Cleaner Production Assessment in Fish Processing

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for

UNEP

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Division of Technology, Industry and Economics

and

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PREFACE

The purpose of the Industrial Sector Guides for Cleaner Production Assessment is to raise awareness of the environmental impacts associated with industrial and manufacturing processes, and to highlight the approaches that industry and government can take to avoid or minimise these impacts by adopting a Cleaner Production approach.

This guide is designed for two principal audiences:

- People responsible for environmental issues at fish processing plants (environmental managers or technicians) who seek information on how to improve production processes and products. In many countries, managers are ultimately responsible for any environmental harm caused by their organisation's activities, irrespective of whether it is caused intentionally or unintentionally.
- Environmental consultants, Cleaner Production practitioners, employees of industry bodies, government officers or private consultants that provide advice to the fish processing industry on environmental issues.

The guide describes Cleaner Production opportunities for improving resource efficiency and preventing the release of contaminants to the air, water and land. The Cleaner Production opportunities described in this guide will help improve production as well as environmental performance.

Chapter 1 provides a brief introduction to the concept of Cleaner Production and the benefits that it can provide.

Chapter 2 provides an overview of the fish processing industry including process descriptions, environmental impacts and key environmental indicators for the industry. The processes discussed in most detail are the filleting of white and oily fish, canning, and fish meal and oil production, as well as cleaning and ancillary operations.

Chapter 3 describes Cleaner Production opportunities for each of the unit operations within the process and examples where these have been successfully applied. Quantitative data is provided for the inputs and outputs associated with each unit operation as an indication of the typical levels of resource consumption and waste generation.

Chapter 4 provides a case study demonstrating the application of Cleaner Production at a fish processing plant.

Chapter 5 describes the Cleaner Production assessment methodology in detail. The methodology can be used as a reference guide for carrying out a Cleaner Production assessment within an organisation.

Annex 1 contains a reference and bibliography list.

Annex 2 contains a glossary and list of abbreviations.

Annex 3 contains a list of literature and contacts for obtaining further information about the environmental aspects of the industry.

Annex 4 contains background information about the UNEP Division of Technology, Industry and Economics (UNEP DTIE).

Monetary figures quoted in this guide are based on 1995–98 figures and presented as US dollars for consistency. As prices vary from country to country and from year to year, these figures should be used with care. They are provided as indicators of capital expenditure and savings only.

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EXECUTIVE SUMMARY

This document is one in a series of Industrial Sector Guides published by the United Nations Environment Programme UNEP Division of Technology, Industry and Economics (UNEP DTIE) and the Danish Environmental Protection Agency. The documents in the series include:

- *Cleaner Production Assessment in Dairy Processing*;
- *Cleaner Production Assessment in Meat Processing*; and
- *Cleaner Production Assessment in Fish Processing*.

This document is a guide to the application of Cleaner Production to the fish processing industry, with a focus on the manufacture of fish fillets, canned fish, fish meal and fish oil at fish processing plants. Its purpose is to raise awareness of the environmental impacts of fish processing, and to highlight approaches that industry and government can take to avoid or minimise these impacts by adopting a Cleaner Production approach.

The life cycle of fish products commences with the capture or growing of fish. Marine fish account for more than 90% of fish production, with the remainder being fresh water fish and fish produced by fish farming.

Fish are processed to produce fresh, frozen or marinated fillets, canned fish, fish meal, fish oil and fish protein products, such as surimi. Approximately 75% of world fish production is used for human consumption and the remaining 25% is used to produce fish meal and oil. Of the fish processed for human consumption, only about 30% is marketed fresh and there is an increasing demand for frozen fish fillets and convenience products.

Fresh fish products are highly perishable and refrigerated storage is required throughout the life of the products to maintain eating appeal and prevent microbiological spoilage. On the other hand, the more highly processed products, such as canned fish, fish meal and fish oil, have a longer shelf life and require less refrigeration. The life cycle ends with consumption by the consumer and disposal or recycling of the packaging.

In this guide, the upstream process of fish capture and farming, and the downstream processes of distribution and post-consumer packaging management are not covered. Instead the guide focuses on the processing of key fish products, namely fish fillets, canned fish, fish meal and fish oil, at fish processing plants.

The guide mainly deals with the processing of fish at on-shore processing facilities. In some of the major fish producing areas, processing can take place at sea on board fishing vessels. While this guide does not cover at-sea processing specifically, some of the basic principles will apply to it.

The processing of fish is a significant contributor to the overall environmental load produced over the life cycle of fish production and consumption. Therefore, the application of Cleaner Production in this phase of the life cycle is important.

As for many food processing industries, the key environmental issues associated with fish processing are the high consumption of water, the generation of effluent streams, the consumption of energy and the generation of by-products. For some sites, noise and odour may also be concerns.

This guide contains background information about the industry and its environmental issues, including quantitative data on rates of resource consumption and waste generation, where available. It presents opportunities for improving the environmental performance of fish processing through the application of Cleaner Production. Case studies of successful Cleaner Production projects are also presented.

Cleaner Production

Cleaner Production is defined as *the continuous application of an integrated, preventive, environmental strategy applied to processes, products and services to increase overall efficiency and reduce risks to humans and the environment*. It is different to the traditional ‘pollution control’ approach to environmental management. Where pollution control is an after-the-event, ‘react and treat’ approach, Cleaner Production reflects a proactive, ‘anticipate and prevent’ philosophy.

Cleaner Production has most commonly been applied to production processes, by bringing about the conservation of resources, the elimination of toxic raw materials, and the reduction of wastes and emissions. However it can also be applied throughout the life cycle of a product, from the initial design phase, through to the consumption and disposal phase. Techniques for implementing Cleaner Production include improved housekeeping practices, process optimisation, raw material substitution, new technology and new product design.

The other important feature of Cleaner Production is that by preventing inefficient use of resources and avoiding unnecessary generation of waste, an organisation can benefit from reduced operating costs, reduced waste treatment and disposal costs and reduced liability. Investing in Cleaner Production to prevent pollution and reduce resource consumption is more cost effective than relying on increasingly expensive ‘end-of-pipe’ solutions. There have been many examples that demonstrate the financial benefits of the Cleaner Production approach as well as the environmental benefits.

Water consumption

Water is used for holding and transporting fish, for cleaning equipment and work areas, and for fluming offal and blood. Automated processing equipment generally has permanently installed water sprays to keep equipment clean and to flush offal away.

Rates of water consumption can vary considerably depending on the scale and age of the plant, the type of processing, the level of automation and the ease with which equipment can be cleaned, as well as operator practices. Typical figures for fresh water consumption per tonne of fish intake are 5–11 m^3 for fish filleting, 15 m^3 for canning and 0.5 m^3 for fish meal and oil production. Fish meal and oil production also consumes about 20 m^3 of seawater per tonne of fish intake.

In most parts of the world, the cost of water is increasing as supplies of fresh water become scarcer and as the true environmental costs of its supply are taken into consideration. Water is therefore becoming an increasingly valuable commodity and its efficient use is becoming more important.

Strategies for reducing water consumption can involve technological solutions or equipment upgrade. However substantial benefits can also be gained from examining cleaning procedures and operator practices.

Some key strategies for reducing water consumption are listed below and the use of these techniques would represent best practice for the industry:

- using offal transport systems that avoid or minimise the use of water;
- installing fixtures that restrict or control the flow of water for manual cleaning processes;
- using high pressures rather than high volumes for cleaning surfaces;
- reusing relatively clean wastewaters for other applications; for example, thawing wastewaters could be used for offal fluming or for initial cleaning steps in dirty areas;
- using compressed air instead of water where appropriate;
- installing meters on high use equipment to monitor consumption;
- using closed circuit cooling systems;
- pre-soaking floors and equipment to loosen dirt before the final clean;
- recirculating water used in non-critical applications;
- reporting and fixing leaks promptly.

Effluent discharge

Most water consumed at fish processing plants ultimately becomes effluent. A characteristic of fish processing that has a bearing on the effluent loads is the highly perishable nature of fish and fish products. As the quality of the fish deteriorates over time, product yield decreases and product losses contribute to the waste loads. These losses often find their way into the effluent stream.

Fish processing effluent contains high levels of organic matter due to the presence of oils, proteins and suspended solids. It can also contain high levels of phosphates and nitrates. For the basic fish processing operations, sources of effluent are the handling and storage of raw fish prior to processing, fluming of fish and product around the plant, defrosting, and the cleaning of equipment and work areas throughout the process. For canning operations, effluent is also generated from the draining of cans after precooking and from spillages of sauces, brines and oil. Major sources of effluent from fish meal and fish oil production are bloodwater from the unloading and storage of fish, high-strength effluent from the centrifuges and condensate from evaporators.

Effluent quality is highly dependent upon the type of fish being processed. Pollution loads generated from the processing of oily fish species are much higher than from white fish species, due to the high oil content and the fact that these species are usually not gutted or cleaned on the fishing vessel.

Fish processing effluent contains scraps of flesh, blood and soluble substances from entrails, as well as detergents and other cleaning agents. Effluent from the processing of oily fish can also contain very high levels of oil. Typical ranges for the COD loading in fish processing effluent per tonne of fish intake are 50 kg for the filleting of white fish, 85 kg for the filleting of oily fish, 116 kg for canning and 42 kg for fish meal and oil production.

Strategies for reducing the pollutant load of fish processing effluent focus on avoiding the loss of raw materials and products to the effluent stream. This means capturing materials before they enter drains and using dry cleaning methods.

Some key strategies are listed below:

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

Energy consumption

Energy consumption depends on the age and scale of a plant, the level of automation and the range of products being produced. Processes which involve heating, such as the cooking of canned fish and fish meal and oil production, are very energy intensive, whereas filleting requires less energy. Typical figures for the energy consumption per tonne of fish intake are 65–87 kW.h for the filleting, 150–190 kW.h for canning and about 32 KW.h for fish meal and oil production, plus 32 litres of fuel oil.

Energy is an area where substantial savings can be made almost immediately with little or no capital investment, through simple housekeeping efforts. Some key strategies are listed below:

- implementing switch-off programs and installing sensors to turn off or power down lights and equipment when not in use;
- improving insulation on heating or cooling systems and pipework.;
- favouring more efficient equipment;
- improving maintenance to optimise energy efficiency of equipment;
- maintaining optimal combustion efficiencies on steam and hot water boilers;
- eliminating steam leaks;
- capturing low-grade energy to use elsewhere in the operation.

In addition to reducing a plant’s demand for energy, there are opportunities for using more environmentally benign sources of energy. Opportunities include replacing fuel oil or coal with cleaner fuels, such as natural gas, purchasing electricity produced from renewable sources, or co-generation of electricity and heat on site. For some plants it may also be feasible to