Natsurv 18:

Water and Wastewater Management in the Pelagic Fishing and Fish Processing Industry

(Edition 2)

Marlene van der Merwe-Botha, Gary Quilling,
Peter Wille, Bertie Steytler

WATER RESEARCH COMMISSION

TT 839/20

NATSURV 18

WATER AND WASTEWATER MANAGEMENT IN THE PELAGIC FISHING AND FISH PROCESSING INDUSTRY

(Edition 2)

Report to the

Water Research Commission

by

Marlene van der Merwe-Botha, Gary Quilling, Peter Wille, Bertie Steytler

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EXECUTIVE SUMMARY

Purpose of study

The purpose of National Survey (NATSURV 18) is to review the status of the South African Pelagic Fishing and Fish Processing Industry with specific focus on specific water use and effluent generation rates, specific energy consumption rates and best practices in the management of water and effluent. The study provides an overview of the most pertinent norms and standards, as well as legislation that regulates the industry on international and local levels.

Methodology

The research approach included a literature review, engagement with national environmental managers, site specific surveys and site visits, and processing of data and information.

Site selection

Eleven pelagic processing sites were identified, of which 6 sites responded positively. The sites that participated and contributed to this study, included:

1. Lucky Star in St Helena Bay;
2. Amawandle Pelagic in Laaiplek, Velddrif;
3. Oranjevis in St Helena Bay;
4. West Point Processors in St Helena Bay;
5. Gansbaai Marine in Gansbaai; and
6. Afro Fishing in Mossel Bay.

The common denominator to the participating plants was that all own and operate canning plants, where fish is landed, processed, canned, cooked in the can, prepared with sauces, sealed and distributed. Five of the sites have value-add processes, whereby fish are processed to fish oil and fish meal, for distribution as protein source to the animal feed market.

Process flow diagrams were used to illustrate the source and intake of raw water, generation of effluent and energy consumed during each process. The environmental impacts were measured in terms of intensity parameters, including specific water intake (SWI – m^3 of fresh water consumed per ton of production), specific effluent volume (SEV – m^3 of effluent generated per ton of production), specific electricity consumption (SEC – kWh of electricity consumed per ton of production) and specific fuel consumption (SFC – GJ of fuel energy consumed per ton of production). International benchmarks for each of these parameters were derived from literature information, and used to compare the South African industry with expected norms and performance.

Note: SWI is also known as Specific Water Consumption (SWC), and SEV is also known as Specific Effluent Generation (SEG)

Site assessments

Water consumption

- Raw water is mostly supplied by local municipalities, although some extraction from groundwater and seawater was also evident. Two sites employ Reverse Osmosis (RO) purification, with other sites indicating that they are considering same.
- The weighted average SWI for the assessed South African sites were found to be 6,82 m^3/t (ranging from 2,42 to 9,14 m^3/t) vs an indicated benchmark of 8,60 m^3/t.
- The weighted average SWI of the assessed South African sites was at 79% of the derived benchmark value (literature), meaning that the SA industries use less water per ton of product produced than expected. The values ranged from 28% to 205% (achieved SWI vs benchmark) for the assessed sites.

Wastewater generation

- Due to lack of flow measurement, the generation of effluents could not be calculated and compared to benchmarks. Diurnal trends (pollutant loads on environment) could not be quantified.
- Constituents such as BOD/COD, turbidity, ammonia, fats/oil/greases at point of discharge (mostly to sea or municipal systems) are monitored according to coastal water discharge permits. The limits are mostly significantly exceeded, making the effluent quality non-compliant to the required legal specifications.
- All the South African sites have some form of screening as the final effluent treatment before release to the environment. Treatment comprises mostly of pre-treatment, with no secondary or further treatment.
- There is no evidence of water reuse in the industry.

Energy consumption

- The weighted average SEC for the assessed South African sites were found to be 170,9 kWh/t (ranging from 93,8 to 288,8 kWh/t) vs an indicated benchmark of 85,2 kWh/t.
- The weighted average SEC of the assessed sites were at 201% of the derived benchmark value (literature), meaning that the SA industries use more electricity per ton of product produced than expected. The values ranged from 142% to 293% (achieved SEC vs benchmark) for the assessed sites.

Fuel consumption

- The weighted average SFC (coal and fuel oil) for the assessed South African sites were found to be 7,4 GJ/t (ranging from 3,0 to 10,5 GJ/t) vs an indicated benchmark of 5,0 GJ/t.
- The weighted average SFC of the assessed sites were at 148% of the derived benchmark value (literature), meaning that the SA industries use more fuel for thermal energy per ton of product produced than expected. The values ranged from 82% to 496% (achieved SFC vs benchmark) for the assessed sites.

In summary, the assessed SA sites use less water than expected to achieve their production rates when compared with international benchmarks, but they use significantly more electricity and fuel than expected, mostly for heating purposes.

Best practice

Some of the cleaner production technology principles were implemented to aid in the reduction of water consumption, such as spill prevention, minimising contact time between fish and water and by raising awareness amongst staff. Other practices were described to reduce fresh water consumption, including:

- modification of the cutting tables by installing high-pressure cleaning sprayers on the blades which cut off heads and tails;
- introduction of shut-off valves when the production line is stopped results in freshwater savings and a corresponding reduction in effluent load;
- technology was introduced that magnetically lowers the pilchard cans into retort baskets, which replaces the need for water in the retort baskets.

Compliance

The study included commentary from the Department of Environment, Forestry and Fisheries (DEFF) on the regulation of the industry and the use of Coastal Water Discharge Permits (CWDP). DEFF deals with fish processing plant applications on a *case-by-case* basis. As of July 2020, approximately 21 CWDP applications had been received from fish processing plants and 11 CWDP had been issued.

DEFF comments that many of the fish processing plants were authorised by the Department of Water and Sanitation and the transition arrangement required the facilities to comply with the conditions of the DWS authorisation until the CWDP is issued in terms of the ICMA. The objective of the CWDP process is not to burden the industry, but is to work in partnership with the facilities to ensure that the coastal waters are maintained and improved for all beneficial uses. In addition, the conditions in the CWDP endeavours to mitigate potential impacts on the marine environment.

With regards to effluent quality monitoring, CWDP stipulates the effluent limits that the applicant must adhere to in order to maintain the water quality in the receiving environment. The CWDP also requires the applicant do daily or weekly monitoring to ensure that their effluent complies with the limits of the CWDP. Finally, the CWDP details the monitoring, reporting, contingency planning, analyses of samples, investigation and compliance review requirements that the DEFF will have oversight of.

The results of the survey indicate that all assessed sites have permits in place. However, all sites struggle to meet the coastal discharge permit conditions with respect to BOD/COD, turbidity, ammonia and Fats, Oils, Greases (FOG). This is mostly due to the lack of treatment, which again becomes a factor of cost noting the challenging environment in which this industry finds itself.

Norms and Standards

A number of sites, but not all, conforms to the following standards:

- ISO 22000 certification
- South African National Standards (SANS)
    - SANS 10330:2007: HACCP
    - SANS 17025 – Sampling accreditation
    - SANS 0241 – Drinking water quality (raw input water)
- Hazard Analysis and Critical Control Point System (HACCP) Certification: International
- Brand Reputation through Compliance (BRC) Global Standards
- Feed Materials Assurance Scheme (FEMAS)
- International Fishmeal and Fish Oil Organisation – Responsible Supply (IFFO-RS) certification
- World Wide Fund (WWF) Southern African Sustainable Seafood Initiative (SASSI)
- Marine Stewardship Council (MSC)

Recommendations

A number of recommendations were made noting the gaps and challenges that the South African operators face, in lieu of international best practice:

- The high capital cost associated with effluent treatment plants appears to be the major stumbling block to implement state of the art treatment technologies. The study recommends the application of pinch technology (no evidence of its application could be found on the assessed sites) to facilitate the decreased size of necessary effluent treatment plants, thereby reducing the associated cost.
- A barrier to the application of such investigations is the lack of measurement in this industry. Not one of the sites could close a water balance due to insufficient data. This study recommended the improvement of this situation.
- Reducing the effluent to be treated, and treating effluent to reuse qualities will aid in the reduction of water consumption even further.
- The reason for the higher electricity consumption when compared to international benchmarks is unclear but could partially be related to the use of seawater desalination RO plants to provide fresh water. Electricity consumption can be reduced by favouring more efficient equipment (such as pumps, compressors, centrifuges), implementing switch-off programs and installing sensors to turn off or power down lights and equipment when not in use and by making use of variable frequency drives instead of control valves.
- Fuel efficiency can be improved by improving boiler efficiency, insulation of hot surfaces, recuperation of heat in condensates as well as increased staging in concentration plants. On the steam systems, optimal combustion efficiencies must be ensured on boilers and steam and condensate leaks must be eliminated.
- Interventions should be taken to define the water and energy systems via:
    - Measurement
        - Measure water flows to define water distribution and balances,
        - Measure electricity distribution to different plant systems,

        - Measure steam distribution,
    - Compile system water and energy balances
    - Cost charting.
- Future research may be directed to an optimisation study at a selected site and replicated at the remainder of the industry. Such a strategy will include generation of targets for SWI, SEV, SEC and SFC and pathways for achieving such, followed by monitoring and continuous improvement thereof.

Conclusion

This report concludes a review and national survey of the South African pelagic fish and fish processing industry at time of 2020, as an update of the previous NATSURV Report published in 1987 (WRC TT 28/87).

By comparing the 2020 and 1987 findings, it can be concluded that the 1987 report focused mostly on effluent generation, with limited work done on water consumption and no work done on energy management. The effluent volume was based on quotas, with an average of 14.4 m^3/t, compared to the 2020 figure of one site only, being 16.3 m^3/ton. The average effluent COD, SS and FOG concentrations were reported at 1 308, 2 203 and 136 mg/l (average of 10 factories) respectively compared to the 2020 data of COD ranging from 60-8 000 mg/l and FOG ranging from 0-17 566 mg/l.

In terms of water consumption, no water consumption values could be derived in the 1987 report for canning plants, only for fishmeal plants. The SWI was based on the fish quotas, not on the actual fish intake and reported to be 0,84 m^3/t. In the 2020 study, the SWI/SWC is based on production values. In the case of fish meal plants, 75% of the fish does not end up in the product but becomes part of the wastewater. The comparative SWC of the 1987 report is therefore 0,84/0,25 = 3,28 m^3/t, assuming the entire quota was fed into the plant.

It can be concluded that the SWI within the pelagic fishing industry has improved since the initial report, and that effluent flow and quality were more intensively monitored in 1987 compared to 2020.

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  - Steve Brown (Gansbaai Marine); and
  - Deon van Zyl (Afro Fishing).

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ABP	: Animal by-product
BAT	: Best Available Technology (or Technique)
BOD	: Biochemical Oxygen Demand
BRC	: British Retail Consortium
BRC	: Brand Reputation through Compliance
COD	: Chemical Oxygen Demand
CP	: Cleaner Production
CWDP	: Coastal Water Discharge Permit
DAF	: Dissolved Air Flotation
DAFF	: Department of Agriculture, Forestry and Fisheries
DEA	: Department of Environmental Affairs
DEPA	: Danish Environmental Protection Agency
DOC	: Dissolved organic carbon
DWS	: Department of Water and Sanitation
ECF	: Elemental Chlorine Free
EEZ	: Exclusive Economic Zone
EMS	: Environmental management systems
EU	: European Union
FAO	: Food and Agriculture Organization
FDM BREF	: BAT Reference Document in the Food, Drink and Milk Industries
FEMAS	: Feed Materials Assurance Scheme
GDP	: Gross Domestic Product
GFSI	: Global Food Safety Initiative
GMP	: Good Manufacturing Practice
HACC	: Hazard Analysis Critical Control Points
HACCP	: Hazard Analysis and Critical Control Point System
HCR	: Harvest Control Rule
HRC	: Harvest Control Rule
I&J	: Irvin & Johnson
ICMA	: Integrated Coastal Management Act
IED	: Industrial Emissions Directive (IED 2010/75/EU)
IFFO	: International Fishmeal and Fish Oil Organisation
IFFO-RS	: IFFO Global Standard for Responsible Supply
IFS	: International Food Standard
IFSA	: International Feed Standard Alliance
IP	: Intellectual Property
ISO	: International Organisation for Standardisation
ISS	: Institute for Security Studies.
KPI	: Key Performance Indicator
KPIs	: Key Performance Indicators

KZN	: KwaZulu-Natal
LCA	: Life Cycle Assessment
LT	: Low-temperature
MF	: Microfiltration
MPA	: Marine Protected Areas
MPG	: Marine Protection and Governance
MSC	: Marine Stewardship Council
MTM	: Marine Transport and Manufacturing
NATSURV	: National Survey
NPL	: National Pollution Laboratory
NRCS	: National Regulator for Compulsory Specifications
OMP	: Operations Management Procedure
Ors	: EU's Outermost Regions
PAH	: polyaromatic hydrocarbons
PCBs	: polychlorinated biphenyls
PFD	: Process Flow Diagram
RFA	: Responsible Fisheries Alliance
Rhodes ESS	: Rhodes Economic Sector Study
RISA	: Resource Information Systems Inc.
RO	: Reverse Osmosis
SCADA	: Supervisory control and data acquisition
S.E.C.I.F.A	: South East Coast Fishing Industry Association
SANAS	: South African National Standards
SAPFIA	: South African Pelagic Fishing Industry Association
SASSI / WWF-SASSI	: WWF's Southern African Sustainable Seafood Initiative
SBUs	: Specialised Business Units
SEC	: Specific Energy Consumption
SEG	:Specific Effluent Generation (same as SEV)
SEV	: Specific Effluent Volume
SPSWG	: Small Pelagic Scientific Working Group
SS	: Suspended Solids
SSF	: Small Scale Fisheries
SWC	: Specific Water Consumption
SWI	: Specific Water Intake (same as WSC)
TAB's	: Total Allowable Bycatches
TAC's	: Total Allowable Catches
TCF	: Total Chlorine Free
TDS	: Total Dissolved Solids
TOC	: Total organic carbon
UF	: Ultrafiltration
UK	: United Kingdom
UNEP	: UN Environment Programme

UNEP DTIE	: United Nations Environment Programme Division of Technology, Industry and Economics
US$	: United States Dollars
USA	: United States of America
UV	: Ultraviolet
UWWTD	: Urban Wastewater Treatment Directive 91/271/EEC
VAP	: Value-added products (plants)
WFD	: Water Framework Directive 2000/60/EC
WRC	: Water Research Commission
WSDP	: Water Services Development Plan
WSU	: Walter Sisulu University
WWF	: World Wide Fund for Nature
WWTW	: Wastewater Treatment Works.

1 INTRODUCTION

The National Survey (NATSURV) series of publications have been developed by the Water Research Commission of South Africa from the mid-1980's onwards. The intention of the publications was to document water and wastewater management and best practice within different important industrial sectors in the South African economy.

The initial document in the series was the "*Guide to Water and Waste-Water Management in the Pelagic Fishing Industry*" (WRC Project No. 97; TT 28/87) and was issued by Binnie & Partners in 1987. Subsequently to this document, many changes have occurred in the industry's legal, commercial and operational environments which necessities an update of the document.

1.1 Project Objectives

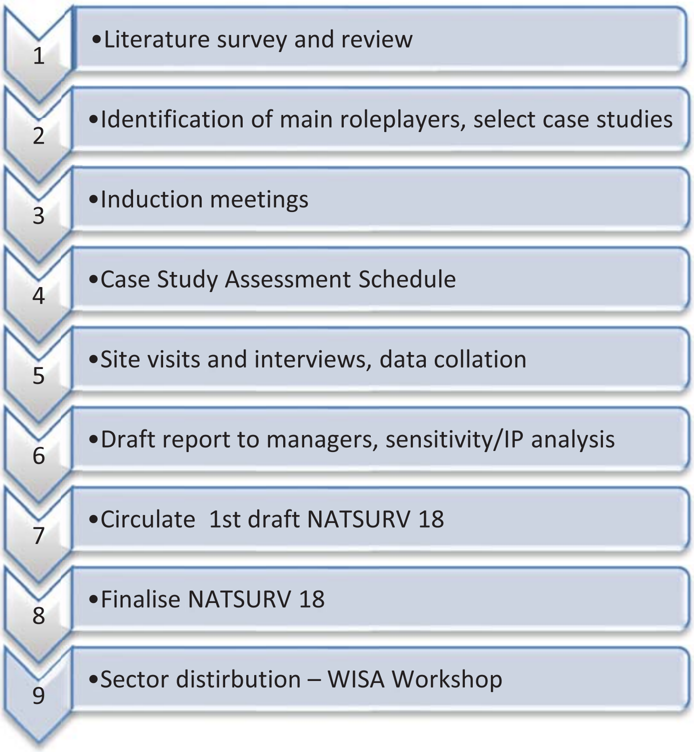
The aim of this project was to assess the South African Pelagic Fishing and Fish Processing Industry to obtain an overview of the operations, water use, effluent production, energy use, best practice implementation and legislative environment in which this industry is regulated.

The study objectives are:

1. To provide a detailed overview of the Pelagic Fishing and Fish Processing Industry in South Africa, its changes since 1980 and its projected changes, by using representative samples of the respective industries as case studies;
2. Critically evaluate and document the "generic" industrial processes of the Pelagic Fishing and Fish Processing Industry in terms of current practice, best practice and cleaner production.
3. Determine the water consumption and specific water consumption and where possible, recommend targets for use, reuse, recycling and technology adoption;
4. Determine wastewater generation, typical pollutant loads and best practice technology adoption;
5. Determine local electricity, water and effluent tariffs and bylaws within which these industries function and critically evaluate if the trends and indicators are in line with water conservation demand management and environmental imperatives;
6. Evaluate the specific industry's water and wastewater management processes adopted and recommend fundamental principles and guidelines that are important for the water users;
7. Evaluate the industry adoption of the following concepts: cleaner production, water pinch, energy pinch, life cycle assessments, water footprints, wastewater treatment and reuse, best available technology and ISO 14 001;
8. Provide and outline the manner in which industries may prevent, minimise and mitigate possible water pollution.

1.2 Methodology

The approach followed for this study was as follows:



1. **Literature survey and review**
   A literature survey and review was undertaken to cover the South African Pelagic Fishing and Fish Processing Industry, the technologies, growth and changes, including an inventory of Pelagic Fishing and Fish Processing industries in South Africa.
2. **Identification of main role-players**
   The main role-players in the industry potential case studies were identified and shortlisted to represent the industry.
3. **Induction meetings**
   Engagement with the Group Environmental Manager/s or equivalent contact person in the identified companies, to relay the purpose and approach of the study, and obtain consent to participate in the study. A signed letter by the WRC Project Leader was supplied to convey the purpose of the project and request participation. Confidentiality Agreements were signed where required. 'SurveyMonkey' or electronic questionnaire surveys were not considered based on the general poor responses normally received when using these media.
4. **Case Study Assessment Schedule**
   A 'NATSURV Case Study Assessment Schedule' was developed to prepare the selected companies for the site visit and data collection. The schedule included the processes, practices related to water, energy and wastewater, national industry-specific targets, benchmarks and the legislative framework. The schedule was also used to gather information from other sites which were not visited in person.
5. **Site visits and interviews, data collation**
   Site visits were undertaken during which information and data were gathered, using the Assessment Schedule as guidance. This information was processed and used to develop schematics and flow diagrams for each site, as well as to conduct comparative analysis on the following:
   a. Water use and water quality
   b. Energy use and efficiency
   c. Wastewater generation / use and quality
   d. Management of all the above
   e. Status quo and targets in each area

f. Comparison to benchmark figures
g. Technology applied or planned in each area.

6. **Circulate draft report to managers, sensitivity / IP analysis:**
The draft reports were sent to site managers for their input and changes. Data or information that were regarded as 'sensitive' or as 'Intellectual Property' were removed or changed. Each company received only their 'site-specific' extract from the overall Report to protect privacy and IP. Each site was provided with an alphabetic number (Site A, B, C…) to ensure anonymity.
7. **Circulate 1st draft NATSURV 18**
The draft NATSURV report was circulated to the WRC Reference Group for further input and guidance.
8. **Finalise NATSURV 18**
The final report and guideline incorporated input from the Reference Group, followed by quality assurance, printing and release via the WRC knowledge distribution networks.
9. **Sector distribution**
The NATSURV report is presented at the WISA Biannual Conference in a WRC Workshop session on 11 December 2020.

1.3 Research Output

The study delivered the following outputs:
1. NATSURV 18: Water and Wastewater Management in the Pelagic Fishing and Fish Processing Industry (2nd Edition, 2020)
2. Inventory (names and contact details) of all Pelagic Industries and key role players in South Africa.

2 INDUSTRY OVERVIEW

2.1 Fishing and Fish Processing Industry:

2.1.1 Setting the scene

The term 'Fishing Industry' describes *any industry or activity that is involved in the harvesting/capturing, culturing (production or growing), processing, preserving, storing, transporting, marketing or selling fish or fish products*. The industry is defined by the Food and Agriculture Organization (FAO) of the United Nations as; "*including recreational, subsistence and commercial fishing, and the harvesting, processing, and marketing sectors*".

The three main sectors of this industry are:

- **The commercial sector:** comprises of enterprises and individuals associated with wild-catch or aquaculture resources and the various transformations of those resources into products for sale. It is also referred to as the "seafood industry", although non-food items such as pearls are included among its products;
- **The traditional sector**: comprises of enterprises and individuals associated with fisheries resources from which aboriginal people derive products in accordance with their traditions;
- **The recreational sector:** comprises of enterprises and individuals associated for the purpose of recreation, sport or sustenance with fisheries resources from which products are derived that are not for sale.

The commercial sector of the fishing industry is represented by the following value chain:

Commercial fishing and fish farming which produce the raw fish
↓
Fish processing factories which produce the processed fish as product
↓
Marketing and retail of the final fish products

Generally, a ***Fishery*** is an entity engaged in raising or harvesting fish, which may involve the capture of wild fish or raising fish through fish farming or aquaculture. ***Aquaculture*** is the term used for the production of fish and other seafood (e.g. finfish, crustaceans, molluscs and aquatic plants) in fresh water or marine water resources is called aquaculture or aqua farming. ***Mariculture*** is a specialised branch of aquaculture involving the cultivation of marine organisms for food and other products in the open ocean, an enclosed section of the ocean, in tanks, ponds or raceways which are filled with seawater.

2.1.2 Current Global Fishing and Fish Processing

A report by the State of World Fisheries and Aquaculture: Meeting the Sustainable Development Goals (SDG) (FAO, 2018) states that global fish production peaked at 171 million tonnes in 2016, with aquaculture representing 47% of the total production (53% non-food uses are excluded, e.g. reduction to fishmeal and fish oil). Growth has mainly been in the aquaculture sector, whilst the capture fishery sector has remained static since 1980s. The 2016 global capture fisheries production was identified as being 90.9 million tonnes, which was a decline from the previous 2 years.

Table 2-1: World fisheries and aquaculture production and utilization (million tonnes – excludes aquatic mammals, reptiles & plants) (FAO, 2018)

Category:	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Production						
Capture						
- Inland	10.7	11.2	11.2	11.3	11.4	11.6
- Marine	81.5	78.4	79.4	79.9	81.2	79.3
Total Capture	**92.2**	**89.6**	**90.6**	**91.2**	**92.6**	**90.9**
Aquaculture						
- Inland	38.6	42	44.8	46.9	48.6	51.4
- Marine	23.2	24.4	25.4	26.8	27.5	28.7
Total Aquaculture	**61.8**	**66.4**	**70.2**	**73.7**	**76.1**	**80.1**
Total World Fisheries & Aquaculture	**154.0**	**156.0**	**160.8**	**164.9**	**168.7**	**171.0**
Utilisation (*2014-2016 provisional estimates*)						
Human Consumption	130.0	136.4	140.1	144.8	148.4	151.2
Non-food Uses	24.0	19.6	20.6	20.0	20.3	19.7
Population (*Billions – Source UN 2015*)	7.0	7.1	7.2	7.3	7.3	7.4
Per Capita apparent consumption (kg)	18.5	19.2	19.5	19.9	20.2	20.3

The table indicates that world total marine catch was 79.3 million tonnes in 2016, representing a decrease of almost 2 million tonnes from the 81.2 million tonnes in 2015. The catches of anchoveta by Peru and Chile, which are substantial yet highly variable because of the influence of El Niño, accounted for 1.1 million tonnes of this decrease. Other major countries and species, particularly cephalopods, also showed reduced catches between 2015 and 2016. China, as the world's top producer, had stable total marine catches in 2016, but the inclusion of a progressive catch reduction policy in the national Thirteenth Five-Year Plan for 2016-2020 is expected to result in significant decreases in the years following 2016 (FAO, 2018).

Due to the reduced fish catches, fishmeal and fish-oil production fluctuate according to changes in the catches of these species. Over time, adoption of good management practices and the implementation of certification schemes have decreased the volumes of catches of species targeted for reduction to fishmeal. Fishmeal production peaked in 1994 at 30 million tonnes (live weight equivalent) and has followed a fluctuating but overall declining trend, since then (FAO, 2018).

In 2016, landings from fisheries directed for fishmeal production were down to less than 15 million tonnes, because of reduced catches of anchoveta. However, owing to the growing demand for fishmeal and fish oil and driven by high prices, a growing share of fishmeal is being produced from fish by-products, which previously were often wasted. By-products account for 25-35% of the total volume of fishmeal and fish oil produced, noting some regional differences (FAO, 2018).

A projection of fisheries, aquaculture and markets up to 2030 shows that the major growth in production is expected to originate from aquaculture, expecting to reach 109 million tonnes in 2030. The 2030 capture fisheries production is expected to reach about 91 million tonnes, 1% higher compared to 2016, but having a 7% less market share compared to aquaculture. Despite reduced capture fisheries production in China, world capture fisheries production is projected to increase slightly through increased production in other areas if resources are properly managed (FAO, 2018).

The increasing role of aquaculture aspect is graphically depicted as follows:

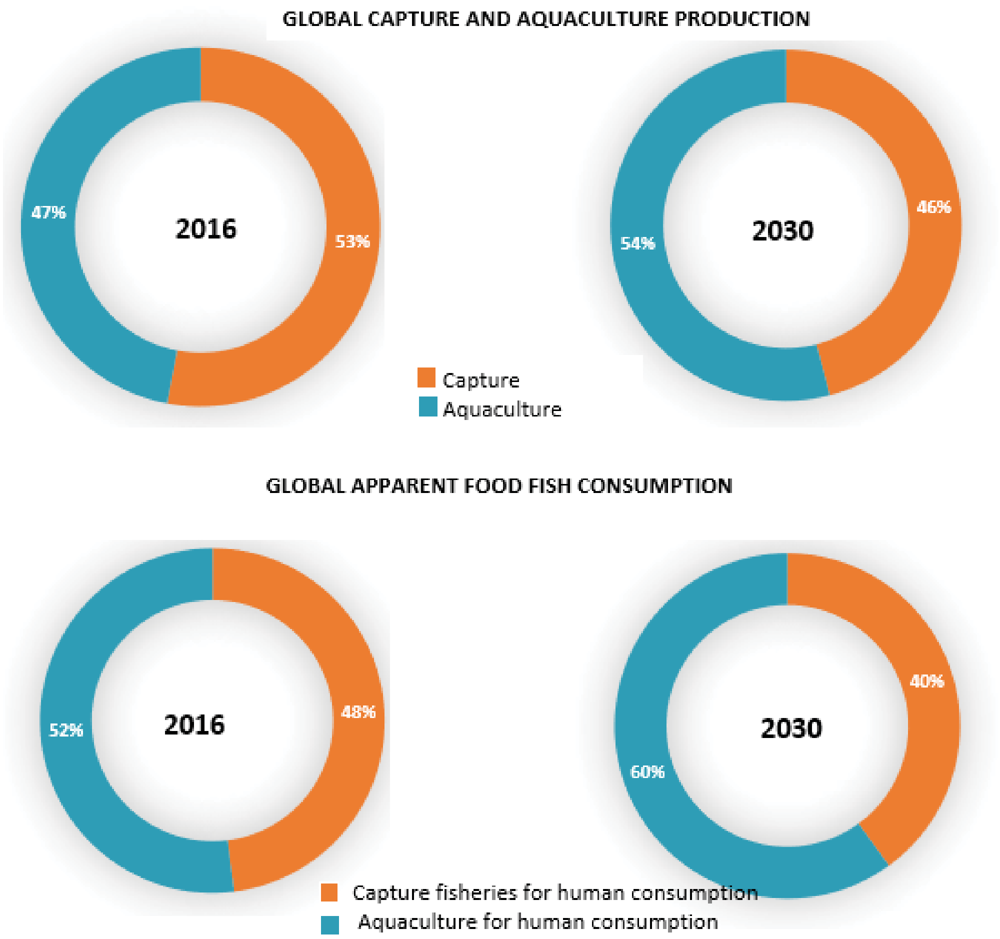


Figure 2-1: The increasing role of aquaculture (FAO, 2018)

Positive and negative factors influencing this limited growth include (FAO, 2018):

- Negative – a 17% decrease of capture fisheries in China due to the implementation of new policies;
- Positive – increased catches in some fishing areas where stocks of certain species are recovering due to improved management;
- Positive – increase in catches in waters of countries with underfished resources, where new fishing opportunities exist, or where fisheries management measures are less restrictive;

- Positive – enhanced use of fishery production, including reduced onboard discards, waste and losses as driven by legislation or higher market fish prices (for both food and non-food products);
- Negative – the El Niño phenomenon is expected to reduce catches in South America, especially for anchoveta, resulting in an overall decrease of world capture fisheries production of about 2%.

Around 16% of the capture fisheries yield is expected to be used to produce fishmeal and fish oil, with a 19% increase in production in 2030, compared to 2016. Most of this growth will be derived from improved use of fish waste, cuttings and trimmings obtained from fish processing.

Fishmeal produced from fish by-products will represent 34% of the world's fishmeal production in 2030, compared to 30% in 2016. Caution is given regarding the use of fish by-products on the composition and quality of the resulting fishmeal and/or fish oil, with possible effects including lower protein and increased ash (minerals) and small amino acids (e.g. glycine, proline, hydroxyproline), in comparison with products obtained from whole fish. This difference in composition may hinder increased use of fishmeal and/or fish oil in feeds used in aquaculture and livestock farming (FAO, 2018).

The Department of Environmental Affairs and Tourism (1994-2009) indicated that South Africa's fishing industry contributes at least R5 billion a year (0.7%) to the GDP. The aquaculture production is in the region of 4 000 tons a year. In 2013/2014, the sector worth was around R6 billion per annum and employing 27 000 people in the commercial sector, with many families depending on this resource for food and the basic needs of life (Department of Environmental Affairs and Tourism, 2009).

The projected fish production for 2030 (live weight equivalent) is depicted as follows:

Table 2-2: Global projected fish production for period 2016 to 2030 (live weight equivalent) (FAO, 2018)

Country	**Fisheries and aquaculture**			**Aquaculture**		
	Production (1 000 tonnes)		**Growth, 2016-2030 (%)**	**Production (1 000 tonnes)**		**Growth, 2016-2030 (%)**
	2016	**2030**		**2016**	**2030**	
Asia	121 776	144 666	18.8	71 546	97 165	35.8
China	66 808	79 134	18.4	49 244	64 572	31.1
India	10 762	13 407	24.6	5 700	8 212	44.1
Indonesia	11 492	15 15`8	31.9	4 950	8 253	66.7
Japan	3 872	3 427	–11.5	677	745	10.1
Philippines	2 821	3 229	14.4	796	1 085	36.3
Republic of Korea	1 894	1 831	–3.3	508	632	24.4
Thailand	2 493	2 757	10.6	963	1 305	35.6
Viet Nam	6 410	8 087	26.1	3 625	5 085 4	0.3
Africa	11 260	13 556	20.4	1 982	3 195	61.2
Egypt	1 706	2 657	55.7	1 371	2 302	68.0

Country	Fisheries and aquaculture			Aquaculture		
	Production (1 000 tonnes)		Growth, 2016-2030 (%)	Production (1 000 tonnes)		Growth, 2016-2030 (%)
	2016	2030		2016	2030	
Morocco	1 448	1 712	18.2	1	2	33.3
Nigeria	1 041	1 231	18.2	307	418	36.2
South Africa	618	590	–4.5	5	6	1.9
Europe	16 644	17 954	7.9	2 945	3 953	34.2
European Union	6 463	7 025	8.7	1 292	1 664	28.8
Norway	3 360	3 909	16.3	1 326	1 719	29.6
Russian Federation	4 932	5 244	6.3	173	291	67.9
North America	6 703	6 470	–3.5	645	744	15.4
Canada	1 063	1 099	3.5	201	249	24.2
United States of America	5 364	5 371	0.1	444	495	11.4
Latin America and Caribbean	12 911	16 035	24.2	2 703	4 033	49.2
Argentina	759	853	12.4	4	4	3.4
Brazil	1 286	1 885	46.6	581	1 097	89.0
Chile	2 535	3 665	44.6	1 035	1 309	26.4
Mexico	1 732	1 993	15.1	221	316	42.6
Peru	3 897	4 450	14.2	100	221	120.9
Oceania	1 640	1 973	20.3	210	299	42.1
Australia	269	289	7.3	97	151	55.7
New Zealand	532	560	5.3	109	143	31.0
World	170 941	200 955	17.6	80 031	109 391	36.7
Developed countries	28 050	28 720	2.4	4 498	5 762	28.1
Developing countries	142 885	172 235	20.5	75 532	103 630	37.2
Least developed countries	12 978	14 434	11.2	3 749	5 487	46.3

The statistics for South Africa depict an overall growth reduction of 4.5% in terms of combined Fisheries and Aquaculture, but an individual growth of 1.9% in Aquaculture. These figures compare poorly with other developed and developing countries, which shows 2.4 and 20.5% overall growth and 28.1 and 37.2% growth in Aquaculture, respectively.

This research report explores the statistics and underlying reasons for South Africa deviation from the international benchmark parameters.

2.2 Pelagic Fishing and Fish Processing: International Perspective

Pelagic fish can be categorised as coastal or oceanic fish, based on the depth of the water the fish inhabit. Coastal pelagic fish inhabits sunlit waters up to 655 feet deep, typically above the continental shelf, and include forage fish species such as anchovies, sardines, shad, and menhaden, as well as the predatory fish that feed on them. Oceanic pelagic fish typically inhabit waters below the continental shelf, and include larger fish such as swordfish, tuna, mackerel, and even sharks (NOAA, 2019).

Pelagic fish are highly migratory and generally show shoaling behaviour. Pelagics comprise different taxonomic groups, which contribute to their rich species diversity and abundance. Of note is that the various names may differ in different areas of the world. In India, the important pelagic fishes are clupeids such as wolf herring, oil sardine, lesser sardine, Hilsa, anchovies, as well as Bombay duck, halfbeaks, fullbacks, flying fishes, ribbon fishes, carangids, Indian mackerels, seer fishes, tunas, billfishes, barracudas, mullets and unicorn cod.

The FAO's State of World Fisheries 2018 reports an increase in the global fish consumption from 9 kg per capita in 1961 to 20.2 kg in 2015. The average annual increase in fish consumption exceeds the average population growth and is also higher than the growth in meat consumption. In Europe, seafood consumption was around 24 kg per capita in 2016. Large variations are found within countries with a fish consumption of only 5.2 kg per capita in Hungary and 57 kg per capita in Portugal (FAO, 2018) (Rustad, 2018) (European Market Observatory for fisheries and aquaculture (EUMOFA), 2019).

The main products consumed globally are tuna (canned), cod, salmon, Alaska pollock, shrimps, mussel and herring. The internal demand of seafood in the EU is met through imports and cover 60% of the total supply in 2016. Salmon, cod, tuna, Alaska pollock, fishmeal and shrimps are the most imported products. On the other hand, almost 13% of EU supply is exported, mostly including herring, mackerel, blue whiting, tuna, fishmeal and fish oil.

Pelagic fish species such as herring and mackerel are also among the main species exported from the EU. The total amount of small pelagics caught in the EU in 2016 was around 1,800,000 tons and the import and export were 600,000 and 690,000 tons, respectively. The consumption of these species was around 1,700,000 tonnes (Rustad, 2018).

Most of the Atlantic herring and mackerel landing in Norway and Ireland is frozen and exported (600,000 tonnes) to other countries for processing. Most of the Baltic pelagic fish (sprat and herring) is used for fish meal because of the lack of a local consumer market (Rustad, 2018).

The supply balance sheet provides an estimate of the supply available for human consumption, both as total consumption and as per-capita consumption. The table below provides the supply balance at EU level as a total and by commodity group and main commercial species for 2017 as per all their member states. The table shows that small pelagics, tuna, tuna-like species, coupled with groundfish (e.g. cod, halibut sole) form the greatest by weight/production in catches, as well as the largest quantity in terms of import, export and consumption.

Table 2-3: Supply balance at EU level as a total and by commodity group and main commercial species for 2017 as per all their member states. (EUMOFA, based on elaboration of EUROSTAT data, 2019)

Commodity Group	Production (t)		Import (t)		Export (t)		Apparent Consumption (t)			Per capita Consumed (kg)		
	Catches	Aqua culture	Catches	Aqua culture	Catches	Aqua culture	Catches	Aqua culture	Total	Catches	Aqua culture	Total
Bivalves, molluscs & aquatic invertebrates	226,229	625,895	128,433	192,499	39,866	15,370	314,796	803,024	1,117,820	0.62	1.57	2.19
Cephalopods	98,578	2	688,864	0	45,579	1	741,864	1	741,864	1.45	0	1.45
Crustaceans	194,503	576	488,007	394,952	127,547	781	554,963	394,747	949,710	1.09	0.77	1.86
Flatfish	177,505	13,345	139,555	852	67,982	342	249,078	13,855	262,933	0.49	0.03	0.51
Freshwater fish	15,113	115,661	77,987	287,056	11,454	8,947	81,646	393,769	475,416	0.16	0.77	0.93
Groundfish	761,285	0	2,794,031	355	418,558	0	3,136,758	355	3,137,113	6.13	0	6.13
Miscellaneous aquatic products	39,109	95	291,227	0	35,281	0	295,056	95	295,151	0.58	0	0.58
Other marine fish	308,857	185,840	380,925	96,114	117,120	17,645	572,662	264,309	836,971	1.12	0.52	1.64
Salmonids	4,192	410,181	986	1,129,293	1,668	174,664	3,509	1,364,810	1,368,319	0.01	2.67	2.68
Small pelagics	1,770,445	0	633,126	0	755,408	0	1,648,163	0	1,648,163	3.22	0	3.22
Tuna and tuna-like species	430,127	20,418	1,487,521	32	313,664	7,404	1,603,984	13,045	1,617,029	3.14	0.03	3.16
Total	4,025,943	1,372,012	7,110,664	2,101,153	1,934,127	225,154	9,202,480	3,248,011	12,450,491	18.01	6.36	24.35

The table following provides an overview of the pelagic supply balance in Europe, with herring being the species of choice in terms of production and consumption/capita.

Table 2-4: Small Pelagic commodity group supply balance at EU level as a total and main commercial species for 2017 as per all their member states. (EUMOFA, based on elaboration of EUROSTAT data, 2019)

Main Commercial Species	Production (t)	Import (t)	Export (t)	Apparent Consumption (t)		Per capita Consumption (kg)	
	Catches				Total	Catches	Total
Anchovy	139,728	47,630	31,160	156,199	156,199	0.31	0.31
Herring	574,500	262,525	232,521	604,505	604,505	1.18	1.18
Horse mackerel, Atlantic	145,430	1,111	117,899	28,642	28,642	0.06	0.06
Horse mackerel, other	66,874	1,468	5,817	62,526	62,526	0.12	0.12
Mackerel	404,412	157,957	227,835	334,535	334,535	0.65	0.65
Sardine	220,720	158,554	83,769	295,505	295,505	0.58	0.58
Sprat (=Brisling)	209,805	507	22,912	187,400	187,400	0.37	0.37

China is the largest-, and the EU the 5th largest world producer of fishery and aquaculture products, covering 3% of global production in 2016 (5,6% for catches and 1,2% for aquaculture). Products caught by Member States' fleet represent more than 80% of the supply, and the remaining 20% is represented by farmed fish.

Fisheries play an important role in the economies of some of the EU's Outermost Regions (ORs). The Atlantic and Indian Ocean fisheries for tuna and other large pelagic fish are exploited by five of the EU's seven ORs; Azores, Madeira, Canary Islands, Reunion and Mayotte (Megapesca Lda: Ian Goulding, 2015). The ORs contribute about 10% in the Atlantic and 16% in the Indian Ocean of the EU's tuna catches. This is 13% of the EU's tuna catches, but was significantly increased when Mayotte, with 5 large purse seiners, became an OR at the start of 2014. The contribution of the ORs to the total large pelagic catches in each region is relatively small, i.e. 4% in both cases (Megapesca Lda: Ian Goulding, 2015).

In terms of fish processing within the ORs, the tuna sector is served by 14 processing establishments, 10 of which are directly linked to the tuna canning sector (the others linked to swordfish preparation in Reunion). However, there are only 6 operating canneries, with the 5 most significant ones located in the Azores. Other establishments prepare tuna for subsequent canning in the continental EU in the form of frozen tuna. The annual average of raw material inputs for these 14 establishments is approximately 28 413 tonnes, of which 70% is utilised by the Azores' establishments. Around 43% of the raw material is imported in the form of frozen tuna (Megapesca Lda: Ian Goulding, 2015).

As can be seen from the above review of global statistics and trends, pelagic fishing is conducted globally, but the main fisheries are located along the Peruvian and Chilean coasts where the cold Humboldt current generates wide oceanic upwelling and consequently, high primary productivity.

2.3 South African Fisheries

South Africa´s fish industry is focused on international markets, with exports generating R6.5 billion in 2015, >50% going to the European Union (EU). South Africa is a net exporter of fish, most of which are frozen whole or in fillets (SADC-EU EPA Outreach South Africa, 2017).

In terms of the inland sub-sector, there is no significant inland commercial fisheries in South Africa. Productivity of inland waters is deemed too low to support large-scale commercial fisheries. Most formal commercial fisheries attempted on inland waters in recent years have proved non-viable due to the low yields and the low prices for freshwater fish (PJ Britz1, 2015). Recreational exploitation of freshwater fish on inland rivers and impoundments is extensive, with small subsistence fisheries in places. However, most freshwater or inland fisheries are related to a limited number of aquaculture developments.

Exports of fish are heavily influenced by the strength of the South African Rand and fuel prices. The management of TAC (total allowable catch) as a tool to manage and achieve optimal stock levels of fish and the unpredictable annual fluctuations in the biomass of small pelagic fisheries also influence the amounts exported annually.

A study by Rhodes University "*An Economic and Sectoral Study of the South African Fishing Industry*" (Sauer, 2003 Vol1) (Sauer, 2003 Vol2)) indicate that the predominant, vessel based fisheries in South Africa are:

- Abalone Fishery
- West Coast Rock Lobster Fishery
- Linefish Fishery
- Hake Handline Fishery
- Hake Handline Fishery
- Shark Longline Fishery
- Tuna Longline Fish
- Tuna Baitboat Fishery
- Squid Jig Fishery
- South Coast Rock Lobster Fishery
- Pelagic Fishery
- Inshore Trawl Fishery
- Deep-sea Hake Trawl Fishery
- Toothfish Fishery
- Prawn Trawl Fishery.

According to the Rhodes Economic Sector Study (ESS), the South African Commercial Fishing Fleet structure has three distributions, namely micro-small, medium-large and a very large distribution, with the various fisheries categorised as follows:

Micro-small distribution:

- Abalone fishery
- West coast rock lobster fishery
- Linefish fishery
- Hake handline fishery.

Apart from some spill-over from micro-small fisheries, the medium-large distribution is considered to consist of two groups, the medium size line fisheries and inshore trawl fisheries. The inshore trawl fishery vessels are on average larger than the medium sized line fish vessels.

Medium size line fisheries comprise of:

- Hake longline fishery
- Shark longline fishery
- Tuna longline fishery
- Tuna bait boat fisher
- Squid jig fishery
- Inshore trawl fisheries consist of:
  - Inshore hake and sole trawl fishery
  - Pelagic fishery
  - Prawn trawl fishery.

The large distribution of vessels consists of three fisheries all using different gear types:

- South coast rock lobster fishery
- Deep-sea hake trawl fishery
- Toothfish longline fishery.

The possibility of multi-species fisheries is inherent in this arrangement. There is, however, an important distinction between a multi-species fishery and a single-species fishery that is subsidised by another single-species fishery.

- A multi-species fishery is one where a number of different species are targeted by the same vessel on a sustainable basis and should be managed accordingly;
- A single-species fishery subsidises another if the other fishery is over-fished and needs to redirect its catch to the subsidising fishery.

The main commercial fisheries target 5% of the known fish species found in South African waters and are identified as follows (SADC-EU EPA Outreach South Africa, 2017):

- **Cape hake** (Merluccius capensis and Merluccius paradoxus): 40% of total SA catch value
  - Deep sea/demersal trawl (West Coast): 84% of hake TAC
  - Deep sea longline and handline (West and South Coast): 10% of hake TAC
  - Inshore trawl (Mossel Bay and Port Elizabeth): 6% of hake TAC
- **Pelagic fish**: 25% of total SA catch value
  - Offshore small pelagic purse seine for anchovy and sardine (West Coast)
  - Offshore tuna bait and pole fishery for longfin and yellowfin tuna (Cape Town)
  - Offshore large pelagic longline fishery for tuna, shark and billfish (whole coast and beyond Exclusive Economic Zone (EEZ))
- **Crustaceans**: 7% of total SA catch value
- **West Coast rock lobster** (Cape West & Southwest coasts between Cape Town & Cape Agulhas)
- **Cephalopods:** 7% of total SA catch value
  - Squid jig fishery (Port Elizabeth and Port St Francis).

Most fishing is done along the continental shelf between St Helena Bay and Port Elizabeth. The industry's major fishing ports, processing factories and service industries are found in the Western Cape of which the value-adding industries are also located mainly around the harbour areas. There are no auctions/wholesale markets in South Africa (SADC-EU EPA Outreach South Africa, 2017).

2.4 History of Pelagic Fishing and Fish Processing Industry in South Africa

The demersal fishery started around 1897 in South Africa, with the Pelagic Industry being established off the Western Cape (St Helena Bay area) after the Second World War (1943). The initial focus was on pilchard (sardine, being young pilchard) and maasbanker (horse mackerel) fish, due to the increased demand for canned products during the war period.

The focus was expanded in 1954 to include chub mackerel, followed by anchovy and red-eye in 1964 and 1966 respectively. Pilchard landings ranged between 102 000-30 000 tons in 1951 with a substantial increase in landing in 1958 (194 000 tons) and in 1962 (410 000 tons). Thereafter catches started to decrease and after 1966, effectively collapsed to below 100 000 tons and remaining at this low level until 1995 (Sauer, 2003 Vol2).

Smaller mesh purse-seine nets were introduced to compensate for the decline in the pilchards by allowing the exploitation of anchovy, including juvenile fish. This led to an increase in anchovy landings of up to 600 000 tonnes in the late 1980s, with anchovy forming about 80% of the total pelagic landings. The overfishing in 1989 led to the landings falling by 50% and decreased further to 40 000 tonnes in 1996 (Sauer, 2003 Vol2) (DAFF, 2016).

With the introduction of conservative management strategies, sardine catches increased to 374 000 tonnes during the early-2000s. The rapid fish population growth occurred particularly on the Cape South Coast. During this time (2001-2005), anchovy catches also recovered, resulting in total pelagic landings in excess of 500 000 tonnes. Several successive years of low sardine recruitment followed 2005, with annual sardine catches reduced to 90 000 tonnes (2008-2016), after which time anchovy catches dominated the fishery again with average catches of 200 000 tonnes (2013-2016). Round herring catches have never dominated pelagic landings, with the total annual landing never exceeding the 100 000 tonnes mark since 1960s (DAFF, 2016).

In terms of consumer trends and demands, pelagic fishery production forms the bulk of the fish production consumed locally. Canned pilchards are a popular protein source and fishmeal production is utilised in the agricultural sector. Annual fish consumption in South Africa was estimated at 7.5 kg per capita in 2009, which was relatively low compared to global consumption of 17 kg/capita/year. South African consume mainly white and red meat, as most of the population prefers livestock and poultry protein (Seafish.org, 2019).

There are several reasons for South Africa's relatively low consumption of seafood, some of these being:

- South Africa does not traditionally have a seafood eating culture, with seafood consumption predominantly the domain of the middle- and upper-income groups;
- The exception is canned sardines – South Africa is one of the largest sardine-eating nations in the world and canned sardines form the staple diet for a large portion of the population;
- Traditional family restaurants cater for the middle-income group, consuming relatively large quantities of whitefish, cheap calamari and the smaller prawns;
- Allergies to molluscs are common;
- A growing number of consumers have either adopted a meat-free diet by becoming vegetarian or vegan, or have significantly reduced their red meat intake, turning to fish and poultry instead;
- Prices of seafood vs. red meat and chicken is high, with chicken and pork being the most affordable meat. With the price of meat increasing, fish is becoming a more affordable source of protein. The price of fish is currently in-between that of chicken and red meat;

The following is noted regarding consumption trends in South Africa:

- Fish and seafood market trends are largely influenced by market price, species availability, and ease of accessibility for consumers;
- Increasingly, market trends are influenced by consumer awareness programmes like the WWF's Southern African Sustainable Seafood Initiative (SASSI) and eco-labels like the Marine Stewardship Council (MSC);
- Increasing consumer and retailer awareness of environmental and sustainability issues has resulted in increased demand for environmentally friendly and sustainable seafood products;
- This growing market shapes perceptions and a number of global conservation initiatives are in place to incentivise responsible fisheries and suppliers.

2.5 Current Pelagic Fishing and Fish Processing in South Africa

South Africa has important marine resources including 3 600 km of coastline that includes the confluence of two ocean currents. The warm Agulhas current running down the east coast carries fewer nutrients and consequently fisheries are smaller and more focused on communal coastal fishing. The cold Benguela, which runs north along the west coast, is richer and supports a wide array of biodiversity. The Exclusive Economic Zone (EEZ), where only South African vessels may fish, covers 1071 883 km² (SADC-EU EPA Outreach South Africa, 2017).

DAFF emphasises the importance of the pelagic fishery to the economy for the following reasons (SADC-EU EPA Outreach South Africa, 2017):

- the sector is the second most important in value (second only to the hake fishery);
- pelagic fish are a high-quality source of protein: fish meal and oil are used as protein supplements in both agriculture and aquaculture;
- direct employment and employment in related industries is large; and
- energy produced by plankton is transferred to large-bodied predatory fish, marine mammals and seabirds.

Historically, the small pelagic fishery is the largest South African fishery by volume and in terms of direct and indirect employment, and the second most valuable after the demersal fishery (deep-water trawl targeting cape hakes) (DAFF, 2016).

The South African Pelagic Fishing Industry Association depicts the 2018 pelagic industry (South African Pelagic Fishing Industry Association (SAPFIA), 2019) as follows:

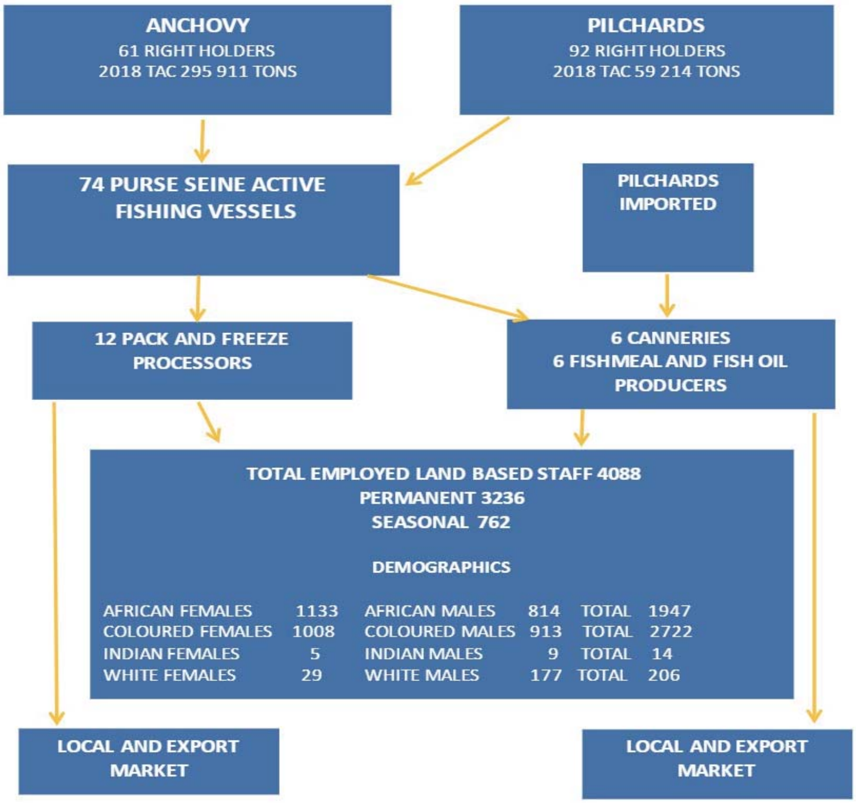


Figure 2-2: SAPFIA perspective on the South African Pelagic Fishing Industry in 2018 (South African Pelagic Fishing Industry Association (SAPFIA), 2019)

[Disclaimer: Figures as at 25 July 2018 of SAPFIA Members employees; and Facts and Figures for land-based employment consists of SAPFIA members only]

The pelagic fishery is a limited-access, rights-based fishery, based on three species: sardine, anchovy and round herring. These species are found in waters ranging from the Orange River in the west to Port Alfred in the east and are caught with a mixture of wooden and steel-hulled purse seine vessels. Anchovy and round herring are reduced to fishmeal, whereas most of the sardines caught are canned, although some are marketed as fresh fillets or bait (Oceana Group Limited Scientific reports, 2012).

Historically, the fisheries for sardine and anchovy were managed separately. In 1991, the anchovy fishery began to be regulated through the use of an Operations Management Procedure (OMP) approach, which is an adaptive management system that is able to respond rapidly, without increasing risk, to major changes in resource abundance (DAFF, 2016). Since 1994, the first joint anchovy-sardine OMP were implemented and became managed using a joint OMP that involves a trade-off between maximising overall sardine and anchovy catches, whilst minimising the risk of resource collapse (DAFF, 2016) & (Hutchings K, 2014). OMP-14 is the management procedure which recommends the Total

Allowable Catches (TAC's) and Total Allowable Bycatches (TAB's) for sardine and anchovy in local waters since 2015 to 2018 (adopted by the Small Pelagic Scientific Working Group (SPSWG 29 October 2014) (The South African Pelagic Fishing Industry Association (SAPFIA) -TAC, 2019).

OMP-18 replaced OMP-14 as per decision by the SPSWG. This team comprises of an experienced group of biologists, stock assessment scientists, NGOs and industry representatives. OMP-18 determines the sardine and anchovy catch limits, which is dependent on sardine biomass estimates obtained from the annual October/November hydro-acoustic survey. It includes a new Harvest Control Rule (HCR) for calculating the directed >14 cm sardine Total Allowable Catch (TAC) and associated ≤14 cm sardine Total Allowable Bycatch (TAB). The OMP formulae has been developed to ensure low probabilities that the abundances of sardine and anchovy might drop below agreed threshold levels, under which successful future recruitment might be compromised. This OMP is therefore designed to respond to the state of the small pelagic stocks (anchovy and sardine primarily) in a calculated and precautionary way (Oceana Group, 2018).

SAPFIA has also implemented a dedicated observer programme, working collaboratively with CapMarine and DAFF, aimed at monitoring catches of anchovy and sardine, as well as other bycatch species. This programme provides valuable information on not only operational patterns, but also on catch size distributions, bycatch and other biological data that is used by DAFF scientists in the daily management of the fishery.

According to the Rhodes ESS, most of the catch is processed before being marketed, e.g. pilchard is canned for human consumption; and anchovy and round-herring are converted to fishmeal (Sauer, 2003 Vol1) (Sauer, 2003 Vol2) (SADC-EU EPA Outreach South Africa, 2017). Canned sardines are consumed domestically and exported to regional southern African markets; likewise, frozen sardines are sold in both domestic and international markets (mostly to the East or Mauritius).

Fresh small pelagic fish have high tariffs but are not exported, due to the high logistical cost associated with low-priced fresh products. It is a product that will not benefit immediately from liberalisation but that may hold potential in the future.

"*Assessment of the Socio-Economic Implications of a Reduced Minimum Sardine Tac for the Small Pelagics Purse-Seine Fishery*" reports a decreasing number of pack-and freeze processors (26 in 2004 to 12 in 2013) (Hutchings K, 2014).

An infrastructure inventory of the Pelagic Industry South Africa (Sauer et al., 2003) are:

- 8 fishmeal plants;
- 6 canning factories;
- >40 bait packing facilities.

3 PELAGIC FISH PROCESSING INDUSTRY OVERVIEW

3.1 General

The assessment of water, effluent and energy management by the fish industry requires an understanding of the process and operations.

Processing fish applies various preservation techniques that aim to retain product quality and increase shelf life, including:

- temperature control using ice, refrigeration or freezing;
- control of water activity using drying, salting, smoking and freeze-drying;
- physical control of microbial fish loads through microwave heating or ionizing irradiation;
- chemical control of microbial activity and loads by adding acids;
- oxygen level control, such as vacuum packaging.

Fish process operations consider the following aspects:

- Application of best waste management techniques in the operation;
- Production of value-added products through further processing
    - This is becoming more common due to an increased demand for ready-to-eat or minimum preparation-time food products.

Preliminary processing – processing can occur on-board or be land-based and involves the full or partial separation of edible/perishable parts from inedible ones. This process allows for portions that meet customer demand requirements and/or further processing needs, e.g. inclusion of inedible parts with animal feed production. The separation includes descriptions such as headed and gutted fish fillets, V-cut fillets, butterfly fillets, fish after nobbing, which may be labour intensive but more often mechanised (Tomczak-Wandzel, et al., 2015). The machinery used in preliminary processing include specialised machines for scaling, gutting, deheading, nobbing, filleting, skinning, cutting and meat separation, whereas those used in pre-processing process are freezers, de-icers or graders.

Problems relating to the operations and equipment include:

- Machinery requires large quantities of water, of which the flow often is uncontrolled and excessive;
- High-strength effluent is produced due to waste being cut or mashed into the water by the mechanical equipment, resulting in a high content of solids and oils from the ungutted fish;
- Ineffective separation at source leads to wastage on the floor around installations. This problem is found at the processing machines, as well as catch trays, chutes, conveyors and flumes built to transport the fish, products and waste.

Other operational aspects that impact on water management include (Tomczak-Wandzel, et al., 2015):

- **Freezing & Thawing:**

Freezing must be accomplished quickly and is a separate process from low temperature storage. The three basic methods of freezing fish include air blast-, contact/plate-, and immersion/spray freezing. Thawing is the process of changing a product from frozen to unfrozen using methods such as water immersion or spray, air or steam, as well as microwave and radio frequency systems. The type of thawing method used depends cost, throughput, timescale, size, efficiency and effect on product quality.

- **Grading:**

Grading by size and separation of species ensures uniform flow in preparation for next processes. Fish grading is used extensively for small, pelagic fish, e.g. herring, mackerel, sprat and sardines. The material is graded according to maximum thickness and correlated with the length of the fish. Most frequently, the grading take place in an opening slit formed by some vibrating elements, or between rotating rollers.

- **Scaling:**

Scaling takes place manually or by machines, each with distinctive advantages. Two types of scaling machines are most often used, i.e. drum machines that graze the fish past the rough walls of the rotating drum, and machine scrapers which passes the fish across stationary or moving scrapers.

- **Deheading and gutting:**

Deheading is done by hand (smaller freshwater fish) and or mechanically (larger fish 20-40 cm). Manual processing is popular due to minimal losses. Cutting includes round cut (lowest meat loss), straight cut and contoured cut (for boneless and skinless fillet). The Nordic BAT identifies the amount of deheaded waste produced from fish processing to be around 27-32% (Tomczak-Wandzel, et al., 2015). Gutting involves the removal of internal organs and optionally cleaning the body cavity of the peritoneum, kidney tissue and blood. The tables used are constructed of special material for easy rinsing, cleaning, disinfection and do not absorb fluid.

- **Filleting and skinning:**

This process is predominantly mechanised and consists of several unit operations: pretreatment, fish filleting, trimming of fillets, packing and storage. Fish skinning machines are designed to scrape the fish skin from fish fillets and to ensure high operational output and limited damage to the skinned side.

Other than canning, fishmeal and fish oil processing (discussed in sections following), the key processes are (Tomczak-Wandzel, et al., 2015):

- Salting – lowers the moisture content of fish to kill bacteria, prevents microorganism survival and growth, and improves fish texture. Preservation by salt includes:
  - Pickle salting which covers the fish which are packed in layers in watertight containers with salt, which forms a saturated brine solution that covers the fish;
  - Brine salting involves immersion of the fish in a saturated salt solution and is done as temporary method before fish is dried, smoked, or processed;
  - Dry salting is done by applying granular salt onto the fish, with ratios 10-35% salt to fish weight.

- Smoking – hot smoking cooks the product using heat and smoke, whereas cold smoking uses smoke, with both procedures dehydrating the fish product.
- Drying – sun drying is often done in combination with salting.

3.2 Canning and pet food production

Canning is a sterilisation technique that kills microorganisms and prevents further microbial contamination by deactivating degradable enzymes. In this process, fish are sealed in containers and heated to high temperatures for a given amount of time. The waste stream resulting from this operation is the water used during fish transport and preservation on the boats. The wastewater from this stage contains blood, fish, rocks and sand from the fishing boats tanks (Raquel O. Cristovao, 2015).

This process is followed by preliminary processing, whereby the fish is placed in brine, a process that requires water and produces an effluent especially rich in salt, blood and scales. Then follows the scaling, deheading and degutting and filleting and skinning, resulting in an effluent mainly contaminated with salt, blood and fish solid waste that is not suitable as food. The fish washing process water is a waste stream containing blood, oil, flakes, salt and fish tissues (potential for blood water reclamation). Cooking is then done via direct steam contact, pressurised cooking or deep frying, whereby the water is drained and the fish cooled through water spraying. The two sources of wastewater generated by this process are:

- Wastewater originating from the cooking – high concentration of organic material and fats
- Wastewater from washing and cooling (usually seawater) – low organic load, high salinity.

The actual canning process follows, which includes the adding of sauces (olive, sunflower or soybean oil, water, or in a tomato, chilli or mustard sauce), spiking and can washing. This final wash also leads to an effluent that contains fish fat (Raquel O. Cristovao, 2015). Finally, the sealed cans are sterilised with steam and cooled with water, which also generates wastewater.

Literature confirms that the fish canning industry consumes a large amount of water during the cleaning, washing, cooling, thawing, and ice removal operations (AWARENET, 2005). Consequently, this industry generates large quantities of wastewater which is difficult to treat due to the high content of organic matter, salts, oil and grease (UNEP, 2000) (Tomczak-Wandzel, et al., 2015).

The following process flow diagrams summarise the canning operation for tuna in brine and pet food production, and illustrate the process units where intake of water and production of wastewater takes place. Energy is used throughout the process, as will be investigated further in this study.

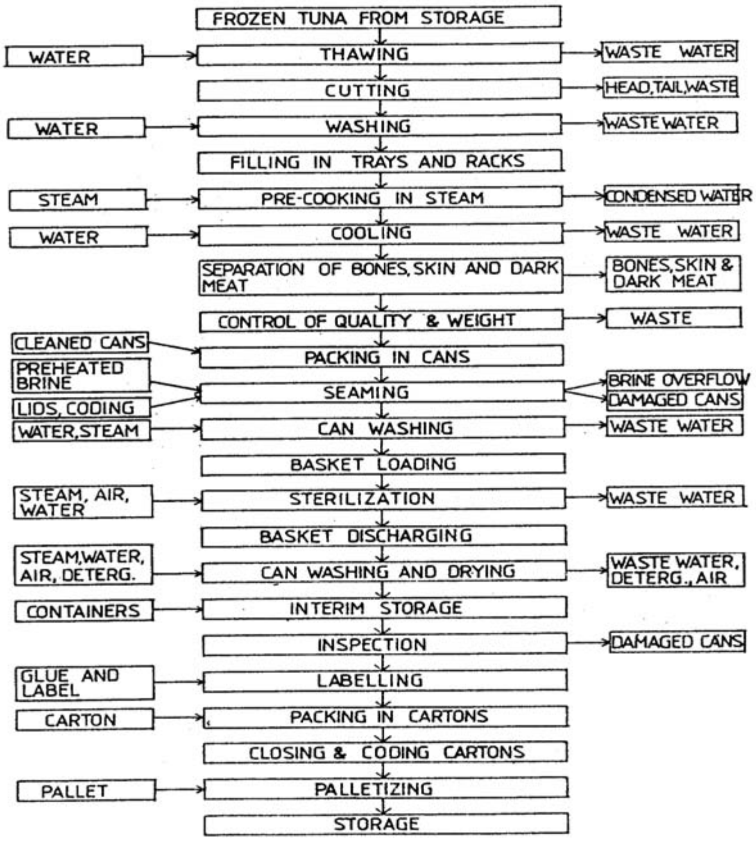


Figure 3-1: Processing flowchart of canned tuna in brine (Myrseth, 1985)

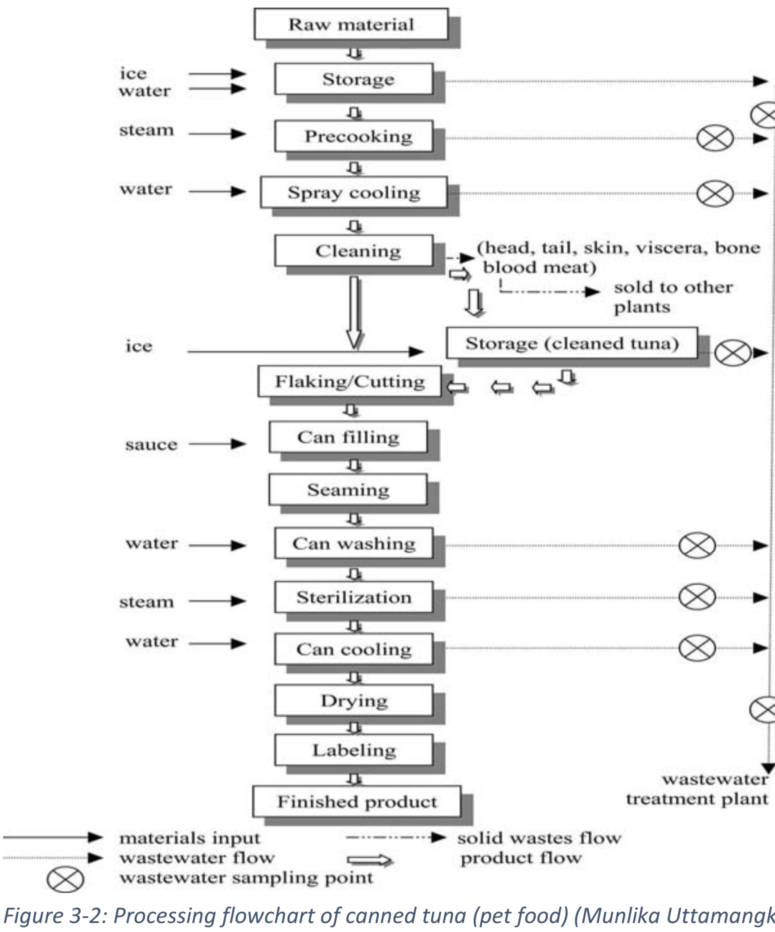


Figure 3-2: Processing flowchart of canned tuna (pet food) (Munlika Uttamangkabovorn, 2003)

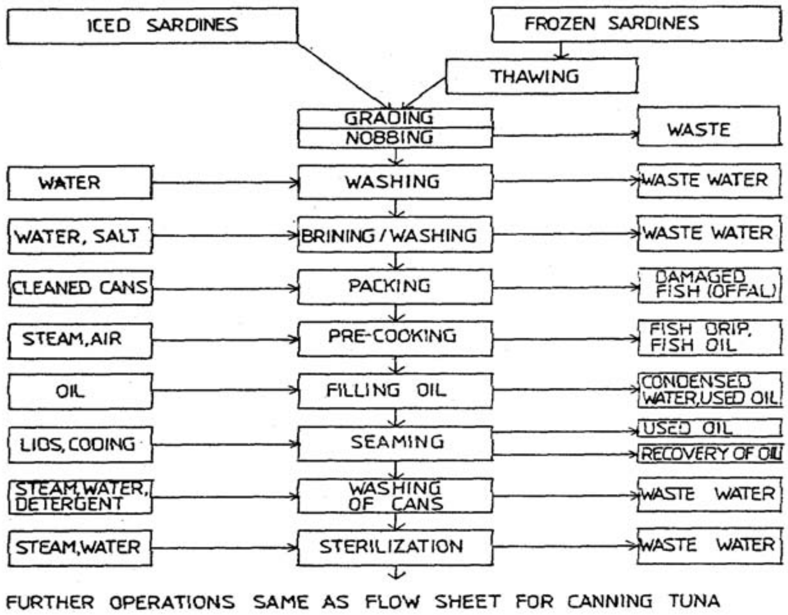


Figure 3-3: Processing flowchart of canned tuna in brine (Myrseth, 1985)

3.3 Fishmeal and Fish Oil

The production of fishmeal and fish oil involves a wet rendering process, both on land and ship. Differences are found in equipment type, but the steps of cooking, pressing, separating and drying remain similar. Fish are cooked and pressed to separate the solids from the liquids. The solids eventually become fishmeal, while the liquids are processed further to recover suspended solids that escaped the press and to separate and recover the oil. The water left from fish oil recovery is called stickwater, which has a high viscosity and is 'sticky'. The composition of the fish meal depends on the raw material and type of process used to recover the product.

Fishmeal is identified as a proteinaceous flour-type material derived from processing (boiling, pressing, drying, grinding) whole fish (usually small pelagic fish or bycatch), as well as residues and by-products from fish processing plants (fish offal) and is used mainly as agriculture feeds for domestic livestock (poultry, pigs, cattle, etc.).

Fish oil is obtained through the pressing of the cooked fish and subsequent centrifugation and separation. Both fishmeal and fish oil can be produced from whole fish, fish trimmings or other fish by-products resulting from processing. Many of the species used, such as anchoveta, have comparatively high oil yields, but are rarely used for direct human consumption (FAO, 2018).

The table below provides an indication of the fishmeal exports by top 15 countries from 2008 to 2015 (000Mt). The data for 2011-2015 was adopted from IFFO Fishmeal and Fish Oil Statistical Yearbook 2016, whereas 2008-2010 data were adopted from IFFO Fishmeal and Fish Oil Statistical Yearbook 2013 (Seafish, 2016).

Table 3-1: Fishmeal exports by top 15 countries 2008 to 2015 (ranked according to 2015 figures) (000Mt) (Seafish, 2016)

'000 tonnes	2008	2009	2010	2011	2012	2013	2014	2015	Ave 2011-2014
Peru	1,560	1,538	1,084	1,281	1,328	849	850	705	1,077
Chile	521	609	316	331	306	236	255	192	282
Germany	20	20	30	197	232	168	203	144	200
Denmark	209	207	208	211	185	197	177	203	192
USA	89	79	77	183	188	149	160	148	170
Thailand	21	26	110	73	63	126	172	155	108
Iceland	158	94	70	90	120	121	80	144	103
Ecuador	81	91	81	89	93	99	79	70	90
Morocco	76	92	89	67	72	84	134	110	89
Mexico	80	94	57	62	113	106	73	39	89
Russia	46	33	47	51	46	47	50	62	48
South Africa				39	59	18	52	57	42
Mauritania	11	24	33	32	32	29	66	56	40
Norway	64	27	22	25	18	21	35	64	25
India	9	14	13	10	11	25	52	48	24

South Africa is the 12th largest exporting country for fish meal, with Peru, Chile and Germany having the highest tonnage export.

3.4 Operational process for fishmeal and fish oil production

The raw material is first unloaded from the fishing vessel by crane, wet fish pump, pneumatic elevator or mechanical conveyor. The fish is weighed or measured by volume before being transported to pits or tanks for the storage of raw material. Upon entry line into the factory, the fish is weighed and sampled, and enters the following processing steps to produce fish oil and fishmeal from fish and fish cuttings (see graphic flowchart for steps) (Kasmiran, 2018):

1. **Cooking:** Steam cooking coagulates the protein, ruptures the fat deposits and releases the oils. The most common practice of cooking is heating raw material to 95-100˚C within 15-20 minutes. Some sources state temperatures of 85-90°C and emphases that clean conveyors and storage pits, short storage time and reduced temperatures minimises micro-organisms and product spoilage. Lower temperatures also reduce fish enzyme activity (autolysis), another form of spoilage (IFFO - International Fishmeal and Fish Oil, 2017).
2. **Draining**: The cooked fish mass is screened to separate free liquid from the solids.
3. **Pressing (or centrifugation)**: Mechanically pressing (screw press) removes a large fraction of the liquids from the solids producing a press liquor (oil and water) and a press-cake (semi-moist meat and bones). Some factories use tricanters instead of presses to separate solids, oil and water.
4. **Press liquor separation**: Decanters separate fine solids from the liquid fraction. Separators (centrifuges) split the liquid fraction into oil and stickwater, and polishing water washes the

crude oil before it is pumped to storage. This step is omitted if the oil content of the fish is <3%.

5. **Evaporation**: Stickwater is a mixture of water, suspended and dissolved solids, salts and fat, containing about 8-10% total solids made up of 5.6% protein, 0.6% fat, 1.8% ash and 92% moisture. If the factory uses steam dryers, then the waste heat from the dryer can be used to heat and evaporate the stickwater. The stickwater passes through evaporators to reduce its volume and form a concentrate. A typical steam drier contains coils through which super-heated steam passes. These coils raise the temperature to 90°C (controlled by flow rate).
6. **Drying**: The solids from the decanter separation and the press cake are mixed and partially dried. The partially dried fishmeal is mixed with concentrated stickwater and the drying is completed to 10% moisture. Modern factories use steam and indirect hot air dryers, but older factories still use the direct fired hot air dryers. Low temperature driers such as indirect hot-air or vacuum driers, operate at lower temperatures and use less energy (IFFO - International Fishmeal and Fish Oil, 2017).
7. **Grinding**: Grinding of the meal into a desired particle size involves the meal passing through a vibrating screen furnished with a magnet, to remove extraneous matter like pieces of wood and metal (for example, fish hooks), before entering the hammer mill (FAO, Fishery Industries Division, 1986).
8. **Cooling and stabilization**: The fishmeal is cooled and antioxidant is added, usually ethoxyquin, although certain markets prefer natural antioxidants based on tocopherols.
9. **Packaging**: The fishmeal is packed in 50 kg bags or 1000 kg totes. Alternatively, the fishmeal can also be stored in a holding and blending silo before bagging, pelleting, or storing in bulk.
10. **Optional fish oil carbon treatment**: If the crude fish oil is destined for the omega-3, animal feed, aquaculture or pet food market and if analysis indicate the presence of dioxins, furans and or polyaromatic hydrocarbons, it can be treated with activated carbon to reduce the levels of these compounds.

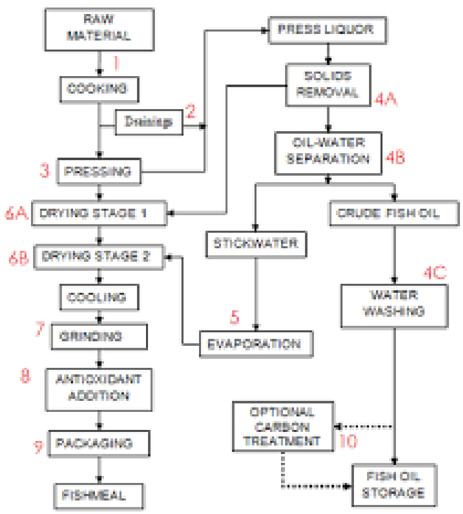


Figure 3-4: The Wet Reduction processing steps to produce fish oil and fishmeal from fish and fish cuttings (Bimbo, 2011; FAO, 1986) (Kasmiran, 2018)

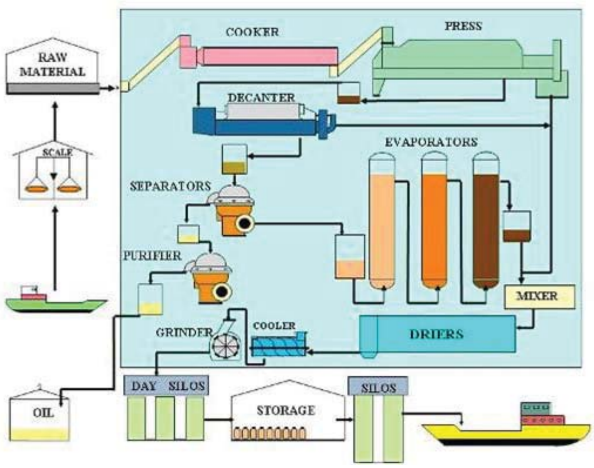


Figure 3-5: Graphical depiction the flow process of fishmeal and fish oil production (IFFO - International Fishmeal and Fish Oil, 2017)

To prevent odour, factories can be deodorised by air suction from all tanks and machinery. The air passes through a scrubber and is then burned in the steam boiler or treated with chlorine, after which a further scrubber removes residual chlorine.

Fish by-products and offal constitute 70% of the fish used in industrial processing (FAO, 2018). Historically these had been wasted or used directly as feed for aquaculture, livestock, pets or animals. However, more recently the value of fish by-products is realised:

- Heads, frames and fillet cut-offs and skin can be used directly as food or processed into fish sausages, cakes, snacks (crispy snacks, nuggets, biscuits, pies), gelatine, sauces and other products for human consumption;
- Small fish bones, with a minimum amount of meat, are consumed as snacks in some Asian countries;
- By-products are also used in the production of feed (not only in the form of fishmeal and fish oil), biodiesel and biogas, dietetic products (chitosan), pharmaceuticals (including oils), natural pigments, cosmetics and constituents in other industrial processes;
- Some by-products, in particular viscera, are highly perishable and should therefore be processed while still fresh. Fish viscera and frames are a source of potential value-added products such as bioactive peptides for use in food supplements and in biomedical and nutraceutical industries;
- Shark by-products (cartilage, but also ovaries, brain, skin and stomach) are used in pharmaceutical preparations and reduced to powder, creams and capsules.
- Fish collagens are used in cosmetics and in extraction of gelatine.

Optional fish oil carbon treatment:

As mentioned, crude fish oil contains mono-, di- and triacylglycerols along with impurities (non-triglyceride substances), which need refining. The objective of refining is to remove the contaminants that could affect the quality of the oil, thereby reducing the shelf life and consumer acceptance. The refining process is tailored according to the composition of the crude oil and other variables such as fish species, geographical location of the source and extraction method (Vaisali et al., 2015). If the fish oil is destined for the omega-3, animal feed, aquaculture or pet food market, activated carbon treatment is applied. The general steps involved in refining crude marine oils include (Kasmiran, 2018):

a) *Carbon treatment*: (optional) performed on the starting crude oil if the oil is to be sold on the non-industrial market. The treatment is to ensure the removal of dioxins, furans, and polyaromatic hydrocarbons (PAH);
b) *Oil storage*: insoluble impurities, trace moisture and some phospholipids will precipitate out in the tanks (combination is known as "foots");
c) *Degumming*: removes phospholipids, sugars, resins, proteinaceous compounds and trace metals along with other slimy substances;
d) *Alkali refining*: alkali, e.g. sodium hydroxide is added to the degummed oil to precipitate the volatile fatty acids, pigments, phospholipids, oil insoluble material, water soluble material and trace metals as soap stocks, which are removed by centrifugation or water washing;

e) *Water washing/silica treatment*: water is added to the oil, mixed and left to separate the water from the oil resulting in saturation of the water with contaminants like soaps, oxidation products and trace metals;
f) *Drying*: remove moisture from the oil;
g) *Adsorptive bleaching & carbon treatment*: bleaching clays and/charcoal is added to the oil to remove many minor impurities like colour compounds, oxidation products, trace metals, phospholipid remains, sulphur compounds, dioxins, furans, PAH and possibly some polychlorinated biphenyls (PCBs);
h) *Winterisation*: the process of winterisation consists of a crystallisation (or partial solidification) by cooling the oil, followed by a separation of solids (higher melting triglycerides, waxes) which can be scooped or filtered out. This is used to enhance the unsaturated triglycerides;
i) *Deodorisation*: is generally carried out by a conventional steam distillation process where compounds like free fatty acids, mono-diglycerides, aldehydes, ketones, chlorinated hydrocarbon and pigment decomposition products are removed. Based on the vapour pressure and volatility at high temperature (180˚C-220˚C) the components are stripped from the oil. This is usually the finishing step and results in a bland tasting oil;
j) *Vacuum stripping or thin film, molecular or short path distillation*: Removal of chlorinated hydrocarbons, fatty acids, oxidation products, PCBs and free cholesterol. Sometimes this step is used as a replacement for the deodorization step;
k) *Packaging:* The final refined oil, either vacuum distilled and or deodorized fish oil, is packaged into microencapsulation, soft gelation capsules and bottles.

3.5 Quality Assurance

Most factories operated by IFFO Members Hazard Analysis Critical Control Points (HACCP), have quality checks in place to ensure safe production and assured quality. This system involves independent inspectors who ensure critical control points are identified and controls monitored and recorded, e.g. product temperature, moisture, microbial count, etc. Any deviation outside tolerance limits is investigated and resolved with full documentation for future reference (IFFO - International Fishmeal and Fish Oil, 2017).

Producers supplying markets within the EU are encouraged to adopt the International Feed Standard Alliance (IFSA) quality assurance scheme, which covers quality assurance from raw material through the factory, storage and transport to the end user. The scheme includes the Dutch Good Manufacturing Practice (GMP)+ and UK Femas schemes and is expected to become the main quality assurance scheme for raw materials across Europe and elsewhere (IFFO - International Fishmeal and Fish Oil, 2017).

4 WATER AND WASTEWATER MANAGEMENT

Fish processing is a water-intensive industry and as such, the water consumption and the production of high-strength wastewater is of concern worldwide (Chowdhury & A.Srinivasan, 2010). Large amounts of water are used during all processing steps, including cleaning, cooking, cooling, sanitisation and floor washing. These processes typically require a source of high-quality water at a considerable cost to the facility. At the end of the processing chain, wastewater and residues are produced and need to be treated and/or disposed. The principal financial issues associated with water and effluent management are the direct costs associated with:

- Water supply – payment to water suppliers, costs of abstraction from groundwater or surface water bodies, sampling and analytical costs; and
- Treatment of waste streams (European Bank for Reconstruction & Development, 2009).

4.1 Raw Water

Historically, fish processing typically requires the provision of high-quality raw water either through deep offshore extraction of sea water, municipal water supplies, abstracting and treatment of surface water or using groundwater. Water is used for holding and transporting fish to the landing point, for holding and transporting fish on land, for cleaning equipment and work areas, and for fluming offal and blood. Automated processing equipment generally has water sprays to clean equipment and to flush offal away (COWI Consulting Engineers and Planners AS, Denmark, 1999).

European Directive 98/83/EC identifies the parametric water quality values that are to be met by water intended for human consumption or used in food-processing industries. This directive allows wastewater reuse during the industrial process, but requires that water must meet or be treated to meet the following standards:

Table 4-1: Parametric values established by the European Directive 98/83/EC for water intended for human consumption or used in food-processing industries (Raquel O. Cristovao, 2015).

Parameter	Unit	Parametric value
Aluminum as Al	mg/l	200
Ammonium as NH_4		0.50
Calcium as Ca	mg/l	-
Chlorides as Cl	mg/l	250
Clostridium perfringens (including spores)	N/100 mL	0
Color as PtCo	mg/l	20
Conductivity	mS/cm, 20°C	2500
Total hardness as $CaCO_3$	mg/l	-
pH	units	≥ 6.5 - ≤ 9
Iron as Fe	mg/l	200
Magnesium as Mg	mg/l	-
Manganese as Mn	mg/l	50
Microcystin – full LR	mg/l	1

Parameter	Unit	Parametric value
Smell, 25°C	Dilution factor	3
Oxidability as O_2	mg/l	5
Sulphates as SO_4	mg/l	250
Sodium as Na	mg/l	200
Flavour, 25°C	Dilution factor	3
Colony-forming units	N/ml, 22°C	without abnormal change
Coliform bacteria	N/100 mL	0
Total organic carbon (TOC) as C	mg/l	without abnormal change
Turbidity	UNT	4
α-total	Bq/l	0.5
β-total	Bq/l	1
Tritium	Bq/l	100
Total indicative dose	mSv/year	0.10
Residual disinfectant	mg/l	-

A 2008 study identified similarities and differences between the South African National Standard for drinking water and drinking water standards of the Netherlands, the EU and the WHO guidelines. The comparison was made on the concentration limits of health-related chemical parameters that are reported in all four of the guidelines, as summarised in Table 4-2: Health Related Chemical Parameters (inorganic) (Mamba, 2008)

Table 4-2: Health Related Chemical Parameters (inorganic)

Determinand	Unit	WHO max limit	EU max limit	NL max limit	SA max limit
Aluminium	µg/ℓ	200	200	200	300
Ammonia	µg/ℓ	No guideline	500	200	1000
Antimony	µg/ℓ	5	5	5	10
Arsenic	µg/ℓ	10	10	10	10
Bromate	µg/ℓ	Not mentioned	10	1*	Not mentioned
Chromium	µg/ℓ	50	50	50	100
Copper	mg/ℓ	2	2	2	1
Iron	µg/ℓ	300	200	200	200
Lead	µg/ℓ	10	10	10	20
Manganese	µg/ℓ	500	50	50	100
Mercury	µg/ℓ	1	1	1	1
Nickel	µg/ℓ	20	20	20	150
Sodium	mg/ℓ	200	200	150	200
Zinc	mg/ℓ	3	Not mentioned	3	5
Chloride	mg/ℓ	250	250	150	200
Cyanide	µg/ℓ	70	50	50	50
Fluoride	mg/ℓ	1.5	1.5	1.1	1
Sulphate	mg/ℓ	500	250	150	400
Selenium	µg/ℓ	10	10	10	20
Nitrate	mg/ℓ	50 (as total N)	50	50	10 (as total N)
Nitrite	mg/ℓ	50 (as total N)	0.5	0.1	10 (as total N)

** With disinfection a maximum of 5 µg/ℓ is allowed (as 90 percentile value with a maximum of 10 µg/ℓ)* (Mamba, 2008)

Table 4-3: Health related Chemical Parameters (Organic) (Mamba, 2008) (Mamba, 2008) represents the determinands that are organic chemical compounds found in drinking water. The WHO limits had not been included as these guidelines list the individual organic compounds without classifying such (Mamba, 2008).

Table 4-3: Health related Chemical Parameters (Organic) (Mamba, 2008)

Determinand	Unit	NL max limit	EU max limit	SA max limit
Polycyclic aromatic hydrocarbons (PAHs) (sum)	µg/ℓ	0.10	0.1	Not mentioned
Trihalomethanes (sum)	µg/ℓ	25	110	200
Polychlorinated biphenyls (PCBs) (individual)	µg/ℓ	0.10	Not mentioned	Not mentioned
PCBs (sum)	µg/ℓ	0.50	Not mentioned	Not mentioned
Pesticides (individual)	µg/ℓ	0.10	0.1	Not mentioned
Pesticides (sum)	µg/ℓ	0.50	0.5	Not mentioned
Tetra- and tri-chloroethene (sum)	µg/ℓ	10	20	Not mentioned
Vinyl chloride	µg/ℓ	0.50	0.5	Not mentioned
Dissolved organic carbon (DOC) Total organic carbon (TOC)	mg/ℓ	*	*	10

** No abnormal changes*

The guideline values given in the two tables above represent an upper limit of the concentration of individual chemical species that does not exceed tolerable risk to the health of the consumer over a lifetime of consumption (Mamba, 2008).

A conclusion of the study was that the EU drinking water standard, though not as strict as that of the Netherlands, on the whole falls within the guidelines of the WHO. The South African drinking water standard was found to be least strict compared to the other standards. Furthermore, the South African standard gives allowances to exceed the operational maximum limits within a given time period. The study recommended that the organic chemical determinands be included in the South African standard and that the limits be set for the individual groups of these moieties (Mamba, 2008).

4.2 Water Consumption

Several factors impact on the rate of water consumption, including the scale and age of the plant, the type of processing, the level of automation, ease with which equipment can be cleaned, operated and maintained, as well as operator practices. In the Sector Guide published by the United Nations Environment Programme – Division of Technology, Industry and Economics (UNEP DTIE) and the Danish Environmental Protection Agency report, "Cleaner Production Assessment in Fish Processing", typical figures for fresh water consumption per ton of fish intake are (COWI Consulting Engineers and Planners AS, Denmark, 1999):

- 5-11 m^3/ton for fish filleting;
- 15 m^3/ton for canning;
- 0.5 m^3/ton for fish meal and oil production;
- Fish meal and oil production also consumes about 20 m^3/ton of seawater per ton of fish intake.

Turkey is an example of excessive water consumption per ton of fish intake, prior to the implementation of cleaner production opportunities (Water Scarcity Solutions & 2030 Water Resources Group, 2016), reporting consumption rates of:

- 28.4 m^3/ton during thawing (defrosting with water) and gutting.

In a Thailand case study, the water consumption in canned tuna (pet food) processing was 13.0 m^3/ton of raw material. The major sources of wasted water being the spray cooling process (4.7 m^3/ton) and equipment and floor washing (4.5 m^3/ton). Water conservation measures were implemented at three of the processing steps, being:

- installation of pressure spraying nozzles for spray cooling;
- use of hot water (60°C) instead of cold water;
- reduced amount water used (opening the valve only 45°C) for can washing;
- educating the plant personnel on water conservation for equipment and floor washing.

After the conservation measures had been implemented, water consumption was reduced by 66%, 55% and 14% across the three process units, respectively, reducing the net water consumption from 13 to 8.8 m^3/ton of raw material, representing a 32% reduction in overall water consumption (Munlika Uttamangkabovorn, 2003). The results per process unit, before and after conservation, are summarised in the table following:

Table 4-4: Water consumption in canned tuna (pet food) process before and after the implementation of the water conservation measured (Munlika Uttamangkabovorn, 2003)

Source	Water consumption (m^3/ton of raw material)	
	Before	**After**
Thawing / storage	0.7	0.7
Precooking	0.5	0.5
Spray cooling (after precooking)	4.7	1.6
Can filling	0.4	0.4
Can washing (after seaming)	0.9	0.4
Sterilization	0.6	0.6
Can cooling (after sterilisation)	0.5	0.5
Storage (cleaned tuna)	0.2	0.2
Equipment and floor washing	4.5	3.9
Total	**13.0**	**8.8**

For South Africa, the 2018 Fishing Handbook comments that the 2018 water crisis in the Western Cape was so severe that water survival strategies had to be found to ensure production remained unaffected by stringent water restrictions (George Warman Publications, 2018). Strategies at Pioneer Fishing's two processing plants in Saldanha Bay included stock taken of fresh water usage at each step of the value chain, use of reverse osmosis to recapture water lost in steam cooking, reuse to produce ice to pack fish, and revising factory cleaning protocols and the installation of a 500-ton water tank. In the longer term, the company has supported local government to build a large-scale desalination plant for the benefit of all Saldanha-based industries including the water-intensive aluminium smelters.

At Laaiplek and St Helena Bay, the Oceana Group commissioned two desalination plants of 0.8 Ml/day and 0.6 Ml/day capacity in 2018. The names of the desalination plants being Vukuzenzele Amanzi at St Helena Bay and Umthombo Wethemba at Laaiplek, translated as “make water yourself” and “fountain of hope”, respectively.

Furthermore, Sea Harvest’s Saldanha plant launched its desalination plant and an effluent plant for recycling purposes, delivering 1.15 Ml/day potable water (George Warman Publications, 2018).

4.2.1 Reduce Water Intake by the Industry

Higher efficiencies and better management practices in the fish industry is mostly driven by the increasing cost of water, energy and scarcity in fresh water resources. Key strategies and best practices for reducing water consumption have been document early on in the history of the fish industry (COWI Consulting Engineers and Planners AS, Denmark, 1999). Strategies include technological solutions, equipment upgrade and adopting cleaner procedures and best operator practices. Many of these strategies are still being applied and improved upon, as published by various industries and case studies (Water Scarcity Solutions & 2030 Water Resources Group, 2016):

- closed recirculation system for recycling thawing water;
- water recycling and effluent treatment of the cleaning water where gutting takes place, comprising of screening, sedimentation and floatation, ozonation and recirculation pumps;
- using offal transport systems that avoid or minimise the use of water;
- installing fixtures that restrict or control the flow of water for manual cleaning processes;
- using high pressures rather than high volumes for cleaning surfaces;
- reusing relatively clean wastewaters for other applications; for example, thawing wastewaters could be used for offal fluming or for initial cleaning steps in dirty areas;
- using compressed air instead of water;
- installing meters on high use equipment to monitor consumption;
- using closed circuit cooling systems;
- pre-soaking floors and equipment to loosen dirt before the final clean;
- recirculating water used in non-critical applications;
- effluent treatment and reuse systems including oil separators for fish oil recovery (specifically in pelagic fish processing);
- reporting and fixing leaks promptly.

The Oceana Group reported 30-40% reduction in water consumption at its factories in St Helena Bay and Laaiplek during June 2017-2018, by switching from potable water use to seawater and re-using waste heat condensate for cleaning (Oceana Group, 2018).

5 WASTEWATER PRODUCTION, TREATMENT AND DISCHARGE

A high percentage of water consumed at fish processing plants is ultimately transformed to effluent. The perishable nature of the product leads to high levels of organic waste, phosphates and nitrates discharged through the effluent stream. Effluent sources from the various processes are identified as being:

- Cleaning, beheading, deboning and filleting the fish is water intensive, as food safety and hygiene are essential. Wastewater is generated from the following processes
    - Transport from landing stage to processing point (docks, receiving area and washing area)
    - Thawing/de-icing, grading and scaling
    - De-heading and removal of tails
    - Gutting
    - Freezing
    - Filleting, de-skinning and trimming
    - Boiling (mackerel).
- Further processing includes breading, filling insertions, pickling, canning during which preservatives are added such as salt, vinegar, food oils and/or fats. Liquid wastes include bloodwater and brine from drained storage tanks, and water discharged from washing and cleaning. The salts and fats are also important factors in the choice of a treatment system. Options for dealing with wastewater include:
    - Discharge of wastewater to the municipal sewer
    - Discharging to surface water
    - Reusing of wastewater
    - Valorising of wastewater for extraction of ABPs and oils
    - Sludge treatment.
- Freezing, and to a lesser extent, packaging, storing and dispatching also has effluent production implications.

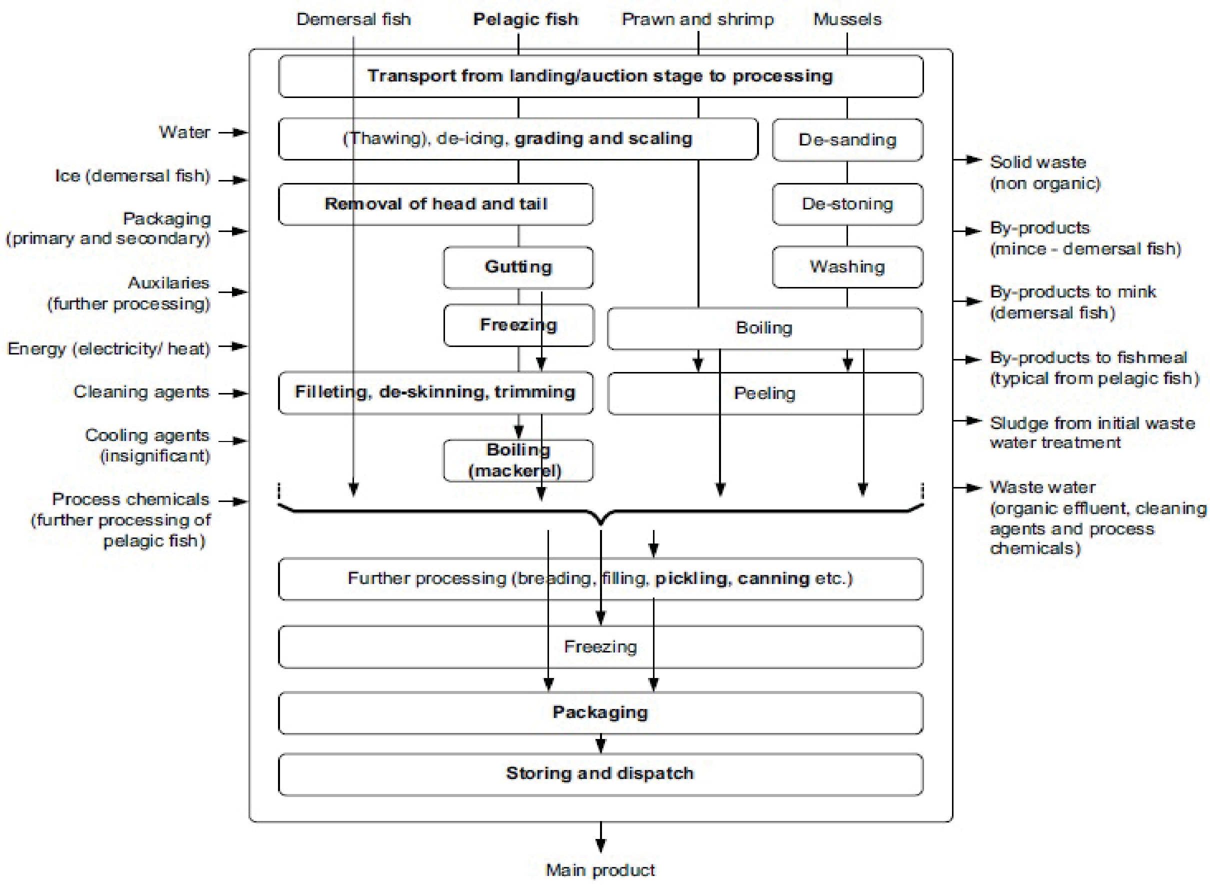


Figure 5-1: Different processes and overview of the main categories of inputs and outputs of the four main product categories (or product chains) in the Danish fish processing industry (Mikkel Thrane, 2009)*

Waste produced during fish processing operations can be solid or liquid. The wastewater thus contains active organic contaminating organisms in soluble, colloidal and particulate form. Pollutant issues typically relate to:

- High solids levels;
- High organic levels;
- Elevated levels of salts;
- Oil and grease;
- Ammonia;
- Cleaning agents (including chlorine bleaches and surfactants).

Depending on the particular operation, the degree of contamination may be small (washing operations), mild (fish filleting), or heavy (bloodwater drained from fish storage tanks). The effluent quality is also dependent on the type of fish being processed, with oily fish species (most often pelagic) contributing higher oil and solids concentrations to the final effluent compared to white fish species, due their oil content and the fact that they are not gutted and cleaned at sea.

The magnitude of waste management requirements therefore depends on the volume of waste generated, the nature of the pollutants, the rate of discharge to the receiving environment, and the capacity of the receiving environment to assimilate the pollutants.

Wastewater treatment is often minimal, with the exception of primary screening and/or filtering to remove solids (European Bank for Reconstruction & Development, 2009). Primary treatments include physical methods such as floatation, screening, and sedimentation to remove oil and grease and other suspended solids. Secondary treatment methods typically include biological and physico-chemical technology.

The Pelagic Industry Processing Effluents Innovative and Sustainable Solutions report on the Nordic regions (2015) reports that only 3,7% of 27 participants from Denmark, Iceland, Norway, Sweden were using advanced wastewater treatment processes. The respondents indicated that >44% use no treatment, >44% use physical processes such as filtration, centrifugation, etc., with <19% using more advanced technologies in treating their wastewater (Nordic Innovation, 2015). The schematic below provides the breakdown of the various treatment technologies used by the survey's participants for wastewater treatment.

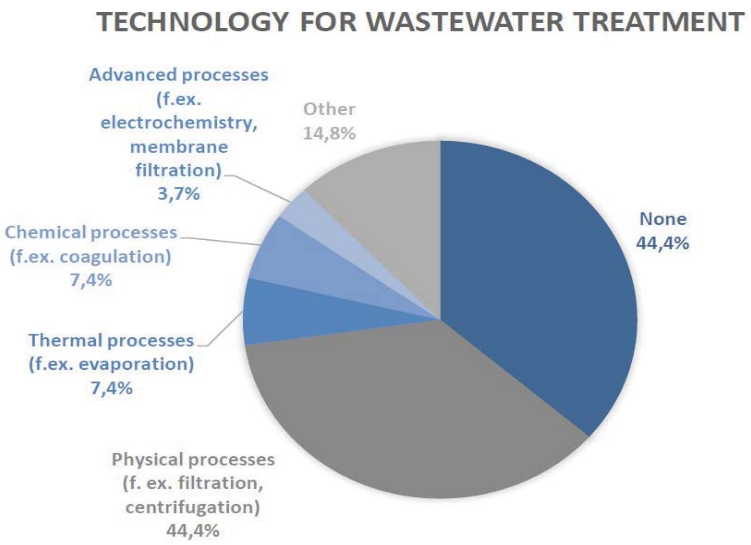


Figure 5-2: Technologies used by participants for wastewater treatment (Nordic Innovation, 2015)

Around 40⁺% of the respondents commented that they would have an interest in treatment technology that would lower COD/BOD more efficiently, whilst >48% indicated an interest in reuse of water (Nordic Innovation, 2015).

5.1 Regulation of Wastewater Discharge

Treated wastewater is typically discharged into local water bodies (freshwater or marine) or into municipal sewers. As fish processing effluents can be toxic to fish and other aquatic organisms, precaution is typically taken to ensure that the receiving waterbody is able to degrade the organic and inorganic waste components without risk to the receiving environment. For this reason, fish processing effluents are a closely regulated industry internationally and in South Africa (DEFF, Rueben Molale interview, 2020).

In South Africa, discharge of fish processing wastewater mainly occurs through marine outfalls. The 2015 DEA report "Status Quo of Effluent Disposal to Marine Environments in South Africa" (WSP & CSIR, 2015) identified known fish processing operations discharging into the marine environment. It is commented that these fish processing facilities are predominately located on the west coast of the Western Cape in Saldanha, St Helena Bay and surrounds and predominantly discharge to the surf zone, with one known estuarine discharge into the Berg Estuary. Fish processing operations typically favour port or enclosed environments (embayment) for operations and logistics (i.e. close to harbours), and therefore although volumes discharged may not be significant, the impact of the discharge is typically into waters with a low dispersive capacity and can lead to high nutrient loading (as BOD) and nuisance issues associated with odours and discoloration.

Table 5-1: Fish Processing Outfalls in South Africa (WSP & CSIR, 2015)

Outfall Name		**Location**	**Discharge Point**
1	Drommedaris Fisheries	Saldanha Bay, WC	Surf Zone
2	Eyethu Fishing (Pty) Ltd	Port Elizabeth, EC	Surf Zone
3	Foodcorp	St Helena Bay, WC	Surf Zone
4	Gansbaai Marine Pty Ltd	Gansbaai, WC	Surf Zone
5	Hannasbaai Fishing Company	St Helena Bay, WC	Surf Zone
6	Jaloersbaai Pty Ltd.	St Helena Bay, WC	Surf Zone
7	Lamberts Bay Foods Limited	Lamberts Bay, WC	Surf Zone
8	Lucky Star Limited	St Helena Bay, WC	Surf Zone
9	Marine Product	Laaiplek, WC	Estuary
10	North Bay Canning	Doring Bay, WC	Surf Zone
11	Ocean Lobster Limited	St Helena Bay, WC	Surf Zone
12	Oceana Lobster Limited	Elands Bay, WC	Surf Zone
13	Oceana Lobster Limited	Hout Bay, WC	Surf Zone
14	Oranjevis	St Helena Bay, WC	Surf Zone
15	Sandy Point Fishing	St Helena Bay, WC	Surf Zone
16	Sea Harvest Corporation Pty Ltd.	Saldanha, WC	Surf Zone
17	Southern Sea	Saldanha Bay, WC	Surf Zone
18	St Helena Bay Fishing	St Helena Bay, WC	Unknown
19	St Helena Bay Fishing*	Stompneusbaai, WC	Surf Zone
20	Suid Oranje Vissery	St Helena Bay, WC	Surf Zone
21	Viking Fishing Company*	Mossel Bay, WC	Unknown
22	Walker Bay Fisheries	Hermanus, WC	Surf Zone
23	West Point Processors / Fishing	St Helena Bay, WC	Surf Zone

**outfall still to be confirmed*

The discharge of treated wastewater is highly regulated internationally, based on an environmental (integrated) permit. This also applies for discharge from a fish processing industry irrespective of the recipient environment, e.g. freshwater, marine water or municipal sewer. Fish processing activities are subject to monitoring and possible enforcement action to ensure compliance with emission standards under the EU Water Framework Directive 2000/60/EC (WDF) and Urban Wastewater Treatment Directive 91/271/EEC (UWWTD). These directives required fish processing facilities to meet the environmental objectives for good ecological and chemical status of surface waters by 2015. In 2019, an evaluation of EU legislation on urban wastewater treatment found the legislation to remain fit for purpose, although its effectiveness could be improved. Findings from both the Joint Research

Centre and the European Environment Agency demonstrated that the regulatory pressure resulted in an improved aquatic environment in the EU, mostly by decreasing nitrogen and phosphorus discharge to rivers and seas by 32% and 44%, respectively (Directorate General Environment, 2019).

Effluent discharge has direct financial implications for the processing plant through (European Bank for Reconstruction & Development, 2009):

- Fees for discharge licenses and permits;
- Monitoring costs;
- Fines and penalties for negative environmental impacts or breaches of permit limits.

In the 2009 Fish Processing Sub-Sectoral Environmental and Social Guideline, the European Bank commented that the costs associated with upgrading facilities to meet industry best practice standards, are prohibitive and that processors have been prepared to pay the penalties imposed by regulators, rather than invest in new systems. More stringent environmental legislation may make this approach less viable and companies may need to spend considerable sums in order to achieve acceptable effluent discharge quality (European Bank for Reconstruction & Development, 2009).

The UNEP DTIE sectoral guide identifies typical ranges for the COD loading in fish processing effluent per ton of fish intake as (COWI Consulting Engineers and Planners AS, Denmark, 1999):

- 50 kg COD/ton for the filleting of white fish;
- 85 kg COD/ton for the filleting of oily fish;
- 116 kg COD/ton for canning;
- 42 kg COD/ton for fish meal and oil production.

Strategies for reducing pollutant load of fish processing effluent focus on avoiding the loss of raw materials and products to the effluent stream by capturing materials before entering drains and using dry cleaning methods. Key strategies included:

- sweeping up solid material for use as a by-product, instead of washing it down the drain;
- cleaning dressed fish with vacuum hoses and collecting the blood and offal in an offal hopper rather than the effluent system;
- fitting drains with screens and/or traps to prevent solid materials from entering the effluent system;
- using dry cleaning techniques where possible, by scraping equipment before cleaning, pre-cleaning with air guns and cleaning floor spills with squeegees.

Waste reduction could occur through more effective recovery of marketable by-products, for example Surimi (a paste made from fish) and flaked fish products created from previously undervalued fish parts, residue and offal. An alternative to produce fish meal and oil, the fish waste can be converted into silage, a nutritious animal feed. Hydrolysed fish wastes can be used for fish or pig meal, as well as fertiliser components.

Valorisation of wastewater from the fish canning industry typically involves blood-water recovery by improving the production efficiency and costs associated with implementation of successful filtration methods (M Hayes, 2019). Fish blood is recovered similarly to that of blood recovered from cattle and other mammals, both in terms of its collection for ABP processing or for food ingredient processing.

The safety and treatment of recovered pelagic blood-waters in terms of the microbial and heavy metal load, is a subject of ongoing research (M Hayes, 2019). It is widely advocated that pelagic processing plants should be designed and operated in a manner that prevents animal by-product (ABP) from entering marine waters by ensuring effective pre-treatment screening. If a plant is only handling Cat3 ABP, then this can be sent to a Cat3 rendering plant. (*Category 3 material is defined in Article 10 of Regulation (EC) 1069/2009. Category 3 materials are considered low risk. Category 3 materials include parts of animals that have been passed fit for human consumption in a slaughterhouse but which are not intended for consumption* (DAERA, 2019)*).*

5.2 Characteristics of Fish Processing Wastewaters

Contaminants present in fisheries wastewater are an undefined mixture of substances, mostly organic in nature. A detailed analysis of each component is often considered impractical and costly. An evaluation of available analyses gives an overall view of the character of the constituents that are present, as follows:

- Physico-chemical;
  - pH
  - Solids content
  - Temperature
  - Odour
- Organic Content;
  - Biochemical oxygen demand
  - Chemical oxygen demand
    - Total organic carbon
- Oil and grease;
  - Varies based on the processing operation and fish species
  - Impact on oxygen transfer in the water, aesthetic undesirable, and reduce capacity of wastewater ducts
  - Measured by extraction with solvent (Standard Methods, 2015)
- Nitrogen and Phosphorous;
  - cause proliferation of algae (algal bloom)
  - concentration is reportedly minimal at most plants.

The 1996 FOA Fisheries technical paper on wastewater in the fishery industry summarises the key characteristics and concentrations of fish processing wastewaters (Gonzales, 1996), as is shown in the table following.

Table 5-2: Characteristics of Fish Processing Wastewaters – Ranges reported in literature (Gonzales, 1996)

Effluent	BOD	COD	Grease/oil	Total solids	Suspended solids	Ref. No.
Finfish processing (manual)	3.32 kg/t		0.348 kg/t		1.42 kg/t	1
Finfish processing (mechanic)	11.9 kg/t		2.48 kg/t		8.92 kg/t	1
Patagonian hake filleting	327-1063 mg/l	550-1250 mg/l	8.3-79.9 mg/l			2
Herring filleting	3428-10000 mg/l		857-6000 mg/l			3 & 4
Tuna canning	6.8-20 kg/t		1.7-13 kg/t		3.8-17 kg/t	1
Sardine plant	9.22 kg/t		1.74 kg/t		5.41 kg/t	1
Blue crab plant	4.8-5.5 kg/t		0.21-0.3 kg/t		0.7-0.78 kg/t	1
Clam plant (mechanic)	5.14 kg/t		0.145 kg/t		10.2 kg/t	1
Clam plant (conventional)	18.7 kg/t		0.461 kg/t		6.35 kg/t	1
Fish meal plant	2.96 kg/t		0.56 kg/t		0.92 kg/t	1
Fishpumping water	2100-7400 mg/l		10-1504 mg/l	14.5-48.2 mg/l		5
Fishpumping water	3050-67200 mg/l		1300-17200 mg/l	18.4-64.9 mg/l		8
Bloodwater (fishmeal plant)	23500-34000 mg/l	93000 mg/l	0%-1.92%	2.4%-6.3%		6 &7
Stickwater (fishmeal plant)	13000-76000 mg/l		60-1560 mg/l	25-62 mg/l		5

Note source data references: 1: Middlebrooks (1979); 2: Gonzalez (1983); 3: Sorensen (1974); 4: Herborg (1974); 5: Cuadros and Gonzalez (1991); 6: Parin et al., 1979; 7: Civit et al., 1982 8: Nemerow (1971)

The wastewater characteristics of canned tuna (pet food) process water has higher COD, TS and SS, compared to that from can-washing and storage processes. The highest pollution load reported was found in precooking wastewater, whereby the fish released high organic content liquid during steaming. Wastewater characteristics in a Thailand canned tuna (pet food) processes are depicted in the table below (Munlika Uttamangkabovorn, 2003).

Table 5-3: Wastewater characteristics in canned tuna (pet food) process (Munlika Uttamangkabovorn, 2003)

Parameters	Storage	Precooking	Spray cooling	Can washing	Storage (cleaned tuna)	Combined Wastewater
pH	7.4	6.4	7.4	8.4	8.8	7.3
COD (mg/l)	4364	66222	7911	45	16	3248
O&G (mg/l)	25	1727	167	20	0	216
TS (mg/l)	4688	57192	6750	308	302	3799
SS (mg/l)	752	7000	599	16	16	742

A South African specialist report provides specific information as to the average wastewater production per ton of seafood processed and confirms the quality to be dependent on the type of seafood being processed. Typical ranges for the COD loading in fish processing effluent per tonne of fish intake for South Africa are similar to those of the UNEP DTIE sectoral guide mentioned above:

- 50 kg COD/ton for the filleting of white fish;
- 85 kg COD/ton for the filleting of oily fish;
- 116 kg COD/ton for canning; and
- 42 kg COD/ton for fish meal and oil production.

The table below provides a South African perspective of the average wastewater production per ton of seafood processed, and the approximate quality of this wastewater depending on the seafood processed (Coastal Environmental Services , 2011):

Table 5-4: Average wastewater production per ton of seafood processed, and the approximate quality of this wastewater depending on the seafood processed (Coastal Environmental Services , 2011)

Type of processing	Water (m^3/ton)	BOD (kg/ton)	SS (kg/ton)	Oil and Grease (kg/ton)
Marine finfish				
-conventional plant	5	3	1-2	0.4
-mechanised plant	14	12	9	2.5
Canned sardine	9	9	5-6	27
Blue crab				
-conventional plant	1-2	5-6	1	0.2-0.3
-mechanised plant	29-44	22-23	12	4-7
Clam plant				
-conventional plant	5	5	10	0.2
-mechanised plant	20	19	6	0.5
Salmon plant				
-conventional plant	4-5	2-3	1-2	0.2-8
-mechanised plant	19-20	45-51	20-25	5-7
Mussel	20-120	60	N/A	N/A

5.3 Treatment of Fish Processing Wastewaters

Fish processing wastewater contains predominantly biodegradable organic matter, high COD and BOD, moderate to high salt and acidity levels, and pathogens. No significant amounts of toxic chemicals have been reported (Hansen and Cheong, 2007) (Nordic Innovation, 2015). Internationally and locally, municipalities receiving the effluent require pre-treatment before discharge into the municipal system (Saldanha Bay Municipality, 2018). Most of the South African municipalities specify effluent quality discharge limits, thereby requiring industries to treat the wastewater in order to meet the guidelines and stringent standards (Refer Section 9.2.3).

Apart from compliance requirements, best management practice and treatment technology are also required in aiming at achieving a safe effluent and sludge which could be disposed, recycled or converted to a value-added product (Coca et al., 2011) (Nordic Innovation, 2015).

A typical purpose-driven treatment process is illustrated in the following flow diagram, showing the preliminary-, primary-, secondary- and tertiary treatment phases and associated technologies:

Raw wastewater →	Pre-treatment →	Primary treatment →	Secondary treatment →	Tertiary treatment →	Sewers or water bodies
Main purpose	Separation of coarse particles	Removal of suspended solids and fats + neutralisation	Eliminate colloids matter and reduce COD, BOD, P, NH_3	Polishing phase - to eliminate defined pollutants	
Main techniques	Mechanical Screening steps	Physical or physical/ chemical - e.g. sedimentation, flotation (+/- chemicals), centrifugation	Chemicals and biological (aerobic or anaerobic processes)	Physical or chemical processes e.g. membranes (MF, UF, RO) or precipitation	

Figure 5-3: Typical treatment process for wastewater from the food industry (Nordic Innovation, 2015)

Observations from literature sources can be summarised as follows, as pertaining to the latest trends in primary, secondary and tertiary treatment phases:

- *Primary treatment* usually includes sedimentation;
- Oil-based effluent need to be subject to the removal of free oils from the emulsion or suspension, typically through gravity or centrifugal separations;
- *Secondary treatment* aims at reducing the organic load through biological treatment (anaerobic and aerobic) and secondary sedimentation;
- High oil-content wastewater is subjected to further secondary treatment through chemical treatment, flocculation (chemical coagulation-flocculation) and membrane filtration (microfiltration (MF) and ultrafiltration (UF)) (Nordic Innovation, 2015) (Raquel O. Cristovao, 2015);
- Membrane separation technologies, specifically ceramic membranes, have distinctive features (M Hayes, 2019):
  - no chemicals required, low use of energy, low processing costs, and easy scale-up,
  - pH resistant (0 to 14), high-temperature applications, can be sterilised, strong and rigid,
  - Polymer membranes currently dominate the wastewater treatment sector, due to their lower price compared to ceramic membranes. However, they need frequent filter replacements and, although designed to resist neutral, acid or basic pH values, not all three ranges are tolerated with the same filter type;
- Ultrafiltration (UF) processes allow for potentially valuable proteins to be concentrated and recycled into the fish meal process, improving its quality and the economic benefits from the raw material, likewise the treated water can be discharged into the sea or reused in the plant;
- The recovery of proteins from the effluents of a fishmeal plant requires an integrated process based on a combination of MF and UF membranes, whereby membrane fouling can be best be managed by using MF as a pre-treatment preceding UF (M Hayes, 2019);

- *Tertiary treatment* usually involves physico-chemical processes to reduce the dissolved organic and inorganic compounds, with the main methodologies being membranes (MF, UF or reverse osmosis (RO)), activated carbon adsorption, ultraviolet (UV) disinfection and/or evaporation;
- These technologies also facilitate the removal of finely dispersed, emulsified and soluble oil fractions in oil-containing effluent.

The reuse of fish canning wastewater is optimised by removing the suspended particles (primary treatment), the organic matter content in the biological aerated reactor (secondary treatment) and finally, the remaining salts and microorganisms (tertiary treatment). Reuse technology is best applied by combining conventional treatments, such as sedimentation, chemical coagulation-flocculation and aerobic biological degradation (activated sludge process), followed by polishing via reverse osmosis RO and UV disinfection (Raquel O. Cristovao, 2015). This research study reports high removal efficiencies of:

- 99.9% for dissolved organic carbon (DOC);
- 99.8% for oil and grease (O&G);
- 98.4% for total suspended solids (TSS);
- above 96% for anions and cations;
- 100% for heterotrophic bacteria (cfu).

The research team reported a high quality final clarified effluent with potential to be recycled or reused in the industrial plant, with significant benefits on pollutant reduction, reduced water intake and cost. Typically, energy and chemicals costs are in the order of 0.85 €/m^3 to produce effluent with recycle value. This is 60% reduction from a baseline cost if the goal is only to meet the legislated standards for effluent discharge. This cost can offset the tap water intake used for the industrial plant costs which approximate 2.1 €/m^3, thereby translating to a significant saving and smaller pollutant footprint (Raquel O. Cristovao, 2015).

6 ENERGY CONSUMPTION

Similar to water use and effluent generation, energy consumption is also dependent on the age of the infrastructure, scale of the plant, level of automation and the range of products being produced. Energy-intensive processes are associated with heat-induced processes such as cooking of canned fish and fish meal, as well as oil production, whereas filleting requires less energy.

The UNEP DTIE sectoral guide identifies typical figures for the energy consumption per ton of fish intake (COWI Consulting Engineers and Planners AS, Denmark, 1999):

- 65-87 kWh per ton fish for filleting;
- 150-190 kWh per ton fish for canning;
- ±32 kWh per ton fish for fish meal and oil production;
- ±32 liters per ton fish of fuel oil.

Different fuels are being used by fishmeal plants, being fuel oil and/or electric power. Most fishmeal plants are connected to a high voltage electrical current from a municipal source and have power substations of their own. Fishmeal plant with indirect drying requires fuel primarily for steam production in the boiler. High energy prices during the last decade have inspired most factories to assess opportunities to implement energy efficiency and to reduce fuel consumption, mostly by improving boiler efficiency, insulation of hot surfaces, recuperation of heat in condensates as well as increased staging in concentration plants. The tables following summarises the estimated fuel oil consumed when press-cake meal and whole meal are produced, as well as the power consumption per ton of processed raw fish (FAO, Fishery Industries Division, 1986):

Table 6-1: Indicative consumption of fuel oil (FAO, Fishery Industries Division, 1986)

Size of plant: raw material (ton/24 h)	Fuel oil consumption per ton of raw material (kg)		
	Press-cake meal	Whole meal	
	Without evaporation plant	With evaporation plant	With additional waste recovery heat
10-60	35	55	-
100-200	34	50	44
250-500	33	48	41
>500	30	45	38

Table 6-2: Indicative Electric power consumption (FAO, Fishery Industries Division, 1986)

Size of plant: raw material (ton/24 h)	kWh consumption per ton of raw material	
	Without evaporation plant	With evaporation plant
10-60	30	35
100-200	28	33
250-500	26	31
>500	25	30

Substantial energy savings have been achieved, relatively rapidly with little or no capital investment, by implementing the following energy efficiency solutions:

- implementing switch-off programs and installing sensors to turn off or power down lights and equipment when not in use;
- improving insulation on heating or cooling systems and pipework;
- favouring more efficient equipment;
- improving maintenance to optimise energy efficiency of equipment;
- maintaining optimal combustion efficiencies on steam and hot water boilers;
- eliminating steam leaks;
- capturing low-grade energy to use elsewhere in the operation;
- Other options:
    - using more environmentally benign sources of energy,
    - replacing fuel oil or coal with cleaner fuels, such as natural gas,
    - purchasing electricity produced from renewable sources,
    - co-generation of electricity and heat on site,
    - recovering methane from the anaerobic digestion of high-strength effluent streams to supplement fuel supplies.

7 CLEANER PRODUCTION, BAT AND 4TH INDUSTRIAL REVOLUTION

7.1 Cleaner Production (CP)

The UN Environment Programme (UNEP) describes cleaner production (CP) as: ''*...the continuous application of an integrated preventive environmental strategy to processes, products, and services to increase overall efficiency, and reduce risks to humans and the environment.*''

The Danish fish processing industry is considered a pioneer in the implementation of cleaner production and environmental management systems. Danish policies as early as 1980's focused on achieving CP solutions in the fish industry, before adding on end-of-pipe solutions such as discharge to a WWTW as default. The initial focus was on the pelagic segment of the fish processing industry, which produced high organic matter, thus high BOD and COD levels, due to on-land fish gutting and high oil content. Further attention was given to improve environmental management systems (EMS) and occupational health and safety on-site, particularly directed to the reduction of water consumption and wastewater production. The key drivers being high water costs and the introduction of gradually more stringent emission limits for wastewater. After initial focus on water and wastewater aspects, the focus gradually expanded to include energy consumption from 2000 to 2005. CP is viewed as a preventive strategy which address both manufacturing processes and products, and which regards the development of cleaner products as the most radical type of improvement.

The CP approach was characterised by (Mikkel Thrane*, 2009):

- Adoption of CP, instead of (or before) end-of-pipe solutions;
- Focus on water input and wastewater output;
- Focus on 'on-site' problems and solutions;
- A shift from technical CP projects to a focus on organisational aspects (e.g. EMS).

Following on the UNEP understanding, six concepts of solutions are identified:

1) Good housekeeping practice;
2) Reuse and recycling;
3) Substitution of hazardous materials and chemicals, etc.;
4) Process optimisation;
5) Technology change and innovations;
6) Development of cleaner products.

Not all the activities undertaken to achieve CP have been or will be equally effective and may thus require some iterative improvements. Environmental initiatives undertaken include aspects such as:

- Spill prevention (the optimisation of production equipment to increase the utilisation of the fish), fuel switching and separation of fish oil (the use of cyclones for the separation of fish oil from wastewater);
- Removal of tails and head earlier in the production process (e.g. before freezing), which leads to recovery of valuable by-product which is otherwise lost, whilst the tails also contribute to

higher COD levels. The result being reduced COD levels, more waste could be sold as a valuable by-product and increased cold storage capacity;

- Separate fish from water to the extent possible and reduce contact time between fish and water (dry transport of fish; dry removal of guts and skin). The benefit of dry transport impact on water saving, reduced organic matter in wastewater, and increased fish offal that can be sold for fish meal production or pet food. The fish offal becomes dryer and increase in value because less energy is required for evaporation during the production of fish meal;
- Reduce mechanical treatment of fish offal, i.e. extraction of herring roe which is normally wasted. Disruptive technology / machines were developed for this process, with the trademark ensuring a separate royalty income;
- Water consumption reduction was achieved through improved housekeeping practices mainly related to more efficient cleaning procedures, and by raising awareness amongst the staff, e.g. by encouraging staff to record water consumption after each shift/day.

Data from the Danish CP monitoring programme (1989-2005), showed the following achievements (Mikkel Thrane*, 2009):

- Less fish mass had been transformed into COD in the effluent, with COD emissions reduced by a factor 5;
- The average water consumption per ton raw material was reduced with a factor of 2-3;
- No significant reductions in energy consumption were recorded, which was attributed to the "later initiation" of energy reduction processes. Automation had increased and a general tendency existed to include more freezing capacity on the premises instead of using external suppliers.
- In addition, more fish had been taken out as valuable by-products, which included:
    - fish oil (extracted via centrifugation);
    - fish meal and pet food (e.g. extracted from filter conveyor and dry removal of skin and guts, as well as own pet food production plant); and
    - Herring roe (from roe separator rather than discard as waste).

Some of the negative aspects experienced in the initial CP introduction included (Mikkel Thrane*, 2009):

- Experimentation involved advanced filtration involving heat centrifugation, reverse osmosis and nano-filtration, which reduced the effluent levels to almost zero and provided valuable by-products. However, the technology was costly and found to be unreliable;
- Considerable amounts of cleaning agents and energy (electricity) was required. Life Cycle Assessment (LCA) studies indicated that the environmental benefits were eroded by the significant energy consumption, which illustrated the limitations of the end-of-pipe approach.

With the gradual introduction of new emission limits, fish processing companies are provided with an opportunity to adapt to stricter emission limits through preventive solutions. This type of self-regulation has also been promoted through green taxes on water and energy, as well as subsidies to preventive technological solutions and EMS that create the basis for continuous improvements.

7.2 Best Available Techniques

Best Available Technology (BAT) strives to ensure minimum environmental impact without compromising the economic performance of the installation. BATs typically have a strong dynamic character and are highly influenced by scientific and technical progress. BATs are therefore, often selected based on technical feasibility, environmental benefits and economic profitability.

One focus area of BAT involves the implementation of disruptive technologies to reduce water consumption and improved use of waste and by-products from the processing activities. The report "BAT in fish processing industry: Nordic Perspective" (2014), provided input into the EU process under the Industrial Emissions Directive (IED) (*Industrial Emissions Directive (IED 2010/75/EU))* for preparation of the BAT Reference Document in the Food, Drink and Milk Industries (FDM BREF). The Nordic countries obtained positive results on the recovery of fish by-products, with scope for further improvement. Overall, the reference document concluded that fish proteins are valuable and that reuse of the by-products is economical beneficial and is considered an area for future development of BAT (Tomczak-Wandzel, et al., 2015).

One characteristic of the Nordic fish processing industry is that it is constantly being modernised and automated for improved efficiency, quality, environmental protection, and with investments designed to adapt the sector to the available resources and environmental conditions. The aim of this approach is two-fold (Tomczak-Wandzel, et al., 2015):

- to minimise all possible sources of pollution from processing plants; and
- to ensure that the best available technology is used, with limit values set, especially for wastewater discharges.

BATs do not only refer to the technology applied at an installation, but also to the design, build, operation and maintenance of the installation. This mindset and practice is achieving significant savings due to higher productivity, reduced water and energy consumption, as well reduced effluent volumes with improve quality (Tomczak-Wandzel, et al., 2015).

In summary, fish processing activities impact on the environment via:

- Water consumption – all fish processes require large volumes of high quality water for the transportation, production and cleaning of the fish produce;
- Wastewater production – the high demand for water translates to the generation of large volumes of wastewater from several processes, including thawing, washing, gutting, filleting, skinning, canning, smoke processing, fish-food processing and cleaning of the equipment and process areas;
- Solid waste – residues after primary and secondary processing, as well as sludge from the wastewater treatment plant;
- Energy consumption – depending on the installation, equipment and type of fish processing, with the source of energy (from fossil fuels or renewable) also being an important consideration;
- Air emissions;

- Noise and odor.

In lieu of the above, the principles in BAT in the fish processing industry are:

- Quick separation of wastes and process water;
- Elimination of unnecessary usage of water and energy;
- Applying the technology which minimises the usage of water and energy;
- Development and application of new technology and techniques which focus on improving overall environmental performance, without compromising hygiene and food standards.

Consumption and emission targets and benefits can be obtained with BAT and/or CT, as summarised in the following table (Tomczak-Wandzel, et al., 2015):

Table 7-1: Achievable consumption and emission benefits, obtainable with the implementation of BAT and/or cleaner technology (CT) measures in the fish processing industry

Best available technique	Environmental benefit						
	Reduced waste generation	**Reduced water consumption**	**Reduced wastewater generation**	**Reduced odor**	**Reduced energy consumption**	**Minimise losses of raw material**	**Optimise quality of final product**
Minimise storage time of fresh raw material	X			X	X	X	X
Use only high-quality fish though collaboration with upstream suppliers	X					X	
Operate regular maintenance programs	X	X	X		X	X	
Thaw mackerel, whitefish and scrimps in containers with water mixed by bobbling air		X	X				
Avoid scaling of fish if subsequently skinned		10-15 m³/t			X		
When scaling, use filtrated recirculated scaling water for preliminary fish rinsing		<70% reduction					
Remove and transport skin and fat from the skinner drum by vacuum suction		~50% reduction	95-98% COD load reduction				
Operational problems related to cleaning has been experienced		Wash water is needed					
Remove and transport fat and viscera from mackerel by vacuum suction	E.g. by-products for fish-meal production	~50% reduction	30-50% COD load reduction				
Operational problems related to cleaning has been experienced		Wash water is needed					
Use fine mesh filter conveyor belts to transport solid products, by-products and waste to enable their recovery	E.g. by-products sold for fish-meal production	~50% reduction	30-50% pollution load reduction				

Best available technique	Environmental benefit						
	Reduced waste generation	Reduced water consumption	Reduced wastewater generation	Reduced odor	Reduced energy consumption	Minimise losses of raw material	Optimise quality of final product
For filleting: reduction depending on the type of fish processed and which BAT are applied		50-90% reduction	X				
- Remove frames from fish fillets mechanically - Where possible replace nozzles with mechanical devices - Where nozzles or spray cleaning are needed, install presence-activated sensors							
Apply dry collection of solid waste		X	Organic substances reduced				
Apply dry cleaning of equipment			35% BOD reduction for shellfish				

7.3 Fourth Industrial Revolution

The term "Industry 4.0" is applied to strategies of digitalisation and automation of the manufacturing process, based on the integration of disruptive technologies which lead to intelligent, autonomous and decentralised plants ("smart factories") which communicate and cooperate with each other and with humans in real time. The denomination "4.0" stands for the fourth industrial revolution; and is related to a group of emerging technologies with high development potential, such as the Internet of Things, smart manufacturing, cloud computing and artificial intelligence.

Industry 4.0 technologies impact on fish factories predominantly terms of automation, data driven decision making and optimisation, and rethinking the processing steps along the value chain. The use of software platforms is key to gaining full production control, e.g. "Innova Food Processing Software" from Marel Fish. By tracking and analysing data generated by machines in real time, fish processors become more competitive (Marel, 2019).

In a Government Europa Quarterly article titled "*Aquaculture 4.0: applying industry strategy to fisheries management*" Hector Martin of Smalle Technologies explains how the innovative Industry 4.0 technologies is revolutionising the aquaculture industry and fishery management strategies (Government Europa: Maritime & Fisheries News, 2019):

"It is expected that the Industry 4.0 will allow a growth in the European manufacturing sector from 15-20% by 2030, as well as leading to benefits in different areas. For instance, the sustainability and the efficiency in the use of resources in the manufacturing processes can be improved using that approach. Moreover, the integration of consumers in the design and manufacture processes will enable the mass customisation of goods; and human-oriented tools and processes can improve work conditions.

However, the implementation of Industry 4.0 also presents challenges. Some examples of these challenges are the IT security issues that can arise due to the massive exchange of data between manufacturing systems or the required development of broadband industrial communication channels. In addition, the digitalisation of the complete value chain requires companies to share information and decentralise the decision-making process, which is a significant change in the management structure of many plants. The significant investment needed to implement the 4.0 strategies initially can be a general issue for most companies".

8 SOUTH AFRICAN POLICY AND PRACTICE CONSIDERATIONS

Several stakeholders and actors are active in the South African fishing sector, as pertaining to processes, systems and synergies with the international community's water and effluent management strategies.

8.1 Operation Phakisa

Operation Phakisa is a national 'fast-results' delivery programme launched in July 2014 to aimed at assisting to implement the National Development Plan, with the ultimate goal of boosting economic growth and create jobs. The Oceans Economy programme focuses on unlocking opportunities in the fisheries industry and the critical role of marine resources (mainly fishing) in the economy and livelihoods of South Africans (Ismail Akhalwaya - MPSG, 2015):

Figure 8-1: Operation Phakisa: Unlocking the Economic Potential of South Africa's Oceans (Ismail Akhalwaya - MPSG, 2015)

A total of 27 different pressures were identified on the marine and coastal ecosystems, 5 of which are large pelagic long-line fishery, offshore demersal trawl fishery, shipping, oil and gas wells, and reduction of freshwater flow to the coastal and marine environment. Fishing was identified as the biggest pressure on marine ecosystems (National Biodiversity Assessment (NBA 2011)). The LAB explored two aspects of protection:

- environmental protection and surveillance, and
- policing of the oceans.

The proposed Phakisa Marine Protected Areas (MPA) network offers benefits for South Africa's fisheries in terms of net migration (spill-over) of adult fish into adjacent areas and increased export of eggs and larvae, as well as access to new markets through eco-certification (e.g. green fishery certification that enhances exportability).

Operation Phakisa resembles the "Malaysian Big Fast Results Methodology", by having access to "laboratories" consisting of more than 600 South African maritime professionals and experts from 68 institutions. In 2014, this expert group reappraised the South African maritime sector and identified 6 areas with the greatest economic growth and employment potential (Timothy Walker - ISS, 2018):

- Marine Transport and Manufacturing (MTM);
- Oil and Gas (O&G);
- Aquaculture;
- Marine Protection and Governance (MPG);
- Small Harbours Development; and
- Coastal and Marine Tourism.

The laboratories developed detailed plans for expanding each sector which consisted of around 47 detailed initiatives, over 2 900 specific activities and over 400 key performance indicators (KPIs) in total (Timothy Walker - ISS, 2018).

More recently, the Oceans Economy Summary Progress Report (2019) reported that the National Pollution Laboratory (NPL) has been established and is operated by the Walter Sisulu University (WSU) at the Mthatha Campus. The laboratory collects and analyses samples from the coastal provinces, including remote sampling in KZN (Melinda Swift: Oceans Economy Secretariat, 2019). According the 2019 findings, water quality was found to be acceptable, with the exception of high mercury and iron concentrations (Melinda Swift: Oceans Economy Secretariat, 2019).

The establishment of new small harbours, development of coastal properties and redevelopment of proclaimed small harbours have been identified as critical workstreams within in the Small Harbours Mini-Labs workstreams. These harbours refer to the existing 12 Proclaimed Fishing Harbours ((Western Cape) and new Priority Small Harbours in Port Nolloth (Northern Cape), Port St Johns (Eastern Cape) and Port Edward (Kwa-Zulu Natal) (Melinda Swift: Oceans Economy Secretariat, 2019). The report does not clarify the extent of the development in terms of provision for fish processing facilities, management options or potential for aligned industry development, etc.

8.2 Pelagic Sector Stakeholders

A number of stakeholders and organisations are involved in the South African fishing and fish processing industry:

- ➢ FishSA is a voluntary association which consist of various industry sectoral associations, with the purpose of enabling a business environment where members can perform competitively and profitably. Membership includes:
  - South African Deep-Sea Trawl Industry Association
  - SA Midwater Trawling Association

- SA Pelagic Fishing Industry Association (SAPFIA)
- SA Squid Management Industrial Association
- SA Tuna Association
- South Coast Rock Lobster Industry Association
- West Coast Rock Lobster Association
- South East Coast Fishing Industry Association (S.E.C.I.F.A.)
- Fresh Tuna Exporters Association
- SA Patagonian Toothfish Industry Association
- SA Hake Longline Association.

➢ Department of Agriculture, Forestry and Fisheries (DAFF)
- The National Government Department responsible for governance, management, oversight of South African Fishing Industry.

➢ Responsible Fisheries Alliance (RFA)
- A partnership of like-minded organisations working together to ensure that healthy marine ecosystems underpin a robust seafood industry in southern Africa. Formed in 2009, the Alliance members contribute resources and time towards the sharing of information, expertise and competencies to positively effect responsible fishing while influencing policy and fishery governance. Membership includes:
  - I&J
    - I&J is a vertically integrated South African company with substantial investments in fishing, food processing and aquaculture.
    - Woodstock Factory – I&J's major, state-of-the-art fish processing factory is based in Woodstock, a suburb of Cape Town. Here, the processing of natural hake cuts such as fillets, steaks and loins is carried out.
    - VAP including par-fried, char-grilled, coated and microwaveable seafood products are processed at I&J's value-added processing factory, situated in Paarden Eiland, adjacent to Cape Town harbour.
    - A Cold Storage facility is situated in Paarden Eiland, where the finished products are stored and distributed locally and internationally.
  - Oceana Group Ltd
    - Oceana Group is the largest fishing company in Africa.
  - Sea Harvest
    - The Sea Harvest Group is a leading, internationally recognised fishing and food business with operations in South Africa and Australia, servicing retail and foodservice customers in 22 countries.
    - Sea Harvest operates two fresh fish factories one in Saldanha Bay and another in Cape Town that process fresh hake and by-catch species into a variety of chilled and frozen products; and a value-added plant in Saldanha that produces a wide assortment of crumbed, battered and sauced products.
    - Sea Harvest has implemented many short- and medium-term controls at its Saldanha Bay processing facility, which have led to the company reducing its freshwater consumption by 30% since March 2017, compared to the same period in 2016.

The South African Pelagic Fishing Industry Association (SAPFIA) is a legally recognised industrial body which represents a large number of Right Holders who hold approximately 68.6% of sardine rights and 81.7% of anchovy rights in the small pelagic fishing sector. SAPFIA, through their members, have access to 6 canneries, 6 fishmeal and fish oil producers and 12 pack and freeze processors. Membership includes 34 companies, some of which are (full list in Appendix B):

- Balobi Processors (Pty) Ltd
- Cape Pilchard Pioneer Cc
- Community Processors and Distributors (Pty) Ltd
- Eyethu Fishing (Pty) Ltd
- Gansbaai Marine (Pty) Ltd
- Khulani Fishing (Pty) Ltd
- Lucky Star Limited
- Pioneer Fishing (West Coast) (Pty) Ltd
- Premier Fishing Sa (Pty) Ltd
- Terrasan Pelagic Fishery (Pty) Ltd
- Viking Inshore Fishing (Pty) Ltd
- West Point Fishing Corporation (Pty) Ltd

Other stakeholders include the Seafood Companies in South Africa as identified in the Trade-Seafood Industry Directory (full list in Appendix B):

- Artisanal Fishers
  - Representatives of 43 Traditional Fishers, operating for six years, supplying West Coast Rock Lobster (Jasus Lalandi)
- Atlantic Seafood
  - Suppliers of Atlantic cod, anchovies, angelfish, brill, barracuda, black tiger shrimps, cuttlefish, calamari, capelin, caviar, krill, crayfish, Dover sole, Dey fish, eel, flounder, grey mullet, jack mackerel, haddock, hake, halibut, herring, Greenland halibut, horse mackerel, kingklip, langoustines, nephrops, lemon sole, Canadian and European lobsters, rock lobster, Atlantic mackerel, mahi mahi, marlin, monkfish, blue mussels, milkfish, octopus, pangasius, basa, pike perch, plaice, red mullet, striped mullet, redfish, saithe, sardine, seaweed, squid, salmon trout, salmon, pilchards, sardinella, Scottish & Norwegian salmon, seabass, shrimps, seabream, skate, swordfish, tilapia, gurnard, tongue sole, yellowfin tuna, turbot, yellowtail, wolf fish
- Balobi Trading
  - Balobi is a group of companies that own their own fleet of fishing vessels in the Squid, Sardine and Hake fishing Sectors. They catch, process, market, sell and export their own product as well as other fishing vessels product.
- Snoekies Foods
  - Established in 1951, contracted to fishing boats operating off Cape Town and Namibia. Wholesalers and exporters of hake, kingklip, lobster, horse mackerel, red fish, sole, snoek salted, kabeljou, yellow tail, tuna.
- Yulyfish

- Import and export sardine, sardinella, mackerel, horse mackerel, hake, hoki, squid, shrimps, cuttlefish, mahi mahi, dorado, bass, merluza, capelin, herring, alaska pollock, anchovy, cherne, notothenia, pangasius, tongue sole, saury, tilapia, blue shark, yellow fin tuna, skipjack, bonito, octopus, yellowtail, ribbonfish, lobsters, redfish, pomfret, canned fish, dry fish and bait, etc.

8.3 The Role of Key Actors in Water and Effluent Management

A number of major role players can be identified in terms of their prominence and shaping of the sector in terms of water, wastewater and energy management.

8.3.1 SEA HARVEST (Sea Harvest Group, 2019)

Sea Harvest commented that it drives and reports on a number of environmentally focussed actions:

- Adhering to bycatch limitations to protect non-target species, such as kingklip and monk;
- Adhering to sustainable fishing principles under-pinned by the industry's MSC certification;
- Complying with all conditions stipulated in the environmental permits issued to the company and relevant legislation;
- Striving to reduce freshwater consumption to protect this natural resource in a water scarce country.

Water Management

Sea Harvest recognises the impact of climate change on weather patterns, leading to poor rainfall, low dam levels and severe water restrictions in the Western Cape and has subsequently, implemented several short- and medium-term controls at its Saldanha Bay processing facility. These interventions resulted in a 30% reduction of freshwater consumption by March 2017, compared to the same period in 2016.

Sea Harvest is a member of the Saldanha Bay Water Quality Forum Trust, a forum where all environmental issues affecting the Saldanha Bay region are discussed.

Figure 8-2: Sea Harvest Environmental Achievements

Some of the published achievements by Sea Harvest include:

- 71% recycled waste in 2016;
- Total Emissions: 136 031.38 tCO_2eq in 2015;
- 99% Marsh Audit Environmental Score in 2016;
- >30% cumulative saving on freshwater consumption at the Saldanha Bay Processing facility;
- MSC certified.

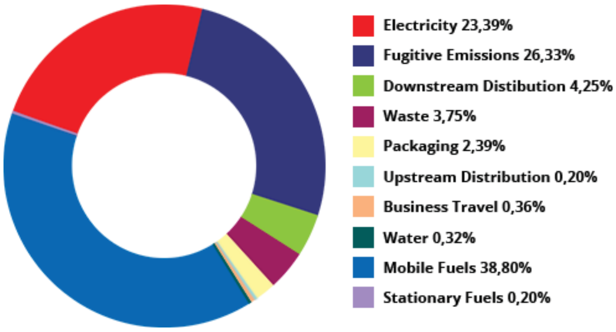


Figure 8-3: Graphic representation of Sea Harvest's environmental reduction achieved.

Fishing

Cape hake, horse mackerel, pilchards and anchovy are caught off the west and south coasts of South Africa, where the unpolluted, nutrient-rich water of the cold Benguela current sweeps up from the Antarctic. Fishing takes place 15 to 120 nautical miles from the shore at depths of up to 800 m, using Sea Harvest's own fleet of single and twin fresh fish trawlers, 6 factory freezer trawlers and purse-seine vessels. Besides Cape hake, horse mackerel, pilchards and anchovy's, the fleet also catches a variety of by-catch species like monkfish, kingklip and snoek.

At sea, fish are headed and gutted on fresh fish trawlers, and packed on ice for delivery to the company's shore-based processing facilities. Sea Harvest processes the fresh catch into fillets, loins, steaks and moulded portions which are quick frozen, locking in taste and texture. A wide range of smoked, coated, crumbed and other value-added seafood products are also produced at the company's land-based processing facilities.

Sea Harvest reports that their state-of-the-art factory-freezer-trawlers catch and immediately process and freeze Cape hake and assorted by-catch species into a range of frozen-at-sea products. Products include Cape hake fillets, headed & gutted (H&G) hake, monkfish tails, other by-catch species and premium fishmeal.

Operations

Sea Harvest is headquartered in Cape Town with regional offices in Johannesburg, Durban and Maputo. Sea Harvest operates a fresh fish factory in Saldanha Bay and in Cape Town that process fresh hake and by-catch species into a variety of chilled and frozen products. A value-added plant is located in Saldanha that produces an assortment of crumbed, battered and sauced products.

8.3.2 OCEANA GROUP LIMITED 2017 (Oceana Group, 2019)

Oceana Group is the largest fishing company in Africa and an important participant in the Namibian, Angolan and US fishing industries. The Group was incorporated in 1918 and is listed on the Johannesburg (JSE) and Namibian (NSX) stock exchanges. Oceana employs 5 225 people, of whom 3 366 are directly employed and 1 889 are indirectly employed (cited: 2019).

Lucky Star: canned fish and fishmeal

The Lucky Star division is predominantly fishing for inshore pelagic species (pilchard and anchovy) and production, marketing and distribution of fishmeal and branded canned fish products, particularly pilchards under the Lucky Star label and pet food under the Lucy Pet brand in Southern Africa. Canned pilchards command a major share of the Southern African market.

Lucky Star owns and manages a versatile fleet (including joint ventures) of six steel, ten wooden and two fibreglass vessels that operate from four ports. The canneries are located at St Helena Bay, Hout Bay and at Walvis Bay in Namibia, with an Oceana joint venture cannery in Velddrift.

Lucky Star: fishmeal and fish oil

Lucky Star's three fishmeal (reduction) plants are located at St Helena Bay, Hout Bay and Laaiplek from where its fleet of vessels operates, targeting industrial fish, particularly anchovy. Fishmeal produced is sold locally and abroad, as product but also as ingredient in animal and aquaculture feed and as fertiliser. Fish oil is used in animal and aquaculture feed and also in the pharmaceutical and chemical industries.

More than 50% of Lucky Star's fishmeal is manufactured to high protein standards and is sought after by feed manufacturers to service the growing offshore mariculture and aquaculture industries. The fishmeal plants are certified by the regulatory agencies of China, the EU, Australia and Middle Eastern countries to enable fishmeal produced to enter the overseas markets.

Production

The fish is harvested in the waters of the Benguela Current and Agulhas Current Marine Ecosystems. Harvesting constraint limits are strictly enforced by government authorities employing sustainable fisheries strategies. Small pelagic fish are targeted by a fleet of 18 purse seine vessels and delivered to one of the three geographically strategically placed plants, thereby ensuring freshness of raw material.

One plant employs indirect hot drying technology, another steam drying technology and the third has two-stage drying consisting of steam and indirect hot air drying, thereby producing a low-temperature (LT) product. Meso-pelagic fish is harvested by one of the four mid-water trawler factory ships. Product that is not frozen is immediately, is reduced to fishmeal with steam drying technology.

Certification and quality

Strict in-house quality control is reported to be maintained with frequent analysis in laboratories, and verified by independent accredited laboratories according to customers' requirements. Products are tested for dioxin and PCBs to ensure that levels remain below the regulated standard.

The South African plants have also implemented FEMAS (Feed Materials Assurance Scheme), which is a third-party assurance scheme that ensures the principles of HACCP and Good Manufacturing Practice are applied during the production process. Rigorous controls are enforced across the process and supply chain, in order to meet international “good practice” and maintain the safety and specification of the feed ingredients. The three plants have International Fishmeal and Fish Oil Organisation (IFFO) Global Standard for Responsible Supply (IFFO-RS) certification, in recognition of responsible sourcing, production and supply practices.

Oceana Lobster

The lobster and squid division includes two specialised business units (SBUs), which share similar attributes in processing and marketing, and where synergies in administration make management more effective and the businesses more profitable. The company places high value on its peer and international recognition of quality product, i.e. live and frozen lobster. Products are marketed to the Far East, Europe, Australia and the USA.

Oceana Lobster Limited is the lobster processing operation of the Oceana Group which exists over 90 years. The factories are situated along the West Coast of South Africa and the Cape Peninsula. The company comments that it operates in accordance with ministerial controls and annual TACs to ensure the sustainability of the resource. These controls include adhering to a minimum carapace length, no fishing during the closed season, complying with catch limits and a prohibition on catching females in berry or soft-shelled specimens.

Oceana Lobster operates a fleet of 9 specialised vessels, catching along a 100 km stretch of South Africa’s coastline, with access to the international airport. The company operates 3 HACCP-accredited processing plants, which produce live, whole frozen, nitrogen frozen lobsters and lobster tails. The complete process is handled in accordance with HACCP standards – from catching and processing, maintaining the cold chain, to arrival in international markets. Research, development and training aims at meeting international standards.

Calamari fishing

The lobster and squid division include two SBUs, with similar attributes in processing, marketing, administration and management. The division is internationally recognised as a producer and exporter of live and frozen South African rock lobster and frozen squid product. Oceana conducts its squid operations through its subsidiary, Calamari Fishing Proprietary Limited (Calamari Fishing), based in Port Elizabeth.

Five of Calamari Fishing’s vessels have converted their on-board sea freezing processors to IQF standard for squid, whereby squid are placed on a tray to be blast frozen to -30°C. The vessels are fitted with sophisticated temperature analysing equipment, sonar plotters, on-board processing, packing and blast freezing equipment. Squid are caught by hand-line jig method between Cape Town and Durban, mainly in the Eastern Cape and immediately blast frozen at sea. The product is landed to an HACCP-accredited factory at Port Elizabeth on South Africa's East Coast to be boxed and sold to Europe and Japan. The main markets are Italy, Spain, Portugal, Greece and Japan. The fishing seasons are from end-November to mid-October.

8.3.3 Irvin & Johnson (I&J)

I&J is a vertically integrated South African company with substantial investments in fishing, food processing and aquaculture. Woodstock Factory, I&J's major, state-of-the-art fish processing factory is based in Woodstock, Cape Town, where the processing of natural hake cuts such as fillets, steaks and loins is carried out. Value-added products such as par-fried, char-grilled, coated and microwaveable seafood products are processed at I&J's VAP factory, situated in Paarden Eiland, adjacent to Cape Town harbour. From the Paarden Eiland Cold Storage facility, the finished products are stored and distributed locally and internationally.

I&J have achieved accreditation from the Marine Stewardship Council (MSC) and been since 2004. In 2012, I&J signed a pledge to WWF-SASSI. This participation agreement is a formal commitment to work with WWF-SASSI to ensure that by 2016 I&J only sells seafood products that are:

- Certified by the Marine Stewardship Council; or
- Green-listed by WWF-SASSI; or
- Certified by the Aquaculture Stewardship Council (for species originating from fish farms); or
- Subject of a time-bound fishery improvement project

The company reports an enduring emphasis on quality resulting in I&J securing accreditation from the world's leading quality assurance organisations including Brand Reputation through Compliance (BRC now BRCGS) and International Food Standard (IFS) (FIS: I&J, 2020). The BRC Standard demands high levels of compliance and the certification programme is vast ranging from food safety planning, site and process controls, as well as gaining management buy in. The International IFS is a unique standard recognised by the Global Food Safety Initiative (GFSI) and developed for all food producers. The IFS was created by German retailers in 2002 with its purpose to verify the safety and quality of products and product compliance with applicable laws and standards. The IFS introduce uniform requirements and transparency in the supply chain, from raw materials to the end product. The company's fishing vessels and processing facilities are EU accredited and HACCP compliant.

8.3.4 Pioneer Fishing

Pioneer Fishing is a trawling and fish processing business that produces a wide range of fish products for local and export markets. The infrastructure includes a fishing fleet, processing factories and engineering services, and it also markets and distributes its products.

The company reports that has the following facilities (FIS: Pioneer Fishing, 2020):

- A modern hake, squid and frozen sardine EU/HACCP factory is operated in Port Elizabeth on the East Coast;
- A modern 1000 ton per day fishmeal/oil and

- A 300 ton per day EU/HACCP sardine canning factory in St Helena Bay on the West Coast.

The Pioneer Fishing group consists of different operating companies, e.g. Pioneer Fishing, Eyethu Fishing, Sea Pride Processors and Oranjevis. Pioneer Fishing owns and operates 2 processing plants in Saldanha Bay. Fresh water usage is monitored across every stage of the value chain. Reverse osmosis is used to recapture water lost during the steam cooking process for reuse from a 500-ton water tank. The reuse water is used to produce ice to pack fish and for cleaning protocols (Fishing Handbook, 2018) (George Warman Publications, 2018).

The Engineering News reported on the Danish funded/CSIR CP project, including white-fish processing factories and 6 pelagic canneries in Oranjevis, in St Helena, as a joint venture between Pioneer Fishing (West Coast), TerraSan Pelagic Fishery and Eyethu Fishing. The company produces canned pilchards, fish meal and fish oil under the Sea Pride brand. A number of modifications was successful with regard to CP at Oranjevis (Stanford, 2004):

- Use of recycled refrigerated seawater to transport the fish from the boat holds to the cannery, at a capital cost of R1,2-million;
- Distribution of the fish to the cutting tables by dry conveyors;
- Reduction in the use of seawater as raw water intake;
- Reduction in organic pollution as the fish is not damaged by mechanical handling or increased temperatures in transfer;
- Energy savings of R163 000 a year as result of decreased use of seawater pumps;
- Installation of high-pressure cleaning sprayers on the blades of the cutting tables;
- Introduction of shut-off valves when the production line is stopped, resulted in freshwater savings and reduction in effluent load;
    - Technology cost of R5 000-R8 000 a table,
    - savings recorded are R3 000 a year.
- Technology was introduced that magnetically lowers the pilchard cans into retort baskets, which replaced the need for water in the retort baskets;
- The magnetic lowerator is saving freshwater, reducing the use of chemical disinfectant and reducing damage to the cans;
    - R85 000 technology cost,
    - freshwater savings of R8 000 a year,
    - improved working environment.

8.3.5 Balobi Trading

Balobi consist of a group of companies that own a fleet of fishing vessels in the squid, sardine and hake fishing sectors, catching, processing and marketing squid, pilchard, hake and line fish. Blast freezers, packing and processing facility and cold storage holding rooms are situated in on the quayside at Port St Francis. The Group produces and supplies fresh, clean flake ice to their own purse sein and long line vessels and for production in the processing facility.

A simple, temperature controlled, hormone free technique is used to ensure quality is preserved. The water used for ice production is tested regularly in the laboratory to ensure it measures up to the highest standard. Specialised blast freezing is applied with a capacity of 40 MT per day, as well as the capacity to generate electricity if required. All suppliers are required to adhere to a strict cold-chain procedure and monitoring system on board and during processing. Fish is being chilled to prevent the formation of histamine and other bacterial infestations.

Infrastructure

The processing factory is located in an 800 m² facility on the quay at the Port St Francis Harbour. The establishment contains the following:

- A 200 m² process area
- Ice plant producing 30 MT flake ice
- Automatic temperature alarms
- 1 x 30 MT holding room at -20°C
- Cutlet machine
- 1 x 12 MT chiller
- Packaging store
- 1 x 40 MT blast freezers
- Standby electricity generator.

The holding room is designed to store product in custom built steel cages which are stackable up to 3 tiers high. This modular concept allows for versatility of storing various sizes and grades of frozen product. In order to optimise use of the limited processing area, a system was designed whereby the processing floor area could easily be changed or reconfigured to suit the various processes that are engaged in.

Quality control

The fish processing facility complies with the EU code CE, is HACCP approved, implements a preventative food safety system in every step in the manufacture, storage and distribution, and food products are scientifically analysed for microbiological, physical and chemical hazards.

The Balobi Group aims to achieve the highest percentage pass rate for annual NRCS audit in the Eastern Cape by rigorous application of the HACCP system. Key staff members are certified HACCP team leaders with defined responsibilities who meet regularly with the HACCP operational team for review of the effectiveness of the system. Seven basic principles are employed in the development of HACCP plans that meet the stated goal. These principles include hazard analysis, CCP identification, establishing critical limits, monitoring procedures, corrective actions, verification procedures, and record-keeping and documentation.

Waste removal

Solid and liquid waste at the facility is removed on an hourly basis during production. Waste removal facilities are placed at strategic points relative to production flow, which is monitored continuously. Cleaning agents and disinfectants are certified by an accredited institute for which certificates are displayed, and detailed records of their suppliers are also kept. Detailed procedures for cleaning and disinfection of processing facilities before, during and after processing are adhered to. A pest control company registered by the Department of Agriculture, controls pests and provides regular updates on industry developments.

9 REGULATORY ENVIRONMENT

9.1 International Regulation of Environmental Permits

Internationally (Europe, Unites Kingdom and Wales, Eastern Europe, Caucasus, and Central Asia (EECCA), USA), environmental (integrated) permits are required for the discharge of treated wastewater. The permit system applies for discharge from a fish processing industry irrespective of the recipient environment, e.g. freshwater, marine water or municipal sewer, and requires information on the following:

- The company;
- Production and the process technology applied;
- Purpose and scope of the present use of water, the amount of wastewater and pollution parameters applicable. This is described in terms of any consumption of water, energy, chemicals, materials, etc. and all emissions (to water, air), waste production and waste management;
- Environmental protection processes applied, including the treatment technology and the amount of wastewater (measurements or estimates).

Fish processing activities are subject to monitoring and possible enforcement action to ensure compliance with emission standards under EU Directive 76/464/EEC and the UWWTD. The EU WFD requires fish processing facilities to meet the environmental objectives for good ecological and chemical status of surface waters by 2015.

9.2 South African Regulatory Framework

The Department of Water and Sanitation (DWS) and Department of Environment, Forestry and Fisheries (DEFF) are the custodians and national regulator of water and water services in South Africa. This is in accordance with the National Water Act (Act 36 of 1998), Water Services Act (Act 108 of 1997) National Environmental Management Act (Act No. 107 of 1998) and, of most relevance to marine and coastal resources, the Integrated Coastal Management Act (2008).

Water Use Licenses, authorisations/ permits and policy are based on the principles of resource protection and the waste management hierarchy. This approach also encapsulates newer global trends around business seeking alternative opportunities around resource recovery, reuse, beneficiation and the broader concept of Circular Economies.

RESOURCE PROTECTION AND WASTE MANAGEMENT HIERARCHY
Step 1: Pollution Prevention
↓
Step 2: Minimisation of Impacts
Water reuse & reclamation
Water treatment
↓
Step 3: Discharge or disposal of waste and/or wastewater
Site-specific risk-based approach
Polluter pays principle

Water Services Authorities are responsible to set standards pertaining to water and effluent management in cities and towns, and to enforce such standards through municipal bylaws and its associated tariffs.

Industry has their own self-regulatory management instruments to ensure best management practice and compliance to environmental and water management performance imperatives. As example, ISO 14001 is the only component of the ISO 14000 series of environmental standards that is required for certification, which require organisation to consider all legal requirements before certification is granted. By promoting ISO certification, the DWS and DEFF are able to extend its capacity to regulate and monitor the water resource, raw water abstraction, water quality and marine discharge.

The section that follows provides a high-level overview of the most pertinent legislation and regulations pertaining to water and effluent management, and also provides an extract of typical industrial effluent charges and conditions as pertaining to marine disposal of effluent that would be applicable to the fishing and fish processing industry in South Africa, and thus also applicable to the pelagic fishing industry.

9.2.1 Industry Standards and Specifications

A number of standards and specifications applies to the industry which includes inherent properties which drive water use improvement in the Fisheries industry. Typically, standards used in the pelagic fishing and fish processing industry in South Africa include:

- ISO 9001: Quality Management;
- ISO 14001: Environmental Management;
- OHSAS 18001: Occupational Health and Safety;
- ISO 31000 – Risk Management
    - For new projects, HAZOP studies are performed by a multi-disciplinary team;
- ISO 50001 – Energy Management;
- ISO 55000 – Asset Management;
- ISO 22301 Business Continuity Management System;

- SANS 10330:2007: Hazard Analysis and Critical Control Point System (HACCP System);
- ISO 22000 certification – Food Safety Management System (HACCP is focused on food safety, ISO also includes business processes and structures);
- International HACCP Certification – referring to Hazard Analysis and Critical Control Points an internationally recognised, science-based, food safety system that is used to help ensure the manufacture of safe food products. This standard focuses on preventing problems before they occur, rather than trying to detect failures through end-product testing. HACCP methodology has been standardized internationally by the Codex Alimentarius Commission. The information provided by Codex is used around the world in the development of HACCP programs (e.g. SANS 10330);
- BRC Global Standards: a safety and quality certification programme to guarantee the standardisation of quality, safety and operational criteria and ensure that manufacturers fulfil their legal obligations and provide protection for the end consumer;
- SANS 17025 – Sampling accreditation;
- SANS 0241 – Applies as potable water supply is used as raw input water;
- SANS 587:2017: Edition 3 – South African National Standard for Canned fish, canned marine molluscs and canned crustaceans, and products derived therefrom;
- FEMAS – Refers to Feed Materials Assurance Scheme, a third-party assurance scheme that ensures the principles of Hazard Analysis (HACCP) and Good Manufacturing Practice are adequately applied during the production process;
- IFFO-RS certification – IFFO Global Standard for Responsible Supply (IFFO-RS) certification. IFFO recognises the importance of responsible sourcing, responsible production and responsible supply practices;
- Increasingly, market trends are influenced by consumer awareness programmes like the WWF's Southern African Sustainable Seafood Initiative (SASSI), and eco-labels like the Marine Stewardship Council (MSC). These programmes ensure that products come from sustainably managed resources that provide environmental, social and economic benefits (Seafish.org, 2019).

9.2.2 National Legislation

National government promulgates Acts, Regulations, Policies and Frameworks, and set norms and standards whereby compliance is monitored and regulated. A summary of the relevant legislation is provided in the table following.

Table 9-1: National Legislation relevant to water and effluent management in the pelagic fish processing industry

Gov. Dept.	Regulation	Sector covered and applicable area to Industry	Main aspects	Of note to Industry
Justice and Constitutional Development	The Constitution of the Republic of South Africa, 1996 (Act 108 of 1996)	All industries: All aspects of water use and discharge	Supreme law of the Republic of South Africa providing and confirms a number of rights as well as provides the overarching legislative foundation for environmental management in South Africa.	Enshrines the concept of sustainability; specifying rights regarding the environment, water, access to information and just administrative action.
Environmental Affairs	Environment Conservation Act, 1989 (Act 73 of 1989)	All industries: All aspects of water use and discharge	This Act has largely been replaced by the National Environmental Management Act, 1998 (NEMA).	Sections specifically relevant to the industrial water and wastewater management are: • 21. Identification of activities which will probably have detrimental effect on the environment; • 26. Regulations regarding environmental impact reports.
	National Environmental Management Act, (Act 107 of 1998)	All industries: All aspects of water use and discharge	Reinforces the constitutional rights and promotes reasonable legislative and other measures that: • prevent pollution and ecological degradation; • promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development	• Development must be socially, environmentally and economically sustainable; • Waste must be avoided. or where it cannot be altogether avoided, minimised and re-used or recycled where possible and otherwise disposed of in a responsible manner; • Development, use and exploitation of renewable resources and the ecosystems of which they are part do not exceed the level beyond which their integrity is jeopardised; • Environmental management must be integrated, pursue the selection of the best practicable environmental option, e.g. option that provides the most benefit or causes the least damage to the environment as a whole, at a cost acceptable to society – in the long- and short term; • "Polluter pays" principle, whereby the 'Waste Discharge Charge System' applies; • Pollution prevention is everybody's responsibility and environmental pollution or degradation, in so far as it is

Gov. Dept.	Regulation	Sector covered and applicable area to Industry	Main aspects	Of note to Industry
				authorized by law or cannot reasonably be avoided or stopped, must be minimised and rectified; • Management of Emergency incidents
	National Environmental Management: Waste Act, (Act 59 of 2008)	All industries: Production process, waste & wastewater minimisation, resource recovery, waste & wastewater discharge	Reforms the law regulating waste management in order to protect health and the environment by providing reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development; It provides for compliance and enforcement; and for matters connected therewith.	• Sets norms and standards on a national and provincial level; • Outlines the requirements for waste management plans; • Outlines waste management measures such as reduction, reuse, recycling and recovery; • Storage collection and transportation; • Treatment, processing and disposal; • Licensing requirements; Remediation of contaminated land and registration on the waste information system.
	No.35572 – Notice 614 Of 2012: Waste Classification and Management Regulations, 10 Augustus 2012	All industries: Production Process, waste & wastewater minimisation, resource recovery, waste & wastewater discharge	• Defines the regulation of the classification and management of waste in a manner which supports and implements the provisions of the Act; • Establishes a mechanism and procedure for the listing of waste management activities that do not require a Waste Management License; • Prescribes the requirements for the disposal of waste to landfill; • Prescribes the requirements and timeframes for the management of certain wastes; and • Prescribes the general duties of waste generators, transporters and managers.	• Requirement to classify waste ito SANS 10234 and period of re-classification; • Management of waste and recording of hazardous waste, e.g. safety data sheet, labelling, etc.; • Conditions of mixing and treating waste is linked to the potential for re-use, recycling and waste recovery; • Assessment and disposal of waste in accordance with the *Standard for Assessment of Waste for Landfill Disposal;* • Motivation for- and consideration of listing Waste Management Activities that do not require a Waste Management License; • Requirements regarding record keeping and waste manifest system; • Prescribes the general duties of waste generators, transporters and managers.
	National Environmental Management: Waste Amendment Act, 2014 (Act No. 26 of 2014)	All industries: Production process, waste & wastewater minimisation, resource	To amend the National Environmental Management: Waste Act, 2008, so as to:	The amendment of the Waste Act, brought with it changes to key definitions contained therein. Most notable in this respect were the changes to the definition of 'waste' itself, as well as that of 'recovery'.

Gov. Dept.	Regulation	Sector covered and applicable area to Industry	Main aspects	Of note to Industry
		recovery, waste & wastewater discharge	• to establish a pricing strategy for waste management charges and to provide for the content and application of the pricing strategy; • to establish the Waste Management Bureau and provide for the objects, functions, funding, financial management, reporting and auditing, immovable property and manner of operation thereof.	The definition of waste has been amended to remove the previously applied exclusion of 'by-products' from the definition thereof, and has furthermore been linked to two non-exhaustive lists of hazardous (Category A) and general (Category B) waste streams/industry sectors under "Schedule 3 Defined Wastes" to the Waste Amendment Act.
	National Environmental Management: Integrated Coastal Management Act (No24 of 2008) (and amendments)	All water users impacting on coastal environment and or utilising coastal resources	The ICM Act establishes the statutory requirements for integrated coastal and estuarine management in South Africa and include norms, standards and policies associated with it.	Of specific interest to the industry is *Chapter 8: Marine and Coastal Pollution Control section 69: Discharge of effluent into coastal waters*, relating to Authorisation and action required for obtaining authorisation & the conditions under which authority for discharging of effluent that originates from a source on land into coastal waters may be granted. According to section 69 of the ICMA, any person who intends to discharge effluent that originates from land-based sources needs to obtain authorisation through a Coastal Waters Discharge Permit (CWDP) or a General Discharge Authorisation (GDA). The CWDP is intended to regulate high risk effluent, whilst the GDA is intended to regulate low risk effluent.
	National environmental management: air quality act, 2004 (act no. 39 of 2004)	All industries: All aspects of production	To reform the law regulating air quality in order to protect the environment by providing reasonable measures for the prevention of pollution and ecological degradation; to provide for national norms and standards regulating air quality monitoring, management and control by all spheres of government.	• Encourages the implementation of cleaner production and clean technology; • Identifies priority areas and the management thereof; • Listing of activities resulting in atmospheric emissions; • Pollution prevention plans; • Measures in respect of dust, noise and offensive odours; • Licencing of listed activities.
	No 1210 – National ambient air quality	All industries	Sets limits for SO_2, NO_2, particulate matter (PM10), Ozone, Benzene, lead and carbon monoxide emissions.	Could impact on the choice of technology used in industry and wastewater treatment processes.

Gov. Dept.	Regulation	Sector covered and applicable area to Industry	Main aspects	Of note to Industry
	standards, 24th December 2009			
	Act No. 20 of 2014: National Environmental Management: Air Quality Amendment Act, 2014	All industries	To amend the National Environmental Management: Air Quality Act, 2004, so as to substitute certain sections. Some of the changes relate to: • the establishment of the National Air Quality Advisory Committee; • to provide for the consequences of unlawful commencement of a listed activity; • to provide for monitoring, evaluation and reporting on the implementation of an approved pollution prevention plan; • to clarify that applications must be brought to the attention of interested and affected parties soon after the submission to the licensing authority; • to provide for a validity period of provisional atmospheric emission License; • to create an offence for non-compliance with controlled fuels standards; • to provide for the development of regulations on climate change matters and the procedure and criteria for administrative fines.	Of specific note to industry is the following: • Industries operating without the required atmospheric emissions Licenses (AELs) will now be required to apply for retrospective authorisation of their activities and could be liable for a maximum administrative fine; • Where an air emission activity is also classified as a Listed EA Activity and a waste management activity under the Waste Act, potential for an integrated License if the competent authority is authorised to issue EAs and WMLs under NEMA and the Waste Act respectively; • Time period placed on the validity of a provisional atmospheric emission License.
Water and Sanitation	**National Water Policy for South Africa – White Paper (April 1997)**	All water users	Sets out the policy of the Government for the management of both quality and quantity of South Africa's water resources. The first step in the review of the National Water Act of 1956.	

Gov. Dept.	Regulation	Sector covered and applicable area to Industry	Main aspects	Of note to Industry
	National Water Act – 1998 (No. 36 of 1998)	All water users	It is the primary statute providing the legal basis for water management in South Africa and has to ensure ecological integrity, economic growth and social equity when managing and using water. Provides the legal framework for the effective and sustainable management of SA water resources that is rivers, streams, dams, and ground water. It contains rules about the way that the water resource (surface and ground water) is protected, used, developed, conserved, managed and controlled in an integrated manner. The NWA introduced the concept of Integrated Water Resource Management (IWRM), comprising all aspects of the water resource, including water quality, water quantity and the aquatic ecosystem quality (quality of the aquatic biota and in-stream and riparian habitat). The IWRM approach provides for both resource directed and source directed measures: • Resource directed measures aim to protect and manage the receiving environment; • Source directed measures aim to control the impacts at source through the identification and implementation of pollution prevention, water reuse and water treatment mechanisms. The integration of resource and source directed measures forms the basis of the hierarchy of decision-taking aimed at protecting the resource from waste impacts.	Of specific interest to Industry are: • Chapter 1 Interpretation and fundamental principles; • The section dealing with how water will be protected, used, developed, conserved, managed and controlled; ○ Chapter 2 Water management strategies ○ Chapter 3 Protection of water resources ○ Chapter 4 Use of water ○ Chapter 5 Financial provisions • Chapter 14 Monitoring, assessment and information; • The section dealing with Mechanisms to address appeals, offences and remedies; ○ Chapter 15 Appeals and dispute resolution ○ Chapter 16 Offences and remedies.
	National Water Amendment Act – 1999 (No. 45 of 1999) and	All water users	To amend the National Water Act, 1998 so as to effect contextual improvements; and to change the procedure for the appointment of members of the Water Tribunal; and to provide for matters connected therewith.	

Gov. Dept.	Regulation	Sector covered and applicable area to Industry	Main aspects	Of note to Industry
	National Water Amendment Bill – 1999			
	Water Services Act – 1997 (No. 108 of 1997)	All water users	Deals mainly with water services or potable (drinkable) water and sanitation services supplied by municipalities to households and other municipal water users. It contains rules about how municipalities should provide water supply and sanitation services.	The sections of specific pertinence to Industry are: • Section 7 – Industrial use of water; • Section 9 – Standards; • Section 10 – Norms and standards for tariffs.
Agriculture, Forestry and Fisheries	**Marine Living Resources Amendment Act, 1998 (No. 18 of 1998)**	All water users impacting on coastal environment and or utilising coastal resources	Makes provision for the conservation of the marine ecosystem, the long-term sustainable utilisation of marine living resources, the orderly access to exploitation, utilisation and protection of certain marine living resources; provides for the exercise of control over marine living resources in a fair, equitable and beneficial manner to South Africans;	Of specific interest to Industry ito impacting on water, wastewater & energy management are: • Chapter 1 Interpretation and fundamental principles; • Chapter 3 – Sect 18 – deals with the granting of rights, including the aspects relating to operating 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.(3) The Minister may require an environmental impact assessment report to be submitted by the applicant and (7) The Minister may determine sustainable conservation and management measures • Chapter 4: Marine Protected Areas – sect. 43.2(c) – waste discharging requires permission; • Chapter 8: sect 77.2(v) – regulating and controlling the operation of fish processing establishments, including quality control measures and inspection of such establishments; • Chapter 8: sect 77.2(w) – (w) regarding the prevention of marine pollution.

Gov. Dept.	Regulation	Sector covered and applicable area to Industry	Main aspects	Of note to Industry
	Marine Living Resources Amendment Act, 2000 (no 68 of 2000)	All water users impacting on coastal environment and or utilising coastal resources	The purpose of the Act is to amend the Marine Living Resources Act, 1998, so as to permit the extension of certain rights to undertake commercial or subsistence fishing, engage in mariculture or operate a fish-processing establishment; and to provide for matters connected therewith.	
	Marine Living Resources Act: Policy on allocation and management of commercial fishing rights in large pelagic longline fishery: 2015 (No. 1128 of 2016) – "Large Pelagic Policy: 2015"	Commercial Large Pelagic Longline Fisheries	The purpose was to provide a policy on the allocation and management of Commercial Fishing Rights in the Large Pelagic Longline Fishery and the short name for the policy is "Large Pelagic Policy: 2015". The policy thus sets out objectives, criteria and considerations that will guide the allocation, evaluation, and management of fishing rights in the fishery and it will thus guide the Delegated Authority in taking decisions on applications in this fishery.	To facilitate local economic development, preference will be given to applicants for the allocation of rights in the Large Pelagic fishery who will land catches at harbours situated outside of metropolitan areas, and process catches at land-based processing establishments outside of metropolitan areas. Metropolitan areas include the areas under the control of metropolitan (category A) municipalities (City of Cape Town; Nelson Mandela Bay Metropolitan Municipality; and Buffalo City Metropolitan Municipality).

	Marine Living Resources Act: Policy on allocation and management of rights to operate fish processing establishments; 2015 (No. 1138 of 2015): – "Fish Processing Establishment Policy: 2015".	Fishery and Fish Processing Industry	The policy sets out objectives, criteria and considerations that will guide the allocation, evaluation, and management of fishing rights in the fishery. This policy will thus guide the Delegated Authority in taking decisions on applications in this fishery.	This policy also specifically refers to the water and wastewater management of the processing facility. Section 6.2.6 e& g specifically identifies that the applicant is to provide a Business plan that includes a detailed description of:
				• (e) processing methods and operational plan/s including:
				  ○ Design and technology;
				  ○ Water quality monitoring;
				  ○ Effluent discharge;
				  ○ Quality control measures;
				  ○ Sanitary and hygiene measures; and
				  ○ Hazard Critical Analysis Control Points (HACCP).
				• (g) the use of any kind of chemicals, disinfectants, therapeutants and anaesthetics, that may be used or result from the operation. Methods of application that are being considered for use must also be outlined in the proposal;

Gov. Dept.	Regulation	Sector covered and applicable area to Industry	Main aspects	Of note to Industry
				• (k) Information on how the facility will minimize and prevent potential negative environmental impacts. Of further note is the section 6.2.10 which comments that in terms of the need for a Coastal waters discharge permit. It specifically refers to the National Environmental Management: Integrated Coastal Management (ICM) Act, 2008 (Act 24 of 2008) which addresses a number of issues relating to coastal pollution including the discharge of effluent into coastal waters. The provisions of Chapter 8 of the ICM Act, in particular section 69 thereof, regulates the discharge of effluent into coastal waters from any source on land. Such activities, in addition to any other permit or authorisation which may be required by any other law, require a coastal waters discharge permit obtained from the DEA.

The principal regulatory framework governing fisheries management can be summarised as:

- Section 24 of South Africa's Constitution, 1996 (Act 108 of 1996);
- The Marine Living Resources Act of 1998(18) (and associated regulations and specific permit conditions);
- National Environmental Management: Integrated Coastal Management Act (No24 of 2008) (and amendments).
- The National Environmental Management: Waste Act, 2008 (Act No.59 of 2008);
- The National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004);
- The National Environmental Management Act: Protected Areas, 2003 (Act No. 57 of 2003);
- The National Environmental Management: Environmental Impact Assessment Regulations, 2010.

There are several other Acts and policies that supplement the marine legislative framework and that work in conjunction with the MLRA:

- National Environmental Management Act, 1998 (Act 107 of 1998);
- The National Environmental Management: Protected Areas Act (No. 57 of 2003);
- The National Environmental Management: Biodiversity Act (No. 10 of 2004);
- The Maritime Zones Act (No. 15 of 1994);
- Sea Birds and Seals Protection Act (No. 46 of 1973);
- Sea Shore Act (No. 21 of 1935);
- The Nature and Environmental Conservation Ordinance (Ordinance 19 of 1974);
- Water Services Act, 108 of 1997;
- Marine Living Resources Act: Policy on allocation and management of commercial fishing rights in large pelagic longline fishery: 2015 (No. 1128 of 2016) – "Large Pelagic Policy: 2015".
- National Guideline for the Discharge of Effluent from Land-based Sources into the Coastal Environment – 2014 Department of Environmental Affairs (RSA DEA, RP101/2014)
- Draft South African Water Quality Guidelines for Coastal Marine Waters – Volume 1: Natural Environment and Mariculture Use – 15 March 2019 – Department of Environmental Affairs (RSA, DEA, 2018).

Of particular note is the National Programme of Action for the Protection of the Marine Environment from Land-Based Activities (NPoA). In 2008, the DEA developed an NPoA to give effect to the Global Programme of Action as an international treaty. South Africa is a signatory to the Washington Declaration which formalised the GPA in 1995 and is therefore obliged to undertake national action that is consistent with the commitments enshrined in the GPA. Although the NPoA is not a legal document, it is nevertheless relevant as it recommends several actions that would contribute toward the management of marine pollution from land-based sources (RSA DEA, RP101/2014).

The regulation of water use is based on the likely risk, nature and extent of potential impact of the proposed activity on a water resource. The level of potential risk of impact determines the choice of regulatory means. Water use can be authorised in various ways, including:

- Schedule 1 water uses where minimal risk or no risk exists, and water can be used without a license or registration of the use. The category allows people to use water for a garden, animals or small-scale non-commercial food garden;
- General Authorisations are issued to permit the use of raw water without a license in specific areas or catchments, and implies water use with low risk impact;
- Water Use Licenses are applied for medium to high risk impacts and have conditions attached which state how long it is valid.

The National Regulator for Compulsory Specifications (NRCS) has developed specific Compulsory Standards that are applicable to fisheries and fish processing, these being:

- Compulsory specification for the manufacture, production, processing and treatment of canned meat products (VC8019)
    - Sections of relevance in terms of water use and wastewater are:
        - Section 4.2.9 Hand washing facilities
        - Section 4.2.10 Foot-baths and boot-wash basins
        - Section 4.2.13 Thawing areas
        - Section 4.2.26 specifically deals with Effluent sewage and waste disposal.
        - Section 4.2.27 Comfort facilities
        - Section 4.2.29 Facilities for washing and laundering of protective clothing
        - Section 4.3.6 Heat processing equipment – specifically as it relates to steam and water – subsection i) Water retorts:
        - Section 4.3.13 Facilities for storage, treatment and distribution of water supplies
        - Section 4.3.14 Disinfecting and cleaning facilities
        - Section 4.4 Water: Subsections: 4.4.1 Potable water; 4.4.2 Chlorination of water for container cooling in the retorts; 4.4.3 Steam; 4.4.4 Ice; 4.4.6 Water for cleaning; 4.4.7 Non-potable water
        - Section 4.5.2.8 Installations for the treatment of water (see 4.3.13 and 4.4.1)
    - Compulsory specification for the manufacture, production, processing and treatment of canned fish, canned marine molluscs and canned crustaceans (VC8014)
        - The focus of the specification is to ensure that a factory/ processing facility will comply and have an effective product safety management system, as required by clause 4.1 of this Compulsory Specification and SANS 587.
        - Included are requirements relating to:
            - valid NRCS approval certificate of compliance per each production batch as well as the facility
            - regular microbiological and chemical testing by accredited testing facilities identified by NRCS
    - Compulsory specification for frozen fish, frozen marine molluscs and frozen products derived therefrom (VC8017)
        - Similar to canned fish, the facilities need to comply in terms of frozen fish, frozen marine molluscs and frozen products to the principles of HACCP, as recommended by the Codex Alimentarius Commission and required by SANS 587.

Separate management plans for each of the main fishery sectors are however, still being developed. Existing Lawful Use (ELU) allows commercial users of raw water before the new Act came into effect in 1998 to carry on using that water until such time as they are called upon to apply for a license under compulsory licensing. Such users must have registered the use and apply for verification of the water use when requested by DWS. Verification confirms how much water may be used lawfully.

Disposal of land-derived wastewater to the marine environment is subject to a number of legal (statutory) requirements. According to the DWS Water Quality Management Series: "Operational policy for the disposal of land-derived water containing waste to the marine environment of South Africa: Sub-Series No. MS 13.2 Section 4: Ground Rules", specific policies relate to the disposal of land-derived wastewater to the marine environment. In the subsequent 2014 *Department of Environmental Affairs National Guideline for The Discharge of Effluent from Land-Based Sources into The Coastal Environment*, these Ground Rules were reaffirmed with some changes in Section 4. These 33 Ground Rules and their implications are described below (RSA DEA, RP101/2014):

Table 9-2: Ground Rules identifying the specific policies relating to the disposal of land-derived effluent to the marine environment (RSA DEA, RP101/2014)

Rule	Ground Rules Related to the Legislative Framework:
1	***Marine Disposal of Effluent:*** *The discharge of any effluent into the coastal environment from a land-based process in which it has been heated must be authorised by the DEA in terms of section 69 of the ICMA.* *Principle supported: Integrated Assessment Approach* *The ICMA states that no person is allowed to discharge effluent from sources on land into coastal water except in terms of a general authorisation contemplated in subsection (2) or a CDWP issued under section (3) of the ICMA.* *The following activities must be authorised by a permit under section 69 of the ICMA:* • *New applications to discharge land-based effluent to the coastal environment;* • *Existing discharges that have been authorised in terms of the NWA (1998) and the Water Act (1956) of land-based effluent to the coastal environment;* • *Upgrades or extensions of existing WWTW or industrial facilities that result in a change in the effluent composition or volumes;* • *Any existing discharges to the coastal environment that were not approved in terms of the original authorisation.* *NOTE:* • *In the context of this national guideline, currently, only municipal and industrial effluent discharges (i.e. point discharges) are required to be authorised under Section 69 of the ICMA. However, this does not exclude diffuse sources (such as urban stormwater) from being licensed. The DEA will determine criteria and thresholds for issuing CWDPs and GAs.* • *Land-based activities within harbour areas that qualify as a water use, under section 21 of the NWA of 1998, are also the responsibility of the DWA and may require a licence issued by the DWA in addition to a CWDP/GA issued by the DEA. These include contaminated (or polluted) stormwater run-off from an industrial premises as well as the discharge of polluted seawater that was used in an industrial process on land. In the case of commercial harbours, the National Ports Authority, as the landowner, is responsible for ensuring that developments and activities within its boundaries meet the requirements of national law, such as those required under the NWA and the ICMA.*
2	***Marine Disposal of Effluent – Requires EIA:*** *Any discharge of land-based effluent to the coastal environment from an activity triggering any of the Listing Notices in the Environmental Impact Assessment (EIA) Regulations under the NEMA, is subject to the applicable environmental authorisation issued under the NEMA: EIA Regulations (2010) administered by the DEA and / or a CWDP in terms of Section 69 of the ICMA, unless the activity conforms to a standard as prescribed in section 24 of the NEMA and in terms of the ICMA. Principle supported: Integrated Assessment Approach*

Rule	Ground Rules Related to the Legislative Framework:
	The Environmental Assessments must be performed in accordance with the EIA Regulations (2010) under the NEMA and must investigate all alternatives, including recycling/re-use. *This applies to:* • *New proposals to dispose of land-based effluent to the coastal environment;* • *Existing discharges of land-based effluent to the coastal environment that are not classified as an existing/lawful water use (and that have not been subject to an EIA);* • *Upgrades or extensions of existing WWTW or industrial facilities that result in a change in the effluent composition or volumes (a permit is issued based on a specific effluent volume and composition, therefore for such changes the discharger legally may re-apply); and* • *Any existing discharges to the coastal environment that were not approved in terms of the original authorisation.* *Failure to comply with any conditions stipulated in the permit and/or authorisation will be a violation of the law and is subject to prosecution. Where the potential impact of an existing lawful effluent discharge has not been assessed properly or where there is reason to believe that such discharge has a negative impact on the receiving coastal environment, the permit holder will be requested to engage in specific studies, as would be required for a permit authorisation process. The extent of such investigations will depend on potential risks and the sensitivity of the receiving coastal environment. An EIA, as such, will not necessarily be needed in such instances, unless listed activities are triggered. According to the EIA Regulations of 2010, only independent, qualified environmental assessment practitioners may undertake an EIA. It is the responsibility of the applicant and the environmental assessment practitioners to obtain the assessment criteria upon which the CWDP/GA are issued so as to comply with the requirements for the evaluation of the receiving environmental impact of the coastal discharge.* *NOTE:* *Where a NEMA listed activity is triggered, an environmental authorisation will inform the CWDP authorisation process unless the activity conforms to a standard as prescribed in section 24 of the NEMA. The environmental authorisation process does not necessarily guarantee the issuing of a CWDP by the DEA.* *In instances where a NEMA listed activity is triggered, the CDWP/GA will not be issued without an environmental authorisation. Such applications for a CWDP/GA may be lodged in parallel to the application for an environmental authorisation to obtain a reference number and the assessment criteria that address matters pertaining to the impacts to the receiving environment as to avoid unnecessary delays in the process. Pre-consultation meetings will be held with applicants when required. The applicable impact studies and public participation processes conducted by the applicant will assist the CWDP/GA application process. Where no listed activities in the NEMA are triggered, the environmental authorisation process will not be applicable and the CWDP/GA process will then be the only process. In such instances, the DEA may prescribe a basic public participation process.*

Rule	Ground Rules Related to the Legislative Framework:
3	***Marine Disposal of Effluent Permit review period:*** *A CWDP is valid for a period up to 5 years subject to a midterm review as stipulated in the conditions upon which the permit is granted. Revisions to permit conditions can further be motivated on the grounds of negative impacts on the environment and non-compliance with permit conditions.* *Principle supported: Integrated Assessment Approach* *NOTE:* *Subsequent to the National Workshop in 2012, DEA has decided that the CWDP will be issued for a validity period of up to 5 years with a mid-term review.* *As the competent authority, the DEA is required to report on the status of the pipeline discharges and their impact on the environment every 3 years. All issued permits will therefore be reviewed to consider the following:* • *Compliance with all permit conditions;* • *Re-assessment of whether the discharge of the effluent can still be considered as the Best Practical Environmental Option, taking the hierarchy of decision making into account (refer to Basic Principle: Pollution Prevention and Waste Minimisation),* • *Review of monitoring reports to assess, for example, whether monitoring objectives that were defined as part of the monitoring programme (refer to Ground Rule 28) have been met.*
4	***Marine Disposal of Effluent in Marine Protected Area – Prohibited:*** *The discharge of land-based effluent to any area declared a Marine Protected Area under the Marine Living Resources Act (Act No. 18 of 1998) is prohibited, unless the Minister of Environmental Affairs provides permission to do so.* *Principle supported: Pollution Prevention, Waste Minimisation and Precautionary Approach.* *The Marine Living Resources Act (1998) prohibits, amongst other activities, the discharge of waste to any marine protected area, unless the Minister of Environmental Affairs provides permission to do so. However, the Minister may grant permission in cases in which such activity is to the benefit of the MPA, which is unlikely to be the case for an effluent discharge.* *For proposed discharges to the coastal environment the boundaries of both existing and proposed MPAs must be taken into account. Where the influence of the discharge to the coastal environment overlaps with the boundaries on a proposed MPA, mitigating actions, if required, must be decided upon in consultation with the responsible authorities, in this case the DEA will consult with the DWA, DAFF and/or the relevant municipality. In instances where an MPA has been established and is already occupied by an existing pipeline, all reasonable precautionary measures must be taken to ensure impacts to the MPA are mitigated.*
5	***Marine Disposal of Effluent – Effluent discharge charge:***

Rule	Ground Rules Related to the Legislative Framework:
	Any land-based effluent discharge to the coastal environment may be subject to a disposal charge to be developed in consultation with stakeholders. *Principle supported: Polluter Pays Principle* *The aims of such a disposal charge would be to:* • *Promote and encourage the efficient use of water resources;* • *Promote the internalisation of environmental costs by polluters; and to* • *Recover some of the costs of coastal water quality monitoring carried out by the permitting authority.*
	Ground Rules Related to Management Institutions and Administrative Responsibilities:
6	***Marine Disposal of Effluent – Participatory Management approach:*** *The discharge of land-based effluent to the coastal environment is currently governed by the DEA under the ICMA, however, the DEA will work in consultation with relevant local, provincial and national government departments (in particular the DWA in cases where discharge occurs in an estuary), as well as local management institutions (such as pipeline or catchment forums). This collaboration is required to ensure effective cooperative governance in the management of waste discharges to the coastal environment of South Africa.* *Principle supported: Participatory Approach*
7	***Marine Disposal of Effluent – Participatory Management & Compliance monitoring by local management institutions:*** *The discharge of land-based effluent to the coastal environment (offshore, surf zone or estuaries) must be managed (which includes, but is not limited to, monitoring and compliance) through a local management institution such as the establishment of forums. This can be an existing institution, such as a pipeline forum, monitoring committee, pipeline advisory committee, water quality committee or catchment forum. Representation must include government authorities (i.e. that hold jurisdiction), as well as non-government role players (e.g. industries, users of the coastal environment and Non-Governmental Organisations.* *Principle supported: Participatory Approach.*
	Ground Rules Related to Sensitive Areas:
8	***Estuarine Disposal of Effluent – Not considered unless exceptional circumstances:*** *Estuaries are classified as 'sensitive areas'. The discharge of municipal and industrial effluent to these systems will therefore not be considered except in exceptional circumstances in which such inflows are required to improve or maintain the resource quality objectives (also taking into account effects of water quantity) or where the ecological functioning has been irreversibly modified to support commercial harbours where exemption to this rule may be considered. In the latter case, the resource quality objectives of other designated beneficial uses of the area, however, must be met as a minimum. Therefore, applications for a CWDP for estuaries require consultation with the DWA.* *Principle supported: Pollution Prevention, Waste Minimisation AND Precautionary Approach; Integrated Assessment Approach.*

Rule	Ground Rules Related to the Legislative Framework:
	NOTE: *In issuing a CWDP, the DEA will consider the provisions made in the NEM: BA with reference to the estuarine classification.*
9	***Marine Disposal of Effluent – Avoidance of surf zone:*** *The surf zone is classified as a 'sensitive area'. The discharge of municipal and industrial effluent to the surf zone should therefore be avoided. Where legitimate motivation can be provided (e.g. in cases in which seawater used on land is returned to source), the environmental quality objectives for the study area must be met as a minimum. These include objectives pertaining to alteration of the natural salinity regime (in the case of freshwater discharges) and aesthetic impacts associated with the visibility of the discharge practice on land.* *Principle supported: Pollution Prevention, Waste Minimisation AND Precautionary Approach* *The surf zone is classified as a sensitive area for the following reasons:* • *Discharging freshwater into sheltered saline environments such as the surf zone modifies the natural salinity regime, with potentially negative impacts on the ecosystem.* • *Because discharges to the surf zone do not have a distinct 'initial dilution process' as encountered in offshore discharges (i.e. dilution generated by jet momentum and buoyancy effects that occur between the outlet ports and the sea surface), it is most likely that there will be a zone of non-compliance in the receiving environment, unless the constituent concentration in the effluent is equal to the environmental quality objectives (i.e. 'compliance at end of pipe').* • *The complex physical dynamics encountered in the surf zone largely reduce the accuracy with which transport and dispersion processes can be quantified, a key requirement in assessing the suitability of discharge of land-based effluent to the coastal environment as an option.* • *These ecologically sensitive areas are transition areas between the land and the sea, providing unique habitats for a diversity of biota.* *A large proportion of beneficial uses of the coastal environment (e.g. recreation and marine aquaculture) occur in the surf zone (i.e. beaches). The high real estate value along the coast is often strongly linked to acceptable aesthetics and water quality at beaches, which can be severely compromised by inappropriate discharge of effluent.*
10	***Marine Disposal of Effluent:*** *Discharges of land-based effluent to the offshore coastal waters through a coastal outfall should be considered as the preferred option over any estuary or surf zone discharge, unless the suitability of the areas to accommodate such activities is properly assessed.* *Principle supported: Pollution Prevention, Waste Minimisation and Precautionary Approach* *Suitability of the coastal environment (generally defined as the area beyond the surf zone, in which circulation patterns are usually more uniform) for the discharge land-based effluent through a coastal outfall mainly depends on:*

Rule	Ground Rules Related to the Legislative Framework:
	• *Circulation characteristics* • *Stratification in the water column* • *Morphology of the seabed (with specific reference to the proximity of depositional areas where pollutants/contaminants may accumulate)* • *Presence of offshore reefs and islands, also considered sensitive areas.* • *Risk of damage, e.g. if situated along shipping routes* • *Proximity of other existing marine outfalls.*
	Ground Rules Related to Environmental Quality Objectives:
11	***Marine Disposal of Effluent – Site-specific Environmental Requirements (recommended target Values):*** *Site-specific environmental quality objectives for the coastal environment (excluding estuaries) must take into account the South African Water Quality Guidelines for coastal marine waters (RSA DWAF, 1995a) or any future updates thereof. In instances where a standard is proposed and for which concurrence is required from the DEA, such a standard must be in line with this guideline, more stringent, applicable and responsive.* *Principle supported: Pollution Prevention, Waste Minimisation and Precautionary Approach; Receiving Water Quality Objectives Approach* *The South African Water Quality Guidelines for Coastal Marine Waters (DWAF, 1995a) provide recommended target values for a list of substances in relation to aquatic ecosystem requirements as well as for other beneficial uses. However, the information provided in these documents is not exhaustive and does not provide target values for ALL possible substances. Therefore, in setting environmental quality objectives for the marine environment, the information contained in the guideline documents should be supported by information from additional sources such as published literature, best available international guidelines and site-specific data.* • *List I substances are regarded as being particularly hazardous because of their toxicity, persistence and bioaccumulation and must be eliminated from effluent discharges.* • *List II substances, in contrast, are considered less hazardous but nevertheless have a deleterious effect on the aquatic environment.* • *List II substances must be controlled. List II substances, therefore, are typically those for which specific environmental target values must be determined.* *Recommended lists are provided in Operational policy for the disposal of land-derived water containing waste to the marine environment of South Africa: Guidance on Implementation [RSA DWAF Water Quality Management Series 13.3]).*
12	***Potential Estuarine Disposal of Effluent – Assessment Approach:***

Rule	Ground Rules Related to the Legislative Framework:
	Where, in exceptional circumstances (as listed in Ground Rule 8), a discharge to an estuary is considered, resource and environmental quality objectives must be determined according to the methodology for estuaries developed by the Directorate: Resource Directed Measures (RSA DWAF, 2004 and any future updates thereof). Estuaries are included in the definition of 'the water resource' in the National Water Act and objectives therefore must be determined in accordance with Chapter 3 of this Act. *Principle supported: Receiving Water Quality Objectives Approach*
13	***Marine Disposal of Effluent – Environmental Requirements in Mixing Zone:*** *Environmental quality objectives must be complied within the area beyond the initial mixing zone.* *Principle supported: Pollution Prevention, Waste Minimisation and Precautionary Approach; Receiving Water Quality Objectives Approach* *The initial mixing zone is defined as the area in the water column in which the initial dilution process takes place whereby 'clean' seawater is entrained during the rise of the buoyant plume. The degree of dilution and the geometry of the rising plume depend on the buoyancy of the effluent, as well as the current profile and stratification in the water column.* *Instances whereby this rule may be relaxed include microbiological parameters that do not necessarily affect the health of aquatic ecosystems, but rather affect specific beneficial uses (e.g. recreation and marine aquaculture) that may be at a distant location from the point of discharge. Microbiological parameters are also further subject to secondary dilution and decay while being transported away from the initial mixing zone.*
	Ground Rules Related to Municipal Effluent:
14	***Marine Disposal of Effluent – Must form part of and be evaluated within WSDP & IDP:*** *South Africa is a water scarce country. Coastal discharge of land-based municipal effluent (particularly freshwater) will therefore only be considered where it has been evaluated in terms of the Water Services Development Plan for a particular municipal area (required under the Water Services Act [Act No. 108 of 1997], and which, in turn, forms part of the Integrated Development Plans required in terms of the Local Government Transition Act [Act No. 209 of 1993]). This requirement supports the concept of a 'Master Plan for water supply/demand and effluent treatment'.* *Principles supported: Pollution Prevention, Waste Minimisation and Precautionary Approach; Integrated Assessment Approach.* *It is crucial that effluent discharges be managed within a 'Master Plan'3 for water, taking into account, for example:* • *Water supply and future water demand* • *Reserve requirements for river and estuaries (under the NWA)* • *Groundwater resources*

Rule	Ground Rules Related to the Legislative Framework:
	• *Surface water resources* • *Sanitation (including reticulation systems)* • *Effluent treatment and disposal* • *Trade effluents* • *Stormwater reticulation and discharge.* *It is crucial that the upgrading of WWTW also be addressed as part of the holistic 'Master Plan' for water.*
15	***Trade Effluent Impact & Requirements on Municipality:*** *Municipal WWTWs receiving industrial effluent (also referred to as trade effluent) will be subject to the Ground Rules for Industrial Effluent (refer to Ground Rules 19 to 22). Service Providers or Local Authorities operating such treatment works will be required to prepare industrial effluent management plans (as part of the 'Master Plan'). It is also the responsibility of the Service Provider or Local Authority to investigate possible synergistic and/or cumulative effects which may occur as a result of the interaction between different (industrial) effluent inputs.* *Principles supported: Pollution Prevention, Waste Minimisation and Precautionary Approach; Integrated Assessment Approach* *It is the responsibility of the Service Provider or Local Authority operating a WWTW to ensure that industrial effluent discharges to the works adhere to the ground rules for Industrial Effluent (refer to section 4.4.2).*
16	***Effluent Collector Networks fall outside of this Policy**:* *The design, construction and management of collection systems (i.e. the land-based facilities at which the effluent is collected prior to discharging to the coastal environment) are outside the scope of this guideline. The design, construction and management of such systems must comply with related policies and specifications of the DWA and DEA.* *Principles supported: Pollution Prevention, Waste Minimisation and Precautionary Approach; Integrated Assessment Approach* *Policy and specifications on sanitation, e.g. sewage collecting systems, are generic and not necessarily relevant only to effluent that is disposed into the coastal environment. As a result, this national guideline on coastal effluent discharges are not prescriptive regarding collecting systems and refers to relevant policies and frameworks on sanitation. In South Africa, guidelines on sanitation systems for settlements, for example, use population density, in terms of households per hectare, as a guideline. Such guidelines are discussed in further detail in documents such as:* • *Strategic Framework for Water Services (RSA DWAF, 2003a)* • *Managing the water quality effects of settlements (RSA DWAF, 1999b; RSA DWAF, 2002a).*

Rule	Ground Rules Related to the Legislative Framework:
	Furthermore, the environmental authorisations issued and environmental management programmed approved by the DEA (provincial or national departments) for such infrastructure will prescribe best practices for the construction and management thereof.
17	***Marine Disposal of Effluent – Minimum Treatment Requirements:*** *In general, and in support of responsible discharge including taking into account the sensitivity of the receiving environment, the following treatments apply to the following zones after the publication of this National Guideline:* *i. Primary treatment will be required as a minimum for all new or proposed discharge of municipal effluent to the offshore coastal environment.* *ii. Preliminary treatment will be accepted as a minimum requirement for all existing municipal effluent discharges to the offshore coastal environment, provided that the receiving environment is suitable for this coastal discharge and that the environmental (or resource) quality objectives are met. However, future expansions or upgrades to such existing coastal outfalls will require primary treatment of the effluent prior to discharge unless it can be proven that key socio-economic factors require otherwise. Nevertheless, environmental (or resource) quality objectives must still be met and take into account the interest of the whole community (as defined in the ICMA).* *iii. Secondary treatment with disinfection will be required as a minimum for all discharges of municipal effluent to the surf zone and estuaries (where such discharges are allowed – refer to Ground Rules 8 and 9).* *NOTE:* *The above sets the minimum requirements. Where such levels of treatment still do not meet the requirements of the receiving environment, as defined in terms of the environmental (or resource) quality objectives, higher levels of treatment will be required. Furthermore, in order to determine realistic objectives, applications for a CWDP will be evaluated on a case-by-case basis. The receiving environmental objectives will dictate the level of treatment required for discharges not covered under municipal effluent. Operators of WWTWs must investigate methods to continuously improve the operations that affect the effluent quality and quantity.* *Principle supported: Pollution Prevention, Waste Minimisation and Precautionary Approach* *Government's policy (White Paper on a National Water Policy for SA, 1997) is to strengthen source controls with the final aim of getting as close as possible to a situation in which there is zero discharge of effluent to the environment. In light of this, the DWA and DEA can therefore require or recommend more stringent levels of treatment based on, for example, the outcome of pre-assessments or detailed investigations, as part of the permit authorisation process.* *Internationally, primary treatment, and even secondary treatment, is increasingly being put forward as the minimum for treatment levels for discharge to the offshore coastal environment. For example, in the United States, Australia and the European Community, this minimum rule applies for service populations of between 50 000 and 150 000. For larger service populations these countries require at least secondary treatment, in many instances including disinfection*
18	***Sludge Disposal:***

Rule	Ground Rules Related to the Legislative Framework:
	The disposal of sludge arising from effluent treatment facilities (e.g. primary, secondary and tertiary) must be in accordance with the Minimum Requirements for Waste Disposal by Landfill (DWAF, 1998) and the 'Sludge Guidelines' (1998 as amended in 2000) of the DWAF or any future updates of such policies or guidelines. *Principles supported: Pollution Prevention, Waste Minimisation and Precautionary Approach; Integrated Assessment Approach*
	Ground Rules Related to Industrial Effluent:
19	***Industrial Effluent Discharge – Definite License Required:*** *Industrial discharges has not been defined as yet under the ICMA, however, under Section 21 of the NWA, the following water sources have been classified as industrial effluent, requiring a licence, for discharge to the coastal environment:* • *Water used in an industrial process on land.* • *Contaminated (or polluted) stormwater run-off originating from industrial areas that passes through man-made structures (such as canals, pipelines, etc.) excluding rivers and municipal sewerage, directly into the estuary, surf zone or coastal waters, freshwater or seawater used as cooling water on land, e.g. Power Generation (cooling water intake and discharge).* • *Seawater used in an industrial process on land, e.g. seafood processing, coastal mining activities and return flows from oceanariums/aquariums.* *The above classification remains valid until appropriate regulations have been developed under the ICMA.* *Principle supported: Integrated Assessment Approach.*
20	***Industrial Effluent Discharge – Define waste stream in terms of both volume (quantity) and quality:*** *An industry, discharging effluent to a municipal WWTW or directly to the coastal environment (or applying for a permit to do so), will be required to provide a detailed description of the waste stream in terms of both volume (quantity) and quality (i.e. listing all substances present and their concentrations and loads). Where industries discharge effluent to a WWTW, the water services provider is responsible for obtaining this information from the industry concerned. The DEA or local authority may also require a detailed inventory of the raw materials, as well as process material, used by an industry.* *Principle supported: Pollution Prevention, Waste Minimisation and Precautionary Approach* *It will be the responsibility of an industry to supply a detailed description of their effluent to the DEA. Such information is crucial to the permit application process both in terms of evaluating potential impacts appropriately, and of evaluating suitable effluent treatment options.* *Toxicity testing will not be considered as a substitute where detailed description of the composition of the effluent is not available. However, these tests are valuable techniques to be used as supplementary tools, for verifying impact assessment studies based on the detailed effluent composition.*
21	***Industrial Effluent Discharge – Potential Pre-treatment required if to municipal WWTW with Marine outfall:***

Rule	Ground Rules Related to the Legislative Framework:
	Industrial effluent discharged to a municipal WWTW disposing to the coastal environment will be subject to appropriate pre-treatment. It is the responsibility of the local authority operating the WWTW to ensure compliance in this regard. *Principle supported: Pollution Prevention, Waste Minimisation and Precautionary Approach* *Appropriate pre-treatment is required to ensure that the:* • *WWTW and associated equipment are not damaged;* • *Operation of the WWTW and the treatment or re-use of sludge are not impeded; and* • *Discharge from the WWTW does not adversely affect the coastal environment.*
22	***Industrial Effluent Discharge – If containing radioactive substances ensure Mineral & Energy compliance:*** *Effluent containing radioactive substances is governed by the Department of Energy (in concurrence with the DEA and DWA) and must comply with policy developed in this regard.* *Principles supported: Pollution Prevention, Waste Minimisation and Precautionary Approach; Integrated Assessment Approach* *The Department of Energy is presently developing a national radioactive waste management policy and strategy in conjunction with the various role players in South Africa. Draft policy and strategy documents will soon be made available to the public for discussion (http://www.radwaste.co.za/regulation.htm).*
	Ground Rules Related to Diffuse Effluent Sources:
23	***Assessment of existing or new marine disposal facility – Ensure diffuse effluent discharges accounted and planned for:*** *Diffuse land-based effluent (such as urban stormwater run-off, agricultural return flows and contaminated groundwater seepage) discharged into the coastal environment should not have any negative impact on the receiving environment, i.e. the environmental quality objectives must be met.* *Principles supported: Pollution Prevention, Waste Minimisation and Precautionary Approach; Integrated Assessment Approach* *Although these activities are currently not licensed by DWA and DEA, the Departments may require local authorities that are, for example, responsible for stormwater management, to take measures to mitigate negative impacts.* *Input from diffuse effluent discharges MUST be taken into account when conducting the scientific and engineering assessments for either an existing or new coastal disposal facility. References to methods for calculating the volume and composition of, for example, urban stormwater inputs are provided in RSA DWAF Water Quality Management Sub-Series 13.3.*
	Ground Rules Related to Scientific and Engineering Assessment:

Rule	Ground Rules Related to the Legislative Framework:
24	***Discharge License Application* – *Show holistic approach followed re Design, Construction & Implementation:*** *An application for a CWDP will only be considered where a holistic process has been followed for the discharge of land-based effluent to the coastal environment. This implies that potential impacts on the receiving environment be investigated in both the near and far field, taking into account other anthropogenic activities and waste inputs so as to address possible synergistic and/or cumulative effects. Guidelines in this regard are provided in RSA DWAF (Operational Policy for the disposal of land-derived water containing waste to the marine environment of South Africa – Water Quality Management Sub-Series MS13.2).* *Principle supported: Integrated Assessment Approach* *When assessing proposed discharges of other waste input (such as, diffuse effluent inputs (e.g. urban stormwater inputs) and dredging activities (relevant to harbour areas), a holistic approach should be taken into account. This would also require that other responsible authorities and role players (in this case the DEA and NPA) be represented on the local management institution.* *Guidelines in this regard are provided in Operational policy for the disposal of land-derived water containing waste to the marine environment of South Africa: Guidance on Implementation (RSA DWAF Water Quality Management Sub-Series 13.3).*
25	***Discharge Permit Application* – *Design, Construction & Implementation to Ensure compliance approach followed to qualify for License:*** *A permit application for the discharge of land-based effluent to the coastal environment will only be considered where a discharge system is designed, constructed and operated in accordance with recognised scientific, hydraulic and structural guidelines in order to meet environmental quality objectives.* *Principle supported: Pollution Prevention, Waste Minimisation and Precautionary Approach* *Further guidance in this regard is provided in RSA DWAF Water Quality Management Sub-Series 13.3.*
26	***Discharge Design* – *Modelling* – *used recognized techniques:*** *Recognised numerical modelling techniques must be applied in the scientific and engineering assessment and design of a coastal disposal system, as and where considered appropriate, according to recognised scientific and engineering guidelines.* *Principle supported: Pollution Prevention, Waste Minimisation and Precautionary Approach* *In the application of numerical modelling techniques, the following must be complied with:* • *The model chosen be appropriate to the situation in which it is utilised* • *The model must be calibrated and validated against a full data set adequately describing the site-specific physical and chemical oceanographic conditions* • *Sensitivity analysis must be conducted to demonstrate the effect of key output parameters, based on the variation in input data and controlling assumptions.*

Rule	Ground Rules Related to the Legislative Framework:
	• *The reporting of model output must include a clear description of assumptions, summary of numerical output, confidence limits and sensitivity and implications and the dilution, transport and fate of relevant substances, in both the near and far field.* *Further guidance in this regard is provided in RSA DWAF Water Quality Management Sub-Series 13.3.*
27	***Discharge Design – Design approach to accommodate changes to site-specific discharge conditions:*** *A precautionary approach must be followed in the assessment and design of any coastal disposal system in which the temporal and spatial coverage and accuracy of physical and chemical oceanographic data do not adequately describe site-specific conditions.* *Principle supported: Integrated Assessment Approach; Pollution Prevention, Waste Minimisation and Precautionary Approach* *In practice, due to time and financial constraints, it is often not possible to collect physical and chemical oceanographic data on spatial or temporal scales that would adequately describe site-specific conditions. The accuracy of prediction of near and far field dilutions, and subsequent compliance to environmental quality objectives largely depends on the adequacy of physical oceanographic data such as currents, stratification, wind, waves and tides (both statistical or real-time). Therefore, where data are not considered to be adequate, a conservative approach must be followed. Typically, this is achieved through, for example, a higher degree of treatment and/or by increasing discharge depth and/or distance from a specific beneficial use area (e.g. as determined by the pipeline length).*
	Ground Rules Related to Monitoring and Contingency Plans:
28	***O&M – Monitoring Programme:*** *Any authority or industry responsible for the operation and management of a coastal disposal system will be subject to the implementation of a monitoring programme.* *Principles supported: Pollution Prevention, Waste Minimisation and Precautionary Approach; Integrated Assessment Approach and Participatory Approach* *The presentation of data to the DEA must be in a specified format and at a predetermined frequency, as will be dictated by the DEA. This is discussed in further detail in the DWAF Operational Policy of 2004 (RSA DWA, 2004a).*
29	***O&M – Influent stream composition and flow Monitoring:*** *Authorities operating WWTW that receive industrial effluent (also referred to as trade effluents) must ensure that monitoring programmes are implemented to record the individual flow and composition of such effluent inputs prior to entering the effluent reticulation system, as part of their industrial effluent management plan.* *Principles supported: Pollution Prevention, Waste Minimisation and Precautionary Approach; Integrated Assessment Approach and Participatory Approach* *Data on the individual flow and composition of waste streams must be reported to the DWA on request.*

Rule	Ground Rules Related to the Legislative Framework:
30	***O&M – Contingency Planning:*** *Any authority or industry responsible for the operation and management of a coastal disposal system will be required to prepare contingency plans pertaining to maintenance shutdowns, failure in operations or emergency incidents. Such emergency Incidents are subject to the reporting provisions of Section 30 of the NEMA.* *Principles supported: Pollution Prevention, Waste Minimisation and Precautionary Approach; Integrated Assessment Approach and Participatory Approach* *Guidance on contingency planning for the discharge of land-based effluent to the coastal environment is discussed in further detail in the RSA DWAF Water Quality Management Sub-Series 13.3.*
31	***O&M – Performance reporting:*** *Any authority or industry responsible for the operation and management of a coastal disposal system will be required to provide the DEA with a regular evaluation of the performance of the coastal disposal system. The DEA will consult with the DWA on the evaluation of the performance in the case of a discharge into an estuary.* *Principles supported: Pollution Prevention, Waste Minimisation and Precautionary Approach; Integrated Assessment Approach and Participatory Approach* *The RSA DWAF Water Quality Management Sub-Series 13.3. includes guidelines on the format and the frequency at which information on the performance of a coastal disposal facility should be provided and are discussed in further detail. Reporting may include the distribution of information to the public.*
32	***Non-Compliance:*** *Where performance evaluations indicate non-compliance with the predetermined specifications (including the environmental quality objectives), the authority or industry responsible for managing the effluent will be required to propose mitigating actions to ensure compliance (e.g. rehabilitation or alternative treatment options). The responsible authority and the industry operating the effluent disposal system will be required to implement such actions at their own cost upon approval of the DEA.* *Principle supported: Pollution Prevention, Waste Minimisation and Precautionary Approach and Polluter Pays Principle* *As a standard condition in permits, non-compliance must be reported to the DEA as well as actions taken to ensure compliance. The DEA will work with the permit holder in order to improve compliance but directives could be issued to the permit holder for non-compliance. Only after failure to react to such a directive, will prosecution follow. The DEA, through its Environmental Management Inspectorate, will investigate and take the appropriate action.*

Rule	Ground Rules Related to the Legislative Framework:
33	***Decommissioning of a marine discharge structure:*** *The decommissioning of a coastal discharge structure must be addressed in the planning stages as part of the EIA process (if an EIA is required), supporting the cradle-to-grave principle. In the case of existing coastal discharge structures (authorised prior to the publication of this national guideline), the authority, service provider or industry responsible for the operation and management of the coastal discharge will be required to conduct decommissioning in an environmentally responsible manner which must conform, inter alia, to the duty of care principle contained in section 28 of NEMA. This may require an EIA. Negotiations should be conducted on a case-by-case basis, involving the DWA, DEA, the permit holder, service providers or industry responsible for the coastal discharge and any other parties that may be affected by the decommissioning process.* *Principles supported: Pollution Prevention, Waste Minimisation and Precautionary Approach; Integrated Assessment Approach* *With regard to existing facilities, a decommissioning plan must be submitted within 12 months of the date of issue of a CWDP or GA or as requested by the DEA.*

Reference: Republic of South Africa, Department of Water Affairs and Forestry, 2004. Water Quality Management Series, Sub-Series No. MS 13.4. Operational policy for the disposal of land-derived water containing waste to the marine environment of South Africa: Appendices. Edition 1. Pretoria

The DEA guideline further comments on Industrial Effluent as follows (RSA DEA, RP101/2014):

- "*Operational policies regarding the discharge of industrial effluent to the environment (including the coastal environment) are extensive and follow different approaches (RSA DWAF, 2004b). Important aspects are highlighted below.*
- *One approach is to identify specific industrial installations that are required to obtain authorisation to operate. For example, in the European Community the Directive on integrated pollution prevention and control (96/61/EC) provides a list of industrial installations and a set of common rules on permits (www.europa.eu.int/comm/environment/ippc). The permits have to be based on the concept of Best Available Techniques (BAT) and, realising that in many cases BAT entail quite radical environmental improvements which could jeopardise many jobs, the directive grants listed installations an 11-year transition period. The directive also identifies specific aspects that need to be taken into account when determining best available techniques.*
- *Another approach towards eliminating or minimising effluent from industrial installations is to regulate the operations and processes for specific industries, based on the concept of Best Available Techniques. For example, Canada sets specific standards, guidelines and an environmental code of practice for numerous industrial activities under the Canadian Environmental Protection Act of 1999.*
- *With regard to the discharge of industrial effluent into WWTWs, most countries require that pre-treatment be applied so as to prevent damage to equipment, that the treatment or re-use of sludge is not impeded and that there will be no adverse effect on the coastal environment.*
- *Under Section 69 (1) of the ICMA, no person may discharge effluent from a source on land into coastal waters except in terms of a GA or a CWDP. However, this would apply only to discharges into the coastal environment which is subject to the definition of effluent under the Act.*
- *At present, South Africa's legislation therefore does not distinguish between different types of industries but rather subjects all industries to the requirement of a CWDP or a GA, including discharges to the coastal environment."*

9.2.3 Municipal Bylaws

Section 21 of the Water Services Act require all municipalities (WSAs) to implement bylaws which contain conditions for the provision of water services at local level. The bylaws must set standards and tariffs and the municipality must monitor compliance and enforce adherence to the bylaws. A selection of bylaws and tariffs from different metropoles and municipalities, representing a selection of municipalities that have fishing and fish processing and/or have ocean-based activities, are described in this section.

9.2.3.1 eThekwini Metropolitan Municipality

Important policy documents from the eThekwini Municipality include:

- Policies and Practices of the eThekwini Water and Sanitation Unit (EWS, 2013) which outline the policy related to provision of water and sanitation services;

- Water Services Development Plan (EWS, 2011);
- Sewage Disposal Bylaws (EWS, 1999); and
- Tariff schedule provides the related costs (EWS, 2014).

Any industry wishing to discharge to a wastewater treatment works must apply for a trade effluent permit. Requirements for this permit include the undertaking of a cleaner production assessment to identify measures to reduce the consumption of water and generation of wastewater at source. Trade effluent will not be accepted if it contains concentrations of substances above stated limits and separate limits are provided for sewerage works with a capacity both greater than, and less than, 25 Ml/day. A third set of limits is applicable for industry discharging directly to one of the two sea outfalls (EWS, 2011).

Industrial, commercial and institutional customers are charged for the acceptance of sewage into the Municipal sewerage system by means of a volume-based sewage disposal charge which replaced sewerage rates from 1 July 2010.

In addition to the above charge, Industries that are permitted to discharge trade effluent and with a COD >360 mg/l and SS >9 mg/l (pollution loading exceeding that of 'normal' domestic sewage) are charged for their high strength effluent at the rate calculated as given in Equation 1 (EWS, 1999).

Equation 1:

$$\text{Volume based charge} + V\left(\frac{COD}{360} - 1\right) + Z\left(\frac{SS}{9} - 1\right)$$

Where:

COD	: Chemical Oxygen Demand in mg/l
SS	: Settleable Solids in l/l
V	: rate for the treatment in the treatment works of standard domestic effluent having a prescribed COD value
Z	: rate for the treatment in the treatment works of standard domestic effluent having a prescribed settleable solids value

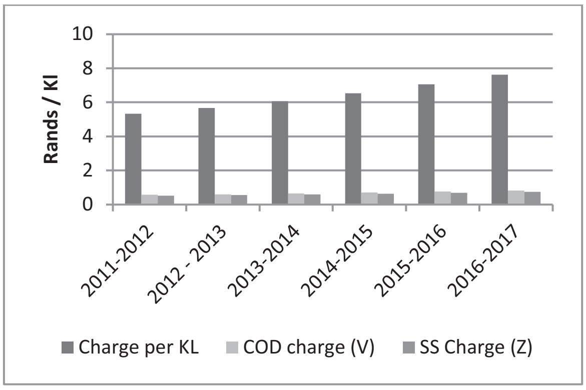
The volume of trade effluent discharged is determined by either a trade effluent meter, which is read every month and readings forwarded to the municipality, or through a water balance questionnaire which is filled in by the company. The water balance questionnaire subtracts the volume of domestic effluent, water used in product, in the process and loss due to evaporation from the incoming volume to give a percentage of trade effluent produced. Limits for effluent quality are set depending on the size of the receiving wastewater treatment works.

Data on basic unit cost for water and effluent and the values for V and Z are provided in the table following.

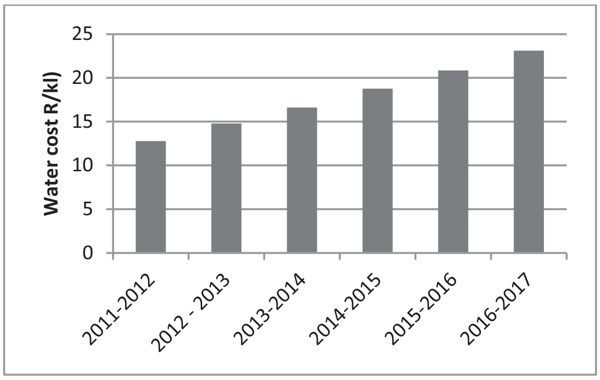
Table 9-3: Basic unit costs for water and effluent in eThekwini Municipality (EWS, 2014)

Period	**Effluent**			**Water**
	Rand / Kl	**COD charge (V)**	**SS Charge (Z)**	**R /Kl**
2011-2012	5.34	0.57	0.52	12.8
2012-2013	5.68	0.6	0.56	14.79
2013-2014	6.07	0.65	0.59	16.63
2014-2015	6.54	0.71	0.64	18.78
2015-2016	7.06	0.76	0.69	20.84
2016-2017	7.62	0.82	0.74	23.14

The trends on water and effluent costs from 20211/2012 to 2015/2016 are shown below.



(a): Trends in charges for eThekwini Municipality with predicted increase



(b): Trends in water price for eThekwini Municipality with predicted increase

Figure 9-1: The trends on water and effluent costs from 20211/2012 to 2015/2016

9.2.3.2 City of Cape Town Metropolitan Municipality

The City of Cape Town has bylaws relating to Wastewater and Industrial Effluent (COCT, 2013, promulgated 2014) which sets out the requirements and limits for industrial effluent discharge which outlines the permitted use of treated effluent (e.g. for irrigation, etc.). The City defines industrial effluent as follows: “any liquid, whether or not containing matter in solution or suspension, which is given off in the course or as a result of any industrial trade, manufacturing, mining or chemical process or any laboratory, research, service or agricultural activity, and includes matter discharged from a waste grinder and any liquid other than domestic effluent…”

Limits are set for effluent discharge with respect to general pollution loads such as COD and electrical conductivity, as well as for chemical substances, heavy metals, and inorganic content (Schedule 1 of the Wastewater and Industrial Effluent). Failure to comply with these limits results in the application of a surcharge factor (CoCT, 2013).

Equation 2:

$$Vw\ (SVC) + VieT\ (COD\text{-}1000)/1500 + VieT\ (SF)$$

Where:

Vw	= total volume, expressed in kilolitres, of wastewater discharged from the premises during period concerned.
SVC	= sewerage volumetric charge in terms of the sanitation tariff.
Vie	= total volume, expressed in kilolitres, of industrial effluent discharged from premises during period concerned.
T	= cost, as determined by the council, of treating 1 kilolitre of wastewater.
COD	= chemical oxygen demand of the effluent in milligrams per litre. (If COD < 1 000, the COD factor falls away).
SF	= surcharge factor of the effluent calculated according to the formula:

SF = (X-L)/L

where

X	= concentration of one or more of the parameters listed in Schedule 2.
L	= limit applicable to that particular parameter.

9.2.3.3 Saldanha Bay Municipality: By-Law Relating to Water Supply, Sanitation Services and Industrial Effluent

Saldanha Bay Municipality (WC014) is a local municipality located on the West Coast of South Africa, approximately 140 km north of Cape Town. It forms part of the West Coast District Municipality (DC1), situated in the Western Cape Province. The area includes the towns of Hopefield; Langebaan, Saldanha, Jacobsbaai, Vredenburg, Paternoster and St Helena Bay.

Saldanha Bay Municipality has bylaws relating to Wastewater and Industrial Effluent which sets out the requirements and limits for industrial effluent discharge which outlines the permitted use of treated effluent (e.g. for irrigation, etc.) (Saldanha Bay Municipality, 2018). The Municipality defines industrial effluent as follows: "any effluent produced from the use of water for industrial purposes, and for the purposes of this by-law includes any effluent except standard domestic effluent or storm water; " whereby industrial purposes, in relation to the supply of water, is: "premises used for manufacturing, retailing and service industries, generating electricity, land-based transport, construction or any related purpose". Of note is that high strength sewage is defined as: "industrial sewage with a strength or quality greater than standard domestic effluent in respect of which a specific charge as calculated in accordance with the municipality's Tariff Policy may be charged".

An industry wishing to discharge to a wastewater treatment works must apply for a trade effluent permit. Requirements for this permit include initial pre-treatment, with conditions such as:

- the removal of settleable solids;
- the removal of fat, oil and grease;
- undertaking any further treatment as may be deemed necessary when more information on the composition of the effluent being discharged is available after sampling and analysis;
- taking special steps to ensure that no sea water can enter the municipal sewerage system prevention of ingress of sea water to municipal system.
- Limits are set for effluent discharge with respect to general pollution loads such as greater PV or COD (Chemical Oxygen Demand) value, a lower pH value, or a higher caustic alkalinity or electrical conductivity than specified in Schedule A. Failure to comply with these limits results in the application of a surcharge factor.

Part 24 of their Measurement of quantity of effluent discharged to sewage disposal system deals with the aspect of discharge via sea outfall:

1) The provisions of this part shall apply equally to industrial effluent discharged into any of the municipality's sea outfalls, subject to any additional conditions specific to sea outfalls that may be imposed.
2) Where industrial effluent is accepted for discharge into a sea outfall it shall be delivered to the point of acceptance approved by the municipality by means of a pipeline constructed and maintained by the permitted person
3) No industrial effluent shall be accepted for discharge into a sea outfall unless-
   a) it complies with the standards and criteria set out in Schedule A;
   b) it is proved that such effluent-
      i) is not toxic to marine fauna or flora;
      ii) contains no constituents in concentrations which can create a nuisance on the beaches or in the sea, or a health hazard or which may have an adverse effect on bathing or other recreational areas;
      iii) contains no floating material;
      iv) contains no substance which may be prejudicial or injurious to the municipality's sea outfalls and associated sumps, sewers, plant and equipment or to its employees;
      v) contains no materials capable of creating a nuisance by frothing; and
      vi) contains no standard domestic effluent;
   c) it complies with any applicable standards in terms of the National Water Act, 1998 (Act No. 36 of 1998).
4) The municipality may relax or vary the standards and criteria in Schedule A, provided that such relaxation or variation shall not constitute a relaxation or variation of those matters referred to in subsection (3).
5) The delivery pipeline from the premises concerned to the point of acceptance shall be maintained in a proper condition and free from any leaks.
6) Acceptance of the industrial effluent shall be subject to review at any time.

Table 9-4: Saldanha Bay Schedule A: Trade Effluent Discharge Limits

PHYSICAL AND CHEMICAL CONDITIONS REQUIRED BEFORE EFFLUENT ACCEPTANCE		
SUBSTANCES ACCEPTABLE IN LIMITED CONCENTRATIONS ONLY		
No person shall discharge effluent into the sewerage system which has:		
Parameter	**Allowed Specifications**	**Units**
a temperature at the point of entry in excess of;	43^0	C
a pH greater than 10,0 or less than 6,0;	6,0-10,0	
Chemical oxygen demand (COD) greater than	4 000	mg/l
Electrical conductivity – not greater than	250	mS/m at 25°C
Caustic alkalinity (expressed as $CaCO_3$)	2 000	mg/l
Substance not in solution (including fat, oil, grease waxes)	2 000	mg/l
Substances soluble in petroleum ether	500	mg/l
Sulphides, hydro-sulphides and polysulphides (expressed as S)	50	mg/l
Parameter	**Allowed Specifications**	**Units**

Substances from which hydrogen cyanide can be liberated in the drainage installation, sewer or sewage treatment works (expressed as HCN)	20	mg/l
Formaldehyde (expressed as HCHO)	50	mg/l
Non-organic solids in suspension	100	mg/l
All sugars and / or starch (expressed as glucose)	1 500	mg/l
Available chlorine (expressed as Cl)	100	mg/l
Sulphates (expressed as SO_4)	1 800	mg/l
Fluorine-containing compounds (expressed as F)	5	mg/l

No person shall discharge effluent into the sewerage system which contains a substance, either alone or in combination with other substances, having a concentration in excess of those listed below.		
(a) Chemical Substances other than metals		
Parameter	**Allowed specifications**	**Units**
Fats, vegetable oil and like substances	400	mg/l
Sulphides, or substances from which hydrogen sulphide can be liberated (expressed as S)	5	mg/l
Cyanides or substances from which hydrogen cyanide can be liberated (expressed as HCN)	20	mg/l
Sulphates (expressed as SO_4)	500	mg/l
Suspended solids	1 000	mg/l
Tar products and distillates	50	mg/l
Chloride (expressed as Cl)	1 000	mg/l
(b) Metals		
Group 1		
Chromium (hexavalent)	0	mg/l
Chromium (trivalent)(expressed as CrO3)	10	mg/l
Copper (expressed as Cu)	10	mg/l
Manganese	20	mg/l
Nickel (expressed as Ni)	5	mg/l
Zinc (expressed as Zn)	20	mg/l
Iron (expressed as Fe)	20	mg/l
Silver	5	mg/l
Cobalt	5	mg/l
Tungsten	5	mg/l
Titanium	5	mg/l
Cadmium	5	mg/l
Total collective concentration of all metals in Group 1	*50*	mg/l
Group 2		
Parameter	**Allowed specifications**	**Units**
Arsenic (expressed as As)	5	mg/l
Boron (expressed as B)	5	mg/l
Lead (expressed as Pb)	5	mg/l
Selenium (expressed as Se)	5	mg/l
Parameter	**Allowed specifications**	**Units**

Arsenic (expressed as As)	5	mg/l
Mercury (expressed as Hg)	5	mg/l
Cadmium (expressed as Cd)	5	mg/l
Total collective concentration of all metals in Group 2	10	mg/l
(c) Radio-active wastes		
Any radio-active waste or isotopes: such concentration as may be laid down by the Atomic Energy Corporation or any State Department.		
PROHIBITED EFFLUENTS		
No person shall discharge effluent into the sewerage system which 1) whether or not it is listed in the effluent standards or which either alone or in combination with other matter, may - i) generate or constitute a toxic substance dangerous to the health of persons employed in the maintenance or operation of the sewerage system; ii) be harmful to the sewerage system, or iii) adversely affect any of the processes whereby sewage is normally treated or the re-use of purified sewage effluent or the disposal of solids arising from the treatment process; 2) is in the form of steam at the point of entry into the sewerage system; 3) contains any substance of whatever nature likely to produce or give off explosive, inflammable, poisonous or offensive gases in such sewerage system; 4) shows any visible signs of oil, tar or associated products or distillates, bitumen's or asphalts or their emulsions, or emulsions of oil or grease or fats 5) contains any solids which may in the opinion of the local authority have an effect on the sewerage system; 6) contains any solvent immiscible in water; 7) contains dye or dye residues; 8) contains any substances in such concentration as may in the opinion of the local authority interfere with the sewerage system or adversely affect the quality of reclaimed water; 9) contains any non-biodegradable substance (e.g. blood) or 10) Contains stormwater or ground water.		

Industries classified as WET industries are compelled to enter into an effluent agreement with Council. Wet industries with a signed agreement shall pay, over and above a fixed availability fee, based on the size of the erf, industrial effluent charges based on the following formula, depending whether metered or not metered disposal of effluent (Saldanha Bay Municipality, 2018).

Metered industrial effluent: (Saldanha Bay Municipality, 2018)

Equation 3:

$$C = V \{R + T (COD/1000)\}$$

Where:

C = Treatment cost
V = Volume of Industrial effluent
R = Cost of conveying of 1 Kilolitre runoff
T = Cost or treating of 1 kg COD
COD = Chemical oxygen requirement per mg per litre.

Not metered industrial effluent: Volume derived from water consumption: (Saldanha Bay Municipality, 2018)

Equation 4:

$$C = fQ \{R + T (COD/1000)\}$$

Where: C = Treatment Charge fQ = Effluent volume calculated using the average water consumption of the previous 3 months R = Cost of transporting 1 kl runoff T = Cost of treating 1 kg of COD COD = Chemical Oxygen Demand in mg per litre

With regard to wet industries without a signed agreement, the Council reserves the right to charge the higher of the fixed availability fee, based on the size of the erf, plus the determined fixed industrial effluent tariff OR the fixed availability fee, based on the size of the erf, plus the industrial fee as per the above formula, depending whether metered or not metered disposal of effluent (Saldanha Bay Municipality, 2018).

9.2.3.4 Overstrand Municipality: By-Law Relating to Water Supply, Sanitation Services and Industrial Effluent

Overstrand Municipality, which covers areas such as Gansbaai, etc., has bylaws relating to water supply (Chapter 2) and wastewater/ sewerage and Industrial Effluent (Overstrand Municipality, 2009). These sets out the requirements and limits for industrial effluent discharge which outlines the permitted use of treated effluent. (Chapter 3 parts 1 & 2). Formal application to municipality for discharge into municipal sewers required for industrial effluent and must include initial pre-treatment to ensure that it complies with Schedule A limits (*Schedule A not available on web*) prior to discharge.

The Overstrand LM Draft Water Services Development Plan WSDP (Overstrand LM and WorleyParsons, 2019) , show the Commercial and Industrial sewerage tariff structures for Overstrand Municipality for the 2017/2018 financial year and the previous three financial years summarised in the table below (Subject to 15% VAT).

Table 9-5: Commercial and Industrial sewerage tariff structures for Overstrand Municipality for the 2017/2018 financial year and the previous three financial years summarised

Consumer /Description	Tariff Code	Category	17/18	16/17	15/16	14/15
Consumption – All other (Including Commercial, Industrial, School, Sport, etc.)	SE7D1	Per kl (based on 90% of water usage) per unit per month – this percentage may be adjusted according to the Tariff Policy after investigation The Municipal Manager may also institute a cap on the volume of sewage if appropriate to the consumer.	R12-22	R11-54	R10-88	R10-26

The Tariff Policy (Overstrand LM, 2020) identifies the following aspects relevant to industrial effluent:

- A monthly basic charge shall be levied on all properties or units within urban areas, irrespective of the type of service available.
- A sewage usage charge will be levied on all properties or units that produce sewage or have a water meter. For the category "ALL OTHER USERS (Including Commercial, Industrial, School, Sport, etc.)", the sewage volume will be deemed to be 90% of water consumption. The 90% may be adjusted by the Municipal Manager as appropriate to the consumer. The Municipal Manager may also institute a cap on the volume of sewage if appropriate to the consumer.
- An effluent fee shall further be payable by factories and other industrial users where the wastewater emanating from such users requires special purification measures by the Municipality. Such fees shall be based on the toxic content of the wastewater concerned and the costs of purification.
- A monthly infrastructure charge will be levied on all properties or units.

Table 9-6: The Tariff Policy (Overstrand LM, 2020) identifies the following tariff relevant to industrial water supply, specifically marine customers:

Detail	**Basic Charge (Rand/meter/ month)**	**Unit Charge / kℓ**	**Level of Consumption (Rand/kiloliter/ month)**
Normal Tariff	**X**	**X**	(i) 0-5 800 kℓ (ii) >5 800 kℓ
Restriction Tariff 1 (levels 2 & 3 restrictions) **PLUS 30% of Normal Tariff**	**X**	**X**	(i) 0-5 800 kℓ (ii) >5 800 kℓ
Restriction Tariff 2 (levels 4 & 5 restrictions) **PLUS 60% of Normal Tariff**	**X**	**X**	(i) 0-5 800 kℓ (ii) >5 800 kℓ
Restriction Tariff 3 (level 6 restrictions) **PLUS 100% of Normal Tariff**	**X**	**X**	(i) 0-5 800 kℓ (ii) >5 800 kℓ

10 IDENTIFICATION AND DESCRIPTION OF PELAGIC FISH INDUSTRIES

10.1 Identification and selection of industries for site assessment

As indicated by the Methodology and Literature Study, a number of pelagic fish and fish processing plants were identified and shortlisted for site visits and assessment in terms of their water, wastewater and energy management. The following table summarises the industries that were approached to participate in the WRC surveys, based on their status as active members of SAPFIA.

Table 10-1: Table showing the specific industries, mainly pelagic and some mixed, earmarked for site visit

#	Type	Group	Area	Rationale for Inclusion / Exclusion
1	Pelagic	Pioneer Fishing	Saldanha Bay	- 2 processing plants - Manufacture canned, frozen fish products, fishmeal, fish oil
2	Pelagic	Oceana Group	Laaiplek, St Helena Bay	- 2 desalination plants (0.8 Ml/d & 0.6 Ml/d): - Cannery (Lucky Star) & Fishmeal (reduction) plant (Oceana Fishmeal) - Operational areas are in Cape Town, Hout Bay and St Helena Bay.
3	Pelagic	Oceana Group	Hout Bay	- Cannery (Lucky Star) & Fishmeal (reduction) plant (Oceana Fishmeal)
4	Pelagic	Oceana Group	Walvis Bay in Namibia	- Cannery (Lucky Star) & Fishmeal (reduction) plant (Oceana Fishmeal)
5	White fish / demersal	Sea Harvest	Saldanha Bay	- Desalination plant & effluent treatment plant (recycling) – 1.15 Ml/d 2 fresh fish factories in Saldanha Bay and Cape Town - 1 value-added plant in Saldanha that produces an assortment of crumbed, battered and sauced products - Not pelagic
6	Pelagic	Oranjevis	Sandy Point Harbour; St Helena Bay	- Cannery – a joint venture between Pioneer Fishing (West Coast), TerraSan Pelagic Fishery and Eyethu Fishing - 100 000t operation producing canned pilchards (Sea Pride brand), as well as manufacturing fish meal and fish oil
7	Pelagic	St Helena Bay Fishing Industries	Stompneusbaai; St Helena Bay	- Cannery, part of Lucky Star
8	Pelagic	Premier Fishing's Southern Sea Fishing	Saldanha Bay	- Premier Fishing (trading as Southern Seas Fishing) re-commission and upgrade its existing fishmeal and fish oil plant in Saldanha (2013). - Located in Pepper Bay on western side of Saldanha Bay
9	Pelagic	Gansbaai Marine	Gansbaai Harbour; Gansbaai	- Produce canned fish and fish meal

#	Type	Group	Area	Rationale for Inclusion / Exclusion
10	Pelagic	West Point Fishing & West Point Processors	St Helena Bay	- Pelagic fish processing factory which catch and process pilchards, sardines and middle-cut - Production capability of 20 ton/hour raw fish in cannery and 50 tons/hour raw fish in fish meal plants - Major upgrades to the cannery, fishmeal plant and jetty were undertaken between 2005 and 2013, paving the way for HACCP accreditation in 2012 and ISO 22000 certification in 2013, making West Point Processors the first food processing factory in SA to achieve this.
11	Pelagic	Afro Fishing (Pty) Ltd	Mosselbay	- EIA Feb 2019 expansion of the current Afro Fishing facility to include fish meal and oil reduction processes as a new canning store addition - The expansion project will include fish meal and oil reduction plant, fish freezing plant, cold store, fish meal warehouse, and a new canned product warehouse - The reduction process will include cooking, pressing, liquid-solid separation, steam drying, waste heat evaporation, oil-liquid separation, cooling / grinding / bagging, and boilers for steam generation.
12	Mixed incl Pelagic	Balobi Processors (Pty)Ltd	Port St Francis; between St Francis Bay and Cape St Francis	- Group of companies with own fleet of fishing vessels - Squid, sardine and hake fishing - Catch, process, market, sell and export their own product as well as other fishing vessels product.
13	Hake Demersal	I&J (Irvin & Johnson Limited)	Woodstock	- Vertically integrated South African company with substantial investments in fishing, food processing and aquaculture. - Woodstock Factory is the largest I&J fish processing factory based in Woodstock, Cape Town - Value-added products, including par-fried, char-grilled, coated and microwaveable seafood products are processed at I&J's factory in Paarden Eiland, Cape Town harbour - Cold Storage facility situated in Paarden Eiland. - Not in the pelagic industry
14	Lobster, pelagic catching	Drommedaris Fisheries	Stompneusbay; St Helena Bay	- Catching and packing of cape lobster, sardines and anchovies, to be processed by other factories
15	Hake	Eyethu Fishing (PTY) Ltd	Old Tug Wharf, Port Elizabeth Harbour, Port Elizabeth	- Chokka squid and pilchard fishing - Squid, mackerel and hake fishing, and hake processing and freezing - Parent Pioneer Fishing (Pty) Ltd. - Not a pelagic processor
16	Hake Pelagic	Visko Sea Products	St Helena Bay	- Marketer of Fish Products, including pelagic - Not a processor

From the above 1st order identification, a total of 11 factories were selected as a scientifically representation of the pelagic fish industry of South Africa. These included:

1. Lucky Star in St Helena Bay
2. Amawandle Pelagic in Laaiplek, Velddrif
3. Oranjevis (Pioneer Fishing) in St Helena Bay

4. West Point Processors in St Helena Bay
5. Gansbaai Marine in Gansbaai
6. Afro Fishing in Mossel Bay
7. Sceptre Fishing
8. Risar Fishing
9. Balobi Processors
10. Komicx Products
11. 82 Boundary Rd BK.

10.2 Introduction to Site Surveys

Letters of invitation and questionnaires were sent to the eleven identified pelagic processing sites (December 2019). The potential participants were identified using the SAPFIA database, and selected based on indications of being processors. Fifty-five percent (55%) of the industries responded positively, 9% declined participation and 36% did not respond despite follow-up communications.

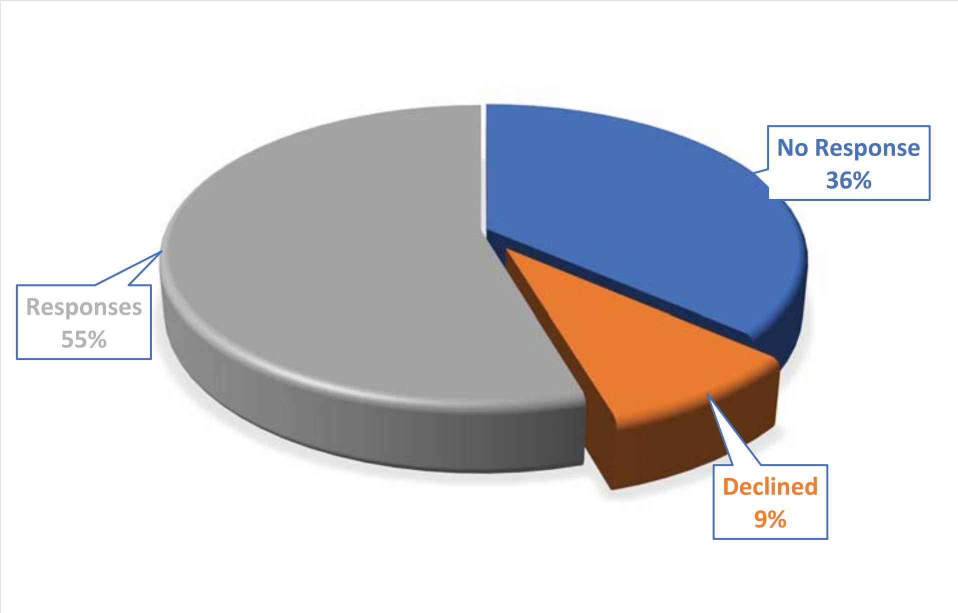


Figure 10-1: Pelagic Processing Industry Participation

The industries which responded, but declined to participate, indicated that financial distress, due to the lack of raw fish, and lack of capacity to contribute meaningful to the research, as the basis for their rationale. It is suspected, but unconfirmed, that the non-respondents were in similar situations or may already have closed business. Four of the eleven parties decided to participate straight away, another two were convinced to participate by assuring confidentiality of key information. Therefore, a 55% participation figure was achieved.

The sites that responded to an invitation by the WRC to participate included:

1. Lucky Star in St Helena Bay;
2. Amawandle Pelagic in Laaiplek, Velddrif;
3. Oranjevis in St Helena Bay;
4. West Point Processors in St Helena Bay;

5. Gansbaai Marine in Gansbaai; and
6. Afro Fishing in Mossel Bay.

The common denominator to the participating plants was that all own and operate canning plants, where fish is landed, processed, canned, cooked in the can, prepared with sauces, sealing and distribution. Five of the sites have value-add processes, whereby fish are processed to fish oil and fish meal, for distribution as protein source to the animal feed market.

This section provides a high-level overview of general process flows within the surveyed facilities. The information is presented as typical since some of the specifics are regarded as intellectual property to provide a competitive edge.

10.3 Process Description of Canning Plants

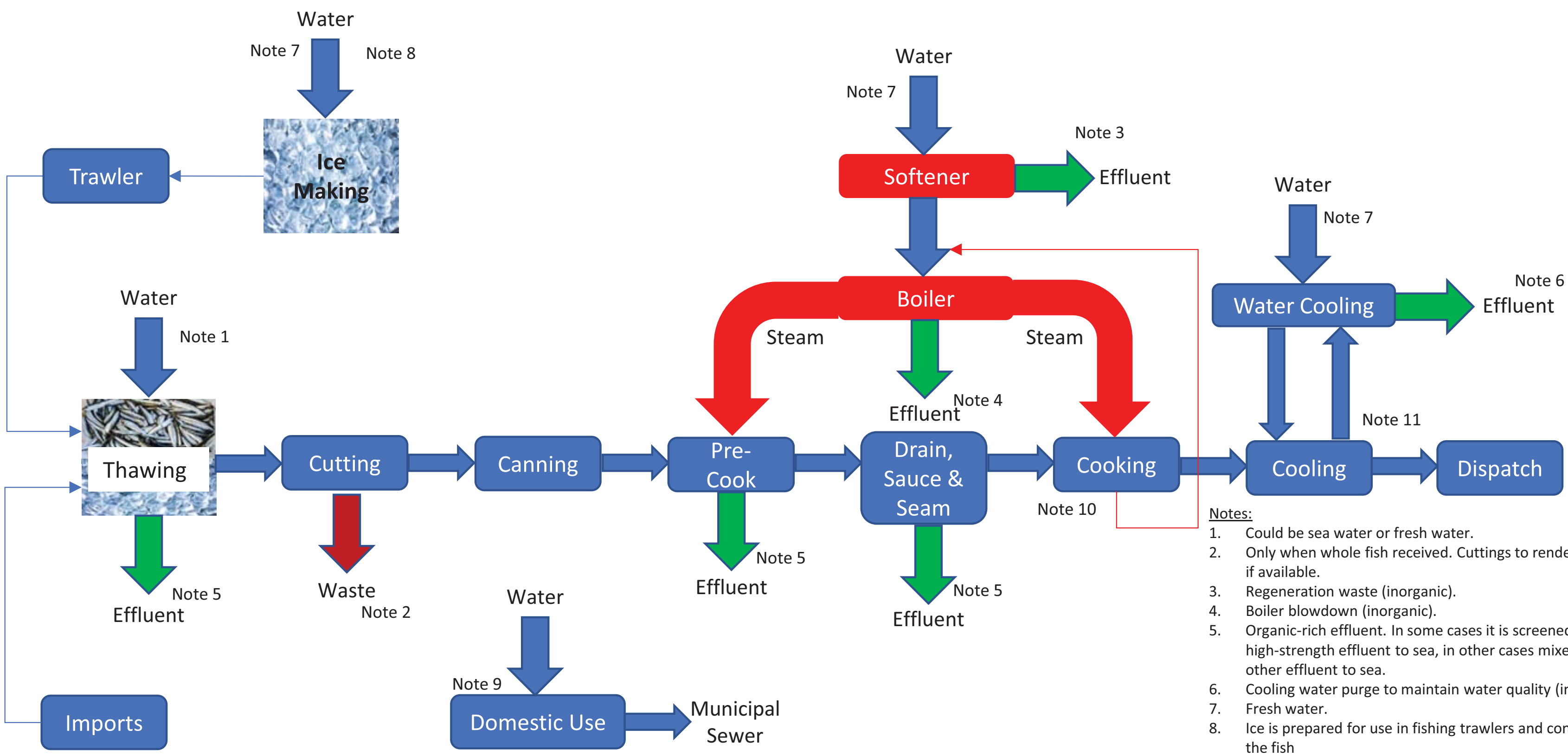
Site visits and photographic images confirmed that the six participating canned fish industry follows similar processes, with minor deviations found within each site. Such differentiations are not reported, due to the competitive nature of the industry and/or aspects related to Intellectual Property (IP). The generic stages are summarised hereunder, as illustrated in the Process Flow Diagram following.

- Thawing
- Washing
- Grading
- Pre-cooking
- Saucing.
- Seaming
- Final cooking
- Cooling
- Labelling and dispatch

Figure 10-2: Photo Image of Filled Cans in Storage ready for Labelling and Dispatch at Afro Fishing

At all facilities, cans are manufactured off-site and delivered to site. Cans are pre-treated (sterilised) via air purging, using pressured steam purge. Some industries do not sterilise the cans at this stage, as all plants apply sterilisation in the downstream pre-cooking and cooking processes. The water condensate that forms during the process and cleaning is directed to drain.

Imported fish are generally brought into the factory in a frozen state, mostly in the form of cutlets. Fish caught in company-owned vessels is landed within the factory as whole fish. When caught locally, the netted fish is discharged into chambers on the boat filled with approximately 30% ice and 30% sea water, the remaining 40% volume being available for storing fish. The ice is usually produced on-site.



Notes:

1. Could be sea water or fresh water.
2. Only when whole fish received. Cuttings to rendering in fish meal plant if available.
3. Regeneration waste (inorganic).
4. Boiler blowdown (inorganic).
5. Organic-rich effluent. In some cases it is screened and discharged as high-strength effluent to sea, in other cases mixed and discharged with other effluent to sea.
6. Cooling water purge to maintain water quality (inorganic).
7. Fresh water.
8. Ice is prepared for use in fishing trawlers and containers to preserve the fish
9. For kitchens, ablutions, etc..
10. Condensate returns to boiler in some cases. Potential contamination causes disposal in other cases.
11. Final cooling by air

Figure 10-3: Typical Pelagic Fish Canning Plant Process Flowchart representing the Assessed Plants

Figure 10-5: Photo Image of a Pre-Cooker at Afro Fishing

Figure 10-4: Photo Image of Thawing Chamber at Afro Fishing

The incoming fish is generally first stored in cold storage to ensure that sufficiently large production runs can be done to limit production costs. Cooling in storage is accomplished using chillers. The refrigerant is ammonia or freon and cooling towers are used to dissipate heat to the atmosphere. The fish is thawed prior to processing, as frozen fish is brittle and can easily break resulting in a loss in product.

The thawing of fish is achieved by immersing the fish (and ice) in water. Some sites use fresh water for thawing, other sites extract sea water for processing purposes. The ice melts in the water, with the temperature of the water and fish rising to about 5°C. The temperature cannot be allowed to rise higher that the critical limit of 8°C, to prevent the cultivation of bacteria during handling before cooking.

The fish and water are separated, with the resultant water containing scale, blood and guts of fish that may have ruptured during the transfer process to the thawing vessels. After separation from the fish, the water is discharged to sea after screening. This effluent stream contains mostly organic compounds from the fish, such as blood and scales.

The thawed fish, after separation from the water, is fed via a perforated conveyor to the canning section. If required, the heads and tails of the fish can be automatically removed by cutters, and the guts of the fish can be removed through vacuum suction. The offcuts are routed to the fish meal plant (if available) or is sent to another fish meal facility. Mostly the fish is received as cutlets, with no solid waste or liquid being produced.

For canning purposes, the fish is graded according to size and manually selected (or rejected). The fish is automatically orientated and inserted in the cans on rotating table machines, referred to in the industry as auto-packers.

The cans remain open at the top as they are placed and fed to a pre-cooker, also referred to as exhaust boxes. The pre-cooker is closed and the entire chamber is heated with direct steam. The steam pressure is reduced to facilitate the temperature to be controlled typically between 85 and 95°C (below water boiling temperature). The cans remain inside the pre-cooking process typically for 30 minutes. Most of the water and oil from the fish would now have separated.

Figure 10-6: Photo Image of a Boiler at Gansbaai Marine

The cookout liquids in the cans are then removed in a dewatering reel, using a rotary draining technique. The drained liquid is discarded to the effluent system. Excess steam from the pre-cookers is released to atmosphere and any condensate is drained to effluent.

Steam for the pre-cooker (and main cooker) is generated on-site in steam boilers. The boilers are fired on fuel oil or coal. Coal ash is produced as solid waste from the facility, which is typically removed from site by waste removal contractors. Emissions (primarily carbon dioxide) are routed to the atmosphere from the boilers.

The steam pressure is typically maintained at 10 bar or 1000 kPa. Feed water to the boilers are prepared by softening fresh water (or desalinated water, if available) using ion exchangers, regenerated with sodium chloride (table salt).

After liquid had been drained from the cans, sauce is added to the can, typically tomato sauce or chilli sauce. The sauces are prepared on site.

Vacuum is drawn on the cans, thereby draining any remaining liquid from the can. The vacuum in the can is maintained which allows the selected sauce to enter the can under negative pressure, leaving about 5 mm head space. The cans are then capped and sealed.

Figure 10-7: Photo Image of Sauce Addition and Can Seaming Machine at Afro Fishing

The outside of the cans is washed with water to remove any remnants of the water and/or oil drained from the cans or sauce that may have spilled in the process. All liquid discharged from the cans is discharged with the other effluent streams.

The cans are coded before being transferred to the next process. Subsequently, the cans are packed into steel crates. The canned fish is now ready for the final cooking process. The crates are loaded into

Figure 10-8: Photo Image of Fish Cookers at Afro Fishing

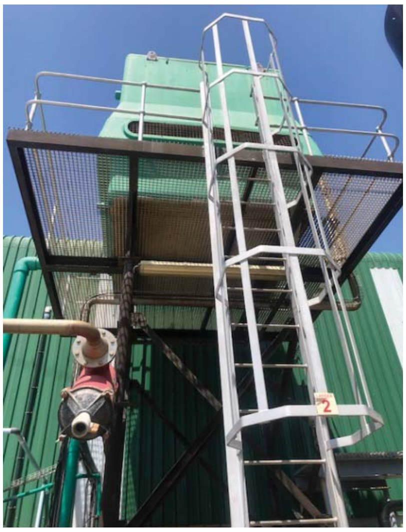


Figure 10-9: Photo Image of a Cooling Tower at Afro Fishing that assists in Retort Cooling after Cooking

Figure 10-10: Photo Image of Final Canned Products at Afro Fishing

the cooker on a batch basis, at which stage, steam is applied into the cooker. The cooker is slightly pressurised with the steam so that the temperature can be raised to approximately 121°C. The fish and sauce cook inside the cans for about 75 minutes.

Once the cooking step is completed, the steam is closed to the cooker. Pressure is released from the cooker by purging with air. The air also assists to partially cool the cans.

In some canneries, the cooker is then filled with cooling water. Once filled, the water is pumped out through a cooling tower. The recooled water is used to fill the cooker a second time for further cooling. This step may be repeated until a temperature of 45 to 55°C has been reached. Some canneries use air cooling, which may take longer.

The water is reused as often as possible. The main control parameters are chloride and pH, as these two constituents are primary causes of corrosion and potential damage to the can. The cans can be made from steel, with a tin (Sn) coating. When all the water removed from the cookers, the trays are placed on the floor where further natural cooling occurs. The cans are then labelled and stored to be dispatched to distributors and customers.

10.4 Process Description of Fish Meal Plants

Fish destined for the VAP (value-add plants) such as fish meal and fish oils, are usually caught in local waters. Similar to international practice, these species would typically be fish not suitable for human consumption, such as anchovy (Engraulis capensis) and red herring (Etrumeus whiteheadi).

Fish meal is produced primarily as a high protein source for animal feeds. Lately, aquaculture has proved to be a significant market. About 23% by mass of the incoming fish is converted to fish meal, of which 2% of the mass is converted to fish oil, a valuable by-product in the fish meal process. The remaining 75% comprise of water. The fish are offloaded from the boats and trawlers using different methods.

Generally, the use of water is avoided in order to minimise the water to be weighed (and paid for) with the fish, and to have less effluent to manage and discharge. Fish is transported mainly using pneumatic systems, open vane type pumps and perforated conveying belts. In some cases, water is still used, mainly for the purpose of preserving the quality of the fish product.

Figure 10-11: Photo Image of Gansbaai Offloading Jetty

In some cases, the water that is transferred through the perforated belts, is intercepted, and screened using typically 500-micron wedge wire screens. The recovered solids are added to the fish. The water from the dewatering screens contains blood and other high dissolved organic fractions and is routed to effluent.

The fish is weighed (for payment purposes and monitoring of quotas) before being transferred into holding tanks. The fish is transferred by a screw conveyor to a hopper, where formalin is added to the whole fish. The use of formalin is dependent on the type of fish. The formalin provides coagulation and binding characteristics to the fish (to assist in the water separation process after the cooker) and acts as a biocide (to prevent bacterial activity).

The raw fish is then fed into a cooker, where it cooks for about 20 minutes at temperatures >85°C. The cooked fish is then fed to either a screw press or a decanter where the solids are removed from the liquids.

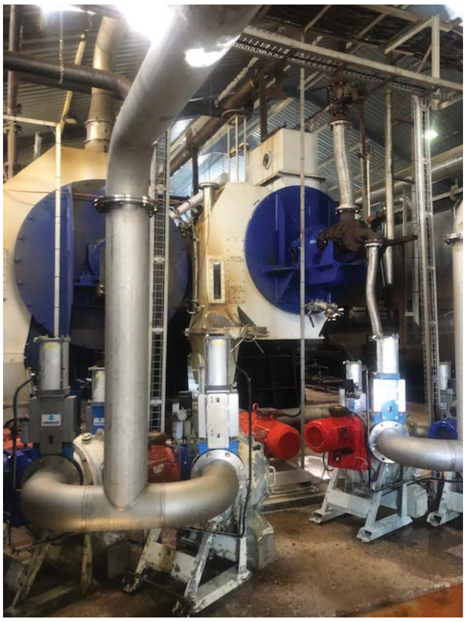


Figure 10-12: Photo Image of Fish Meal Cooker at Lucky Star, St Helena Bay

Figure 10-13: Photo Image of Decanting Centrifuges at Lucky Star, St Helena Bay

The liquid consists of a water phase and an oil phase. These phases are separated in decanting centrifuges, that employs the density difference between the liquids to separate them. The solids are fed to a dryer.

In some cases, the oil is heated and washed using clean water with some heat prior to dispatch. This is to reduce the solids and moisture content in the oil. In other cases, the oil is dispatched as is. The main parameter that is monitored in the oil is its free fatty acid content, being a critical specification.

The water phase contains between 6 and 10% solids, which is heated and pumped to the so-called Stick Water Plant. This name has been coined due to the 'sticky' biological content in this water. In this plant, water is evaporated from the solids so that the solids content is increased from 10% to 35%.

Notes:

1. In some cases air or open vane pumps are used to minimise use of water.
2. Volume depends on method of offloading. The screening and water recovery is not done on all sites, depending on the off-loading method employed.
3. Regeneration waste (inorganic).
4. Boiler blowdown (inorganic).
5. Organic contamination. On some sites water cooled condensers are not used, but the effluent from the evaporators are similar. In one case, this water is successfully used for lawn watering.
6. In some cases, waste heat from the dryers is used as heating medium for the initial evaporators and steam for the final evaporators. In other cases, only steam is used for all evaporators.
7. Fresh water.
8. In some case, hot gas is used as energy source to the dryer instead of steam.
9. This step is not applicable to all sites.
10. On some sites water cooled condensers are not used, but the effluent from the evaporators are similar. In one case, this water is successfully used for lawn watering.

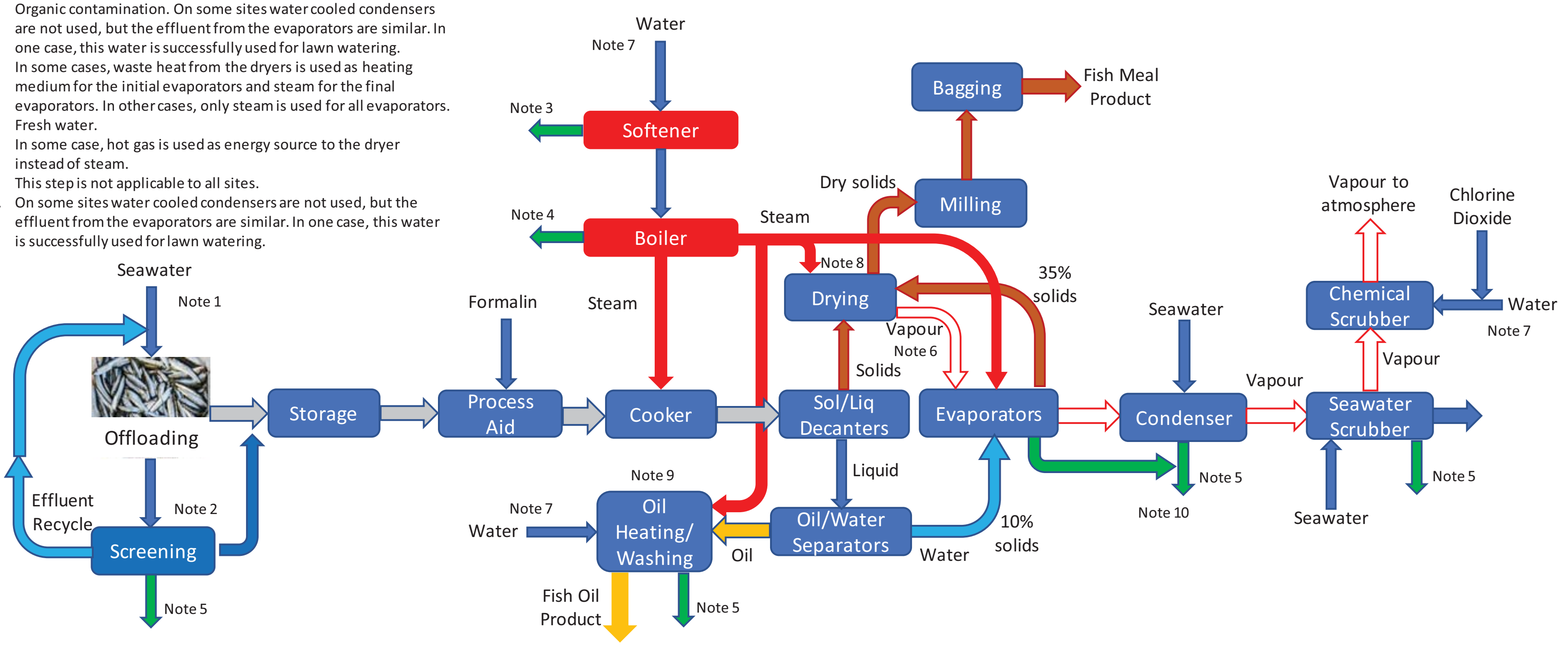


Figure 10-14: Typical Pelagic Fish Meal Processing Plant Flowchart

Figure 10-16: Photo Image of Evaporators at West Point Processors

Figure 10-15: Photo Image of Set of Dryers at Gansbaai Marine

This plant is operated under vacuum, thereby reducing the boiling point of the water. This makes it possible to use waste energy sources at lower temperature as the heat source. Within the plants surveyed, heat sources were either:

- Steam from the boilers, in which case condensate was recovered and recycled to the boilers, or;
- Dryer off-gas and vapour.

Some process condensate is formed from the stick-water, which is routed to effluent.

The 35% solids product stream from the stick water plant is combined with the solids from the presses/decanters. This is jointly fed to the dryer. Two dryer types are used in industry, namely direct contact dryers (direct contact of live steam) and indirect contact dryers, i.e. no contact between heat source and dryer. The solids feed has a moisture content of about 55%. By application of heat, the moisture is evaporated to reduce the moisture content in the solids to between 5 and 10%. The temperature in the dryer is typically around 80 to 105°C. The heat to the dryer is supplied from varying sources in the sites surveyed:

- Steam;
- Boiler flue gas;
- Hot gas produced from firing fossil fuels.

The hot and dried meal is pneumatically transported to hammer mills. The transport air cools the meal to large extent.

The mill is used to reduce the particle size of the meal.

Antioxidant is added to the fish meal before it is bagged in 1-ton bulk or 50 kg bags for dispatching purposes. Every bag is tested for key parameters (protein, moisture, fat, free fatty acids, histamine, Total Volatile Base Nitrogen) before being shipped.

Vapour from the evaporators is scrubbed with seawater. Odorous fractions that do not condense in the scrubber (e.g. sulphur compounds) are oxidised in a second scrubber using sodium hypochlorite (typically 15% chlorine) before being released to atmosphere.

Figure 10-17: Photo Image of Bagging of Fish Meal at Lucky Star, St Helena Bay

10.5 Automation

The general level of automation is limited in terms of overall process control within the factory site. There are degrees of automation of individual equipment items, e.g. packing, sauce addition, etc. Some of the sites have a SCADA system for monitoring and process control purposes, whereas other sites rely on physical inspections, manual procedures and recording data in operational logbooks. All the sites have significant potential to increase automation. However, the general trend in the industry is to make maximum use of labour and support local job creation (from a social responsibility point of view).

The fish industry in general are facing hardships of various kinds during this research study (2019-2020) and will probably only embrace the advantages that the fourth industrial revolution offer once the industry can operate at full design capacity again, the main limit being raw fish availability due to the applied quota system. Currently, increasing automation is not seen to increase production.

11 WATER, EFFLUENT AND ENERGY MANAGEMENT IN THE SOUTH AFRICA PELAGIC FISH INDUSTRY

Desktop analysis, coupled with physical site visits to the six participating industries, resulted in a fair amount of data and information collected for each case study. In lieu of confidentiality, an alphabetical referencing system is applied where A, B, C, D, E and F reference the different case sites. The results for the six sites presented hereunder in terms of water, effluent and energy management. The results are compared and benchmarked in a later section of the report.

11.1 Site A

Site A produces fish meal and fish oil and has a pilchard cannery. Most of the pilchards are imported due to the limited available fish in South African waters. The fish for the fish meal and oil is mostly caught in South African waters. Two docks are available for offloading, one for the fish meal plant and one for the cannery.

11.1.1 Water and Effluent Analysis at Site A

Fresh water is imported from the local municipality, which complies with drinking water standard SANS 0241:2015. During the drought of 2018, a reverse osmosis (RO) seawater desalination plant was installed to reduce the reliance on municipal supplied water. Feed water to the RO plant is sourced from boreholes that provide water with low solids content. This water is abstracted under a water use license. The RO plant recovers 40% of the feed water as permeate, and 60% remains as brine. The brine becomes part of the effluent stream from the site.

Permeate and freshwater is combined in a tank and distributed to the various plant sections for processing and cleaning purposes. The well water flow and the freshwater flow is measured on a continuous basis. No other water measurements take place; hence, no data is available to track water distribution to the cannery and the fish meal plants separately.

Water is used at the boilers for steam generation, with both the fish meal plant and cannery plant using steam. The boilers are coal fired. Water is also used for process cooling. Other uses for the freshwater include equipment cleaning and factory cleaning, as well as for the thawing of incoming frozen fish.

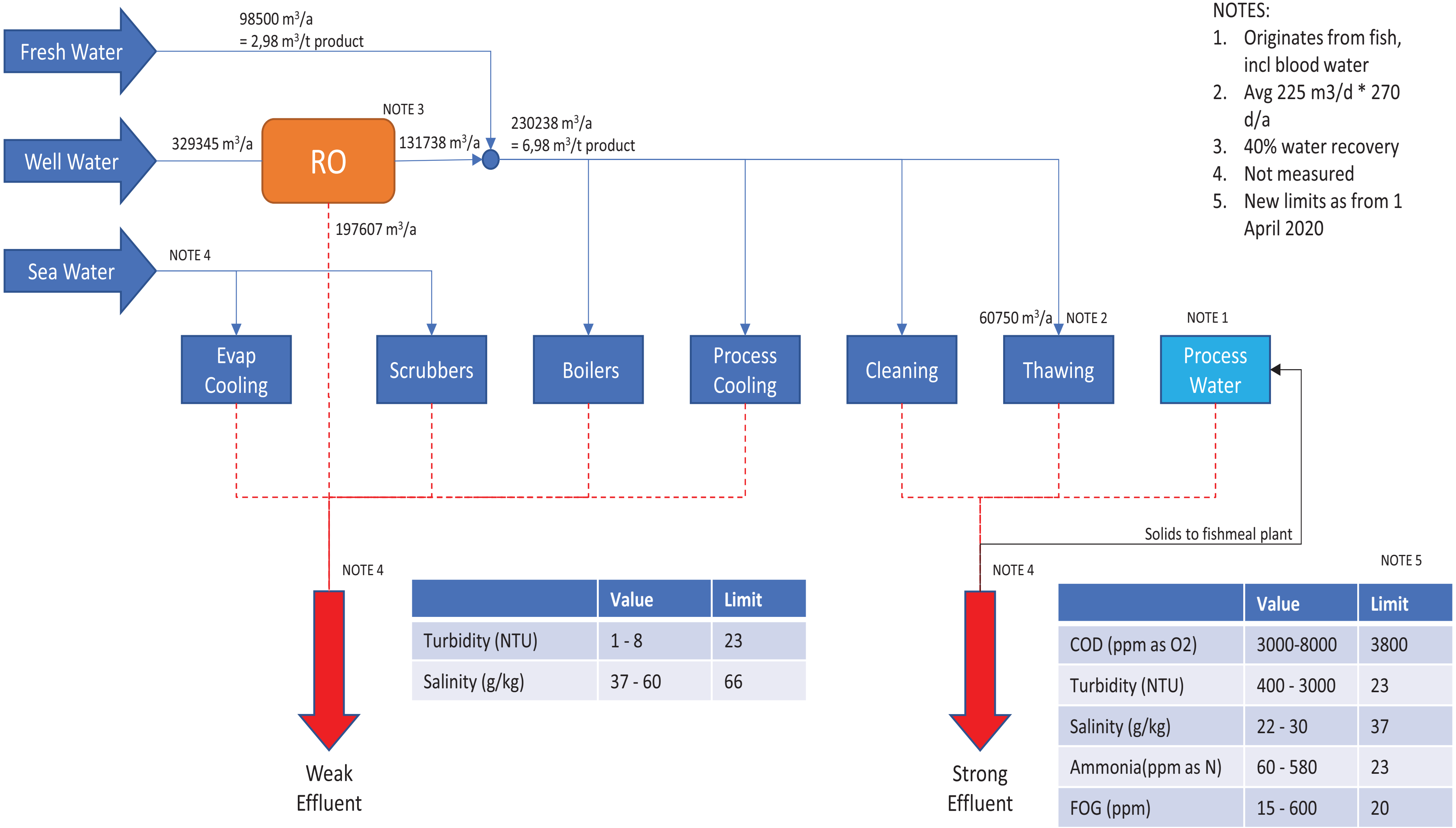
The specific water intake (SWI) is defined as:

$$SWI = \frac{total\ water\ consumption\ (m3)}{total\ mass\ of\ product\ (ton)}$$

Site A uses 6,98 m^3 of water (fresh water and RO permeate combined) per metric ton of product. When RO permeate is regarded as an "internal" water and the SWI is calculated based on fresh water import only, the SWI is 2,98 m^3/t product.

The flow diagram hereunder provides the key characteristics of water and effluent flow during the processing of fish at this site:

- 329 354 m^3 of well water (filtered seawater) is used to feed the RO plant, producing 131 738 m^3 of permeate. This permeate is augmented by 98 500 m^3 municipal water and used to feed the boilers and cooling systems. It is also used to thaw incoming fish and for general cleaning purposes.
- Seawater is imported for cooling at the waste heat evaporators and scrubbing purposes. The seawater flow is not measured.
- The split of water between the respective processes within which water is used, is not measured.
- Effluent production is not monitored in terms of flow but is almost 100% of the water intake (minus evaporation losses). Since seawater intake is not measured, it is not possible to quantify the effluent volume.
- Weak effluent is characterised by low COD value (inorganic contamination only) and typically originates from RO brine, boiler blowdown, scrubbers, used cooling water, etc.
- Strong effluent is characterised by higher COD content and typically originates from thawing, cleaning and separated process water (water inherent to fish).
- Both weak and strong effluents are discharged to sea, at different points.
- Limits are set through the Coastal Water Discharge Permit (CWDP) with respect to constituents. According to these limits, the weak effluent complies, but the strong effluent does not comply with respect to COD, ammonia, FOG and turbidity.
- Any solids recovered in the effluent screens are fed to the fish meal process.



	Value	Limit
Turbidity (NTU)	1 - 8	23
Salinity (g/kg)	37 - 60	66

	Value	Limit
COD (ppm as O2)	3000-8000	3800
Turbidity (NTU)	400 - 3000	23
Salinity (g/kg)	22 - 30	37
Ammonia(ppm as N)	60 - 580	23
FOG (ppm)	15 - 600	20

Figure 11-1: Site A Water and Effluent Flowchart

Seawater is imported for cooling at the waste heat evaporators. The other main use is at the scrubber. The off-gas from the drier is routed through seawater in the scrubber to cool and condense the vapour. The seawater flow is not measured.

Effluents are generated from various plant sections as depicted in the flowchart. The streams with potential high COD content are combined as strong effluent, and the remainder combines as weak effluent.

The strong effluent is routed through a screen (to remove most of the solids) before being discharged to sea. Note that the raw fish contains about 70-75% water and blood. This is removed in the process and reports to the strong effluent as well. This is represented in the diagram as Process Water. The weak effluent is directly disposed to ocean, without screening.

Similar to raw water intake, there are also no flow measurements on any of the effluent streams. The Specific Effluent Volume (m^3/t product) can therefore not be determined, for purposes of this study.

The high strength effluent is regularly sampled and analysed and compared with the effluent limits set by the CWDP permit. Site A is consistently exceeding the limits set for COD, turbidity, ammonia and fats, oils and greases, as can be observed from the table depicted in the flow diagram. Management has approved a project to install a dissolved air flotation (DAF) plant to remove the remaining solids and fats from the stream prior to discharging. This should improve the compliance rate.

No water / effluent balance can be formulated for this site, due to the lack of flow and quality monitoring across the various intake, processing and output stages.

11.1.2 Energy Analysis at Site A

This facility uses electricity to power drives (for pumps, motors, centrifuges, conveyors, etc.) and for lighting. The total electricity consumption is measured, but the distribution within the facility is not measured.

The specific energy consumption (SEC) is defined as:

$$SEC = \frac{total\ electricity\ consumption\ (kWh)}{total\ mass\ of\ product\ (ton)}$$

In the case of Site A, this was found to be 148,5 kWh/t product.

A portion of the electricity is consumed by the reverse osmosis unit, thus resulting in increased electricity use to reduce freshwater consumption.
Given that a RO typically consumes 2,7 kWh/m^3 permeate produced, the impact of using RO on Site A in terms of electricity consumption is 10,8 kWh/t product. This means that this site consumes 10,8 kWh/t more electricity in exchange for a reduction in specific water consumption of 4,0 m^3/t product.

The following figure shows the energy mix for this site, differentiating between electrical energy and thermal energy. Thermal energy is expressed in GJ to be consistent with convention.

The total electricity consumption of 4 900 000 kWh/a translates into the SEC of 148,5 kWh/t product.

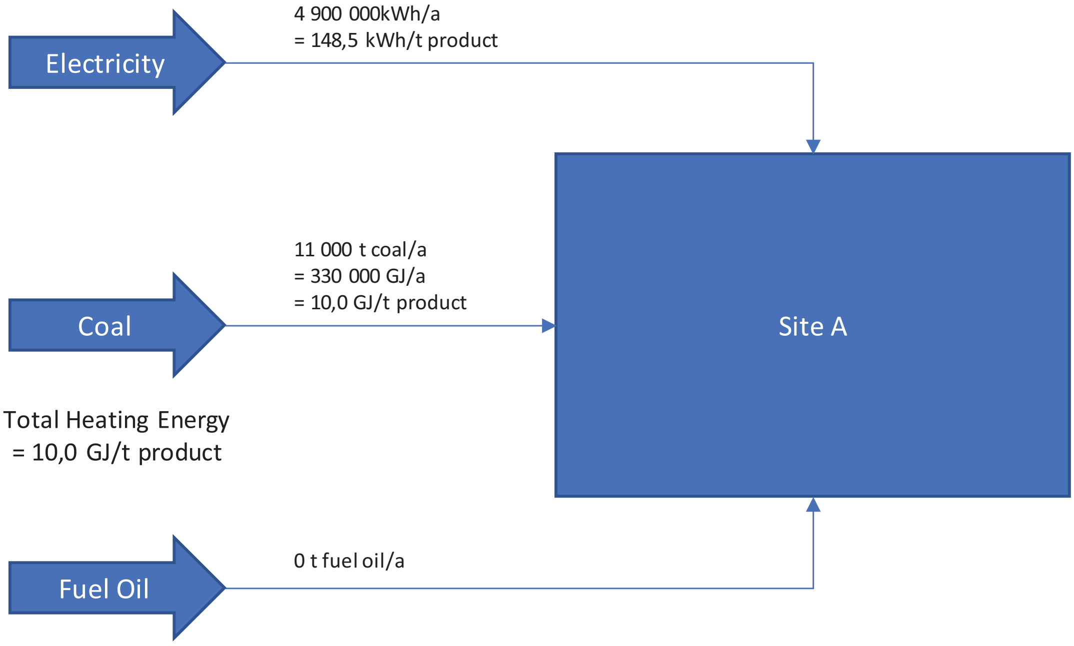


Figure 11-2: The Energy Mix at Site A

For process heating purposes, the site generates steam by firing bituminous coal. Coal is sourced from the Mpumalanga coal fields. The amount of coal consumed is measured at 11 000 t/annum. At a calorific value of 30 MJ/kg, the energy consumption is therefore 330 000 GJ/a.

$$SFC = \frac{total\ heating\ energy\ consumption\ (GJ)}{total\ mass\ of\ product\ (ton)}$$

Specific Fuel Consumption was found to be 10,0 GJ/t product, meaning that 10 GJ of energy must be supplied to produce each ton of product.

The resultant amount of steam generated, and the distribution of steam, are not measured, making it difficult to optimise energy consumption.

The major consumers of thermal energy on the fish meal plant are:

- fish meal cookers;
- fish meal driers;
- evaporators that concentrate the solids.

The fish meal plant has been designed to make use of waste heat for thermal requirements instead of steam. In this case, boiler flue gas is used as heating medium to dry the fish meal. Waste heat from the dryers are consumed in the evaporators to reduce the steam requirements.

The major consumers of thermal energy in the canning plants are cookers, which require a steam supply for heating:

- pre-cooker;
- main cookers.

11.1.3 Summary of Site A Metrics

Ideally, the metrics of the fish meal plant and the cannery should be defined separately, but due to lack of measurement such comparison is not possible. The lack of monitoring of the amount of effluent generated does not allow calculation of the amount of effluent generated per ton of product.

Table 11-1: Site A Metrics

Metric	Units	Result
Specific Water Intake (SWI)	m^3/t product	6,98 (incl RO permeate) 2,98 (excl RO permeate)
Specific Electricity Consumption (SEC)	kWh/t product	148,5
Specific Fuel Consumption (SFC)	GJ/t product	10,0

11.1.4 Compliance of Site A

Site A needs to comply with the local municipal bylaws which stipulate the supply and cost of water, electricity, and wastewater / solids discharge.

Site A also has a water use license from DWS for the extraction of borehole water, which specifies the allowed amount to be extracted and the application of that water.

The site also has a Coastal Water Discharge Permit from the Department of Environment, Forestry and Fisheries, which places the compositional limits on the water discharged to ocean.

11.2 Site B

Site B predominantly produces fish meal and fish oil, and has a pilchard cannery. This site’s primary focus for pilchards is on South African waters. Reduced fishing quotas has resulted in imports of pilchards, whereas the fish for the fish meal and oil is mostly caught in South African waters. Two docks are available for offloading, one for the fish meal plant and one for the cannery.

11.2.1 Water and Effluent Analysis at Site B

Freshwater is imported from the local municipality and is compliant with drinking water quality, i.e. SANS 0241:2015. This facility did not experience a significant problem during the drought of 2018 because of good communication and cooperation with the local municipality. At the same time, production rates were lower due to limited availability of fresh fish catches, thus reducing the demand for freshwater anyway.

Site B only has one source of freshwater, being the municipal water supply. The freshwater intake is distributed to the various plant sections. All intake water volumes are continuously measured. No other water measurements take place; thus, no data is available in terms of the water split to the cannery and the fish meal plants, respectively.

A part of the input water is transferred (via ion-exchange softening) to the boilers for steam generation, whereby both the fish meal plant and cannery uses steam. The boilers are coal fired. Water is also used for process cooling. Other uses for the freshwater are equipment cleaning and factory cleaning.

The specific water intake (SWI) is defined as:

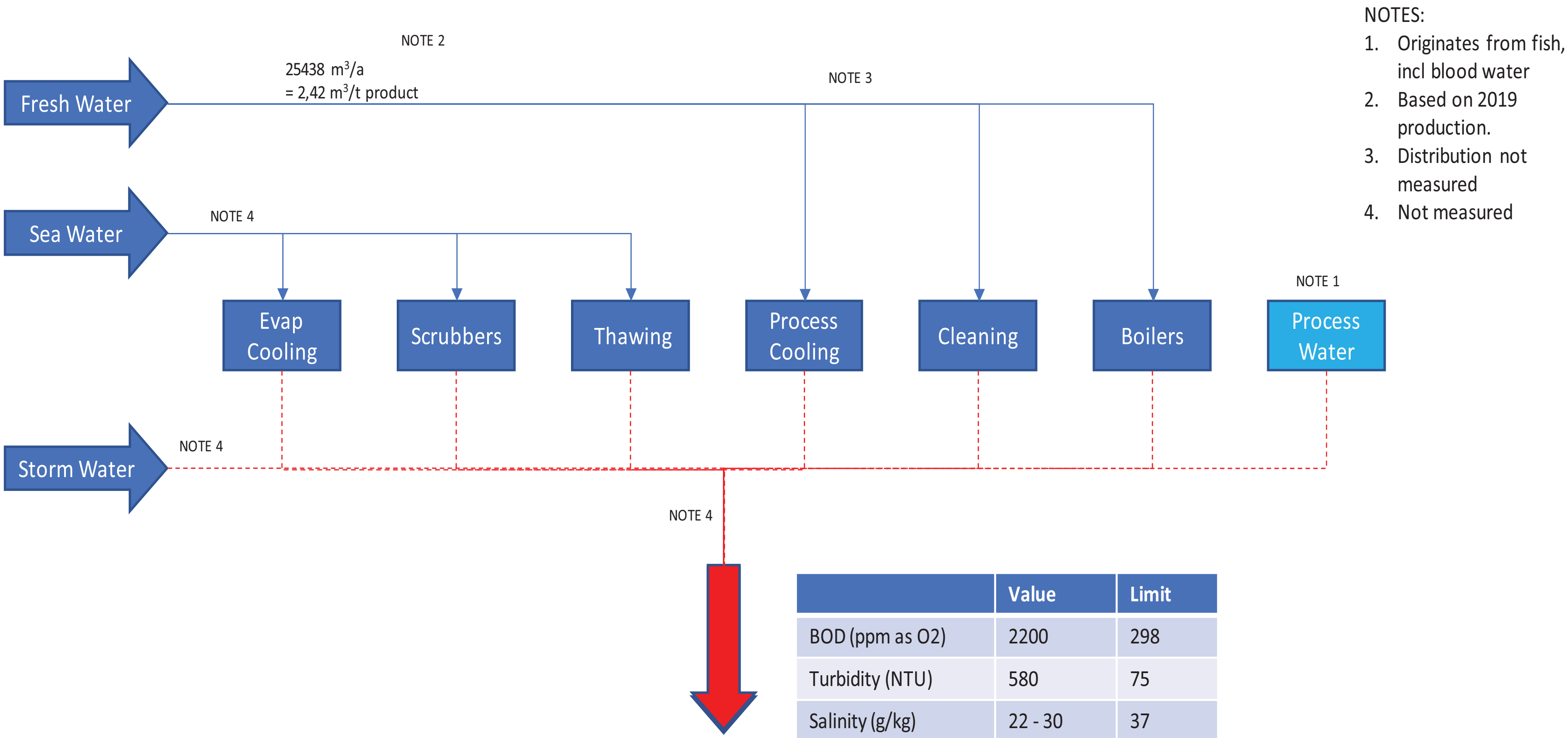
$$SWI = \frac{total\ water\ consumption\ (m3)}{total\ mass\ of\ product\ (ton)}$$

Refer to the flow chart for Site B on the next page.

- In total, the water consumption is 25 438 m^3, translating to an SWI of 2,42 m^3 of fresh water per metric ton of product. The water is used to feed the boilers, for process cooling and for cleaning purposes.
- Seawater is imported for:
    - Cooling at the stick water plant evaporators.
    - Scrubbing water. The off-gas from the drier is routed through seawater in the scrubber to cool and condense the vapour.
    - Thawing of frozen incoming fish.
- The seawater flow is not measured.
- Effluents are generated from various plant sections as depicted in the flowchart. All the effluent streams are combined in a sewer and routed for sea discharge, together with stormwater collected from the site.
- There are no flow measurements on any of the effluent streams. The specific effluent volume (m^3/t product) can therefore not be determined.

The effluent is regularly sampled, analysed and compared with the limits set in the Coastal Water Discharge Permit (CWDP). This facility is consistently over the limits set for BOD, turbidity and ammonia. There is no effluent treatment, other than simple screening of large sized solids, which is reworked into fish meal.

No projects are planned for water- or effluent optimisation. No water / effluent balance can be formulated for this site, due to the lack of flow and quality monitoring across the various intake, processing and output stages.



	Value	Limit
BOD (ppm as O2)	2200	298
Turbidity (NTU)	580	75
Salinity (g/kg)	22 - 30	37
Ammonia(ppm as N)	190	40
FOG (ppm)	0,1	10

Figure 11-3: Site B Water and Effluent Flowchart

11.2.2 Energy Analysis at Site B

This facility uses electricity to power drives (for pumps, motors, centrifuges, conveyors, etc.) and for lighting. The total electricity consumption is measured, but the distribution within the facility is not measured.

The specific energy consumption (SEC) is defined as:

$$SEC = \frac{total\ electricity\ consumption\ (kWh)}{total\ mass\ of\ product\ (ton)}$$

The following figure shows the energy mix for this site, differentiating between electrical energy and thermal energy. Thermal energy is expressed in GJ to be consistent with convention.

The total electricity consumption of 1 509 601 kWh/a translates into the SEC of 143,5 kWh/t product.

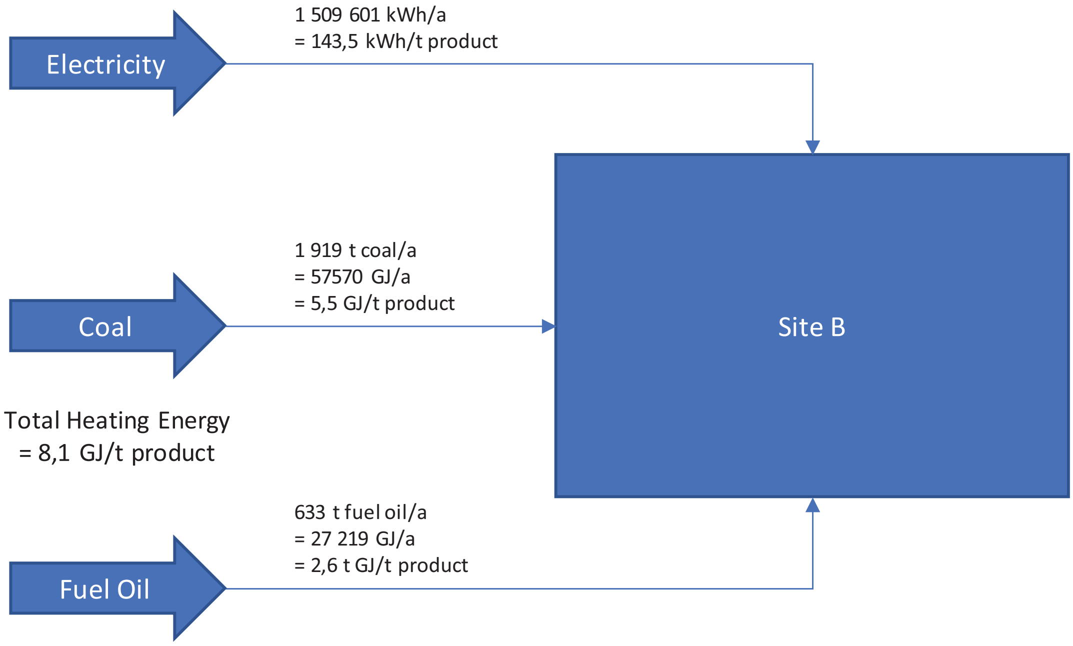


Figure 11-4: The Energy Mix at Site B

For process heating purposes, the site generates steam by firing bituminous coal. Heat for drying is supplied by burning fuel oil and generating hot gas. Coal is sourced from the Mpumalanga coal fields at a rate of 1919 t/a. At 30 MJ/kg, this translates into an energy input via coal of 57 570 GJ/a. Fuel oil (633 t/a) is sourced from oil refinery byproducts. At 43 MJ/kg, this translates into an energy input via coal of 27 219 GJ/a.

The amount of coal consumed is measured, but the resultant amount of steam generated, and the distribution of steam, are not measured, making it difficult to optimise energy consumption. Fuel oil consumption used for drying is measured.

The major consumers of thermal energy generated from coal on the fish meal plant are:

- fish meal cookers;

- evaporators that concentrate the solids.

The major consumers of thermal energy in the canning plants are cooking which uses steam as heat source:

- pre-cooker;
- main cookers.

Specific Fuel Consumption is defined as:

$$SFC = \frac{total\ heating\ energy\ consumption\ (GJ)}{total\ mass\ of\ product\ (ton)}$$

In this case, it was calculated to be 8,1 GJ/t product, 5,5 GJ/t sourced via coal and the balance of 2,6 GJ/t sourced via fuel oil.

11.2.3 Summary of Site B Metrics

Ideally, the metrics of the fish meal plant and the cannery should be defined separately, but due to lack of measurement this is not possible. The lack of measurement on effluent systems also makes it impossible to calculate the amount of effluent generated per ton of product.

Table 11-2: Site B Metrics

Metric	Units	Value
Specific Water Intake (SWI)	m^3/t product	2,42
Specific Electricity Consumption (SEC)	kWh/t product	143,5
Specific Fuel Consumption (SFC)	GJ/t product	8,1

11.2.4 Compliance of Site B

Site B needs to comply with the local municipal bylaws which stipulate the supply and cost of water, electricity, and wastewater / solids discharge.

Site B does not require a water use license from DWS, as they purchase their water directly from the municipality, and thereby conforms to the municipal bylaws and water tariffs.

The site has a Coastal Water Discharge Permit from DEFF, which places the compositional limits on the water discharged to ocean.

11.3 Site C

Site C produces fish meal and fish oil, and has a pilchard cannery. Most of the pilchards are imported due to the limited available fish in South African waters. The fish for the fish meal and oil is mostly caught in South African waters. Two docks are available for offloading, one for the fish meal plant and one for the cannery.

11.3.1 Water and Effluent Analysis at Site C

Fresh water is imported from the local municipality, which complies with drinking water standard SANS 0241:2015. This facility did experience water availability problems during the 2018 drought. The installation of a seawater desalination plant was investigated but rejected due to the high cost involved.

Site C only has one source of freshwater, being the municipal water supply. The freshwater is distributed to the various plant sections. The freshwater flow is continuously measured and manually recorded on a monthly basis. There is no data in terms of the water split to the cannery and the fish meal plants. This site measures boiler feed water flow, but the numbers were not made available for this research study.

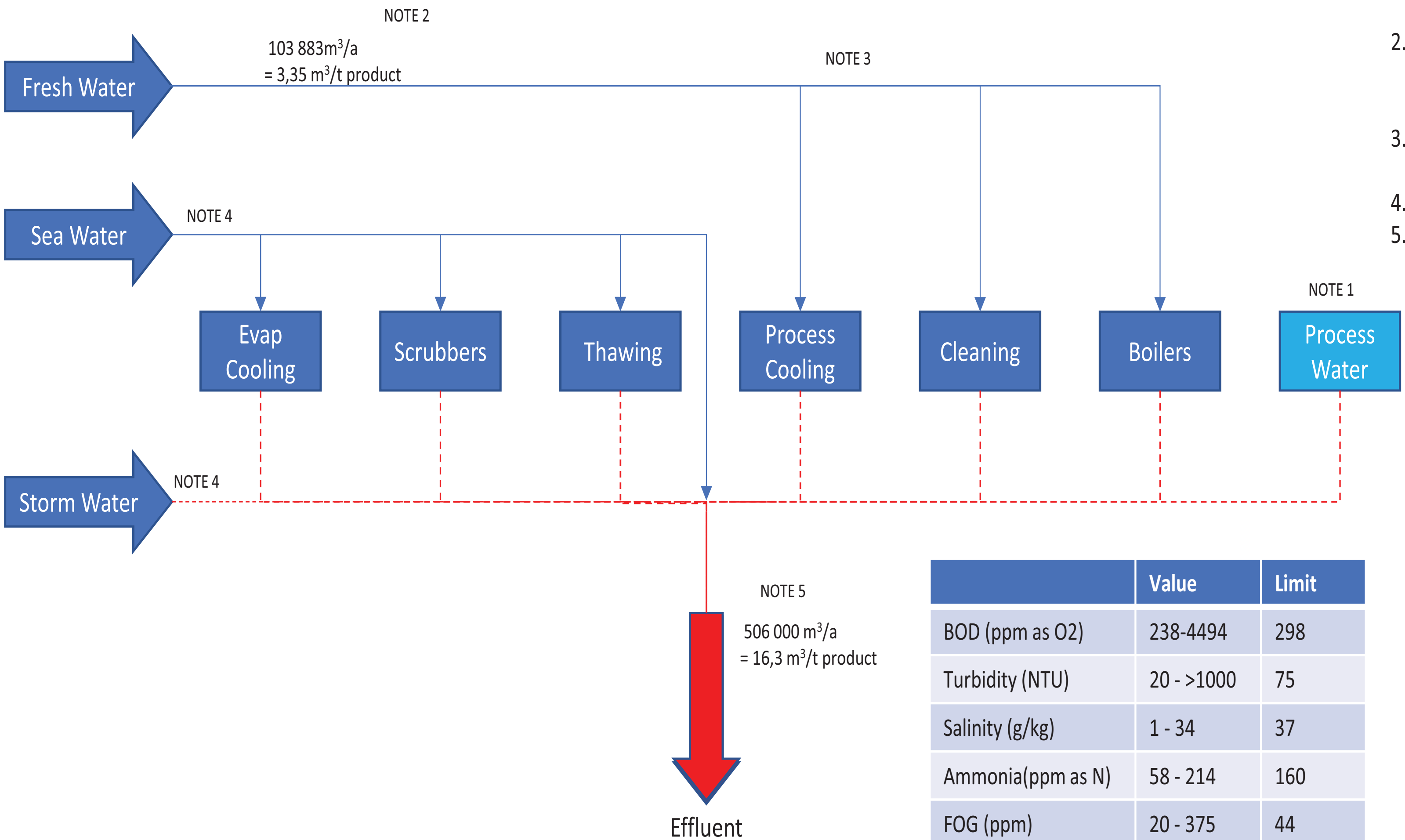
The specific water intake (SWI) is defined as:

$$SWI = \frac{total\ water\ consumption\ (m3)}{total\ mass\ of\ product\ (ton)}$$

Site C uses 3,35 m^3 of freshwater per metric ton of product, based on a total recorded intake flow of 103 883 m^3/a.

The flow diagram hereunder provides the key characteristics of water and effluent flow during the processing of fish at this site, summarised as follows:

- A part of the freshwater intake is transferred (via ion exchange softening) to the boilers for steam generation, both the fish meal plant and cannery uses steam. Some of the boilers are coal fired, the others are fired using heavy fuel oil (HFO).
- Freshwater is also used for process cooling purposes and for cleaning of equipment and floors.
- Seawater is imported (not measured) for thawing of fish, scrubbing of vapours before atmospheric release and for cooling at the evaporators.
- All the effluents from the different process sections, as well as stormwater, are combined in a single outlet sewer that discharges to sea. Seawater is added to this stream for dilution purposes in an effort to achieve the concentration limits as stipulated in the coastal water discharge permit.
- The total effluent outlet flow is measured at 506 000 m^3/a.



	Value	Limit
BOD (ppm as O2)	238-4494	298
Turbidity (NTU)	20 - >1000	75
Salinity (g/kg)	1 - 34	37
Ammonia(ppm as N)	58 - 214	160
FOG (ppm)	20 - 375	44

NOTES:

1. Originates from fish, incl blood water
2. Based on combined production of cannery, fish meal and fish oil.
3. Distribution not measured
4. Not measured
5. The combined discharge to sea is measured.

Figure 11-5: Site C Water and Effluent Flowchart

There is flow measurement on final effluent discharge to sea, but no flow measurements on any of the contributory effluent streams. Since the measurement includes dilution water, the specific effluent volume (m^3/t product) cannot be determined.

The effluent is sampled and analysed on a monthly basis. The results are compared with the limits set in the CWDP Permit and compliance are calculated. Due to dilution with seawater, the compliance rate to the limits are better than it would have been without the dilution effect. Data in terms of percentage compliance was not made available.

No projects are planned for water or effluent optimisation. No water / effluent balance can be formulated for this site, due to the lack of flow and quality monitoring across the various intake, processing and output stages.

11.3.2 Energy Analysis at Site C

This facility uses electricity to power drives (for pumps, motors, centrifuges, conveyors, etc.) and for lighting. The total electricity consumption is measured, but the distribution within the facility is not measured.

The specific energy consumption (SEC) is defined as:

$$SEC = \frac{total\ electricity\ consumption\ (kWh)}{total\ mass\ of\ product\ (ton)}$$

The following figure shows the energy mix for this site, differentiating between electrical energy and thermal energy. Thermal energy is expressed in GJ to be consistent with convention. The total electricity consumption of 4 100 000 kWh/a translates into the SEC of 132,3 kWh/t product.

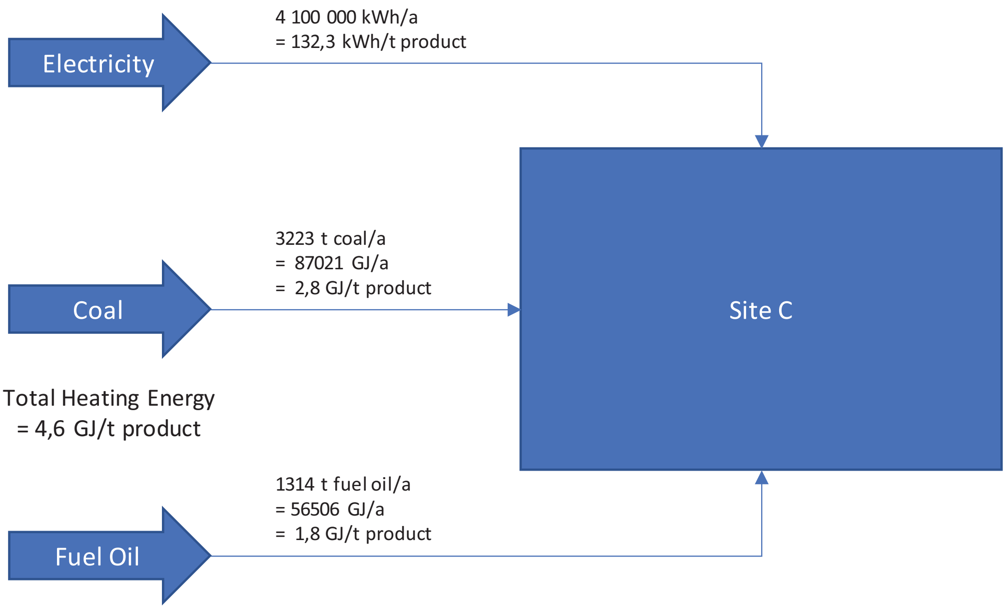


Figure 11-6: The Energy Mix at Site C

For process heating purposes, the site generates steam by firing bituminous coal in some of the boilers and heavy fuel oil in other boilers. Coal is sourced from the Mpumalanga coal fields and fuel oil is sourced from crude oil refineries. In this case, the amount of boiler feed water is measured, but the distribution of steam is not measured, making it challenging to optimise energy consumption.

The major consumers of thermal energy generated from coal on the fish meal plant are:

- fish meal cookers;
- dryers;
- evaporators that concentrate the solids.

The fish meal plant has been designed to make use of waste heat for thermal requirements instead of steam. Waste heat from the dryers are consumed in the evaporators to reduce the steam requirements.

The major consumers of thermal energy (provided via steam) in the canning plants are:

- pre-cooker;
- main cookers.

Specific Fuel Consumption is defined as:

$$SFC = \frac{total\ heating\ energy\ consumption\ (GJ)}{total\ mass\ of\ product\ (ton)}$$

In this case, it was found to be 4,6 GJ/t product, 2,8 GJ/t sourced via coal and the balance of 1,8 GJ/t sourced via fuel oil.

11.3.3 Summary of Site C Metrics

Ideally, the metrics of the fish meal plant and the cannery should be defined separately, but due to lack of measurement this is not possible. The use of dilution on the effluent also makes it impossible to calculate the amount of effluent generated per ton of product.

Table 11-3: Site C Metrics

Metric	Units	Value
Specific Water Intake (SWI)	m^3/t product	3,35
Specific Electricity Consumption (SEC)	kWh/t product	132,3
Specific Fuel Consumption (SFC)	GJ/t product	4,6

11.3.4 Compliance of Site C

Site C needs to comply with the local municipal bylaws which stipulate the supply and cost of water, electricity, and wastewater / solids discharge.

Site C does not require a water use license, as they purchase their water directly from the municipality and conforms to the municipal bylaws and water tariff structures.

The site has a CWDP permit from DEFF, which places the compositional limits on the water discharged to ocean.

11.4 Site D

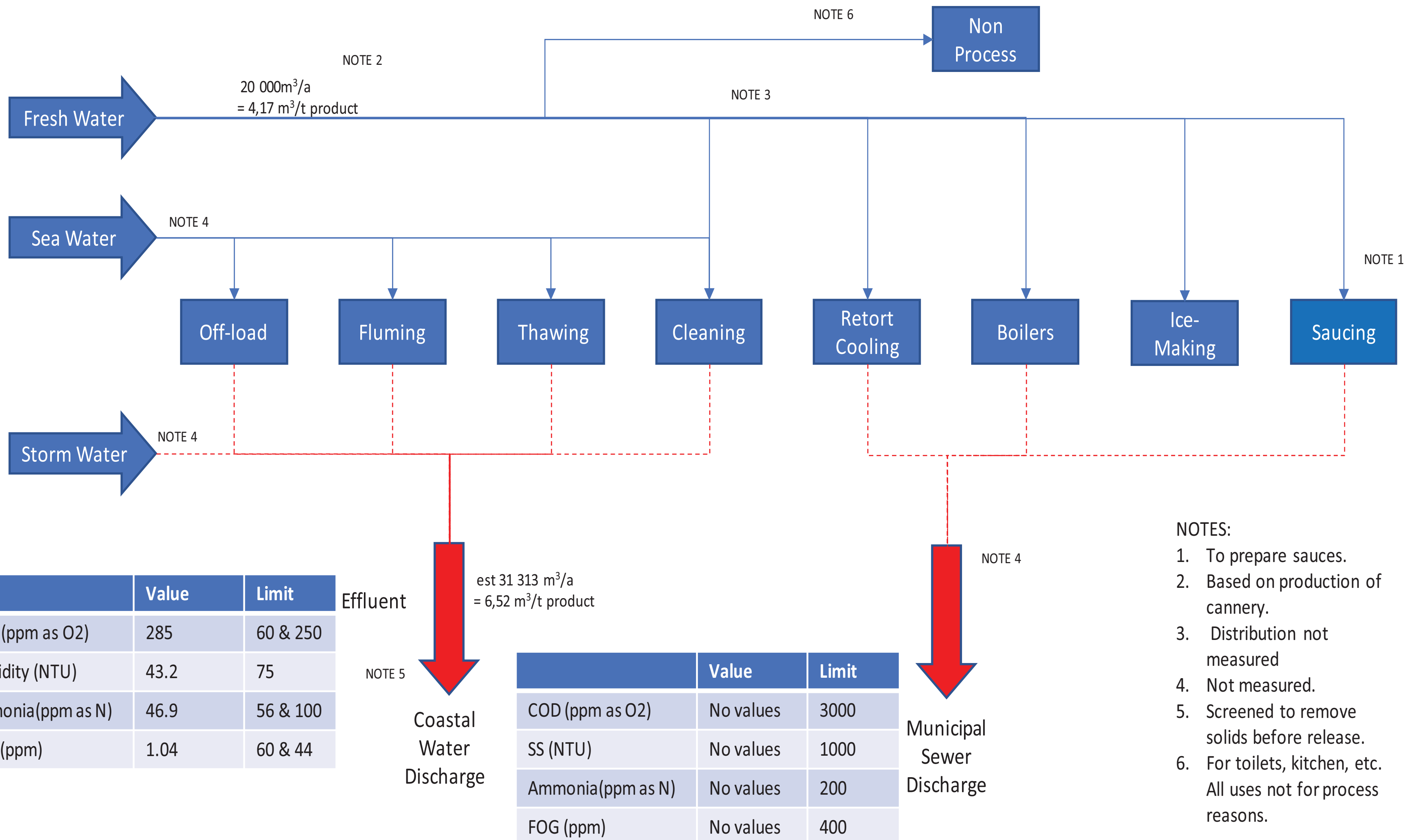
Site D produces only canned pilchards, most of which are imported due to the limited available fish in South African waters. A dock for offloading is available in the harbor and truck deliveries are also facilitated.

11.4.1 Water and Effluent Analysis at Site D

Fresh water is imported from the local municipality, which complies with drinking water standard SANS 0241:2015. The freshwater is distributed to the plant sections. The freshwater inflow is continuously measured and recorded on a monthly basis for payment purposes. No other water measurements take place, so there is no data in terms of the water split between the plant sections. The quality of the freshwater is not monitored.

A flowchart depicting the water and effluent for this site is presented below and summarised as follows:

- Incoming freshwater (20 000 m^3/a) is distributed for:
    - steam generation at the boilers (after ion exchange softening) – the boilers are fuel oil fired;
    - process cooling, making of ice and for preparation of sauces;
    - Other uses , e.g. equipment cleaning and factory cleaning;
    - Ablution and kitchen facilities.
- Seawater is imported but not measured, and used for:
    - Fish Offloading
    - Fluming
    - Thawing
    - Cleaning of floors, etc.



	Value	Limit
BOD (ppm as O2)	285	60 & 250
Turbidity (NTU)	43.2	75
Ammonia (ppm as N)	46.9	56 & 100
FOG (ppm)	1.04	60 & 44

	Value	Limit
COD (ppm as O2)	No values	3000
SS (NTU)	No values	1000
Ammonia (ppm as N)	No values	200
FOG (ppm)	No values	400

Figure 11-7: Site D Water and Effluent Flowchart

- Effluents are generated from various plant sections as depicted in the flowchart.
  - The water that were in direct contact with fish are collected, screened for solids removal and routed as final effluent to sea discharge, together with stormwater collected on the site. This effluent is sampled and analysed for comparison to the Coastal Water Discharge Permit limits on an ad-hoc basis.
  - Water that were not in direct contact with fish is separately collected and discharged to the municipal sewer under agreement, without any further treatment. This effluent is not sampled and analysed.

The specific water intake (SWI) is defined as:

$$SWI = \frac{total\ water\ consumption\ (m3)}{total\ mass\ of\ product\ (ton)}$$

Site D uses 4,17 m^3 of freshwater per metric ton of product, based on a total reported intake flow of 20 000 m^3/a.

For seawater discharge of effluent, two possible discharge destinations are available,

- into the harbor at the adjacent jetty and
- into the open sea outside the harbour, directly on the coast.

The site has some flexibility to discharge effluent, depending on pollution loads. The discharge limits are different for the two destinations, as follows.

Table 11-4: Site D Coastal Water Discharge Limits

Analysis	Open Sea Limit	Harbour Limit
BOD (ppm as O_2)	250	60
Turbidity (NTU)	75	75
Ammonia (ppm as N)	56	100
Fat, Oil, Grease (ppm)	60	44

The only effluent treatment is screening for large solids before discharge. The screenings are sent to a fish meal producer in Atlantis where fish meal is prepared from the waste. Effluents that were not in direct contact with fish are collected and discharged to the municipal sewer, together with domestic wastewater from ablutions and kitchens.

There are no flow measurements on any of the effluent streams. The specific effluent volume (m^3/t product) can therefore not be determined. It could also not be derived by assuming a percentage of intake water, since the seawater intake is also not measured.

The effluent is sampled and analysed on an ad-hoc basis. It is compared with the limits set in the CWDP Permit. Only one sample analysis was received for analysis during this study. This result was over specification in terms of BOD, but within specification on the remainder of the set limits.

No projects are planned for water or effluent optimization. No water / effluent balance can be formulated for this site, due to the lack of flow and quality monitoring across the various intake, processing and output stages.

However, this site is in the planning stages to construct a fish meal and fish oil plant on the adjacent site, targeted to come on-line in 2022. This company has the opportunity to heed lessons and recommendations from this report in terms of water and energy optimisation.

11.4.2 Energy Analysis at Site D

This facility uses electricity to power drives (for pumps, motors, conveyors, etc.) and for lighting. The total electricity consumption is measured, but the distribution within the facility is not measured.

The specific energy consumption (SEC) is defined as:

$$SEC = \frac{total\ electricity\ consumption\ (kWh)}{total\ mass\ of\ product\ (ton)}$$

The following figure shows the energy mix for this site, differentiating between electrical energy and thermal energy. Thermal energy is expressed in GJ to be consistent with convention. The total electricity consumption of 450 000 kWh/a translates into the SEC of 93,8 kWh/t product.

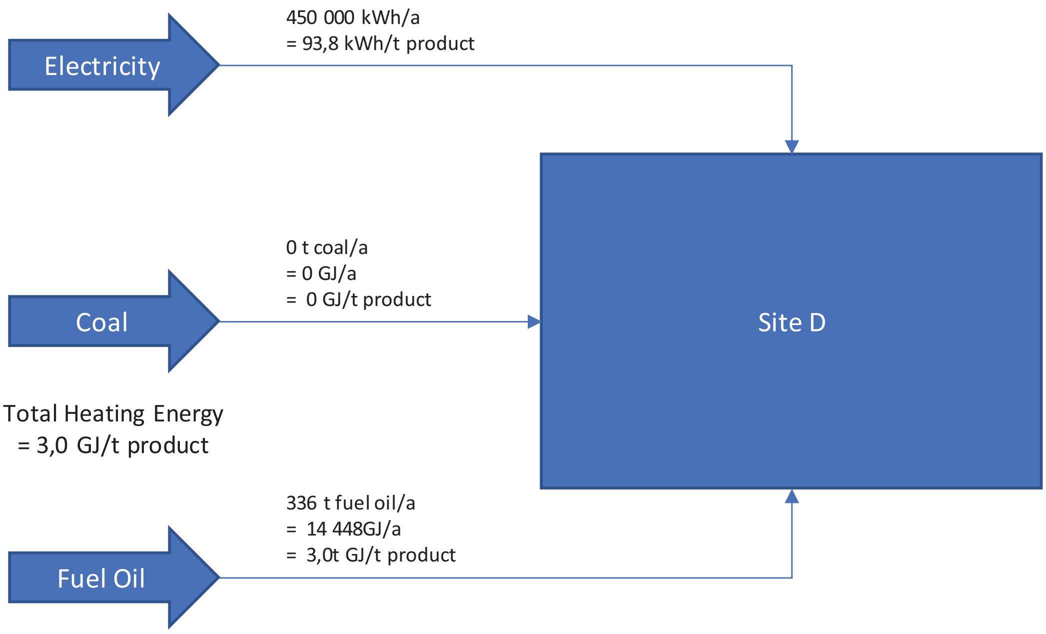


Figure 11-8: The Energy Mix at Site D

For process heating purposes, the site generates steam by firing fuel oil. Fuel oil is sourced from oil refinery byproducts. The amount of fuel oil consumed is measured, but the resultant amount of steam generated, and the distribution of steam, are not measured, making it difficult to optimise energy consumption.

The fuel oil consumption is 336 t/a. At a calorific value of 43 MJ/kg, the annual energy consumption is 14 448 GJ.

The major consumers of thermal energy in the canning plant are the cookers, whereby steam is used to provide heat:

- pre-cooker;
- main cookers.

Specific Fuel Consumption is defined as:

$$SFC = \frac{total\ heating\ energy\ consumption\ (GJ)}{total\ mass\ of\ product\ (ton)}$$

In this case, the SFC was found to be 3,0 GJ/t product.

11.4.3 Summary of Site D Metrics

The lack of measurement on effluent systems also makes it impossible to calculate the amount of effluent generated per ton of product.

Table 11-5: Site D Metrics

Metric	Units	Value
Specific Water Intake (SWI)	m^3/t product	4,17
Specific Electricity Consumption (SEC)	kWh/t product	93,8
Specific Fuel Consumption (SFC)	GJ/t product	3,0

11.4.4 Compliance of Site D

Site D needs to comply with the local municipal bylaws which stipulate the supply and cost of water, electricity, and wastewater / solids discharge. It has an agreement with the municipality for discharge into the wastewater transport and treatment system, subject to compositional concentration limits.

Site D does not require a water use license from DWS, as they purchase their water directly from the municipality.

The site has a Coastal Water Discharge Permit from DEFF, which places the compositional limits on the water discharged to sea, differentiating between the two discharge options.

11.5 Site E

Site E produces fish meal, fish oil, and also has a pilchard cannery. Most of the pilchards are imported due to the limited available fish in South African waters. The fish for the fish meal and oil is mostly caught in South African waters. Two docks are available for offloading, one for the fish meal plant and one for the cannery.

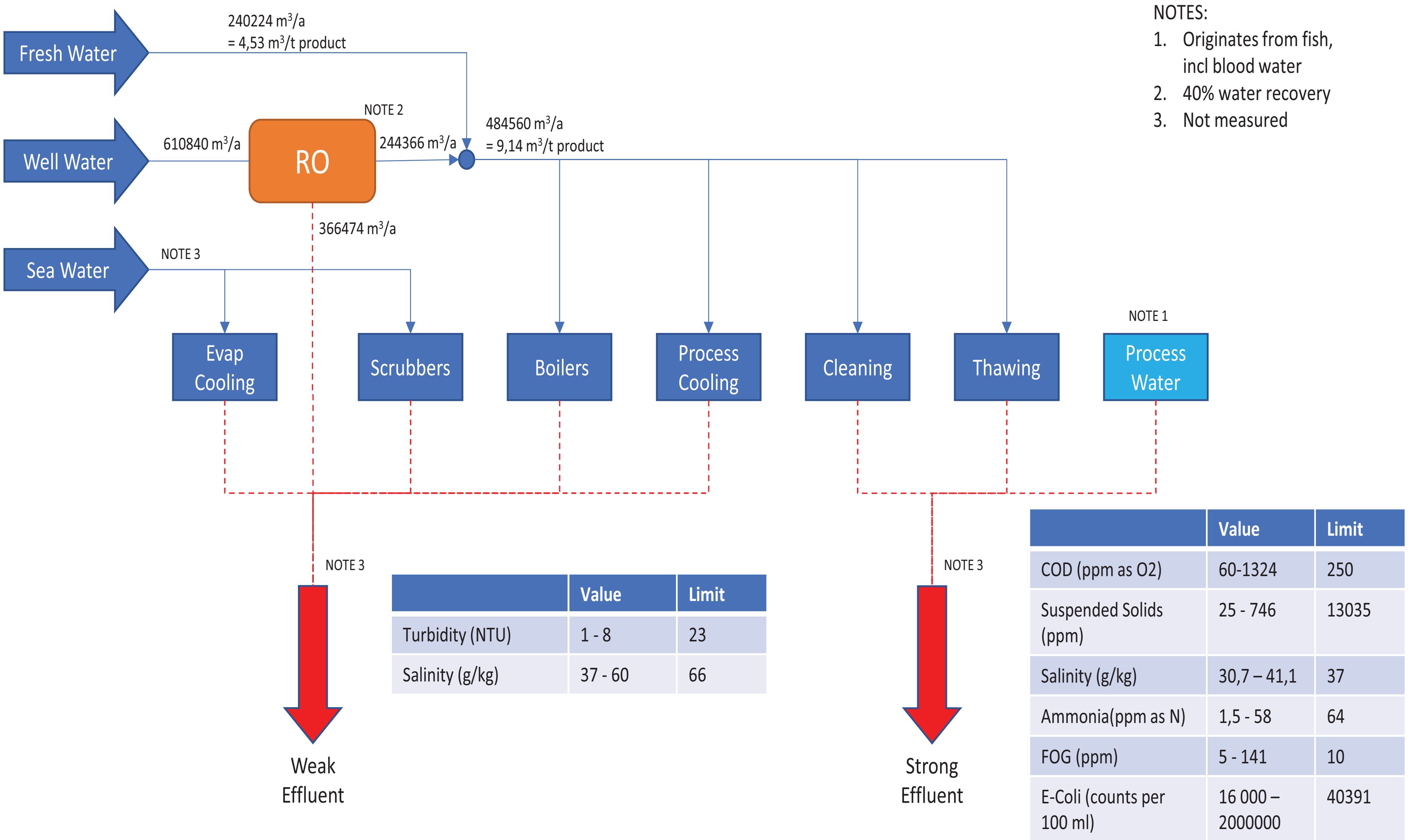
11.5.1 Water and Effluent Analysis at Site E

Fresh water is imported from the local municipality, which complies with drinking water standard SANS0241:2015. During the drought of 2018, a reverse osmosis seawater desalination plant was installed to reduce the reliance on municipal supplied water. Feed water to the RO plant is sourced through boreholes that provide water with low solids content. This water is abstracted under a water use license. The RO plant recovers 40% of the feed water as permeate, and 60% remains as brine. The brine becomes part of the effluent stream from the site.

Permeate and freshwater is combined in a tank and distributed to the plant sections. The well water flow and the freshwater flow is measured. No other water measurements take place, so there is no data in terms of the water split to the cannery and the fish meal plants.

The flowchart following shows the incoming freshwater sourced from the municipality at a rate of 240 224 m^3/a:

- The freshwater is combined with 244 366 m^3/a of RO permeate, the RO being fed with 610 840 m^3/a of water extracted from beach wells (under a water use license).
- The total freshwater consumption is 484 560 m^3/a.
- Freshwater is distributed as follows:
    - to the boilers for steam generation, both the fish meal plant and cannery uses steam – the boilers are coal fired.
    - for thawing frozen raw fish;
    - for process cooling;
    - use in equipment cleaning and factory cleaning.
- Seawater is imported for
    - cooling at the waste heat evaporators.
    - scrubbing of offgases in the scrubber. The offgas from the drier is routed through seawater in the scrubber to cool and condense the vapour.
    - The seawater flow is not measured.



	Value	Limit
Turbidity (NTU)	1 - 8	23
Salinity (g/kg)	37 - 60	66

	Value	Limit
COD (ppm as O2)	60-1324	250
Suspended Solids (ppm)	25 - 746	13035
Salinity (g/kg)	30,7 – 41,1	37
Ammonia(ppm as N)	1,5 - 58	64
FOG (ppm)	5 - 141	10
E-Coli (counts per 100 ml)	16 000 – 2000000	40391

Figure 11-9: Site E Water and Effluent Flowchart

The specific water intake (SWI) is defined as:

$$SWI = \frac{total\ water\ consumption\ (m3)}{total\ mass\ of\ product\ (ton)}$$

Site E uses 9,14 m^3 of water (fresh water and RO permeate combined) per metric ton of product. When RO permeate is regarded as an “internal” water and the SWI is calculated based on fresh water import only, the SWI is 4,53 m^3/t product.

Effluent characteristics for this site are depicted in the flow diagram and summarised as follows:

- Effluents are generated from various plant sections. The streams with potential high COD content are combined as strong effluent, and the remainder combines as weak effluent.
- The strong effluent is routed through a screen (to remove most of the solids) before being discharged to the environment.
- Note that the raw fish contains about 70-75% water and blood. This is removed in the process and reports to the strong effluent as well. This is represented in the diagram as Process Water.
- The strong effluent is disposed a few hundred meters off the coast to ensure efficient dispersion.
- The weak effluent is directly disposed close to the beach, as per permit allowance.

There are no flow measurements on any of the effluent streams. The specific effluent volume (m^3/t product) can therefore not be determined. It cannot be estimated since seawater flow is also not measured.

The high strength effluent is typically sampled and analysed on a monthly basis. It is compared with the limits set in the Coastal Water Discharge Permit (CWDP). This facility is consistently over the limits set for COD, turbidity and fats, oils and greases. It also appears to be regularly over the set limit for E-coli. Based on available results, it appears that ammonia is within discharge limits. Information to establish trends over time were not be made available during this study.

Management has approved a project to install a dissolved air flotation (DAF) plant to remove the remaining solids and fats from the stream prior to discharging. This should improve the compliance rate.

11.5.2 Energy Analysis at Site E

This facility uses electricity to power drives (for pumps, motors, centrifuges, conveyors, etc.) and for lighting. The total electricity consumption is measured, but the distribution within the facility is not measured.

The specific energy consumption (SEC) is defined as:

$$SEC = \frac{total\ electricity\ consumption\ (kWh)}{total\ mass\ of\ product\ (ton)}$$

In the case of site E, this was found to be 183,0 kWh/t product.

A portion of the electricity is consumed by the reverse osmosis unit, thus increase electricity use to reduce freshwater consumption. Given that a RO typically consumes 2,7 kWh/m^3 permeate produced, the impact of using RO on site E in terms of electricity is 12,4 kWh/t product. This means that this site consumes 12,4 kWh/t more electricity in exchange for a reduction in specific water consumption of 4,61 m^3/t product.

The following figure shows the energy mix for this site, differentiating between electrical energy and thermal energy. Thermal energy is expressed in GJ to be consistent with convention. The total electricity consumption of 9 701 000 kWh/a translates into the SEC of 183,0 kWh/t product.

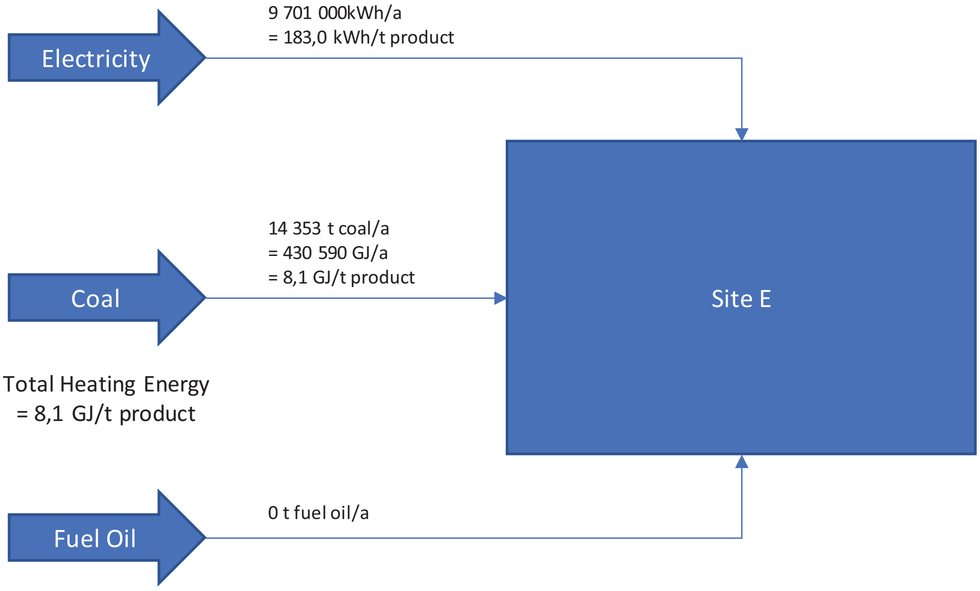


Figure 11-10: The Energy Mix at Site E

For process heating purposes, the site generates steam by firing bituminous coal. Coal is sourced from the Mpumalanga coal fields. The amount of coal consumed is measured at 14 353 t/annum. At a calorific value of 30 MJ/kg, the energy consumption is therefore 430 590 GJ/a.

The resultant amount of steam generated, and the distribution of steam, are not measured, making it difficult to optimise energy consumption.

$$SFC = \frac{total\ heating\ energy\ consumption\ (GJ)}{total\ mass\ of\ product\ (ton)}$$

Specific Fuel Consumption was found to be 8,1 GJ/t product, meaning that 8,1 GJ of energy must be supplied to produce each ton of product.

The major consumers of thermal energy on the fish meal plant are:

- fish meal cookers;
- fish meal driers;
- evaporators that concentrate the solids.

The fish meal plant has been designed to make use of waste heat for thermal requirements instead of steam. Waste heat from the dryers are consumed in the evaporators to reduce the steam requirements.

The major consumers of thermal energy in the canning plants are cookers, which requires steam for heating:

- pre-cooker;
- main cookers.

11.5.3 Summary of Site E Metrics

Ideally, the metrics of the fish meal plant and the cannery should be defined separately, but due to lack of measurement this is not possible. The lack of monitoring of the amount of effluent generated does not allow calculation of the amount of effluent generated per ton of product.

Table 11-6: Site E Metrics

Metric	Units	Value
Specific Water Intake (SWI)	m^3/t product	9,14 (incl RO permeate) 4,53 (excl RO permeate)
Specific Electricity Consumption (SEC)	kWh/t product	183,0
Specific Fuel Consumption (SFC)	GJ/t product	8,1

11.5.4 Compliance of Site E

Site A needs to comply with the local municipal bylaws which stipulate the supply and cost of water, electricity, and wastewater / solids discharge.

Site E also has a water use license from DWS for the extraction of borehole water, which specifies the allowed amount to be extracted and the application of that water.

The site also has a CWDP permit from DEFF, which places the compositional limits on the water discharged to ocean, for both the strong and weak effluents.

11.6 Site F

Site F produces fish meal, fish oil, and has a pilchard cannery. Most of the pilchards are imported due to the limited available fish in South African waters. The fish for the fish meal and oil is mostly caught in South African waters. Two docks are available for offloading, one for the fish meal plant and one for the cannery.

11.6.1 Water and Effluent Analysis at Site F

Freshwater is imported from the local municipality and is compliant with drinking water quality (SANS 0241:2015). This facility does not have a seawater desalination plant to reduce freshwater import from the municipality. Numerous water savings initiatives were implemented over the years, such as:

- Use RO concentrate to produce ice;
- Use RO concentrate for toilet flushing in the admin building.

Note that the reverse osmosis (RO) unit at this site is to prepare boiler feed water from freshwater and is not installed for seawater desalination.

From the flowchart for site F, the following can be noticed:

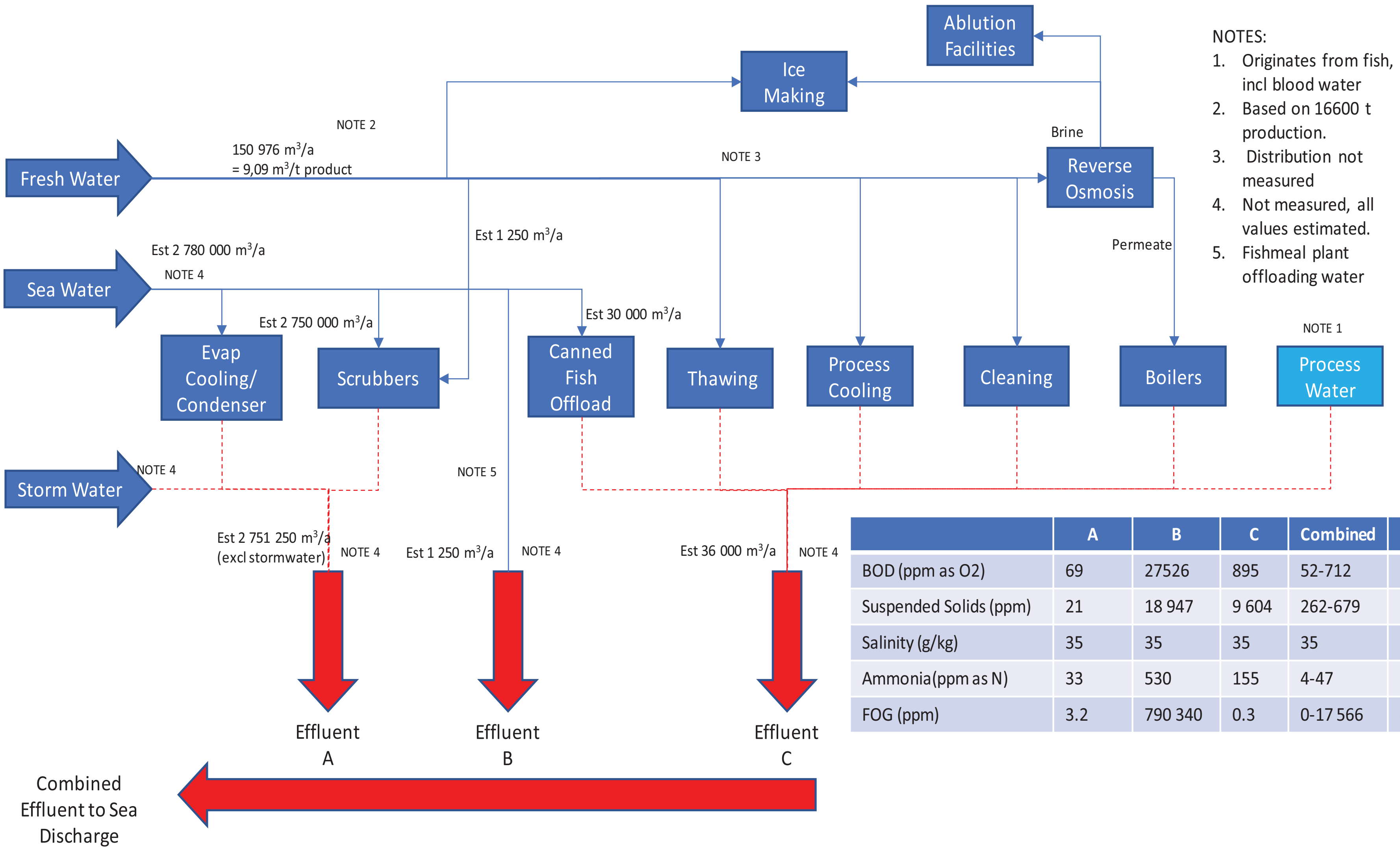
- Site F only has one source of freshwater, being supplied by the municipality. The freshwater is distributed to the plant sections as follows.
    - Boilers – some of the water stream is fed (via reverse osmosis treatment) to the boilers for steam generation, both the fish meal plant and cannery uses steam. The boilers are coal fired. Some RO brine goes to ice making and ablutions.
    - Freshwater is fed to icemaking.
    - Water is used for process cooling.
    - Thawing of frozen fish into the cannery.
    - Other uses for the freshwater are equipment cleaning and factory cleaning.
- The freshwater flow is measured. No other water measurements take place, so there is no data in terms of the water split to the cannery and the fish meal plants separately.

The specific water intake (SWI) is defined as:

$$SWI = \frac{total\ water\ consumption\ (m3)}{total\ mass\ of\ product\ (ton)}$$

The specific water intake (SWI) for this facility is 9,09 m^3 of water per metric ton of product.

- Seawater is imported for the following uses:
    - Cooling at the waste heat evaporators.
    - Drier off gas scrubbing. The off gas (vapour) from the drier is routed through seawater in the scrubber to cool and condense the vapour.
    - Fish offloading for the cannery.
- The seawater flow is not measured. At full production capacity, the seawater flow is estimated to be 2 780 000 m^3/a.
- The effluent is collected from three geographical areas (A,B,C) and then all combined in a sump, from where it is pumped to be discharged into the sea close to the beach. The flowchart shows estimates for effluent flows at full capacity production, but there are no measurements on site, so specific effluent volume cannot be established.



	A	B	C	Combined	Limit
BOD (ppm as O2)	69	27526	895	52-712	298
Suspended Solids (ppm)	21	18 947	9 604	262-679	75
Salinity (g/kg)	35	35	35	35	37
Ammonia(ppm as N)	33	530	155	4-47	160
FOG (ppm)	3.2	790 340	0.3	0-17 566	44

Figure 11-11: Site F Water and Effluent Flowchart

The effluent is regularly sampled and analysed monthly (records not made available). It is compared with the limits set in the Coastal Water Discharge Permit (CWDP). This facility regularly exceeds the limits set for BOD, turbidity and ammonia. Data has not been available to determine the percentage exceedance during this study.

Projects are planned for water or effluent optimisation:

- Installing a cooling tower for lube oil cooling to reduce water consumption.
- Connect all toilets to RO concentrate.
- Drill boreholes and use that water for thawing of fish.
- Solids recovery from blood water – aiming at reducing pollutants to sea and increase solid yields in the fish meal plant.

No water / effluent balance can be formulated for this site, due to the lack of flow and quality monitoring across the various intake, processing and output stages.

11.6.2 Energy Analysis at Site F

This facility uses electricity to power drives (for pumps, motors, centrifuges, conveyors, etc.) and for lighting. The total electricity consumption is measured, but the distribution within the facility is not measured.

The specific energy consumption (SEC) is defined as:

$$SEC = \frac{total\ electricity\ consumption\ (kWh)}{total\ mass\ of\ product\ (ton)}$$

The following figure shows the energy mix for this site, differentiating between electrical energy and thermal energy. Thermal energy is expressed in GJ to be consistent with convention. The total electricity consumption of 4 794 430 kWh/a translates into the SEC of 288,8 kWh/t product.

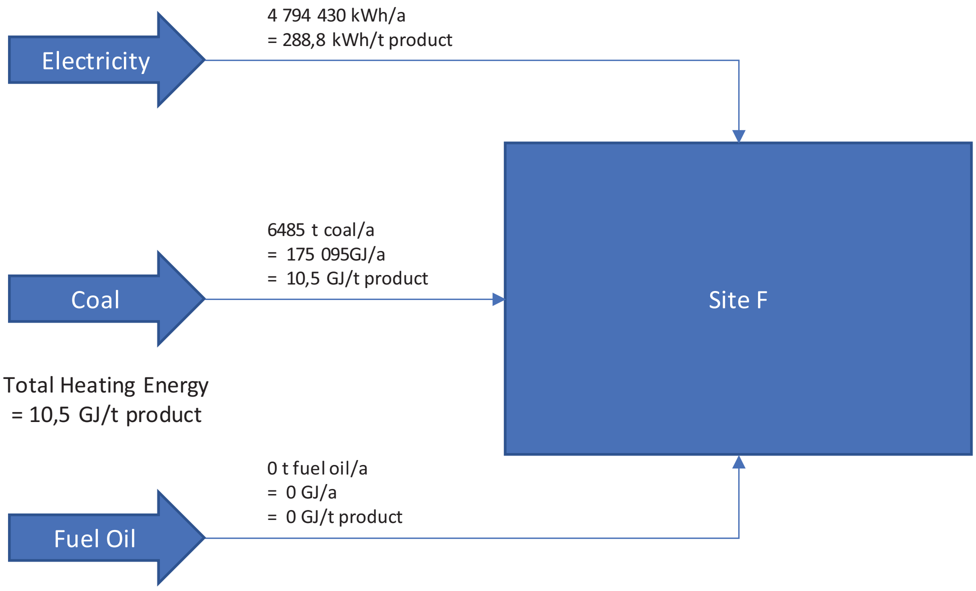


Figure 11-12: The Energy Mix at Site F

For process heating purposes, the site generates steam by firing bituminous coal. Coal is sourced from the Mpumalanga coal fields at a rate of 6 485 t/a. At 27 MJ/kg, this translates into an energy input via coal of 175 095 GJ/a.

The amount of coal consumed is measured, but the resultant amount of steam generated, and the distribution of steam, are not measured, making it difficult to optimise energy consumption.

The major consumers of thermal energy generated from coal on the fish meal plant are:

- fish meal cookers;
- evaporators that concentrate the solids;
- fish meal driers.

The fish meal plant has been designed to make use of waste heat for thermal requirements instead of steam. Waste heat from the dryers are consumed in the evaporators to reduce the steam requirements.

The major consumers of thermal energy in the canning plants are:

- pre-cooker;
- main cookers.

Steam supplies the required heat to these cookers.

Specific Fuel Consumption is defined as:

$$SFC = \frac{total\ heating\ energy\ consumption\ (GJ)}{total\ mass\ of\ product\ (ton)}$$

In this case, it was found to be 10,5 GJ/t product.

11.6.3 Summary of Site F Metrics

Ideally, the metrics of the fish meal plant and the cannery should be defined separately, but due to lack of measurement this is not possible. The lack of measurement on effluent systems also makes it impossible to calculate the amount of effluent generated per ton of product.

Table 11-7: Site F Metrics

Metric	Units	Value
Specific Water Intake (SWI)	m^3/t product	9,09
Specific Electricity Consumption (SEC)	kWh/t product	288,8
Specific Fuel Consumption (SFC)	GJ/t product	10,5

11.6.4 Compliance of Site F

Site F needs to comply with the local municipal bylaws which stipulate the supply and cost of water, electricity, and wastewater / solids discharge.

Site F does not require a water use license, as the site purchase their water directly from the municipality.

The site has a CWD Permit from DEFF, which places the compositional limits on the water discharged to ocean.

12 SITE COMPARISON AND BENCHMARKING OF RESULTS

12.1 Raw Water Source and Quality

At all assessed sites, water played a significant part across the entire pelagic fishing and processing value chain. Water is typically sourced from the sea, from the municipal water supply or from groundwater/boreholes, depending on the usage requirements.

Sea water is typically used for fish conveying, thawing of the incoming raw fish and to scrub the vapour (odours and solids) from the evaporators before release to atmosphere. In some cases, fresh water is used for thawing of the raw fish. Fresh water is also employed for cooling purposes and to generate steam after softening. Furthermore, fresh water is also used to make ice (for freezing the fish in the fishing trawlers), for preparing sauces, for cleaning purposes and for ablution facilities.

In two of the assessed sites, RO seawater desalination plants were installed to supplement fresh water. Other sites also investigated the option during the drought of 2018, but projects were rejected due to technical issues (such as lack of beach well supply capacity) or simply due to costs involved. Another complicating consideration was the operation of such a plant in an environment subjected to regular power outages.

Many sites have indicated during the study that they utilise municipal potable water as the fresh water source for their processing activities. In these cases, the water quality generally complies with quality specifications in the water use agreement. Where municipal drinking water supply is used as raw input water, SANS 241: 2015 usually applies. The specifications on RO permeate is the same as for drinking water. Mostly, the produced permeate is of a higher quality (less contaminants). The permeate (where produced) is typically combined with drinking water before routed to process.

The sea water consumption (flow) is not measured at any of the factories that were visited. The main reason for this lack of monitoring seems to be the lack of charging for the water and hence, optimisation would not reduce cost. Seawater also serves to dilute impurities that are returned to sea (blood, scales, etc). A further factor would be that the permit does not regulate and/or enforce the monitoring of water intake in volumetric quantum.

Fresh water is measured at all the sites, but distribution to different processing units inside the factories are not measured. Water use and optimisation of water consumption is therefore not a key priority at a number of the sites, making it difficult to monitor water use and to optimise on the consumption.

Due to the drought conditions and ongoing uncertainty of secure water supply, two of the sites resorted to implementing RO plants to reduce the reliance on fresh water. The RO plants take seawater via beach wells as feed and typically operate at 40% water recovery, with the brine being discharged into the sea.

12.2 Water Use

Six pelagic and fish processing sites were assessed during this study and their water consumption patterns were analysed. The sites were found to have varying specific water intake (SWI).

Benchmark SWI figures are available for fishmeal and canning plants separately. The specific water consumption can be compared with the values as per (COWI Consulting Engineers and Planners AS, Denmark, 1999). The fish meal figure was converted from 0.5 m^3/t raw fish to 2.0 m^3/t product, since 75% of the fish mass is lost during production, being mostly water.

The benchmark values for the two plant sections are therefore:

- SWI = 15 m^3/t product for canning;
- SWI = 2.0 m^3/t product for fish meal and oil production.

Unfortunately, the overall absence of measurement (e.g. the split of freshwater for fishmeal and canning plants) does not allow this study to reach a conclusion and use benchmarks on:

- a detailed comparison between processes within the sites.
- direct comparison to the above benchmark values per plant section.

The relative production rates of the two plant sections (fish meal and canning) are different from site to site, as demonstrated in the following table.

Table 12-1: Fishmeal/Cannery Production Ratio Comparison

Site	Total Fish Meal/Oil Production (tons/annum)	Cannery Production (tons/annum)	Ratio (Fishmeal/Cannery)
A	13 000	20 000	65%
B	6 309	4 212	150%
C	17 500	13 500	130%
D	0	4 800	0%
E	23 000	30 000	77%
F	13 495	3 105	435%

Sites A and E have higher production in the canning section than in the fish meal section, whereas sites B, C and F have lower production in the canning section than in the fish meal section. Site D has only a cannery.

Benchmarks can be calculated for each specific production ratio (as per above table) and compared to site-specific SWI. By calculating the SWI percentage deviation from the benchmark, it allows for a method to compare the SWI achievements between the assessed sites.

The benchmark SWI for each site x is defined as follows:

$$SWI(Bx) = \frac{(2{,}0 * Fish\ Meal\ Production(x) + 15{,}0 * Canning\ Production\ (x))}{(Fish\ Meal\ Production(x) + Canning\ Production(x))}$$

Where: B = Benchmark and x = site and production rates are in t/a

Using the above formula, the benchmark specific water consumptions for the various sites are therefore as per the following table.

Table 12-2: Calculating Benchmark SWI for Each Site

Site	Total Fish Meal/Oil Production (tons/annum)	Cannery Production (tons/annum)	Benchmark SWI (m^3/t)	Assessed SWI (m^3/t)
A	13 000	20 000	9,88	6,98
B	6 309	4 212	7,20	2,42
C	17 500	13 500	7,66	3,35
D	0	4 800	15,00	4,17
E	23 000	30 000	9,36	9,14
F	13 495	3 105	4,43	9,09
SA	**73 304**	**75 617**	**8,60**	**6,82**

The table also shows the assessed SWI for each site (last column). The weighted average benchmark SWI for all the sites are also calculated and compared to the weighted average achieved SWI in the last row. The information in the table is shown graphically in the following figure.

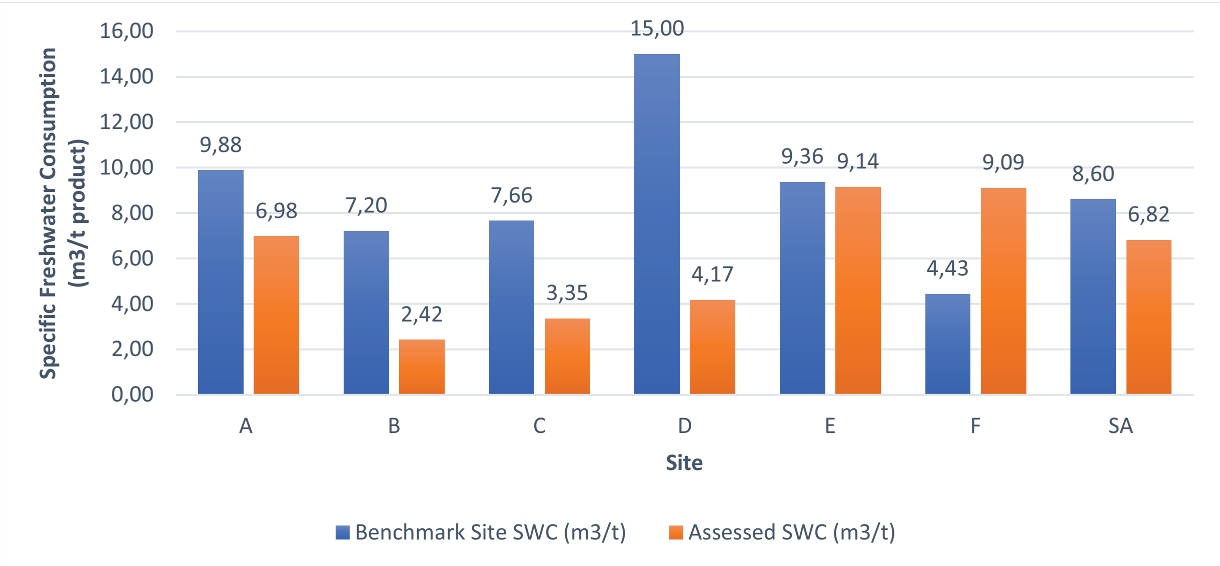


Figure 12-1: SWI Benchmark Comparison for Assessed Sites

All sites (A to E) exceeded (i.e. is lower) the benchmark specific water consumption figures, except for Site F (9,09 vs benchmark 4,43 m^3/t) which did not meet the benchmark value. The weighted average combined SA result of 6,82 m^3/t also exceeded than the benchmark of 8,60 m^3/t.

It is noted that for sites A and E, RO permeate was included in the calculation of SWI. If the RO permeate would be omitted, the comparison to the benchmark would be even better. Site A would be 2,98 vs reported 6,98 m^3/t and site E would be 4,53 vs reported 9,14 m^3/t. This shows the value of the RO desalination plants.

From the above, it can be concluded that the South African sites that participated in this research, compared and performed well above the industry accepted norms and standards.

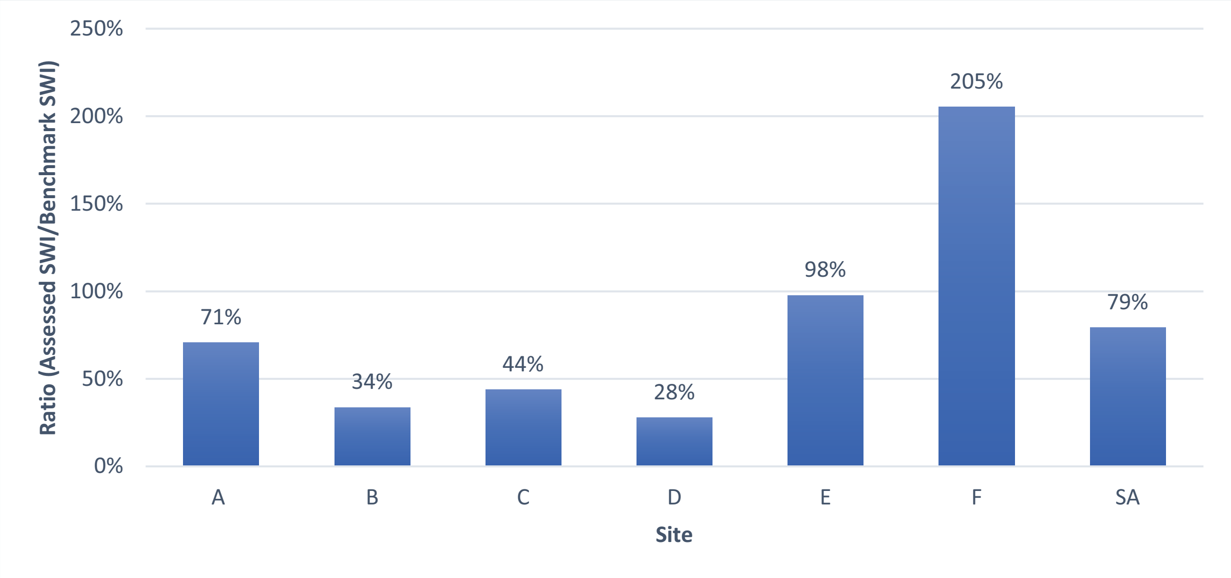


Figure 12-2: Comparing Assessed Site SWI Achievements

The above figure also allows the sites to be compared against each other. A scientific way of comparing the achieved SWI to the benchmark SWI, is by expressing it as a percentage (i.e. achieved/benchmark).

Note: Percentages above 100% would indicate higher than expected SWI and means that performance is worse than the benchmark. Conversely, percentages below 100% indicate better performance than the benchmark.

Sites B (34%), C (44%) and D (28%) outperformed sites A (71%), E (98%) and F (205%). A prime reason for this difference may be in the fact that the better performing sites use seawater for thawing, whilst the other sites use fresh water for thawing purposes.

Sites B, C and D all achieved SWI less than 50% of the benchmark, whereas sites A and E achieved SWIs are between 50% and 100% of the benchmarks, all these sites therefore performing better than the benchmark. Only site F is significantly above 100% of the benchmark, using about double the amount of water than expected using the benchmark.

12.3 Effluent Generation

12.3.1 Assessed Sites Effluent Management

All wastewater discharges are generally collected in drainage systems and pumped to sea. In some cases, high strength wastewater is discharged through a separate system than low strength wastewater. High strength wastewater is generally high in biological and solids contamination, where strength wastewater low is generally only high in salinity.

The total wastewater flowrate is measured only in one case, namely site C. The specific wastewater flow for this site for 2019 was 16,3 m^3/ton product. Unfortunately, it is a case with only one combined effluent stream (including dilution with seawater), so also in this case the flow of high strength wastewater could not be established.

Due to lack of quantification throughout the industry, no conclusions can be drawn with respect to wastewater efficiencies. The focus (including those of the authorities) appears to be primarily on the monitoring of final effluent quality at discharge point and not on mass loadings and/or flow rates.

The separation of high- and low strength wastewaters is ideal if treatment is required, but this also increases the concentration of pollutants and may create the impression that the quality wastewater is worse when compared to a site where all water is combined and discharged as a single (diluted) stream. Without the necessary quantification of both the total streams and all the contributory streams (flow and composition), the wastewater systems cannot be optimised.

Historical data from the Water Quality Management Series: Sub-Series No. MS 13.4: *Operational policy for the disposal of land-derived water containing waste to the marine environment of South Africa*, references earlier report in 1988 and 2000 around the industrial waste discharges to the surf zone and estuaries and the specific reference to the discharge from fisheries along the coast *(Fijen, 1988, CSIR, 1991, Taljaard et al, 2000; G. McConkey, DWAF Western Cape Regional Office, pers. comm., V Venfolo, DWAF Northern Cape Regional Office, pers. comm.)*

The table following provides an extraction only highlighting the fisheries component.

Table 12-3: Industrial waste discharges to the surf zone and estuaries with specific reference to the discharge from fisheries along the coast (modified). (Department of Water Affairs and Forestry, 2004. Water Quality Management: CSIR Environmentek & WAMTechnology, 2004)

Surf Zone: Location	Location & Type	Estimated Flow (m^3/day)
North Bay Canning, Doring Bay	Surf Zone – Fishery/Cannery	No info
Lamberts Bay Canning, Lamberts Bay	Surf Zone – Fishery/Cannery	No info
Sandy Point Fishing, St Helena Bay	Surf Zone – Fishery/Cannery	No info
Suid Oranje Vissery, St Helena Ba	Surf Zone – Fishery/Cannery	3 600
Drommedaris Fisheries, St Helena Bay	Surf Zone – Fishery/Cannery	560
West Point Fishing, St Helena Bay	Surf Zone – Fishery/Cannery	55
St Helena Bay Fishing, Stomneusbaai	Surf Zone – Fishery/Cannery	18 000

Surf Zone: Location	Location & Type	Estimated Flow (m^3/day)
Sea Harvest, Saldanha Bay	Surf Zone – Fishery/Cannery	3 546
Southern Sea, Saldanha Bay	Surf Zone – Fishery/Cannery	7 307
Marine Products, Gans Bay	Surf Zone – Fishery/Cannery	11 682
Tuna Marine, Hermanus	Surf Zone – Fishery/Cannery	12
Walker Bay Fisheries, Hermanus	Surf Zone – Fishery/Cannery	36
Sea Plant Products, Hermanus	Surf Zone – Fishery/Cannery	36
Marine Product, Laaiplek	Estuary (Berg) – Fishery	130 000

12.3.2 Characteristics of Assessed Sites Processing Effluents

The following table indicates typical effluent characteristics in terms of concentration. Due to the lack of flow data, no results in terms of loading on the receiving water bodies could be calculated.

Table 12-4: Typical Effluent Compositions

Site #	COD/BOD (ppm as O_2)	Turbidity (NTU)	Salinity (psu)	Ammonia (ppm as N)	Fats, Oil & Grease (ppm)
A	COD 3000-8000 (3800)	400-3000 (23)	22-30 (37)	60-580 (23)	15-600 (20)
B	BOD 2200 (298)	580 (75)	22-30 (37)	190 (40)	0,1 (10)
C	BOD 238-4494 (298)	20 - >1000 (75)	1-34 (37)	58-214 (160)	20-375 (44)
D	285	43,2	-	46,9	1,04
E	COD 60-1324 (250)	25-746 (75)	30,7-41,1 (27,3)	1,5-58 (64)	5-141 (10)
F	BOD 52-712 (298)	SS 262-679 (?)	35 (37)	4-47 (160)	0-17566 (44)

**Discharge limits for the components mentioned are shown in (brackets)*

From the above table, it is evident that the sites are generally challenged to achieve the desired discharge limits. In all the cases, with the exception of Site A and E, BOD is used rather than COD to indicate organic content of the effluent. Based on the nature of fish products, the use of BOD is more sensible and aligned with best international practice. BOD is also a good design parameter in case a plant wishes to design and construct a biological treatment plant to improve wastewater quality or to comply with effluent quality discharge standards.

In all the cases, the organic contamination in the wastewater discharge streams regularly exceeds the required discharge limits by significant amounts. Considering that the coastal water discharge limits were only applicable since 2018, it is noted that all the facilities have been constructed many years prior to 2018 and were therefore not designed to meet those specifications.

The organic contamination seems to occur in conjunction with exceedance in turbidity limits. Turbidity is mostly related to suspended solids in the stream. The ammonia concentration in the wastewater also seems problematic in achieving the required regulatory limits. Ammonia is related to the high protein content of fish.

Two of the sites show relatively good compliance in terms of the fats, oil and grease limits. This is probably due to higher awareness rather than better processes.

One of the facilities indicated that aeration of thawing water is undertaken to reduce the BOD, with some degree of success. Some of the respondents have indicated that they are considering the installation of a Dissolved Air Flotation (DAF) system to treat the wastewater prior to discharge.

Currently, the only treatment of the wastewater comprises of screening before discharge. The license conditions do not prescribe particular treatment methods, but requires conformance to the various concentration limits. The implementation of efficient DAF or appropriate treatment technologies should be instrumental in achieving compliance to discharge requirements.

12.4 Energy Consumption

Energy is provided via two sources to the sites, namely in the form of electricity and in the form of fuel. The former is supplied via the local municipality as per the consumption charge for kWh and other charges such as demand charge for kVA. Fuel is provided in the form of coal or in the form of fuel oil, or a combination thereof. For purposes of this survey, electricity and fuel are separately calculated, compared between the sites, and separately benchmarked against published values.

12.4.1 Electricity consumption

Up to 2008, the price of electricity is South Africa was relatively low and the price increases were below the inflation rate. However, since the 2008 electricity crisis the price increases on electricity were significantly higher than the consumer price index. This becomes an increasing challenge for industry at large, and for the pelagic fishing industry. The figure below compares the Eskom tariff increases against the published inflation figures (Moolman, 2019).

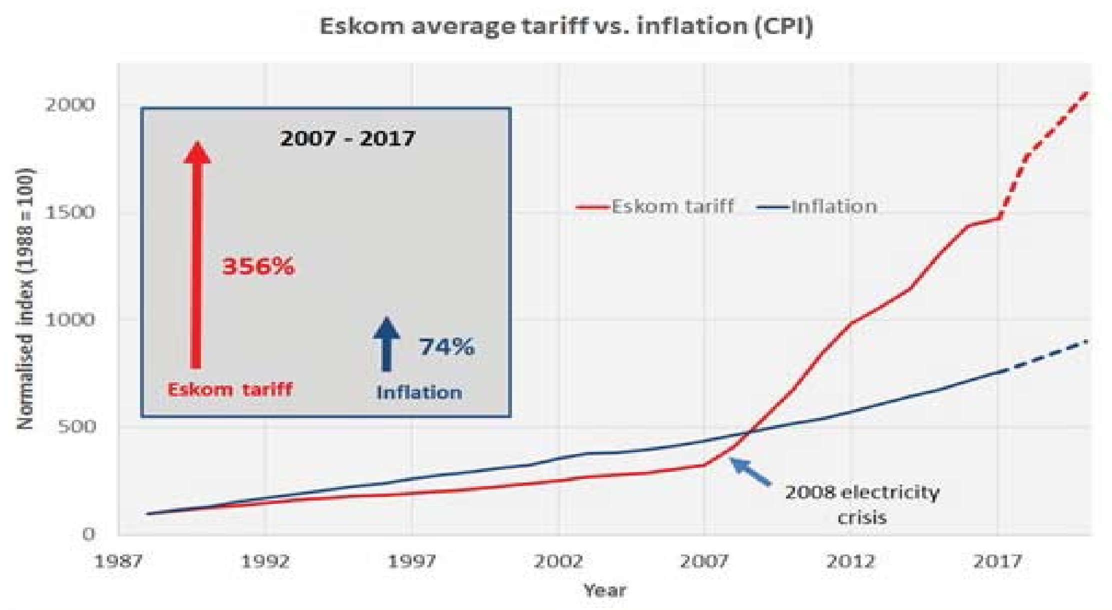


Figure 12-3: Eskom Tariffs vs Inflation (Moolman, 2019)

According to FAO (2018), a fish meal processing plant with an evaporation plant (as all assessed fish meal plants have) should consume about 140 kWh of electricity per ton of product (35 kWh/ton raw fish * 4 ton raw fish/ton product). A cannery is expected to consume about 32 kWh/ton of product (COWI Consulting Engineers and Planners AS, Denmark, 1999), in this case having 1 ton product/ton raw fish.

As is the case with water measurement, the lack of distribution measurement (e.g. the split of electricity for fishmeal and canning plants) makes it difficult to compare the results directly between sites. The production ratio between the two plant sections is different from site to site, as shown in Table 13-1. It was therefore decided to find a benchmark figure for the production ratio for each site and to compare the SEC for each site against its own identified benchmark. By calculating the SEC percentage deviation from the benchmark, allows for a method to compare the SEC achievements between the assessed sites.

The benchmark SEC for each site x is defined as follows:

$$SEC(Bx) = \frac{(140{,}0 * Fish\ Meal\ Production(x) + 32 * Canning\ Production\ (x))}{(Fish\ Meal\ Production(x) + Canning\ Production(x))}$$

Where: B = Benchmark and x = site and production rates are in t/a

The benchmark specific electricity consumptions for the various sites are therefore as follows.

Table 12-5: Calculating Benchmark SEC for Each Site

Site	Total Fish Meal/Oil Production (tons/annum)	Cannery Production (tons/annum)	Benchmark SEC (kWh/t)	Assessed SEC (kWh/t)
A	13 000	20 000	74,5	148,5
B	6 309	4 212	96,8	143,5
C	17 500	13 500	93,0	132,3
D	0	4 800	32,0	93,8
E	23 000	30 000	78,9	183,0
F	13 495	3 105	119,8	288,8
SA	**73 304**	**75 617**	**85,2**	**170,9**

The table also shows the assessed SEC for each site in the last column. The weighted average benchmark SEC for all the sites are calculated and compared to the weighted average achieved SEC in the last row. The information in the table is shown graphically in the following figure.

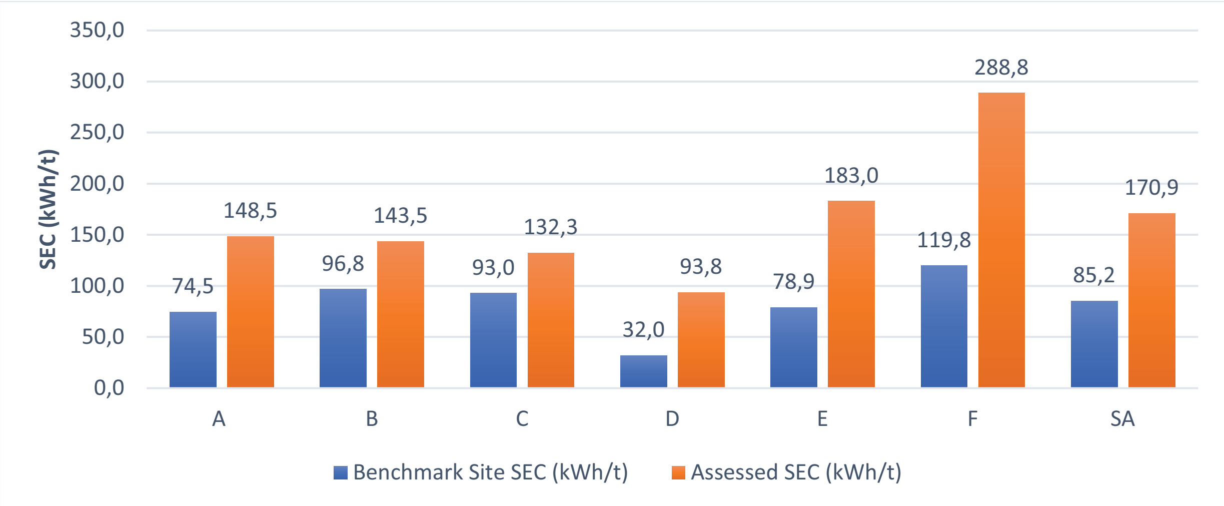


Figure 12-4: SEC Benchmark Comparison for Assessed Sites

The specific electricity consumption is higher than the benchmark values in all cases. As a result, the weighted average SEC for the assessed South African sites (marked SA) of 170,9 kWh/t exceeds the benchmark value of 85,2 kWh/t by 101%.

Figure 12-5: Comparing Assessed Site SEC Achievements

Note: Percentages above 100% would indicate higher than expected SEC and means that performance is worse than the benchmark. Conversely, percentages below 100% indicate better performance than the benchmark.

Sites A (199%), B (148%) and C (142%) use less than double the expected amount of electricity for the produced products, and Sites D (293%), E (232%) and F (241%) use more than double the benchmark amounts. Overall, the assessed South African sites use about double the amount of electricity than would be expected, compared to the published values. This means that the electricity cost per ton of product could potentially be halved by identifying the high energy consumers and increase energy efficiency at all sites.

12.4.2 Effect of Load Shedding

All the sites indicated the detrimental effect of load shedding on their operations, efficiency and cost. Only one of the sites (canning operation) had a generator available. This generator could sustain 50% throughput capacity during load shedding events. Two of the sites were considering installing generators during 2020 to reduce the effect of load shedding.

All the other sites indicated that load shedding resulted in a complete plant shutdown. Lost time varied between 3+ hours to 6 hours downtime with every load shedding event. If the interruption due to load shedding events lasted too long (> 8 hours), the fish in process has to be discarded for product quality reasons.

12.4.3 Fuel

According to FAO (2-018), a fish meal processing plant with an evaporation plant (all assessed fish meal plants have evaporation plants) should consume about 220 kg fuel oil per ton of product (55 kg/ton raw fish X 4 ton raw fish/ton product). The FAO indicates the expected fuel oil use for thermal energy as 230 litre/h for 15 t raw fish/h (Myrseth, 1985). Given fuel oil density of 0,92 kg/l, a canning plant should consume about 14,1 kg fuel oil per ton of product.

Some of the plants use coal as their thermal source, so it was decided to express thermal energy use as GJ/a, converting to this using the calorific values of the fuels (43 MJ/kg for fuel oil, and 30 MJ/kg for coal). The benchmark thermal energy use for fish meal plants are therefore 9,5 GJ/t product, and for the canning plants it is 0,6 GJ/t product.

As is the case with water measurement, the lack of distribution measurement (e.g. the split of fuel for fishmeal and canning plants) makes it difficult to compare the results directly between sites. The production ratio between the two plant sections is different from site to site, as shown in Table 13-1.

For the purposes of this project, it was therefore decided to find a benchmark figure for the production ratio for each site and to compare the SFC for each site against its own identified benchmark. By calculating the SFC percentage deviation from the benchmark, allows for a method to compare the SFC achievements between the assessed sites.

The benchmark SFC for each site x is defined as follows:

$$SFC(Bx) = \frac{(9{,}5 * Fish\ Meal\ Production(x) + 0{,}6 * Canning\ Production\ (x))}{(Fish\ Meal\ Production(x) + Canning\ Production(x))}$$

Where: B = Benchmark and x = site and production rates are in t/a

The benchmark specific fuel consumptions for the various sites are therefore as follows.

Table 12-6: Calculating Benchmark SFC for Each Site

Site	Total Fish Meal/Oil Production (tons/annum)	Cannery Production (tons/annum)	Benchmark SFC (GJ/t)	Assessed SFC (GJ/t)
A	13 000	20 000	4,1	9,0
B	6 309	4 212	5,9	7,5
C	17 500	13 500	5,6	7,4
D	0	4 800	0,6	3,0
E	23 000	30 000	4,5	7,3
F	13 495	3 105	7,8	10,5
SA	**73 304**	**75 617**	**5,0**	**7,9**

The table also shows the assessed SFC for each site in the last column. The weighted average benchmark SFC for all the sites are calculated and compared to the weighted average achieved SFC in the last row. The information in the table is shown graphically in the following figure.

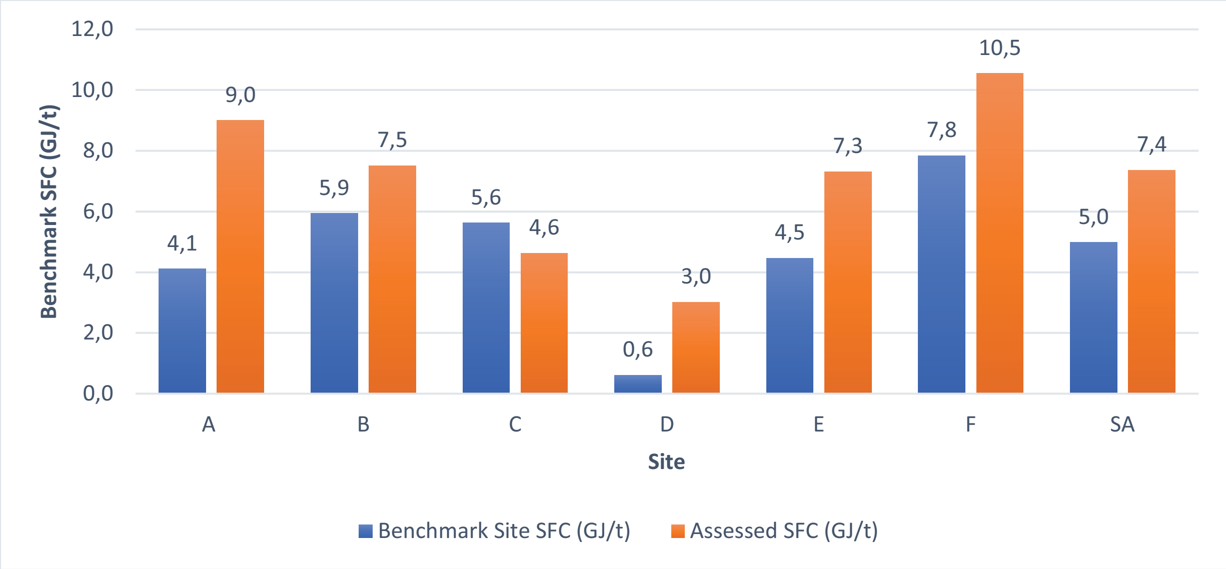


Figure 12-6: SFC Benchmark Comparison for Assessed Sites

The specific fuel consumption is higher than the benchmark values in all cases, except for Site D (0,6 vs 3,0 GJ/t). As a result, the weighted average SFC for the assessed South African sites (marked SA) at 7,4 GJ/t exceeds the benchmark value of 5,0 GJ/t significantly.

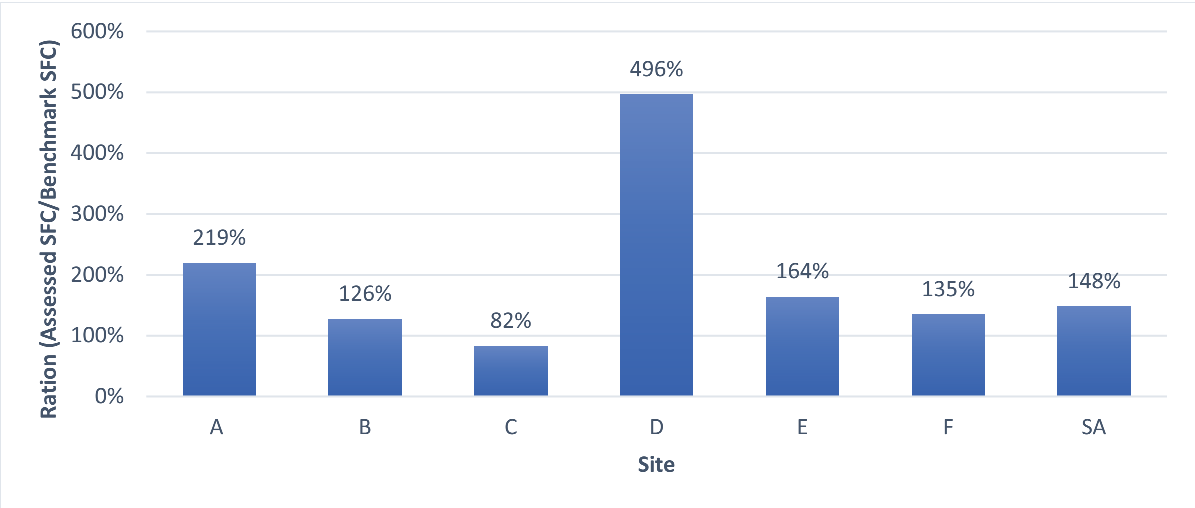


Figure 12-7: Comparing Assessed Site SFC Achievements

Note: Percentages above 100% would indicate higher than expected SFC and means that performance is worse than the benchmark. Conversely, percentages below 100% indicate better performance than the benchmark.

Sites B, E and F use more, but less than double, the expected amount of fuel for the produced products. Site A uses slightly more than double the expected value and site D uses five times the benchmark amount. Site C appeared to perform better than the benchmark, using 82% of the expected fuel per ton of product. Overall, the assessed South African sites use about 48% more fuel than would be expected, compared to the derived benchmarks.

13 SOUTH AFRICAN INDUSTRY CONFORMANCE TO STANDARDS, SPECIFICATIONS AND REGULATIONS

13.1 Conformance with Industry Standards

From the site assessment and interviews with site management, it can be concluded that the fishing industry is aware of the best management practice and the various norms and standards that are required to conduct its business. A number of the major fishing companies have identified that they are committed to ensure compliance with industry standards and environmental initiatives and regulations, as well as best management and operational practices.

During the literature study, the following key standards and specifications were identified that are generally conformed to by the industry:

- ISO 22000 certification
- SANS 10330:2007: Hazard Analysis and Critical Control Point System (HACCP System).
- HACCP Certification (International)
- BRC Global Standards
- SANS 17025 – Sampling accreditation
- SANS 0241 – applies as potable water supply is used as raw input water
- FEMAS
- IFFO-RS certification
- WWF's Southern African Sustainable Seafood Initiative (SASSI)
- Marine Stewardship Council (MSC)
- Water use and discharge permit (as issued by DWS and/or DEFF).

The table following summarises the responses from the sites assessed during 2019/20, in terms of standards applied.

Table 13-1: Applied Standards as per Industry Response

Applied Standards	Site A	Site B	Site C	Site D	Site E	Site F
IFFO RS	x		x		x	
ZA (State Vet)	x				x	
FEMAS	x		x		x	
HACCP		x	x	x		
SANS 10330		x				
SANS 10049		x				
SANS 0241	x	x				x
ISO 22000	x		x		x	
DAFF / DEFF permits	x	x	x	x	x	x
Other				ISO – work in progress		

x = subscribe to standards

From interviews with stakeholders, it was concluded that each commercial fishery sector has policies that provide guidelines for the issuing of fishing rights, as well as a strategy designed to secure transformation of the fishing industry through a balance of maintaining an environment in which large companies would continue to invest and small companies would be able to develop.

The small anchovy fishery is mostly regulated via the adoption of an Operations Management Procedure (OMP), which is an adaptive management system that is able to respond rapidly, without increasing risk, to major changes in resource abundance (DAFF, 2016).

The South African Small Pelagic Fishing Industry Association (SAPFIA) has also implemented an observer and monitoring programme working collaboratively with CapMarine and DAFF. This programme provides valuable information on not only operational patterns, but also on catch size distributions, bycatch and other biological data that is used by DAFF scientists to manage and regulate the fishery industry.

13.2 Commentary by DEFF (July 2020)

According to DEFF, "…The majority of the fish processing plants in South Africa are situated along the coast-line, which include canning industry and fishmeal plants. The sources of marine pollution that originates for the fish processing plants include the following:

- Fishing vessels – the disposal of bilge water at the sheltered waters next to the jetties
- Blood water
- Dewatering and pressing of fish after cooking,
- Wash-water, usually associated with packaging of fish
- Plant and floor washing
- Fish oil polishing
- Cooling water.

The effluent generated from fish processing plants varies due to production technology and the internal processes. However, the below generic pollutants are associated with fish processing plants:

- Suspended solids
- Biodegradable organic matters
- Inorganic nutrients (ammonia and phosphate)
- Microbiological contaminants.

In light of the above, the Department deals with fish processing plant applications on a *case by case* basis. Many of the fish processing plants were authorised by the Department of Water and Sanitation and the transition arrangement required the facilities to comply with the conditions of the DWS authorisation until the CWDP is issued in terms of the ICMA. The objective of the CWDP process is not to burden the industry, but is to work in partnership with the facilities to ensure that the coastal waters are maintained and improved for all beneficial uses. In addition, the conditions in the CWDP endeavours to mitigate potential impacts on the marine environment.

With regards to effluent quality monitoring, CWDP stipulates the effluent limits that the applicant must adhere to in order to maintain the water quality in the receiving environment. The CWDP also requires the applicant do daily or weekly monitoring to ensure that their effluent complies with the limits of the CWDP. Finally, the CWDP details the monitoring, reporting, contingency planning, analyses of samples, investigation and compliance review requirements that the DEFF will have oversight of.

To date, approximately 21 CWDP applications has been received from fish processing plants and 11 CWDP has been issued..."

(DEFF References, July 2020: Rueben Molale, Control Environmental Officer Grade A and Dr Yazeed Peterson, Director: Coastal Pollution Management).

14 FINDINGS AND RECOMMENDATIONS

14.1 Main Findings from NATSURV Study

Following a detailed Literature Study, the use of published international benchmarks was applied to draw conclusions on the efficiency and performance of each site, and for South Africa as a whole, in terms of (specific) water use, energy consumption and fuel consumption. Due to lack of monitoring and information, the specific effluent volume could not be calculated and compared to benchmark values.

Figure 14-1: Assessed Sites Achievements vs Benchmarks

The weighted average specific water consumption (SWI) of the assessed South African sites were at 79% of the derived benchmark value (literature), meaning that the SA industries use less water per ton of product produced than expected. The values ranged from 28% to 205% (achieved SWI vs benchmark) for the assessed sites.

The weighted average specific electricity consumption (SEC) of the assessed sites were at 201% of the derived benchmark value (literature), meaning that the SA industries use more electricity per ton of product produced than expected. The values ranged from 142% to 293% (achieved SEC vs benchmark) for the assessed sites.

The weighted average specific fuel consumption (SFC) of the assessed sites were at 148% of the derived benchmark value (literature), meaning that the SA industries use more fuel for thermal energy per ton of product produced than expected. The values ranged from 82% to 496% (achieved SFC vs benchmark) for the assessed sites.

In summary, the assessed SA sites use less water than expected to achieve their production rates, but they use significantly more electricity and fuel for heating purposes than expected.

The next section outlines the key observations made by the NATSURV research team during the study.

14.1.1 Lack of Information

Compared to other major industries in the country, the pelagic fish and fish processing industry exhibits a substantial lack of internal monitoring in terms of water, effluent and energy use. No water and/or energy balances were demonstrated in any of the evaluated sites.

Whilst the industry finds itself in a particularly difficult environment in terms of quotas and availability of feed for processing, and therefore in resultant financial difficulty, and hence may perceive detailed information generation as counter-productive, an opposing rationale could be that to optimise and survive during difficult circumstances, and industry need to have intimate knowledge of the micro operational environment in order to optimise each element within value chain. The lack of monitoring data would disallow optimisation and the ability to make informed decisions. To some schools of thought, this aspect is concerning as this may potentially signal the end of many companies, but more significantly, the existence of an entire industry.

14.1.2 Water Consumption

Total water consumption into each site is measured, but only for reasons of payment for the resource and not for managerial oversight or process benefit. Nevertheless, the South African industry is comparing favourably with indicated benchmark, possibly rooted against the impact of droughts across the fishing coastline areas.

The weighted average specific water consumption for the assessed South African sites were found to be 6,82 m^3/t (ranging from 2,42 to 9,14 m^3/t) vs an indicated benchmark of 8,60 m^3/t.

14.1.3 Effluent Generation

Due to lack of flow measurement, the generation of effluents could not be calculated and compared to benchmarks. Diurnal trends (pollutant loads on environment) could not be quantified.

Other than simple solids screening, there exist no treatment of effluent on any of the assessed sites. On two of the sites, highly polluted organic effluent is separated from low organic effluent. This paves the way for potential targeted treatment technologies to be introduced.

Some key parameters (BOD/COD, turbidity, ammonia, fats/oil/greases) in the discharged effluents to sea are monitored according to coastal water discharge permits. The limits are mostly significantly exceeded, making the effluent quality non-compliant to the required legal specifications.

14.1.4 Energy Consumption

Total electricity, coal and fuel oil consumption into each site is measured, but only for reasons of payment for the resource and not so much for management oversight or energy optimisation.

The information was sufficient to compare the South African industry to indicated benchmarks. South African industries are not comparing favourably with the benchmarks. The weighted average specific electricity consumption for the assessed South African sites were found to be 170,9 kWh/t (ranging from 93,8 to 288,8 kWh/t) vs an indicated benchmark of 85,2 kWh/t. The weighted average specific fuel (coal and fuel oil) consumption for the assessed South African sites were found to be 7,4 GJ/t (ranging from 3,0 to 10,5 GJ/t) vs an indicated benchmark of 5,0 GJ/t.

Two of the sites have reverse osmosis seawater desalination systems that increases electricity consumption. Some sites display reuse of thermal energy better than other sites.

14.2 Study Aim vs Reality

The following table summarises the initial study objectives and compare the main findings to each objective. Deviations initiated most of the recommendations to follow.

Table 14-1: Summary of Study Objectives and Results

NATSURV Objective	Literature findings	South African sites
To provide a detailed overview of the Pelagic Fishing and Fish Processing Industry in South Africa, its changes since 1980 and its projected changes, by using representative samples of the respective industries as case studies.	A detailed overview of the industry was made possible by sourcing various publications. International information and case studies were more available compared to local work.	Record keeping in industry was found to be poor, and other than could be found in literature, no records of change since 1980 could be found during site surveys.
Critically evaluate and document the "generic" industrial processes of the Pelagic Fishing and Fish Processing Industry in terms of current practice, best practice, and cleaner production.	The various industrial process was well described in the literature review section of this report. Good information exists on current and best practice, cleaner production – mostly in the international space than locally.	The main production processes were "claimed" to be subject to cleaner production principles – yet this could not be evidenced in terms of effluent and waste generation. This is mainly due to lack of measurement.
Determine the water consumption and specific water consumption (local and global indicators, targets; benchmarks, diurnal trends) and recommend targets for use, reuse, recycling and technology adoption.	Literature was used to establish a basis in terms of performance targets, typical ranges, benchmarks and global indicators. These were used to inform the South African site assessments and compare with international standards	This was established, within the environment of extremely limited measurement.
Determine wastewater generation, and typical pollutant loads (diurnal	Sources of wastewater generation, composition and typical loads could	Total lack of measurement, and extraordinarily little treatment

NATSURV Objective	Literature findings	South African sites
trends) and best practice technology adoption.	be derived from the literature review.	evident. Serious lack in adoption of best practices.
Determine local electricity, water, and effluent prices and bylaws within which these industries function and critically evaluate if the trends and indicators are in line with water conservation demand management and environmental imperatives.	Several bylaws were assessed, in addition to the standards and specifications that exist for the industry. Pricing were not detailed, only tariff structures.	This information was not made available.
Critically evaluate the specific industry's water and wastewater management processes adopted and recommend fundamental principles and guidelines that are important for the water users.	Principles and guidelines were described in the literature study, as pertaining to water use, management practice, BAT and cleaner production.	See the recommendations below.
Evaluate the industry adoption of the following concepts: cleaner production, water pinch, energy pinch, life cycle assessments, water footprints, wastewater treatment and reuse, best available technology, and ISO 14 001. Provide and outline the manner in which industries may prevent, minimize and mitigate possible water pollution.	The literature survey mentioned and described these principles, as basis for the site assessment and evaluation of the identified factories.	Some applications of cleaner production (on main processes), but little evidence of quantification and application of best practices and standards. See the recommendations below.

14.3 Comparison of 1987 and 2020 data

The initial document in the NATSURV series was the "*Guide to Water and Waste-Water Management in the Pelagic Fishing Industry*" (WRC Project No. 97; TT 28/87), issued by Binnie & Partners in 1987. Subsequently to this document, many changes have occurred in the industry' legal, commercial and operational environment which necessities an update of the document. By comparing the key findings of the two survey reports, it is noted that the 1987 focused primarily on effluent generation, with limited focus on water consumption, and nothing in terms of energy management.

The 1987 survey reported extensively on effluent management and treatment options, including screening, settling, chemical dosing, floatation and membrane processes. The effluent volume was based on quotas, with an average of 14.4 m^3/t, compared to the 2020 figure of one site only, being 16.3 m^3/ton. The average effluent COD, SS and FOG was reported at 1 308, 2 203 and 136 mg/l (average of 10 factories) compared to the 2020 data of COD ranging from 60-8 000 mg/l and FOG ranging from

0-17 566 mg/l. It appears as if quality and volumes of effluent were more intensively monitored in 1987 compared to 2020.

No water consumption values could be derived in the 1987 report for canning plants. The 1987 report derived a value of water consumption (not intake) for fish meal plants. The SWI was based on the fish quotas, not on the actual fish intake and reported to be 0,84 m^3/t. In the 2020 study, the SWI/SWC is based on production values. In the case of fish meal plants, 75% of the fish does not end up in the product but becomes part of the wastewater. The comparative SWC of the 1987 report is therefore 0,84/0,25 = 3,28 m^3/t, assuming the entire quota was fed into the plant.

The international benchmark for fishmeal plants is 2,0 m^3/t. The SWC in 1987 was therefore 164% of the benchmark. The 2020 average SWI was 79% of the benchmark (canning plants included). It is therefore concluded that the SWI within the pelagic fishing industry has improved since the initial report – 64% more than the benchmark value to 21% less than the benchmark value.

14.4 Necessary Priority Interventions

Based on the gaps identified during the site surveys, and drawing insight from international best practice, a number of actions can be recommended to improve the management of the water, effluent and energy systems in the pelagic fish and fish processing industry of South Africa. By implementing these measures, optimisation would be possible, however, compliance will become more expensive.

14.4.1 Step 1 – Measure

In the wisdom of early scientists: "To measure is to know" and to "To know is to manage". This management philosophy is particularly true for the local pelagic fish industry. However, to measure costs money. It is difficult to motivate this expenditure as the return on such investment is difficult to quantify and economic hardship has already fallen upon local fisheries. One view to take is that the proper management of the systems is virtually impossible without measurement and interpretation of the data. Proper system management paves the way for financial optimisation and eventual maximising of profits.

On the water systems, the following may be implemented:

- seawater intake flow should be measured;
- flow distribution and use of seawater in individual systems must also be measured;
- flow distribution and use of freshwater to all the systems must be measured;
- the total distribution of water should add up to the water intake;
- effluents are generated in various units and must be measured at each process unit – this should be done whether the effluent originates due to freshwater or seawater intakes;
- the total effluent discharge flows should also be measured
- all effluent sources should be analysed for identified key water quality constituents. This will aid to define mass loadings of impurities onto the effluent systems.

On the energy systems, the following may be implemented:

- the electricity distribution to individual plant systems must be measured to establish a basis for a system wide definition and identification of optimisation opportunities;
- noting that one of the assessed sites embarked on this requirement;
- coal and fuel oil are mostly used to generate steam for thermal heating purposes;
- the steam generated from each boiler should be measured;
- the total steam flow and the distribution of steam to individual process units must also be measured.

The provision of measurement can be provided in phases. It may be true that measurement of 20% of those indicated may have 80% impact. Some of the lower impact streams can be accounted for via assumptions or estimations.

14.4.2 Step 2 – Water and Energy Balances

Based on the required measurements, or at least the key measurements, water and energy balances should be compiled for the entire facility. These balances are best updated on a daily basis to establish trends, impacts, deviations, causes, etc.

The water balances should account for the distribution and ultimate destination of all incoming water. The water balances should also account for the loading of pollutants and impurities into the streams and the contributions of these loadings on the final effluent compositions.

Likewise, energy balances across the facility will quantify the application of energy on a continuous basis and compare that to the actual process demands for energy. This is applicable to both electrical and thermal energy.

14.4.3 Step 3 – Cost Charting

The established water and energy balances can form the basis for charting of costs. Both incoming water and energy have costs associated with it. These costs can now be assigned to individual process units (analogous to an accounting system – sources and application of funds).

This cost charting exercises form the basis for the funding of any identified optimisation projects.

14.5 The Need and Benefits of Optimisation

With the credible data and accurate information in hand, improvement opportunities or opportunities for more cost-effective compliance to permit requirements can be identified. Continuous improvement and system optimisation are important due to several reasons.

14.5.1 Environmental impact

Environmental pressures on industry in general, and the fishing industry, are always increasing. These pressures will intensify as the world population increases, as climate change takes hold and as natural resources become depleted. In line with this, environmental legislation is likely to become more stringent.

It is the responsibility of each industry to minimise its impact on the environment, whether legislated or not. Industry should always strive to minimise its carbon footprint (by minimising the use of fossil-based energy) and water footprint (by minimising water use).

The loading of pollutants onto the natural environment should be minimised. Permits and authorisations should investigate the inclusion of load-based limits, instead of – or in addition to concentration and flow-based limits.

14.5.2 Financial

The South African fishing industry is operating well below installed production capacity due to quota limitations. To keep the business financially viable, the cost of production must be minimised. The minimisation of water intake and energy requirements can go a long way in contributing to this.

Often, contaminants in effluents are wasted product, which could be recovered as value-add product. Recovering these by-products and preventing these contaminants reporting to effluent, can have a beneficial impact on income and financial viability of the industry, whilst reducing the impact of pollution on the water resource at point of discharge.

It is possible that improvement in environmental footprints may very well increase the profitability of the enterprise.

14.5.3 Social

The potential demise of the fishing industries will have a significant social impact within the communities where they operate. They are typically significant employers within these communities, associated with significant job creation and some secondary economies.

14.5.4 Food Security

South Africa needs to ensure its security of food supply. The potential reduction or closure of fishing industries will adversely affect this objective. Water and energy management and security of uninterrupted supply are therefore, a significant enabling factor to the industry's wellbeing and future growth.

14.5.5 Saving an Industry

The entire South African Pelagic Fishing industry is under severe financial pressure, mostly due to limitations in resource. When resource was in abundance (when the factories were constructed) there was not much pressure on optimisation. Now, water management and optimisation are key requirements for the survival of the industry as worst case, and growth of the industry as best case.

14.6 Recommended System Optimisation

14.6.1 Generic Potential Improvement Actions

Best practices are continually evolving and it is possible that yesterday's best practice is no longer considered as best practice today, but rather normal operating procedure.

The areas of best practice listed hereunder are generally applied worldwide in the industry. The assessed industries have all implemented some of the following actions to a larger or lesser degree, but not in all cases. The following general improvement approach is typically recommended:

- Promotion of Cleaner Production (CP) – instead of (or before) end-of-pipe solutions;
- Focus on water input and wastewater output;
- Focus on 'on-site' problems and solutions;
- Focus away from technical CP projects to more organisational aspects regarding improved environmental management systems (EMS) and occupational health and safety (OHS).

CP concepts to incorporate and investigate:

1) Good housekeeping practice;
2) Reuse and recycling;
3) (Substitution of hazardous materials and chemicals, etc.;
4) Process optimisation;
5) Technology change and innovations;
6) Development of cleaner product.

From the literature review, it could be seen that a reduction in water consumption is imperative, with a number of synergies to be attained in relation to energy consumption, COD discharge and better utilisation of the fish (less fish end up in the effluent stream). Taking from international best practice, several improvement opportunities could be considered by the South African industry:

- Spill prevention (the optimisation of production equipment to increase the utilisation of the fish), Some of the concept identified included:
    - sweeping up solid material for use as a by-product, instead of washing it down the drain.
    - cleaning dressed fish with vacuum hoses and collecting the blood and offal in an offal hopper rather than the effluent system.
    - fitting drains with screens and/or traps to prevent solid materials from entering the effluent system.
    - using dry cleaning techniques where possible, by scraping equipment before cleaning, pre-cleaning with air guns and cleaning floor spills with squeegees

- Separation of fish oil (the use of cyclones for the separation of fish oil from wastewater).

- Removal of tails and head earlier in the production (e.g. before the freezing process) – this can lead to recovery of valuable by-products, which may otherwise be lost and contributing to higher COD levels. The expected result would be:
    - reduced COD levels,
    - allow for more waste which could be sold as a valuable by-product, and
    - increased utilisation of the available cold storage capacity.

- Separate fish from water to the best extent possible and reduce contact time between fish and water. Consider dry transport of fish and dry removal of guts and skin. Dry transport is a great benefit for the environment. It saves water, it reduces the content of organic matter in wastewater, and it provides more fish offal that can be sold for fish meal production or pet food. It should also be noticed that the fish offal becomes dryer and more valuable because less energy is needed for evaporation during the production of fish meal.

- Investigate options of reducing mechanical treatment of fish offal and potential uses of the by-product as well as development of machines to accommodate these actions.

- Investigate potential applications of blood-waters recovery technologies that are viable and environmentally beneficial. Further research into practical application and use in the South African environment may be necessary.

- Investigating fuel/energy options and switching to what is most appropriate, taking into account the reality scenarios of South Africa and the requirements of the facility. Other options identified include:
    - using more environmentally benign sources of energy.
    - replacing fuel oil or coal with cleaner fuels, such as natural gas,
    - purchasing electricity produced from renewable sources, or
    - co-generation of electricity and heat on site.
    - For some plants it may also be feasible to recover methane from the anaerobic digestion of high-strength effluent streams to supplement fuel supplies.

- In terms of improving energy use, some of the recommendations include, but are not limited to:
    - implementing switch-off programs and installing sensors to turn off or power down lights and equipment when not in use.
    - improving insulation on heating or cooling systems and pipework.
    - favouring more efficient equipment.
    - improving maintenance to optimise energy efficiency of equipment.
    - maintaining optimal combustion efficiencies on steam and hot water boilers.
    - eliminating steam leaks.
    - capturing low-grade energy to use elsewhere in the operation.

It is recommended that these actions are incorporated into Life Cycle Assessments (LCA) to ensure that the benefits gained from one option is not eroded by the adverse impacts of another.

Two approaches to water and energy optimisation are presented below.

14.6.2 Water Pinch Studies

All industrial processing plants present opportunities for improvement and optimisation. This section provides some generic optimisation opportunities based on observations made during the site visits and evaluation of available data. These recommendations are not necessarily site-specific and may not be applicable to all sites.

Why should one optimise with respect to water and energy?

Water and energy accounts for a significant portion of a process plant's interaction with the environment. By optimisation, environmental impacts are minimised.

In a water scarce country, as South Africa is, the cost of water and energy provision, as well as the likelihood of interrupted supply will increase. This presents a significant risk on any process-based operation. Optimisation will reduce risk and, in some cases, may even show a direct return on investment.

An important pre-condition to enable optimisation of any system is thorough quantification of that system. In general, the distribution of water within the factories were not measured. Whilst the incoming water stream would be measured (mainly for billing purposes), the application of the water to the different plant sections are not separately recorded.

By measuring water to all distribution points, the application of all the incoming water can be accounted for and provide a sound basis for water management. If losses occur, say due to a pipe leak, the data will alert such a condition. Such information can also indicate inefficient points of water application, assist to indicate process upsets, or trace defects in product quality, production chain, etc.

Most of the sites included in the surveys have both a fish meal plant and a canning plant. The two processes are significantly different, but since their water consumption rates are measured as a total, the specific water rates between the factories are difficult to sensibly compare. As a starting point and as a minimum, the water feed to the fish meal plant and the canning plant should be separately measured, with the total adding up to the total intake water. Ideally, the water fed to individual operations, such as the boiler or the cooling system should also be measured. Such measurements (while assisting to account for all incoming water), will assist to identify optimisation opportunities in terms of water use.

Water flow also forms the basis upon which energy balances, and hence energy use optimisation, can be based. Very often, water and energy optimisation occur in unison. For example, a wastage in steam leads to higher energy consumption and to higher water consumption. In some cases, water and energy optimisation may compromise each other. For example, the use of a cooling tower may improve energy efficiency but reduces water efficiency (due to water evaporating). By switching to air cooling, water use is minimised, but energy use is comparatively increased. Such integrated optimisation is only possible through the understanding that measurement brings.

This makes a case for seawater consumption to also be measured, even though seawater (or groundwater) use is not charged. Integrated system evaluations are recommended. Pinch analysis has been shown to be effective for such analyses. A pinch analysis involves defining all required water uses in the system in terms of flow rate and purity requirements, typically referred to as water sinks. Secondly, all singular water sources are identified, also in terms of flow rates and purity.

All water sinks are combined in a chart, sequenced from low purity to high purity. See blue curve in the figure below. Similarly, internal water sources are also plotted. These are streams coming out of internal processes and do not include water imported from external sources. See the red curve in the diagram below. The concept is to position the source curve against the vertical axis, and to “slide” the blue curve from the right under the red curve until the two curves touch. The point where the two curves touch is referred to as the pinch point.

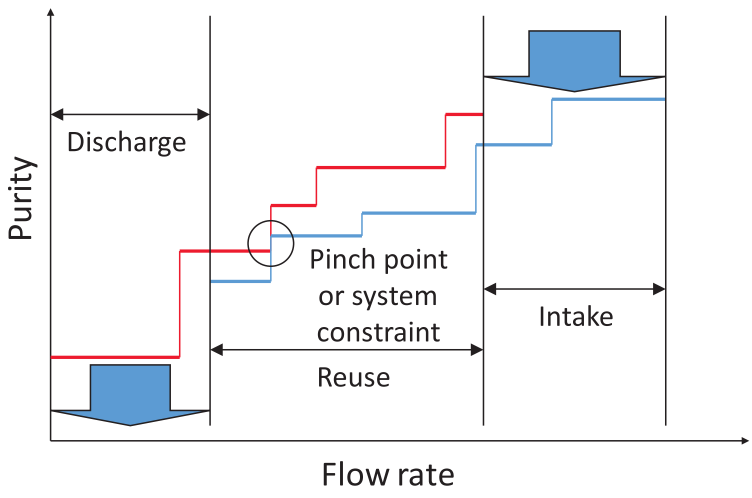


Figure 14-2: Typical Pinch Chart

The chart can be divided into three regions, namely a discharge region, a reuse region, and an intake region. The reuse region shows the reuse potential of streams and where they could be reused. If these reuses cold be implemented, the chart shows the resultant water intake and water discharge flowrates for such an optimised system.

To further reduce discharge (and intake) flows, industry typically targets the final combined effluent for treatment. Usually the final effluent is the most impure and requires the highest cost to treat. Pinch analysis assists to target the more opportune streams to treat, and assists to identify the required quality to which it should be treated. For example, the source immediately to the left of the pinch point can be treated only to the quality requirement of the sink immediately to the right of the pinch point. This allows greater overlap of the curves and resultant savings in both intake and discharge flows, as can be illustrated in the figure below.

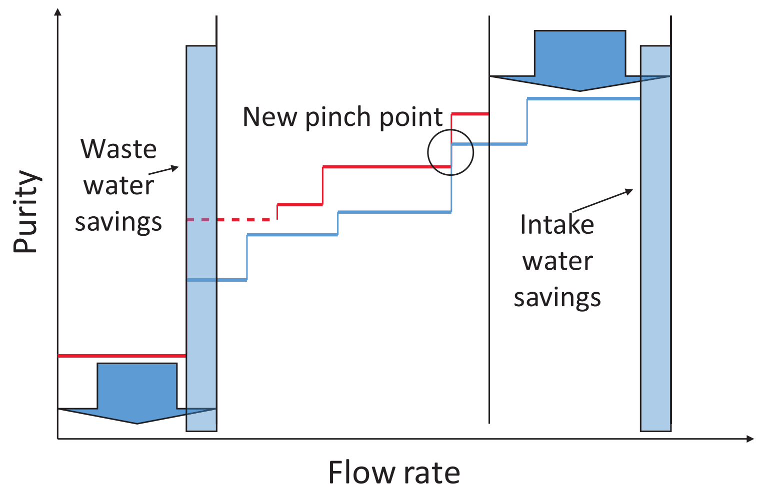


Figure 14-3: Targeted Cost-Effective Treatment for Water Savings

Typical recommendations that may emanate from such a study could be items such as:

- Route Boiler Blowdown and softener regen to combine with well water as feed to RO plants (where available);
- Segregation of streams into say high and low organic, treat only high organic streams to render it reusable, potentially as:
    - Cooling water.
    - Thawing water.
    - Fluming water.
    - etc.
- Feed treated DAF water to RO (where available);
- Use some wastewater streams directly for cooling purposes;
- Use RO brine for thawing.

14.6.3 Energy Pinch Studies

Energy pinch studies are analogous to water pinch studies, with the main objective of the energy pinch methodology being:

- to minimise energy input, typically steam;
- to minimise cooling, typically cooling water.

The purpose of the pinch study is to find the optimal application of heat across multiple processes. For example, the cooling requirement in one process may partially or fully address the heating requirement in another process.

During the surveys it was evident that sites considered thermal energy optimisation to certain degrees. It is clear (based on the wide range of SFC's encountered) that the efficiency of such optimisation attempts varied.

14.7 Industry Model Case Proposal

It is recommended that sites secure funds to perform such in-depth optimisation studies within their own sites and or that research partners make funds available for such study on one of the assessed sites. The study results can then be shared with the other sites to replicate and tailor to their own systems, as a national best practice in this industry. Such a study would typically include the following phased approach:

14.7.1 Stage 1: Site Selection

A site is to be selected that could serve as a model for the remainder of the industry. Such a site should:

- contain all the processing components that could be encountered at the other sites;
- have sufficient flow monitoring in place or be prepared to put sufficient flow monitoring in place;
- have personnel suitably qualified, preferably with an engineering background, to assist with the study;
- be dedicated to improving its environmental and financial performance.

14.7.2 Stage 2: Measure and Record

Identify all critical measurement requirements. The required measurement systems should be installed where not already available. Collect and record the measured data for an extended period (to be defined) and record all relevant cost information.

14.7.3 Stage 3: Compile Mass and Energy Balances

Based upon the recorded data, compile overall site mass and energy balances. Define appropriate evaluation ranges from the balances for optimisation evaluations. Based on these selected ranges, perform cost charting exercises. This forms the basis for the business case evaluation of identified optimisation opportunities.

During this phase, all critical variables need to be defined and targets set for:

- Specific Water Intake (SWI);
- Specific Electricity Consumption (SEC);
- Specific Fuel Consumption (SFC);
- Specific Effluent Volume (SEV)

Water and energy system management procedures will be defined and informed at the hand of the balances.

14.7.4 Stage 4: Optimisation Analysis

Perform site wide optimisation analysis at the hand of selected methodologies, such as water pinch and energy pinch. Identify optimisation opportunities to move the site closer to or better than indicated target and benchmark values in terms of SWI, SEC, SFC and SEV.

14.7.5 Stage 5: Select Optimisation Strategy

Based upon recommendations from the optimisation analysis, select and define an optimisation strategy (roadmap). Motivate the strategy and compile a report to share with other role players in the industry.

14.7.6 Stage 6: Implement and monitor the Strategy

The site upon which the study was based, can proceed with implementation. Monitoring and continuous improvement is a crucial part of this phase to ensure the desired (measurable) impact is obtained. Ideally, the site will share their findings and lessons learnt with industry partners.

14.7.7 Stage 7: National replication of the strategy

The other sites first need to adapt the analysis/recommendations to their own systems and circumstances, before proceeding with implementation. Ideally, the sites will find value to share and compare their findings and lessons learnt across the industry and at international platforms.

Notably, issues of IP and competitive advantage may become a discussion point amidst different companies. However, this approach is not naïve in this sense, as it does relate to IP aspects, but rather focus on best management and operational practice within a collaborative Community of Practice, which is for the benefit of the whole industry.

15 CONCLUSION

The Pelagic fishing industry in South Africa was studied in terms of applied water management practices, with the inclusion of energy due to the close relation between water and energy.

The research approach was to firstly gain insight into the general processing systems employed in the industry and the generic water and energy use, from local and international literature. The literature study revealed that the Scandinavian countries are typically on the forefront in this industry in terms of environmentally friendly practices.

The environmental impacts are measured in terms of intensity parameters, such as specific water consumption (SWI – m^3 of fresh water consumed per ton of production), specific effluent volume (SEV – m^3 of effluent generated per ton of production), specific electricity consumption (SEC – kWh of electricity consumed per ton of production) and specific fuel consumption (SFC – GJ of fuel energy consumed per ton of production). International benchmarks for each of these parameters were derived from literature information, and used to compare the South African industry with expected norms and performance.

The literature study assisted in creating an understanding of the South African Pelagic Fishing industry and identifying the major role players in terms of fish processing operations. Several of the operators were then contacted (case studies), to provide site specific data to compare the achievements of the local industry compared to the derived benchmark parameters.

Five fishmeal and fish oil processing plants and six canning plants were surveyed, compared to the infrastructure inventory of eight fishmeal plants and six canning factories. Therefore, a significant portion of the processing operations were included in the survey.

In terms of water consumption, the South African operations were found to use less fresh water than expected when compared to international benchmarks, on average 6,82 m^3/t (ranging from 2,42 to 9,14 m^3/t) vs an indicated benchmark of 8,60 m^3/t. Of the assessed sites, 33% uses more water than the benchmark.

Availability of water to the industry was restricted during the drought of 2018, and hence there were significant efforts expended to reduce water consumption. Some of the cleaner production technology principles were implemented to aid in the reduction of water consumption, such as spill prevention, minimise contact time between fish and water and by raising awareness amongst staff.

Some practices were described to reduce fresh water consumption, including:

- Modification to the cutting tables by installing high-pressure cleaning sprayers on the blades which cut off heads and tails;
- Introduction of shut-off valves when the production line is stopped results in freshwater savings and a corresponding reduction in effluent load;

- Technology was introduced that magnetically lowers the pilchard cans into retort baskets, which replaces the need for water in the retort baskets.

In terms of effluent generation, the performance of the South African industry could not be assessed due to lack of measurement. Not one of the sites could provide data to facilitate the calculation of SEV (Specific Effluent Volume). All the South African sites have some form of screening as the final effluent treatment before release to the environment. Treatment seems to be pre-treatment at best, with no secondary or further treatment. There is no evidence of water reuse in the industry.

In order to facilitate reuse, literature indicated that primary and secondary treatment (and potentially also tertiary treatment) would be required. None of these were evident during the surveys.

The South African sites struggles to meet the coastal discharge permit conditions with respect to BOD/COD, Turbidity, ammonia and FOG due to the lack of treatment. At least one of the sites diluted their effluent with seawater before release. The study included commentary from the Department of

The high capital cost associated effluent treatment plants appear to be the major stumbling block to implement state of the art treatment technologies. For this reason, this study recommends the application of pinch technology (no evidence of its application could be found on the assessed sites). Such application can result in the decreased size of necessary effluent treatment plants, thereby reducing the associated cost.

A barrier to the application of such investigations is the lack of measurement in this industry. Not one of the sites could close a water balance due to insufficient data. This study recommended the improvement of this situation.

By reducing the effluent to be treated, and by treating effluent to reuse qualities will aid to reduce the water consumption even further.

In terms of electricity consumption, the South African operations were found to use significantly more (201%) power than expected when compared to the benchmark. None of the SA sites could achieve the benchmark value. Given the increasing cost of energy in South Africa, energy optimisation as part of water management strategies holds significant potential.

The reason for the higher electricity consumption is unclear but could partially be related to the use of seawater desalination reverse osmosis plants to provide fresh water. Literature indicated that electricity consumption can be reduced by favouring more efficient equipment (such as pumps, compressors, centrifuges), implementing switch-off programs and installing sensors to turn off or power down lights and equipment when not in use and by making use of variable frequency drives instead of control valves.

In terms of fuel consumption, the SA industries use 48% more fuel for thermal energy per ton of product produced than expected. Only one, or 16,6% of the assessed sites, achieved the benchmark fuel consumption.

Literature indicates that fuel efficiency can be improved by improving boiler efficiency, insulation of hot surfaces, recuperation of heat in condensates as well as increased staging in concentration plants. On the steam systems, optimal combustion efficiencies must be ensured on boilers and steam and condensate leaks must be eliminated.

The study concluded with some recommended interventions, with the first priority to define the water and energy systems.

- Measurements;
  - Measure water flows to define water distribution and balances,
  - Measure electricity distribution to different plant systems,
  - Measure steam distribution,
- Compile system water and energy balances;
- Cost charting.

These actions assist in proper definition of the water and energy systems, noting that ill definition is a major concern at present. Once the system has been properly defined, the system has a basis from which it can be optimised in terms of water consumption, effluent generation, electricity consumption and fuel consumption.

Some generic actions have been proposed based on international best practice as outlined in the literature. The application of water and energy pinch studies have also been proposed and described in this NATSURV report.

It is recommended that such an optimisation study first be performed on a selected site and then rolled out to the remainder of the industry. The following steps are suggested:

- Site Selection;
- Measure and Record;
- Compile Mass and Energy Balances;
- Optimisation Analysis;
- Select Optimisation Strategy;
- Implement the Strategy.

Such a strategy will include generation of targets for SWI, SEV, SEC and SFC and pathways for achieving such, followed by monitoring and continuous improvement thereof.

This report concludes a review and national survey of the South African pelagic fish and fish processing industry at time of 2020, as an update of the previous NATSURV Report published in 1987 (WRC TT 28/87).

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Appendix A: South African National Water Use Regulations

A.1 South African National Water Use Regulations

In April 2002, the Department of Water Affairs issued both the Compulsory National Standards in terms of Section 9(1) of the Act and Norms and Standards for Tariffs in terms of Section 10 of the Act; provide a framework or model within which Local Government can provide efficient, affordable, economical and sustainable access to water services. To make it easier for Local Government to implement the regulations, the Department of Water Affairs and Forestry (DWAF) has developed a set of guidelines or a road map for Water Services Authorities (WSAs) and other Water Services Institutions (WSIs).

A.1.1 Compulsory National Standards: Regulations under section 9 of the Water Services Act (Act 108 of 1997))

Section 9(1) of the Act allows the Minister to set compulsory national standards for Water Services Institutions (WSIs) when they supply potable water and sanitation services to citizens. Compulsory national standards are a single set of regulations that are applied in the same way to all WSIs across the country and that everyone must follow.

These regulations are to protect citizens, municipalities and WSIs. They are also there to make sure that there are good systems to manage water services to planning and provision. Of specific relevance to industry are the sections on:

- 8. Use of Effluent: the regulation says:
    - 8(1) A water services institution must ensure that the use of effluent for any purpose does not pose a health risk before approving that use.
    - 8(2) Any tap or point of access through which effluent or non-potable water can be accessed, must be clearly marked with a durable notice indicating that the effluent or non-potable water is not suitable for potable purposes.
    - 8(3) A notice contemplated in subregulation (2) must be in more than one official language and must include the PV5 symbolic sign for non-potable water as described in SANS 1186: Symbolic Safety Signs: Part: Standards, Signs and General Requirements.
- 9. Quantity and Quality of Industrial Effluent Discharged into a Sewerage System:
  The regulation states that a water services institution is only obliged to accept the quantity and quality of industrial effluent that the system is capable of purifying or treating. This is done to ensure that any discharge to a water resource complies with any standard prescribed under the National Water Act.
  The Guidelines comments that before a WSI allows an industry or business to join its sewerage system it must take into account the effect this will have on the amount (quantity) and especially the characteristics (quality) of the effluent that will eventually be released from the sewage system into a water resource.

If there is a danger to the sewage treatment process or a violation (abuse) of the permit, the WSI should only agree to accept the effluent once the harmful substances have been removed or reduced.

Industries must:

- Take care (treating) of their effluent early so that it meets their permit conditions;
- Separate effluent substances (matter) and take care of the harmful parts; or
- Collect harmful flows of liquid or gas that are then removed by suitable waste disposal service providers (contractors).

The amount and the strength of the effluent must be taken into account together to get the total poison load (weight). Industries must not be allowed to dilute effluent to meet the required limits. From time-to-time WSIs must monitor the effluent released by large industrial users to make sure that they are always taking the necessary steps to keep up with their responsibilities.

A.1.2 Norms and Standards for Water Services Tariffs: Regulations under Section 10 of the Water Services Act (Act 108 of 1997)

These regulations are intended as a guide to WSIs for how to provide good services to citizens while allowing them to decide how they actually set the tariffs (fees / charges) for these services. The regulation states that a water services institution must, when setting tariffs for water services provided to consumers and other users within its area of jurisdiction, differentiate, where applicable, between specific categories, which includes but is not limited to:

- industrial use of water supplied through a water services work and
- discharge (tariff) of industrial effluent to a sewage treatment plant;

A.2 Regulations Relating to Compulsory National Standards and Measures to Conserve Water

These regulation include that a water services institution is only obliged to accept the quantity and quality of industrial effluent or any other substance into a sewerage system that the sewage treatment plant linked to, that system is capable of purifying or treating, to ensure that any discharge to a water resource complies with any standard prescribed under the National Water Act.

A.2.1 General and Special Standards: No. 9225: Regulation No. 991 18 May 1984: Requirements for the Purification of Wastewater or Effluent (Government Gazette 18 May 1984)

This prescribes the following requirements for the purification of wastewater or effluent produced by or resulting from the use of water for industrial purposes:

1) Special Standard: Quality standards for wastewater or effluent arising in the catchment area draining water to any river specified in Schedule I or a tributary thereof at any place between

the source thereof and the point mentioned in the Schedule, in so far as such catchment area is situated within the territory of the Republic of South Africa.

2) Special Standard For Phosphate
3) General Standard: Quality standards for wastewater or effluent arising in any area other than an area in which the Special Standard is applicable, as described in paragraph 1.
4) Methods Of Testing

A.2.2 National Regulator for Compulsory Specifications Act (Act No. 5 of 2008), as Amended Through the Legal Metrology Act (Act No. 9 of 2014)

The National Regulator for Compulsory Specifications, as established by the National Regulator for Compulsory Specifications Act, 2008 (Act No. 5 of 2008) as amended through the Legal Metrology Act (Act No. 9 of 2014).

The purpose of the Act is to provide a legal framework for the administration and maintenance of compulsory specifications in the interests of public safety and health or for environmental protection in the Republic; and to establish the National Regulator to administer compulsory specifications.
The compulsory specifications are aligned with international guidelines and practices and are harmonised with the Standards and Codes of Practice of Codex Alimentarius. They apply to all products sold in South Africa (whether locally produced or imported) and exports to other countries.
The minimum requirements of the compulsory specifications are based on:

- Pre-requisites – Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP).
- Guidelines set by Codex Alimentarius.

The compulsory specifications address:

- Requirements for the factory:
- Construction, layout and conditions.
- Equipment for production.
- Quality of the water used during handling and processing.
- Requirements for employees engaged in the handling, preparation, processing, packaging and storage of the product.
- Hygienic layout of factory, equipment and processes.
- The handling, preparation, processing, packaging and transportation of the product.

Ingredients and product:

- Product specific composition and quality.
- Microbiological requirements.
- Chemical requirements.
- Packing and packaging material.
- Labelling.
- Methods of physical, chemical and microbiological evaluation

In addition to the FAI, the sector is regulated by the Department of Trade and Industry and the Department of Agriculture Forestry and Fisheries.

A.3 DWAF (DWS) Water Management Policies and Strategies for Industry

A.3.1 The National Water Resource Strategy: Water for an Equitable and Sustainable Future: June 2013 Second Edition

The NWRS2 builds on the first NWRS published in 2004. The purpose of the NWRS2 is to ensure that national water resources are protected, used, developed, conserved, managed and controlled in an efficient and sustainable manner towards achieving South Africa's development priorities in an equitable manner over the next five to 10 years. This Strategy responds to priorities set by Government within the National Development Plan (NDP) and National Water Act imperatives that support sustainable development. The NWRS2 acknowledges that South Africa is a water-stressed country and is facing a number of water challenges and concerns, which include security of supply, environmental degradation and resource pollution, and the inefficient use of water.

The purpose of the strategy is to:

- facilitate the proper management of the nation's water resources
- provide a framework for the protection, use, development, conservation, management and control of water resources for the country as a whole
- provide a framework within which water will be managed at regional or catchment level, in defined water management areas
- provide information about all aspects of water resource management
- identify water-related development opportunities and constraints

The NWRS is the legal instrument for implementing or operationalising the National Water Act (Act 36 of 1998) and it is thus binding on all authorities and institutions implementing the Act.

Chapter 7 Water conservation and water demand management (WCWDM) is specifically pertinent to industry, wherein it is stated that:
"Given the diversity of industry and types of mining, the nature of water use in the industry and mining sectors is highly varied. If the water supplied to industries through the water services sector is included, this sector uses close to 16% of the total water demand in South Africa. The successful integration and implementation of WCWDM into operations and the creation of a water-wise business culture should be prioritised within the industrial and mining sectors."

"All industries use water in either their main or secondary activities, including office buildings. The use of water per unit output can range by order of magnitude within any one industrial sector and also between industrial sectors. In many cases, the range in water use within a sector is greater than the differences in water use even between sectors."

However, there is considerable scope to implement WCWDM in the industrial sector, particularly for those industries that have not yet implemented water-efficient technologies and systems.

As such this section puts forward a number of objectives and strategic actions, which include but are not limited to:

- Ensure that relevant, practical interventions are implemented by all sectors
- Implement water allocation and water use authorisation that entrenches WCWDM
- Strengthen compliance monitoring and enforcement
- Implement water resource infrastructure development in the context of WCWDM
- Setting Water use efficiency targets

The DWA has developed a National Strategy for Water Reuse, which provides a considered approach to the implementation of water reuse projects. The National Strategy for Water Reuse is a sub-component of, and is consistent with the NWRS2 (see Annexure D).

This strategy comments on Water treatment technologies as follows: "The choice of treatment technology is a function of both the nature of the pollutants in the water and the required quality of the re-use water. An overview of applicable treatment technologies for water re-use is given in their Table 2, in terms of Category of Pollutant and Applicable Technologies.

The best practice in water re-use projects applies the multiple barrier approach to the control and removal of pollutants. This implies that in the sourcing, treatment and distribution of reclaimed water several control, technological and management barriers are set up to achieve a high level of assurance with respect to pollutants removal and producing a reclaimed water fit for use and safe for human consumption."

The need for re-use in Industry is highlighted by the comment: "The re-use of water is already widely implemented by water intensive industries (through process water recycling and cascading water uses). The extent of re-use and the specific details as to how water is reused is industry and process specific. Nevertheless, industrial water use is typically organized according to the quality of water required, as follows:

- Processes requiring high quality water such as steam generation, wash-water in clean environments, foods processing, final product rinsing, product make-up, etc.;
- Processes requiring moderate water quality such as for cooling, refrigeration, general washing and rinsing, etc.; and
- Processes requiring low water quality such as for raw material hydraulic transport, ore washing and milling, dust control, minerals processing, etc.

As many industries do not require high quality water for process applications, they can therefore use treated wastewater from municipalities and treated effluents from other industries. The wastewater from the upstream user must, however still be adequately treated and prepared for subsequent industrial use.

Industries can be operated as zero effluent discharge (ZED) facilities by adopting the principle of water recycling and re-use. This may require the treatment of industrial effluent to a high standard to allow re-use of water even by sensitive water users, such as for human consumption."

A.3.2 Water Conservation and Water Demand Management Strategy for the Industry, Mining and Power Generation Sectors, August 2004

The DWA has developed a National WCWDM Strategy, supported by three subsidiary strategies, focussing on water services, agriculture, and industry, mining and power generation. The Water Conservation and Water Demand Management Strategy is a fundamental step in promoting water use efficiency and is consistent with the National Water Act, which emphasises effective management of water resources.

Each sectoral strategy document provides a detailed background of the sector with regard to WC/WDM, and outlines the expected strategic outputs, which are each linked to at least one of the objectives of the overall strategy. It highlights the outputs and the activities to be carried out to give effect to WC/WDM.

The Strategy comments that the Industry, Mining and Power Generation Sector (IMP sector) offers numerous opportunities for contributing to WC/WDM because of its diversity. Such opportunities include the efficient of use of water, pollution abatement, re-use and recycling of water and implementing the use of water-efficient technologies. This strategy aims at ensuring that such opportunities are pursued and implemented.

The IMP sector strategy document is structured as follows:

- A background to the IMP sector in South Africa (Chapter 2);
- A description of the process followed to develop the strategy as well as the overall generic objectives of the NWC/WDMS to which the IMP sector strategy is a contribution (Chapter 3);
- A situation analysis and the opportunities for WC/WDM in the IMP sector (Chapter 4);
- A description of the institutional roles (Chapter 5)
- Detailed outputs, their linkages to the generic objectives, activities associated to each and the responsible institution. These activities are prioritised to provide a framework for action for achieving the specific output. This chapter constitutes the bulk of the strategy (Chapter 6);
- A description of guidelines and tools to support the implementation of the IMP sector strategy (Chapter 7); and
- Conclusions outlining the contribution of the IMP strategy to the NWC/WDMS and the NWRS, future reviews of the NWRS and challenges (Chapter 8).

The Strategy states: "There is considerable scope to implement WC/WDM in the industrial sector, particularly for those industries that have not implemented water saving technologies and systems. The opportunity exists for optimising the use of water without significantly raising the cost of production.

Industrial activities impact severely on water quality through pollution. Pollution abatement techniques can be used in the sector by adopting modern technology. Economic tools such as incentives or penalties can be used to achieve the desired levels of pollution, but the sector might not yet be ready to make use of them.

This is the focus of the proposed Waste Discharge Charge System. International experience has shown that, because of processes such as treatment, recycling and reuse, charging for waste discharge has a greater impact on the efficient use of water within an industry than the price of abstracted water."

A.3.3 National Guideline for the Discharge of Effluent From Land-based Sources into the Coastal Environment: Department of Environmental Affairs (2014)

The Integrated Coastal Management Act, 2008 (Act No. 24 of 2008) (ICMA) is aimed at regulating the discharge of effluent into the coastal waters from any source on land (Section 69) by requiring that such discharges are authorised under a permit or general authorisation. In order to achieve this goal the DEA has taken the responsibility to adopt and revise the 2004 version of an Operational Policy, which was developed under the previous Department of Water Affairs and Forestry (DWAF, into a National Guideline for Coastal Effluent Discharges from Land-based Sources that takes cognisance of legislation and principles developed post 2004.

This guideline states that it includes a hierarchy of decision-making which contains elements of the Receiving Water Quality Objectives approach, as well as the precautionary principle of environmental protection through source reduction, minimisation, treatment, re-use, etc. This hierarchy was developed by the DWA and remains valid in this document (Section 3: Basic Principles includes the details of the hierarchy). Because the DEA supports this approach, an application to dispose of effluent to the coastal environment must demonstrate that all reasonable efforts have been made, firstly to prevent waste, and secondly to minimise it. Only thereafter will minimum effluent standards or standards based on the receiving environment approach, whichever is strictest, be considered.

Section 1 provides the introduction and context of the guideline and Section 2, provides the structure of the guideline document. Section 3 covers the Basic Principles, which provides the broad framework or direction within which to prescribe ground rules for effluent discharge practices, as well as the management thereof. The basic principles were distilled from the broader international and national legislative context to give international and national credibility to the guideline.

Section 4 covers the Ground Rules, which were derived within the broader framework of the Basic Principles, provides more specific rules that will be applied by Government when, for example, considering permit applications for the discharge of land-based effluent to the coastal environment. Section 4.4.2 relates specifically to ground rules for industrial effluent.

Section 5 of this guideline focuses on the Management Framework. This provides a generic and structured approach within which the management and control of discharge of land-based effluent needs to be conducted. Such a framework typically consists of the following components that will be evaluated in the issuing of CWDPs or GAs. Included in the section is a summary and the significance of new legislative instruments to coastal environmental management. The old DWA's 2004 Operational Policy, on which this guideline is founded provided a summary of the older legislative instruments mentioned above and still bears relevance to this national guideline.

A.3.4 Small-Scale Fisheries (SSF) Policy: Department of Environmental Affairs (2012)

In June 2012, the Small-Scale Fisheries Policy for the marginalized and excluded fishers in South Africa was adopted by Cabinet. The new small-scale fisheries policy moves away from an individual allocation of rights, largely commercial focus to one which is collective and has a developmental focus. More importantly, the policy gives legal recognition to small-scale fishers.

A.3.5 South African Water Quality Guidelines

The original South African Water Quality Guidelines were a series of nine documents published by the Department of Water Affairs and Forestry (DWAF). They formed an integral part of the water quality management strategy to maintain South Africa's water resources fit for use. The guideline documents were divided into two sets:

- Water Quality Guidelines for Fresh Water
    - Volume 1: Domestic Water Use
    - Volume 2: Recreational Water Use
    - Volume 3: Industrial Use
    - Volume 4: Agricultural Use: Irrigation
    - Volume 5: Agricultural Use: Livestock Watering
    - Volume 6: Agricultural Use: Aquaculture
    - Volume 7: Aquatic Ecosystems
    - Volume 8: Field Guide
- Water Quality Guidelines for Coastal Marine Waters
    - Volume 1: The Natural Environment
    - Volume 2: Recreational Use
    - Volume 3: Industrial Use
    - Volume 4: Mariculture (the effects and target values related to human health also apply to the collection of seafood along the coast).

The South African Water Quality Guidelines are used as a basis to inform water users about the physical, chemical, biological and aesthetic properties of water. It consists of the water quality criteria, the Target Water Quality Range (TWQR), and support information, such as the occurrence of the constituent in the aquatic environment, its effects on water uses, how these effects can be mitigated and possible treatment options.

One of the goals of the Department of Water Affairs and Forestry (DWAF) is to maintain the quality of South Africa's water resources such that water quality remains within the Desired Water Quality Range for a particular industrial process category; this includes pre-treatment. The DWAF encourages all stakeholders concerned with the quality of South Africa's water resources to join forces and aim to maintain water quality within the Desired Water Quality Range, where and whenever possible.

For this reason, the Desired Water Quality Range in the South African Water Quality Guidelines is referred to as the Target Water Quality Range (TWQR). The TWQR for a particular water use is defined as the range of concentrations or levels at which the presence of the constituent would have no known adverse or anticipated effects on the fitness on the water assuming long-term continuous use, and for safeguarding the health of aquatic ecosystems. There have been subsequent revisions of the documents and all the different TWQR for all the different water use sectors are dealt with in South African Water Quality Guidelines Volumes one to seven. The TWQR for all these water use sectors are summarised in Volume 8.

Of note is that there are two Volume 3 relating to Industrial Water Use, these being:

- Guidelines for fresh water: The South African Water Quality Guidelines Volume 3 Industrial Use (DWAF, 2nd Edition 1996)
- Guidelines for marine water: South African Water Quality Guidelines for Coastal Marine Waters. Volume 3: Industrial Use (DWAF, 1st Edition 1995).

The Pelagic Fishery and Fish Processing Industry will mainly be impacted by Volumes 3 of the guidelines and as such a short summary of each is included:

- Volume 3: South African Water Quality Guidelines for Coastal Marine Waters – Industrial Water Use
- The focus of this guideline is more on the use of seawater in a number of industrial related activities. Section 5 is regarded as the 'heart' of these documents (containing the target values), with the information contained in Sections 2-3 being complementary to that section. The content of the various sections are as follows:

- SECTION 1. Introduction This section contains general information on the need for water quality guidelines, the assumptions and limitations of this project, details on how to use these documents and a short overview of the South African coastal areas
- SECTION 2. Characterisation Of Industrial Use Of Seawater (The Different Industrial Uses) This section comprises a general description of the different industrial uses in South Africa, a list of typical problems and indications as to the relevance of different water quality properties/ constituents
- SECTION 3: Typical Water Quality Problems Associated With Industrial Use Of Seawater. This section provides details on typical water quality problems associated with industrial use, the subgroups that may be affected and a list of water quality properties/ constituents which may cause such problems
- SECTION 4: Background Information On Water Quality Properties/ Constituents Related To Industrial Use Of Seawater. This section provides background information on water quality properties/ constituents such as natural occurrence, fate in the environment, interdependence on other constituents, potential source and measuring techniques

- SECTION 5: Effects Of Change In Water Quality Related To Industrial Use (Including Target Values). This section contains Target Values for the relevant water quality properties/constituents related to the different industrial sub-uses, as well as factual information on the effects of specific concentration ranges

Volume 3: South African Water Quality Guidelines: Fresh Water – Industrial Water Use
The South African Water Quality Guidelines for Industrial Water Use is essentially a user needs specification of the quality of water required for different industrial uses. It provides the information needed to make judgements as to the fitness of water to be used for industrial purposes.

The guidelines are applicable to any water that is used for industrial purposes, irrespective of its source (municipal supply, borehole, river, etc.) or whether or not it has been treated.

Industries are defined as systems of water-using processes, in which fitness for use of the water is assessed in terms of the following norms:

- its potential for causing damage to equipment (e.g. corrosion and abrasion)
- problems it may cause in the manufacturing process (e.g. precipitates and colour changes)
- impairment of product quality (e.g. taste and discolouration)
- complexity of waste handling as a result of using water of the quality available

The guideline is divided into six chapters:

- Chapters 1-4 provides an introduction to the guidelines, define some important water quality concepts, explain how industrial water use was characterised for the purpose of developing these guidelines, describe how the guidelines were developed and provide guidance on how they should be used.
- Chapter 5 provides the guidelines for the different water quality constituents.
- Chapter 6 consists of appendices which provide additional support information

The South African Water Quality Guidelines for Industrial Water Use will be periodically reviewed. The purpose of the reviews is to:

- add guidelines for constituents not yet included in the guidelines;
- update the guidelines for constituents currently included in the guidelines as relevant new information from international and local sources becomes available on the water quality or support information for water quality constituents.

A.3.6 The National Regulator for Compulsory Specifications (NRCS)

Imports of seafood and seafood products were strictly controlled by the South African Bureau of Standards (SABS). The Food and Associated Industries (FAI) section of the SABS administered the following compulsory standards for seafood until regulatory functions were transferred in 2008 to the National Regulator for Compulsory Specifications (NRCS).

The NRCS is an entity of the department of Trade and Industry established to administer compulsory specifications and other technical regulations with the view to protect human health, safety, the environment and ensure fair trade in accordance with government policies and guidelines.

NRCS protects the health and safety of consumers by ensuring compliance to food safety regulations (compulsory specifications) of fish and fishery products (mainly frozen fish, crustaceans and molluscs) and canned meat. Spoilage or contamination of these products poses a serious threat to human health. This is facilitated through their Foods and Associated Industries (FAI) – Regulated Food and Food Products, which regulates:

- -Canned Meat and Canned Meat Products
- -Canned Fish, Canned Marine Molluscs and Canned Crustaceans
- -Frozen Fish and Frozen Marine Molluscs
- -Frozen Rock Lobsters
- -Frozen Shrimps/Prawns, Langoustines and Crabs
- -Smoked Snoek
- -Live abalone

Compulsory Specifications are technical regulations that require conformity of a product or service to health, safety or environmental protection requirements of a standard, or specific provisions of a standard. The term is only used in South Africa.

The table below lists the Food and Associated Industries Compulsory Specifications:

Appendix Table 1: Lists the Food and Associated Industries Compulsory Specifications

VC nr	Date of Gazetting	Title
VC 8014	22-Jun-18	Compulsory specification for the manufacture, production, processing and treatment of canned fish, canned marine molluscs and canned crustaceans
VC 8017	24-Apr-15	Compulsory specification for frozen fish, frozen marine molluscs and frozen products derived therefrom
VC 8019	09-Jul-04	Compulsory specification for the manufacture, production, processing and treatment of canned meat products
VC 8020	04-Jul-03	Compulsory specification for frozen rock lobster and frozen lobster products derived therefrom
VC 8021	22-Mar-74	Compulsory specification for smoked snoek
VC 8031	24-Apr-15	Compulsory specification for frozen shrimps (prawns), langoustines and crabs
VC 9001	15-June-12	Compulsory specification for live aquacultured abalone
VC 9104	19-Aug-16	Compulsory specification for live lobsters
VC 9107	10-Aug-18	Compulsory specification for aquacultured live and chilled raw bivalve molluscs

The following are of specific relevance to this study:

A.3.7 Compulsory specification for the manufacture, production, processing and treatment of canned meat products (VC8019)

This specification specifies requirements for the manufacture, production, processing and treatment of canned meat products intended for human consumption and was issued in Government Notice R. 791 (Government Gazette 26531) on 9 July 2004. (https://www.nrcs.org.za/siteimgs/vc/VC8019.pdf).

Sections of relevance in terms of water use and wastewater are:

- Section 4.2.9 Hand washing facilities
- Section 4.2.10 Foot-baths and boot-wash basins
- Section 4.2.13 Thawing areas
- Section 4.2.26 specifically deals with Effluent sewage and waste disposal.
- Section 4.2.27 Comfort facilities
- Section 4.2.29 Facilities for washing and laundering of protective clothing
- Section 4.3.6 Heat processing equipment – specifically as it relates to steam and water – subsection i) Water retorts:
- Section 4.3.13 Facilities for storage, treatment and distribution of water supplies
- Section 4.3.14 Disinfecting and cleaning facilities
- Section 4.4 Water: Subsections: 4.4.1 Potable water; 4.4.2 Chlorination of water for container cooling in the retorts; 4.4.3 Steam; 4.4.4 Ice; 4.4.6 Water for cleaning; 4.4.7 Non-potable water
- Section 4.5.2.8 Installations for the treatment of water (see 4.3.13 and 4.4.1)

A.3.8 Regulation 628 (22 June 2018): Compulsory specification for the manufacture, production, processing and treatment of canned fish, canned marine molluscs and canned crustaceans (VC8014)

This Compulsory Specification applies to the manufacture, production, processing and treatment of canned fish, canned fish products, canned marine molluscs, canned marine molluscs products, canned crustaceans and canned crustacean products. It replaces the Compulsory Standard Specification for the manufacture, production, processing and treatment of canned fish, canned fish products and canned marine molluscs (Government Notice R. 790 of 9 July 2004).

(http://www.nrcs.org.za/siteimgs/vc/VC8014.pdf)

The focus of the specification is to ensure that a factory/ processing facility will comply and have an effective product safety management system, as required by clause 4.1 of this Compulsory Specification and SANS 587. Aspects of relevance are:

- Facilities will need a certificate of approval issued by the NRCS. (conformity of production requirements as prescribed in Annex A – A.1)
- The factory /processing facility may not dispatch canned fish, canned marine molluscs and canned crustaceans and products derived therefrom, without a valid NRCS approval certificate

of compliance per each production batch for products produced in the Republic of South Africa.

- Regular microbiological and chemical testing of canned fish, canned marine molluscs and canned crustaceans and products derived therefrom against the requirements of this Compulsory Specification by accredited testing facilities identified by NRCS

A.3.9 Regulation 979 (4 July 2003): Compulsory specification for frozen fish, frozen marine molluscs and frozen products derived therefrom (VC8017)

The Compulsory Specification for frozen fish, frozen marine molluscs and frozen products Government Notice No. R. 979 (Government Gazette 25172) came into effect on 04 July 2003 and covers the requirements for the handling, preparation, processing, packaging, freezing, storage and quality of frozen fish, frozen marine molluscs, frozen fish products and frozen marine molluscs products intended for human consumption. It also covers requirements for factories and employees involved in production. (http://www.nrcs.org.za/siteimgs/vc/VC8017.pdf)

Aspects of relevance are:

- Facilities will need a certificate of approval issued by the NRCS. (conformity of production requirements as prescribed in Annex A – A.1)
- The factory /processing facility may not dispatch frozen fish, marine molluscs and canned crustaceans and products derived therefrom, without a valid NRCS approval certificate of compliance per each production batch for products produced in the Republic of South Africa.
- Regular microbiological and chemical testing frozen fish, canned marine molluscs and canned crustaceans and products derived therefrom against the requirements of this Compulsory Specification by accredited testing facilities identified by NRCS
- The principles of HACCP, as recommended by the Codex Alimentarius Commission, shall as a minimum be used for the implementation of a product safety management system

A.4 Other Regulations

A.4.1 Environmental Management Regulations and Administrative Guidelines: Current

Recent regulatory changes relating to a revised system for Waste Classification (i.e. SANS 10234), as well as the introduction of autonomous Standards for the Assessment and Disposal of Waste to Landfill, in terms of the Waste Classification and Management Regulations, essentially repealed the associated provisions of the DWAF Minimum Requirements. These regulatory changes are defined in:

- R634 Regulation Gazette 10008 Vol 578, No. 36784 Of 23 August 2013: National Environmental Management: Waste Act, 2008 (Act No. 59 Of 2008): Waste Classification And Management Regulations

- R635 Regulation Gazette 10008 Vol 578, No. 36784 Of 23 August 2013: National Environmental Management: Waste Act, 2008 (Act No. 59 Of 2008): National Norms And Standards For The Assessment Of Waste For Landfill Disposal
- R636 Regulation Gazette 10008 Vol 578, No. 36784 Of 23 August 2013: National Environmental Management: Waste Act, 2008 (Act No. 59 Of 2008): National Norms And Standards For Disposal Of Waste To Landfill

The development and immediate implementation of these regulations provide mechanisms which:

- Facilitates the implementation of the waste hierarchy to move away from landfill to reuse, recovery and treatment
- Separates waste classification from the management of waste
- Diverts waste from landfill and into utilisation where possible
- Provides measures to monitor the progress

Other current regulations that do not specifically focus on water use, but could influence are:

- Department of Environmental Affairs (DEA) DRAFT Regulations to Exclude a Waste Stream or a Portion of a Waste Stream from the Definition of Waste (GN R 1006 of 14 November 2014);
- NEMA Environmental Impact Assessment Regulations – GN R 982 of 4 December 2014;

A.4.2 Environmental Management Regulations and Administrative Guidelines: Historical

Some of the historical policies that relate and can act as additional guidelines with regard to environmental governance are:

- GN51/15428/32 of 21 January 1994 – general environmental governance policy
- GN449/15726/1 of 9 May 1994 – deals with the classification of terrestrial and marine protected areas on the basis of management requirements. It contains an internationally accepted framework for nature conservation.
- R1182 Regulation Gazette 5999, No. 18261 of 5 September 1997 in terms of section 21 of the Act. R1182 lists the identified activities. In Schedule 1, paragraph 1(i), (j), (k) and in Schedule 17 important water-related aspects are dealt with. (The EIA for these purposes must be done according to R1183 of the same date).
- White Paper on the conservation and sustainable use of South Africa's Biological Diversity, Notice 1095 of 1997, No. 18163, 28 July 1997.
- White Paper on Environmental Management Policy for South Africa, Notice 749 of 1998, No. 18894 dated 15 May 1998.

A.4.3 Agenda 21 (International Commitments)

Agenda 21 (international) is a comprehensive non-binding, voluntarily implemented plan of action to be taken globally, nationally and locally by organizations of the United Nations System, Governments, and Major Groups with regard to sustainable development.

Agenda 21 is a 300-page document divided into 40 chapters that have been grouped into 4 sections:

- Section I: Social and Economic Dimensions is directed toward combating poverty, especially in developing countries, changing consumption patterns, promoting health, achieving a more sustainable population, and sustainable settlement in decision making.
- Section II: Conservation and Management of Resources for Development Includes atmospheric protection, combating deforestation, protecting fragile environments, conservation of biological diversity (biodiversity), control of pollution and the management of biotechnology, and radioactive wastes.
- Section III: Strengthening the Role of Major Groups includes the roles of children and youth, women, NGOs, local authorities, business and industry, and workers; and strengthening the role of indigenous peoples, their communities, and farmers.
- Section IV: Means of Implementation: implementation includes science, technology transfer, education, international institutions and financial mechanisms.

Of specific pertinence to Industry are Sections 2 & 3 and specifically Chapter 30, which deals with strengthening the role of Business and Industry.

Agenda 21 comments that the improvement of production systems through technologies and processes that utilize resources more efficiently and at the same time produce less wastes ("achieving more with less") is critical in achieving sustainability for business and industry. Similarly, facilitating and encouraging inventiveness, competitiveness and voluntary initiatives are necessary for stimulating more varied, efficient and effective options. To address these major requirements and strengthen further the role of business and industry, including transnational corporations, the following two programmes are proposed.

- Promoting cleaner production
- Promoting responsible entrepreneurship

Further development and evolutions of Agenda 21 were the following summits:

- Rio+5 (1997)
- Rio+10 (2002)
- Agenda 21 for culture (2002)
- Rio+20 (2012).

A.4.4 United Nations: Commission on Sustainable Development: Report on the Sixth Session (22 December 1997 and 20 April-1 May 1998): Economic and Social Council: Official Records, 1998: Supplement No. 9

Following on from Agenda21 and the Rio Declaration on Environment and Development is the work of the Commission on Sustainable Development: Report on the Sixth Session, with specific reference to Decision 6/2: Industry and sustainable development and Chairman's summary of the industry segment of the sixth session of the Commission on Sustainable Development.

During this session, a number of recommendations were made by the Commission which were based on the report of the Secretary-General on "industry and sustainable development" and the report of the Inter-sessional Ad Hoc Working Group on Industry and Sustainable Development (annex to section). Some of the recommendations include the following comment and recommendations:

- The Commission called upon industry to increase its efforts, as appropriate, in the areas of responsible entrepreneurship and employment of various corporate management tools, including environmental management systems and environmental reporting, to improve its environmental performance. Governments and industry must work together to develop policies to ensure that conformance with standards is not too costly or difficult to achieve for companies in developing countries and for small and medium-sized enterprises.
- Eco-efficiency, cost internalization and product policies are also important tools for making consumption and production patterns more sustainable. In this regard, attention should be given to studies that propose to improve the efficiency of resource use, including consideration of a tenfold improvement in resource productivity in industrialized countries in the long term and a possible factor of four increase in industrialized countries in the next two or three decades.
- Business and industry should be encouraged to develop and implement voluntary guidelines and codes of conduct that can help to promote and disseminate best practices regarding environmentally, and socially responsible entrepreneurship, and to develop further those that already exist. To be effective, business and industry need to develop and implement such codes by themselves, for that will ensure their commitment to the process.

A.5 South African Municipal Legislation

National government sets national norms and minimum standards and monitors compliance with these standards.

At a local level, it is the responsibility of water services authorities (municipalities that have been allocated responsibility for water and sanitation services) to set local standards through bylaws, to monitor and enforce adherence to these local bylaws. The development of municipal water services bylaws allows a municipality to regulate the rights and responsibilities of citizens, businesses and other entities with respect to municipal services.

The Section 21of the Water Services Act states that every water services authority must implement bylaws which contain conditions for the provision of water services, and which must provide for at least:

a) the standard of the services;
b) the technical conditions of supply, including quality standards, units or standards of measurement, the verification of meters, acceptable limits of error and procedures for the arbitration of disputes relating to the measurement of water services provided;
c) the installation, alteration, operation, protection and inspection of water services works and consumer installations;
d) the determination and structure of tariffs in accordance with section 10;

e) the payment and collection of money due for the water services;
f) the circumstances under which water services may be limited or discontinued and the procedure for such limitation or discontinuation; and
g) the prevention of unlawful connections to water services works and the unlawful or wasteful use of water.

National government, together with SALGA, has developed a model set of water services bylaws that may be used as a basis for municipalities to draft bylaws relevant to their own particular context. As such there tends to be standard set of information that are normally associated with municipal water services bylaws, these being information relating to:

- Definitions
- Permission to Discharge Industrial Effluent/ Application
- Control of Industrial Effluent / condition of acceptance
- Metering and Assessment of Industrial Effluent
- Prohibited Discharges

Some municipalities have specific bylaws promulgated in reference to industrial effluent, e.g. "Mangaung Metropolitan Municipality: Bylaws Relating to the Discharge of Industrial Effluent" as promulgated by Local Government Notice No 60 of 26 September 2008.

A.5.1 Generic Water Services Bylaws and Information Requirements Relating to Industrial Effluent

Emfuleni Local Municipality's Water Services Bylaws of 21 May 2004 have been used as base information for the section following in order to provide Industry with realistic expectation of the information and rigour required.

Application for disposal of industrial effluent into the sewage disposal system of the municipality must be made in the format prescribed by the municipality. It needs to be noted that a municipality shall not be obliged to receive any industrial effluent into its sewage disposal system, in which case the reasons for refusal to accept such affluent must be conveyed to the applicant. The applicant industry must enter into a written agreement, to be furnished by the municipality, and the subsequent discharge of industrial effluent should be subject to the conditions stipulated in the agreement.

The municipality may determine and publish norms, standards and guidelines which describe appropriate measures that can be taken to prevent the discharge of substances into the sewage disposal system that-

- are dangerous to the health of a person employed for the maintenance or operation of sewage systems;
- may be harmful to the sewage disposal system; or

- may have a harmful effect on any of the processes normally applied to treat sewage or on the re-use of treated sewage effluent or the disposal of solid substances which emanate from the treatment process.

The applicant industry must ensure that industrial effluent discharged into the municipality's sewage disposal system complies with the norms and standards.
Measurement of quantity and determination of quality of industrial effluent discharged:

- Must be measured or estimated as water supplied
- May need to incorporate into drainage system, devices requested by municipality which will assist them in determining the tempo, volume and or composition of the effluent

A Municipality will raise charges for industrial effluent discharges, which will be based on a formula for industrial effluent as prescribed in a schedule with pre-set conditions:

- Customers to conduct prescribed test on regulated intervals
- Municipality will use the standard municipal testing methods to ascertain effluent strength in terms of chemical oxygen demand (COD), suspended solids, Ammonia concentration, ortho-phosphate concentration as well as Group1 and Group 2 metals, pH value and conductivity.
- For discharge quantity calculation purposes at the various discharge points, the total quantity of water consumed will be allocated amongst the discharge points
- Cost of conveying and treating industrial effluent shall be determined by the municipality
- Discharge costs could also be undertaken as fixed monthly cost charges determined by taking into account the effluent strengths, volume
- Some municipalities also limit the volume of discharge that they can accept, e.g. 10 000 kl/month from an individual consumer
- Approval for discharge can be withdrawn if consumer fails to
    - comply with industrial effluent discharge standards as prescribed by the schedule and or written permission;
    - comply with a notice lawfully served and
    - pay for assessed charges

Appendix Table 2: Parameter's allowed specification

Parameter	Allowed Specification
PV not exceeded	1000-1400 ml/l (ranges for various municipalities)
pH within range	6.0-10.0
Electrical Conductivity – not greater than	500 mS/m at 20°C
Caustic Alkalinity (expressed as $CaCO_3$)	1000-2000 mg/l (ranges for various municipalities)
Substances not in solution (including fat, oil, grease waxes and like substances)	50-2000 mg/l (ranges for various municipalities)
Substances soluble in petroleum ether	500 mg/l

Parameter	Allowed Specification
Sulphides, hydrosulphides and polysulphides (expressed as S)	5-50 mg/l (ranges for various municipalities)
Substances from which hydrogen cyanide can be liberated in drainage installations, sewer or sewerage treatment works (expressed as HCN)	20 mg/l
Formaldehyde (expressed as HCHO)	50 mg/l
Non-organic solids in suspension	100 mg/l
Chemical oxygen demand (COD)	5000 mg/l
All sugars and/or starch (expressed as glucose)	1000-1500 mg/l (ranges for various municipalities)
Available chlorine (expressed as Cl)	100 mg/l
Sulphates (expressed as SO_4) or Sulphite (expressed as SO_3)	1800 mg/l 1500 mg/l (ranges for various municipalities)
Fluorine – containing compounds (expressed as F)	5 mg/l
Anionic surface active agents	500 mg/l
Suspended solids SS	1000 mg/l
Phosphate and phosphatecontaining compounds (expressed as P)	100 mg/l
Sodium (expressed as Na)	120 mg/l

Metals: Group 1:

Appendix Table 3: Metals: Group 1

Metal	Expressed as:
Manganese	Mn
Chromium	Cr
Copper	Cu
Nickel	Ni
Zinc	Zn
Iron	Fe
Silver	Ag
Cobalt	Co
Tungsten	W
Titanium	Ti
Cadmium	Cd

The total collective concentration of all metals in Group 1 (expressed as indicated above) in any sample of effluent, shall not exceed 20-50 mg/l (ranges for various municipalities), nor shall the concentration of any individual metal in sample exceed 5-20 mg/l (ranges for various municipalities).

Metals: Group 2:

Appendix Table 4: Metals: Group 2

Metal	Expressed as:
Lead	Pb
Selenium	Se
Mercury	Hg

The total collective concentration of all metals in Group 2 (expressed as indicated above) in any sample of effluent, shall not exceed 10-20 mg/l (ranges for various municipalities), nor shall the concentration of any individual metal in sample exceed 5 mg/l.
Other elements:

Appendix Table 5: Other elements

Element	Expressed as:
Arsenic	As
Boron	B

The total collective concentration of all elements (expressed as indicated above) in any sample of effluent, shall not exceed 5-20 mg/l (ranges for various municipalities).

Radio-Active Wastes:
Radio-active wastes or isotopes: Such concentration as may be laid down by the atomic energy Board or any State Department. Radio-active waste must comply with safety standards as contemplated in section 36 of the National Nuclear Regulation Act, 1999. Some of the Municipalities also reserve the right to limit the total mass of any substance or impurity discharged per 24 hours into the sewers from any premises.

A municipality can relax or vary standards if it represents the best practicable environmental solution and will take into consideration aspects such as:

- industrial customer is operating and maintain at optimal level
- technology being used is best available option in terms of industrial customer's industry
- industrial customer is implementing a programme of waste minimisation, which complies with national waste minimisation standards
- cost of granting the relaxation
- environmental impact or potential impact of relaxation / variation

A Municipality can set specific condition relating to the discharge of industrial effluent, which include, but is not limited to, conditions such as the following:

- require the industry to subject the effluent to an initial preliminary treatment to ensure that it conforms to their minimum receiving discharge standards.

- require the industry to install equalising tanks, valves, pumps, appliances, meters and other equipment necessary to control the rate and time of discharge into the municipal sewer system
- require the industry to install a separate drainage system for conveyance of their effluent to an specific point, before accepting the effluent discharge
- require the industry to provide adequate facilities for overflow conditions and detection of overflow, standby equipment and other appropriate means of preventing contravening discharges

Information required by a municipality from the industry relating to their making an application for industrial effluent discharge includes, but is not limited, to the following sets of information:

- Part 1: basic nature and details of industry:
  - Full Business and property details
  - Ownership of premises
  - Description of industrial process by which effluent will be produced
  - No employees, residency on premises and if a canteen is provided
  - Designated signatory
- Part 2: Relates to consumption of water:
  - Total no of litres of water consumed in 6 months (metered), broken down into:
    - Water purchased from municipality
    - Water from boreholes or other sources
    - Water entering with raw materials
    - Section of plant served by meter
    - Using the above quantities develop and show total average per month in kl/month consumption (Total A)
  - Water consumption (kl/month) determined as follows:
    - Industrial water use (Total B), broken down into:
      - Quantity of water in product
      - Quantity of water lost by evaporation
      - Quantity of water used in boiler make-up
      - Quantity of water for cooling
      - Quantity of water for other uses (e.g. gardens, etc.)
    - Domestic water use (Total C), broken down into:
      - Total no of employees (allow 1 kl/person/month)
      - Total no of employees permanently resident on the premises (allow 1 kl/person/month)
  - Effluent discharged into the sanitation system:
    - Metered volume (if known) (Kl/month), otherwise
    - Estimated unmetered volume discharge (kl/month) can be calculated as being = (Total A minus- (Total B plus Total C))
    - Estimated rate of discharge need to be provided (kl/hr)
    - Period of maximum discharge in a day (e.g. 07h00 to 08h00, etc)

- Pre-treatment of effluent before discharge (Insert sizes, capacities, etc., where pre-treatment is present): Type of Treatment:
  - Screens (hand raked) (area in m^2)
  - Screens (mechanical) (area in m^2)
  - Comminutors
  - Grit Tanks
  - Grease Traps
  - Sedimentation Tanks (Vol in m^3 and area in m^2)
  - Biological processes: Types :
- Part 3: Relates to information regarding the composition of the industrial effluent (chemical and physical characteristics):
  - Maximum temperature of effluent (°C)
  - pH value
  - Nature and amount of settleable solids
  - Organic content (expressed as Chemical oxygen demand – COD)
  - Maximum total daily discharge (kilolitres)
  - Maximum rate of discharge (kl/hr)
  - Period of maximum discharge in a day (e.g. 07h00 to 08h00, etc.)
  - Should any substances or their salts, listed in the table below, be formed on the premises, the substance and the average concentration likely to be present in the effluent needs to be identified.
  - If Radioactive Wastes or Isotopes will be present in the effluent this needs to be stated and defined.

Element	**(mg/l)**	**Compounds**	**(mg/l)**	**Other Substances**	**(mg/l)**
Arsenic		Ammonium		Grease and/or Oil	
Boron		Nitrate		Starch and/or sugars	
Cadmium		Sulphide		Synthetic detergents	
Chromium		Sulphate		Tar and/or tar oils	
Cobalt		Others(specify)		Volatile Solvents	
Copper				Others (specify)	
Cyanide					
Iron					
Lead					
Manganese					
Mercury					
Nickel					
Selenium					
Titanium					
Tungsten					
Zinc					
Others (specify)					

- Part 4: Relates to condition regarding the acceptance of industrial effluent, which could include, but not be limited to the following:
    - The industrial consumer will have available descriptions and statements of the dimension of grease and oil traps, screens, dilutions and neutralising tanks and any other provision made for the treatment of the effluent prior to discharge to the sanitation system
    - The industrial consumer will have available plans showing the water and sanitation reticulation systems on their premises
    - The industrial consumer will notify the municipality as soon as possible, and within the municipal agreed timeframe, of any changes to the nature or quantity of the industrial effluent. If these are planned changes, the municipality needs to be appraised before these changes are affected.
    - Proof of effluent quality (independent assessor) may be required or a similar method to confirm the application details regarding the effluent composition may be required within a specified timeframe.

Appendix B: South African Stakeholders

The South African Pelagic Fishing Industry Association (SAPFIA) is a legally recognised industrial body which represents a large number of Right Holders who hold approximately 68.6% of sardine rights and 81.7% of anchovy rights in the small pelagic fishing sector. Membership includes 34 companies:

- 82 Boundary Road Bk
- Amawandle Pelagic (Pty) Ltd
- Balobi Processors (Pty) Ltd
- Cape Pilchard Pioneer Cc
- Combined Fishing Enterprises Cc
- Community Processors and Distributors (Pty) Ltd
- Edwards Fishing Cc
- Eigelaars Bote (Edms) Bpk
- Extra Dimensions 70 (Pty) Ltd
- Eyethu Fishing (Pty) Ltd
- Gansbaai Marine (Pty) Ltd
- Impala Fishing (Pty) Ltd
- Jaffa's Bay Fishing Cc
- Khulani Fishing (Pty) Ltd
- Komicx Products (Pty) Ltd
- Lucky Star Limited
- (Pty) Ltd
- Manetrade 2094 Cc
- Marinata Vissersvroue Organisasie Bk
- Paternoster Vissery Bpk
- Pioneer Fishing (West Coast) (Pty) Ltd
- Phakamisa Fishing (Pty) Ltd
- Premier Fishing Sa (Pty) Ltd
- Quayside Fish Suppliers Cape (Pty) Ltd
- Reiger Visserye Cc
- Soundprops 1167 Investments (Pty) Ltd
- Terrasan Pelagic Fishery (Pty) Ltd
- Tirade Props 153 (Pty) Ltd
- Trakprops 22 Pty Ltd
- Ukloba Fishing (Pty) Ltd
- Umzamani Fishing Cc
- Vermont Fishing (Pty) Ltd
- Viking Inshore Fishing (Pty) Ltd
- West Point Fishing Corporation

Potential other stakeholders would be the Seafood Companies in South Africa. The Trade-Seafood Industry Directory indicates these as being:

- Artisanal Fishers
  - Representatives of 43 Traditional Fishers, operating for six years, supplying West Coast Rock Lobster (Jasus Lalandi)
- Atlantic Seafood
  - Suppliers of Atlantic Cod, Anchovies, Angelfish, Brill, Barracuda, Black Tiger Shrimps, Cuttlefish, Calamari, Capelin, Caviar, Krill, Crayfish, Dover Sole, Dey fish, Eel, Flounder, Grey mullet, Jack Mackerel, Haddock, Hake, Halibut, Herring, Greenland Halibut, Horse Mackerel, Kingklip, Langoustines, Nephrops, Lemon Sole, Canadian and European Lobsters, Rock Lobster, Atlantic Mackerel, Mahi, Marlin, Monkfish, Blue mussels, milkfish, octopus, Pangasius, Basa, Pike Perch, Plaice, Red Mullet, Striped Mullet, Redfish, Saithe, sardine, seaweed, squid, salmon trout, salmon, pilchards, sardinella, Scottish & Norwegian salmon, seabass, shrimps, seabream, skate, swordfish, tilapia, gurnard, tongue sole, yellowfin tuna, turbot, yellowtail, wolf fish
- Balobi Trading

- Balobi is a group of companies that own their own fleet of fishing vessels is the Squid, Sardine and Hake fishing Sectors. They catch, process, market, sell and export their own product as well as other fishing vessels product.

➢ Blue Wave Seafoods
- Products worked with are: Hake, Kingklip, Ling, Angel Fish, Lobster, Horse Mackerel, Jack Mackerel, Snoek, Barracuda, Squids, Ribbon Fish, Soles, Dorado, Monkfish, Canned Pilchards, Canned Sardines.

➢ Braxton Shipping
- Based in Durban that owns vessel El Shaddai and fishes Patagonian Tooth Fish (Seabass). They export wholesale HGT caught wild, frozen at sea to Wholesalers.

➢ Crumb Choice
- Independently owned Food Manufacturing Company producing Fish Fingers, Fish Cakes, and more food coatings to the Industry.

➢ Devia SA (Pty) Ltd
- Supply frozen fish and canned fish to West Africa and East Africa. Main products are Horse Mackerel, Mackerel, Tilapia W/R and G+S, as well as canned Pilchards.

➢ Fish Bait Sea Products
- Importers and exporters of frozen fish products including lobster (Jasus lalandii), Hake, Merluccius, gurnard, john dory, kingklip, mackerel, horse mackerel, monk, pilchard, ribbonfish, sole and bait products

➢ Gannet Sea Products
- Importers of Pacific Saury for longline fish bait, processors and exporters of sardine, pilchard handlaid for fish bait.

➢ Gordon's Bay Fisheries
- A large supplier of fresh and frozen seafood products, export and supplier to cruise ships world-wide. Seasonal fresh fish, Crayfish, Prawns, Oysters, All seafood products as well as all catering products seafood & other

➢ Lobster Mobster (Pty) Ltd
- Fishermen, producers, processors, exporters and wholesalers of Fresh & frozen Tuna, Frozen Hake and Frozen and Live West Coast Rock Lobster.

➢ Oceans Best Trading (Pty) Ltd
- Service restaurants, casino groups in Gauteng and export Seafood via airfreight to neighbouring countries. Vannamei prawns, calamari, kingklip, prawn meat, mussels.

➢ Skye Seafood Unlimited
- Producers, processors, wholesalers and retailers of Kob, Kingklip, Hake, Sole, Panga, Silvers, Gurnard, White Stumpnose, Santer, Maasbanker, Mackerel, Cape Salmon, Yellowtail, John Dory, Ribbon, Snoek, Octopus, Mullet, Pilchard Bait, Red Roman, Red Stump, Oysters, Crayfish, Skate wing, Prawns, Angel fish, Squid, Mussels, Calamari, Crab, Marinara Mix

➢ Snoekies Foods
- Established in 1951, contracted to fishing boats operating off Cape Town and Namibia. Wholesalers and exporters of hake, kingklip, lobster, horse mackerel, red fish, sole, snoek salted, kabeljou, yellow tail, tuna.

➢ Supa Packers Fish Processors Pty Ltd

- Processors, wholesalers, Importers & Exporters of Frozen Fish & Shellfish – Hake, kingklip, ling, sole, dorado, butterfish, blue nose, shark, horse mackerel, mackerel, snoek, barracouta, angelfish, cardinal, redfish, yellowfin, yellowtail.

➢ Thalassina
  - Exporters, processors, agents of loligo squid, octopus, jasus lalandii lobster, merluccius capensis hake, red mullet, sole, swordfish, albacore tuna, breaded fish fingers and Canned Sardines in Tomato Sauce and in Chilli Sauce.

➢ The Fishermans Deli
  - Importers, processors and wholesalers of Norwegian Salmon, Sardines, Rock Cod, Soles, Kingklip, Blue Nose, Butterfish, Cape Salmon, Cardinal, Dorado, Kabeljou, Red Snapper, Salmon, Tuna, stumpnose, emperor, barracuda, gurnard, oysters, Yellowtail, Salmon Trout, Shark, Skate Wings, Bream, Monk, Tuna Lion, Angelfish, Hake, Snoek, Calamari, Octopus, Crab, Langoustine, Lobsters, LM Prawn, Black Tiger Prawn, Shrimps, Oysters, Mussels, Molluscs, Smoked Salmon Products, Smoked Fish, Marinated Fish Products, Herrings

➢ World Focus
  - Exporters and wholesale suppliers of Live Fresh Oysters, Live Fresh Diamond Oysters, Fresh South African Pacific Oysters (Crassortia Gigas), Live Lobster, West coast rock lobster (Jasus Lilandii), Frozen South African greenlip abalone (Haliotis midae), Mozambique caught pink and red prawns, Langoustines. World Focus was started in late 2006

➢ Yulyfish
  - Import and export sardine, sardinella, mackerel, horse mackerel, hake, hoki, squid, shrimps, cuttlefish, mahi mahi, dorado, bass, merluza, capelin, herring, alaska pollock, anchovy, cherne, notothenia, pangasius, tongue sole, saury, tilapia, blue shark, yellow fin tuna, skipjack, bonito, octopus, yellowtail, ribbonfish, lobsters, redfish, pomfret, canned fish, dry fish and bait, etc.