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Analysis of Fuel Cost/Catch Prices Ratio in Artisanal Fisheries Gillnet in the Egadi Arcipelago (Siciliy)

V. Maccarrone[1], G. Buscaino[1], G. Buffa[1], A. Bellante[1], F. Filiciotto[1], S. Vitale[1], P. Labruzzo[1,2], M. Sprovieri[1], C. Buscaino[1], G. Tranchida[1]
1, Institute for Coastal Marine Environment, CNR, Capo Granitola (TP), Italy
2, Department of Environmental Sciences, University "Ca' Foscari", Venezia, Italy
vincenzo.maccarrone@unime.it

Abstract

Sustainable development of fisheries requires methods and tools to measure and compare the impact of human activities on the environment. The markets of the agroalimentary sector requires products that respect the principles of environmental and economic sustainability. The large industrial fisheries are easily adapted to new market conditions but the artisanal industries are finding many difficulties to follow the new trends. The present work aims to evaluate the consumption and fuel costs for 1 kg of fish product of a boat along the coast of Favignana Island. From May to June 2006, a 9 meters of lenght boat with Fiat Aifo inboard engine (130 KW) was used. During the experiment, the routes and the fishing time were recorded. In 29 fishing trips 601.7 kg of product were catched, comprising 26 different fish species. The boat engine worked for 5.03 per trip hours with a fuel consumption of 22 $kg \cdot h^{-1}$ on average. The fisheries product was sold on the local market at an average price of € 10.74 / kg. The results show that the average fuel consumption per kg of fish was 4.46 kg, with a great incidence of about 30% on the cost of product. Ours results indicate the great importance of the additional factors to the traditional parameters of fish catch. Moreover, studies like this are laying the basis knowledge for analyzing the Life Cycle Assessment (LCA) of fisheries products.

1 Introduction

Sustainable development requires methods and tools to measure and compare the impacts of human activities, both goods and services, on the environment [1]. Managing products life cycle (Life Cycle Assessment) is a framework methodology for the estimation and evaluation of environmental impacts that can be attributed to goods and services. The Life Cycle Assessment (LCA) can be used in several impact assessments that include: climatic changes, reduction of the stratospheric ozone layer [2, 3], the so-called "smog" accumulating in the troposphere, eutrophication [4, 5], acidification [6, 7], toxicological stress on ecosystems and / or human health, exploitation of renewable and non-renewable resources [8, 9], water and soil, noise, and many others. The markets of the food industry are increasingly requiring food products in accordance with the principles of environmental and economic sustainability, in order to meet two conditions: the growing demand for low environmental impact-products and the improved energy efficiency of the production cycle [10]. The production of the Italian fishing fleet was, in 2003 [11], 312.000 tons per year (€ 1.466 million Euros). Small-scale fisheries accounted for to 51.333 tons per year with an average price of production of to € 6.68/kg, i.e. the highest income-yielding fishing system in Italy. Despite product's high quality, the small coastal fishing is undergoing a major crisis in the recent years, partly because of the policies aimed at to reducing fishing effort, as well as the increased production costs (fuel consumption per kilogram of catch). Seafood globally occupies a major share of the proteins consumed by the world population; then, the demand for fish products by highly industrialized countries is growing steadily [12]. Within this context, the rules for the production and regulation of trade are playing a key role in many sectors of the fishing industry [13]. The evolution of the Italian and European legislation increasingly leading towards specific production standards is pushing the fishing industries to improve industrial eco-efficiency. Markets for marine environment-friendly products are quantitatively increasing: as a result, further studies and tests on fishery products LCA are needed. Today, commercial fishing is characterized by an almost predominant use of diesel-cycle engines and many studies on fishing trawlers have already discussed the impact of fuel prices on fisheries incomes (kg fuel/kg fish) [10].

2 Materials and Methods

2.1 Study area

The study was conducted in the Egadi Archipelago, Sicily. The Egadi are a group of three islands: Favignana (33 km^2), Marittimo (12 km^2) and Levanzo (10 km^2) and some smaller islets and reefs including the island of Formica and the rock of Maraone. The waters surrounding the islands are part of a Marine Protected Area established in 1991 and now managed by the Trapani Coastal Guard (Figure 1). Sea bottoms are characterized by sandy and rocky substrates covered with extensive of oceanic Posidonia meadow, hosting a wide variety of flora and fauna. Artisanal fisheries is an important sector of local economy and it is practiced throughout the years in the waters surrounding the islands [15]. The studies on the production cycle were performed from March to May 2006 close to the island of Favignana (Figure 1).

2.2 LCA general aspects

The analysis on the LCA management is characterized by a precise and detailed classification of emissions, resource consumption, as well as the emission trading being relevant at each stage of production [16]. This study is referred to as the "from cradle to grave" product analysis, including raw materials, energy acquisition, materials production, manufacture, use, recycling, final disposal, etc (Figure 2). The life cycle, which includes the associated materials and energy flows, is called product system [17]. Each LCA to be properly implemented should identify in advance: an objective, its scope and an associated functional unit. In this study, the main points of criticism of small-scale fisheries are identi-

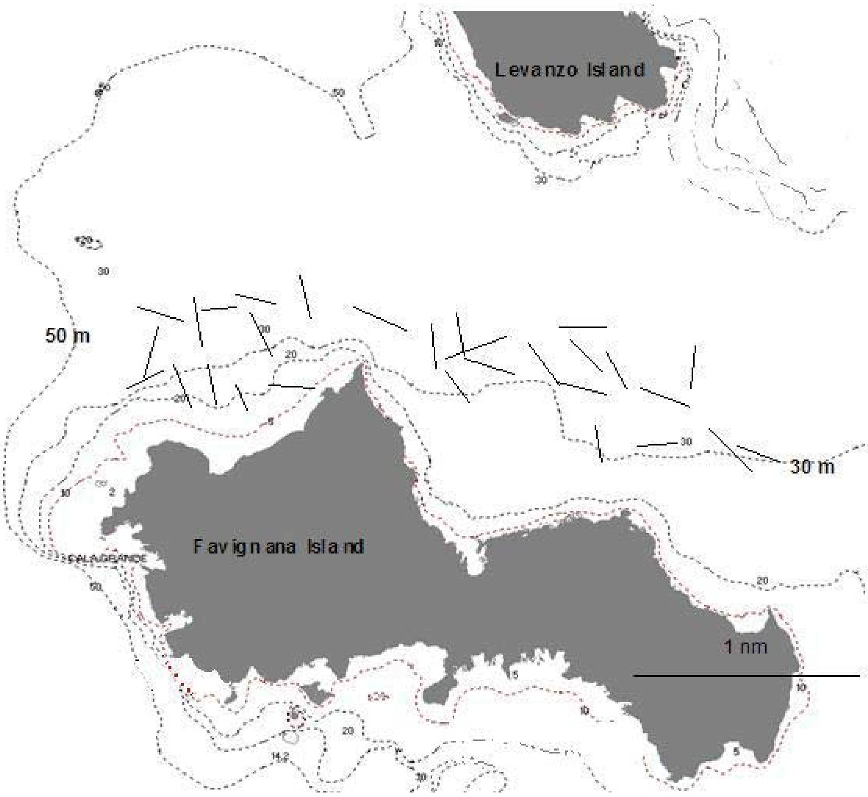

Figure 1: Map of the study area. The black lines represent the nets position

fied and assessed, in order to highlight any Key Success Factor (KSF) in comparison to other types of fishing and find out feasible management strategies different from those undertaken to date. The definition of the objective and scope for the LCA provides a description of the product in terms of system, boundaries and functional unit. The functional unit is the base enabling goods or services to be compared and analyzed. One of the main opportunities provided by the LCA is the ability to compare different types of production, through the same functional unit. The knowledge of build and environmental costs of a building, of a boat, of one kg of salmon, are typical applications of this method. Such a methodological choice allows to compare products, even very different among themselves, through the use of a single unit in order to identify opportunities and production-related weaknesses [18]. The main objective of the inventory of a product life cycle (Life Cycle Inventory) is to estimate what kind of and how many resources are commonly used, what waste is produced and what emissions are caused or may be associated to this particular type of fishing. LCI shows how the production of waste or emissions can be very complex.

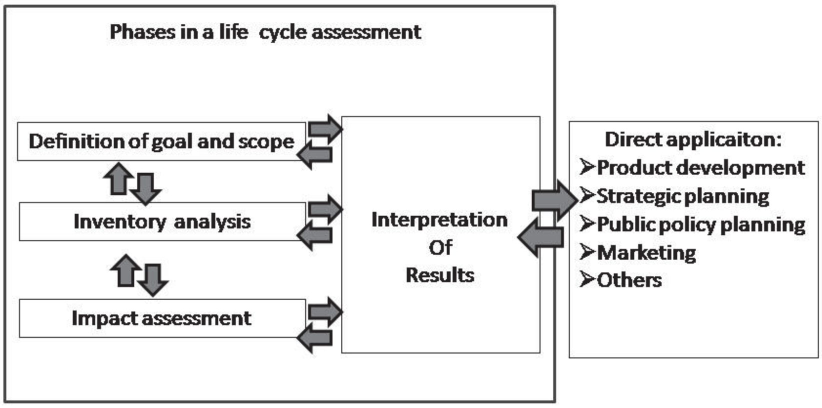

Figure 2: Phases and applications of an LCA (based on ISO 14040, [14]).

This survey can be analyzed geographically, by identifying several areas where waste or emissions are produced. The approaches are basically of two types:

- splitting the amount of emissions for each stage of production (fishing, processing, disposal, transportation, sales);
- comparing the stress produced at different times or in multiple generations of contemporary production.

The life cycle-associated processes and the related material and energy flows into and out of the system enable to represent the production system and its relationship with the natural system. The network of these relations among the production system, the inventory of used materials and the exchanges with the environment, can be linked to the so-called "boundaries of a system".

2.3 System Boundary

The boundary of the system is represented by the whole set of intermediate products' process flows, which carry one or more defined functions [17]. The boundary of the system is divided into a number of process units; these are in turn linked by flows of intermediate products. The boundaries of the system in this preliminary study include every phase of the fishing process, until the sale/delivery of the product on the docks. The study of the system starts with an inventory of materials needed for the production, i.e. fuel and fishing equipment. In the

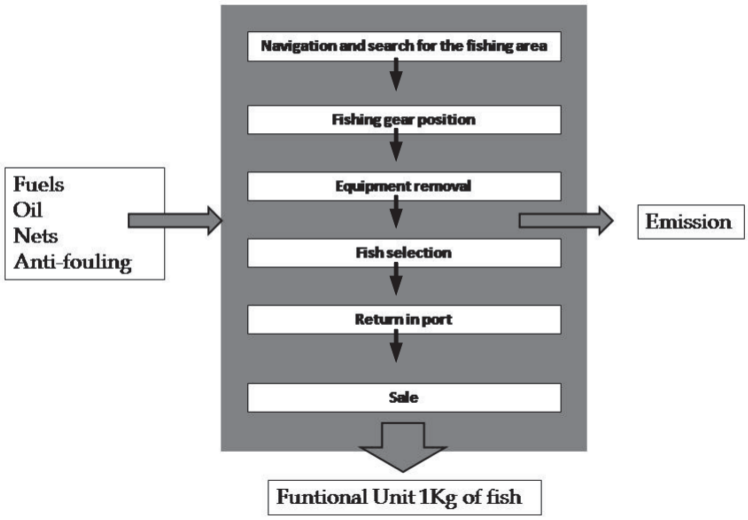

Figure 3: A simplified system boundary of artisanal fisheries.

case of artisanal fishing practiced in Favignana, the product can be directly sold on the docks, or delivered to other operators who sell seafood in the local market. Currently, the majority of fish and seafood is sold to wholesalers in Favignana who resell it in Trapani. The Favignana local market is able to almost entirely absorb the production only in the tourist season (from June to August). In Figure 3, the boundaries of the systems are divided into 6 process units, which are described below:

1. The identification and choice of the fishing area is crucial for the success of the trip and it can be affected by many variables: weather conditions, presence of other fishing gears, shipping, seasonality, type of boat, onboard equipment, etc.
2. Fishing gears positioning. Once the fishing area has been chosen and the on board fishing devices (depth sounder, GPS) have been operated, the net is hauled in accordance with the sea bottom features, (morphobathymetry), coastal streams, tides, etc.
3. Equipment removal. After a variable time, usually 6 hours, the nets are hauled in by an electro-hydraulic winch powered by the engine board.
4. Fish selection. The fishery product is selected by species and size, stowed in special boxes and covered by ice.
5. Return to port. The fishing vessel returns to port during the fish selection and preparation activities.

6. Sale. The fishery catches are directly sold to end-users in a local market and/or sold to traders and destined to other markets or restaurants.

2.4 Functional Unit

It seems clear that the complexity of LCA does not allow a direct approach, but systemic and gradual. Preliminary studies relating to the analysis of product life cycle need an LCI, as described above. The result will lead to the compilation of a ”road inventory”: this will comprise the use of resources, functional unit- associated emissions, including substances and chemical compounds. The functional unit enables to highlight the energy performance of the product/service for which an LCA is to be carried out [19, 20]. In this case, the functional unit is represented by kg of diesel fuel needed to produce one kg of food fish: this choice will allow to compare different LCA developed for other types of fishing. In addition, the same LCI will permit to compare functional units specifically addressed to a resource target (red mullet, cod, anchovy, etc.) [21].

3 Results

3.1 Inventory Results

The results of the LCI analysis (Table 1) include either data associated to a traditional LCA approach, or the data characterizing the sole fishing activity. The quantitative uncertainties on the materials involved in the process do not prevent to identify the most important activities for improving environmental performance.

3.2 Fishing

The data on catches and consumption were obtained using a 9-m long boat practicing traditional fishing along the coast of the island of Favignana, equipped with an inboard 130 KW Fiat Aifo engine. During the experiment, the marine-weather conditions and sampling effort were recorded, and the trip as well. The net was hauled daily and it fished for some hours after the dawn. The geographical coordinates of the starting and ending points of the net, and the intermediate points as well, were recorded for each minute of positioning. Also, the time spent for positioning and launching the net, as well as the net immersion time, were calculated. At the end of the fishing activity, after the return to port, the weighing and measuring of the species, and the economic assessment of species caught, were carried out. These data allowed to calculate the costs and kg of fuel consumed per kilogram of fish produced. 27 fish species were caught along 29 days. The catch was characterized mainly by two species, i.e. Boops boops and Sardinella aurita, representing respectively 31.92% and 19.44% of the total catch weight, and 28.14% and 17.14% in terms of economic value. Fish discards were represented by: undersized and non-commercial species, and partially looted species of commercial interest. In all three cases, the weight of non-tradable products was considered irrelevant for the purposes of life cycle inventory. In fact, both undersized and non-commercial species are caught alive, so that they can be re-introduced into the ecosystem. Furthermore, non-tradable species represent a negligible weight, i.e. less than 1% of the total catch.

Unit process	Specific Data	General Data
Energy Production		
Diesel	✓	
Raw Production		
Gas emission		✓
Lead Sinkers for Fishing Net		✓
Fishing Nets		✓
Fishing Net float		✓
Fisheries		
Fishing Species	✓	
Motor hours	✓	
Oil	✓	

Table 1: Data specifications

3.3 Fuel Consumption

Most fishing boats craft uses an inboard diesel engine. The vessel under study is one of the largest operating in the archipelago, and its average fuel consumption is 22 $\mathrm{l{\cdot}h^{-1}}$. On average, for each day of fishing 109.07 liters (92.70 kg) of fuel were consumed and 22.78 kg of fish product were landed and selled (5.25 liters/1 kg fish).

3.4 Conservation

The maximum time the fish spends on board, from capture to the landing, is 2h. The storage conditions in this time frame comprises the fish storage in plastic tanks filled with water and ice, taking care not to cause excessive heating of the catch. This period from catch to processing has to be minimized to avoid loss of organoleptic quality. The ice used for storage is bought in dedicated production facilities, therefore such material is not considered in the LCI.

3.5 Equipment

The use of equipment may also play a significant impact on production costs and environmental concerns. In our experiment, the boat was equipped with two 900 m long monofilament nets, 2.2 m high and provided with jersey No. 11 (i.e. 11 knots in 25 cm of the stretched mesh). It was estimated that the net was almost completely renewed every 2 years. This figure is extremely significant due to the depredation activities and damage caused by dolphins. The nets were provided with a quantity of lead and net floats proportional to their size. The loss of lead-sinkers, replaced floats and nets are not included in this phase of the LCI.

3.6 Anti-Fouling

Antifouling paints covering the hulls of ships and boats contain biocide components, aimed at countering the growth of organisms on immersed surfaces, that reduce the frictional resistance to advancement and would tend to grow over time. The anti-fouling varnish (3 $\mathrm{lt{\cdot}year^{-1}}$) was painted annually on the vessel used for the experiment.

4 Conclusions

This preliminary analysis of coastal fisheries around Favignana allowed to get some methodological assumptions as a preliminary base for further and more thorough study on the entire production cycle, through the "from cradle to grave" approach. The incidence of production and environmental costs in the fishery industry is now a critical factor. Lowering the cost of production is a competitive advantage for firms occupying the same niche, but this saving does not always entail a reduction of the enterprise's ecological footprint. This LCA preliminary study in the fishing industry showed that one of the major costs for fishing activities around small islands is represented by the fuel. The low standards in improving the boats energy performance, together with the current situation of fishery markets, reduce the market shares even for high-quality products. The current funding system provided by the EFF should, if properly directed, be enable to promote gradual and structural measures aimed at improving the eco-efficiency of the fishing vessels. In addition, it would be desirable to support these interventions with the most innovative tools of soft-economy in order to strategically reorganize some sectors of fisheries. In fact, it is important to invest in on high-quality products and intangible assets such as reduced emissions, discards reduction, preservation of endangered species (dolphins, turtles, seagrass, etc.), buyers lobby groups, etc.

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