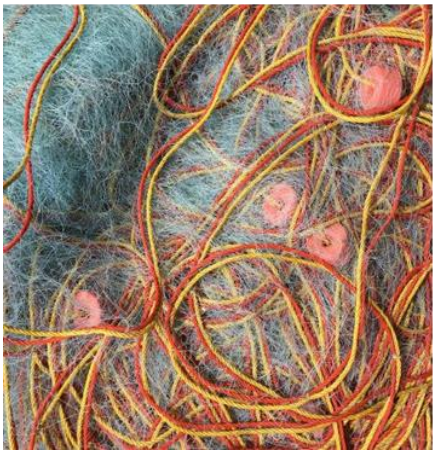

Determination of postharvest fish losses (PHFL) in Seychelles' fisheries value chains

Seychelles Fishing Authority

N014/SWIO3/C/2022/C3

Final Report

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1 Introduction

The wild capture fisheries and its associated postharvest (PH) industry are a critical economic resource within the Seychelles, accounting for more than 90% of total exports and employing nearly 17% of the active population. There is a clear need to ensure that the processes utilised within these two industries provide the highest quality, but also the most sustainable, product. In this respect, there has been an increasing focus on processes that provide a value addition (mainly associated with processing caught fish into different 'products' for different markets – e.g., through various processing procedures), and the contribution of such activities and value-added products for the continued growth of the sector and the country's economy (e.g., Seychelles Fisheries Sector Policy & Strategy 2019[1], Fisheries Comprehensive Plan 2019[2]). Despite this, one form of 'value addition' is in identifying and reducing any loss of value from within both the marine capture and processing PH industries – in this respect, reducing PH fish loss (PHFL)[3]. However, within the Seychelles, there is still little understanding of the breadth and extent of PHFL within both capture and PH industries, including best practice to ensure where losses occur these are reduced.

Loss of fish quality or value (as well as quantity) can occur throughout a fisheries' supply chain. However, loss if most likely to occur following landing of the catch (i.e., on board the vessel)[4], hence the emphasis on 'postharvest' fish loss. Within this, there are a number of different parameters that may structure such loss:

- Time between death and final use or consumption;
- Temperature abuse, with high ambient temperatures creating favourable conditions for fish spoilage;
- Poor handling practices, which can lead to sustained and increased microbial contamination, hastening the spoilage rate of fish. Such poor handling practices can include using dirty equipment, fish boxes and baskets; not washing fish; washing fish in dirty water; placing fish on dirty surfaces; and physically damaging fish by throwing or standing on them; and
- Differential timing of spoilage depending on the type of fish (e.g., higher oil content).

Besides spoilage, PHFL can be caused by at-sea discards of small-sized fishes, as well as fishes that are not valuable enough to land for sale; poor on-board processing techniques damaging fish; animal predation and insect infestation; inadequate packaging and storage practices leading to damage of the end product; and market dynamics, especially fluctuations in demand and supply of fish and fish products affecting the price per fish and therefore income.

Understanding how such practices relate to the wild capture and processing industries within the Seychelles will allow this work to examine the breadth and extent of PHFL, and provide recommendations for reduction or remediation of such losses. Therefore, in understanding

1 Seychelles Fisheries Sector Policy and Strategy, 2019, Government of Seychelles.

2 Fisheries Comprehensive Plan, Ministry of Fisheries and Aquaculture, November 2019, Government of Seychelles

3 Defined as fish either discarded or sold at a relatively low price, because of quality deterioration or owing to market dynamics impact the development of the fishing sector

4 Though in-water depredation of captured fish can reduce the quantity and quality of the individual fish (e.g., Mandelman, J.W., Cooper, P.W., Werner, T.B. et al. Shark bycatch and depredation in the U.S. Atlantic pelagic longline fishery. Rev Fish Biol Fisheries 18, 427–442 (2008). https://doi.org/10.1007/s11160-008-9084-z)

and supporting the Seychelles Fishing Authority in reducing PHFL within the Seychelles, this project examines three objectives:

- **Objective 1:** Characterization and quantification of PHFL throughout the fisheries supply chain, focusing on the nearshore artisanal and semi-industrial sectors;
- **Objective 2:** Development of a framework for monitoring of PHFL throughout the supply chain of the nearshore artisanal and semi-industrial sectors, and provision of recommendations on policy support to promote industry compliance with monitoring; and
- **Objective 3:** Provision of recommendations for mitigation measures to reduce PHFL, inclusive of potential business opportunities and economic gain from investing in the processing of fisheries by-product.

This Final Report providing details of all analyses, results and findings of the study, including non-technical summaries for review and stakeholder validation. Importantly, this report highlights the substantial gaps in the quantification and historical assessment of PHFL within the Seychelles (Task 1) and the data collected to inform such gaps (Task 2 and Task 3). This work then uses a case study structure to examine new technologies and practices to reduce PHFL within the Seychelles (Task 4). Recommendations for the range of recovery products which may be suitable for development within the Seychelles is provided (Task 5), while solutions and methods for fisheries waste disposal that meet the environmental policies of Seychelles are then discussed (Task 6), with the development of a framework, reporting tools and database for continuous monitoring of PHFL then developed (Task 7). Recommendations for amending current legislation and regulation to support the reduction of PHFL and waste, and that promote opportunities for investment in recovery products are provided (Task 8).

This work also summarises the outcomes of the stakeholder training on the monitoring framework, tools, data collection and reporting (Task 7), undertaken on the 10th October within the Seychelles.

2 Section 1: Mapping the type and breadth of PHFL in the Seychelles – where are the problems?

Within this Section 1 of this Seychelles PHFL project, we provide a detailed explanation of the Seychelles fishing industry, structured around describing the artisanal and semi-industrial fishing sectors, their fishing activities and catch composition. We then use that information to map and discuss the various ways that PHFL will be developed within the different supply chains. Taking this information, we then utilize a case study approach to provide broad and substantial recommendations for reducing such PHFL.

2.1 Gap analysis of postharvest fish loss (PHFL) in the Seychelles (Task 1)

This work provides a detailed understanding of the current PHFL in the Seychelles fishing industry, within both offshore and onshore sectors[5]. This has been developed by undertaking a gap analysis of all relevant information pertaining to PHFL in the Seychelles using two simultaneous approaches: (i) a comprehensive literature review; and (ii) key stakeholder engagement. Detailed methodology for each is provided in Annex 1 . To engage with the list of stakeholders, a substantial questionnaire was developed, encapsulating a range of questions to determine the extent, breadth and depth of PHFL within the different fishing industries throughout the Seychelles. Seychelles wild capture fishing industry

The Seychelles' fisheries industry comprises three commercial subsectors: the artisanal, semi-industrial and industrial fisheries:

Artisanal fleet: This is practiced solely by Seychellois fishers (i.e., fishers based in the Seychelles), with the artisanal fleet comprise five vessel types (Figure 1).

- **Mini-Mahé**: Small 5 to 7m open fiberglass boats powered by outboard motors (> 15 hp). The artisanal fleet is dominated by these vessels
- **Lekonomi** and **Lavenir**: Partially decked whaler vessels, 6.5 m to 8 m in length, made of fiberglass and equipped with an icebox and a one-to-two-cylinder inboard engine powered by inboard motors.
- **Whaler**: Open-decked clinker-constructed vessels, 9 to 12 metres in length, with inboard engines. These vessels are usually partially decked, built of fiberglass and accommodate 6 to 7 people. Most are now equipped with iceboxes and undertake fishing trips of 3 to 6 days.
- **Schooners**: wooden-hull decked vessels usually between 10 to 15 metres and equipped with a three-to-four-cylinder diesel inboard engine and an icebox of 2,500 to 3,000kg capacity. Schooners undertake fishing trips averaging 8 days on the edge of the Mahé and Amirantes Plateau.

5 Offshore encapsulates commercial fishing activities licensed by SFA identified under the Ministry of Fisheries Comprehensive Plan, where the emphasis will be on understanding cold chain management, fish handling and by-catch discarding at sea; onshore focuses on the PH industry, which will include fish handling upon debarkation, fish processing plants and fish mongers.

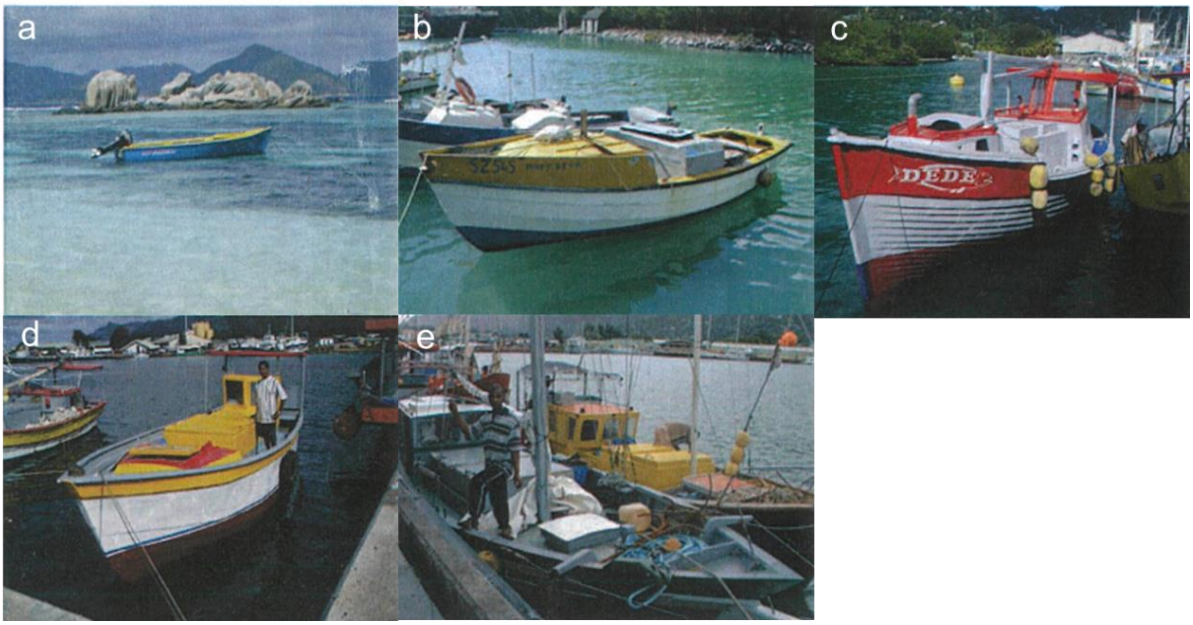

Figure 1 Artisanal fishing vessels within the Seychelles: (a) Mini Mahe; (b) Lekonomi; (c) Whaler; (d) Lavenir; and (e) Schooner.

This fishery predominantly operates throughout coastal waters up to the Mahé Plateau edge, covering 41,000 square kilometres of water. However, schooners and some whalers have a much greater range and can also fish the outer islands of the Seychelles. In this respect, the larger sized vessels (e.g., > 6m) are equipped with echo sounders and GPS.

The artisanal fleet is characterized by a multispecies resource base, predominantly targeting the semi-demersal Caranx spp. (trevally) and demersal resources such as Lutjanus spp. (snappers), *Aprion virescens* (green jobfish), *Epinephelus* spp. (groupers), and *Lethrinus* spp. (emperors). Pelagic species such as *Euthynnus affinis* (bonito) and tuna found on the Mahé and Amirantes Plateau are also targeted. The larger demersal hand line vessels also occasionally target the offshore banks in the southern island group.

The handline fishery using hooks and lines is by far the most important type of fishing technique, accounting for more than 74% of total annual fish landings (Figure 2). Handline are used to target reef fish species, including snapper (lutjanids), grouper (serranids), emperor (lethrinids) and trevally (carangids). Each handline fisher operates a single monofilament hand line containing between 6 and 12 hooks per line, with each hook is usually baited with a piece of pelagic fish (e.g., Indian mackerel or bonito). The second most important artisanal fishing, accounting for 15% of total annual landings is the trap fishery. Traditionally traps have been fabricated from bamboo, though metal mesh is now slowly becoming more common (Figure 2). Traps are used to target reef fish species, including rabbitfishes (siganids), parrot fishes (scarids) or juvenile's groupers (serranids) and snappers (lutjanids).

There have been substantial changes in the artisanal fishery associated with reductions in landings. For example, despite an increase of 194% in fishing effort from vessels powered by outboard engine boats (i.e., whalers and schooners) between 1993 and 2018, catches dropped significantly between 1993 and 2016 from approximately 5,000MTs to 2,500MTs per year (Ministry of Fisheries and Agriculture, 2019; Seychelles Fishing Authority, 2016). In addition, the trap fishery originally targeted mostly inshore fish species associated with reefs (and protected lagoons) and inshore shallow water banks. However, over the last 20 years this fishery has moved further offshore, up to a distance of 30km from the granitic islands. Despite this, other than a minimum mesh size of 40mm for traps, and a ban on spear fishing

and on the use of demersal trawl nets, there are no management measures relating to the artisanal fishery.

Figure 2 Handline fishing activity (left) and demersal traps (right) used in the Seychelles artisanal fishing sector.

Semi-industrial fleet: This fleet is longliner based, with vessels ranging from 14 to 23 metres, with an average of 5 – 6 crew per vessel (Figure 3). Target species include swordfish, bigeye and yellowfin tuna, as well as sea cucumber fishing activities, with sharks and marlin being the most common bycatch. This fishery operates on the high seas and in the Seychelles Exclusive Economic Zone (EEZ) along the edge of the Mahé Plateau. Peak landing of the semi-industrial fleet was approximately 500 MT/year with swordfish being the predominant species (60% of the catch) followed by yellowfin and bigeye tuna.

Figure 3 Semi- industrial longliner.

Industrial longline and Purse seine tuna fishery: This fleet is composed of large foreign-owned licensed vessels that fall into two main categories: the tuna purse seine fishery, composed of EU vessels, French and Spanish, Seychelles registered vessels and the longline fishery made up mostly of Taiwanese, Japanese and South Korean vessels. As of 2023, this fleet contains 44 purse seine vessels (13 Seychelles flagged) and 144 longliners (28 Seychelles flagged) with roughly 35% of vessels being Seychelles flagged across the entire fleet. The remaining majority of vessels are from Distant Water Fishing Nations (DWFNs) such as China, Taiwan, the European Union, and South Korea (Seychelles Fishing Authority, 2020).

The total catch for the Seychelles EEZ (excluding the artisanal sector) was 440,020 metric tonnes in 2021 across all sectors (Seychelles Fishing Authority, 2021). Over 99% of this was caught within the industrial fishery. Approximately 73,000 metric tonnes of the industrial catch were landed in 2021 where it entered the postharvest industry. Assuming no semi-industrial catches (1,758 metric tonnes) or artisanal catches (2,346 metric tonnes) were transhipped, the total fish tonnage entering the postharvest industry in the Seychelles was roughly 77,000Mt in 2021 (Seychelles Fishing Authority, 2021).

The tuna purse seine fishery targets mostly surface swimming yellowfin tuna (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*). Traditionally, purse seiners fished over free swimming schools of both species, until the 1990s where changes were introduced to the fishing strategy of purse-seiners, with the extensive use of floating objects, such as FADs. The composition of species and size resulting from this type of fishing varies considerably in comparison to traditional fishing over free schools, since skipjack is the main catch and there is a higher rate of smaller yellowfin and bigeye tuna (*Thunnus obesus*). The majority of the bycatch from this fleet comprises juvenile tuna, mahi-mahi (*Coryphaena hippurus*), rainbow runner (*Elagatis bipinnulata*), and snapper species (Lutjanus spp.) (Seychelles Fishing Authority, 2020).

Figure 4 Industrial purse seiner.

Industrial longliners target large deep-swimming tuna, in particular bigeye (favoured by Japanese longliners), which fetches a higher price on the Japanese sashimi market. The longline gear used by the industrial longliners consists of three basic components: the mainline, the branch line, and the baited hook. All of these parts are adaptable for targeting specific species through changes in materials, lengths, and deployment strategies. Using small buoys and float lines to suspend the gear below the surface results in a pelagic longline

set that targets pelagic tunas, swordfish (*Xiphias* spp), billfish and other free-swimming predators. The gear is very effective at capturing large pelagic fishes, such as bigeye tuna, yellowfin tuna, and albacore (*Thunnus alalunga*), broadbill swordfish (*Xiphias gladius*), and other billfishes.

Figure 5 Industrial longliner.

2.1.1 Seychelles postharvest industry

There are two major processing streams that landed catch can, or will, move through as they are processed in the Seychelles: (i) fish mongers/local markets and/or direct sale from vessels to locals, or (ii) processing plants (including major canneries, e.g., Indian Ocean Tuna Ltd). Fish mongers and direct sales from fishing vessels account for around 70% of artisanal fisheries landings market (Ministry of Fisheries and Agriculture, 2018).

Marketing of fish locally

Direct sales outlets (i.e., fish shops) are run by a number of processors and are predominantly where local access to semi-industrial fished species occurs. These are owned and run by Oceana Fisheries; Sea Harvest; JHL Fisheries; FishTech; Rass Fish and Indian Ocean Tuna Ltd (which hold a monthly sale to the public, but does not have a fish shop /market). Local markets are where the majority of fish species from the artisanal industry are marketed and sold. Within the Seychelles, although there are 19 markets (of which fish are sold at), only nine of these are active, with seven being abandoned, one being under construction (Anse Aux Pins) and one having been demolished (Table 1). In addition to both direct sales and local markets, there are 'unofficial and unregulated' fish processors (locally referred to as 'fishmongers'), As they are unlicensed, it is not possible to ascertain actual figures for the numbers operating illegally.

Table 1 Active and Inactive markets within the Seychelles.

No.	Fish market	Status	Comments
1	Belombre	Active	Fishermen use the landing shed as a market or may sell fish on pallet near the landing shed
2	Anse Etoile	Active	
3	Perseverance	Active	Temporary fish market
4	Cascade	Active	New

No.	Fish market	Status	Comments
5	Anse Aux Pins (Opposite Seychelles Commercial Bank)	Active	
6	Anse Royale	Active	
7	Baie St Anne	Active	New
8	Grand Anse Praslin	Active	
9	La Digue	Active	Being used for sale of fruits and vegetables
10	Glacis	Inactive	New
11	Mont Fleuri	Inactive	Abandoned
12	Les Mamelles (near the bridge/opposite Mohan workshop)	Inactive	Abandoned
13	Point Larue (opposite Police Academy's entrance)	Inactive	Abandoned
14	Anse Aux Pins (at the entrance of Ile Soleil)	Inactive	Under construction
15	Bougainville (near Kalavedi shop)	Inactive	Abandoned
16	Takamaka (at the Intendance junction close to the main road)	Inactive	Abandoned
17	Baie Lazare (in the vicinity of the Cable & Wireless substation & near the main road)	Inactive	Abandoned
18	Baie Lazare (near SPTC bus depot)	Inactive	Abandoned
19	Anse Boileau	Inactive	Demolished

Postharvest processing within the Seychelles

There are a number of major processing organisations within the Seychelles. By far the largest of these is the Indian Ocean Tuna Ltd (owned by Thai Union Group) which produces an average of 1.5 million cans of tuna per day[6]. Such tuna is obtained from EU vessels (operating on the high seas, and the EEZ of coastal states under both private and FPA arrangements), Seychelles vessels (under EU beneficial ownership) and occasionally raw materials imported from other regionals (SW Pacific and E Atlantic).

IOT takes raw material tuna from the purse seine fishery (mostly skipjack and yellowfin tuna). The cannery is one of the largest tuna canneries in the world with seven cold stores to store 25 days' supply of fish. The factory has a fishmeal production factory (previously owned by Ocean Products Seychelles), which extracts oil using proprietary technology from the tuna heads for fish oil for use in the pharmaceutical industry. The IOT installed a waste water treatment plant (US$9.8 million investment) in 2018 on their premises to reduce the amount of waste being sent to local landfill.

In addition, nine other processors operate in the Seychelles (OPS, which has been taken over by a subsidiary of Thai Union) with Amirante Fisheries and Ocean Basket being the largest. These processors deal predominantly with tuna species (e.g., albacore, yellowfin), but also take catches from the semi-industrial fishery Industrial bycatch (i.e., bycatch from the industrial fishing fleet) is also available to processors (Ministry of Fisheries and Agriculture, 2018).

6 https://www.foodbusinessafrica.com/thailand-fish-processor-thai-union-to-inject-us10-5m-in-seychelles-based-subsidiary/

The large processing plants mostly focus on producing value added products for export to Thailand, the United States of America, the Ivory Coast, as well as Turkish, Spanish, and Sri Lankan markets. Such products include canned tuna and fresh and frozen tuna portions (loins, fillets, collars etc.). A small portion (30%) of the artisanal catch is purchased by processors (e.g., Oceana Fisheries, Sea Harvest, Rass Fish) with a focus on a range of predominantly reef and small pelagic species (job fish, emperor, carangid) (Ministry of Fisheries and Agriculture, 2018).

2.1.2 Postharvest fish loss within the Seychelles

Three main phases have been identified in which PHFL may occur within the Seychelles PH industry: (i) before the fish are processed; (ii) while the fish are being processed; and (iii) during export and marketing. Below we provide a synopsis of each and provide recommendations for reducing PHFL within such phase

2.1.2.1 Before the fish are processed (Phase 1)

No data exist for PHFLs that occur on fishing vessels in any of the three fleets, nor are there any reported figures on PHFLs at landing sites across all fleets. Overall, there is no understanding of PHFL which may occur within the artisanal and semi-industrial fleets during fishing activities and at landing and storage on-board, including any loss of biomass or value associated with handling, on-board processing (i.e., gutting) and on-board packaging. For the industrial fleet it is reported that there is the potential for the breaking of the 'cold-chain' at landing sites for up to six hours when dealing with bycatch. Catches from the industrial purse-seine fleet are unloaded from vessels along a conveyor belt, with any bycatch being removed and placed on the dock. Tipper trucks owned by processing plants then collect this purchased bycatch and take it to their facility where it is cleaned, graded, and blast-frozen to re-establish the cold-chain (Ministry of Fisheries and Agriculture, 2018). This phase can result in the cold-chain being broken for up to six hours for bycatch (Ministry of Fisheries and Agriculture, 2018).

Recommendations:

Reduction of waste: *Further progress in reducing potential PHFL may be made with regard to waste disposal, with the establishment of a facility to produce value-added products from raw waste material processed on board vessels (e.g., heads, gills, guts and fins) into pet food or fish meal would improve PHFLs (Seychelles Fishing Authority, 2020).*

Data collection: *Further understanding of the activities associated with fishing within the artisanal and semi-industrial fishing fleets. Focus on collection of data on handling and processing activities undertaken on board, including where gutting or filleting are undertaken. Any further information on how fish are packaged within holds, and any specific activities that may impact the quality of such fish, especially associated with the grading of such fish by processors.*

2.1.2.2 While fish are being processed (Phase 2)

PHFL may occur at the processing stage of the plant production line, that is the gutting and breaking down of a fish into its associated value-added products. While most of the semi-industrial fishing fleet guts and removes the gills of their fish (i.e., under the Export of Fishery Products (Sanitary) Regulations, 2010, processing plants are not allowed to accept ungutted fish unless it is bycatch), bycatch can be exported whole and ungutted. PHFL may occur at this stage where improper hygiene occurs or where fish are left too long as a result of production line build up. This could be alleviated by ensuring an adequate workforce in both

skill and number, as well as the appropriate tonnage of fish being bought for the processing plant at any one time.

Of six surveyed processors within the Seychelles, five listed their fish waste disposal figures which varied from 1.66% of the total biomass processed up to 20% of the total biomass processed (Seychelles Fishing Authority, 2020). There is no information available where processing occurs on fishes outside of the processing plants. Although such processing is expected to occur within local markets / fish shops etc, there is no data to determine whether best practice is undertaken within such situations.

Recommendations:

Reduction of waste: *Further progress in reducing potential PHFL may be made with regard to waste disposal, with the establishment of a facility to produce value-added products from raw waste material (e.g., guts, heads and fins) into pet food or fish meal would improve PHFLs (Seychelles Fishing Authority, 2020).*

Enhancement of facilities: *The Ministry for Fisheries and Agriculture 2018 fisheries value chain report identifies some areas where infrastructure changes may alleviate PHFLs. It highlights that previous government initiatives to increase capacity have not been successful. For example, within Providence new fish processing facilities were built and opened in 2014[7]. However, stakeholders believe that the facilities have been poorly designed and are too small to alleviate processing issues. In addition, such facilities have a reduced ability to sustain the cold chain, due to the lack of common cold storage unit built within Providence. This has meant that any space-related PHFLs in the semi-industrial and artisanal fishery (cold chain broken due to lack of storage) have not been alleviated by developments that were meant to do just that. It recommends better alignment between available fisheries resources, business plans being implemented and facility design, fit-out and capacity.*

Further training in handling: *Where processors have responded to the survey, the stock response for in-house PHFL has been that it is due to a lack of training or a lack of manpower (e.g., response given for why there is no PHFL monitoring at the packaging and sales phase). The survey states: "There is a need for training on how to measure and reduce PHFL at all levels of processing in a processing plant". However, the Seychelles Fishing Authority 2019-2020 annual report, states that fish quality assessment training using the Torry freshness scale and quality index method was delivered to participants in the Seychelles. It also states that training workshops on the introduction of advanced Hazard Analysis Critical Control Point (HACCP[8]) implementation was carried out. This should help businesses better plan their production lines (Seychelles Fishing Authority, 2020). It seems that while processing companies should be encouraged to invest more in their workforce, the crux of the issue is that current levels of reporting on where, how, and why PHFLs occur within plants is not sufficient to understand how to solve the problem of PHFL.*

Further monitoring of PHFL: *None of the six responding plants monitor PHFL through the packaging and selling phases of the value chain. Plants stated that the cause for this lack of monitoring was due to the lack of inhouse manpower and a lack of know-how amongst employees. This should also extend to ensure the monitoring of PHFLs at both the packaging*

7 https://www.nation.sc/archive/242786/-new-fish-processing-facilities-open-at-providence

8 HACCP is a management system in which food safety is addressed through the analysis and control of biological, chemical, and physical hazards from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product.

and the sales phase of production. This will ensure more accurate PHFL reporting by processors to the SFA.

In addition, there is very little reporting around the financial losses/figures associated with PHFLs in the Seychelles. There is also no reporting around fish losses on fishing vessels themselves, or at the transhipment stage of the industrial fishery. Finally, the SFA 2020 survey had no responses from any processing plants that produce value added products from industrial target species catches (SFA, 2020). A better understanding of how the industrial fishery operates with regard to efficiency and PHFLs could allow a more holistic approach to improving infrastructure and regulation so that it helps all the Seychelles fisheries reduce PHFLs. Finally, as mentioned above, in-house reporting from processors must improve to allow the relevant ministries and authorities (Seychelles Fishing Authority) to help processing companies reduce their PHFL and become more efficient - which can only be of use to said companies.

Phase 3 Export and marketing

Where processing plants have difficulty with exporting fresh products, a backlog of product, fish storage space is filled leading a surplus of packaged product occurring. Where this delayed exporting occurs, there is potential for processors to offload into the local market with five out of the six processors selling on local markets as well as exporting.

Delay to exportation occurs for a number of reasons. Historically, the export procedure has been laboursome, requiring a trade certificate from the SFA (origin of catch and sustainable source certificate), a health certificate from the Seychelles Bureau of Standards (SBS), an export permit from customs, and the clearing and shipping phase. Some of these steps are not automated, requiring phone calls (to the SBS) which can cause delays. However, this is no longer the case, especially now that the SFA and SBS have set up an office in Providence to facilitate the export procedure. An export permit is only required once upon setting up of a business and not at every exportation.

Incorporating IT systems for automated processing and issuing of certificates when exporting will help prevent the bottlenecks seen at this stage of the value chain. Furthermore, every bycatch export unit is currently inspected before shipping which causes delays. This could be eased to one in every five per shipment (per company) for example (Ministry of Fisheries and Agriculture, 2018).

Processing plants cited numerous challenges to exportation of their products. These are listed below (Seychelles Fishing Authority, 2020):

- HS Code (Harmonized System codes - numerical codes used by customs authorities to classify traded products and determine their duties and taxes): The different agency e.g., Ministry of Health, Trade and the Seychelles Bureau of Standards (SBS) cannot determine the right HS code for value added products;
- High air freight and raw materials cost;
- High cost of utilities and other local services;
- Lack of proper machinery;
- Lack of trained manpower;
- Standards set by the export market are too high to make it economically feasible to export;
- Availability of spare parts on the local market; and
- Difficulty to obtain catch and non-Illegal Unreported and Unregulated (IUU) certificates.

Recommendations:

Enhancement of cold storage: *One positive step to limiting PHFLs is the unveiling of the Central Command Cold Store (CCCS) which will provide a number of processors the opportunity for ultra-low temperature storage (-40°C) (Ministry of Fisheries and Agriculture, 2018). However, the airport cold storage facilities currently run by Air Seychelles is made up of two rooms, a chiller room held at 1-2 °C and the freezer room held at -18°C. These rooms, in particular the chiller room have been deemed inadequate to the point that exporters deliver their products straight to the loading apron (Ministry of Fisheries and Agriculture, 2018).*

2.1.3 Stakeholder identified issues resulting in PHFL

Representatives of the artisanal fishery

Within the artisanal industry, the Seychelles market is based on weight more than quality. In this respect, PHFL are predominantly associated with economic losses (i.e., loss of the 'grade' of fish, and therefore the value of the fish) more than gross loss (i.e., loss of biomass), as fish can still be sold that are not 100% fresh.

One of the main issues artisanal stakeholders stated results in economic loss was associated with cold chain management on the vessel and shore. On board vessels such issues with cold chain management are likely associated with low quantities of (usually flake, but also plate) ice available for fishers on a daily basis. This may be associated with the number of ice-making plants within the Seychelles (15 – all of which are managed by the SFA and provide ice at a subsidised rate to fishers), which have a reduced ability to provide substantial amounts of ice for all fishers. Any lack of ice availability on a daily basis is exacerbated by there being no quota for fishers – it is first come, first served. Therefore, larger vessels (predominantly semi-industrial) may take more than what they will need in a single fishing session, reducing the availability of ice for any other vessels.

Stakeholders also stated that the quality of ice provided may be compromised due to lack of strict hygiene practices within the ice plants. Fishers that do not work in the plants are able to enter the plants, while the lack of a dedicated ice chute at any of the ice plants result in ice being manually moved from the plant to the vessel. Lastly one stakeholder stated that there can be sediment in the ice, due to lack of ice plant maintenance. All three issues have the potential to contaminate the ice provided by the plant.

Issues with cold chain management on-board vessels are also associated with the lack of ice-making machines on board vessels, as well as the use of relatively basic insulated holds in the majority of vessels. This results in ice only being viable for several days, reducing the time in which fishers can remain fishing and viably freeze their catch. On the majority of vessels (mini Mahe, Mahe, schooner) there is no space for such ice-making machines, with the inclusion of such machines likely to lead to higher fuel costs associated with the extra weight of the machine.

Issues with PHFL on-board artisanal fishing vessels are also associated with storing and handling of caught fishes. Firstly, the reduced space within the hold of artisanal vessels results in fishers stacking individual fish with little space between individuals. This results in less space being available for ice to be packed surrounding each individual, potentially resulting in reduced freezing effects. This was stated as an important factor reducing the quality of carangids. Importantly, issues with fish handling on board vessels may result in nearly half of the catch being rejected due to high grading.

Once caught on-board, a reduction in the quality of the fish may occur firstly due to fish being clubbed to immobilise fish (which can bruise the skin of the fish, reducing the grade of the fish to a grade C), as well as when landed fish are left out in the sun and not directly being placed within the ice. Any issues the fish being left in the sun following landing may be more important on smaller vessels that do not have cover from the sun (Mahe, Lekonomi); larger vessels are covered, so there is less likely to have fish directly in sunlight. Stakeholders stated that there has been a recent increase in capacity training to have fishers place fish on ice directly after being caught.

Once landed and placed within the hold, reductions in the quality of the caught fish may be associated with melting of the ice, which can be exacerbated by vessel movement. During rough weather the rolling movement of the vessel will impact the ice touching the side of the hull, with such ice melting faster, with fish not in contact with the ice (i.e., more in contact with melted ice) degrading faster than fish in contact with ice.

On disembarkation, the quality of fish may be impacted by poor handling techniques, which may be exacerbated by the lack of fish grading before sale, with therefore no incentive to increase handling to reduce quality loss. Such degradation this may be associated with fish being packed too tightly into freezer boxes, and effectively being squashed under the weight of ice (and other individuals). Stakeholders stated that barracuda are highly likely to be impacted in this way. The use of chutes to move fish from the vessel to the transport would reduce such impacts of disembarkation.

At the market, fish are displayed and sold ungutted, it is only upon the customer's request that fish are gutted. All active fish markets are equipped with water points for the washing of fish, which may reduce any contamination of the fish. Lastly, fish may be dipped in seawater before sale, to enhance their visual appeal, but which warms up the fish potentially leading to the fish spoiling earlier than if left frozen.

Issues with post handling may also be associated with the transport of fishes from the vessel to the market. Most artisanal stakeholders stated that there is no specific reefer (i.e., refrigerated) trucks to haul catch from vessels to the markets within the Seychelles. Most fishes are moved using open flatbed trucks, which have little to no ice[9] (). Such lack of specialised transport will result in reduction in the quality of the fish.

Representatives of the semi-industrial industry

Within the semi-industrial fishery (based nearly solely on catches of tuna), cold chain management is relatively well developed, with good practices in handling undertaken within the Seychelles. In this respect, fish are received on ice or in cool boxes with ice, with fishes then moved into chillers and freezers which are working to their acceptable temperature range. All processing is undertaken in air-conditioned rooms, with fishes stored on ice during and after immediate processing. The quality of this cold chain is to ensure that no fish are left outside in non-controlled environment and temperature monitoring is undertaken during all fish processing.

To enhance the cold chain management of fish, one stakeholder stated the need to move away from freezers and start using blast freezers. The use of such technology would improve the quality of landed fish (in this respect, the stakeholder was focusing on tuna), ensuring that fish remain as A grade products. In addition, one stakeholder did state that issues with the

9One stakeholder mentioned that garbage trucks have been used to transport fish to markets, but reviews from the steering committee of the project argued that this does not represent what is 'normal' – therefore this has been added as a footnote, but is not discussed in detail in the main text of this report.

volume of ice available for semi-industrial vessels will reduce the days fishing activities can occur. In this respect, the stakeholder states that there is insufficient volume of ice available in a timely manner (i.e., from SFA ice plants). Such lack of ice reduces the quality of the fish, lowering its grade and monetary value on the market.

In terms of handling fish, the best practice within the semi-industrial industry has fishers avoiding hitting fish in areas that may damage the skin on post harvesting, which includes avoiding storing fish on top of one another. This will be vital when fish are small to avoid mashing the tissue. All fish are gutted at sea after capture, with this waste discarded at sea, as under the Export of Fishery Products (Sanitary) Regulations, 2010, no ungutted fish are allowed in the processing plant except for bycatch (such bycatch only occurs in the industrial fishery). Once landed, during cleaning of fish (the waste from this will be fish trimmings, such as the head and gills), all waste is separated from cleaned fish (i.e., to use for other purposes such as dog food), with all fish placed on ice before and during cleaning. To ensure the quality of fish during disembarkation, reducing the use of nets is preferable (to reduce squashing of fish), while to enhance graded, any damaged fishes on-board are separately stored on ice, so they can be used for other processing (e.g., dog food).

The methods used to clean fish may impact the quality of the fish. For example, one stakeholder stated that there can be a loss of grade when cutting the fish, when bleeding the cutting must not touch the backbone of the fish, as the quality will degrade when the fish is later added to ice.

The processing of fish, and importantly the cost of utilities, may be an important factor leading to PHFL. For example, one processor stated that it was cheaper to get rid of fish than process it (i.e., valorisation). Such costs will be predominantly associated with the storage of the processed 'waste' in cold store, as well as the logistics needed to process such waste into a viable product.

PHFL may also be associated in the semi-industrial fishery with the length of the trip. The average length of fishing trips within the semi-industrial fleet is 15 days. However, such long trips reduce the likelihood of landed catch being able to market it as 'fresh fish'. The ideal fishing trip is stated by stakeholders as being 10 days.

Stakeholders stated that warmer water temperatures reduce the potential catch of the semi-industrial fleet, with broad reductions in catch apparent in the last 15 months (i.e., January 2022 – end of April 2023). In this respect, the stakeholder has been landing 50% less than expected. In addition, one stakeholder stated that there has been increased degradation of fish happening on the line, as fish are warming in the water due to increases in water temperature.

Where fishers focus on sea cucumber, PHFL may be associated with the use of salt as the 1st preservative. All landed sea cucumber individuals are primarily salted on board the vessel to ensure that they do not spoil before being landed. However, salting (instead of pre-boiling the sea cucumber) leads to a much higher loss in weight (and price) than if pre-boiling occurs. Such methodology is associated the lack of logistics needed to pre-boil on board vessels. Importantly, stakeholders also stated that losses in sea cucumber can occur if there is a delay in salting the individuals, or if not, enough salt is added to the individual before landing.

Representatives of the processing industry

Stakeholders stated that PHFL (not associated with 'normal' processing of the fish) occurs due to the heads and skin not being used, with estimates of up to 10% loss of potential

biomass associated not using the head. This could add up to 200 tonnes of loss on a monthly basis.

There is likely loss of grade (and loss of economic gain) if there is mishandling or reduced best practices which reduce the quality of the fish before receiving a grade by the processor (i.e., upon landing of the fish). This will be important, as although there is a negotiation on the grade between the fishers and the processor, after conducting the quality assessment, the processor will have the final say on the grade. Therefore, ensuring the quality of the fish is as high as possible before being graded upon landing will be important to ensure the highest price for the fish and therefore the fisher. The grade received from the processor will be the grade which the fish is shipped as (as the aim of the processor is to ship their product 24 to 48 hours after landing).

One processor stated that there are losses during the fileting process (especially for grouper, snapper and job fish), as there isn't adequate machinery to allow for better filleting and use. Such losses may encompass up to 45% of the potential biomass from the fish.

Stakeholders in the processing industry also stated that issues with cold chain management were likely leading to PHFL. The most pressing issues were the quantity of ice available from the ice plants within the Seychelles, including these not being efficient but also not producing enough tonnage of ice.

Lastly, there were issues associated with the design of boats, especially in the availability of storage, but also the lack of technology in sustaining the cold chain on the vessel. This is predominantly due to lack of technology within the vessels, showing the need for further updating of the artisanal and semi-industrial fleet

2.2 Mapping of the full supply chain for the postharvest industry within the Seychelles (Task 3)

This Task builds on the outcomes of Task 2 (methodology detailed in Annex 2), in which a statistically sound methodology was developed to ensure the efficient and effective collection of the range of PHFL throughout both the offshore and onshore sectors within the Seychelles. This work has been undertaken to determine and highlight the fine-scale issues leading to PHFL within both the artisanal and semi-industrial fishing sectors. To develop such an understanding, a detailed stakeholder engagement using a pre-developed questionnaire was undertaken throughout the artisanal and semi-industrial industries (see details of the questionnaire in Annex 1). This questionnaire was designed to provide industry-specific information on the range of routes to PHFL. The outcome of the stakeholder engagement was identification of the factors which would lead to PHFL:

(i) across the entire supply chain;
(ii) on-board vessels;
(iii) at disembarkation;
(iv) during processing;
(v) at local fish markets (general public);
(vi) from processors to public/hotel industry;
(vii) from processors to international clients; and
(viii) by fish mongers (local) to hotel industry

Below we provide a synopsis of the main factors across the entire supply chain which may lead to PHFL, and a description of the activities leading to PHFL (Figure 6).

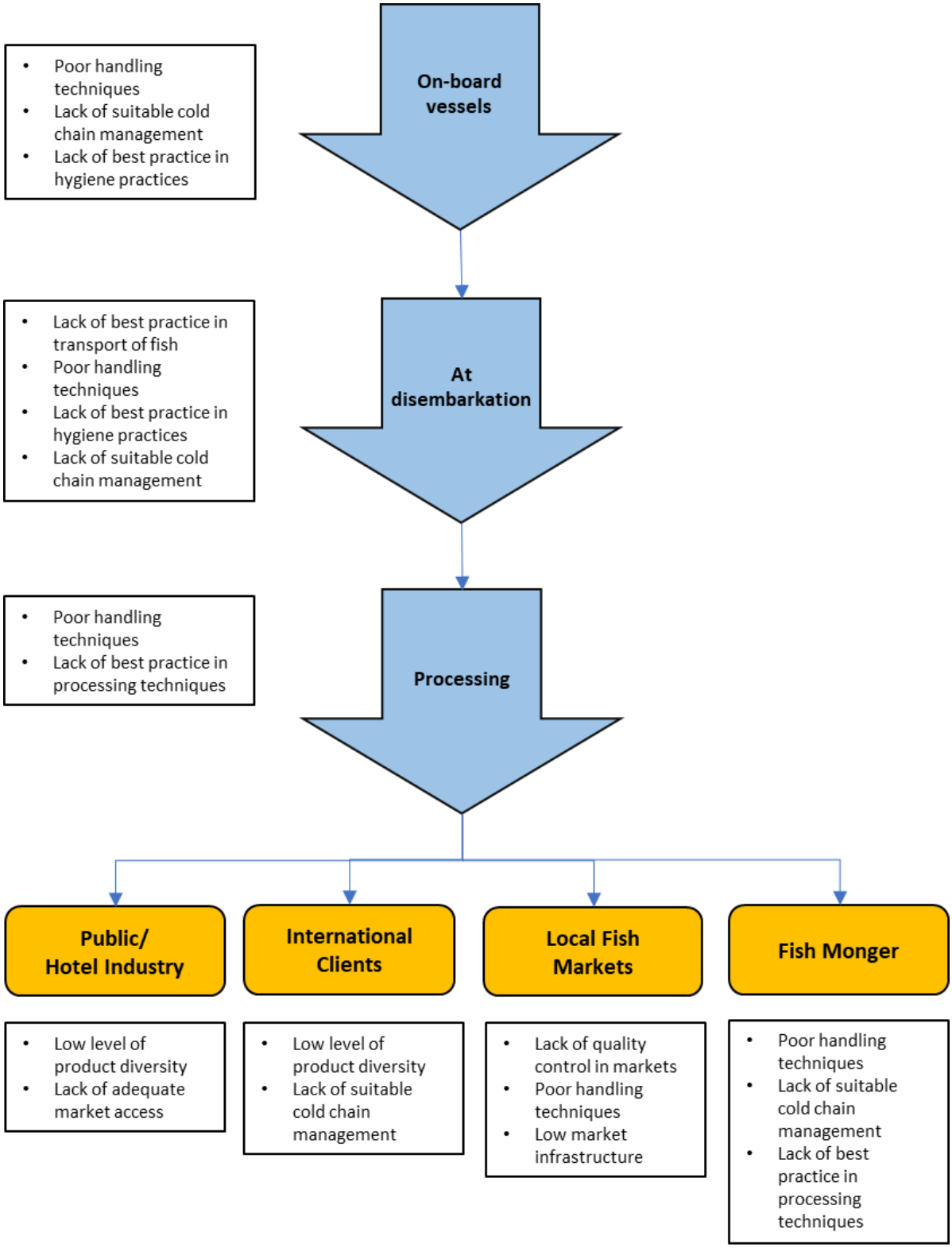

Figure 6 Summary of main factors potentially leading to PHFL throughout the Seychelles artisanal and semi-industrial supply chains.

Table 2 Description of main factors across the Seychelles postharvest supply chain which may lead to PHFL.

Supply chain segment	Main issue leading to PHFL	Detailed Description of Issue
Entire supply chain	Lack of data collection on PHFL	No data exist for PHFLs that occur on fishing vessels in any of the fleets; Lack of reporting around the financial losses/figures associated with PHFLs in the Seychelles; No reporting on fish losses on fishing vessels themselves, or at the transhipment stage of the industrial fishery; There are no reported figures on PHFLs at landing sites across all fleets
	Lack of understanding of best practice to reduce PHFL	Limited Good Manufacturing Practices (GMPs) and Good Hygiene Practices (GHPs) + assumed unconsciousness among semi-industrial and artisanal fishers of the economic (aka: value) losses by spoilage/ putrefaction/ deterioration of their landed fish due to a limited production driven and upstream view of the fish supply chain. Including the opposite holds: unconsciousness about the potential in economic (aka: value) terms of higher quality for their landed fish by a demand driven and more downstream perspective from the market
On-board vessels	Poor handling techniques	(i) fish being clubbed to immobilise, bruising skin and reducing the grade of the fish; (ii) when landed fish are left out in the sun and not directly being placed within the ice.
	Poor handling techniques	Use of block ice will bind and squash fish in the hold, deteriorating the quality of the fish.
	Lack of suitable cold chain management	Low quantities of (usually flake, but also block) ice available for fishers on a daily basis due to the small number of ice-making plants within the Seychelles (three – all of which provide ice at a subsidised rate to fishers).
	Lack of suitable cold chain management	Lack of ice quota, resulting in larger vessels (predominantly semi-industrial) taking more than what they will need in a single fishing session, reducing the availability of ice for any other vessels.
		Reduced space within hold results in individual fish being stacked with little space between individuals, resulting in reduced freezing effects
	Lack of best practice in hygiene practices	Within ice plants: (i) fishers that do not work in the plants are able to enter the plants; (ii) lack of a dedicated ice chute at any of the three ice plants results in ice being manually moved from the plant to the vessel; and (iii) there can be sediment in the ice, due to lack of ice plant maintenance.
At disembarkation	Lack of best practice in transport of fish	Fish being packed too tightly into freezer boxes, and effectively being squashed under the weight of ice (and other individuals).
	Poor handling techniques	Fish dropped, bruised during disembarkation
	Poor handling techniques	Fish heads left on-board (and potentially discarded) after processing
	Lack of best practice in hygiene practices	Fish gutted in areas that are dirty or have low hygiene levels
	Lack of suitable cold chain management	Lack of market (supply > demand), resulting in low fish prices and fish being dumped or left for longer periods before being disembarked

Supply chain segment	Main issue leading to PHFL	Detailed Description of Issue
	Lack of suitable cold chain management	Lack of specific reefer (i.e., refrigerated) trucks to haul catch from vessels to the markets within the Seychelles., with fishes moved using open flatbed trucks, which have little to no ice
During processing	Poor handling techniques	Fish left too long as a result of production line build up.
	Lack of best practice in processing techniques	High use of landfill for waste products due to lack of use of fish waste; Fish heads left on-board (and potentially discarded) after processing
At local fish markets to general public	Lack of quality control in markets	No grading of artisanal catch and therefore no incentive to increase handling to reduce quality loss + it is assumed based on first observation from an end-user perspective no urgency among local Seychellois to inspect and grade the fresh fish at local food markets for high quality.
	Poor handling techniques	Fish may be dipped in seawater before sale, to enhance their visual appeal, but which warms up the fish potentially leading to the fish spoiling earlier than if left frozen.
	Low market infrastructure	Lack of adequate and standardised infrastructure (Victoria and others), including proper drainage; space allocation; storage; ice availability; air-conditioning
Processors to public/hotel industry	Low level of product diversity	Low capacity for development of secondary value-added products, lack of product diversification, resulting in increased waste streams which may have been useful for further product development
	Low level of product diversity	Lack of machinery to process fish, including lack of availability of spare parts on the local market
	Lack of adequate market access	Potentially low local market accessibility, if problems encountered with exporting
Processors to international clients	Low level of product diversity	Low capacity for development of secondary value-added products, lack of product diversification, resulting in increased waste streams which may have been useful for further product development
	Low level of product diversity	Lack of machinery to process fish, including lack of availability of spare parts on the local market
	Lack of suitable cold chain management	Limited cold storage, including inadequate storage at airport
Fish monger (local) to hotel industry	Poor handling techniques	Poorly implemented Good Manufacturing Practices (GMPs)
	Lack of suitable cold chain management	Lack of storage and suitable transport (reefers)
	Lack of best practice in processing techniques	Lack of use of grading standards, reducing need for good handling standards

2.2.1 Quantitative data on PHFL throughout the processing stage/ and range and variety of processing waste

To provide substantial quantitative data on PHFL within the processing, this work has engaged with the fish processing industry within the Seychelles, and undertaken a deep dive into understanding the range of loss (both purposely and accidental) that is associated with processing. To complete this work, we have undertaken a mass-balance audit within four (4) processing plants within the Seychelles (see template audit in Annex 3). These audits have been designed to ensure that the total volume or weight of product (i.e., landed fish) passing

through an entity (i.e., processing plant) and onward to customers can be accounted for, mapping production yields, gains and losses.

Four processing plants were chosen to have mass-balance audits undertaken within their premises. The audits were completed on 23 June 2023; 9 June, 2023; 27 June, 2023; and 5 August, 2023.

Company 1: swordfish (*Xiphias gladius*)

On the 23 June 2023, Company 1 processed a single landed swordfish (*Xiphias gladius*), which had been presented as fresh on ice. The amount of input material to the processor (i.e., before processing) was 566kg and this fish was processed for loins. Loins are produced from high-quality fish that cannot be sold as headed and gutted due to quality issues with a part of the fish. Hence, in order to salvage the fish, it is transformed into loins.

The swordfish was processed, entailing removal of all (waste) body parts: the head and bill, the gills, guts, the fins (dorsal, pectoral, ventral and caudal), the vertebrae and other bones, the skin and assorted offcuts of muscle tissue from filleting and then the cleaning and final preparation of the loins for a retail setting. This reduced the initial input amount of 278kg unprocessed fish to 173.4kg of loins.

Overall, the processing produced a yield of 62% from the unprocessed loins (i.e., final product divided by the raw material input), but only a 49% input from the whole batch of raw fish of 566kg (final product divided by the original input material, before any processing). Importantly, the processing undertaken by Company 1 was not optimal. The carcass was not cleaned properly and held substantial amounts of meat still left on the bone. These were discarded as waste, with no technology within the processing plant to use any of the 'waste' streams associated with the processing of the swordfish.

Company 1: yellowfin tuna (*Thunnus albacares*)

On 23 June 2023, Company 1 also processed a batch of yellowfin tuna, which had been presented as whole fish, fresh on ice. The amount landed was 4,418kg (gutted fish). At landing all fish were then de-headed, with the amount of input material to Company 1 (i.e., before processing) 3,093kg (i.e., fish to be processed were whole, headed and gutted).

The batch of yellowfin were processed, entailing removal of all further (waste) body parts: the skin, vertebrae and other bones, and assorted offcuts of muscle tissue from filleting. This processing reduced the amount of raw material to 1,112kg, which involved cleaning and final preparation of fillets for a retail setting. Overall, there was a yield of 36% from the raw material (i.e., final product divided by the raw material input) – this was processed on the day of the study.

Company 1 does not have any technology within the processing plant to use any of the 'waste' streams associated with the processing of the yellowfin tuna. In addition, the head and guts of the fish had already been processed and discarded before being sent to the processing plant; the heads in particular are not transformed into any biproduct.

Company 2: yellowfin tuna

On 9 June 2023, Company 2 processed a batch of yellowfin tuna, which had been presented as whole fish, fresh on ice. The amount of input material to the processor (i.e., before processing) was 611.6kg, with the batch then processed as whole, headed and gutted and then further into loins.

Part 1 of the procedure started with 309.9kg of raw material (following heading and gutting). This processing entailed removal of all further (waste) body parts: the gills and the fins (dorsal, pectoral, ventral and caudal). With cleaning and final preparation of the whole, headed and gutted product. Overall, the processing produced a yield of 83% from the raw material (i.e., final product divided by the raw material input), but a 51% input from the fish (final product divided by the original input material, before any processing).

Further processing then entailed removal of the vertebrae and other bones, the skin and assorted offcuts of muscle tissue from filleting. This processing reduced the amount of raw material to 301.7kg, with cleaning and final preparation of the loins resulting in a final weight of 159.1kg for a retail setting. Overall, the processing produced a yield of 53% from the raw material (i.e., final product divided by the raw material input), but a 26% input from the whole fish (final product divided by the original input material, before any processing).

The majority of the PHFL produced from the processing of the yellowfin tuna was offcuts and the head. Such processing (i.e., for loins) results in high losses, as large parts of the fish are discarded. The loss inclusive of the head accounted for 42.27%. The weight of the head discarded was 16.5Kg. The processing plant of Company 2 does not have any technology to make use of the waste associated with processing, which will be more likely useful where they are processing for loins, which has a much higher rate of discard than processing for whole, headed and gutted.

Company 3: yellowfin tuna

On 27 June, 2023, Company 3 processed a batch of yellowfin tuna, which had been presented as whole fish, fresh on ice. The amount of input material to the processor (i.e., before processing) was 1,793kg, with the fish processed for loins, tuna belly and dog food.

The batch was processed, entailing removal of all (waste) body parts: the head, the gills, guts, the fins (dorsal, pectoral, ventral and caudal), the vertebrae and other bones, the skin and assorted offcuts of muscle tissue from filleting.

Out of the initial amount, 53.8kg was used for tuna belly (Part 1), while 1,123kg were used for loining (Part 2). The rest were processed as dog food and waste.

Part 1: Using 53,8kg of raw material, cleaning and final preparation of the loins resulted in a final weight of 42.6kg for a retail setting. Overall, the processing produced a yield of 79% from the raw material (final product divided by the original input material, before any processing). This also accounted for only 2% of the initial batch input.

The majority of the PHFL produced from the processing of the yellowfin tuna was offcuts and the head. This product was destined for the local market and was added to the processors on-site retail shop. Company 3 does not have facilities to utilise any of the waste streams from the processing of the tuna.

Part 2: With cleaning and final preparation of the loins the initial weight of 1,123kg resulted in a final weight of 973.83kg for a retail setting. Overall, the processing produced a yield of 92% from the raw material (i.e., final product divided by the raw material input), but a 54% input

from the initial whole fish (final product divided by the original input material, before any processing). A total of 464.17 of dog food was produced from the offcut, in the form of grinded or cut fish. This accounted for 26% of the initial input amount; the rest is waste.

The majority of the PHFL produced from the processing of the yellowfin tuna was offcuts and the head. This product was destined for the local market and was added to the processors on-site retail shop. Company 3 does not have facilities to utilise any of the waste streams from the processing of the tuna.

Company 4: green jobfish (*Aprion virescens*)

On 5 August 2023, Company 4 processed a batch of green jobfish, which had been presented as whole fish, fresh on ice. The amount of input material to the processor (i.e., before processing) was 450kg, with the fish to be processed as whole, headed and gutted.

The batch of green jobfish was processed, entailing removal of all (waste) body parts: the gills and guts. This processing reduced the amount of raw material to 331kg for a retail setting. Overall, the processing produced a yield of 73.5% input from the whole fish (final product divided by the original input material).

The majority of the PHFL produced from the processing of the green jobfish was offal. This product was destined for the local market. Company 4 does not have facilities to utilise any of the waste streams from processing.

Company 4: green jobfish (*Aprion virescens*)

On 5 August 2023, Company 4 processed a green jobfish, which had been presented as a whole fish, fresh on ice. The amount of input material to the processor (i.e., before processing) was 119kg, with the fish to be processed as fillet (without skin).

The green jobfish was processed, entailing removal of all (waste) body parts: the head, the gills, guts and the fins (dorsal, pectoral, ventral and caudal), the vertebrae and other bones, the skin and assorted offcuts of muscle tissue from filleting. This processing reduced the amount of raw material to 55kg for a retail setting. Overall, the processing produced a yield of 46% input from the whole fish (final product divided by the original input material).

The majority of the PHFL produced from the processing of the green jobfish was head, carcass and skin. This product was destined for the local market.

Company 4: Capitaine blanc (*Lethrinus nebulosus*)

On 5 August 2023, Company 4 processed a Capitaine blanc, which had been presented as a whole fish, fresh on ice. The amount of input material to the processor (i.e., before processing) was 10kg, with the fish to be processed as fillet (without skin).

The Capitaine blanc was processed, entailing removal of all (waste) body parts: the head, the gills, guts and the fins (dorsal, pectoral, ventral and caudal), the vertebrae and other bones, the skin and assorted offcuts of muscle tissue from filleting. This processing reduced the amount of raw material to 5kg for a retail setting. Overall, the processing produced a yield of 50% input from the whole fish (final product divided by the original input material).

The majority of the PHFL produced from the processing of the Capitaine blanc was head, carcass and skin. This product was destined for the local market.

2.2.2 Summary of outputs from processing and possible waste streams for valorisation

Across the four processing plants, mass-balance audits were undertaken to quantify and identify the amount and type of waste associated with the processing of different fish species. Within these cases fishes were processed into different products: whole, headed and gutted; dorsal loins; belly loins; and fillets. Although the methods and amount of processing of the fish for the products would have been different, the waste produced was similar in all cases. This waste was: the head, the gills, the guts, the fins (dorsal, pectoral, ventral and caudal), the vertebrae and other bones, the skin and assorted offcuts of muscle tissue from filleting.

All four of the processing plants do not have the machinery that can process any of the produced waste streams into further products. In this respect, 100% of the waste from the processing of the fish in all four plants will likely to be sent directly to the municipal landfill. Importantly, this reduces the potential economic output that can be gained from the processed fish through valorisation of the waste streams and selling such products locally (or even internationally). The use of the landfill will also directly cost the producer, as they need to pay to dump their waste. Within recent (2018) increases in the fees to utilise landfills in the Seychelles, with trucks taking waste to Providence (Mahe) having to pay R50 for the first tonne it unloads there and R100 for every additional tonne. As all four of the producers surveyed are situated in Mahe, this landfill is where they will be expected to be sending their waste to.

The Seychelles has three landfills, one in Mahe and two others in Praslin and La Digue. There have been recent increases in the infrastructure associated with these three areas. It is expected that the same fees apply to the landfills to use them for fish waste from processing factories.

3 Section 2 How best to reduce PHFL within the Seychelles (Task 4)

This second section of the project is based on providing detailed recommendations to reduce PHFL within the Seychelles. This work has been built on the assessment of the entire supply chain of the Seychelles fishing industry (focusing solely on the artisanal and semi-industrial sectors) and where PHFL will be developed (Task 1 – 3). Within this section we utilise a case study approach to outline ways in which PHFL can be reduced, and where international good practice can inform the SFA to support the reduction of such PHFL. In this respect, we firstly focus on international best practice that is applicable **across the entire supply chain** of the Seychelles postharvest industry: (i) utilising the concept of HACCP and the procedures inherent in this to reduce PHFL; and (ii) using the concept of fishermen cooperatives.

We then focus on segments within the Seychelles PH industry, and where specific changes could be made to reduce PHFL. This is **on-board vessels**, **at disembarkation**, **during processing** and then **during the marketing of products** (encompassing at local fish markets (general public), from processors to public/hotel industry, from processors to international clients, and by fish mongers (local) to hotel industry (Annex 4).

3.1 Reducing PHFL across the entire supply chain – the use of HACCP to ensure fish quality

Hazard Analysis Critical Control Point (HACCP) is a tool used by the food industry to ensure that all food consumed is safe to eat. It is a systematic approach to hazard identification, and assessment of risk and control. The concept of HACCP was first introduced during the mid-1960s, when a reliable method for manufacturing pathogen-free food was required by the US space programme. It has successfully been applied in the control of safety in low-acid canned foods globally. Increasingly, regulatory bodies have recognized the usefulness of this tool and it has been incorporated into legislative requirements. The HACCP system is based on seven principles: (i) analysis of current system and assess hazards and risk; (ii) identify critical control points; (iii) set target levels and critical limits; (iv) develop a monitoring system; (v) decide what corrective action is required; (vi) establish a means of verification; and (vii) develop a communication process.

There is the possibility of transferring the use of the HACCP system to the Seychelles postharvest fishing industry (i.e., the artisanal sector), as a means of reducing PHFL, preserving the economic value of fish and improving local seafood supply[10].

Within the Seychelles postharvest fishing industry, the HACCP system is already undertaken by processors that utilize catches from the semi-industrial fishing fleet. This is likely due to processors marketing seafood for an international market, especially those selling goods to Europe (as HACCP was made compulsory in 2004 for all companies that process perishable foodstuffs and/or place them on the market across the European Union). However, it is also expected that the postharvest supply chain that is not associated with local processors (i.e., fishes landed by the artisanal fleet) may not be structured by HACCP procedures.

In the first step of a HACCP, the possible risks that could negatively influence the product are identified (termed a hazard analysis), beginning when the product arrives at the company and ending when it leaves. Where the company is dealing with seafood, the analysis will identify

10 Note: The use of HACCP is already stipulated within the Food Act 2014 (Discussed in detail in Section 4.3 of this report)

factors that may accelerate spoilage of the seafood. This is predominantly associated with excessively high product temperatures (resulting in accelerated bacteria formation, decomposition of the fish protein) and possible infestation with parasites (nematodes in the fish or contact with flies and other insects). Following this, the second step is to identify critical control points. Such points are defined to ensure that previously defined parameters (e.g., for fish, certain product temperatures, storage in/on ice, processing on and with disinfected tools such as cutting boards and measuring devices) are adhered to.

The HACCP system is recorded in writing, employees are trained, and random checks (e.g., incoming goods temperature, storage temperature, water quality of the ice, outgoing goods temperature, cleaning and disinfection cycles) are documented and controlled (e.g., by internal or external inspectors. Overall, HACCP procedures are developed to ensure quality of the seafood and consumer protection (i.e., health and safety). This is a self-controlled system, which has an obligation to control and document all procedures undertaken.

There are a range of activities inherent within the HACCP procedures to enhance the longevity and quality of fresh seafood:

- Reduce the rate of natural spoilage (protein decomposition) by ensuring fish are kept at low temperatures (e.g., within the European Union: 0 – 4°C for fresh fish; 4 – 7°C for processed fish; and -18°C for frozen fish) following landing of the fish;
- Reduce evaporation of water contained in the fish (which naturally is 70 – 80% of the weight of the fish) by moistening with water from melting ice. The aim is to reduce from approximately 5% per day (non-wetted) to less than 1% per day (wetted);
- Negate infestation of the fish by parasites, especially insects (e.g., egg-laying by flies), by storing fish on and/or under ice;
- Avoid cross-contamination with bacteria between different fish species through mandatory cleaning and disinfection of both work surfaces and equipment, when changing the fish species being processed; and
- Avoid cross-contamination with bacteria that may be present in water during ice production and transport through regular disinfection and water testing.

There are a range of requirements in the use of HACCP for fresh seafood in Seychelles to ensure that all stakeholders are able to adhere to such procedures. The first is the need for central HACCP concept (i.e., list of procedures) that can be utilised by all processors and traders of fresh seafood within the Seychelles. This would most likely be one adopted from the EU, but adapted to the local conditions of the Seychelles. Once a central set of procedures are developed, there is likely the need to undertake local training (as well as follow-up training) by local specialists in utilising the HACCP procedures.

Within the Seychelles, a simplified HACCP could be utilised which uses a traffic light system (i.e., red, amber, green) to inspect and control the quality of seafood products. In this instance, green would mean products are of a sufficient and good quality, amber would mean there is factor which may reduce the quality of the fish (e.g., high ambient temperature, lack of cold chain management etc) which may have a potential risk to the consumer, while red would mean that the fish is not for human consumption. In line with using a traffic light system, would be to provide a guideline for prices associated with 'green' and 'amber' products. Green should have a higher recommended general market price compared to orange. In this instance 'red' products are not edible, and should therefore be forbidden to sell and purchased by consumers. Compliance to such standards would need to be associated with regular inspections of markets/areas of selling, with financial penalties for cases where red fish

products are sold. By using such a method, it becomes attractive to those selling fish within markets to maintain and strive for higher quality products (green).

For each stakeholder that uses HACCP, a dedicated folder with instructions and forms for documenting random checks on the use of such procedures will be necessary. In this respect, the use of such procedures will need to be monitored by local authorities to ensure effective implementation while also undertaking an audit of all control documents. For all processors and traders to be able to adhere to HACCP procedures, there will need to be the presence of: (i) ice, which is sufficient and easily accessible; (ii) clean, controlled drinking water; (iii) ice transport containers; (iv) cutting boards and knives; (v) boxes for the storage of processed fish; (vi) ways of cleaning and disinfecting by using temperature (hot water ≥65°C) and/or disinfectants; and (vii) thermometers for temperature control (product surface and core temperature).

3.2 Reducing PHFL across the entire supply chain – using fishing cooperatives

Fishing cooperatives are formed predominantly when small fishing enterprises come together as a group, all of which work in a similar way in a spatially delimited area. Such cooperatives are particularly common in small-scale coastal and inland fisheries, especially if they are seasonal or part-time. Well-known European examples include fishing cooperatives in the North Sea and Baltic Sea focusing on herring fishing with gillnets and fishing cooperatives in the Wadden Sea (North Sea) focusing on grey shrimps (*Crangon crangon*).

For the affiliated fishermen or fishing enterprises, mergers into cooperatives can bring a range of advantages. The most important are the possibility of specialization of individual members, who can take over selected services in the field of procurement, processing, supply and marketing. Such specialisation can lead to a more efficient and lower cost service than if undertaken by individuals. In addition, cooperatives may bundle catches, which can ensure fishers are able to regularly meet market demands, can minimize competitive pressure between individual fishermen, guarantee a negotiating position is on equal footing with larger buyers, while also ensuring joint representation of interests vis-à-vis global markets, politics and environmental organizations. Lastly, cooperatives can create higher creditworthiness when purchasing material and machinery and better purchase prices due to higher purchase quantities.

Within the Seychelles, the use of fishing cooperatives may generate a range of benefits for associated fishermen and the local population. The first would be the joint purchase and operation by a specialist of a local ice supply. Importantly, there are already ice plants by private enterprises and also SFA. Such a service would result in optimisation of the operation of the ice machine, including the regular maintenance and assurance of water and ice quality. In addition, all SFA ice plants undergo microbiological analysis on a monthly basis and random tests to ensure the quality of the ice supplied by SFA. Further, such specialisation may enhance the use of clean reusable containers (instead of sacks) for storage and transport, while also cutting down the amount of movement of different fishers into and out of ice making plants.

Within a cooperative, the joint purchase and operation of a refrigerated vehicle may be facilitated – in this respect, most of the processors for export have their own refrigerated vehicle, but this is lacking in the domestic market. The development of such a service could ensure that the cold chain is maintained from the vessel to the market and/or processor. Such a service could also ensure processed fish products are transported to customers or market places or airports in high compliance with HACCP handling procedures.

More effective marketing of products on the local (or international) market may be facilitated by the development of a cooperative scheme. Such marketing could ensure the price of landing by reducing competition between fishermen in the market and ensuring the quantity of fish being produced. Such marketing may also allow fishermen to offer a larger consistent supply of fish (i.e., more biomass, more regularly), therefore providing a much more reliable service for consumers. Lastly, such optimisation of availability may mean that fishers are able to serve larger and/or more distant customers, while also enhancing their bargaining position.

The development of effective fishing cooperatives within the Seychelles will need to be supported by the Seychelles Fishing Authority, local fishing associations, and also industry associations (e.g., Association of Fish Processors and Exporters Seychelles). Such associations may be able to offer start-up financing, as well as in supporting the development of standardized contracts, legal advice and arbitration in case of disagreements – however, further information is needed to understand whether the structure of existing associations within the Seychelles have such abilities. Further training for members of the cooperative will also be imperative, while also support to ensure orderly financial management of operations: rapid cash flow for all members.

3.3 PHFL generated on-board vessels

A component of PHFL in the Seychelles artisanal and semi-industrial fisheries will occur on-board vessels. Specifically, when landed, (i) fish will be clubbed in order to achieve immobilisation, thereby bruising skin and reducing the quality grade of the fish; and (ii) fish may be left out in the sun and not immediately placed within the ice-filled hold for a length of time (especially if there are a large number of fish being landed in rapid succession). Such activities, resulting in PHFL (both economically and in terms of fish biomass), are likely due to reduced awareness of the impact of such procedures on the quality of the fish product,, the lack (especially for the artisanal sector) of a grading system for fish products and therefore any incentive to ensure a high quality of fish and may also be linked to the size of the vessels to accommodate for the adequate storage and other facilities that will allow for an acceptable quality of the fish.

Tackling handling issues on board vessels (or at landing) will be the cheapest, most sustainable, and least technologically challenging way to reduce all the physical, quality, and market force losses that occur at this point of the post-harvest chain. This will entail setting-up handling standards for both artisanal and semi-industrial, as well as further skills training, and where necessary monitoring and enforcement of such standards; such procedures have been shown to be decisive in reducing high PH losses (e.g., Lake Hawassa region in Ethiopia: Tunsisa, 2019).

Whereby lack of proper training in handling of fish may be an important precursor to PHFL within the Seychelles, stakeholders also identified issues specifically connected with the maintenance of the cold chain and its proper management. These issues encompassed three main problems: (i) insufficient ice availability; (ii) uneven distribution of available ice; and (iii) lack of space on-board constraining amount of ice. For example, stakeholders stated that there were low quantities of ice (usually flake) available for fishermen on a daily basis (there are a total of 16 ice plants in the Seychelles owned by the SFA, which provide ice at a subsidised rate to fishermen). A second main problem is the absence of ice quota, resulting in larger vessels (predominantly semi-industrial) taking an amount of ice exceeding their needs in a single fishing trip with smaller vessels sometimes receiving insufficient quantities of ice. Finally, such issues were compounded by reduced space in a typical vessel hold, leading to

individual fish being stacked with little space between them, resulting in lower ice proportions and diminished freezing effects.

Ensuring availability of adequate ice have been shown to be substantial in reducing high levels of PHFL in a range of documented case studies. For example, with the Bosomtwi-Sam fishing harbour of Ghana the lack of adequate ice contributed to 30% PHFL per trip (Gyan, 2020), within Central Java prolonged and poor on-board handling and storage (including prolonged soaking), equated to a 28% loss in value per fishing trip (Wibowo, 2017), while within Tanzania, on average, 10% of captured fish (in weight) was lost due to spoilage (Mramba and Mkude, 2022).

Further national investment in larger ice machines able to produce higher volumes of ice and in additional areas of the Seychelles would be needed. In addition, replacement of the use of thin plastic ice bags to transport ice (Figure 7) by a well-designed and clear-cut system of insulated boxes, utilising disinfectants to ensure hygiene, could contribute to ice conservation, as applied in other countries (March and Failler, 2022). In this respect, appropriate ice containers were identified as crucial for reducing PHFL within the Bosomtwi-Sam fishing harbour (Gyan, 2020), to both augment fishing trip hours while keeping fish adequately iced to prevent spoilage. Such containers can be manufactured with autochthonous insulating raw materials, such as coconut fibre, sawdust or rice husks (Gyan, 2020). In addition, an Indonesian case-study (Wibowo, 2017) showed the importance of high ice availability, as well as economically-accessible insulated containers.

Figure 7 Fishers loading bags of ice and transporting from local ice-making plants in the Seychelles.

3.4 PHFL generated at disembarkation of the catch

Poor fish handling at disembarkation, comprising: (i) fish being dropped and badly handled during disembarkation, resulting in bruises and quality losses; and (ii) fish heads being left on-board (and potentially discarded as waste) after processing and unloading both lead to enhanced PHFL within the artisanal and semi-industrial fishing sectors. In line with such issues at disembarkation, as in the Ghanian case-study (Gyan, 2020) fish injuries due to poor handling caused up to 30% fish loss before processing and/or the product reached market. In this case study, enhanced fish handling training and improved infrastructure within the harbours were able to reduce PHFL - note that two landing sites for artisanal fisheries and semi-industrial are certified by the Competent Authority. In addition, it was observed in Indonesia (Wibowo, 2017) that between landing and transport (usually between two to three hours), poor handling, inadequate cooling, lack of space, and exposure to ambient conditions led to a non-negligible 4% loss in weight or in value of each fish. In this respect, further training of personnel to carefully handle fish; (ii) encouragement of the greater use of ice and insulated

containers; and (iii) roofing of the landing site and ensuring proper handling of fish from the vessel were all important in reducing PHFL. Lastly, at disembarkation, pre-processing of fish (e.g., disarticulating heads) may also enhance levels of PHFL. This is because such heads are not likely to be processed with the rest of the fish – thereby being relegated to waste streams.

There are also likely issues with cold chain management during disembarkation, resulting in fishes potentially not being kept frozen during unloading of vessels, which may be due to limited ice availability for vessels, but also lack of rigorous handling procedures to ensure the cold chain. Further enhancement of cold chain management within the Seychelles would also be supported by having a single harbour or several main harbours in which vessels (both artisanal and semi-industrial) unload their catch. Of the markets within the Seychelles, Victoria Port is for artisanal and semi- industrial, as this port is close to the processing factories. In addition, most districts have fish markets where the local fisherman can disembark and sell closer to their market, of which fish are then mainly sold directly to the public.

3.5 PHFL generated during the processing of the catch

PHFL in the Seychelles occurs during the processing of fish, which is performed in different stages of the product chain and in varied environments, including on the vessels themselves, within dedicated processing plants, as well as within local markets. In this respect, processing can encompass a variety of tasks, such as receiving, sorting, filleting, weighing, packaging and cold storing of fish and fish products – all of which have the potential to lead to PHFL.

Where PHFL is produced during processing of fish, 'waste' products can be developed (i.e., offcuts, offal, heads etc), with little capacity within the Seychelles PH industry to utilise such waste as biproducts. The IOT has within their factory a fishmeal production facility which also extracts oil using proprietary technology from the tuna heads for fish oil for use in the pharmaceutical industry. In addition, the IOT have a waste water treatment plant, which allows the sludge from waste water to settle out, with the sludge from this sent to landfill. Despite this, there are no further facilities within the Seychelles processing industry to make use of the waste streams associated with fish processing, and develop them into substantially profitable biproducts.

The one biproduct that is predominantly developed by Seychellois processors is dogfood, which is simply ground-up fish waste, that is frozen and sold locally. The majority of processors will sell such products haphazardly, depending on the availability of waste streams. Frozen offcuts can also be bagged and then sold locally as fish bait. The use of such waste streams for pet food or bait are a potential avenue to transform lost biomass into saleable by-products, but will always be low value products that could not be formed into high-value products.

Within the Seychelles there is need to ensure that where processing waste is developed (from processors, but also from local processing including markets), there is a value chain that can use such streams. In this respect, as the machinery for processing such waste is already held by the IOT, one potential avenue is for the IOT to purchase waste from other producers and valorise such waste in their factory. The development of such procedures could be supported by either national mandates to effectively utilize fishing waste, or more international mandates (e.g., ISSF Conservation Measures to cover the sustainable use of fish waste).

3.6 PHFL generated during marketing of products – using a demand driven perspective

This project has identified that PHFL may occur on vessels, but is also likely to occur onshore within the local supply chain. Such PHFL will predominantly be due to spoilage of landed fish, which not only encompasses a loss of the nutritional value of the landed fish, but also the economic value at which the fish can be sold. By approaching such issues from a demand-driven and end-user perspective, potential changes to handling practices may result in a higher economic income to fishers and fish mongers. Therefore, below we examine the activities that will lead to potential spoilage of marketed fish, and determine the likely economic benefits associated with different strategies to reduce such spoilage.

PHFL is more likely to occur within the artisanal, than semi-industrial fishing industries. Within this, PHFL is predominantly associated with the activities surrounding the selling of fresh fish to end-consumers (i.e., non-exported fishes). Therefore, the stage or phase in the local fish supply chain with the highest likelihood of PHFL is just before consumption, during which sellers store fish within market stalls or alongside the road with limited (or a lack of) ice, no air conditioning and (for roadside sellers only) likely little shade.

Value perception within the Seychelles (i.e., predominantly within the artisanal supply chain) is more focused on how to sufficiently feed family members, with availability and quantity driving consumption preferences. This results in the cost of local fish not being solely determined by quality (i.e., freshness), but more the type and quantity of fish (i.e., species and size of the individual). In this respect, there is no use of, but also no impetus, to develop a grading system for locally marketed fishes and therefore no push to practice Good Manufacturing Practices (GMPs) and Good Hygiene Practices (GHPs) among local supply chain actors (fisher, transporter, fish mongers, sales persons and consumer).

Within the Seychelles, where fishes are sold to a processor (mainly semi-industrial, but this can also occur within the artisanal fishing sector), informal procedures to inspect and grade fresh landed fish are utilised. Such grading procedures may be important in pushing fishers to utilise suitable GMPs and GHPs to ensure the highest quality of their landed catch. Despite this, the grading procedures are not undertaken according to a standard or certain agreed methodology, with such grading being an informal inspection (akin to Japanese tuna grading by eye). Such grading at landing (which is undertaken by the processor and the grade of the fish agreed to by the fisher) may then be a disadvantage to fishers, as their bargaining power and therefore ability to attain the highest value for their fish, is often smaller than the purchaser of the fish.

There are a range of potential positive impacts associated with ensuring seafood quality, and therefore the implementation of specific GMPs and GHPs that can be taken up by the artisanal (and where not used already by the semi-industrial) fishing sectors. The main positive impact of ensuring the quality of the seafood available to Seychelles is the lowered risk of that seafood spoiling, and therefore the lower risk of food poisoning associated with consuming the fish. There is also the potential to sell fish at a higher price, if certified as fresh (especially if the product is being sold to the hotel / restaurant / catering industry) or to reduce physical loss of the fish (and all economic gains from selling the fish) through not being able to sell it due to spoilage. Ensuring the quality of the fish may also result in local fishers being able to market and sell their product to exporters, where they could not before. This may be particularly important where fishers are landing large bodied fish (i.e., tuna, mahi mahi, marlin, sailfish) which may not sell for high prices in local markets, but may demand a premium in an international market.

The length of time landed fish is stored on-board the vessel (i.e., in the hold) may be a good predictor for the freshness of the landed fish. Where fishing trips are undertaken between 10 and up to 15 days, the quality of the landed catch will reduce – likely due to melting of ice, but

also a reduced cooling effect through high numbers of individuals being placed into the hold. In this respect, reducing the length of fishing trips may be an important precursor to ensuring reduced PHFL and therefore reduced economic loss of fish. Unfortunately, there has been a change in the last few years of artisanal fishers moving away from coastal areas to offshore habitats, due to diminishing returns from coastal habitats (likely associated with overfishing of key stocks).

Where such longer trips are undertaken, there must be an impetus for reducing ice-loss within the holds, and optimising the cold chain storage. In this respect, the use of well-insulated holds will be vital. However, fishers must also be supplied a sufficient quantity of ice at the start of the trip. Stakeholders have stated that artisanal fishes are not always able to attain adequate quantities of ice at the start of their trip, which may will be vital to ensure landed fish are kept at a storage temperature below at which deterioration of the fish occurs.

4 Section 3 Reducing fish waste and wastage within the Seychelles – how to create economic development

Within this third section of the project, we utilise the outputs from Tasks 1 – 3 and the range of waste streams that are produced by the artisanal and semi-industrial fishing sectors to develop clear recommendations for utilising such streams. These focus on two separate processes. The first process is focused on understanding the different ways in which waste streams may be utilised to produce new products (i.e., valorisation and development of biproducts using such waste streams). In this respect, we discuss the various waste streams developed within the Seychelles and then examine international best practice methodology, including logistic needs and challenges to utilise such waste streams to produce viable and economically feasible products. The second process is in defining the waste streams that will not provide a commercially viable product, and therefore must be discarded. In this respect, we discuss the various ways in which the Seychelles can reduce waste disposal procedures or in the very least make these as environmentally sustainable as possible.

4.1 Recommendations for recovery products (Task 5)

Within this section we use the outcomes of Tasks 1 – 3, regarding where fish waste is predominantly developed within the Seychelles fishing industry, and build on the relevant technologies and practices available to the Seychelles to mitigate PHFL (Task 4), to examine the different options that would be available to this industry to develop recovery products (i.e., valorising 'waste' resources). Within the Seychelles fishing industry (focusing solely on the semi-industrial and artisanal sectors), there are five predominant 'waste' streams: fish heads, fish guts, fish skin, fish carcasses, and (seasonally) whole fish (e.g., mackerel).

Fish heads: These can be part of the waste stream developed during disembarkation (in the harbour), with fish heads disarticulated and stored on-board the vessel for disposal at sea (Figure 8). Fish heads may also form an important waste stream within the processors factories, if whole fish are landed and sent directly to processors. Fish heads may also form part of the waste stream developed within local markets, associated with buyers asking sellers to process single fish following purchase of the fish.

Fish guts: These form part of the waste stream on-board vessels (semi-industrial), where landed fish are gutted (on board the vessel) and such guts (i.e., offal) discarded at sea. As in fish heads, fish guts as a waste stream may also form part of the waste stream within local markets, associated with buyers asking sellers to process single fish following purchase of the fish

Fish skin: During the processing of fish caught by the semi-industrial fishery (within processing plants), the skin is discarded with other offcuts from the fish. If the fish (i.e., tuna) are being canned, such skinning may occur after steaming of the fish. If fish are being sold as frozen or fresh, such skinning will occur when the fish are filleted. Such waste may also be produced within local markets, if processing of sold fish are undertaken.

Fish carcasses: Within the fish processing in Seychelles (from the semi-industrial fishing sector, but also from the artisanal fishery – e.g., within Rass Fish), fish carcasses (i.e., the frame, consisting solely of the backbone and ribs of the fish) are the end result of the fish processing. Within the IOT and Rass Fish such frames may be processed into fish meal, all other processors discard such frames. Included in these frames may also be offcuts of the

filleting process, including skin and meat, due to low quality filleting machinery or (if undertaken by hand) low skilled processors.

Whole fish: Seasonally, there are some fish species that are landed in high numbers and are unable to be sold in such volumes or are landed are only sold as fresh fish. For example, within the Seychelles mackerel is landed in high volume, but is only sold as fresh fish, with local tastes not extending to processed fish. Therefore, if there is no market for the fish the day (or the next day) it is landed, this fish is discarded. Such discarding predominantly entails burying of the fish.

Figure 8 Processing of tuna on-board semi-industrial vessel (in the harbour), with recently separated tuna heads in the background (circled).

There are a number of instances in which the waste streams within the PH industry are being utilised currently within the Seychelles, and several instances where historically these waste streams have been used. Below we provide a synopsis of this information and discuss the challenges in further developing valorisation. This work utilises the output from the stakeholder engagement undertaken within the Seychelles to determine the range of different valorisation options. In this respect, stakeholders were asked to provide their opinion on five listed valorisation options, as well as to provide any further valorisation options. The listed options to stakeholders were:

- Production of fishmeal and fish oil for sale in animal, aqua and pet food industries;
- Ensiling (using formic acid to produce fish silage from fish by-products) to develop ingredients (hydrolysed protein and oil products) for animal and aqua feed;
- Compost production for land restoration, horticulture and agriculture as organic fertiliser;
- Anaerobic digestion with energy recovery (i.e., methane) to produce renewable energy which can be sold to the local power station; and
- Freezing of fish waste to utilise as frozen bait for the local market.

Fishmeal and fish oil

The bulk of the world's fish meal and oil is today manufactured by the wet pressing method. The main steps of the process are cooking for coagulation of the protein thereby liberating bound water and oil, separation by pressing of the coagulate yielding a solid phase

(presscake) containing 60-80% of the oil-free dry matter (protein, bones) and oil, and a liquid phase (press liquor) containing water and the rest of the solids (oil, dissolved and suspended protein, vitamins and minerals). The main part of the sludge in the press liquor is removed by centrifugation in a decanter and the oil is subsequently removed by centrifuge. The stickwater is concentrated in multi-effect evaporators and the concentrate is thoroughly mixed with the presscake, which is then dehydrated usually by two-stage drying. The dried material is milled and stored in bags or in bulk. The oil is stored in tanks (FAO, 1986)

Within the Seychelles 'fish meal' may encompass two different products. The first is the dried fish meal which is the outcome of the above process. The other product which can be labelled as 'fish meal' is simply raw waste from the processing of fish, which is then mashed and sold as fresh or frozen as dog food.

The IOT currently produce (dried) fish meal utilising the tuna frames processed in their factory (predominantly yellowfin and bigeye). The IOT holds the largest fish meal processing plant in the Indian Ocean and one of the largest fish processing facilities. Importantly, this ensures that there is a steady supply of fish waste stream to utilise for the production of fish meal. In addition, Rass Fish Factory (based in Victoria) have recently started to produce fish meal within their factory (mashed fish waste). This is relatively small scale and only takes fishes from the artisanal fishery sector. The majority of the processors within the Seychelles will sporadically produce a mashed fish waste product for use as pet (dog) food.

The IOT produce fish oil from the waste associated with the processing of tuna within their factory. This process was historically run by a company called Ocean Products Seychelles (OPS), which belonged to GOIA Ltd. Their processing was associated with the valorisation of raw material derived from IOTs tuna (i.e., heads of yellowfin and skipjack tuna) processing into high quality products (i.e., omega 3 rich fish oil), intended for nutritional applications. The IOT have taken over the machinery and now produces the fish oil.

Challenges:

- The processing of fish meal or fish oil produces a strong odour, which can be reduced through use of different air filters, but is always going to be a part of the process.
- There is also the need for constant supply of fish, as it takes four or five tonnes of fish to manufacture one tonne of dry fishmeal.
    - In terms of supply, there are no opportunities to store waste from cleaning on board vessels (i.e., heads), therefore any processing that occurs on-board vessels will not be available for use to make fish meal or fish oil
    - In terms of supply, there are no opportunities to store damaged fishes separately on ice on board vessels, so they can be used for further processing of fish meal or fish oil
- Development of fish meal within a processor will need to have support to purchase corresponding specialised machinery/equipment (e.g., to get rid of the salt in the fish waste). The development of this process will also require training of staff.
- The cost of utilities is very high, making it easier and cheaper to get rid of the fish waste than process it.
- Bigger industrial fish processing units usually process the by-products into fishmeal and fish oil. For small-scale processing units, as those that exist predominantly in the Seychelles Islands, however, investing in a fishmeal plant is not economically viable, unless at least 8 tonnes of raw material are available daily (more than 2,000 tonnes per year).
- There must be a high level of traceability in the waste. This will be vital if products are to be sold overseas. Without such traceability there is no way that processors are able

to ensure the chain of custody.
- Such lack of traceability will also be the reason why large processors (e.g., IOT) will not use waste from other processors, as there is no chain of custody associated with such waste, and the IOT cannot ensure the traceability of the waste.

Recommendations:

- Economic support for further processors to start making fish meal, but this will be expensive and need for processors to develop new machinery, as well as further use utilities which are expensive.
    - However, even with a low budget the unwanted parts of fish processing can be traditionally processed into fish meal – such is being done in Rass Fish factory
    - Both on vessels and within processing plants/markets there is a need to provide storage for store fish waste separately. This could entail providing bins for such storage.
- Processors currently working in the Seychelles (e.g., Amirante Fisheries, Ocean Basket) provide their waste streams to the IOT to produce fish meal. This is because it may be too expensive for an individual to venture into it (as the cost of setting up processing machines as well as the cost of utilities are very high in the Seychelles) and therefore there is a need for support from larger organisations to undertake such processing.
    - All processors may potentially need to be able to show the chain of custody of such waste products.
- The quality of the fish meal will also depend on the species used. Within the Seychelles tuna would be the most obvious species to use to develop fish meal. Mackerel may also be useful for such a process, as this species is thrown away when it can't be sold as fresh in the market.
- Ensure that there is a ready market for such a product.

Ensiling (production of fish silage)

The fish silage process (i.e., ensiling) transforms fish waste into a liquid mix of hydrolysed proteins, lipids, minerals and other nutrients, easily digestible by both terrestrial and aquatic animals, while this product can also serve as an excellent fertilizer. Silage produced by adding an organic acid or by adding a fermentable substrate and a bacterial culture, which produces an organic acid, can be stored for years and used when needed.

There are no processing facilities within the Seychelles that utilise ensiling to develop fish silage. However, there are well developed manuals to produce fish silage using such a process[11]. The product out of the ensiling process is mainly utilised in aquaculture facilities, which at present are not well developed within the Seychelles.

Challenges:

- Availability of raw product to develop using ensiling, as there are no opportunities to store waste from cleaning on board vessels, therefore all raw material must be sourced from processors or in local markets

Recommendations:

11 https://www.fao.org/3/i9606en/I9606EN.pdf

- Stakeholders stated that such a process could be implemented within the Seychelles, if waste streams are minced, staff are trained appropriate and the necessary equipment made available.
    - There are a range of basic manuals (produced through the FAO) that provide appropriate methodology for the development of silage.
- Setting up a small-scale unit for fish silage production does not require sophisticated and expensive equipment nor highly advanced training.
- Ensuring there is a market for the final production and sufficient volumes to ensure it is economically viable.

Freezing of fish waste

Freezing encompasses taking the fish waste from processors and freezing it to be sold locally as pet food or fishing bait. Within the Seychelles, freezing of the waste streams from processing is already occurring. For example, frozen dorado and tuna belly have been offered from Oceana Fisheries for bait for local fishermen, while several other processors will provide frozen fish waste for sale. Fish which are destined to be used as dog food is predominantly brined and frozen from the purse seiners that catch them. The frozen fish are then cut into chunks by a band saw and kept frozen until they are purchased by customers.

Challenges

- Some stakeholders stated that the commercial development of frozen fish bait is not going to work, as the quality, the colour of the bait impacts on the type of fish caught.
- Stakeholders also stated that such products may be more suitable as chum and could reduce the baiting process on board the vessel.
- Utilities costs are very high within the Seychelles, with any freezing (and potentially storage) of fish waste likely having a substantial cost to the processor.
- The retail value of pet food/frozen bait is low.

Recommendations

- As the freezing of fish waste could be undertaken at very little cost, there is the likelihood of setting up equipment to provide freezer fish waste at local markets.
- Such costs of processing/storage need to be assessed against the price at which such products can be locally sold.
- If such products were to be developed for an international market, they would need to be able to be traced back to a sustainable supply (e.g., provide a documented chain of custody).

4.1.1 Optimising the Seychelles PH industry – what further changes could be made to utilise fish waste streams?

There are a number of different practices that could be developed within the Seychelles PH industry to further the valorisation of different types of fish waste streams. Of these, there are three main practices that could advance the industry and ensure that it is able to sustainably utilise the fish waste resource produced within the country.

Traceability to ensure cooperation: There is a lack of processing capacity for fish waste in the Seychelles. In this respect, the larger processing companies that already have the machinery, capacity and knowledge to utilise waste streams (e.g., IOT) need to be able to support the smaller processors by buying and using their waste streams.

Development of suitable processing facilities: Although it is outside the scope of the project, there is need to ensure the development of processing factories that are divided up into different areas for processing. Importantly, the requirements of HACCP[12] are that waste streams that are for human use are kept apart from those used for animal feed. Therefore, the further development of processing facilities within the Seychelles must take into account the likelihood that factories that process and market high-grade fish products (e.g., fillets) must also be able to process low-grade/waste streams within the same premises.

Certification in the sustainable use of fish waste/waste streams: At present, the only regulations or certification systems that focus on sustainability of waste streams focus solely on appropriate disposal of the waste streams (e.g., in line with HACCP). There is nothing, either national/international regulations or certification systems, that ensure processors 'sustainably' use their waste streams. In this respect, sustainability would be associated with ensuring the development of waste streams into biproducts. Of the certification systems that focus on seafood, (e.g., Friend of the Sea, ISSF) these focus solely on the traceability of the resource (i.e., to ensure seafood is sourced from a reputable and sustainably fished fishery). In this respect, there is no regional or global certification systems (and no national regulations) to ensure processors further their ability to reuse and valorise by-products and residue streams generated from seafood processing.

To further the development of biproducts and the valorisation of fish waste streams in the Seychelles, there is a need to develop regulations that prioritise the use of such waste streams, and therefore promote more efficient production practices that reduce biomass, energy, or nutrient losses. The development of such practices must take into account the variety of sources from the seafood sector, including the potential volume, value and quality of waste resources. Importantly, such waste streams should be treated on-site as food grade if required for food ingredient generation or feed grade if processed further by approved animal by-product operators. Inherently, some waste streams may need to be discharged to the marine environment, sent to sewage treatment plants, or disposed of in landfills due to the quantities being generated and the requirement for sanitary disposal (e.g., blood, mucus, and residue muscle proteins). However, where possible, actions to reduce and valorise these by-products into food-grade and value-added food ingredients, should be taken.

4.2 Identify solutions and methods for fisheries waste disposal that meet the environmental policies of Seychelles (Task 6)

Fish waste is not only a major environmental problem, but also a huge economic loss. For this reason, a better fish-waste management is needed to overcome these important issues. In this respect, this work has been developed in line with the Seychelles National Waste Policy (2018 – 2023)

. In particular, this work aligns with the Waste Hierarchy, where the development of waste management strategies primarily aims to prevent the generation of waste and to reduce its harmfulness; where this is not possible, waste materials should be reused, recycled or recovered, or used as a source of energy, with as a final resort, waste disposed.

The goal of this Task has been to provide recommendations for the effective disposal of fish waste products, where such waste is unable to be used for by-products. Solid waste management (SWM) has been previously identified as a pressing issue in the Seychelles,

12 HACCP is a management system in which food safety is addressed through the analysis and control of biological, chemical, and physical hazards from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product

requiring a long-term solution (Lai *et al.*, 2016; Krütli *et al.*, 2018). In this respect, scarce land resources represent a crucial limiting factor for local SWM in general and landfilling as the currently employed waste management strategy in particular. Landfilling also produces greenhouse gases and, without proper containment measures, most likely releases leachate that raises potential environmental concerns.

A particular challenge for solid waste management development in the Seychelles is scale. Due to the small population of the country and fragmentation of the territory in its several islands, there is little capital available to support SWM projects, particularly to stimulate recycling initiatives or advanced waste treatment. Additionally, the low volume of total waste generated provides insufficient quantities to have technically feasible treatment systems. The small economies of scale prevent waste businesses from generating revenues to overcome operation and investment costs. Consequently, landfilling presents a seemingly cheaper option for waste treatment, but this poses long term sustainability issues.

Though limited valorisation within the Seychelles may prove effective for handling fish wastes from specific processors (i.e., IOT), the products produced are of low value and likely not economically feasible for small processors to develop. In addition, currently, fish waste generated in the Seychelles is of poor quality, it is not hygienically handled and storage temperatures are often uncontrolled leading to rapid spoilage. In order to yield the best quality for many of these waste products, which in turn would generate the most income, fish waste would have to be handled and stored under hygienic conditions and suitably preserved. Such levels of hygiene will need substantial investment in freezing equipment and storage space. Therefore, the likelihood of processing waste being sent to landfill is still high within the Seychelles. Therefore, in this section we examine a number of ways to potentially minimise the volume of waste generated from the postharvest industry, and therefore reduce the amount deposited in landfill.

Changing of legislation to reduce waste disposal in landfill

The primary way to potentially reduce waste sent to landfill is to introduce further legislation to advance producers to use other routes than landfill (even if it is more expensive). For example, under the Animal By-products Order 1999[13] (United Kingdom), the burial and burning (including landfill) of animal waste from processing and retailing facilities is prohibited if an alternative permitted disposal route exists. If it is possible to take, or arrange for someone else to take, the waste to a disposal route which does not involve burial or burning, that route must be taken, even if it is more expensive. There would be exceptions to this, including if animal waste is in a place where access is difficult or if the quantity of material and distance to premises in which disposal is otherwise permitted do not justify transporting it.

Such changes in legislation will need to be supported (at least in the early phases of implementation) by economic incentives. In this respect, there must be initiatives to enhance the likelihood of producers looking for other ways of processing their waste. Such initiatives must also take into account that any change in legislation need to be aware of the difficulties that disposing of postharvest waste entail. Where those processing fish have little to no option for any other disposal than the use of landfills (or some equivalent of waste disposal), then such activities must be acknowledged. Further infrastructural development may be needed to ensure there are routes to which the majority of processors are able to access to reduce their waste being sent to landfill.

13 https://www.legislation.gov.uk/uksi/1999/646/contents/made

Processing waste at sea

There is already a portion of processing waste (both from the semi-industrial and artisanal fishing industries) that will be discarded at sea. In addition, especially within the artisanal fishing sector, cleaning of fish will occur near the shore (e.g., in the harbour, when landing on a beach), with the waste from such processing likely being thrown into the adjacent water body. This can be a safe and effective means of reducing the amount of waste which is accumulated and sent to on-shore landfills.

Processing waste produced at sea is however, nutritionally rich and can be effectively utilised to produce a range of low-quality fertilisers. However, this waste also contains a high proportion of enzymes and, in the case of viscera, bacteria, resulting in a high rate of spoilage. Therefore, to be used to produce by-products, the material will need to be landed fresh, effective preservation and stowage systems would have to be used on boats to be able to sore such waste, while trip lengths limited. Care would also be necessary to ensure adequate hygiene standards, including separation between edible fish and waste.

With the limited stowage area already available on vessels within the semi-industrial and artisanal fishing fleet, there is likely little impetus to utilise such area for storing fish waste. Such utilisation could be considered, particularly if there are agricultural markets for the product close to the major fish landing centres. However, the low economic value of such products in comparison with the much higher economic value of fish bodies, likely will lead to little interest in retaining such waste.

Further use of different waste streams as (non-processed) products

In reducing the amount of fish waste that is sent to landfill, there is also the need to look further into the different types of products that could be used from fish processing activities. In this respect, there are a range of different parts of processed fish that, without substantial post-processing may form important marketable products

Tongues, Cheeks and Fins: The tongues, cheeks and fins of large fish can be recovered either manually or mechanically. Tongues and cheeks are retailed in some parts of Europe at similar prices to fillets. Tongue and cheek meat can also be used in the production of fish mince or directly in pies, fishcakes and re-formed products. In this respect, tongues and fins from sharks and other cartilaginous species are sought after in Eastern countries for culinary and medicinal purposes.

Fish Heads: Salted and fermented fish heads are considered a delicacy in Nigeria, while in Iceland, popular dishes include dried fish heads softened in dairy whey.

Fish Stomachs: Fish stomachs and fish bladders are considered a culinary delicacy in Iceland, Japan and other Eastern countries. Stomachs must be removed as soon as possible after capture and immediately frozen or kept on ice as only fresh, high-quality stomachs are acceptable. In Japan fish stomachs are often stewed with vegetables and spices. The stomachs may also be partially hydrolysed to create 'changi' a dish with a characteristic flavour and texture or they can be fully hydrolysed to make a highly prized sauce or stock. In Iceland, fish stomach filled with a piece of fish liver is a popular dish.

Roe: Fish roe is derived from the eggs carried by the female during the breeding season. Although caviar is the most famous roe product in Europe and Japan, roe from other fish is eaten in many forms. Milt (fish sperm) can also be eaten. Importantly, roe can make up a large part of the body weight of the fish. Roe is often smoked or dyed red or black to satisfy customer preferences. It may then be frozen, canned or eaten fresh.

Fish Soups, Stocks and Sauces: In some countries, notably in France, fish waste is used in the production of fish soups, stocks and sauces for retail sale. Such products are extremely popular in many Asian countries where they form a staple part of the diet.

Composting

Composting is the process whereby fish waste is mixed with plant waste such as wood chips, leaves, bark, branches, peat, or even sawdust and buried. This process results in microorganisms breaking the fish down, which generates heat which then pasteurizes the resulting fish compost. During this process, the input is reduced to roughly 60% of its initial mass. Compost is a stable soil like material, which improves the soil structure and increases its nutrient availability. Composting is a very well-known and widely applied technology in the Seychelles and therefore could be undertaken to reduce the amount of fish waste sent to landfill.

At present, with the Seychelles there are no commercial processing plants that undertake composting procedures using fish waste. In addition, there were some stakeholders that felt composting was not a viable option, due to the cost of production and the amount of land area that is needed to develop suitable composting facilities. However, if sufficient land was made available, stakeholders felt that composting may be a feasible option, as long as the fish waste was minced. Importantly, composting (expected to be on a very small scale) has been recently adopted by the Rass Fish factory. In fact, composting (or some level of it) is already undertaken within the Seychelles. This is mainly associated with artisanal fisheries, following fishers being unable to sell their produce. This is because it is easier and cheaper to compost or bury on agricultural land for cultivation purposes.

Anaerobic digestion with energy recovery

Anaerobic Digestion is a process enabling the creation of biogas (methane-rich gas) via microbiological digestion of the fish waste in anaerobic conditions. The result of the anaerobic digestion, known as digestate, can be treated as a residue in the form of energy (with a smaller volume), or as a by-product to be used as an agricultural fertilizer. There is the potential for utilising anaerobic digestion to reduce the volume of fish processing waste being sent to landfill. Anaerobic digestion is microbiological degradation of organic waste under the absence of oxygen, of which such processes can reduce the volume of initial input material down to 20%.

The utility of developing an anaerobic digestion plant for the Seychelles has been recently examined (Krütli *et al.*, 2018). This work shows that, dependent on the amount of organic waste that is treated and the quality of that input, a potential anaerobic plant within the Seychelles could reduce the amount of raw fish waste that is sent to landfill, while producing a product that could substitute imported fertiliser and fodder.

The IOT has its own waste water treatment plant (WWTP) and AD plant to process all its organic waste. This processing plant produces 2,000 cubic metres/day of wastewater in its processing and canning operations, with the WWTP designed to remove over 95% of organic contaminants from this waste stream. Such a plant is able to substantially reduce the amount of waste produced by the IOT processing plant, that is disposed of in the local landfill.

The plant consists of an aerobic wastewater treatment as well as an anaerobic digestion step for sludge and slurries. The anaerobic treatment converts organic contamination in sludge and wastewater into biogas, which can be turned into methane and later utilized for energy production and used as fuel for electric power generators or to replace fossil fuels in steam boilers and heaters on the production site.

Further development of separate waste water treatment facilities at each fish processing plant within the Seychelles is likely not an option – both in terms of cost and available space. However, there is a need to examine the utilisation of such waste water treatment plants between several processors. In this respect, there are a range of other processors that are relatively close to this WWTP that could conceivably utilise such facilities. This includes Oceana Fisheries and Sea Harvest, of which both substantial send their fish processing waste to landfill.

However, there are no processors within the Seychelles that are undertaking anaerobic digestion and (to our knowledge) no governmental departments that are requiring the use of anaerobic digestion and energy recovery for future green energy directives. *Processors within the Seychelles* when questioned about anaerobic digestion, stated that the development of such procedures needs to be supported by the government, but that the development of such procedures was viable within the Seychelles.

Incineration

Incineration as a waste treatment technology efficiently reduces waste volume and demand for landfill space. Combustion offers high disinfection of waste, and energy can be recovered for heat or power production. Such technology is well established with state-of- the-art incineration plants effectively reducing municipal, industrial and commercial waste. Despite this, substantial incineration facilities are not yet established in Africa and especially not in Small Island Developing States (SIDS). Such plants need a high degree of investment, with relatively high operating costs and skilled staff.

Although waste incineration technology offers many advantages without heavily depending on enhanced sorting of waste fractions, there is no largescale incineration technology for waste management in the Seychelles. In addition, recent work examining the utility of using incineration to reduce the amount of fish waste (i.e., termed 'putrescent waste') to landfill (Krütli *et al.*, 2018), showed that such waste would not be feasibly reduced by incineration. This is because such waste (which has a high level of liquid within it) is not suitable for grate incineration, due to the liquids seeping through and not being effectively incinerated in such a process. This then would lead to such waste then being mixed in with the ash and discarded within the landfill – negating any utility in being added to an incinerator.

5 Section 4 Framework, recommendations and policy analysis

Within this last section of this project, we develop the overall framework for monitoring of PHFL within the Seychelles, a set of validated recommendations (following from the in-person workshop) and the range of policies that may be developed by the SFA to further the reduction in PHFL within the artisanal and semi-industrial fishing sectors.

This Task also entailed hosting a workshop within the Seychelles, in which the key stakeholders (identified within Task 1, and utilised throughout the project) were invited to attend. This workshop was used to provide an overview of the entire project outcome, including discussing the breadth of PHFL (Task 1, 2), the ground truthing of such FL (Task 3), the practices, technologies to develop waste streams into viable products (Task 4) and the breadth of products that could be encompassed by the Seychelles fishing industry (Task 5), as well as the potential waste management systems needed within the island (Task 6). This workshop then entailed providing detailed training to stakeholders on the monitoring framework, tools, data collection and reporting needed to continuously monitor fish losses (see above Task 7).

5.1 Framework, reporting tools and database development for continuous monitoring of PHFL; stakeholder training on the monitoring framework, tools, data collection and reporting (Task 7)

This Task has entailed developing an easy-to-use reporting tool for all fishers and processing companies to use to report PHFL. This framework has entailed developing a short and concise reporting form within an excel database to which boat and factory owners can itemise/report their weekly/monthly/bi-monthly discard/fish loss. This reporting form has been developed to enable it to be sent to the SFA to be uploaded into a pre-formed excel database developed by the contractors to handle such data.

5.1.1 Framework

Traceability in sourcing of materials may be an important mandate in the use and further development of a framework. For example, Friend of the Sea has a certification for sustainable development of fish feed, fishmeal, fish oil and omega 3[14]. This predominantly focuses on the traceability systems used by the processors. Such systems are to ensure that the raw material used for production originates from certified fisheries and fish farms, or from sustainable sources. Importantly, the origin of material used is traceable back to the suppliers and that these are certified. However, certification is not associated with any best practice on use of waste streams.

5.1.2 Outcomes of the workshop

This Task entailed leading an in-country workshop (10th October, 2023), in which key stakeholders were invited to attend. This workshop provided an overview of the entire project outcome, including discussing the breadth of PHFL (Task 1, 2), the ground truthing of such FL (Task 3), the practices, technologies to develop waste streams into viable products (Task 4) and the breadth of products that could be encompassed by the Seychelles fishing industry

14 https://friendofthesea.org/wp-content/uploads/Audit-Guidance-for-Friend-of-the-Sea-Standards_v1.pdf

(Task 5), as well as the potential waste management systems needed within the island (Task 6). In-group discussions were then facilitated by the contractors to determine any recommendations from stakeholders in enhancing any of the outputs described.

There was relatively poor turnout of stakeholders within the workshop, with three individuals representing government (fisheries export), industrial processors (Indian Ocean tuna Ltd) and artisanal fisheries (head of the Belombre Fishing Association); the SFA and Department of Fisheries were also represented. The lack of workshop attendance led to the SFA requesting MRAG to undertake a further online workshop with a wider stakeholder base. This online workshop will be undertaken within November 2023.

Despite the low turnout, there was a good discussion of the recommendations from the project. In this respect, several points were stated to enhance reducing PHFL within the Seychelles:

1. IOT is interested in taking other processors fishing waste – further discussion between the SFA and IOT is recommended;
2. There is further need to enhance the availability of ice and allotment of ice for all fishers;
3. Further work is needed to ensure all stakeholders selling fish have undertaken training in best practice in handling food products;
4. There is a need to update the legislation within the Seychelles to ensure PH is taken into account; and
5. The market regulations for the Seychelles are in need of update.

This workshop also entailed providing training to stakeholders on the monitoring framework, tools, data collection and reporting needed to continuously monitor fish losses. This framework can be used by the SFA to ensure stakeholders collection information on PHFL. The framework has been provided to the SFA as several excel datasheets, with a screen shot provided for understanding by the readers of this report (Annex 5).

5.2 Policies supporting PHFL and waste reduction and promoting opportunities for investment in recovery products (Task 8)

Within this section we provide a synopsis of the relevant Seychelles legislation and regulation associated with fisheries, focusing on where policies associated with the postharvest industry have been developed and implemented. In this synopsis we view legislation and regulation as two separate concepts: legislation sets out the principles of public policy, whereas regulation implements these principles, bringing legislation into effect.

5.2.1 Legislation and the policies associated with postharvest and PHFL

There are two acts of legislation that have been developed to legislate fishing within the Seychelles, of which one is the main Fisheries Act, the other the legal vehicle for the establishment of the Seychelles Fishing Authority[15]. Two further acts have been identified that may contribute to the successful development of the postharvest industry within the Seychelles, these acts have been developed to ensure a safe and clean environment, as well as to provide safe and health food for the Seychelles population. Below we provide a synopsis

15 http://www.mofbe.gov.sc/fisheries-legislations-and-regulations/

of the relevant sections within each regulation that encompass the postharvest industry, and where changes/additions to such regulations would enhance the postharvest industry.

The following legislation was assessed within this work:

- Fisheries Act of 2014;
- Seychelles Fishing Authority, Establishment Act of 1984;
- Environment Protection Act, 2016; and
- Food Act, 2014.

Fisheries Act of 2014

This legislation encapsulates fishing activities throughout the Seychelles. However, there is nothing within the Fisheries Act in terms of postharvest activities. In this respect, as the postharvest industry is an integral part of the fishing industry within the Seychelles, updates to the Fisheries Act, 2014 could entail further articles that ensure the sustainability of this industry.

Seychelles Fishing Authority (Establishment) Act, 1984

This legislation summarises the mandate of the SFA. There is a single article (6(1)) which mentions that the SFA can carry on any business or enterprise that is associated with postharvest processing, which likely encompasses ice production and managing its distribution, but there is no detail on how this may be best undertaken. However, this enables the SFA to ensure the quality of such activities.

6. (1) Subject to this Act, the Authority has power to do all things necessary or convenient to be done for or in connection with, or incidental to, the performance of its functions and, in particular the Authority may -

(g) carry on any business or enterprise for or in connection with -

(ii) processing, transporting, handling, marketing or distributing fish or fish products;

(iii) exporting fish or fish products;

Food Act, 2014

Within the 2014 Food Act, several articles provide legislation designed to ensure the quality of food products sold within the Seychelles. In this respect, such articles may be suitable for assessment/enactment within postharvest activities. Below we list out such articles and provide a short discussion of their potential utility within the postharvest industry, and where updates/alignment may be needed to ensure suitability.

5 (3) (i) The functions of the competent authority shall be to 'ensure the implementation of appropriate prerequisite programmes including food hygiene and sanitation practices, food safety management system, including good agricultural practices, good manufacturing practices or hazard analysis critical control point, by approved food and feed establishments, food and feed business operators, food and feed importers and exporters, for the handling, processing, manufacturing, transportation, storage and distribution and exportation of food

This article summarises some of the actions that the competent authority must undertake – in this legislation the competent authority is the Public Health Authority, which is under the Ministry of Health within the Seychelles. For this particular article, the actions the Public Health Authority should be undertaking is to provide programmes for Seychelles vendors to learn good practices in food hygiene and sanitation processes, as well as food safety and the use of HACCP in their business. Such programmes are likely to be exceptionally beneficial for all fish mongers within the Seychelles, including those using local markets to sell their fish

(predominantly caught by the artisanal fishing fleet within the Seychelles). Ensuring that the Public Health Authority make such programmes available to fishmongers, will further ensure those marketing fish products are aware of the best practice to keep their product as fresh as possible.

12 (1) A person shall not sell, prepare, package, store, distribute, or display for sale any food under insanitary conditions, whereby the food may be contaminated with physical, biological and chemical contamination or may be rendered unfit for human consumption

This article stipulates the level of quality that a certain food item must be in to be able to be sold. In this respect, there will be a need to ensure such quality is inherent within the fishes (and any invertebrates, as needed) brought to market within the Seychelles. However, this will also need to be monitored by the Public Health Authority, especially where fish are being sold outside of identified markets (i.e., road side stalls).

15 (1) All approved food business operators shall undergo Food Handlers and Food Hygiene Training approved by the Competent Authority

This article builds on Article 5(3) by stating that those within the food industry much undergo specific training approved by the Public Health Authority. Such training should be undertaken for all fishers that sell their fish at markets or within road side stalls, to ensure that they are using best practice to keep their product as fresh as possible for as long as possible.

Environment Protection Act, 2016

This legislation regulates all activities that may pollute the Seychelles environment. There is nothing within this act in terms of postharvest activities.

5.2.2 Fisheries regulations associated with postharvest and PHFL

There are seven regulations that have been developed that encompass aspects to regulate the fishing industry within the Seychelles. These regulations encompass licences, fishing and shark finning, as well as long term strategies for ensuring sustainability of the fishing industry within the Seychelles. Below we provide a synopsis of the relevant sections within each regulation that encompass the postharvest industry, and where changes/additions to such regulations would enhance the postharvest industry.

The following regulations were assessed within this work:

- Public Health Market Regulations, 1975;
- Licenses (Fisheries) Regulations 1987;
- Fisheries Regulations of 1987 as amended;
- Fisheries (Shark Finning) Regulations of 2006 (under Fisheries Act, 2014);
- Fisheries (Mahe Plateau Trap and Line Fishery) regulations, 2021 (under Fisheries Act, 2014);
- Seychelles Fisheries Sector Policy and Strategy 2019;
- Harvest strategy policy and management standards for Seychelles' fisheries; and
- Environment Protection (Waste Services) Regulation, 2021.

Public Health Market Regulations, 1975

This outlines regulations for the safe and effective implementation of food markets throughout the Seychelles. However, the regulations were last updated in 1975 (although have been consolidated to 30 June 2012) and there are clear changes that are needed. Below we provide

each of the regulations that may impact the postharvest industry, the amendment needed in each regulation and the reason for such change.

1. These Regulations consolidate the La Digue, Victoria, Mont Fleuri, Les Mamelles, Praslin and South Mahe Market Regulations

Both Mont Fleuri and Les Mamelles are now inactive and abandoned. In addition, this list of markets needs to now include the following active markets: Belombre, Anse Etoile, Perseverance, Cascade, Anse Aux Pins (Opposite Seychelles Commercial Bank), Anse Royale, Baie St Anne and Grand Anse Praslin.

The market regulations have also been developed to ensure the safe and effective implementation of 'official' markets within the Seychelles. This may mean that any other roadside stalls where fish are marketed and sold are not obliged to adhere to the health and safety practices inherent within the regulations. In this respect, these market regulations need to be expanded to encompass any area in which fish are marketed and sold.

2. (1) The opening hour of a market on days other than Sundays and public holidays shall be- (a) 5.00 a.m. in La Digue (b) 5.30 a.m. in Les Mamelles, Mont Fleuri and Victoria. (c) 6.00 a.m. in Praslin; and (d) 6.30 a.m. in South Mahe

It will be important to ensure that such opening hours align with the landing time of vessels. This will be to ensure the time between fishers landing their catch and bringing these to market is reduced as much as possible.

3. The market shall be cleaned at the end of every day and shall be closed and remain closed until the opening hours of the following morning

There needs to be further stipulation in the level and type of cleaning, including the disinfectants used and level of sanitary quality expected from such cleaning. Such measures should also be associated with weekly checks on the level of cleanliness and whether further cleaning (more frequent) is needed. The market must also have proper drains to receive the washing water and these must be well kept in order to avoid clogging and other problems that result in deficient drainage.

4. No person who has not disposed of any fish or meat before the closing of the market for the day shall sell any such fish or meat outside the market.

There needs to be clear guidance on how this is regulated and enforced.

> *26. (1) No fresh meat, fish or turtle shall be sold or exposed for sale within the limits prescribed in sub regulation (2) in any place other than the market.*

The taking, selling or buying of turtles is illegal under the Wild Animals and Birds Protection Act. Any regulations associated with marketing of turtle meat should be deleted from this regulation

This regulation should also be updated to ensure that fish sold within markets are sitting on/covered in ice until being sold. This regulation must therefore detail how best to keep the cold chain management unbroken from the fisher to the retailer and consumer.

> *26. (1) No fresh meat, fish or turtle shall be sold or exposed for sale within the limits prescribed in sub regulation (2) in any place other than the market. (2) The limits prescribed for the purposes of sub regulation (1) are – (a) An area bounded by the reef on the North, boundary line separating Miss Edoxie Vidot's property from the property of Heirs Kanabady up to the mountain range on the East, mountain range on the south and from*

the Cross near Union Junction following the track up to the main road and from there following the boundary line separating Mr Hossen's property from Mr. Payet's property until it reaches the mountain range on the West, in La Passe, La Digue. (b) An area between Point Cabris at one end and the boundary between the Cotes D'Or Estate and that of Mr. James Sullivan at the other end, in Baie Ste Anne, Praslin. (c) An area bounded by Grosse Roche on the South East, by Pont Bacar on the West, by the mountain side on the North and the reef on the South, in Grand Anse, Praslin. (d) An area bounded by a straight line drawn from Mr. Joseph Jumeau's bridge to the Junction of the Sweet-Escott Cannelles Road and from there to the bridge forming the boundary between Heirs F. Hoareau and Mr. F. Dingwall and on the third side by the sea, in South Mahe.

Such limits should now be updated with GPS points instead of family names and properties

(3) No fresh meat, fish or turtle shall be sold or exposed for sale in Les Mamelles, Mont Fleuri and Victoria in any place other than the market.

This does not take into account that fish are sold fresh from roadside stalls. Therefore, there is a need to ensure that such modes of marketing are included within these regulations, and the proper health and safety measures are stipulated.

17. No person shall sit on or lean against any stall in the market or sing, whistle, shout or make any noise whatsoever in the market.

Unsure of the utility of this regulation and the need for it. This should be deleted

22. Every butcher shall provide, at his own expense, a block whereon to cut his meat. No meat shall be cut except on such block. All butcher's meat shall be exposed for sale on a clean white cloth which shall be renewed daily and covered with clean white gauze so as to prevent flies having access to the meat.

This should be amended to include fishmongers to ensure that any processing of fish is undertaken in the strictest hygiene standards

24. (1) Every butcher and fishmonger shall be bound to have his stall, inside and outside, and his block, washed and cleaned every day to the satisfaction of the market keeper.

There needs to be further stipulation in the level and type of cleaning, including the disinfectants used and level of sanitary quality expected from such cleaning. Such measures should also be associated with weekly checks on the level of cleanliness and whether further cleaning (more frequent) is needed.

26. Every fishmonger cutting up or cleansing fish in the market shall have a vessel placed close to his stall wherein to put the offal. Before vacating his stall, he shall dispose of the offal in such a manner as the market keeper directs.

Further detail should be added here that such offal should be made available to processing plants within the Seychelles, to reduce the loss of biomass that can be valorised into suitable biproducts. Ideally, if the offal is intended for food applications, for instance, to extract fish oil, it should be cooled (especially offal contains organs rich in enzymes and bacteria that spoil quite quickly).

29. Shark shall not be sold within the market unless it is exposed for sale apart from other kinds of fish and shall have been previously cleaned and gutted before entering the market. 30. (1) The following fish known to be dangerous shall not be admitted into the market: - 1. the suisila; 2. the otter wrasse; 3. the wrasse, alias black crab; 4. the large tartara; 5. the crab with red spots; 6. the sea urchin; 7. the hawksbill turtle; 8. the laf; 9. the boule tangue; 10. the

cheval-de-bois; 11. the chemise; 12. the flat wrasse, alias bambara; 13. the remora or sharks pilot.

This list will need to be updated, with the full species names provided (to reduce confusion) and the list of species potentially expanded.

Licenses (Fisheries) Regulations 1987

This regulation encapsulates licences for fishing activities throughout the Seychelles. There is nothing within these regulations in terms of postharvest activities and likely nothing that needs to be further added to these regulations to enhance the postharvest industry.

Fisheries Regulations of 1987 as amended

This regulation encapsulates fishing activities throughout the Seychelles. There is nothing within the Fisheries Act in terms of postharvest activities. As these regulations have become superseded by later regulations, no change to these regulations is recommended.

Fisheries (Shark Finning) Regulations of 2006 (under Fisheries Act, 2014)

Within this regulation a single article (Article 6), allows authorised vessels to process sharks at sea, including discarding guts and heads from such sharks. *6. All fishing vessels authorised under regulation 3 are prohibited from discarding at sea the remnant parts of sharks after the removal of fins except for those parts that result from gutting and beheading*.

This regulation reduces the likelihood that suitable waste from the fishing industry, that could be valorised into biproducts, is made available to on-shore processing plants. This regulation needs to reduce the likelihood of fisher processing their artisanal/semi-industrial catch on board (to then throw the waste overboard), or at least ensure that all fish waste is collected and made available to suitable processing plants on shore.

Fisheries (Mahe Plateau Trap and Line Fishery) regulations, 2021 (under Fisheries Act, 2014)

This regulation encapsulates fishing activities throughout the Mahe Plateau. There is nothing within these regulations in terms of postharvest activities and nothing that should be further added. Importantly, icing/cooling/proper storage in the fishing vessel are not a theme of this regulation.

Environment Protection (Waste Services) Regulation, 2021

This regulation provides a detailed description of the suitable disposal of waste from postharvest processing. In this regulation, fish waste can be described under class 3B, which is waste from processing of fish (called 'putrescent waste'). The treatment options for such waste encompass two methods: deep burial or composting, with the transportation of such waste recommended to be undertaken within a compactor truck or skip.

The treatment options listed do not state that such waste should be placed within landfill (which may then allow fishers to utilise private land to dispose of such waste). However, where costs of such type of disposal are provided, these state that such costs are for the use of the landfill. Therefore, although not inherently stating that waste disposal is only to be undertaken within landfill, there is the likelihood that the regulation is only permitting such disposal to be within landfills. In this respect, this regulation does not state that such waste is able to be disposed of in a natural environment. Therefore, where fish processing is undertaken on board boats, there are no regulations that permit such waste to be thrown overboard (e.g., deheading or gutting fish at sea).

Waste Class and Means of Transportation of classes of waste PART 1 Class of Waste

Class	Description	Treatment option	Notes
3B	Putrescent Waste Waste from processing of meat, fish and other foods of animal origin, animal remain, sludge	Deep burial Composting	Submit request using special waste form

Means of Transportation Per Class

Waste Class	Recommended Vehicle
3B	Compactor Truck or Skip

5.2.3 Fisheries strategies published within the Seychelles

There are several strategies that have been developed within the Seychelles to further enhance the fisheries. These strategies have been undertaken to ensure the sustainability of fisheries within the Seychelles, but also to look forward in progressing this industry. Below we summarise two of the strategies that are most specific for the postharvest industry and highlight where any further additions are needed.

Seychelles Fisheries Sector Policy and Strategy 2019

This strategy provides detail of the challenges facing the Seychelles postharvest industry and discusses the main issues in which further support would enhance this industry. Below we provide a synopsis of the statements that encompass the postharvest industry, and where possible, any further detail needed to enhance this strategy to support the postharvest industry within the Seychelles.

(c) Inadequate Infrastructure to support domestic fishing and value chain development Inadequate Infrastructure support — including markets, ice making plants, repair and landing areas and aging fishing vessels — are the main hindrances to business growth, better fisheries practices, value chains development, and fish products.

This statement is relatively clear in stating issues with the lack of infrastructure for the fishing industry, which also hampers the postharvest industry. This statement could be further refined to ensure the following actions:

- Further development of fisheries-specific markets should be a focus. In this respect, markets that are enclosed, with air conditioning and suitable areas to collect processing waste (to be taken to processing plants for use as biproducts);
- The lack of ice making machines is likely an issue and has been itemised in this strategy. However, also ensuring that all ice plants have a high level of cleaning being undertaken, as well as ensuring the quantity of ice suitable for the number of boats needing the ice, while also potentially looking at privatising such ice plants; and
- Highlighting of development issues associated with the high cost of utilities. Further actions are needed to reduce such costs, and may be associated with further use of green energy sources (e.g., solar).

The Goals and Objectives stated within the strategy encompass a range of statements in support of the fishing industry within the Seychelles, with less specific and direct statements regarding the postharvest industry. However, one statement focuses on optimising the outputs from the industry "*Foster optimum utilisation of fisheries and aquaculture resources to ensure ecological and socioeconomic sustainability in resource-use and domestic developments, while recognising traditional norms*". In this respect, although utilisation in this statement likely means using all available fisheries biomass, such utilisation could also be associated with ensuring all waste from fish processing is used to its full extent. In this respect, further detail could encompass stating that the 'resources' could be both from "*harvesting as well as within the postharvest processing*".

Under 'Policy 3: Infrastructure support and value chain development' several statements are associated with increasing the capacity of the postharvest industry within the Seychelles. These are "*Review and develop a progressive plan to transfer ice-plants and fuel stations to the private sector and/or fisher cooperatives but only where the capacity exists to do so*"; "*Explore and establish strategic fisheries support centres (covering ice plants, supply of fishing gear and equipment, fuel and vessel-repair facilities)*"; and the "*Development training programmes for fishers and fish receivers/fishmongers on proper handling, preservation and processing methods*". All three statements have been developed to ensure the enhancement of the postharvest industry, and therefore do not need to be further improved.

Under 'Policy 4: Building efficiency in the industry', there is one statement that is specifically written to ensure the development of the postharvest industry: "*Promote growth and competitiveness through providing support to small operators (such as small-scale fishers) to enable them to improve their productivity (reducing post-harvest loss) and incomes…*". IN this regulation there may then be an impetus to develop Producer Organisations within the Seychelles. In order to implement technological and operation solutions and take into account the specific socio-economic reality in the Seychelles, a suitable way forward may be to promote a Post-Harvest Fish Technology Platform (PHFTP) approach. This is an integrated approach drawing on the Community Fishery Centers (CFC) concept. The approach focuses on creating an early action or entry strategy to mitigate the inter-woven challenges in the industry. The presupposed benefits include provision of an effective organizational platform for dealing with issues, such as fusion of improved technologies, infrastructure, sources of finance, and market dynamics. It is also a platform for building the institutional capacity of fishers' organizations to meet their development challenges on a sustainable basis.

Harvest strategy policy and management standards for Seychelles' fisheries

The recently updated 'Harvest Strategy Policy and Management Standards for Seychelles' Fisheries', has been developed to ensure the sustainability of the fisheries within the Seychelles. One of the core tents of this strategy is in '*Fostering the optimum utilisation of fisheries resources to ensure ecological and socio-economic sustainability*'. However, this strategy does not provide any indication of any specific harvest strategies that could be enacted to foster such optimisation of utilisation. Therefore, this strategy should include measures to ensure the optimum use of all products from fish (i.e., postharvest) and reduce PHFL. In this respect, the new thoughts on regulation are associated with "…will promoting equitable access for Seychellois citizens to the nation's marine resources". In this respect, just allowing Seychelles citizens to fish resources is not enough. There must be a clear and easy way of landing and selling such resources at a fair an economically justifiable price. In this respect, there is a need to update the postharvest practices to ensure the best quality product is sold at the highest price.

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Annex 1 Methods to complete literature review and stakeholder engagement

Literature Review

Using a desk-based literature review, we will collate and assess the available literature on PHFL within the Seychelles. This literature review will be undertaken within Google Scholar, utilising a range of search strings comprising specific terms to describe (i) the type of fishing activities focused on (e.g., artisanal), (ii) the range of factors which may lead to PHFL; and (iii) the outcomes of such loss.

Importantly, we also use this literature search to collate the range of literature also available to cover other Tasks within this project. Therefore, the search strings also hold terms to describe: (i) steps within the value chain where PHFL could occur (e.g. fish processing factory, handling, vessel) – to provide support for providing solutions to reduce PHFL (**Task 4**); (ii) potential recovery products (e.g. fish meal, fish oil, valorisation) – to provide support for understanding the range of recovery products that may be suitable for the Seychelles (**Task 5**); and (iii) potential solutions to non-biological waste disposal (e.g. fish packaging, disposal, waste products) – to provide support for understanding the range of waste disposal solutions which may be suitable for the Seychelles (**Task 6**).

Boolean logic has been applied to all literature searches, resulting in seven search strings:

- "Seychelles" AND "fish" OR "fisheries" OR "fishing" OR "fished" OR "artisanal" AND "postharvest" OR "postharvest" OR "postharvest loss" OR "postharvest loss" OR "postharvest fish loss" OR "postharvest fish loss" OR "PHFL" OR "value chain"
- "Seychelles" AND "fish" OR "fisheries" OR "fishing" OR "fished" OR "artisanal" AND "Cold chain management" OR "fish handling"
- "Seychelles" AND "fish" OR "fisheries" OR "fishing" OR "fished" OR "artisanal" AND "discard" OR "discard reduction" OR "Discarding"
- "Seychelles" AND "fish" OR "fisheries" OR "fishing" OR "fished" OR "artisanal" AND "Landing site"
- "Seychelles" AND "fish" OR "fisheries" OR "fishing" OR "fished" OR "artisanal" AND "fish processing" OR "fish processing factory" OR "fish processing plant" OR "processing plant" OR "Fish monger" OR "vessel"
- "fish" OR "fisheries" OR "fishing" OR "fished" OR "artisanal" AND "fish meal" OR "fish oil" OR "valorisation"
- "Fish waste treatment" OR "fish waste reduction" OR "fish discards" OR "fish waste management" OR "seafood waste" OR "retail seafood waste" OR "tuna waste" OR "tuna by-products" OR "resource recovery" OR "bio-refinery"

Searches will be restricted to literature published between 2012 to 2022 (11 years). To ensure the most relevant literature is utilised following the searches, the first 25 results from each search string will be saved to a designated library in Zotero[16]. Duplicate references will be removed with the titles of all unique references then screened for relevance. All 'relevant' articles will then be exhaustively reviewed to extract relevant data and information. We are already aware of two pivotal reports that will be utilised within the literature review[17].

16 An open-source reference management software

17 Survey on Post Harvest Fish Loss (PHFL) at the Fish Processing Level (2022). Seychelles Fishing Authority (internal document); Development of Seychelles' seafood sector value chains (2018). third South West Indian

Stakeholder engagement

Key stakeholders within the Seychelles fishing industry were identified (Table 3) and comprised three main groups: (i) the offshore industry; (ii) the onshore industry (NB. Single operations can cover both of these stakeholder groupings); and (iii) 'other' stakeholders (e.g., government, scientists). Those within the offshore industry were expected to answer questions regarding (for example), cold chain management, fish handling on the vessel and discarding at sea. Those within the onshore industry were expected to answer questions regarding (for example) fish handling upon landing, processing methods (processing; packaging) and retail.

To engage with the key stakeholders, a questionnaire was developed, encapsulating a range of questions questioning the extent, breadth and depth of PHFL within the different fishing industries throughout the Seychelles (Table 4). A stratified method to engage stakeholders was utilised. Following introductory emails to inform stakeholders of the project, each identified organisation (and person within that organisation) within the processing industry, fisher association, and Seychelles government was sent the questionnaire and an interview (phone or in-person) undertaken. In-country research organisations (i.e., IRD) as well as representatives of the fishing companies (predominantly the tuna purse seine fishery) were sent an electronic questionnaire.

Questionaries contained a mixture of closed questions with pre-defined answers and open-ended questions, with an emphasis on the collection of empirical and or categorical data. Questionnaires were designed to take no longer than 20 minutes to complete to allow for adequate data collection, whilst ensuring completion of the questionnaire. The final content and structure of the questionnaire was agreed with the Seychelles Fishing Authority and project steering committee prior to dissemination.

Ocean fisheries governance and shared growth project (SWIOFISH3). Advance Africa Management Services (November 2018).

Table 3. Key stakeholders consulted

Industry	Organisation	Potential contact	Why important to this project	Sector
Processing Plant	Amirante Fisheries	Mr. James Lesperance (Managing Director)	Mr Lesperance has vast experience in the fish processing industry. He delas in fish processing and sea cucumber processing. Has experience in processing of different types of fish, including by-catch and is also producing secondary value-added product. He is one of the major fish processing players in Seychelles.	Near shore/ Offshore
	Rass Fish	Ms Samantha Manes (Operations Director)	Has vast experience in the informal fish processing sector ((fish monger) and is now in the formal sector. Hence, will have information on the practices from both the formal and informal section sides of the industry.	Near shore
	Fish Tech	Mr. Jean Claude Hoareau (Operations Manager)	The stakeholder has years of experience in the fishing sector and has worked for 2 major fish processing plants in Seychelles. He has designed layouts and worked on several process improvement features of fish processing plants	Near shore/ Offshore
		David Bentley	One of the stakeholders with that has been in the business the longest. He is one of the former Managing Directors of Indian Ocean Tuna Ltd. This stakeholder has historical and present knowledge that may be useful for this project.	Near shore/ Offshore
	Oceana Fisheries	Neven Cinoti (Food Technologist)	One of the people responsible for the daily operations of Oceana and the one working on all the process improvement, new product development and cost-reduction at the plant.	Near shore/ Offshore
	Marlu Seychelles	Muditha Gunatilake (Managing Director)	One of the processors that has managed to implement a vertical integration system in the processing industry. He has his own fishing fleet and processes what is caught by his vessel. He may be able to allow us to map the entire value chain from catch to plate. He processes mainly Tuna.	Near shore/ Offshore

Industry	Organisation	Potential contact	Why important to this project	Sector
	Fresh Seafood Seychelles	Mr. William Jakob (Managing Director)	The owner of one of only 2 of the processing plant operating at the Providence EU designated landing site. Mr William has also vertically integrated his processes and may be able to provide additional data on processing loss throughout the value chain. His products are only destined for the export market.	Near shore/ Offshore
	Ocean Basket	Mr Louis Bossy	Fish processing in the Seychelles	Near shore/ Offshore
Fisher Association	Belombre Fisher Association	Mr. Rodney Nicole (Representative)	Belombre has a designated EU landing site, used by several boat owners and fishers in the North of Mahé. Mr Nicole would be key in guiding us to the right fisher in that side of the island that may assist with the provision of information. (North Mahe)	Near shore
	Cascade Fisher Association	Mr. Steve Payet (Representative)	The landing site is frequented by several smaller vessels. The Fish market is located at the same site. This would be ideal as it will allow us to be able to gather data on the quality of fish as soon as they are offloaded and sold on the market. (East Mahe)	Near shore
	Baie-Lazare Fisher Association	Mr. Jean-Claude Michel (Representative)	The Baie-Lazare fishers mostly focus on artisanal fishing and may be a prime location to gather information from the fishers in the South. (South Mahe)	Near shore
	Anse Etoile Fishers Association	Mr. Dimitri Maiden (Chairman)	A younger generation fisher, overseeing the association. The stakeholder has experience at sea and given his forward way of thinking may be a key player in the facilitation of data collection.	Near shore
	Fisher & Boat Owners Association (FBOA)	Ms. Nancy Onginjo (Representative)	FBOA is one of the main and largest fishers' association in Seychelles. The members include boat owners and fishers operating on smaller vessels and semi-industrial vessels. They may be one of the main associations to provide fishers with the largest vessels. (Central Mahe)	Near shore

Industry	Organisation	Potential contact	Why important to this project	Sector
	Praslin Fisher Association	Mr. Darell Greene (Chairman)	The stakeholder has been in the industry for several years, he is a fisher, a processor (small scale). His input will be valuable to ascertain the potential loss experienced by the Praslin Fishers.	Near shore
	La Digue Fisher Association	Mr. Ray Payet (Chairman)	Mr Payet has been the focal point for the La Digue fishers for several years. He will be the person to provide information on the various factors impacting fishers on La Digue.	Near shore
	Sea Cucumber Association	Mr Dean Pillay (Chairman)	A qualified sea cucumber fisher with years of experience of the industry	Offshore
	FBOA fisher association	Keith Andre (former chairman, boat owner)	Maitre de Peche with extensive know-how in long-line fishing. Has vast knowledge on on-board fish handling	Near shore/ Offshore
	Anse Boileau Fishermen's Association.	Mr Randolph Valmont		Near shore/ Offshore
Industry Association	Association of Fish Processors and Exporters Seychelles (AFPES)	Mr Bossy (Chairperson)	Extensive experience in the processing and exporting of fish products. Mr Bossy also owns a processing company.	Near shore/ Offshore
Fishermen	Morin Group	Mr Paul Morin (Managing Director)	The Morin family has been involved in the fishing industry for over 15 years. Their main focus being sea cucumber fishery. Deals with sea cucumber diving and processing	Offshore
Research	Institute Research et Development (IRD)	Ms. Marianne Pernak (Researcher)	Marianne is working with IRD and was setting up a monitoring programme for bycatch landed in Victoria by French purse seiners	N/A

Industry	Organisation	Potential contact	Why important to this project	Sector
Seychelles Government	Seychelles Bureau of Standard	Mr. Christopher Hoareau (Chief Fisheries Inspector)	Mr Hoareau was part of the team working on the previous by-catch policy. He has historical and current information on the issues concerning of postharvest development and losses	N/A
	Principle Secretary of Fisheries	Mr. Roy Clarisse	The PS can provide details on the various national and international interventions that Seychelles has been a part of. He has also been in the industry for over 15 years	N/A
Offshore fishing industry	Echebastar	Mr. Gaetan Pierre (General Manager)	Purse seine tuna fishing company	Offshore
	Hunt, Deltel & Co. Ltd	Mr. Christophe Hoareau (General Manager)	Stevedoring for Purse Seine Tuna Transhipment	Offshore
	Aquarius	Mr. Anthony Savy de St. Maurice (General Manager)	Port Agent/ Tuna Transhipment	Offshore
	Seaward	Mr. Selwyn Edmond (General Manager)	Stevedoring for Purse Seine Tuna Transhipment	Offshore
	SAPMER	Mr. Laurent Pinault (Sustainability Manager)	SAPMER - French Purse Seining Company	Offshore
	ATUNSA -	Jon Zulueta Casina (Executive Director)	Spanish Purse Seining Company	Offshore
	ALBACORA -	Gaizka Fradua Aramburu (IO Fleet Coordinator)	Spanish Purse Seining Company	Offshore
	Indian Ocean Tuna Ltd	Mr. Ricardo Luzio (Managing director)	Purse seine fishing company	Offshore

Industry	Organisation	Potential contact	Why important to this project	Sector
	Indian Ocean Tuna Ltd	Techasaratoole, Jamikara (Head of Supply Chain)	Will have information on the supply chain side of purse seine fishery	Offshore

Table 4 Stakeholder Questionnaire

PART 1: Details of Interviewee		
Name interviewee:		
Organisation:		
Type of industry: *[offshore/inshore etc]*		
Stakeholder category: *[government, fishing industry, NGO, science etc]*		
PART 2: Estimate of Losses		
Area	**Question**	**Answer**
Cold chain management	Where exactly do the losses occur?	
	What is the amount of fish loss per tonne of processed raw material (or final product) or, (alternatively) per day.	
	What is the equivalent weight of these losses?	
	Are the losses related to particular species? If so which species?	
	Do the losses vary with seasons or times of high catches?	
	Are the losses due to certain operations? If so, which ones	
	Do you have access to active cooling (machines) or passive cooling (Ice) on your vessel and/or on land when you land the catch?"	

Fish handling on the vessel	How exactly do the losses occur?	
	Roughly, what volume are these losses per trip?	
	Roughly, what volume are these losses per trip?	
	What is the equivalent weight of these losses?	
	Are the losses related to particular species? If so which species?	
	Do the losses vary with seasons or times of high catches?	
	Are the losses due to certain operations? If so, which ones	
Discarding at sea	What are the reasons for discarding part of the catch?	
	Roughly, what volume are these losses per trip?	
	What is the equivalent weight of these losses?	
	Are the losses related to particular species? If so which species?	
	Do the losses vary with seasons or times of high catches?	
	Are the losses due to certain operations? If so, which ones	
Fish handling upon landing	Where exactly do the losses occur?	
	Roughly, what volume are these losses per trip?	
	What is the equivalent weight of these losses?	
	Are the losses related to particular species? If so which species?	
	Do the losses vary with seasons or times of high catches?	
	Are the losses due to certain operations? If so, which ones	
Fish processing plants (processing)	Where exactly do the losses occur?	
	Roughly, what volume are these losses per trip?	

	What is the equivalent weight of these losses?	
	Are the losses related to particular species? If so which species?	
	Do the losses vary with seasons or times of high catches?	
	Are the losses due to certain operations? If so, which ones	
Fish processing plants (Packaging)	Where exactly do the losses occur?	
	Roughly, what volume are these losses per trip?	
	What is the equivalent weight of these losses?	
	Are the losses related to particular species? If so which species?	
	Do the losses vary with seasons or times of high catches?	
	Are the losses due to certain operations? If so, which ones	
Fish mongers (processing)	Where exactly do the losses occur?	
	Roughly, what volume are these losses per trip?	
	What is the equivalent weight of these losses?	
	Are the losses related to particular species? If so which species?	
	Do the losses vary with seasons or times of high catches?	
	Are the losses due to certain operations? If so, which ones	
Fish mongers (Packaging)	Where exactly do the losses occur?	
	Roughly, what volume are these losses per trip?	
	What is the equivalent weight of these losses?	
	Are the losses related to particular species? If so which species?	
	Do the losses vary with seasons or times of high catches?	

	Are the losses due to certain operations? If so, which ones	

PART 3: Practices to reduce losses		
In your view, what could be done to reduce the losses associated with the following areas?		
Area	**Solutions could include?**	**Rank the solutions based on practicability**
Cold chain management		
Fish handling on the vessel		
Discarding at sea		
Fish handling on the vessel		
Fish handling upon landing		
Fish processing plants (biological);		
Fish processing plants (packaging)		
Fish mongers (processing)		
Fish mongers (packaging)		

PART 4: Options to recover biological waste		
In your view, how applicable are the following utilisation opportunities as a way to recover economic value from the biological waste?		
Utilisation option	**Output/Product**	**Answer**
Reduction to fishmeal and fish oil	For sale in animal, aqua and pet food industries	
Ensiling	Ingredients (hydrolysed protein and oil products) for animal and aqua feed	
Composting	Compost production for land restoration, horticulture and agriculture as organic fertiliser	
Anaerobic digestion with energy recovery	Renewable energy sold to power station	

Freezing	Frozen bait	
Others [please specify]		

PART 5: Solution to non-biological waste disposal	
Question regarding waste disposal	Answer
In your view, what are the effective disposal solutions of fish waste products that are unable to be used as by-products?	
Are there technological solutions that you would recommend to reduce fish packaging waste in the Seychelles?	
What are the limiting factors towards effective disposal solutions of non-biological waste from the fisheries value chain in the Seychelles?	

Annex 2 Determination of appropriate primary and secondary data collection methods to gather information on the sector (Task 2)

This Task 2 has been developed to propose appropriate primary and secondary data collection methods to cover the knowledge gaps identified within Task 1. From this work there are several data needs to be undertaken to inform recommendations to reduce PHFL within the Seychelles.

Mapping of the full supply chain for the postharvest industry within the Seychelles – The artisanal and semi-industrial have completely separate supply chains (and value chains), which need to be mapped and the issues at each step of the chain are outlined. In providing a detailed explanation at each of the stages within the supply chain, this work will focus on both the artisanal and semi-industrial stages. Importantly, within the artisanal

- ***Proposed method used to collect and map the Seychelles PHFL supply chain****: The stakeholder engagement undertaken within Task 1 will be used to further develop the map that has already been developed. Within this, the hotspots for PHFL (e.g., biomass loss, value loss etc) will be highlighted and the potential mitigation strategies developed (under Task 4).*

Quantitative data on PHFL throughout the processing stage – the literature review and stakeholder engagement showed that there is little quantitative information on the different processing stages, as well as the PHFL which might occur at each stage. This information will be vital in understanding (i) the practices and technologies which may reduce PHFL (Task 4); recommendations for the range of recovery products which may be suitable for the Seychelles fishing industry (Task 5); as well as the range of issues needed to be tackled to reduce the development of waste and the use of landfill resources within the Seychelles (Task 6)

- ***Proposed method used to collect processing data:*** *Within at least three processing plants (Fresh Seafood Seychelles, Indian Ocean Tuna Ltd, Marlu Seychelles), a mass-balance audit will be undertaken. This is designed to ensure that the total volume or weight of product (i.e., landed fish) passing through each processing plant and onward to customers can be accounted for, mapping production yields, gains and losses. A mass-balance starts when the product selected enters the possession of the processing plant being audited. From this point the product in question can be traced forward through any processing, packaging, storage etc, until the point of sale. An example of a mass balance assessment and calculation is provided below.*
- *Each processing plant will have a separate mass-balance audit undertaken three (3) times and the input/output data at each stage of the processing will be averaged and reported*

Quantitative data on the range and variety of processing waste - There is clear lack of reporting on the range and impact on their business of PHFL from within the processing companies. Importantly, there is no reporting on PHFL at the packaging or selling phase, as well as no data on monthly or seasonal PHFL figures (rather than the average figure that has been provided).

- *Proposed method used to collect processing waste data: As above ('quantitative data on PHFL throughout the processing stage'), within three processing plants replicate mass-balance audits will be undertaken. Each audit will examine both the biological and non-biological waste developed throughout the process, providing average weight and type of waste being developed.*

- *There is also the need to understand how processing waste is handled. This could entail two streams: one that is focused on utilising the waste and producing a biproduct (e.g., fishmeal for use in agricultural settings) and the other where all waste products are sent to landfill (independent of whether such products could be made into a biproduct).*
- *Importantly, three waste streams will be examined:*
    - *Biproduct – utilised for other products (fish meal, oil)*
    - *Waste that could be used for biproduct (lost) – sent to landfill*
    - *Waste that is unusable – sent to landfill*

Annex 3 Example template of mass-balance audit

Step 1: Input/output test			
Species name and scientific name (e.g., *Lutjanus bohar*, two-spot red snapper))**:**		**Description of the final product:**	[e.g., Frozen whole fish]

Step 2: Raw material input						
1	**Input material identification** *(e.g., batch number or other identification):*	[XXX]	**Input material description:**	*[e.g., Whole frozen fish]*	**Amount of Input material in the batch under scrutiny:**	[XXX]
					Unit:	Kg

Step 3: Input material to processing (add rows if necessary)												
1	**Description of processing:**	[XXX]	**Date of processing** (DD/MM/YYYY)**:**	[XXX]	**Input material identification:**	[XXX]	**Production lot number** *(or other identification)***:**	[XXX]	**Amount of raw material used for the lot**:	[XXX]	**Amount of processed product for the lot** (specify unit):	[XXX]
									Unit:	kg	Unit:	kg

Step 4: Sales (add rows if necessary)								
1	**Sales invoice date** (DD/MM/YYY):	*[XXX}*	**Invoice or sales not reference number** (or equivalent):	*[XXX}*	**Production lot number** (or other/equivalent identification)**:**	*[XXX}*	**Amount of the product sold**	*[XXX}*
							Unit:	kg

Step 5: Product still in stock (add rows if necessary)

1	**Test date** (DD/MM/YYYY)**:**	*[XXX]*	**Warehouse name/number** (i.e., Location reference for stock)**:**	*[XXX]*	**Production lot number** (or other/equivalent identification)**:**	*[XXX]*	**Amount of the product in stock on the date of the test**:	*[XXX]*
							Unit:	kg
							Unit:	n/a

Step 6: OUTCOMES (add rows if necessary)										
1	**Input material identification (**e.g., batch number or other identification**):**	*[XXX]*	**Total material in:**	100	**Total product produced**	*[XXX]*	**Amount of the product sold**	*[XXX]*	**Total product still in stock**	*[XXX]*
			Unit:	kg	Unit:	kg	Unit:	kg	Unit:	kg
	Yield (%) (final product divided by the raw material input):	*[XXX]*	**Reason for weight gain or weight loss:**	*[XXX]*			**Notes to explain the yield calculation:**		*[XXX]*	

Annex 4 Factors resulting in PHFL and potential measures to reduce

Segment of supply chain	Main factor	Description of issue	Potential measures to reduce
Entire supply chain	Data collection	No data exist for PHFLs that occur on fishing vessels in any of the fleets; Lack of reporting around the financial losses/figures associated with PHFLs in the Seychelles; No reporting on fish losses on fishing vessels themselves, or at the transhipment stage of the industrial fishery; There are no reported figures on PHFLs at landing sites across all fleets	Framework and capacity training to use framework provided (last task of the project)
	Best practices	Limited Good Manufacturing Practices (GMPs) and Good Hygiene Practices (GHPs) + assumed unconsciousness among semi-industrial and artisanal fishers of the economic (aka: value) losses by spoilage/ putrefaction/ deterioration of their landed fish due to a limited production driven and upstream view of the fish supply chain. Including the opposite holds: unconsciousness about the potential in economic (aka: value) terms of higher quality for their landed fish by a demand driven and more downstream perspective from the market	Capacity training
On-board	Handling techniques	(i) fish being clubbed to immobilise, bruising skin and reducing the grade of the fish; (ii) when landed fish are left out in the sun and not directly being placed within the ice.	Capacity training
	Cold chain management	Low quantities of (usually flake, but also block) ice available for fishers on a daily basis due to the small number of ice-making plants within the Seychelles (three – all of which provide ice at a subsidised rate to fishers).	Larger ice machines, more volume and in more areas of the Seychelles
	Cold chain management	Lack of ice quota, resulting in larger vessels (predominantly semi-industrial) taking more than what they will need in a single fishing session, reducing the availability of ice for any other vessels.	Larger ice machines, more volume and in more areas of the Seychelles. Production of ice and transport of the ice to keep it as cold as possible. Simple system of insulated and isolated, and cleaned with chemicals to ensure hygiene. Transport of the ice in the box - we know that ice is transported in plastic, which reduces utility (ice melts). Innovation on type of ice - northern Europe use ice

			flakes, and exporting (EU to US) use dry ice (keeps an environment colder). Use of cool packs (these all require utilities to cool). Cleaning requirements (best practices for chemicals used and how the cleaning is undertaken). Storage of the ice is the most important, including how it is stored.
	Cold chain management	Reduced space within hold results in individual fish being stacked with little space between individuals, resulting in reduced freezing effects	Training techniques, changes in vessel size/hold size may not be available, there might be utility in cooperative behaviours (use of producer organisation)
	Transport of fish	Use of block ice will bind and squash fish in the hold, deteriorating the quality of the fish.	Availability of flake ice or very small ice cubes (Alexander has that info). Slush ice needs particular equipment and expensive to make; dry ice is expensive (kept at -80C)
	Hygiene practices	Within ice plants: (i) fishers that do not work in the plants are able to enter the plants; (ii) lack of a dedicated ice chute at any of the three ice plants results in ice being manually moved from the plant to the vessel; and (iii) there can be sediment in the ice, due to lack of ice plant maintenance.	Stricter hygiene practices, increased maintenance of ice plants - hygiene protocol having someone provide the fishers the ice (controlling access of the ice); monitoring of the water quality of the ice. Provide the ice to the fishers in 'sealed' boxes (guaranteeing the quality of the fish) - anywhere in the supply chain which shows the quality of the ice. Ensuring the understanding of why ice needs to be very clean/high quality. But small-scale artisanal fishing on shore (beach seine) will potentially not have ice, until transporting (or none at all). Are

			there inspectors of fish at markets and outside markets etc?
Disembarkation			
	Transport of fish	Fish being packed too tightly into freezer boxes, and effectively being squashed under the weight of ice (and other individuals).	The use of chutes to move fish from the vessel to the transport would reduce such impacts of disembarkation.
	Hygiene practices[18]	Fish gutted in areas that are dirty or have low hygiene levels	Providing areas for processing artisanal catch
	Handling techniques	Fish dropped, bruised during disembarkation	Capacity training
	Handling techniques	Fish heads left on-board (and potentially discarded) after processing	Providing avenues for use of such waste resources
	Cold chain management	Lack of market (supply > demand), resulting in low fish prices and fish being dumped or left for longer periods before being disembarked	Development of cooperative/transhipment to ensure fish are able to be brought to market. Potentially one point on each island where fish can be brought to (concentrated area/centralised areas for fish to be landed to - provide a way of enthusing people to use)
	Cold chain management	Lack of specific reefer (i.e., refrigerated) trucks to haul catch from vessels to the markets within the Seychelles., with fishes moved using open flatbed trucks, which have little to no ice (one stakeholder even mentioned that garbage trucks have been used to transport fish to markets)	Develop of specialised refrigerated transport system (specialisation)

18 http://megapesca.com/megashop/Ghana_Upstream_Inspection_Manual.htm

Processing	Handling techniques	Fish left too long as a result of production line build up.	Capacity training, as well as appropriate tonnage of fish being bought for the processing plant at any one time.
	Processing techniques	High use of landfill for waste products due to lack of use of fish waste; Fish heads left on-board (and potentially discarded) after processing	Providing avenues for use of such waste resources: Pet food or fish meal could be a potential avenue to be explored; Establishment of a facility to produce value-added products from waste material (e.g., pet food or fish meal)
Fish market (local) to general public	Markets	No grading of artisanal catch and therefore no incentive to increase handling to reduce quality loss + it is assumed based on first observation from an end-user perspective no urgency among local Seychellois to inspect and grade the fresh fish at local food markets for high quality.	Previous training provided using Torry freshness scale and quality index method + educating local Seychellois about inspecting fish on freshness and quality with the advantage of nutritional value. There needs to be some sort of inspection of the fishes (but how would this occur), but how would this occur? But who would regulate this?
	Handling technique	Fish may be dipped in seawater before sale, to enhance their visual appeal, but which warms up the fish potentially leading to the fish spoiling earlier than if left frozen.	Capacity development, best practice. Ensuring protocol for cold chain management in the market - this comes back to further understanding of how best to ensure quality of the product in the market (hygiene)
	Market infrastructure	Lack of adequate and standardised infrastructure (Victoria and others), including proper drainage; space allocation; storage; ice availability; air-conditioning	Capital development in market + behavioural and cultural awareness training among fish mongers and local Seychellois about nutritional value with higher quality fresh fish
Processors to public/hotel industry	Production	Lack of product diversification	R&D; Capital development

	Markets	Potentially low local market accessibility, if problems encountered with exporting	Cooperative; ensuring processors are able to offload into the local market
Processors to international clients	Markets	Potentially low local market accessibility, if problems encountered with exporting	Cooperative; ensuring processors are able to offload into the local market
	Production	Low capacity for development of secondary value-added products, lack of product diversification; use of cooperative to build the biomass with one person (stimulation of consistent landing value) - David talk about UK cooperatives	Capital development
	Production	Lack of machinery to process fish; availability of spare parts on the local market	Capital development
	Cold chain management	Limited cold storage, including inadequate storage at airport	Development of Central Command Cold Store (CCCS), providing processors the opportunity for ultra-low temperature storage (-40°C); further capital development
Fish monger (local) to hotel industry - ask Margaret Ally about	Handling techniques	Poorly implemented Good Manufacturing Practices (GMPs) - HACCP standards; what is needed to ensure compliance; who controls the quality of the fish (i.e. is this demand led and what recommendations do we do); providing/utilising sealed boxes - branded boxes that 'show' the cold chain management (broken seals/stickers on the boxes) - standard for branding perspective (sticker over the edge of the box lid to show cold chain has been broken) - example of opening a new product in front of you (e.g. wine)	Development of Good Manufacturing Practices (GMP), capacity development in GMPs
	Cold chain management	Lack of storage and suitable transport (reefers)	Development of Good Hygiene Practices (GHPs), capacity development in GHPs
	Processing techniques	Lack of use of grading standards, reducing need for good handling standards - comes back to the demand led way of ensuring quality (sticker on box to ensure cold chain management)	Previous training provided using Torry freshness scale and quality index method

Annex 5 Excel framework to collect PHFL data in the Seychelles

Below is a screen shot of the data collection framework for PHFL in the Seychelles. The live framework has been sent to SFA.