (Gilchrist, 1922). Systematic Parasitology 98 (4): 343-355.
19. Wells ML, Burford M, Kremp A, Montresor M, Pitcher GC. 2021. Guidelines for the study of climate change effects on HABs: introduction and rationale. In: Wells M, Burford M, Kremp A, Montresor M, Pitcher GC (Eds), GlobalHAB. IOC Manuals and Guides No. 88, Paris, UNESCO-IOC/SCOR.
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NOTES

CHAPTER 11

AQUACULTURE TECHNOLOGY DEMONSTRATION CENTRE ACTIVITIES DURING 2021

11. AQUACULTURE TECHNOLOGY DEMONSTRATION CENTRE

11.1 Background to the Project

The ATDC is an aquaculture facility established more than 30 years ago as a fish hatchery and upgraded in February 2013. The ATDC operates on 47 ha of land and is located in the Xhariep District of the Free State province and next to the Orange River downstream Gariep Dam, from where it receives its production water supply.

The ATDC continues to benefit South Africa's freshwater aquaculture sector by serving as a training and technology demonstration facility for young fish farmers, a breeding station for different freshwater fish, and a facility were research and development activities can take place. The intention of the DFFE is to broaden the services of the ATDC to benefit South Africans and Southern African Developing Communities (SADC).

The operation and management of the ATDC are jointly taken care of by the DFFE and the Free State Department of Agriculture and Rural Development (FSDARD) whereby the two departments continued to provide the ATDC with technical and advisory services, as well as financial support to ensure that all the planned activities are implemented.

11.2 Breeding Techniques

In 2021, the ATDC conducted eight artificial breeding (Figure 11.1) sessions of the African sharptooth catfish (*Clarias gariepinus*) for the purposes of research, technology demonstration and maintenance of future broodstock. The broodstock conditioned for a period of two (2) weeks prior every breeding session, fed a conditioned feed, which contained relatively higher contents of animal fats, proteins, vitamins and minerals than the standard formulated feed, which served to improve the quality of gametes produced.

At a water temperature of 28 °C and 11 hours before the actual breeding process, selected female breeders were injected with an aqua-spawn hormone at a dosage of 0.5 mℓ/kg (Figure 11.1A) to induce a smooth release of eggs. During breeding, the eggs were gently squeezed from an anaesthetised female (Figure 11.1B) and, using a dry chicken feather, the eggs were then mixed in a dry container with milt or sperms (Figure 11.1C) collected from a euthanized male to induce fertilization. After two minutes of gentle mixing, the fertilized eggs were then sprayed, single layered, on fine incubation trays installed in the hatching tanks (Figure 11.1D and E). The number of selected broodstock and the subsequent number of one-month-old larvae produced from the eight (8) breeding sessions conducted in 2021 (Table 11.1). The first two (2) breeding sessions were performed in the old Recirculating Aquaculture System (RAS) and other sessions were executed in the new RAS.

Figure 11.1: Artificial breeding of African sharptooth catfish (*Clarias gariepinus*) in the Aquaculture Technology Demonstration Centre recirculating systems

In November, goldfish (*Carassius auratus*) and common carp (*Cyprinus carpio*) were also bred artificially in the new RAS for the purpose of production, training and technology demonstration. These species were bred and kept in a separate production line from the African catfish due to the differences in the required level of water quality parameters such as temperature. For this breeding session, two (2) breeders of each sex and species were selected and kept in separate tanks few days prior the breeding process. Two (2) to three (3) weeks after hatching, a subset of the larvae for Goldfish (n = ± 600) and Common carp (n = ±1 000) were transferred into three (3) external ponds covered with nets for further growth and development. The transfer was also done to compare the growth rates of these larvae between the two (2) production systems.

Date	Number of Selected Breeders	Number of One-Month-Old Larvae Produced
14 – 15 January	2 Females and 1 Male	500
15 – 16 March	2 Females and 3 Males	542
29 – 30 April	2 Females and 2 Males	600
25 – 26 May	2 Females and 2 Males	1 000
21 – 22 July	2 Females and 2 Males	1 784
13 – 14 September	2 Females and 1 Male	1 000
18 – 19 October	2 Females and 1 Male	540
17 – 18 November	2 Females and 1 Male	1 000
TOTAL	**16 Females and 13 Males**	**6 966**

Table 11.1: The number of African sharptooth catfish broodstock selected for breeding and the number of one-month-old larvae produced

11.3 Production Systems

There were four (4) production systems used at the ATDC in 2021 for the purposes of production, technology demonstration and fish rearing, and they are the recirculating system, in other words, RAS, pond culture system, cage culture system and aquaponics system.

11.3.1 Recirculating Aquaculture Systems

There were two (2) recirculating systems which were operational during 2021, and they are the old semi-recirculating African catfish hatchery and the newly established fully RAS with a nursery and an African catfish hatchery. The latter, which was commissioned in March 2021 (Figure 11.2), stocked with some fingerlings and juvenile African catfish from the old RAS during the second quarter of 2021.

The newly established RAS comprises of three (3) independent production lines with 28 grow-out tanks each and an independent African catfish hatchery with three (3) hatching tanks and three (3) sets of zooplankton vessels. The old RAS consisted of four (4) grow-out tanks and six (6) hatching tanks and were all stocked with African catfish from January to June. Table 11.2 shows the fish stocking information in the two (2) recirculating systems for 2021.

Figure 11.2: Commissioning of the new recirculating aquaculture system at the Aquaculture Technology Demonstration Centre

Table 11.2: Number of African sharptooth catfish stocked in the two recirculating systems of the Aquaculture Technology Demonstration Centre at the end of each quarter in 2021

Age group	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Old RAS				
Fingerling	506	0	0	0
Juvenile	210	0	0	0
Broodstock	96	205	0	0
Total	**812**	**205**	**0**	**0**
New RAS				
Fingerling	0	1 601	1 547	1 636
Juvenile	0	253	566	1 222
Broodstock	0	140	255	767
TOTAL	**0**	**1 994**	**2 368**	**3 625**
GRAND TOTAL	**812**	**2 199**	**2 368**	**3 625**

11.3.2. Pond Culture System

There are 36 external ponds at the ATDC, eight (8) of which were stocked with African catfish, goldfish, common carp and Koi carp. The Goldfish and Common carp larvae which were bred on 17-18 November were stocked in three (3) of the eight (8) ponds for further growth and development. Ponds were fertilised every other day with liquefied chicken manure to maintain a rich population of phyto- and zooplankton for the larvae to feed (Figure 11.3).

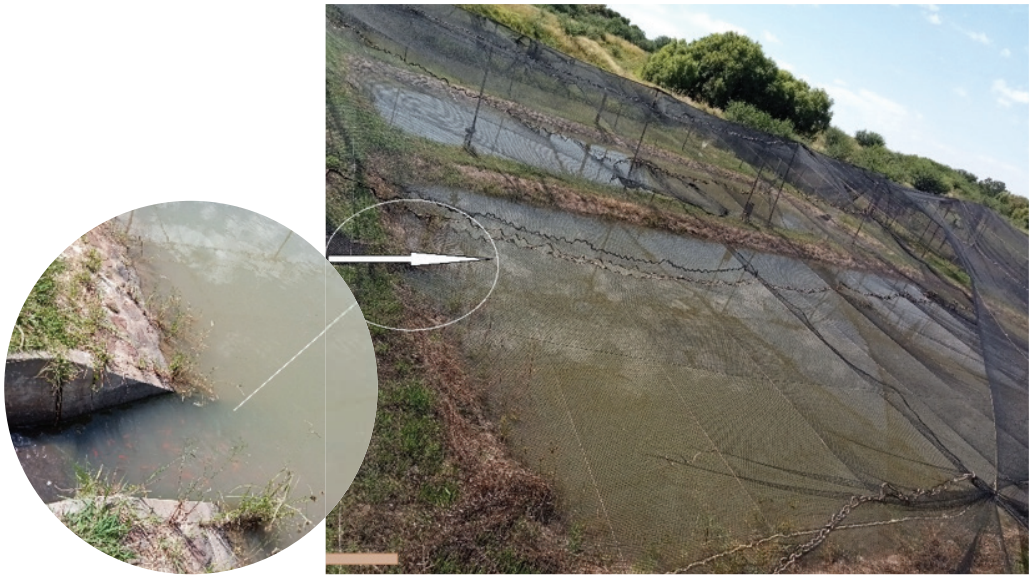


Figure 11.3: A picture of ponds at the Aquaculture Technology Demonstration Centre which were stocked with goldfish and common carp larvae.

11.3.3. Cage Culture System

In the first quarter of 2021, cage culture systems were operational at the ATDC for both technology demonstration and research purposes. Six (6) floating cages installed in a pond (Figure 11.4) were stocked with African sharptooth catfish fingerlings from the old RAS and reared for further growth and development.

Figure 11.4: Floating cage culture system at the Aquaculture Technology Demonstration Centre

11.3.4. Aquaponics System

Three (3) ponds were prepared for aquaponics and a month later after being filled with filtered water; the ponds were each stocked with 100 Common carp, which weigh ± 50 g. At the same time, cucumber, strawberry and lettuce seeds were planted on floating trays (Figure 11.5A). In the new RAS, cucumber seeds were planted on floating trays in three (3) tanks in the same production line (Figure 11.5B).

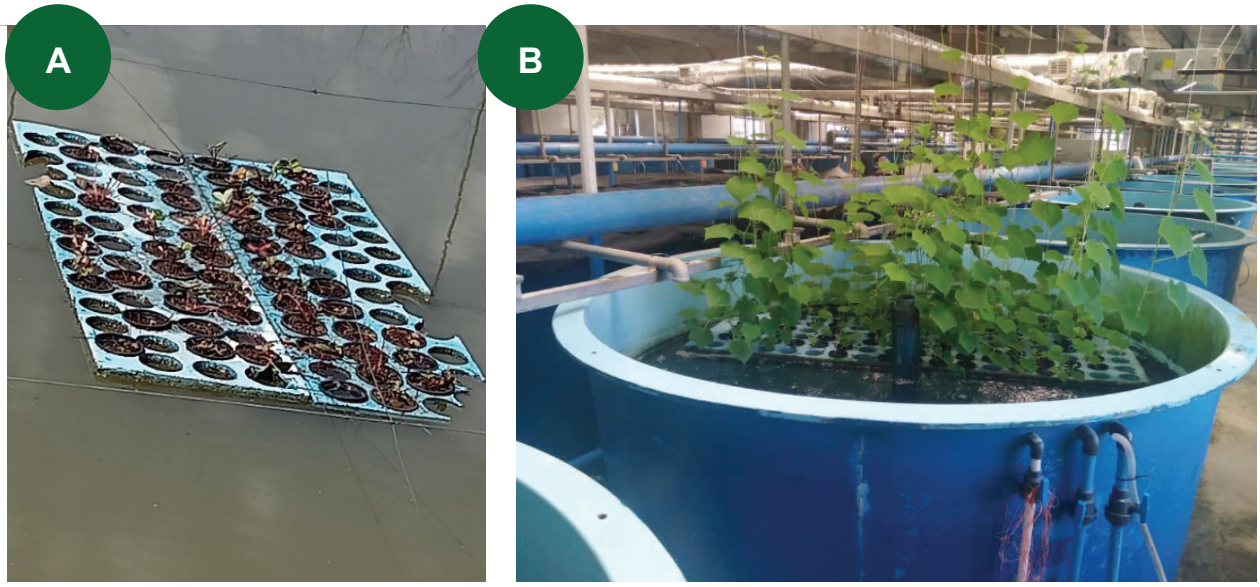


Figure 11.5: Aquaponics systems in external ponds **(A)** and indoor Recirculating Aquaculture System **(B)** of the Aquaculture Technology Demonstration Centre at the end of 2021

11.4 Training and Promotion

Refer to Chapter 12: Training and Capacity Building

11.5 Research and Development

There were five (5) active research projects conducted by officials at the ATDC in 2021 and the projects ranged from fish nutrition, fish health and diseases, aquaculture production systems, aquaculture economics and marketing, and inland fisheries. There was an additional project under fish nutrition which is still in the planning phase and is expected to commence in the following year. The title of the project is “The production of zooplankton for fry rearing of Clarias gariepinus at the Aquaculture Technology Demonstration Centre”.

1. **Fish nutrition:** The development of a cost-effective replacement of fish meal with selected cheaper locally available protein sources in African Sharptooth Catfish (*Clarias gariepinus*).
2. **Fish health and disease:** Application of phytomedicine on Fungi (*Saprolegnia sp.*) and Bacteria (*Aeromonas hydrophobia*, *Pseudomonas aerugnosa* and *Cytobacter columnaris*) detected from fish species at ATDC.
3. **Production systems:** Effect of stocking density and production system on the production of African sharp-tooth catfish (*Clarias gariepinus*).

4. **Aquaculture economics and marketing:** Assessment of socio-economic factors affecting the success and failure of aquaculture projects in the Xhariep District, Free State province.
5. **Inland fishery:** Assessing small scale fisheries potential of Lake Gariep, South Africa.

11.6 Extension Services

The ATDC continued to provide extension services to developing freshwater projects in the country. However, only one project was assisted in terms of the purchasing of fingerlings during 2021. Some of the fingerlings that were stocked in the old RAS (n = 1 524, average mass = 4.47 g) were sold to INMED and collected on 9 March 2021 (Figure 11.7). INMED was also assisted in terms of catfish transportation methods and water quality requirements for optimum growth and reproduction.

Figure 11.6: Packaging of catfish fingerlings sold to the INMED group

NOTES

CHAPTER 12

TRAINING AND CAPACITY BUILDING

12. TRAINING AND CAPACITY BUILDING

12.1 Introduction

The following Training and Capacity building activities were undertaken during 2021 as highlighted below.

National Skills Fund (NSF) Training and internship programme

The former Department of Agriculture, Forestry and Fisheries (DAFF) acquired funding from the Department of Higher Education and Training (custodian of the National Skills Fund) for training, capacity building and mentorship of smallholder/small scale producers and placement of graduates in commercial farms. The Directorate: Aquaculture Technical Services identified suitable commercial aquaculture enterprises for placement of aquaculture graduate for a period of 24 months from November 2020 using the following criteria:

- Commercial or smallholder with potential to become commercial;
- Adequately equipped with resources to enable training of graduates;
- Have market linkages ;and
- The capacity to provide mentor (s) to guide the structured training of graduates.

During 2021, approximately 11 aquaculture graduates remained placed in eight (8) farms which are located in the Western Cape, Free State, EC and Gauteng provinces respectively from the fifteen (15) graduates that were initially placed in 2020. There were four (4) resignations from farms in the EC and Western Cape, respectively, owing to new opportunities and the relocation of one (1) intern from a farm to the DFFE office in the Western Cape province.

Various training programmes were also convened with potential and existing farmers in Gauteng, Mpumalanga, the Western Cape, EC and KwaZulu-Natal provinces. A total number of 257 people were trained on various courses, as illustrated in the table below.

Table 12.1 NSF training statistics for 2021

Course	Province	Quantity
Business and Entrepreneurship	Gauteng	17
Business and Entrepreneurship	Western Cape	7
Business and Entrepreneurship	KZN	79
Business and Entrepreneurship	EC	17
Business and Entrepreneurship	Mpumalanga	23
Aquaculture Farm Management	Gauteng	44
Aquaculture Farm Management	Mpumalanga	23
Government and Management of Co-operatives	EC	70
TOTAL		257

*Same group of people were trained for both courses in Mpumalanga

The above-mentioned courses were held for a maximum of five (5) days in all provinces. The Business and Entrepreneurship course is accredited and made up of three (3) unit standards with a total of thirteen (13) credits as recognized by the Education and Training Quality Assurance (ETQA) body under the South African Qualifications Authority (SAQA). The Aquaculture Farm Management as well as Government and Management of Co-operatives courses were non-credit bearing which offered certificates of attendance to participants.

12.2 Training and Promotion at the ATDC

Owing to challenges associated with the Covid-19 safety regulations, the ATDC was unable to conduct aquaculture training and capacity building to established and aspiring farmers, as well as government officials until the second quarter of 2021.

12.2.1 Training for ATDC Officials

Multiple physical training sessions were hosted by Deep Blue, contractors of the new RAS, at the ATDC RAS prior the commissioning of the system in March to familiarize officials based at the ATDC and relevant stakeholders on the safe operation of the system (Figure 11.6). The officials based at the ATDC also attended a Covid-19 safety protocols training organised by the Occupational Health Directorate of DARD on 13 April. There was also a series of webinars attended by ATDC officials on aquaculture related subjects, and the webinars include:

- *A discussion on aquaculture research and training* hosted by Lilongwe University of Agriculture on 11 February.
- Aquaculture Africa Magazine (AAM) Focus presentation "*Aquatic animal health*" on 19 February.
- AAM Focus presentation "*Current trends in the Tunisian aquaculture sector"* on 25 February.
- AAM Focus presentation "*An online presentation and discussion to feature aquaculture research and training at Stellenbosch University"* on 4 March.
- AAM Focus presentation "*Recirculating Aquaculture System (RAS) – can it work in Africa?* ". The webinar was attended on 18 March.
- AAM Focus presentation "*Aquaculture at the Central Laboratory for Aquaculture Research (CLAR), Egypt"* on 23 March.
- AAM Focus presentation "*Fish health management online training"* on 1 April.
- AAM Focus presentation "*Feed management online training"* on 8 April.
- AAM Focus presentation "*Fish health management online training part 2"* on 22 April.
- AAM Focus presentation "*Practical aquaculture feed management"* on 29 April.

Figure 12.1: Training on the operation of the new recirculating system at the Aquaculture Technology Demonstration Centre

12.2.2 Training for Trainees

Four (4) training sessions were completed in 2021 with a total of 49 individuals trained. Of the 49 individuals who were trained, there were 13 students from an agricultural college in Free State, two (2) DFFE interns from Limpopo and KZN, one (1) established farmer from KZN, 16 private sector farmers from Gauteng and the EC, nine (9) potential farmers from a non-profit organisations in KZN, and eight (8) youth members from the local community in Free State (see Table 11.3).

The content of the training offered included, but was not limited to Fish biology and introduction to freshwater aquaculture fish species; Water quality requirement for fish and the management thereof; Aquaculture equipment; Catfish and Common carp breeding and fry rearing; Fish feeding and nutrition; Fish transportation; Fish diseases and health management; Fish agro processing; Aquaculture farming systems; Bio-security management and aquatic food safety; Environmental legal requirements of freshwater aquaculture; and Aquaculture economics.

Table 12.2: Information on the trainees trained at the Aquaculture Technology Demonstration Centre in 2021

Session	Date	Category	Origin	Number
1	24-26 May	Students, interns and farmers	Free State, KZN and Limpopo	16
2	13-17 September	Potential farmers	Free State and Gauteng	11
3	18-22 October	Potential and private sector farmers	Free State, Gauteng and the EC	11
4	22-26 November	Potential and private sector farmers	Free State and KZN	11
TOTAL				**49**

12.2.3 Awareness and day tours

There were no activities in the line of freshwater aquaculture awareness conducted at or by the ATDC for 2021. However, there was a total of 181 individuals received at the ATDC during five (5) day tour sessions conducted in 2021. From the 181 individuals, 170 were high school learners from local schools, nine (9) local citizens and farmers, and two (2) government extension officers.

12.3 Marine Research Aquarium (Sea Point, Cape Town)

The Research Aquarium was developed as a national facility to support aquaculture research and technology development in the country. Originally, Cape Town's public aquarium built in 1939, the building was later upgraded to a modernised research aquarium in 1997 at the initiative of the then Department of Environmental Affairs and Tourism (DEAT).

The aims of the facility are as follows:

- Focus research and development on the needs of the end user;
- Develop aquaculture expertise;
- Promote skills and transfer technology;
- Assist in identifying and developing new areas for aquaculture such as new species and technology; and
- Provide opportunities for scientists and students to carry out collaborative research.

The facility consists of three (3) levels, containing several purpose-built wet and dry laboratories, six (6) temperature-controlled laboratories, a phytoplankton culture laboratory, an auditorium and a variety of serviced open plan research areas and offices. The floor area covers 1 600 m^2 and is serviced by natural and controlled light conditions and access to filtered sea water. A computerised control system continuously monitors the volume of sea water in the reservoirs, interior temperature and that of the constant temperature laboratories, all electro-mechanical equipment and sensors linked to experiments. A stand-by generator supplies power in case of power failure.

The DFFE's aquaculture research approach is targeted at developing an industry that will contribute towards economic growth. The facility is designed to enable marine scientists to study various aspects of the biology and ecology of a wide variety of marine organisms under a broad spectrum of controlled environmental conditions. It further assists researchers in identifying commercial opportunities in aquaculture and in assessing the suitability of indigenous organisms as potential culture species in the development of an environmentally responsible aquaculture industry. Several research and development projects are carried out in collaboration with local and foreign scientists, tertiary institutions, and the private sector. The facility currently accommodates several students that are co-supervised by the DFFE scientists and provides awareness and introduction exposure to school students to aquaculture on a regular basis.

In 2021, the facility audited quarterly by independent veterinarian to ascertain compliance with best practice for research facilities. Recommendations were implemented, including the refinement of existing and the development of additional Standard Operating Procedures where required. In light of ongoing power supply interruptions, additional uninterrupted power supplies (UPSs) were procured for individual systems and alternative power sources are being investigated. General maintenance and repair of the facility was undertaken, including repair and upgrades to the intake pipeline to ensure continued supply of clean sea water. The facility continues to supply daily water temperature measurements to the South African Weather Service for their national data collection.

12.3.1 Training and Awareness

- The Directorate facilitates second- and third-year aquaculture modules for CPUT students that include both theoretical and practical aspects around aquaculture and research.
- Production Scientist is stationed at University of Limpopo and Rhodes University to support research collaboration, implementation, and capacity development with the institutions in the respective provinces.
- Students from the following universities were co-supervised:
    - University ofthee Western Cape
    - Rhodes University
    - University of Cape Town
    - Stellenbosch University
    - Cape Peninsula University of Technology
    - University of Limpopo
- The Directorate to provide scientific advice and supervise scientist and researchers based at the **Aquaculture Demonstration and Technology Centre in Gariep**, Free State.

- **DFFE Aquaculture Research Presentations.** On 25 February 2021, the Directorate hosted an information sharing meeting to present its current research projects. Meeting was held virtually and attended by 67 participants from industry, government and academia.

12.4 Fisheries Training Programme (Case Study: Impact of Current Legislative Framework on Inland Small-Scale Fisheries in South Africa)

An official within the D: SAM participated in the Fisheries Training programme offered by the University of Akureyri in Iceland for six (6) months. The programme is aimed at candidates from developing countries with the primary objective of assisting countries to achieve their fisheries development goals while upgrading the professional capacity of participating candidates. The case study as mentioned above reviewed the national legislation with an impact on inland fisheries and analysed the provincial environmental management legislation in Limpopo, Free State and Northern Cape provinces. Mini surveys were conducted in Nandoni Dam, Lake Gariep and Vanderkloof Dam to determine the perception of small-scale fishers on the current laws. The legislative analysis shows that the provincial laws in the three (3) provinces focused on regulation of recreational angling activities and there is general lack of compliance from small-scale fishers. The perception from small-scale fishers is that the current laws regulating the sector are unfair and, therefore, legislative reform is needed. Some of the survey results are shared below.

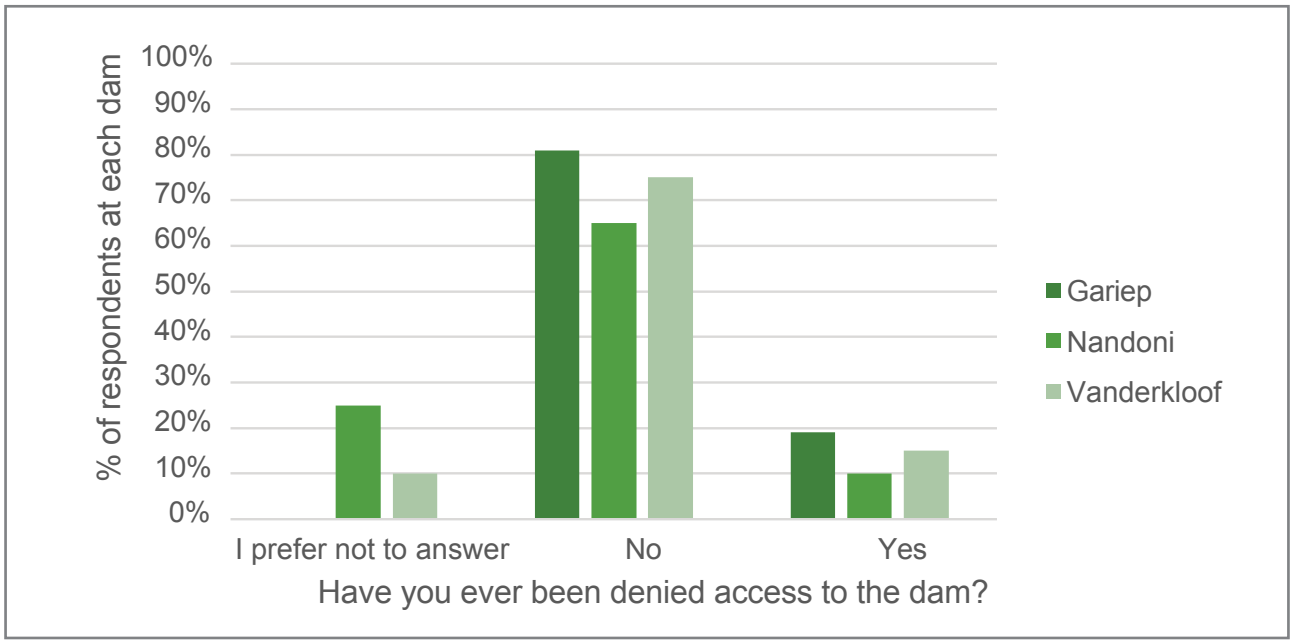


Figure 12.2: Incidents where participants were denied access to the dam compared to each study area

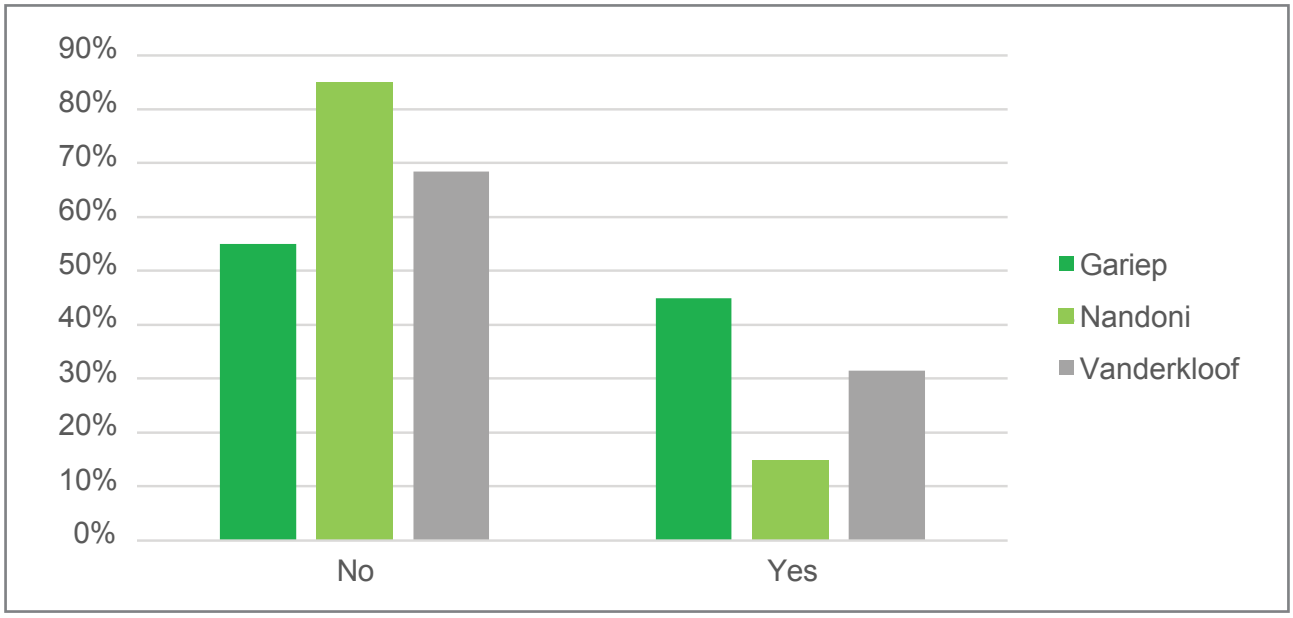


Figure 12.3: Comparison of participants' knowledge of the organisations responsible for monitoring fishing activities in the three (3) study areas

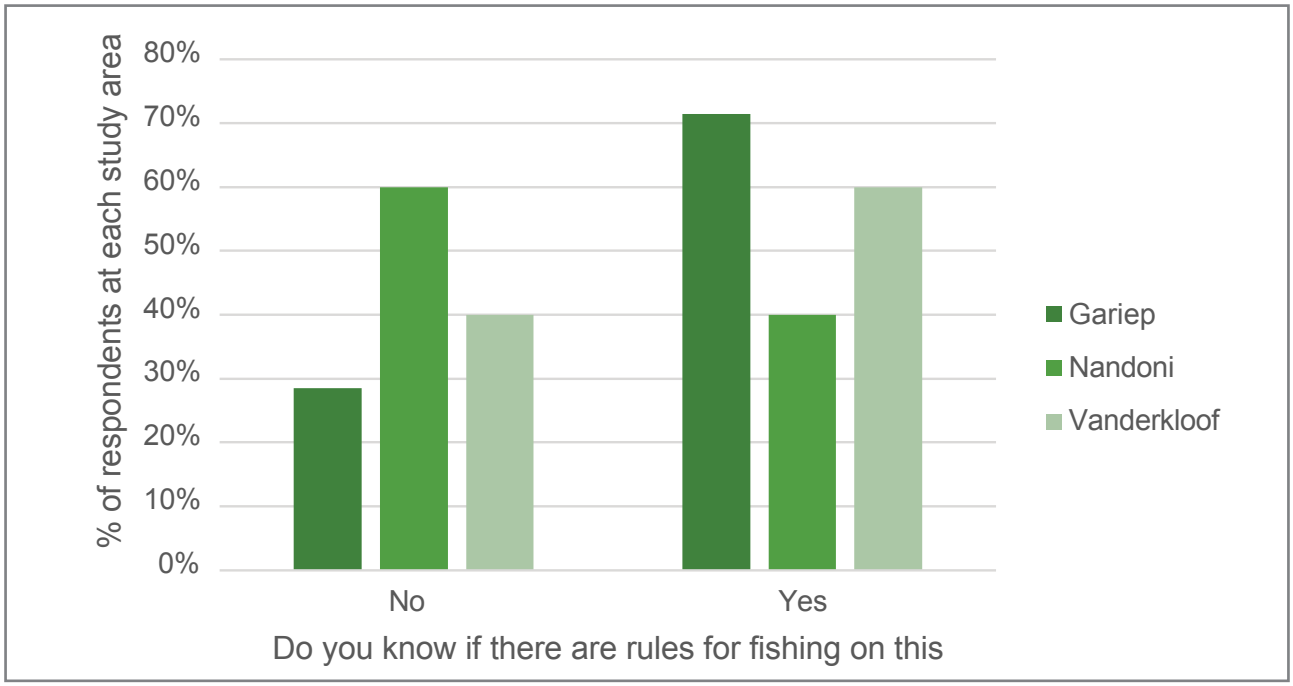
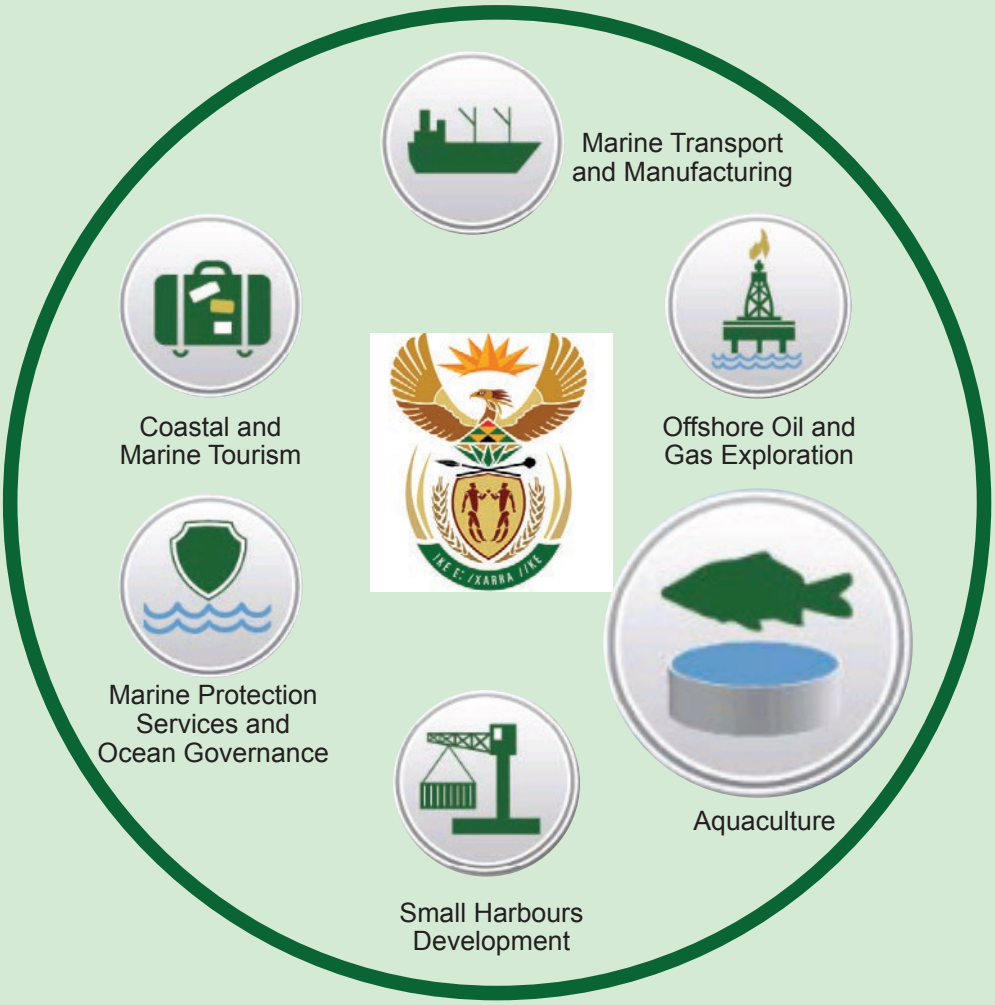


Figure 12.4: Knowledge of fishing rules by fishers from the Nandoni, Gariep and Vanderkloof dams

CHAPTER 13

OPERATION PHAKISA: UNLOCKING THE ECONOMIC POTENTIAL OF SOUTH AFRICA'S OCEANS: YEAR SEVEN REVIEW



13. OPERATION PHAKISA: UNLOCKING THE ECONOMIC POTENTIAL OF SOUTH AFRICA'S OCEANS: YEAR SEVEN REVIEW

13.1 Introduction

Operation Phakisa is a fast result delivery programme launched in July 2014 to help implement the National Development Plan, with the ultimate goal of boosting economic growth and to create jobs. The National Development Plan (NDP) is South Africa's socio-economic development blueprint which enjoins us to create a better life for all citizens in an inclusive society. The NDP guides every sector's plans and policies; programmes; projects and operations – including how budgets, skills and other resources are allocated to move South Africa forward.

Operation Phakisa is a results-driven approach to development, setting clear plans and targets with on-going monitoring of progress; and making these results public in order to address the triple challenges of poverty, unemployment and inequality. It focusses on bringing key stakeholders from the public and private sectors, academia as well as civil society organisations together to collaborate in detailed problem analysis; priority setting; intervention planning and delivery. The Department of Planning, Monitoring and Evaluation leads Operation Phakisa. The DFFE established the Oceans Economy Secretariat to lead the 'Oceans Economy'.

The Operation Phakisa: Ocean Economy programme focuses on:

- Marine Transport and Manufacturing, led by the Department of Transport;
- Offshore Oil and Gas, led by the Department of Mineral Resources and Energy;
- Aquaculture, led by the DFFE;
- Marine Protection Services and Ocean Governance, led by the DFFE
- Small Harbours Development, led by Department of Public Works and Infrastructure; and
- Coastal and Marine Tourism, led by the Department of Tourism.

Each of the focus areas noted above are enabled by skills development and capacity building; as well as research, technology and innovation initiatives. This is led by the Department of Higher Education and Training and the Department of Science and Innovation respectively.

DFFE is the lead department for the Oceans Economy Aquaculture focus area and its deliverables. The Lab concluded that South Africa's aquaculture sector has a high growth potential due to an increasing demand of fish products due to the increasing global population; increasing income by the middle class in developing countries and more awareness on the dietary benefits offered by fish products. Moreover, the capture fisheries yield has been plateauing over the past decade while aquaculture continues to grow over 7.5% per annum. This growth is expected to continue at a higher rate in the future.

The goal is to grow the aquaculture sector in South Africa to play a major role in supplying fish products; an enhanced role in job creation; increased contribution to national income and rural livelihoods. The targets over five years (2019-2024), seeks to grow sector revenue from R0, 67 billion to R3 billion; production by 27 020 additional tons; jobs by 6 560 direct jobs and to ensure increased participation to support transformation in the sector.

The Aquaculture Lab comprised of stakeholders from industry, government and academia who identified nine (9) key initiatives. One initiative addresses the selection and implementation of catalyst projects, improving both the number and productivity of the new farms. Three initiatives relate to the creation of an enabling regulatory environment and others focus on funding support, increasing the skills pool and awareness; and improving access to markets. The initiative nine "Develop and Implement Aquaculture Development Zones (ADZs)" seeks to promote investment into the sector and create an enabling environment.

To deliver these initiatives, the Aquaculture Lab created detailed implementation plans and accompanying budgets, a proposed governance system to take responsibility for initiatives and key performance indicators to help monitor delivery. The highlights outlined are consequences of the progress achieved on the 3 feet (3ft) plans across the three horizons defined by the Lab participants in 2014.

The previous Year One – Year Six Annual Review publications are available on the DFFE website: **https://www.dffe.gov.za/projectsprogrammes/operationphakisa/oceanseconomy**

PROGRESS ON AQUACULTURE KEY PERFORMANCE INDICATORS

It has been six years since the introduction of Operation Phakisa: Oceans Economy and considerable milestones were achieved to grow the aquaculture sector.

13.2 Initiative 1: Selection and Implementation of Catalyst Projects

Since the Lab in 2014, twenty-eight (28) new projects have been assessed and incorporated as part of Operation Phakisa Oceans Economy. In total there are forty-five (45) projects. Six (6) of the original 24 projects conceptualised during the Lab have been removed and placed on business opportunities and one (1) project, Amatikulu Kob, was incorporated in the new ADZ initiative nine. Twenty-four (24) of these projects are considered small, medium and micro-sized enterprises (SMMEs). Twenty-eight (28) of the 45 projects are producing farmed aquaculture animals.

13.3 Initiative 2: Legislative Reform to Promote Aquaculture Development

The Aquaculture Development Bill was approved by Cabinet on 9 May 2018 and introduced to Parliament on 15 June 2018. During the 2021 reporting period, DFFE had

internal consultations on the Bill to explore mechanisms to address concerns raised by industry.

Aquaculture Strategic Environmental Assessment (SEA)

The purpose of the SEA is to identify suitable areas where environmentally sustainable aquaculture development can be prioritised and incentivised. Secondly, it will provide a streamlined and integrated management and regulatory framework to reduce compliance complexities and improve decision-making processes. The study was completed and the next step is implementation.

13.4 Initiative 3: Establishment of an Inter-Departmental Authorisation Committee

Environmental Authorisations issued for Operation Phakisa projects since October 2014:

- Twelve (12) Environmental Impact Assessments (EIA) were completed and authorised, two appeals completed.
- Seven (7) coastal discharge permits were issued.
- Nine (9) biodiversity risk assessments (Barramundi, Coho, King Salmon, Siberian Sturgeon, Rainbow Trout, Catfish, Nile Tilapia, Mozambique Tilapia and Common Carp).
- Seven (7) land leases have been issued.
- Nineteen (19) new water leases were allocated and approved in total. One for an Operation Phakisa aquaculture project in Port Elizabeth and eighteen (18) projects received lease options in Saldanha Bay (ADZ) new water leases were approved for projects in Saldanha Bay.
- The water use license notice for the Vanderkloof dam was received.
- Coastal lease and water use license was issued for Qolora ADZ. Extension of the Environmental Authorisation was granted in October 2020 and is valid until September 2023.
- Twenty-nine (29) marine aquaculture rights were issued.

DPWI Leases

The DFFE and DPWI engaged on the leases and identified land valuation as a blockage of implementation. Discussions are still ongoing to find a way forward.

The DFFE EIA special needs programme were assisting five projects with EIA's (Afrinhlanzi (Pty) Ltd in KwaZulu Natal, Greenies Farm in the North-West province, Arniston Local & Fishing (Pty) Ltd in the Western Cape, Dihlaping Aquaculture in Limpopo and Omega Fisheries (Pty) Ltd in Gauteng. Unfortunately, this programme had to be terminated due to contractual issues with the service provider in November 2021. No alternative solution was found during the reporting period.

13.5 Initiative 4: Establishment of a Globally Recognised Monitoring and Certification System

Certification Framework

The final certification framework for aquaculture products in South African was completed and will assist the country with meeting local and international standards around certification for aquaculture. DFFE is investigating third party certification programmes with the aim of assisting industry to access third party certification required by international markets.

European Union (EU) Export Approval

In order to access European Union (EU) export approval, a National Residue Programme was developed and implemented for abalone, finfish and bivalves. The programme, however, may not be approved due to the veterinary drug residue methods not being validated for the relevant matrices. To address this, DFFE is in the process of finalising a Service Level Agreement (SLA) with the Agricultural Research Council – Onderstepoort Veterinary Institute (ARC-OVI) to validate the required methods and have them accredited.

The National Regulator for Compulsory Specifications (NRCS) is leading engagement around the potential EU audit. The NRCS through the dtic engaged the EU on the audit process, the EU communicated a back-log in member state audits due to the pandemic. New audits need to be done in-person. The EU will communicate the planned audit when the back-log is resolved.

Oyster Listing in China

China listed the wrong oyster species for South Africa, which led to a situation where South Africa could no longer sell oysters to its largest trading partner for this commodity. The NRCS, DTIC and DFFE engaged their counterparts in China to find a resolution, when a response was not forthcoming the matter was escalated. The Chinese Competent Authority requested technical documents on the description and naming of the South Africa oyster species which was provided. Subsequently, the oyster listing was changed on the Chinese website in September 2021, and trade resumed shortly after.

13.6 Initiative 5: Establishment of an Aquaculture Development Fund (Progress)

Aquaculture Species Feasibility Studies

The financial feasibility studies were conducted on key aquaculture species and are guidelines to inform new entrants, government authorities and funders to assist with policy and investment decisions. Feasibility studies were completed for marine finfish, oyster and mussels, tilapia, trout, abalone, catfish, freshwater ornamentals, marron crayfish and aquaponic systems to inform new entrants, funding agencies, policy and investors. The feasibility studies include general economic models based on various production systems per species. The studies indicate market assessments, minimum scale and financial analysis based on inputs from technical experts, industry stakeholders and peer-review workshops.

The feasibility studies and funding directory can be obtained from the links below:
Feasibility Studies: **https://www.environment.gov.za/documents/research#feasibilitystudies**
Funding Directory: **https://www.dffe.gov.za/sites/default/files/docs/developmentfinance_aquaculture.pdf**

Aquaculture Development Funding Working Group

The Saldanha Bay Aquaculture cluster continues to receive support, the DFFE worked closely with SEDA (Small Business Development Agency) to assist the 13 farmers in terms of reviewing their current agreements, mentorship and getting the projects ready for financial support through sefa (Small Enterprises Funding Agency).

The Working Group met in June and November 2021. Presentations were given on the Saldanha Bay aquaculture cluster; Maduo Aquaponics in the North-West and KZN Department of Economic Development, Tourism and Environmental Affairs for Nile Crocodile and Rainbow Trout.

Aquaculture Finance and Investment Seminar

The 2021 Aquaculture Finance and Investment Webinar took place on 24 November 2021 and was attended by over 100 participants.

Engagement with African Development Bank Group

The Aquaculture Delivery Unit (ADU) met with the African Development Bank (ADB) and had an investment pitching session in which Atlantic Royal, Cape Nordic, Saldanha Aquaculture Services and Pearly Beach Abalone presented their projects to the ADB on the 8 December 2021. Out of the projects presented the ADB has shown interest in taking discussions further for Cape Nordic Salmon farm.

13.7 Initiative 6: Capacity and Skills Development (Progress)

The skills and needs analysis assessment of the sector has been completed to inform further interventions and skills requirements. This was funded by AGRISETA and the National Skills Fund (DHET).

The Skills Working Group held two meetings and developed a concept document for a Community of Practice (COP) for aquaculture which was submitted to the National Research Fund (NRF).

13.8 Initiative 7: Coordination for Industry-Wide Marketing Efforts

Marketing and Awareness

The abalone promotional and awareness video was completed for local and international audiences. It is available online at **https://youtu.be/wDIFgVnRnyY**.

The Saldanha Bay ADZ Open Day was held on the 15 June 2021. The purpose was to engage with the local community and stakeholders on the ADZ. It included an exhibition by local farmers. A hybrid meeting was held with approximately 80 people in attendance and the event was broadcast live on YouTube, **https://youtu.be/WqJYtrO_joA**.

13.9 Initiative 8: Preferential Procurement of Aquaculture Products

The acceptability trial for catfish took place in April 2021, during the reporting cycle the feedback of the trial was well received during the reporting period and the Department of Correctional Services was requested to amend procurement guidelines to include freshwater fish. The DCS were awaiting the tilapia suitability assessment prior to taking any steps, unfortunately the tilapia sector experienced challenges with securing ingredients and then had insufficient product to take the trial forward. A decision was, therefore, taken to proceed with the catfish sector and to conduct the tilapia trial once the sector was ready.

13.10 Initiative 9: Develop and Implement Aquaculture Development Zones

Aquaculture Development Zones

Eight (8) ADZs are currently registered and monitored under initiative nine:

13.10.1 Algoa Bay Aquaculture Development Zone

On the 18 June 2021 the appeals decision was received for the Algoa Bay ADZ, with the Minister of Justice and Correctional Services dismissed all the grounds for the appeals. Meaning that the CD:AED can now proceed with the implementation of the Algoa Bay ADZ. The DFFE has started preparing for the statutory bodies to be set up in line with the authorisation in August 2021 and have engaged with TNPA regarding the lease allocation process.

13.10.2 Amatikulu Aquaculture Development Zone

For most of the reporting period, the Amatikulu ADZ was tied up in appeals where the DFFE appealed the rejection of the Environmental Authorisation. As the DFFE was the applicant, the decision had to be taken by the Minister of Justice and Correctional Services. In September 2021, the ADU was informed that the files had been misplaced and that the appeal had to be resubmitted. In November 2021 the EIA appeals decision was received, the Minister of Justice and Correctional Services has dismissed the DFFE appeal meaning the ADZ will not proceed as planned.

13.10.3 Mossel Bay Aquaculture Development Zone

The bid was advertised and cancelled in August 2021, due to there being no bidders who met the criteria. This was the second time the bid had to be cancelled due to unresponsive bidders. The DFFE, therefore, had to engage National Treasury prior to the project being re-advertised.

13.10.4 Richards Bay Aquaculture Development Zone

The ADU has issued a letter to the Port Captain of Richards Bay requesting permission to undertake an EIA of the area. A meeting held on the 6 September 2021, DFFE to work with TNPA legal services to plot a way forward. In November 2021, the DFFE received consent to proceed with the Environmental Impact Assessment for Aquaculture in the Bay.

13.10.5 Vanderkloof ADZ

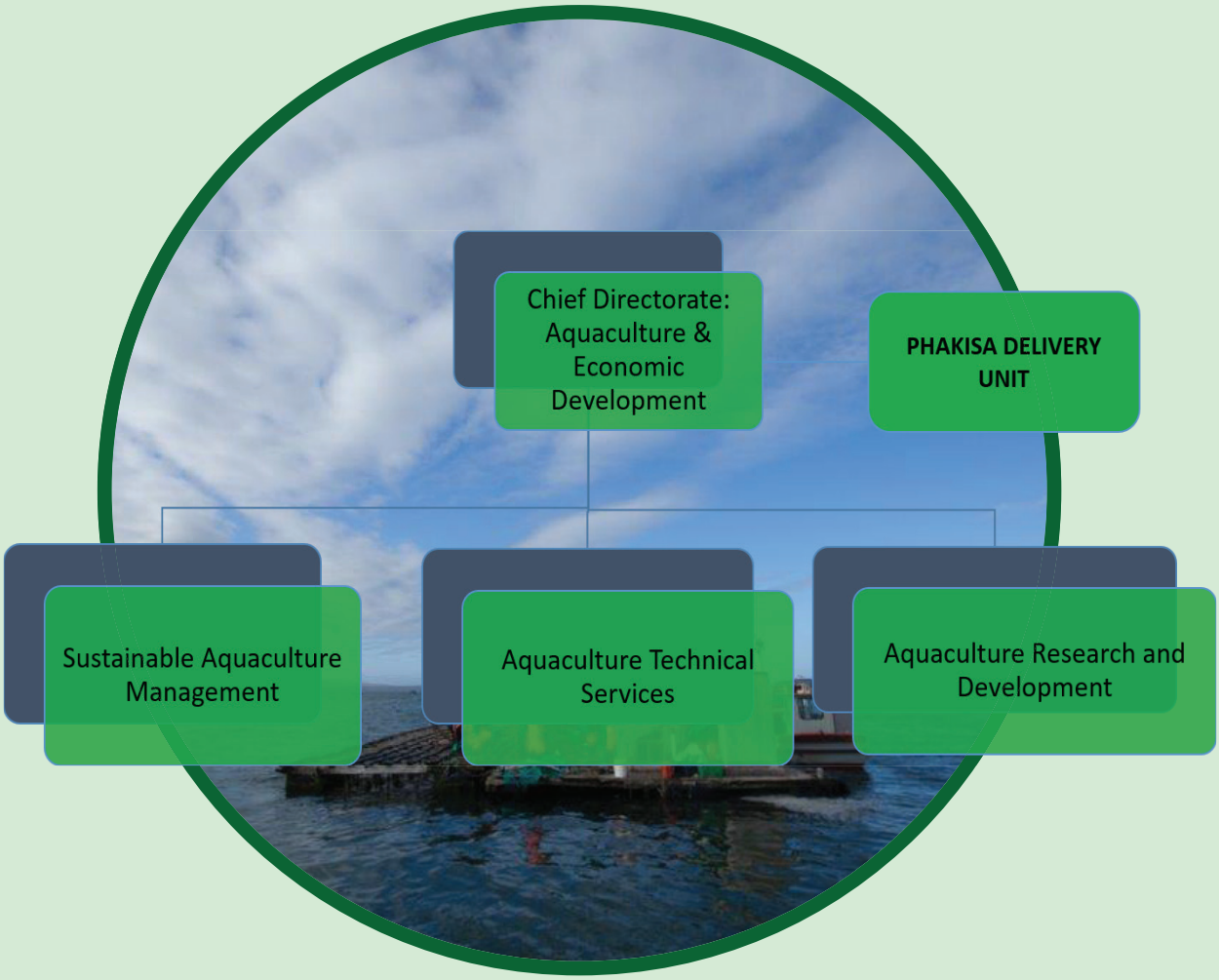
At a meeting on the 24 June 2021 the ADU met with Northern Cape officials to discuss the Vanderkloof project, concerns were raised by the scientific services, which the ADU has agreed to address. The ADU has called for a follow up meeting to address this concerns in November 2021. Legislative challenges with the proposal, with the Northern Cape legislation were raised. In terms of the way forward the trout pilot will be allowed in terms of an exemption, it was, therefore, agreed to have a follow up working sessions to develop specifications for the trout pilot with Northern Cape officials. While this process is underway both Northern Cape and the DFFE will need to engage legal services to find a way forward if the pilot proves successful.

13.10.6 Saldanha Bay Aquaculture Development Zone

The zone implementation is on a continuous basis. In November, the DFFE advertised for the appointment of an Environmental Control Officer for a period of three years.

CHAPTER 14

OVERVIEW OF DIRECTORATES RESPONSIBLE FOR AQUACULTURE FUNCTIONS WITHIN THE DEPARTMENT OF FORESTRY, FISHERIES AND THE ENVIRONMENT



14. OVERVIEW OF DIRECTORATES RESPONSIBLE FOR AQUACULTURE FUNCTIONS WITHIN THE DEPARTMENT OF FORESTRY, FISHERIES AND THE ENVIRONMENT

14.1 Introduction

The aim of the Chief Directorate: Aquaculture and Economic Development is to ensure sustainable growth, responsible management and development of the aquaculture sector as well as the freshwater (inland) fisheries.

FUNCTIONS

- Provide technical support and essential services to aquaculture stakeholders.
- Provide integrated platform for management of aquaculture through effective administration of policies, legislation, certification and institutional arrangements.
- Implement and guide innovation and scientific advice towards the development and sustainable management of the aquaculture sector.
- Implement the Operation Phakisa Oceans Economy Aquaculture Laboratory Initiatives (unit reporting to the CD)

14.2 Directorate: Aquaculture Technical Services

The aim of the Directorate: Aquaculture and Technical Services is to provide technical support and essential services to aquaculture stakeholders.

Functions

- Develop and facilitate the implementation programmes aimed at increasing aquaculture production (ADZs, Aquaculture facilities, Demonstration Centres and hatcheries).
- Provide technical advisory services to aquaculture stakeholders (site assessments, feasibility studies, business plans, marketing, investment opportunities)
- Provide extension (on-farm) support to aquaculture stakeholders
- Facilitate access to funding, investment and markets for the aquaculture sector
- Provide economics support to the sector (marketing, viability, facilitation of funding)
- Develop, manage, facilitate and implement technical training and capacity programmes for aquaculture sector.
- Monitor and report aquaculture sector performance (collect data, analyse and report on sector social economic, investments).

Oversee the development and implementation of aquaculture sector promotion and awareness initiatives for the Chief Directorate in relation to aquaculture.

14.3 Directorate: Aquaculture Research and Development

The aim of the Directorate: Aquaculture Research and Development (D: ARD) is to provide scientific research and advice towards the development and sustainable management of the aquaculture sector.

Functions

- Undertake aquaculture research that supports development of ecologically sustainable aquaculture, in other words, environmental interactions, fish health & diseases, products safety
- Provide support for diversification competitiveness for the aquaculture sector, in other words, genetics research, new species, productions systems, culture technology development and transfer, design and implement pilot/demonstration projects, nutrition and feed development, markets and post-harvest technology
- Provide scientific advice to support the developing aquaculture sector
- Develop and manage stakeholder networks, committees, forums and institutional support pertaining to aquaculture research
- Establish and convene an Aquaculture Scientific Working Group
- Collaboration with local and international research institutions for advancing aquaculture research and development
- Development and dissemination of scientific information through publications, technical reports, manuals and guidelines

14.4 Directorate: Sustainable Aquaculture Management

The aim of the D:SAM is to provide integrated platform for management of aquaculture through effective administration of policies, legislation, certification programmes and institutional arrangements for the sector.

Functions

- Provide technical support towards permitting and licensing for aquaculture activities
- Administration of aquaculture legislation and related regulations
- Develop and implement norms and standards and guidelines for the sector
- Develop, manage and implement environmental, AAH and food safety management programmes
- Develop and manage stakeholder networks, committees, forums and provide institutional support to government entities
- Develop and implement policies, strategies for the aquaculture sector

- Facilitate authorisations to enable aquaculture development
- Manage the freshwater (inland land) fisheries sector relevant policy and legislation

14.5 Operation Phakisa Aquaculture Delivery Unit

The aim of OPADU is to oversee the implementation of Operation Phakisa Aquaculture Initiatives

Functions

- Profiling and investment promotion for Operation Phakisa projects
- Facilitate Phakisa projects enablers, for example, access to markets, land/water, finance and other enablers
- Render advisory on technical and funding opportunities for Phakisa projects
- Trouble shooting and Implementation of initiatives/projects
- Provide technical advisory to Phakisa projects and initiatives
- Provide and coordinate technical evaluation of concepts, 3feet plans, feasibility for Operation Phakisa
- Promotion of Operation Phakisa projects
- Undertake economics impact studies for Phakisa
- Monitor and reporting on Phakisa initiatives
- Facilitate government procurement for aquaculture products

NOTES

CHAPTER 15

OVERALL CONCLUSIONS AND RECOMMENDATIONS

15. OVERALL CONCLUSIONS AND RECOMMENDATIONS

Aquaculture is operational in all nine (9) provinces of South Africa. However, freshwater aquaculture operations are predominant in inland provinces (in other words, GP; LP; MP; NW; FS) while marine aquaculture is predominant in four (4) coastal provinces (in other words, NC, WC, EC and KZN). The status of aquaculture in South Africa for 2021 is based on 195 operational farms represented by 151 freshwater farms and 44 marine farms. The total freshwater production was 1 482,30 tons, which is an increase of of 1,08 tons from 2020 and total marine production was 6 287,66 tons, which increased by 1 722 tons from the previous year, while the total aquaculture production was recorded at 7 769,96 tons. The total aquaculture production in 2021 increased by 1 723,99 tons from the 6 045,97 tons recorded in 2020, which demonstrates an 28% increase. The leading subsectors based on the total freshwater production were trout with 1 145,30 tons, followed by tilapia with 246,60 tons and catfish at 57,6 tons. The leading subsectors based on the total marine production were mussels with 3 420,88 tons followed by abalone with 2 463,29 tons and then oysters with 390,49 tons The total marine production contributed the most towards the total aquaculture production with 81% compared to 19% from the total freshwater production, signifying the need for freshwater aquaculture robust interventions and paradigm shifts in South Africa to improve contributions.

The increase in production can be attributed to the sector recovering from the impact of the Covid-19 pandemic as global markets and opportunities are slowly opening up and demand for fish products is also on the increase. As a result, the projected value of various aquaculture services, including marine and freshwater services, in 2021 was approximately R2 241 342 813 in 2021 (Two Billion Two Hundred Forty-One Million Three Hundred Forty-Two Thousand Eight Hundred Thirteen Rands). In terms of employment, the sector employed about 4 591 people on a full-time, part-time, occasional, or undetermined basis. And indirectly employed over 100 000 people throughout the value chain or in industries related to the sector. However, with increased investments, improved value chains, and strengthened collaborative efforts, on a yearly the industry could employ more than 10,000 people.

Food safety programmes implemented by the DFFE continue to play a crucial role in providing guarantees to domestic and international markets and consumers that South African cultured fish products are safe for human consumption. This was done through the South African Shellfish Monitoring and Control Programme (SASM&CP), South African Aquaculture Marine Fish Monitoring and Control Programme (SAMFM&CP) and the National Residue Control Programme (NRCP).

The growth of the sector depends on investment and suitable areas identified for aquaculture activities. The establishment of a number of ADZs undertaken by the DFFE over the past years aims to encourage investor confidence; create incentives for industry development;

provide aquaculture services; manage the risks associated with aquaculture; job creation; skills development; empowerment of rural communities and most importantly benefit from Special Economic Zones incentives.

The total freshwater and marine production recorded an increase in 2021, although the freshwater contribution continues to be significantly lower at 19% compared to 81% that is contributed by the marine sector. The development and management of the freshwater aquaculture sector is still managed through multiple provincial ordinances, as there no overarching legislative tool on a national level. The DFFE is in the process of developing the Aquaculture Development Bill which seeks to promote sustainable development of the aquaculture sector in South Africa, inclusive of both marine and freshwater subsectors to ensure that the sector contributes to government priorities such as food security, job creation, economic growth and addressing historical imbalances in accessing aquaculture opportunities. Various industry stakeholder consultations were undertaken during 2021 and bilateral engagements to finalise the Bill are still ongoing with further intergovernmental consultations planned for 2023.

The growth trajectory of the sector recorded in the past few years demonstrates great potential to provide food security, job creation, economic well-being of the nation as well as rural development, both for present and future generations.

NOTES

CHAPTER 16

REFERENCES

16. REFERENCES

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BENEFITS OF AQUACULTURE

Potential for the aquaculture sector in South Africa

SATISFY LOCAL DEMANDS,

CONTRIBUTE TO FOOD AND NUTRITIONAL SECURITY,

CREATE SUSTAINABLE JOB OPPORTUNITIES,

FOSTER ECONOMIC DEVELOPMENT,

CAPITALISE ON EXPORT OPPORTUNITIES,

STIMULATE RURAL DEVELOPMENT AND LIVELIHOODS,

ATTRACT FOREIGN DIRECT INVESTMENT,

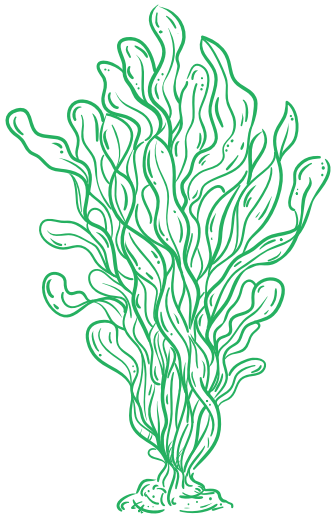
SAFEGUARD SUSTAINABLE ENVIRONMENT INTEGRITY,

CREATE SMME'S AND WEALTH GENERATION OPPORTUNITIES

THROUGH AQUACULTURE.

AQUACULTURE YEARBOOK 2022

STATUS OF THE SECTOR



ISBN: 978-0-621-5099-6

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REPUBLIC OF SOUTH AFRICA