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How to create value from fisheries bycatch?

A case study of the sea cucumber harvested in Galicia

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Diego Fernández Mato

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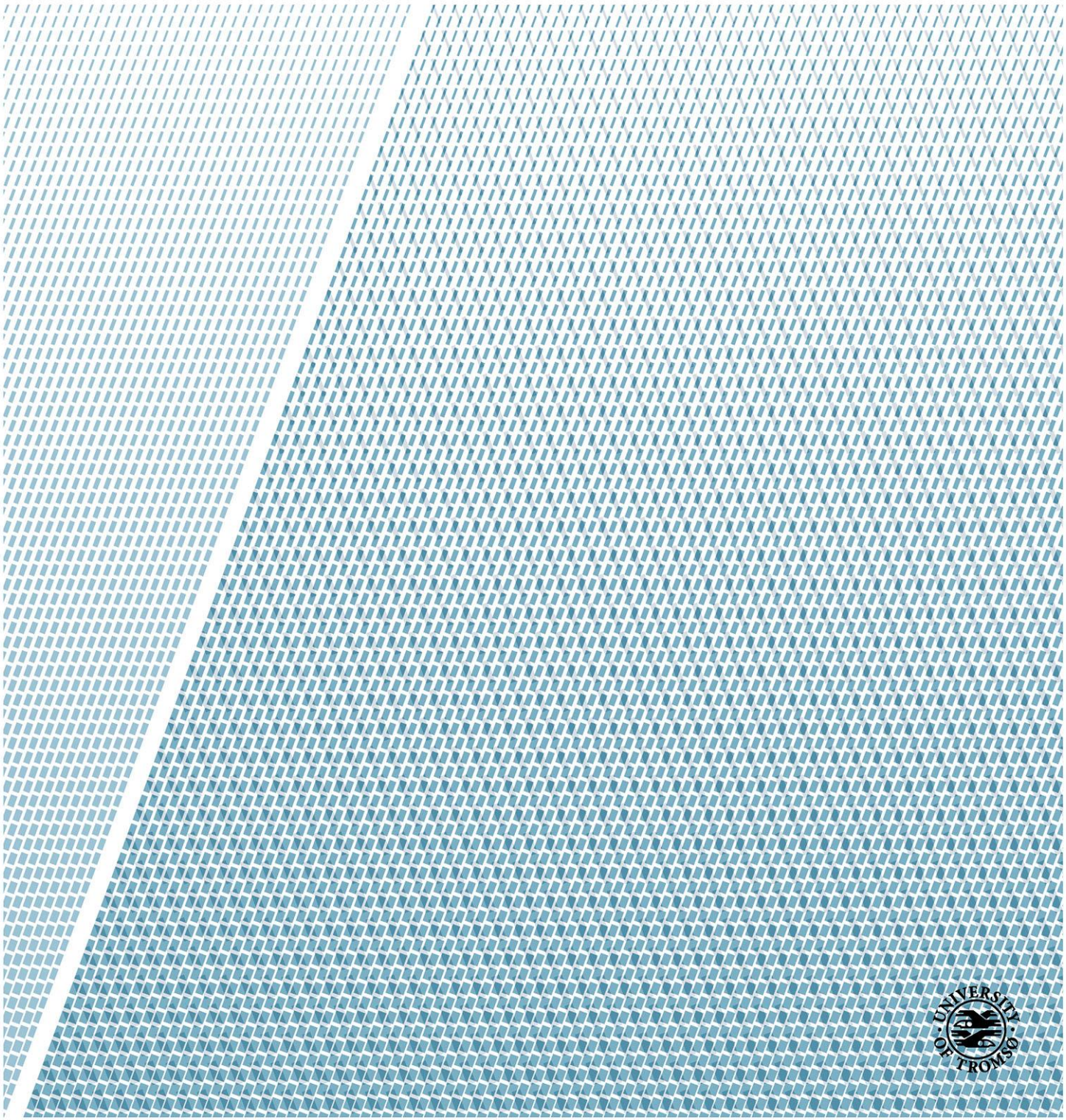

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List of abbreviations

CFCA - Community Fisheries Control Agency

CFP - Common Fisheries Policy

DCF - Data Collection Framework

EC - European Community

EU - European Union

FAO - Food and Agriculture Organization of the United Nations

FLW – Food loss and waste

FSC - Food supply change

GRT - Gross registered tonnage

IEO - Instituto Español de Oceanografía

IMTA - Integrated multi-trophic aquaculture

MAGP - Multi-Annual Guidance Program

MLS - Minimum Landing Size

MS – Member state

NGO- Non-Governmental Organizations

PHP - Philippine Peso

PNG - Papua New Guinea

TAC - Total Allowed Catch

Abstract

One of the main aims in fisheries management is to obtain sustainable fisheries and reduce the waste and losses. Many fish species lives together in many fishing grounds. Fisheries of target species will thus include other species as bycatch. This thesis analyses potential market oriented solutions to solve the problem through by processing products valuable in the market for those species until now discarded. The sea cucumbers harvested by the Galician fleet will be an example of this procedure. The analysis of these resources shows three species possess the required nutritional properties and abundant enough to create values in existing markets. The appreciation of this product in the market permits exportation through the already existing value chain from the fishing vessels to local and Asian markets used for other seafood products.

Key words: Market oriented processing, Bycatch, Sea cucumber, Galicia

1 Introduction

Nowadays, the societies are more concerned than ever about ecosystem health, conservation and saving foods (FAO, 2014). The bycatch generated by targeting the most valued species is under much debate. The new challenge is to reduce food waste of the bycatch by reducing the opportunity cost and making fisheries more biological and economic sustainable.

This master's thesis will focus on the possibility of increasing the market value of the species previously discarded due to a lack of market structure. To illustrate this opportunity we present a case study on sea cucumbers in Galicia. Currently in northwest Spain, where there are many different spices, but only three have the necessary stock size to be considered a possible market product. The three species are *Parastichopus tremulus* captured in the Sole Bank by the Galician trawler fleet; *Parastichopus regalis* and *Holothuria forskali* captured in the estuary of Vigo.

One of the main aims in fisheries is the sustainable harvest of the sea and the first problem that always shows up is bycatch. Bycatch is the not desired fish caught in the net together with the target species. The new challenge is to reduce this food waste by reducing the opportunity costs, reducing or utilizing all the catch to make the fisheries more sustainable.

1.1 What is bycatch?

The institutions that based the decisions on the concept of "common property" have played socially beneficial roles in natural resource management (Ciriacy-Wantrup & Bishop, 1975). The fisheries management is a mean for managing the fishery resources according to the common's interests for biological and economic sustainability. During the last decade, the definition of bycatch has evolved, due to the change in the institutional approach to the problem. The European Union definition of bycatch is the total catch taken accidentally. In order to explain it further the definition used in this paper is the one proposed in *Defining and estimating global marine fisheries bycatch* (Davies, Cripps, Nickson, & Porter, 2009) where they study the bycatch composition from a management point of view.

"*Bycatch is catch that is either unused or unmanaged*". The unused catch is the part of the total catch not used for consumption, sold or reused as bait, while the unmanaged refers to the catch that does not have any specific regulation.

Therefore bycatch is expressed as:

$B = C_t - C_{lm}$

B is the bycatch biomass; C_t the total catch biomass of all species; C_{lm} the total managed catch landed and/or utilized.

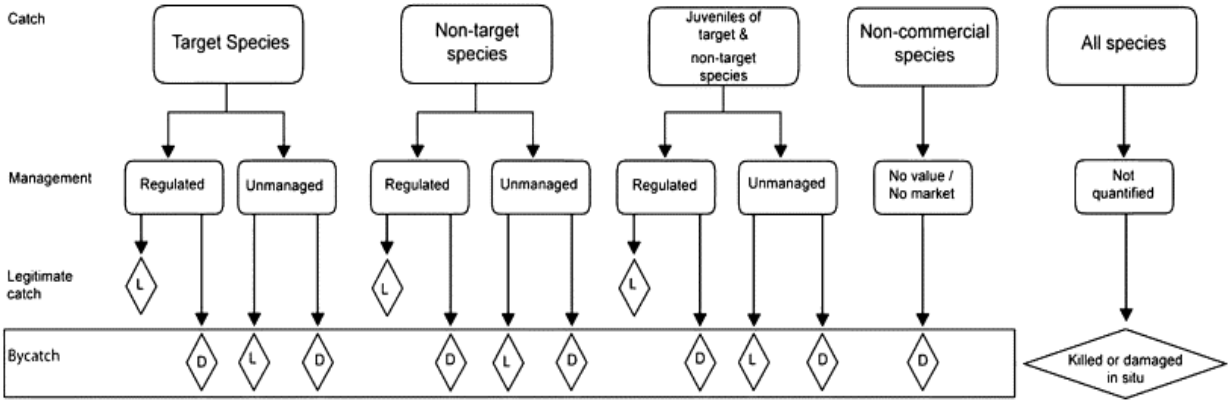

Figure 1 Applying B=Ct–Clm to various fisheries catch elements to determine bycatch. L=landed catch; D=Discarded catch. (Davies et al., 2009)

Landing obligations was established in EU's Common Fisheries Policy (CFP), Article 15 (2013). "All catches of species which are subject to catch limits, caught during fishing activities in Union waters or by Union fishing vessels outside Union waters in waters not subject to third countries' sovereignty or jurisdiction, shall be brought and retained on board the fishing vessels, recorded, landed and counted against the quotas where applicable"(European Parliament and Council of the European Union, 2013). The article established that the unwanted bycatch (part of the catch taken accidentally) under TAC (Total Allowed Catch) regulations needed to be landed on port and not sold for human consumption, though some exemptions applied.

The catch composition after applying the New Common Fisheries Policy can be seen (Figure 2).

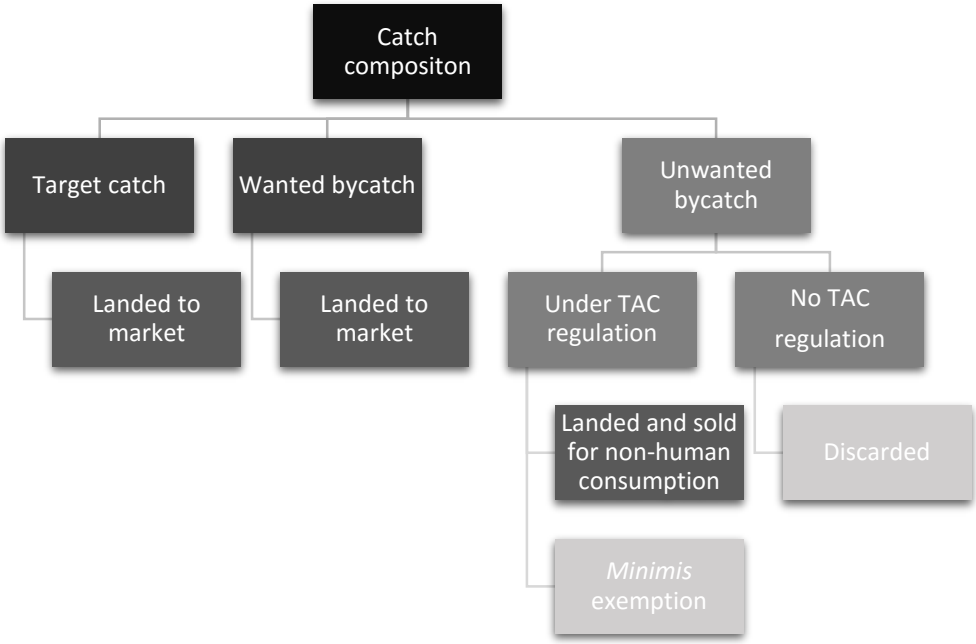

Figure 2 Catch Composition under new CFP

1.2 Drivers for bycatch awareness

Societies are more aware that policy decisions have an impact on ecosystems and can affect future generations. Fisheries are no different. During the last decade, more and more organizations have been created with the aim to raise awareness about the problems in the sea. These concerns have reached a critical level for the European Union to develop one of the most ambitious common fisheries policies in history (Green Paper Reform of the CFP, 2009).

1.2.1 The evolution of sustainable fisheries in the European Union

During the Treaty of Rome in 1957, the European Community (EC) showed the first intention to regulate the fisheries industry. Article 33 states The Common Market shall be extended to agriculture and trade in agricultural products. 'Agricultural products'

means the product of the soil, of stock farming, and from fisheries" (Symes, 1997).The negotiations during 1976 would be known as the first Common Fisheries Policy (CFP) but it was formally created in 1983. The European Community decided that Member States would extend fishing limits 200 miles off the North Sea and the north Atlantic coast starting on 1 January 1977. Some regulations regarding the catch limit was needed as the stock assessment models portrayed that the solution was to establish a Total Allowable Catch (TAC) each year. The TAC for each fishery is based on stock assessment models created by a Population Biologist which included historical track records from each country (Da Conceição-Heldt, 2006)

Back in 1976, there were only ten Member States and the decisions had to be made unanimously (Ginsberg 2007). The review of the CFP during 1992 brought a new host of issues and criticisms. Organizations like Greenpeace began a campaign against the industrial Danish fisheries and the use of beam trawlers, due to the increasing bycatch and benthic area destruction (Walter, 2010). Another controversial issue was the restructuring of the EC fleet without changing the entire fleet capacity (ship size and engine power) and a study regarding this policy showed that too many vessels were chasing too few fish. The Multi-Annual Guidance Program (MAGP) of 1997 aims to reduce the total EC fishing capacity by the reduction of vessels or days-at-sea (Walter, 2010). Before this meeting, the scientific community recommended to lower TACs limits, since their reviews found that the current regulations were too optimistic, and that overfishing is a reality. The pressure of the remaining stakeholders and their

demands were more important for the European Commission than the sustainability and the future of fisheries.

The next CFP review occurred ten years later in 2002. An initial improvement was noted, but the future of European fisheries was still uncertain. Small reductions of the Gross Registered Tonnage (GRT) meant a reduction on the fishing pressure due to the vessel and gear modernization. It signified that a lower number of ships can still catch the same number of fish (Villasante, 2010). Another issue was the enforcement of the CFP rules, since many of the catches were unreported and some vessels did not always follow the MAGP regulations. In April 2003, a new agency was created ensure that all stakeholders followed the CFP, and that the Community Fisheries Control Agency (CFCA) had jurisdiction over the EU (Gray et al. 2003).

The main problem with the CFP is that there was a huge difference between what they said and what was actually accomplished in practice. For example, the commission advisor decided that a reduction of 80% of the TAC would be sufficient to regenerate the cod stock in the North Sea; however, the Council of Ministers only agreed to a 45% reduction (Walter, 2010). As a result, the EU decided to develop a new CFP aimed at sustainability by implementing one of the most controversial legislations of the last few years.

During December 2013, the European Parliament and the European Council ratified the new common fisheries policy that included a progressive ban of discards and the mandatory landing of the fishing fleet in European waters. The aim of this ban was to

reduce the fishing mortality through the adoption of sustainable methods. These methods would allow overfished stocks to recover and it would reduce the negative impacts of fishing activity in all ecosystems (Council regulation no.1380/2013, 2013).

Article 15 established "Mandatory Landing" in all commercial fisheries (species under TACs or Minimum Landing Size (MLS) regulations) in European waters. Discarding, the detrimental practice of throwing unwanted fish overboard has been estimated to occur in 23% of all catches, though this figure is substantially higher in some fisheries. In order to make this process easier for fishermen, the regulations will be phased in starting in 2015 to 2019 (Valeiras et al.) To facilitate this, a series of flexible instruments will be introduced, such as the possibility for Member States to match quota allocations with catch estimates, swap quotas, borrow or bank a limited volume of quota between years, and where appropriate, qualify for a limited *Minimis* exemption.

According to the European Union, the fish with high survival rates will be released back into the sea. The rest of the fish caught would be landed and counted against the quotas (CFP reform,EU, 2012).The fish landed against the quotas would be separated into four different groups:

Undersized fish. In order to minimize the catch of undersize fish the selectivity of the gear needs to improve. Minimum conservation sizes will be set based on biological grounds. The fish in this group can only be sold for fishmeal and pet food production. The money obtained will only cover the landing cost, but will never generate a financial profit.

Fish caught in excess of individual quotas. They can be marketed normally; however, the vessel owner needs to buy or lease quotas from another vessel owner from the same Member State before they complete their own quotas. It is the responsibility of the fishermen to ensure that they have met the necessary quotas.

Overshoot of national quotas has to be dealt with by each Member State (MS) through bycatch reserves. MS can borrow or bank quotas between years, or swap quotas with other MS's. If this is not enough, the overshot quota will be deducted from the following year´s quota.

Under effort management systems. All commercial species above the minimum size can be marketed and sold normally as long as the effort allocated is not exhausted.

1.2.2 Economical point of view

The bycatch is a waste of commercial resources, and they represent a high cost of opportunity for the fishing activity now and with consequences for the future. Most of the bycatches are discarded because it does not reach the Minimum Landing Size (MLS) or due to a lack of market value for that species. It is important to increase the selectivity of the catch to reduce waste. At the same time, we find edible species with a good stock health that are considered bycatch because they lack commercial value. (Johnsen & Eliassen, 2011; Sigurðardóttir et al., 2015).

1.2.3 Environment issues.

The bycatch is considered an unnecessary disturbance of marine ecosystems with unknown consequences. Removing or reducing one species will affect other populations

within the system by disrupting the food chain, and this may leave some species without predators and other predators without prey (Garcia et al., 2012). This may cause a reduction in the biodiversity due to accidental catch of predators, prey, or endangered species.

1.2.4 Management and evaluation.

The bycatch is seen to be a source of unaccounted mortality as long as this catch is unreported and the mortality rates of release remain uncertain, increasing the uncertainty of stock assessments.

In order to create efficient regulation, the managers need a lot of data including bycatches. Nowadays most of the data regarding the bycatch come from studies since the amount of fish discarded is not being recorded by the fishermen. The new CFP states that Member States should develop a "Discard Atlas" that collects the discard levels that occur in regulated fisheries (Valeiras et al., 2014) since the mortality of the bycatch is uncertain in most species.

1.2.5 Ethical concerns

The bycatch is a waste of resources, which brings forward the ethical debate to the fishing industry. Nowadays, society is concerned about the sustainability of many of the earth's resources and fisheries are one of the biggest resources of food for future generations. (Johnsen & Eliassen, 2011; Sigurðardóttir et al., 2015).

The management of natural resources should be an ethical responsibility of the politician and managed as common property (Ciriacy-Wantrup & Bishop, 1975) to

ensure the sustainability of fisheries. The design of the fisheries regime reduces the bycatch and still maintains the social, economic and biological objectives.

The resolutions from the United Nations, the Kyoto Protocol and the Code of Conduct for Responsible Fisheries mentions the need for the reduction in the bycatch and fisheries waste.

The Code of Conduct for Responsible Fisheries discusses the main strategies to solve these problems, by reducing the bycatch and to increase the utilization of the bycatch. The case study of this master thesis will focus on the latter.

1.2.6 The save food movement

In the last decade, the issue of Food Loss and Waste (FLW) has become an important topic for global food systems, including both the public and private sectors. Many initiatives have been aimed at increasing the awareness of this problem in modern society.

The Food and Agriculture Organization of the United Nations (FAO) recently created the program “Global Initiative on Food Loss and Waste Reduction) in order to coordinate information exchange. FLW is an important factor of food security on local and national economies, the natural resource base, and on the environment (FAO, 2014).

Fish discards are the portion of the total catches, which are thrown away or slipped into the sea. They comprise of the following components:

- Species which are intended to be caught, but are spoiled and are unfit for consumption by the act of catching; these discards are food loss.
- Species which are intended to be caught, but do not meet the regulatory or quality standards, such as size; these discards are food loss.
- Species which are not intended to be caught, but are fit for entering the Food Supply Chain (FSC); these discards are food loss.
- Species which are not intended to be caught, and which are not considered food; these discards are not food loss

The sea cucumber in Galicia is included in the third part.

1.3 Research problem.

The new CFP to increase the sustainability of fisheries focus on the reduction of discards demanding all discards to be landed on port. Many studies focus on the utilization of the discards in the market. It is an important change in policy and it will be one of the biggest challenges for the European fisheries during the forthcoming years. This is the first step to a more sustainable fishery, though nevertheless many species are not under a quota system, and therefore are not regulated by this Article 15 (2013).

This master's thesis will focus on the possibility of increasing the market value of the species previously discarded due to a lack of available market structure for the fishing fleet. To illustrate this topic, we will present a case study of the sea cucumber harvest in Galicia. In northwestern Spain there are currently many different types of sea cucumbers, but only three of them have the necessary stock size to be considered as a

marketable product. The three species are *Parastichopus tremulus* captured in the Sole Bank by Galician trawler fleet; the *Parastichopus regalis* and *Holothuria forskali* captured in the estuary of Vigo.

1.3.1 Technical and biological description of sea cucumbers

The sea cucumber has always been appreciated in the Asiatic market due to the high interest in traditional Chinese medicine in this product. The health benefits of the sea cucumber has been tested in different projects, and has become one of the main ingredients in medications that regulate cardiology problems (Hologal, n.d.) but it is also used as a premium product sold in restaurants.

This is the case of the sea cucumbers caught by the Galician fleet, there is three species considered as unwanted bycatch due to a lack of commercial value. This thesis will focus on the possibility of turning these three species into desired bycatch.

1.3.2 Research Questions

The main research question is to identify the factors that influence (constrain/facilitate) a profitable market adoption of sea cucumbers harvested landed by the Spanish fleet

The first question to be investigated is the selection of species with market opportunities. The main criteria is to identify the different species of sea cucumber caught and select the ones with sufficient volume to be marketable.

The second question to clarify is the nutritional analysis of productivity

It must be confirmed that the selected sea cucumbers are suitable for human consumption and at the same time that their nutraceutical properties will enhance the commercial value. The third question is to identify the target market and the product options in the markets and value chains. The possible target market and channels and between the local and the Asian market must be identified and the production process required to satisfy market needs profitable. The fourth question would be the impact of the value creation and the aquaculture option.

1.1 Structure

After having presented introduction, research problem and question, Chapter 2 describes the theoretical framework, the methodology of the thesis, limitations and structure. Chapter 3 focuses on the literature review selected to solve the research question. Chapter 4 looks into the sea cucumber situation in Galicia. In Chapter 5 the results will be discussed and chapter 6 will include the conclusions and recommendations. References will be presented in Chapter 7...

2 Methodology and limitations

The methodology of this thesis is mostly qualitative. I have made use of literature review, field interviews and data analysis.

2.1 Literature review

The articles regarding the Common Fisheries Policy (CFP), the bycatch regulation and the save food movement were searched through the Google Scholar search engine combine with the EU website "EUROLEX". I used the key words "discard", "regulations", "EU" and "ban" for the CFP. The idea was to provide information about the last regulations regarding the bycatch and the reasons behind. Once I found the first articles, I used the snowball strategy (Malhotra & Bricks, 2007) (to find other relevant articles.

To narrow down the thesis I decide to create a case study as an example of bycatch management. I search information about new commercial species in Galicia until I found the project regarding the sea cucumber. Once again, the methodology to introduce the case study was the literature review, using the Google Scholar to find articles regarding the global situation of the sea cucumber around the world. The key words used were "sea cucumber", "trends", "value chain" and "market" to find the first articles and after the snowball strategy was used again.

2.2 Case study (Data collection)

After reading about the situation of the sea cucumber I contacted the fishing association ARVI which I visited during January 2016. They provided a lot of information regarding the sea cucumber and their project Hologal (Hologal, n.d.).

Since I could not find relevant articles regarding the sea cucumber market during the last years. I decide to analyze trade data provided by the Norwegian Seafood Council.

2.3 Limitations

Time was the main limiting factor for the data collection; during my stay in Galicia I was only able to visit ARVI which was the coordinator partner of the Hologal project. I was not able to settle a visit to the other project partners during those days.

Another limitation was the lack of articles regarding the sea cucumber in temperate waters and the new production methods. The lack of reliability of the data supplied by the Chinese government is also a concern pointed out in the previous studies.

To create value for the bycatch species, it is necessary to do an independent study for each species due to their particular characteristics. In some cases the example of one species can be used as market indicator but this is not always the case.

3 Literature review

The consumption levels of sea cucumbers in China have affected the stock market around the world. Nowadays 20% of sea cucumber fisheries are considered depleted and 38% are over-exploited. Only 27% are considered underexploited or moderately exploited, but most of these fisheries are in deeper and temperate waters where the fishing market is still developing (Purcell et al., 2013). Figure 18.

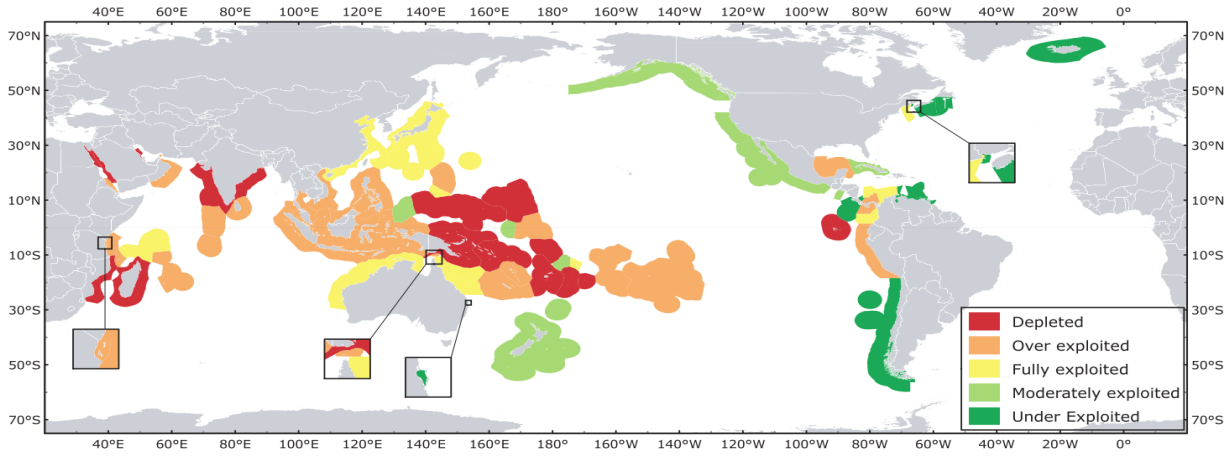

Figure 3 Current status of global sea cucumber fisheries (Purcell et al., 2013)

3.1 Sea cucumber history.

Known as Bêche-de-mer (the name for the dried body wall of the sea cucumber) in the Chinese cuisine, the sea cucumber has been harvested for commercial purposes for more than 1000 years. Papua New Guinea and New Caledonia exported this product to China in early as the 18th and 19th centuries, respectively. It was served as a heath tonic

and as a common dish in banquets. The sea cucumbers used for this dish needed to follow and long process that included repeated boiling and drying, and several days of soaking and washing to obtain the desired dry form (Clarke, 2002).

Most of the sea cucumber used to be traded in Hong Kong, Singapore and Taiwan, yet 80% of the global supply is controlled in Hong Kong. In the past, the lower- value products were sent to Hong Kong for re-export to mainland China. Nowadays, the high-end market in China is expanding and reducing the price difference (Jaquemet and Conand, 1999). The sea cucumber followed this value chain due to the difficult import duty in China while Hong Kong is a duty-free territory (Ferdouse, 2004).

There are approximately 1200 species of sea cucumber, but only 300 can be used as bêche-de-mer, but every year more fisheries try to introduce new species in to the market. The most valuable type of sea cucumbers are the spiked and wild-caught ones. The degree of the dryness process appears to be one of the key factors to determine the price. Most of the dried sea cucumbers are sent by sea or air transport, since they are becoming more popular during October due to holiday and celebrations which cause the price to increase (Clarke, 2002).

The consumption of sea cucumber is mostly associated with high quality dried food like shark fin, abalone, shellfish and other popular seafood among the Chinese people. In most countries, the domestic consumption is almost zero with the exception of China. The major consuming countries and territories in the region are Hong Kong, Taiwan, Singapore and Malaysia (Ferdouse, 2004).

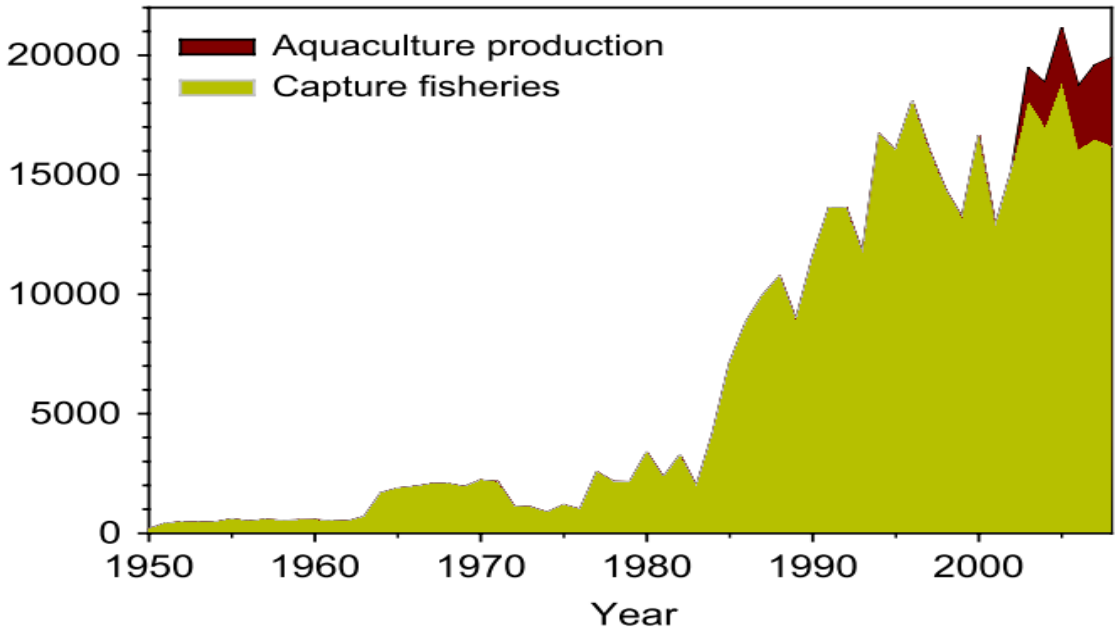

Figure 4 Global sea cucumber production (Purcell et al., 2013)

3.2 Previous studies about the major markets

3.2.1 China

China is the first country that started to consume the sea cucumber and today is the biggest importer. Thus, the status of the sea cucumber in China can be summarized as follows.

The sea cucumber was recorded as a folk remedy and as a "tonic" food in the Bencao Gangmu also known by the Compendium of Materia Medica, written by Li Shizhen during the Ming Dynasty (1368-1644). This is considered as the most complete and comprehensive medical book ever written in the history of traditional Chinese medicine. According to this book, the sea cucumber nourishes the blood, provides vital essences (*jing*), kidney (*qi*) disorders and reduces dryness (especially in the intestines). It is

commonly used to treated weakness, impotence, debility due to age, constipation due to dryness and frequent urination (Chen, 2005). Another popular Chinese name for the sea cucumber is "*haishen*" which means "ginseng of the sea".

In China, around twenty species of sea cucumbers are considered traditional medicine and tonic food. Their body wall or intestine contains a high number of nutrients. For example, the protein content reaches 50% of the dried weight in most edible species. There is also sufficient evidence to say that they are pharmaceutical valuable due to the glucosaminoglycan content that has a physiologically active function, such as the inhibition of some cancers including lung cancer and galactophore cancer; enforcing immune function and anti-aggregation of platelets among other functions (Chen, 2005).

During the economic development in the 1980s, numerous Chinese people improved their standard of living by increasing the consumption of tonic food and luxurious seafood, including the sea cucumber. In order to satisfy the new and increasing demand, the research to develop farmed production became a priority.

Throughout the years, the demand for this product keep increasing in this China while most of the species are overexploited. Thus, the Chinese fishery authorities promoted the seed production of sea cucumber as well as the development of farming and ranching techniques (Chen, 2005). In 2002, the total production of dried sea cucumber in China reached the 6 335 tons, of which 5 865 tons came from the aquaculture sector and only 470 tons from captured production. However, this amount of sea cucumber is

far from meeting the national demand; hence, China imports a lot of dry sea cucumber through Hong Kong.

One of the biggest problems when it comes to analyzing the sea cucumber market is the huge discordant between the data provided from the different countries; therefore, the actual trend of the market is not reflected in the published data. The political issues in areas like Taiwan and Hong Kong sometimes created errors in the trade databases. China consider the trade with Hong Kong as national trade and Hong Kong as international.

For example, according to the statistics from Hong Kong, the re-exports quantity reached 3 543 tons in 2001. It means that the sea cucumber produced in the mainland China, is sent to Hong Kong and distributed back to the mainland China for consumption.

However, according to the statistics reported from China, the annual imports in 2001 reached 2 059 tons from which only 13.5 tons came from Hong Kong. Imports from Indonesia reached 1 146 tons, Philippines 791, Korea Rep. 21, Thailand 56, Canada 17, and Russia 1.2 tons. Most of the Chinese sea cucumbers sent to Hong Kong and returned to mainland China might follow the traditional commercial value chain.

In total, the amount of sea cucumber that goes from the Hong Kong traders to the mainland China is estimated in 5 500 tons (Ferdouse, 2004)

The overexploited sea cucumber in China is for instance, the captures of *A. japonicus*,, which in the 1950s were 140-130 tons of dry sea cucumber in the areas of Shandong

and Liaoning Provinces respectively, but in the 1970s dropped to 30 tons in Shandong and to 40 tons in Liaoning. From there the production went down almost to zero, causing the price of sea cucumbers to increase from 18 Chinese RMB (less than 3US$) per kilogram in 1960 to 3 000 RMB (around 400 US$) in 2002 (Chen, 2005).

The production of sea cucumber in aquaculture and sea ranching started in the northern part of China and its rapid success helped it to expand the sector towards the south.

Apostichopus japonicus is the main species of sea cucumber used in aquaculture in China. The increasing amount of farmed sea cucumber is expected to reduce the pressure in overexploited species caught in the sea. In general, the northern part of China uses two methods for capture, scuba diving or heavy-diving facilities. In the south, the fishermen have designed a facility for harvesting (Chen, 2005).

3.2.2 Hong Kong

The Special Administrative Region of China is the largest importer of sea cucumber in the international market. Hong Kong imports mostly dried tropical sea cucumber of all varieties. The reason behind why almost all sea cucumber goes through Hong Kong and not directly to China is due to the import duty in China while Hong Kong still keeps their status of a duty-free territory (Ferdouse, 2004)

During 2002, the imports reached 4 417 tons at a value of US$ 56 million (US$ 12.70/kg). The main suppliers were Indonesia, the Philippines, Singapore, Papua New Guinea, the Solomon Islands, Madagascar and Australia. The domestic market of Hong Kong consumes around 500-700 tons of dried sea cucumber per year. This consumption

has been constant throughout the years. It is considered to be an expensive and luxury product, mostly consumed by middle-aged groups with high income during the Chinese New Year, weddings, dinners and other types of celebrations. The consumer prefers large and medium sized dry skin-on calcium coated sandfish (*Holothuria scabra*) and teatfish (*Holothuria fuscogilva*), the most expensive of the species (Ferdouse, 2004).

The next figure illustrates the behavior of Hong Kong trades. Hong Kong is one of the most important stages of the value chain for the sea cucumber market.

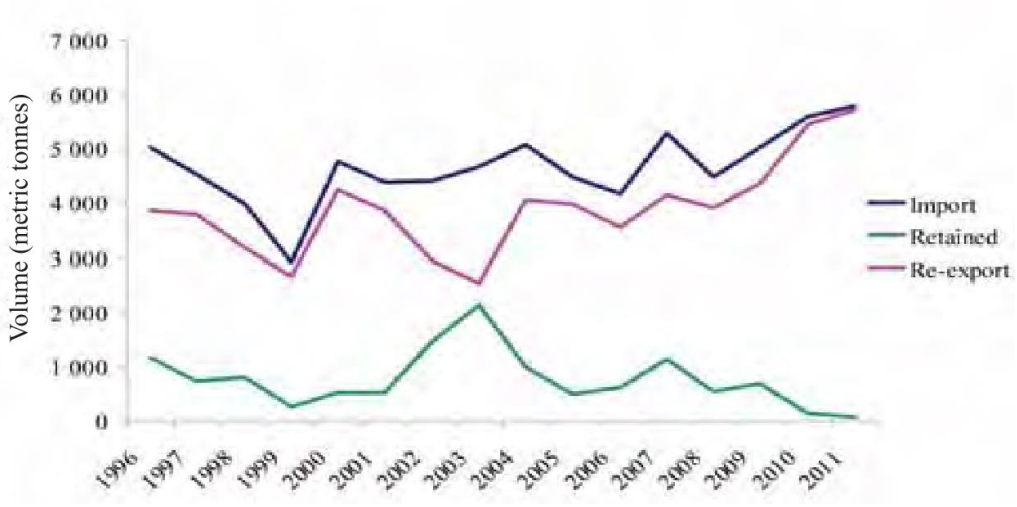

Figure 5 Volume of bêche-de-mer imported and re-exported by Hong Kong (To & Shea, 2012)

3.2.3 Taiwan

The area of Taiwan has a high per capital income and therefore the demand for high value fish and sea product is elevated compared to other parts of China. Another distinctive factor of the Taiwanese market is that the household consumption of sea cucumber is higher than in other areas where the imports reached 1 015 tons during 2002. Traditionally, the market has a preference for spiky tropical and cold water

species. Coldwater sea cucumbers imported from Alaska and Canada come in a frozen form and the one from Peru is also frozen, but it has been processed into dried sea cucumber.

Another important factor is the import duty in Taiwan, which varies between 20-40% of its invoice value. The spiky varieties have lower tariffs compared with other species. Also the frozen product has a reduced import duty compared with the dried/salted products (Ferdouse, 2004).

3.2.4 Singapore

Singapore is considered a traditional trading country when it comes to sea cucumbers. The production of the country is almost none. It is considered as seafood delicacy similar to dried shark fins.

Most of the sea cucumber imported is later exported to other countries. The main supplier during 1997 to 2000 was Hong Kong, followed by India, USA and South Pacific island countries. The best quality sea cucumber comes from Australia and other Pacific countries (Ferdouse, 2004).

Only 2.3 million people in Singapore in 2002 consume a small part of the imported product. In 2015, the population of Singapore was estimated to be 5.5 million where 74% of them are of Chinese ethnicity. Singapore exports most of the bechê-de-mer to the following areas, Hong Kong, Malaysia, and Thailand. Hong Kong demands the highest quality product while Malaysia buys medium grade sandfish of different sizes.

3.2.5 Malaysia

The Malaysian population census was 28.4 million in 2010, where 7 million self-identify as Chinese. This big population group greatly influences the Malaysian market. The market import of fresh, chilled and frozen sea cucumbers comes from Indonesia, but the dried product is predominant like in most of the Asian markets. Similarly to Singapore, Malaysia re-exports half of the sea cucumbers that they buy from other countries. The imports in 1998 were 500 tons, but in 2002 they were only 160 tons.

The consumption of sea cucumber in Malaysia follows the same pattern from other countries, and are mostly consumed in big celebrations like Chinese New Year and at weddings (Ferdouse, 2004).

3.3 Capture methods

Most of the sea cucumber fisheries around the world are considered wild captures. Depending on the country, there are two main types of fisheries, small scale fisheries in low income countries in the tropics, and industrial fisheries in high income countries with cold water. Only China obtains a large portion of their production from aquaculture farms.

3.3.1 Small-scale fisheries

There are many fisheries around the world that harvest sea cucumbers, 66% are considered small-scale fisheries and almost all of the catches are exported to the Asian market. The natural habitat of the sea cucumber in the tropics are primarily shallow

water ecosystems, thus they are easy to harvest. The fishing gears and boats used for these artisanal fisheries are considered simple.

One of the biggest problems in these areas (Central America, South America and Western Indian Ocean) is illegal fishing, where 27% of the fishing boats were operating despite the national moratoria (Purcell et al., 2013).

The fishing methods vary from women and children collecting sea cucumbers from the reef and sand flats at low tide, to diving from small motor boats and even using traditional canoes. Sometimes the fishermen process the sea cucumber due to simplicity of the process, though the main problem of this type of fishery in Indo-Pacific area is the lack of quality control in processing and the long and complex trade chain.

3.3.2 Industrial fisheries

The vessels participating in industrial fisheries are larger and use sophisticated gears to harvest the sea cucumbers. Many aspects differ from the small-scale fisheries. Here only a few boats participate and mostly belong to high-income countries. The value chain is shorter. In Australia for example, two companies own all the vessels fishing along the 2 000 kilometers of coastline (Purcell et al., 2013). The countries involved in the industrial fisheries of the sea cucumber are relatively new to the industry and they are still developing their fishing techniques and management. More and more countries are becoming attracted to the sea cucumber market due to the overexploited status in the traditional market and the high price of the product in the Asian market.

Numerous harvesting methods are used in industrial fisheries. The sea cucumber can be collected by divers or by using drags or trawl gears. For instance, in Canada modified drag gears are used, putting in danger the soft-bottom ground where the sea cucumber inhabits.

The process used in industrial fisheries is similar to the one in small-scale fisheries, but it is much more sophisticated. Hence, the final product is more consistent and can be considered high-quality. Labeling has become another way to increase the price and reputation of the product. The industrial sector is exploring new types of processing such as frozen or vacuum-packed to differentiate their product from the typical dry sea cucumber (Purcell et al., 2013). Canada is creating new products by dividing the sea cucumber into many parts to sell then separately, and Russia is producing hydrated canned sea cucumber.

3.4 Aquaculture

Since the 1950s, China had been researching and developing new methods to produce sea cucumber. They selected the species *Apostichopus japonicus* and in 2001 there were three main farming methods; pond culture, pen culture, and sea ranching or bottom culture. The biggest limitation for the aquaculture sector is the seed production, and the techniques have greatly improved since 1980s, and between 6 and 8 billion juveniles were been released.

3.4.1 Pond culture

Growing sea cucumbers in ponds is very common in China. Many abandoned shrimp ponds from production in the 1990s, were adapted for sea cucumber farming. The old ponds fulfill most of the ideal conditions to produce sea cucumber. The ponds are being close to the low tide mark so the water from the sea can enter the pond without the need of mechanic power. They may also have a good level of salinity, no pollution, a sandy and muddy bottom, at least two meters in depth, a size between one to four hectares, and protection against strong waves or typhoons (Chen, 2005).

In order to create the perfect habitat for sea cucumbers, bricks and stones are added to sea bottom creating piles or rows. These areas will attract small forms of life, which will be used as food for the sea cucumber and at the same time will provide shelter from predators.

3.4.2 Pen culture

Pen culture is similar to the pond culture, but the pens are located on the seashore. When the tide is low, the depth of the water is around 80 to 100 centimeters. The high tide brings nutrients to the sea cucumbers. This method does not offer protection against strong waves or atmospheric phenomena. This method is low cost and a very efficient model, but it is only suitable for small parts of the coastline.

3.4.3 Sea ranching

This method requires a high investment compared with the other two, since more infrastructure and water management is needed. It is a similar process to clams

production in the north of Spain, where a great amount of juveniles are released in an area with good conditions and they are collected a few months later. To be more specific, the proper site needs to have the correct salinity (28 to 31%), temperature (10 to 20 ºC), offers food and shelter, and a depth between 3 to 10 meters then a large amount of seed material can be released and grown for several months (Chen, 2005).

3.5 Sea cucumber products process

3.5.1 Traditional process

Sea cucumber is a product with a long tradition in the Chinese cuisine, and until recent years, the sea cucumber was only eaten raw, boiled, or pickled. In Korea and Japan, the market was for the walls of the sea cucumber and the viscera are eaten raw or pickled. As mentioned previously, the most important product is the dried sea cucumber, marketed as bêche-de-mer. In order to obtain this product the sea cucumber has to follow six traditional stages: boiling, slitting the dorsal side, boiling again, gutting, smoke drying, and finally sun drying. The duration of the process might vary depending on the species, and the sea cucumber will greatly shrink. By the end of the process, the weight of the sea cucumber will be around 10% of the original weight (Conand & Byrne, 1993).

3.5.2 Innovations

Nowadays sea cucumbers can be found in the market as frozen, salted, or in brine among others ways. Most of these innovations come from the high income countries that have joined the recent sea cucumber harvest. They possess the technology and the

experience from other seafood products. As explained before, Canada is marketing different parts of the sea cucumbers independently and Russia is doing the same with canned sea cucumbers.

The Chinese consumes most of the sea cucumbers in the world and they accept any species; however, spiky cucumbers are in higher demand, but most of them come from tropical waters. The expensive species has been in the market for a long time too and the high income countries face the challenge of introducing new species in to the market when the quality focuses more on traditions rather than the nutritional content of the product. The need to differentiate the product and this way increase the price goes thru new conservation procedures, like canned sea cucumber that increase the convenience of the product. For the Occidental market the sea cucumber is relative new product and some adaptation will be needed.

3.6 Value chains

A value chain is a group of activities done by the operators in order to add value to a product, from obtaining the resources, processing and marketing, up to the final sale to the consumer.

The book *Value Chain Analysis for Sea Cucumber in the Philippines* (Brown et al , 2010) explains how one of the value chains for sea cucumbers works. It is important to identify the main operators and activities along chain and afterwards and compare it to the value chain of the Galician sea cucumbers.

The aim of the book was to answer six questions. (1) Who are the key customers' product requirements in terms of species, volume, quality, packaging, delivery schedules, as well as grades and standards? (2) Who are the key players in the chain and what are their respective roles? (3) What are the activities and processes along the chain? (4) How are the flow of product, information and payment along the chain, and (5).What are the logistic issues? Lastly, what are the external influences (e.g., ordinances, regulatory requirements, policies, etc.)?

The analysis of the value chain improved the understanding of industry constraints, making identification and change of factors possible that would increase the growth and competitiveness of the chain, such as the relationships between buyers, suppliers and other market actors.

To improve the value chain, the efficiency of the processes within the business needs to be upgraded by improving either the process, product, function or the overall chain itself. The introduction of new products or the improvement of existing one leads to an upgraded product, but a lot of adjustments can be done once the weakness of the value chain is identified.

1. Key customer and product requirements.

The key market for Philippine sea cucumber is primarily China mainland and Japan, but also Hong Kong. The quality is the biggest requirement in the sea cucumber trade and it all depends on how the product is processed (dried in this case). The process involves gutting, brushing, boiling, smoking and sun drying for several days. Later the trader will

classify the products into three groups, good quality, class "B", or rejected. The aim is to obtain a low moisture content so that the skin does not separate from the flesh. The good quality one might reach 4 000 Philippine Peso (PhP) per kilogram (75€/kg) while the "B" class only 1000 PhP/kg (18€/kg) (Brown, E.O., M.L. Perez, L.R. Garces, R.J. Ragaza, 2010).

2. Key players.

Starting from the divers and collectors, the Sea cucumber goes from hand to hand through many actors like local processors, local traders, buying stations/exporters in Metro Manila, importer/processors and distributors in importing countries

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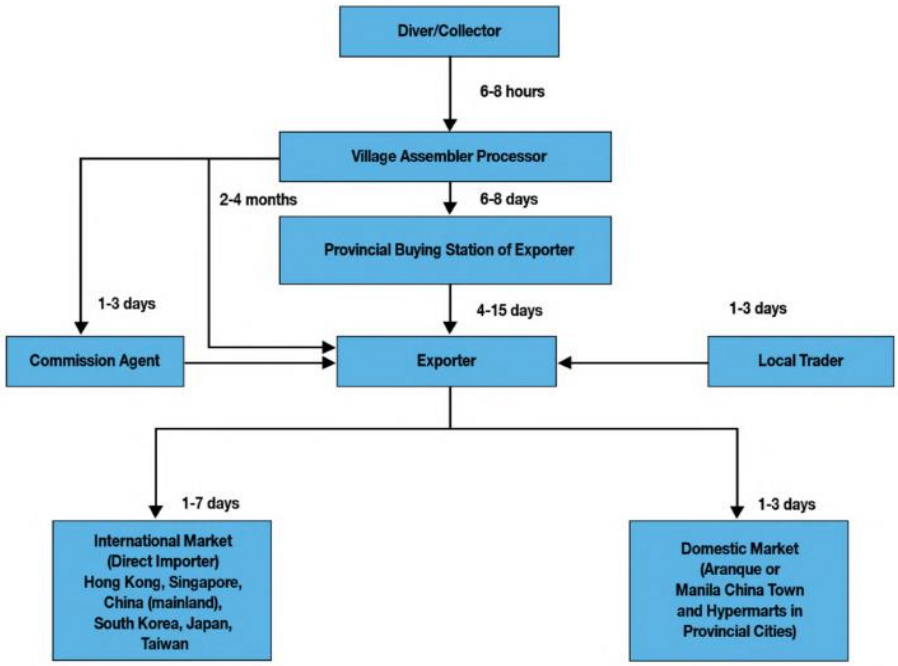

Figure 6 Key Sea cucumber product flow in the Philippines. (Brown et all, 2010)

3. Activities and processing costs.

The fishing activity costs were calculated and the result was an average of 180 PhP/day around 3€ per day (fishing trip of 6-hours) excluding the labor costs. The processing cost was calculated in 21 PhP per kilogram and the cost associated with trading was around 10 PhP/Kg.

4. Product flow.

The product is send to the processors within 6 hours of collection. It takes around 3 days to dry the product and get it ready for packing and storage.

It will be in the storage for few weeks until it reaches the sufficient quantity to sell to the next buyer. In Manila, the product is re-packed in plastic bags and shipped to the export destinations.

5. Logistics issues and external influences.

As in most overexploited fisheries the catches and the average size of the sea cucumber keep decreasing in the Philippine, this is the primary problem for the collectors. Therefore, the divers have to go deeper to collect the same amount of sea cucumbers that requires more expensive scuba diving equipment. The increasing price of fuel was another inconvenience during those years.

Value added along the chain

For example, the value added for the *H. scabra* (good quality) at the level of the exporters was 5.368 PhP/kg (around 100€/kg), and 3 000 corresponds to the collector, 1 200 to the processors, and 1 168 goes to the exporters.

The first conclusion is that the largest value is added at the collector level, because they make an otherwise non-available product available to the market.

It is important to point out that the analyses was done on a per kilogram basis and that one individual exporter managed a larger quantity than the processors, whom at the same time managed the sea cucumbers collected from different divers. Therefore the net income of the exporters is the largest among the players (Brown et al , 2010).

3.7 Main constraining characteristics of the product

One of the main difficulties of cooking sea cucumbers is the lack of taste, its bland texture and fishy smell. Due these factors, proper preparation is required. Most of the traditional dishes are stews with meat broths and extracts to give the sea cucumber an enhanced flavor.

The declining size of the sea cucumbers also affects the processors since they need more time to reach a decent volume to transport to Manila. The collectors where told to not pick the small sea cucumbers and to let the stock recover, but this did not work.

The price of sea cucumbers is determined depending on the species, size and quality. Consumers prefer the well-known species like *H. scabra* or other species that were previously mentioned. The consumer preference increases the value of the spiky species

and the bigger specimens. The industry does not have official quality standards that could guide new producers.

In terms of process quality we can see a lack of labelling from the tropic countries where some of the drying process is still artisanal and sometimes is done by the fisherman himself.

In 2005, 99% of the global trade was in the dried form. The dried sea cucumber is rehydrated for the traditional dish, this process sometimes takes up to seven days (Brown et al, 2010).

4 Case Study (The sea cucumber harvested in Galicia)

In recent years, Galician fisheries began to see the potential of sea cucumbers in the market. The sea cucumber has never been attractive to the locals, but it is well-known for being one of the most expensive in Asia. In order to study the real chances of the sea cucumber becoming a profitable sea resource for the Galician fleet, the government has supported different projects. I contacted ARVI (Asociación de armadores de Vigo), one of the main partners of the Hologal (see more below) project in order to gather information about this resource.

4.1 Selection of the species. Bycatch quantities to determine the production size

One of the main objectives of the Hologal project was to determine the economic potential of the sea cucumber resources and one of the first steps is to know the amount of product available. During sampling it was confirmed a huge amounts of specimens are captured accidently during the fishing activity of other fish species. ARVI estimated that the amount of accidental sea cucumbers captured by their fleet will reach 800 tons each year only extracting the main three species (*Parastichopus tremulus Parastichopus regalis and Holothuria forskali).*

According to the Hologal project, the economic exploitation of the sea cucumber that is now captured accidentally will not affect the stocks. Therefore, they are assuming that

the survival rate of discarded sea cucumbers is equal to zero, but they point out that this assumption needs to be studied further.

Their assumption is that none of the sea cucumber populations are too abundant and therefore if they become a target species with increased effort may have terrible consequences. Hence, before increasing the effort a stock assessment needs to be done.

One of the main problems in most of the sea cucumber fisheries is the lack of knowledge regarding the biology and behavior of echinoderms that leads to management difficulties, this fact combined with the high profitability of fisheries result in most cases with overexploitation of the resource (Purcell et al., 2013).

4.1.1 Experimental data

The data available for the Hologal study was collected through the European project "Data Collection Framework" (DCF) where the Instituto Español de Oceanográfia (IEO) analyzed the captures of the Spanish fleet. The project focused on commercial species and the rest of the species were grouped for the publication. In 2014, they extended their study, creating a group for sea cucumbers.

"Métier is a group of fishing operations targeting a specific assemblage of species, using a specific gear, during a precise period of the year and/or within the specific area" (Deporte, Ulrich, & Bastardie, 2012).

The sampling was composed by 183 hauls in the European fishing grounds and 174 in the national. In order to obtain a better understanding, the IEO created twelve homogeneous sub-division groups depending on the fishing area, fishing gear, season,

and target species. Only three of them caught a significant amount of sea cucumbers to be included in the analysis. These three métiers were:

Métier 1 (Flat fish).OTB_DEF_70_99_0_0. Demersal trawling (mesh size between 70 mm to 100 mm) in a European fishing ground targeting flat fish (*Lepidorhombus boscii and L. whiffiagonis*), monkfish (*Lophius budegassa and L. piscatorius*) and the European hake (*Merluccius merluccius*) as the main by-catch species.

Métier 2 (Hake). OTB_DEF_100_119_0_0. Demersal trawling (mesh size between 100 mm to 119 mm) in a European fishing ground targeting hake, Norwegian lobster (*Nephrops norvegicus*) and monkfish.

Métier 3 (Coastal). OTB_DEF_>=55_0_0. Mix demersal trawling (mesh size above 55mm) in a Spanish fishing ground.

Table 1 Average amount of sea cucumber in kilograms per hauling. Métier 1= Flat fish, Métier 2=Hake, Métier 3= Coastal)

Year	Métier 1 OTB_DEF_70_99_0_0	Métier 2 OTB_DEF_100_119_0_0	Métier 3 OTB_DEF_>=55_0_0
2003	4.2(524.8)	10(328.9)	1.1(328.0)
2004	41.3(375.3)	4.5(207.8)	6.4(249.7)
2005	8.7(304.9)	3.5(221.5)	7.6(318.1)
2006	28.7(409.4)	3.8(153.5)	10(203.4)
2007	13.1(317.6)	8.4(157.6)	9.3(257.3)
2008	22.3(234.8)	28.3(196.9)	6.8(277.0)
2009	14.2(290.1)	12.2(308.4)	9.5(198.8)
2010	13.5(357.1)	34.8(151.5)	24.2(233.8)
2011	30.8(264.8)	77.1(138.6)	23.9(194.1)
2012	3.6(408.5)	17.6(156.0)	11.5(201.9)
2013	7.1(310.0)	na	12.4(203.5)
2014	6.5(325.6)	49.6(123.0)	54.3(223.8)
Average	16.4(434.3)	18.3(253.0)	16.4(298.1)

The results are displayed in Table 1 with each coefficient of variation to point out the big differences in the data collected each year. The Métier 1 shows that during 2004, 2006, and 2011, the amount of sea cucumbers discarded was larger than in the rest of the years for that métier. For the second and third métiers, the amount caught increased during recent years, 2011 and 2014 were the highest for the hake métier; 2014 and 2010 for the coastal métier.

4.1.2 Quantity of each species

The catch was divided in three groups, the two main species of sea cucumbers that had a high enough quantity to be relevant and a group that combines the rest in which included species like *Holothuria forskali, Holothuria polii, Thyone fusus, and Trachythyone tergestina.* For the hake Métier (OTB_DEF_100_119_0_0), it was impossible to obtain this information.

During 2014, the average weights per haul was very different between the two types of métier, from 6.5 kg/haul in the flat fish métier to 54.3 kg/haul in the national Métier 3, 74.9% of the hauls that targeted flat fish no sea cucumber was caught, for the national métier 48.3% of the hauls did not catch sea cucumbers.

The species *Parastichopus* (*Parastichopus regalis* and *Parastichopus tremulus*) represented most of the catches in métiers, 99% in the flat fish métier and 83% in the national métier. As already mentioned, the catches present a high variability, for example there was a haul with 911 kg of *P. regalis.*

Table 2 Average catch per haul (kg/haul), by species and métier during 2014

Catch per haul (kg/haul)	OTB_DEF_70_99_0_0		OTB_DEF_<=55_0_0	
	Average (kg)	%hauls-0	Average (kg)	%hauls-0
Parastichopus regalis	3,5 (0-93)	74,9	48,1 (0-911)	48,3
Parastichopus tremulus	1,9 (0-113)		5,7 (0-136)	
Another sea cucumber	1,1 (0-97)		0,5 (0-42)	

4.1.3 Quantity depending on the depth and distribution

If we check the results, the depth is another factor that affects the quantity of sea cucumbers caught. For example, the *P. regalis* is only caught at depths lower than 150 m but lower than 450 m the quantities are small. *P. tremulus* showed a higher abundance under 200 m.

The areas of higher distribution were the national ones for both species. In the Sole Bank fishing ground only the haul in deep areas presented catches. *P. regalis* is present in the Galician and Asturian coast while the *P. tremulus* was only found off the Galician coast.

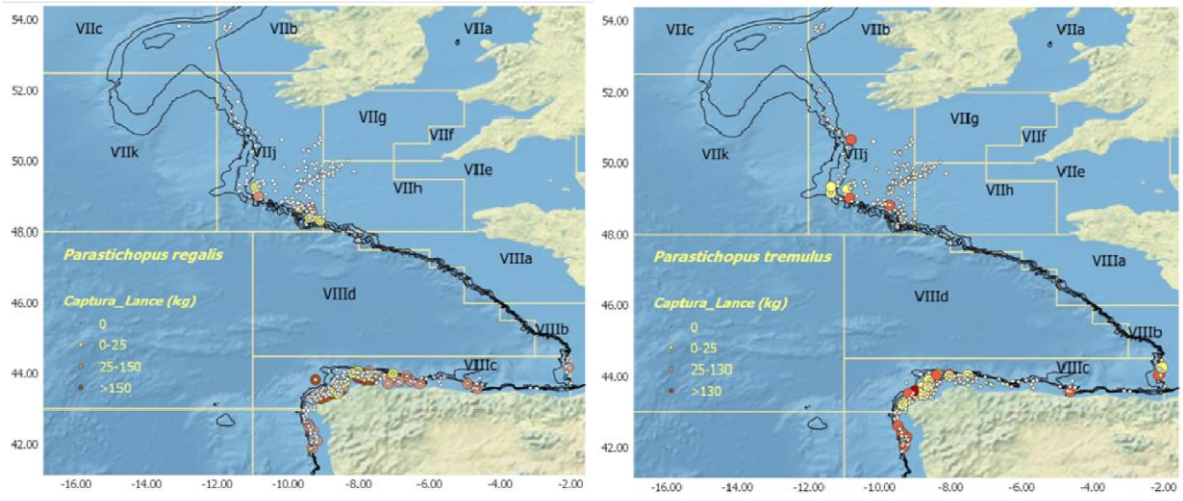

Figure 7 Catch distribution maps for sea cucumbers during 2014

4.1.4 Seasonal variation

Also another interesting factor to take into account is the seasonal variation.

For *P. regalis* the lower catches occur during the third quarter for the EU fleet, and the third and fourth for the national fleet. However, the higher peaks occur during the first and second quarter depending on the area.

For *P. tremulus* the higher peaks occur in the first and third quarter in the European fishing ground, and during the fourth one for the Spanish fishing ground. This seasonal variation does not match the previous studies made during 2014 and therefore further studies are needed.

The reason behind the seasonal variations might be due to the reproductive behavior of the different sea cucumbers, but the moment there are no studies investigating this. In order to obtain a successful and sustainable production of sea cucumbers this needs to become a priority in order to reduce the fishing pressure during the reproductive season.

4.2 Nutritional analysis to determine suitability for human consumption

The three species with a necessary stock size are the *Parastichopus tremulus* captured in the Sole Bank by the Galician trawler fleet; the *Parastichopus regalis* and *Holothuria forskali* captured in the estuary of Vigo. One of the first steps is to know as much as possible about the product before it is sold, therefore we are going to describe the three species.

The *Holothuria forskali* captured for the analysis was fished by divers around the Ría de Vigo during December 2013. This type of holothuroid is a brown-black color, and has an average length between 25 cm to 30 cm and a weight of 150 g.

The *Parastichopus tremulus* captured in Grand Sole were frozen onboard after being gutted. The *P. tremulus* average length is 30-50 cm, and most of the specimens weighed between 100 to 200 g, have a cylindrical body, are slightly flattened, and are a soft orange-red color. The tentacles are arranged in the shape of a mop and normally each specimen contains twenty tentacles (Barnes, 2008).

The average length of *P. regalis* is between 7 to 30 cm and its body is soft, flat and wrinkled, brown-red with white spots. Ebiotec, one of the Hologal project partners in charge of the biological analysis, analyzed the species. They found that three species had good nutritional, sensorial and microbiological properties and a lack of toxicity to produce food and even create new nutraceutical products.

All three possessed good nutritional quality, with high protein content, micronutrients and polyunsaturated acid (44% in the viscera and omega acids are one type of polyunsaturated acids) (Mamelona et al., 2010); these parameters will permit labeling of nutrition and health claims according the current European legislation (Commission Regulation (EU) No. 432/2012).

The three species of sea cucumber contain calcium, magnesium, zinc, manganese and iron. Thus, it will be possible to label the products with the next health claims: "contributes to normal energy-yielding metabolism and normal protein synthesis",

"contributes to the protection of cells from oxidative stress", "contributes to the normal function of digestive enzymes", and lastly "contributes to the normal function of the immune system"(Atanassova et al., 2015).

4.2.1 Onboard nutritional preservation

The fishing fleets in the Sole Bank are big trawlers targeting hake and monkfish among other species. They are big fishing boats that spend several days at sea with small production plants onboard.

The Hologal project studied the option of separating the guts from the main body parts by boiling the body, freezing both the guts and the boiled sea cucumber onboard which will help to preserve all the nutritional characteristics.

The boats don't have the equipment needed to process the sea cucumbers, hence the project to design machinery by Talleres Josmar. The prototype needs to be as compacted as possible and very efficient.

The prototype can be divided into four different areas. The first one is the gutted area, a hollow cylinder with an opening on the top; the cylinder in divided into two parts, one will introduce water to wash inside the sea cucumber and the other one will aspirate the guts and water.

The second part is intended to wash the outside of the sea cucumber. The third one will be a boiling station, and the fourth one will be the freezing area.

The guts can be packed and frozen in special plastic bags in case that they can be used in the pharmaceutical industry.

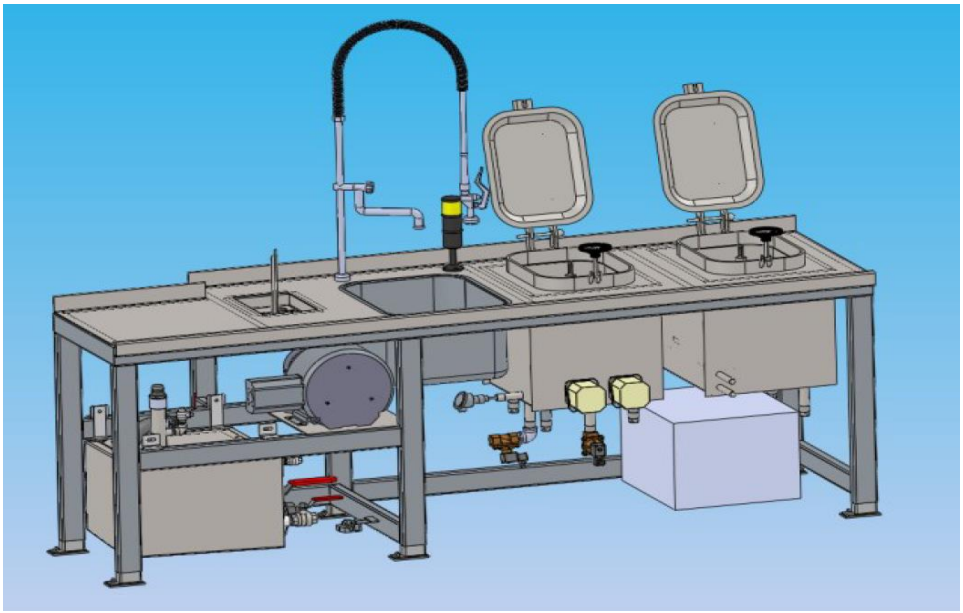

Figure 8 Prototype of onboard sea cucumber equipment

4.3 Market opportunities

In order to make a more precise prediction about the market trend, we analyze the data provided from Norges Sjømatråd for the relevant markets during the recent years, both for dried and frozen sea cucumber. Those markets are the European Union, Hong Kong, Iceland, Republic of Korea, Thailand, Taiwan and China.

Before starting the analysis it important to point out that we only have data from Hong Kong since the year 2008 for dried sea cucumber and since 2012 for frozen. It is the reason why we see a high increase of the quantity during those years. Another thing to have in mind is that Hong Kong is an intermediary in the sea cucumber trade according to the literature review.

At the end of this section, we will analyze the data from the Galician government regarding the sales of the sea cucumber in the Galician ports.

4.3.1 Quantity analysis

First, we will check the market trend of the frozen sea cucumber.

Figure 9 shows the evolution of the frozen sea cucumber exports. The EU export quantity has been growing fast since 2012 and can similar to Hong Kong that according to the previous studies had been the largest provider of sea cucumber to mainland China. The total exported quantity in 2015 is the same as in 2014 but the composition vary. The EU increased from 1049 MT to 2608 MT while the export from Hong Kong was reduced from 3123 MT to 2022 MT.

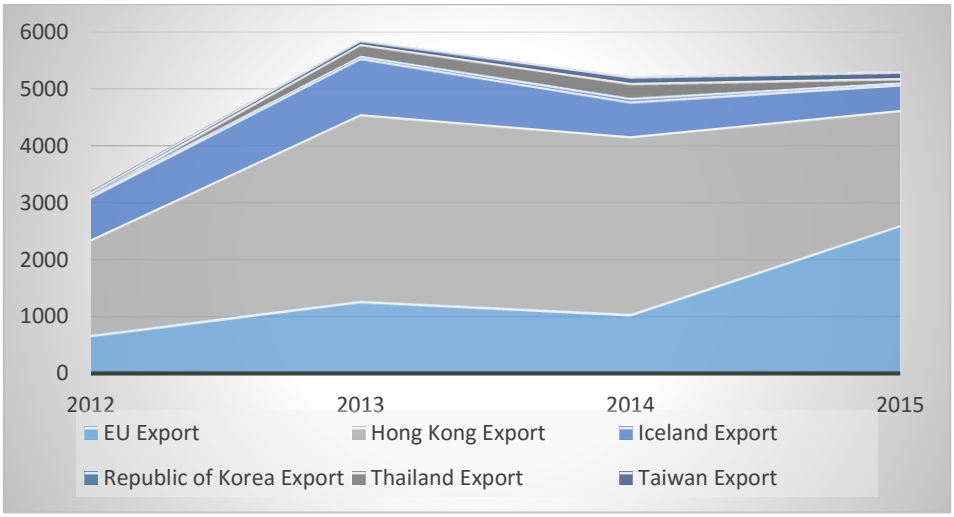

Figure 9 Frozen sea cucumber exports 2012-2015 in metric tons (MT) (Data: The Norwegian Seafood Council)

Figure 10 plot the evolution of imports of frozen sea cucumber of the studied markets. Once again, Hong Kong is the main commercial importer, but during 2013 Hong Kong bought 3956 MT while in 2015 only 2683 MT. The overall quantity that these market bought have the highest pick during 2013. During 2012, the EU import from other markets 909 MT, 1028 during 2013, only 404 during 2014 and 825 in 2015. This information the existence of a potential market for the Galician sea cucumber without the need to export to Asia.

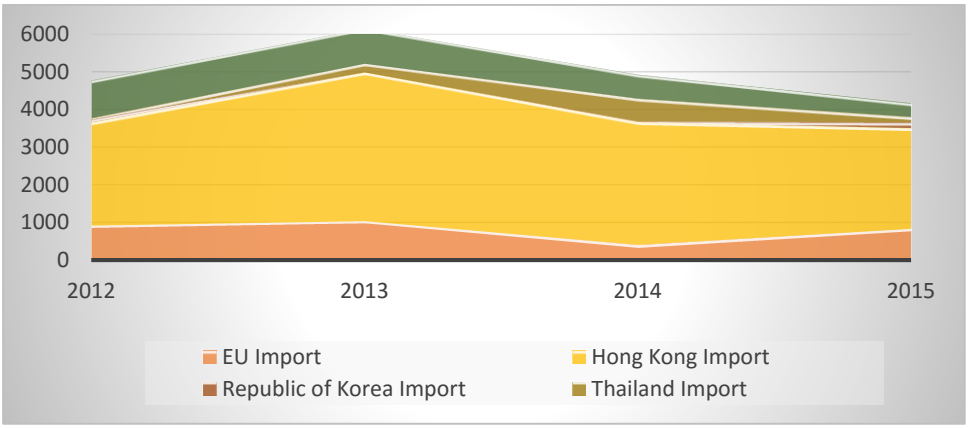

Figure 10 Import of frozen sea cucumber during 2012-2015 (MT) (Data: The Norwegian Seafood council)

Figure 11 shows the Hong Kong market dominance is even bigger in the exportation dried sea cucumber trade. During the last years, the amount of dried sea cucumber that Hong Kong exported was between 5000 to 6000 MT per year. The European Union started to export dried sea cucumber in 2012 with 280 MT and during 2015 was 710 MT.

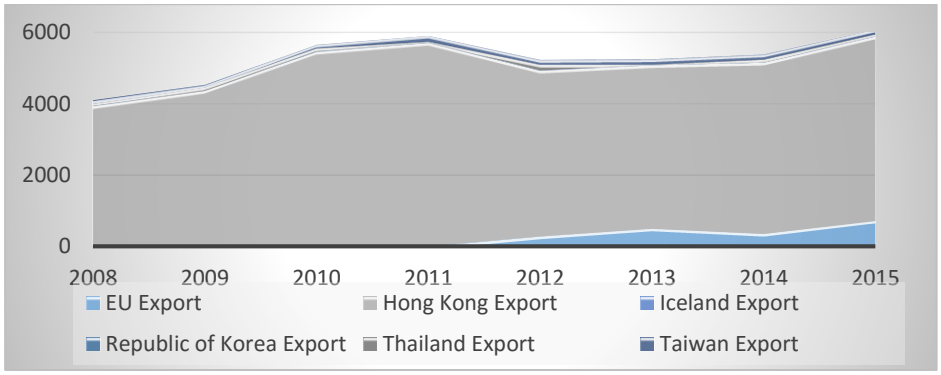

Figure 11 Export of dried sea cucumber to 2008-2014 (MT) (Data: The Norwegian Export Council)

Figure 12 shows the import evolution of dried sea cucumbers. The export quantity from Taiwan has been reduced in recent years while the export from the European Union has been growing exponential since 2012, in which EU import 175 MT of dried sea cucumber to 471 MT during 2015. Nevertheless, the importance of these two markets is almost irrelevant compared with the Hong Kong market.

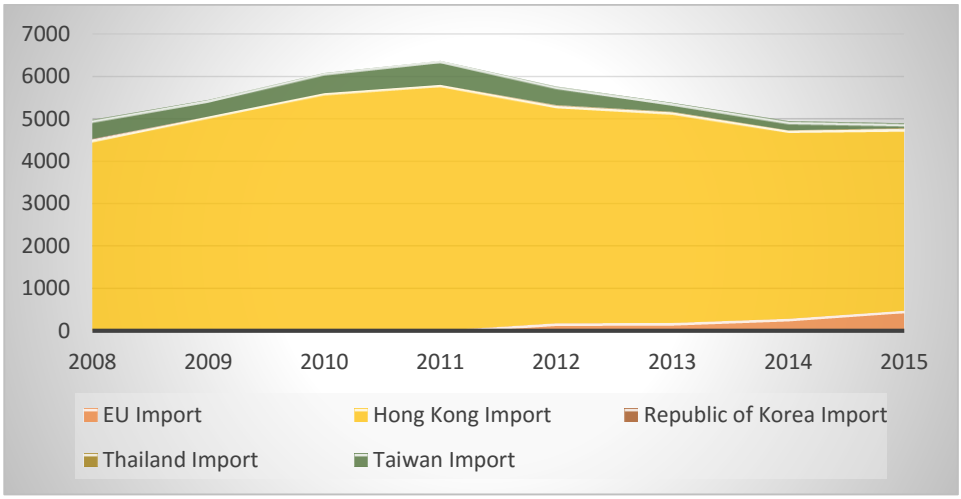

Figure 12 Import evolution of dried sea cucumber 2008-2015 (MT) (Data: The Norwegian Export Council)

Figure 13 shows the total quantity of frozen and dried sea cucumber, the total include both import and export values. The highest pick of for dried sea cucumber happens

during 2011 and for the frozen in 2013. During the last years the dried sea cucumber markets was around 11000 MT per year while the frozen had been declining for the last two years. The reason is probably not on the demand side but to the decreasing supply from overexploited tropical areas and the devaluation of the Yuan since 2015.

These values can be only compared by taking into account that the weight of frozen sea cucumber produced from one fresh sea cucumber is higher than if the weight of dried sea cucumber.

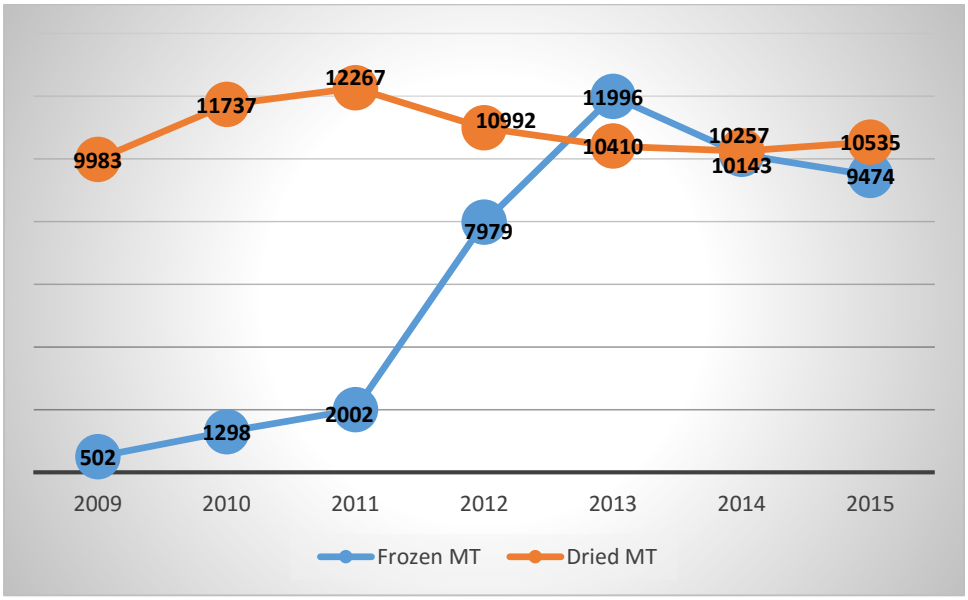

Figure 13 Comparison between total quantities of frozen and dried trade MT (Data: The Norwegian Export Council)

4.3.2 Price analysis

Figure 14 shows the price of dried sea cucumber is more that the doubled in 2015 compared to 10 years before. For the frozen sea cucumber the evolution is even higher,

during the last 10 year where the prices in average have increased from 3.24 €/kg in 2005 to 11.78 €/kg in 2015 an increase of 363%.

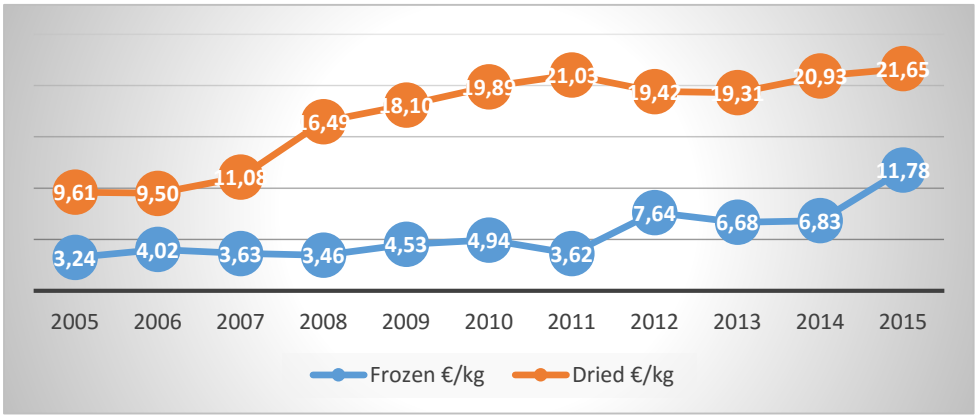

Figure 14 Comparison between frozen and dried prices per kg (Data: The Norwegian Export Council)

Figure 15 shows the price evolution for both dried and frozen sea cucumber exported from Europe. The evolution trend is completely different. Here the price of dried sea cucumber is lower compared with market average and it is almost the same that the frozen.

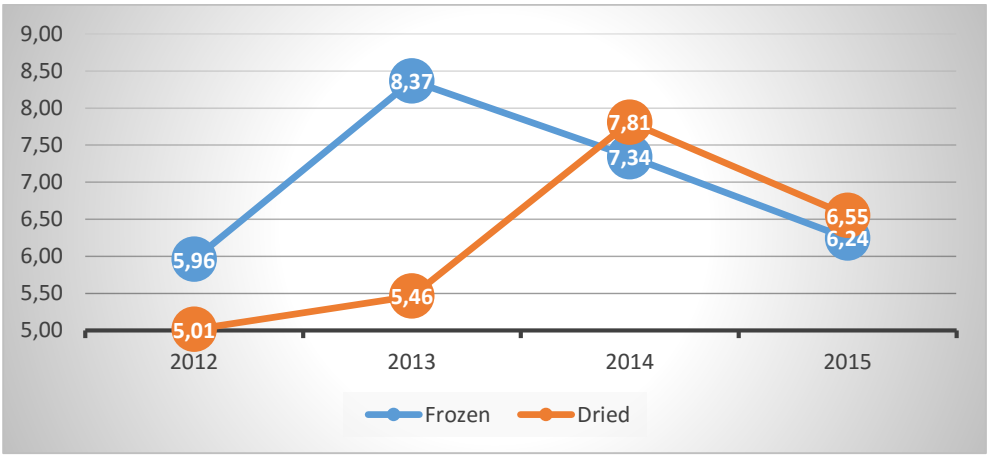

Figure 15 Comparison between frozen and dried prices for European Exports (Data: The Norwegian Export Council)

Figure 16 show the evolution of the money generated in the exportation of frozen and dried sea cucumber during the last 5 years. In 2010, the exported frozen sea cucumber only had a value of 4.4 Millions of Euros, which was six times lower than value of dried sea cucumber (27.4 Millions); during 2015 it reach the 31 million, which represent half of the value of the dried sea cucumber exported that year.

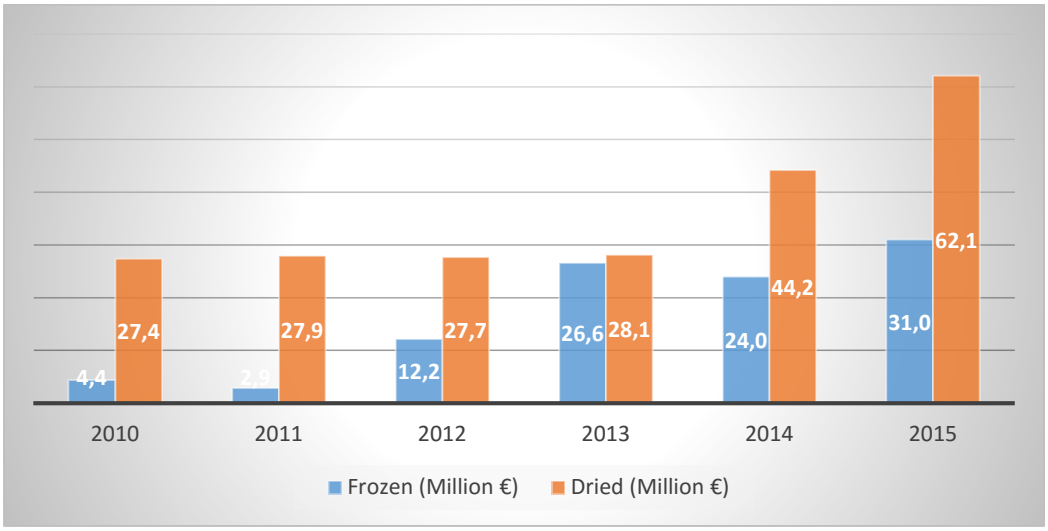

Figure 16 Evolution of the value of the exportation for frozen and dried sea cucumber (Million €) (Data: The Norwegian Export Council)

4.3.3 Galician supply market

During 2013, the first sea cucumber arrive to the Galician fish market in Lonxa. It was a new product arriving from the Sole Bank gutted and frozen. Figure 17 shows that three years after its introduction the price almost doubled but the traded quantity during 2016 was only 20 MT, far away from the bycatch estimation of 800 MT a year for the vessel associated with ARVI alone.

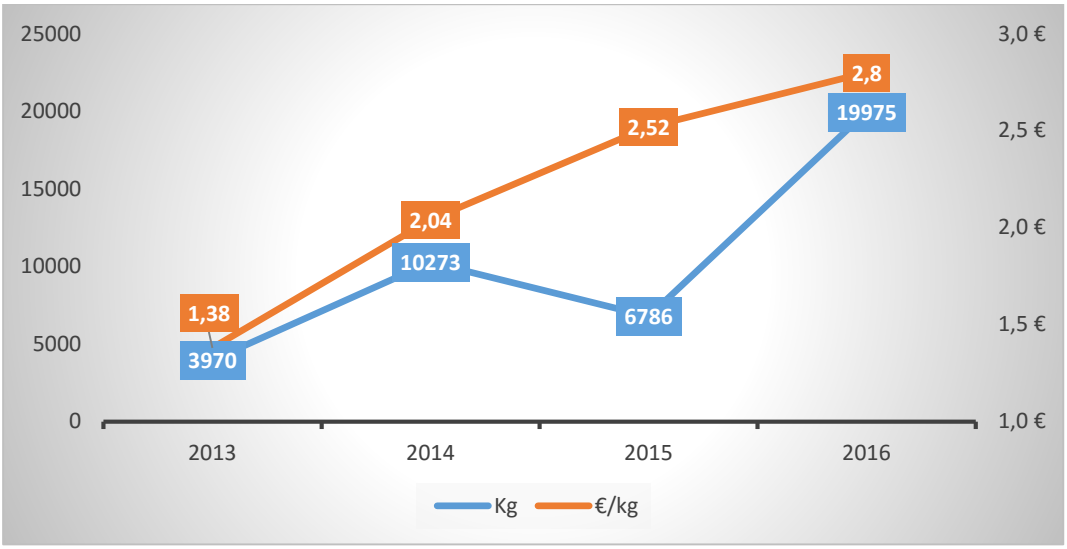

Figure 17 Evolution of sea cucumber prices and quantities in the Galician fish auction

One thing that we have to take into account is that the price the fisherman receive is at the port market level, while the market trade prices with China in the other figures are measured of the export and import level. The stages in the value chain are completely different and have to be taking into account in the price analysis.

Figure 18 shows the variation of the price of frozen sea cucumber in two different stages of the value chain. The orange line show the average price that the Galician fishermen received in the fish auctions in port while the blue one show the transaction price of the EU exportations. That gap is being reduce during the last years but we need to take into account that the quantities keep increasing every year and therefore the profit of the middlemen.

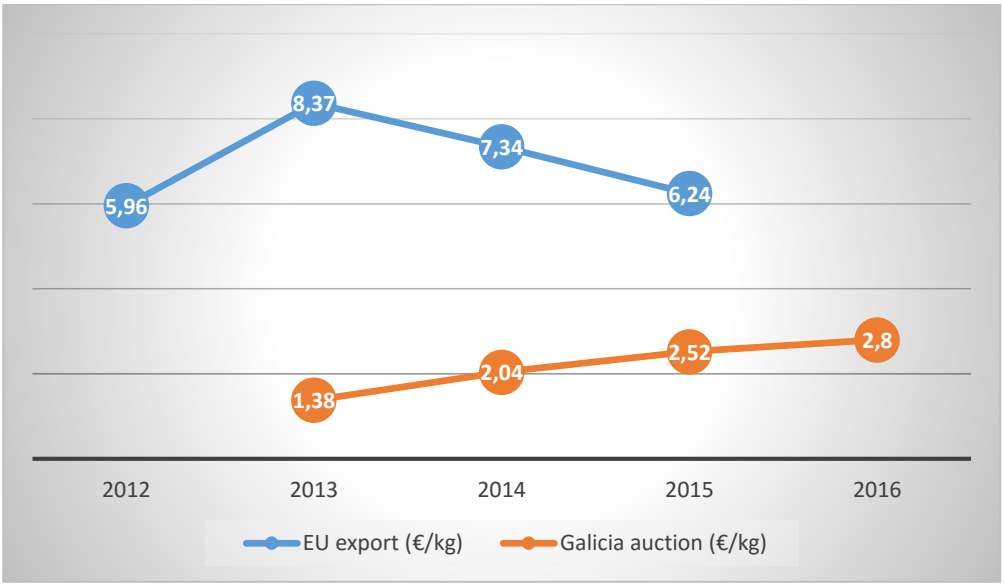

Figure 18 Difference between EU export and Galician auction price

4.3.4 Market opportunity analysis

Hong Kong leads the sea cucumber market; the amount of sea cucumber that goes thru the Hong Kong traders is higher than the summary of the other countries together. This happens to both imports and exports.

The amount of frozen sea cucumber traded in the past years increased enough to reach the amount of dried sea cucumber. However, the differences on the prices per kilogram varies. The prices of frozen sea cucumber increased in average 364% since 2005 and the price of dried sea cucumber in 225%. At any way, the price gap between those two products keeps increasing if all the ten year of the series are talking into account.

Taking into account the evolution of only the last 5 years, the average price of sea cucumber was 3.62 €/kg in 2011 while the dried cost 21.03 €/kg. During 2015 the price

of frozen increased 325% with the result of 11.78 €/kg while the dried sea cucumber only experience an increase of 3% from 21.03 €/kg to 21.65 €/kg.

We can conclude that in recent years the price dried of sea cucumber was stablished around 21 €/kg while the prices of frozen sea cucumber are rapidly increasing. These changes reduce the price gap between the two products.

The difference between the export price and the price that the fishermen receives is still high, while the export quantities keep increasing. If the sea cucumber fishery shows to be profitable the number of fisherman will keep increasing at the same time that the quantities while the EU don't stablish limits, the value chain doesn't need to grow in number of middleman , but they will trade with larger quantities which will lead to more benefits.

4.4 Aquaculture option

As the population keeps increasing each year, also increases the need to find food resources to feed them. The oceans have become one of the biggest hopes to fulfill this task. Nevertheless, the exploitation of only two or three main species will not be enough to achieve it. Successful management of the oceans will exploit a large number of species, but without overexploitation or endanger any of them; the key will be to share the pressure between those species instead of only between those with a high market value. Increasing the added value of a number of species in the market may however contribute to their sustainability as long as they do not become overexploited. Another way to increase the production is through aquaculture.

4.4.1 Land-based aquaculture

Often times in aquaculture, two or more species can be exploited at the same time when those species are ecologically compatible, which means that they require similar environmental conditions, but there is no food competition or space. For example in China there is a high production of abalone *Haliotis discus hannai* that seems suitable to be combined with sea cucumber production (Kang et al., 2003)

The production of juveniles is done on a land-based nursery system. During the winter, the farmers need to heat up the seawater in order to provide the best conditions and avoid the growth reduction and high mortality associated with low water temperature. All of these processes are expensive and sometimes the farmers reduce the seawater exchange to keep farming profitable with the side effect of reducing the water quality. This deterioration of seawater is due to the organic matter such as food residue and feces while increasing the inorganic nitrogen (Kang et al., 2003); in order to reduce the organic matter the sea cucumber was introduced into production and the results were that the growth increased in abalone. This lead to an increase in the farm profits without taking into account the commercialization of the sea cucumber.

Thus, sea cucumbers have been shown to improve the water quality in land-based aquaculture. It would be interesting to study the impact of polyculture on other types of species or as a simple end pipe filter before putting the sea water back into the sea.

4.4.2 Sea-based aquaculture

One of the biggest controversies around aquaculture is its environmental impacts. For instance, the salmon cages produce a deposition of organic matter at the bottom of the sea. These depositions can be food waste, feces and by-products such as medications and pesticides, though normally it is eaten in a pelagic ecosystem. The impact depends a lot on the depth and the water currents (Carroll et al., 2003).

Integrated Multi-Trophic Aquaculture (IMTA) systems produce valuable seafood and at the same time work as waste reducer.

The IMTA includes the different organisms that consume the uneaten food, wastes, nutrients, and by-products of the species. Because of this process, the farm increases their income by selling the products and reducing the impact that production of the first species will have on the ecosystem. The main components are fish, suspension feeders such as shellfish and seaweed, but the more advanced systems include deposit feeders such as sea cucumbers or sea urchins in bottom cages (Chopin et al., 2010). One example of an IMTA is figure 19.

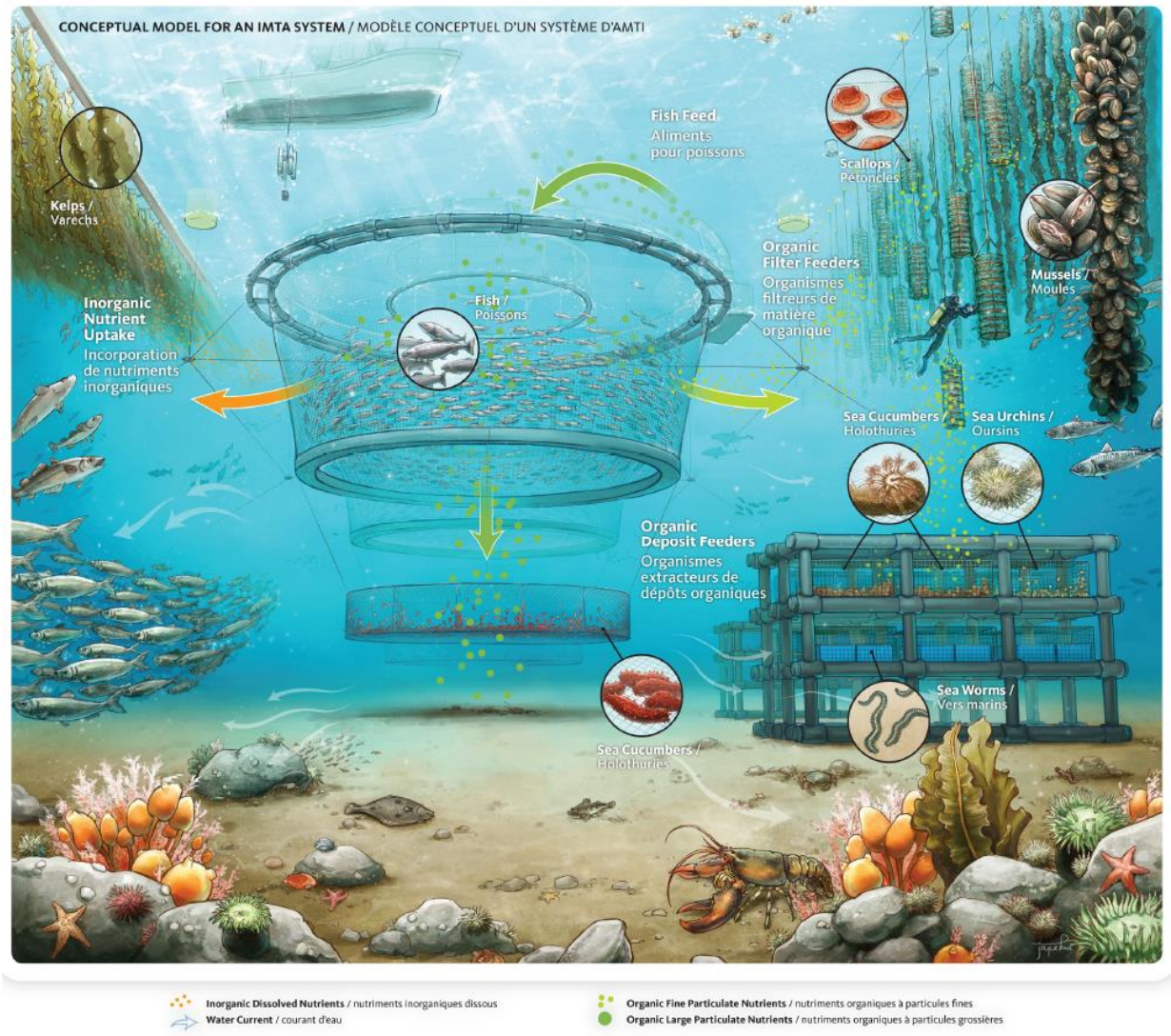

Figure 19 Conceptual model for an IMTA system (Fisheries and Oceans Canada, 2013)

5 Discussion and opportunities

The main research question in this thesis is to identify the factors that influence (constrain/facilitate) a profitable market adoption of sea cucumbers harvested landed by the Spanish fleet as an example of how to create value for the bycatch in the exploitation of other species. This thesis studied the possible market value of the sea cucumber unintended captured as by catch by the Galician fleet.

The results show that three sea-cucumber species are abundant enough and possess the nutritional properties to become successful in the market. The mortality of the sea cucumber captured is sufficient high for commercialization and will not further affect their biomass. The assumption needs to be studied, but the problem is that non-commercial species receive very low attention. The sea cucumber in Galicia is not under any regulation, and the European Union tends to pay more attention to profitable species and to the ones with the support from NGOs like whales, sharks, etc. If the sea cucumber becomes profitable, there is a possibility that become as well a target species, which may lead to overexploitation.

Now, the fishers association that I had contacted (ARVI) estimates that their fleet is capturing around 800 tons of sea cucumbers every year. Most of the sea cucumbers are captured in the Sole Bank, and the best way to preserve them until the boat comes back to port is to freeze them onboard. The small amount of sea cucumbers that each vessel

captures complicates the processing methods. In order to make this product successful, the Galician industry needs to standardize the product.

5.1 Production and transformation options

The consumption patterns in Asia show that sea cucumbers are perceived as expensive products eaten only on special occasions and the consumption increases between October and March. Another special date is the "Mid-Autumn day" in which companies like to give expensive food gifts to employees. The best quality sea cucumbers are sold around the coastal area, the medium and the low quality ones are sold in the interior areas.

As studied in previous parts of this thesis, most of the sea cucumbers are sold dried and therefore it sounds logical to introduce the Galician sea cucumber in the same way. But there are few factors that need to be analyzed. Most of the dried sea cucumbers come from tropical countries where they are caught and dried with traditional techniques, and where the equipment needed during the process is almost non-existent. Another source of sea cucumbers are from Chinese aquaculture where they work with big quantities of sea cucumber and the option to dry the product to reduce the weight is cheap and decreases the transport cost.

Countries like Canada or Russia have already tried another type of processing due to their advanced industry and the need of create a distinct product that will be easily

identified in the market. Hence, Galicia may use the technological advantage to create high quality sea cucumber products and compete with these countries.

The *H. forskali* species may be used to create fresh products since it is caught around the Galician coast and therefore is the only one that reaches the port fresh. The Galician consumers have high preferences for fresh products of any kind, therefore this will be the sea cucumber selected to be introduced in the local market.

One of the biggest differences between the three species is that *H. forskali* can be caught around the coast, so it can reach the market fresh. The fresh sea cucumbers will target local restaurants that want to bring in innovative products to their business. All parts of the sea cucumber can be used, so there is no need for it to be gutted.

Most of the catches, at least during the beginning of the exploitation, might be gutted and frozen. This would be the main process for the exported sea cucumber.

Another option is canning. The canned industry in Galicia is well known and advanced; they are canning lots of different seafood's like mussels, clams, and sardines are the most popular.

According to the information that ARVI provided during my visit in January, the company Portomuiños has already developed four types of canned sea cucumber. One is a natural option of sea cucumber with salt and water, the second includes mushroom broth, the third with umami flavor, and the last one with rice.

The *Stichopus regalis* might be sold ex vessel in a frozen form with a few different options. The main one might be gutted and frozen for export. Three elaborated

processes were studied by Portomuiños. The first one was a roll of the sea cucumber wall without skin. The second is a chupa-chups that breads *S. regalis,* so the consumer will only need to defrost and fry it. The third one is mini burgers with onion, chicken, mushrooms, and spices.

The *Stichopus tremulus* might be marketed as well in a frozen form and as the *S.regalis* as frozen chupa-chups and mini burgers.

These are the main products that ARVI mentioned, but other options are still being studied, for instance as nutraceutical supplements or other canned recipes. After a long process, the extract of *H. forscali* was used to create a powder that combined with Omega-3s will be a perfect food supplement according to ARVI.

5.2 Market and value chain opportunities.

One of the biggest challenges for sea cucumber producers in tropical countries is the long value chain. The large amount of intermediaries complicates the traceability of the product and increases the time it takes to reach the export trader. Another consequence is the increase of the price or the reduction of the selling price for the fishers because each intermediary will want a share of the final price. The Galician companies can use the value chain that they already possess to export the sea cucumber.

This is an example of value chain is south-east Asia.

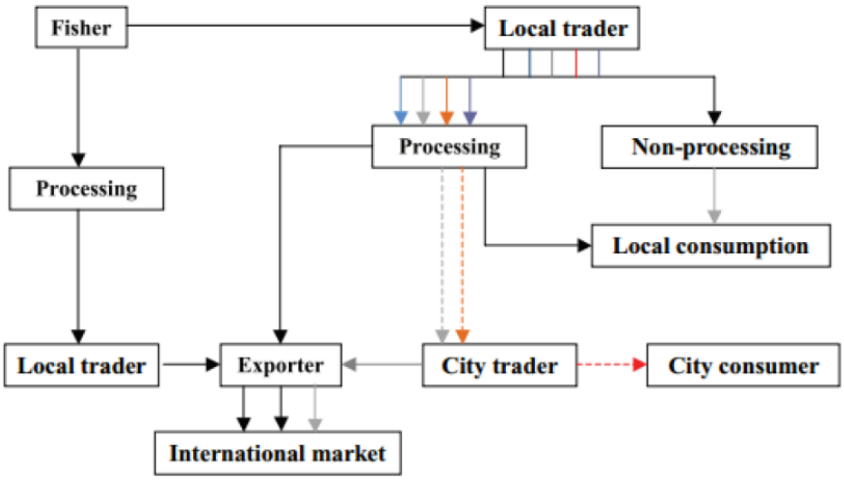

Figure 20 Market potential and challenges for expanding the production of sea cucumbers in south-east Asia (Perez & Brown, 2012)

The Galician fleet needs to use channels already created for the exploitation of other species, most of the fishermen belong to fisher associations and in consequence the coordination between the fleet that exploit the resource should be easier. The biggest difference is between the two types of boats; the big vessels in the Sole Bank and the ones around the Galician vessels. For the first one, new equipment was designed and the sea cucumber will reach port gutted and frozen inside boxes, and from there it can be transferred directly to the exporter or to the processing companies that will transform the products as already explained. For the *H. forskali*, it will reach the port fresh, and it can be sold in the fish auction to the processing companies or directly to the local market. This model reduces the length of the value chain and maximizes the price for the fishermen. Labelling and traceability will be needed to differentiate Galician products. The sea cucumber from Galicia should be distinguished since it is wild captured and they use high quality processing methods.

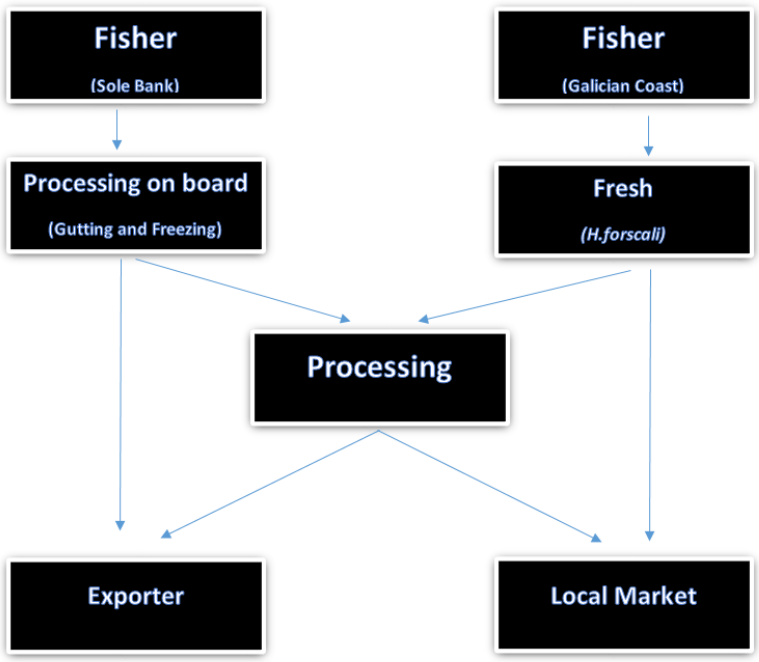

Figure 21 Example of the possible value chain for the Galician sea cucumber

5.3 Aquaculture opportunity

To answers the fourth research question, if Galicia succeeds in creating a value for the sea cucumber, it will become a target species and in the absence of regulation measures will sooner than later be overexploited. That is the reason why I have decided to include the aquaculture option.

The aquaculture production of sea cucumber is a reality as already explained in this paper. China is producing a large amount of *Apostichopus japonicus* through different aquaculture techniques, which is proving to be a profitable business.

The approach will be rather different, we will focus on the synergies that the sea cucumber can have with other species, since one of the biggest controversies around

aquaculture production is how it can affect the surrounding ecosystems. For instance, in the production of fish in sea cages, there is an increase in sediments (feed remains and detritus) in the sea bottom under the cages, which will affect the ecosystem.

Sea cucumbers are detritus feeders which ingest sediment and organic matter including bacteria, protozoa, diatoms, and the detritus of plants and animals (Yokoyama, 2013); therefore, they have the potential to become part of the solution.

The hypothesis that needs to be confirmed is whether the sea cucumber can be used to improve the farming of other seafood. The sea cucumber can reduce the pollution created by the exploitation of other species and at the same time be a valuable species for the Asian market. In almost all marine ecosystems there is at least one species of sea cucumbers, therefore for this improvement there is no need to introduce new species that might threaten the ecosystem. Hence, the combination of those characteristics make the sea cucumber suitable for co-aquaculture production with the benefit to improve the water quality which will lead to a possible increase in the production of other species and reduce the environmental impact at the same time producing an income of its own.

6 Conclusions and recommendations

This study concludes that the composition of bycatch needs to be studied in order to select the species with the potential to be valuable. For instance, in Galicia only three species of sea cucumbers (*Parastichopus tremulus, Parastichopus regalis* and *Holothuria forskali)* possess the potential to do so. The requirements taken in this thesis were species abundancy, suitability for human consumption and attractiveness for adding value in the markets.

Previous studies about the market trends and value chains were in this thesis consulted, but none of them was updated recently. Therefore, the analysis of recent data confirmed that the predominant market still is in Asia. However, previous studies show that almost 99% of the total sea cucumbers were traded in a dried form, while our analysis shows an increase in frozen sea cucumbers.

Regarding the processing options we conclude that drying the sea cucumber is the traditional process and also the cheapest, but takes more labor, and most of the markets in developing countries around the world follow this process. For most of the producing countries, implementing a new procedure for sea cucumbers will be very costly. Countries like in this case, Spain, already have their own technology and the funds to create new sea cucumber products. The gaps between the price of frozen and dried sea cucumbers are decreasing in recent years, and it is even smaller for those exported from the European Union. Convenience is one of the strengths of frozen sea cucumbers since

the dried version needs to be soaked in water for several days for rehydration before consumption. The use of other procedures like canning, which are nowadays used for other seafood and will only need a small adaptability, are highly recommended to add value to sea cucumber processing. Hence, the advice is to focus on frozen over dried sea cucumbers.

The study identified interesting markets. Since we are talking about small quantities of sea cucumbers compared to the total size of the market, it would be desirable to focus on the high-income market in Asia. The idea will be to offer an innovative product on the market, with high quality and traceability, which will be easily differentiated from the rest.

To finish, last research question study the impact in case that Galicia succeeds in the creation of value for sea cucumbers. The study conclude that there is high chances that it will become a target species, and in the absence of regulation measures, it will be an overexploit fishery sooner than later. The introduction of the sea cucumber in the aquaculture industry will have to be taken into account because it is a great opportunity for the sector but at the same time a threat for the Galician fleet.

Further research on the possible impact of transforming a bycatch species into target species need to be done. The Galician sea cucumber show to be a promising business opportunity but further research is needed.

7 References

Atanassova, M., Rey, I. E., Gonzalez, R., Lombardi, V. R. M., Consortiu, H., Biotecnología, E., … Biotecnología, E. (2015). POTENTIAL CONTRIBUTION OF HOLOTHURIAN SPECIES CAPTURED IN GALICIAN WATERS TO A HEART-HEALTHY DIET, (16), 36310.

Barnes, M. K. . (2008). Barnes, M.K.S. 2008. Parastichopus tremulus A sea cucumber. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Retrieved April 18, 2016, from http://www.marlin.ac.uk/species/detail/135

Brown, E.O., M.L. Perez, L.R. Garces, R.J. Ragaza, R. A. B. and E. C. Z. (2010). *Value Chain Analysis for Sea Cucumber in the Philippines. Studies & Reviews 2120. The WorldFish Center, Penang, Malaysia.* (Vol. 53). http://doi.org/10.1017/CBO9781107415324.004

Carroll, M. L., Cochrane, S., Fieler, R., Velvin, R., & White, P. (2003). Organic enrichment of sediments from salmon farming in Norway: Environmental factors, management practices, and monitoring techniques. *Aquaculture*, *226*(1-4), 165–180. http://doi.org/10.1016/S0044-8486(03)00475-7

Chen, J. (2005). Present status and prospects of sea cucumber industry in China. *Advances in Sea Cucumber Aquaculture and Management. FAO Fisheries Technical Paper*, *463*(Table 1), 25–38. Retrieved from http://www.fao.org/3/a-y5501e/y5501e08.htm

Chen, J. (2005). Present status and prospects of sea cucumber industry in China. *FAO Fisheries Technical Paper*, (Table 1), 25–38. Retrieved from ftp://ftp.fao.org/docrep.../FAO/007/y5501e/y5501e02.pdf

Chopin, T., Troell, M., Reid, G. K., Knowler, D., Robinson, S. M. C., Neori, A., … Pang, S. (2010). Integrated Multi Trophic Aquaculture Part II. Increasing IMTA Adoption. *Global Aquaculture Advocate*, (6), 17–20. Retrieved from http://pdf.gaalliance.org/pdf/GAA-Chopin-Nov10.pdf

Clarke, S. (2002). Trade in Asian dried seafood: characterization, estimation and implications for conservation. *WCS Working Paper*, *22*, 1–91. Retrieved from <Go to ISI>://ZOOREC:ZOOR14108047894

Conand, C., & Byrne, M. (1993). A Review of Recent Developments in the World Sea Cucumber Fisheries. *Marine Fisheries Review*, *55*(4), 1–13.

Da Conceição-Heldt, E. (2006). Taking Actors' Preferences and the Institutional Setting Seriously: the EU Common Fisheries Policy. *Journal of Public Policy*, *26*(03), 279. http://doi.org/10.1017/S0143814X06000572

Davies, R. W. D., Cripps, S. J., Nickson, A., & Porter, G. (2009). Defining and estimating global marine fisheries bycatch. *Marine Policy*, *33*(4), 661–672. http://doi.org/10.1016/j.marpol.2009.01.003

Deporte, N., Ulrich, C., & Bastardie, F. (2012). Regional métier definition: a comparative investigation of statistical methods using a workflow applied to international otter trawl fisheries in the North Sea, *69*, 331–342.

European Commission. (2009). GREEN PAPER Reform of the Common Fisheries Policy. *Commission of the European Communities COM(2009)163 Final*, 27 pp. http://doi.org/10.2139/ssrn.1743387

European Parliament and Council of the European Union. (2013). REGULATION (EU) No 1380/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC. *Official Journal of the European Union*, *L354*(28.12.2013), 22–61.

European Union. (2012). CFP reform – the discard ban. *Discards_En. Pdf*, 3. Retrieved from http://ec.europa.eu/fisheries/reform/docs/discard_en.pdf.

FAO. (2014). Save Food: Gloval Initiative on Food Loss and Waste Reduction, 1–83.

Ferdouse, F. (2004). World markets and trade flows of sea cucmber / beche-de-mer. *FAO Fisheries and Aquaculture Technical Paper*, 101–118.

Garcia, S. M., Kolding, J., Rice, J., Rochet, M.-J., Zhou, S., Arimoto, T., … Smith, a. D. M. (2012). (UNIT 3) Reconsidering the Consequences of Selective Fisheries. *Science*, *335*(6072), 1045–1047. http://doi.org/10.1126/science.1214594

Kang, K. H., Kwon, J. Y., & Kim, Y. M. (2003). A beneficial coculture: Charm abalone Haliotis discus hannai and sea cucumber Stichopus japonicus. *Aquaculture*, *216*(1-4), 87–93. http://doi.org/10.1016/S0044-8486(02)00203-X

Mamelona, J., Saint-Louis, R., & Pelletier, É. (2010). Proximate composition and nutritional profile of by-products from green urchin and Atlantic sea cucumber processing plants. *International Journal of Food Science and Technology*, *45*(10), 2119–2126. http://doi.org/10.1111/j.1365-2621.2010.02381.x

Perez, M. L., & Brown, E. O. (2012). Market potential and challenges for expanding the production of sea cucumber in South-East Asia. *Asia-Pacific Tropical Sea Cucumber Aquaculture. ACIAR Proceedings 136*, 177–188. Retrieved from www.worldfishcenter.org/resource_centre/WF_3034.pdf

Purcell, S. W., Mercier, A., Conand, C., Hamel, J. F., Toral-Granda, M. V., Lovatelli, A., & Uthicke, S. (2013). Sea cucumber fisheries: Global analysis of stocks, management measures and drivers of overfishing. *Fish and Fisheries*, *14*(1), 34–59. http://doi.org/10.1111/j.1467-2979.2011.00443.x

S.V. Ciriacy-Wantrup, & Richard Bishop. (1975). "Common Property" as a Concept in Natural Resources Policy, *58*(1972), 713–728.

Symes, D. (1997). The European Community's Common Fisheries Policy. *Ocean and Coastal Management*, *35*(2-3), 137–155. http://doi.org/10.1016/S0964-5691(97)00030-6

To, A. W. L., & Shea, S. K. H. (2012). Patterns and Dynamics of Bêche-de-mer Trade in Hong Kong and Mainland China: Implications for Monitoring and Management. *TRAFFIC Bulletin*, *24*(2), 65–76.

Valeiras, J., Pérez, N., Araujo, H., Salinas, I., & Bellido, J. M. (2014). *Atlas De Los Descartes De La Flota De Arrastre Y Enmalle En El Caladero Nacional Cantábrico-Noroeste*. Retrieved from www.mapdescar.es

Villasante, S. (2010). Global assessment of the European Union fishing fleet: An update. *Marine Policy*, *34*(3), 663–670. http://doi.org/10.1016/j.marpol.2009.12.007

Walter, T. (2010). The EU's Common Fisheries Policy: A Review and Assessment. *EUMA Paper*, *7*(7).

Yokoyama, H. (2013). Growth and food source of the sea cucumber Apostichopus japonicus cultured below fish cages - Potential for integrated multi-trophic aquaculture. *Aquaculture*, *372-375*, 28–38. http://doi.org/10.1016/j.aquaculture.2012.10.022

Appendices

Table 3 Trade of frozen sea cucumbers in MT (The Norwegian Export Council)

Frozen MT	EU		Hong Kong		Iceland		Republic of Korea		Thailand		Taiwan	
year	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import
2005							4	126			167	189
2006							0	21			146	140
2007							1	20	15	6	124	248
2008							7	292	8	1	61	242
2009							39	155	19	0	73	216
2010					796		99	81	5	4	68	245
2011					1173		32	105	4	0	93	595
2012	681	909	1675	2749	760		34	89	2	24	53	1003
2013	1281	1028	3279	3956	980		45	0	207	229	65	926
2014	1049	404	3123	3262	609		72	22	258	600	109	635
2015	2608	825	2022	2683	454		38	153	72	145	112	362

Table 4 Trade of frozen sea cucumbers in 1000 NOK (The Norwegian Export Council)

Frozen 1000 NOK	EU		Hong Kong		Iceland		Republic of Korea		Thailand		Taiwan	
year	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import
2005							169	1491			6822	6085
2006							0	340			6284	4781
2007							379	384	62	81	4787	8213
2008							194	3937	50	8	3347	11985
2009							4340	1801	121	0	3681	11081
2010					15332		21444	1838	29	24	3801	16781
2011					13879		7386	2441	24	0	5076	38227
2012	37499	28380	57161	364975	12455		1456	1996	38	144	3836	55041
2013	99050	46504	95179	463684	14604		4406	0	27953	27312	4599	46522
2014	71189	18716	108141	340547	6890		7869	592	18858	23241	8812	35296
2015	150480	26847	92502	662854	9069		3561	4033	19215	20147	11883	30671

Table 5 Trade of dried sea cucumbers in MT (The Norwegian Export Council)

Dried MT	EU		Hong Kong		Iceland		Republic of Korea		Thailand		Taiwan	
year	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import
2005							2	28			111	750
2006							1	48			159	558
2007							0	56	44		121	500
2008			3929	4492			15	31	55	1	96	456
2009			4358	5050			4	3	94	1	78	395
2010			5457	5603			15	1	85		97	479
2011			5702	5798			18	0	17	0	164	568
2012	280	175	4645	5128			8	11	160	15	139	431
2013	496	186	4583	4965	3		6	0	9	18	148	212
2014	349	283	4803	4437	1		2	0	81	9	145	216
2015	710	471	5172	4278	19		6	0	42	30	122	115

Table 6 Trade of dried sea cucumber in 1000 NOK (The Norwegian Export Council)

Dried 1000NOK	EU		Hong Kong		Iceland		Republic of Korea		Thailand		Taiwan	
year	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import
2005							2873	3363			14269	58655
2006							2461	5993			18062	40750
2007							0	7248	177		14242	52130
2008			183147	1145663			500	1328	57	26	13004	39281
2009			178060	1421716			5989	310	91	113	13398	49944
2010			208664	1855613			18558	194	158		25490	48344
2011			203866	2067357			16065	0	24	0	38030	59140
2012	12970	5128	203295	1662162			11805	835	643	793	27177	48194
2013	25033	5027	202157	1596528	149		7030	0	145	1263	25035	33547
2014	25189	7094	346078	1528308	211		5211	0	1113	379	30683	53103
2015	43001	25682	482079	1547780	8722		6607	0	474	1641	32987	44689