

# Welfare Indicators for Common Carp and European sea bass during live transportation and at harvest

## Short review

Ivona Mladineo, Leonidas Papaharisis



# Welfare Indicators for Common Carp and European sea bass during live transportation and at harvest: short review

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## Abstract

The relevant welfare indicators during the transport and harvest for the two aquaculture important fish species, the European seabass, *Dicentrarchus labrax* and the common carp, *Cyprinus carpio* are provided herein to develop a future monitoring framework and facilitate National Competent Authorities (NCAs) in conducting controls. The indicators have been prospected and then extracted from the meritory scientific and other publicly available literature (i.e., project, meetings and WS reports), reviewed and selected to develop a panel of robust multidisciplinary operational welfare indicators. For easier orientation and technical approach, selected indicators are grouped into three main categories: 1. Resource-based indicators; 2. Management-based indicators; and 3. Animal-based indicators (overall fish population and individual fish). The selected indicators are useful to provide validated, reliable, scalable, and easy-to-use operational welfare score index and assessment method for the European seabass and common carp in transport and harvest.

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## LIST OF ABBREVIATIONS

<b>CFP</b>	Common Fisheries Policy
<b>CMO</b>	Common market organisation
<b>CoR</b>	Committee of the Regions
<b>ECOSOC</b>	Economic and Social Committee
<b>ECTS</b>	European Credit Transfer System
<b>FAO</b>	Food and Agriculture Organisation of the United Nations
<b>GDP</b>	Gross Domestic Product
<b>GM</b>	Genetically-modified

## LIST OF FIGURES

**Figure 1:** Interlinks among factors, welfare state and welfare indicators for the assessment of farmed fish welfare.

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**Figure 8.** Common carp live transport standard operational procedure; OWI<sub>A</sub> welfare indicators expressing fish affected state.

**Figure 9.1.** Slaughtered common carp harvesting standard operational procedure; OWI<sub>A</sub> welfare indicators expressing fish affected state.

**Figure 9.2.** Common carp sold live harvesting standard operational procedure; OWI<sub>A</sub> welfare indicators expressing fish affected state.

## INTRODUCTION

The aquaculture sector has experienced significant growth in recent decades, resulting in advancements in production techniques and a heightened focus on animal welfare. Fish welfare has garnered attention; however, defining and assessing welfare indicators across various species, life-cycle stages, and production systems remains challenging due to the distinct needs and responses of each species. Current welfare monitoring frequently exhibits a deficiency in specificity and scientific rigor, which may result in insufficient welfare assessment. Filling this gap has been now facilitated by listing standardized welfare indicators that are grounded in evidence and tailored to the specific operational conditions of aquaculture environments.

The legal basis for fish welfare in the EU is rooted in broader animal welfare legislation, with no species-specific rules explicitly addressing farmed common carp and European seabass. The Treaty of Lisbon formally recognizes animals as sentient beings, requiring EU policies to consider their welfare. Council Directive (EC) 98/58, which concerns the protection of animals kept for farming purposes, sets general requirements for farmed animals but lacks detailed provisions for fish. Welfare in transport is covered under Council Regulation (EC) 1/2005, which, while mainly focused on terrestrial species, establishes key principles such as minimizing suffering and ensuring suitable environmental conditions for fish welfare, including oxygenation and water quality. Council Regulation (EC) 1099/2009 addresses humane slaughter but does not specify stunning methods for fish. In relation to these regulations, species-specific welfare indicators serve as practical tools for assessing compliance with general welfare principles outlined in the welfare legal framework.

Standardized welfare indicators provide a foundation for consistent welfare assessments across different aquaculture facilities and countries. In addition to regulatory benefits, evidence-based OWIs respond to the growing consumer and retailer demand for transparency and humane practices in food production.

## GLOSSARY

For the better understanding of the reader a glossary describing the material terms used is necessary. The following glossary is sourced by Pavlidis et al., 2024<sup>1</sup>. This way readers will be familiarized with terms such as factors, welfare state, welfare indicators and the interrelations between them as featured in **Figure 1**.

### 1. Overall welfare assessment

A systematic, independent and documented process for monitoring and evaluating the degree of fulfilment of all welfare needs, as well as the welfare status of the animals associated with infrastructures, procedures and operations for a selected group of animals during a defined period.

### 2. Factors (or input factors)

Any aspect of the physical environment, rearing system, management practices and resources available to the animal having potential positive or negative effects of its welfare status (Modified EFSA Panel on Animal Health and Welfare (AHAW<sup>2</sup>)). Factors may impact the welfare status of a fish either positively or negatively.

### 3. Indicators

Welfare indicators are empirical measurements of specific traits or states that based on evidence are deemed to be correlated to a greater or lesser extend with an individual's affective state. The indicators are mutually exclusive.

### 4. Operational Welfare Indicators (OWI)

Indicators (see above) that are reliable, replicable, practical and feasible for veterinary inspectors use at farms.

### 5. Welfare state

An individual's animal experienced affective state at a given moment in time; aggregate quality ("quality of life") of an individual's subjective experiences over a given time. An animal is in good state of welfare

<sup>1</sup> <https://doi.org/10.26248/4V5N-7V19>

<sup>2</sup> <https://efsa.onlinelibrary.wiley.com/doi/pdf/10.2903/j.efsa.2012.2767>

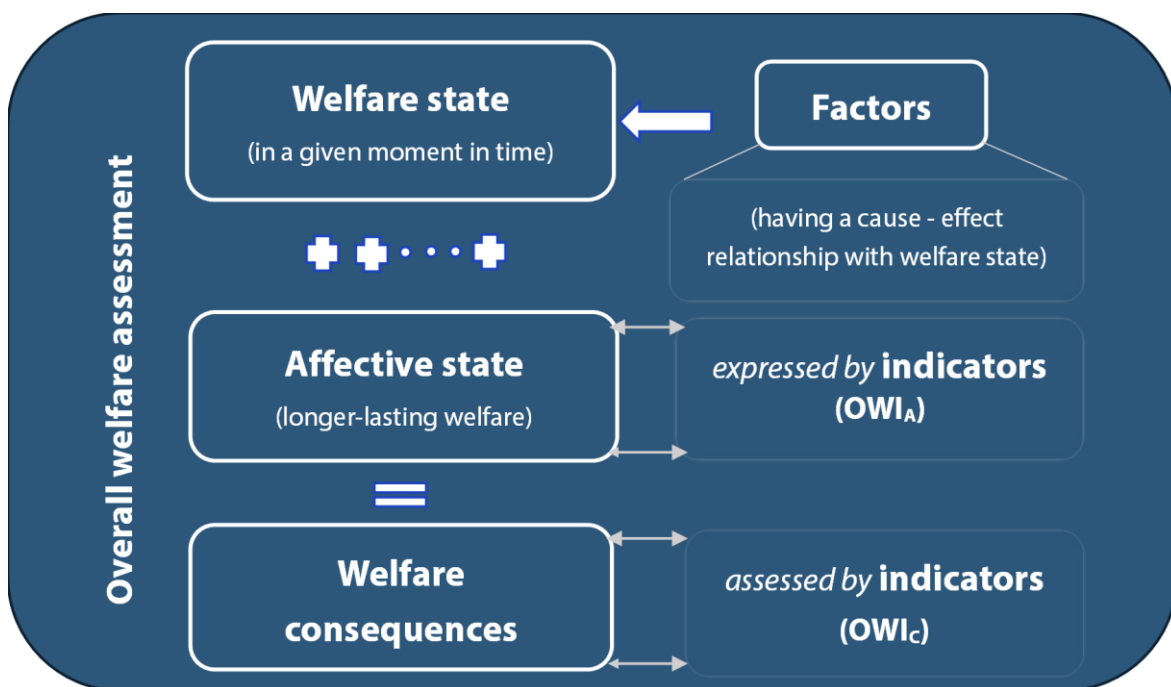
if (as it is indicated by scientific evidence “it is healthy, comfortable, well nourished, safe and able to express innate behavior and is not suffering by unpleased states such as pain, fear or distress<sup>3</sup>).

## 6. Affective state

Longer-lasting mood states (emotions and other feelings that are experienced as pleasant or unpleasant) which are not caused by a single stimulus but are the result of an accumulation of experience over time.

## 7. Welfare consequences

These are the result of a factor or the factors that affect an animals welfare status. Taken as measurements or observations of animal’s features or qualities will provide information about the welfare status of an individual. Welfare indicators assess the welfare consequences.



**Figure 1.** Interlinks among factors, welfare state and welfare indicators for the assessment of farmed fish welfare.

<sup>3</sup> Broom, D.M and Johnson, K.G., 2000. Stress and Animal Welfare. Springer/Kluwer Scientific & Business Media, pp. 211

## METHODOLOGY

### Literature review and data mining

The scientific team systematically searched prominent academic research databases, including Scopus, PubMed, Web of Science, ScienceDirect, and BioMed Central. These sources provided access to peer-reviewed articles that cover a wide range of scientific fields relevant to aquaculture, such as fish biology, environmental science, and animal welfare.

In addition to academic databases, other bibliographic resources were searched to capture diverse forms of information. This included Google Scholar, WorldCat, and Open Grey, which provided access to grey literature such as technical reports, studies, and findings from organizations and research centers. This broad search captured insights beyond peer-reviewed studies, including industry insights, practical reports, and non-published studies, contributing a wider perspective on fish welfare practices and needs.

Search keywords included combinations of the following: welfare AND/OR indicators AND/OR assessment AND/OR good husbandry practices AND/OR transport AND/OR slaughter AND/OR humane slaughter AND/OR species name (European sea bass; *Dicentrarchus labrax* OR Common carp; *Cyprinus carpio*); aquaculture.

Criteria for selection were that the research articles, reports, and studies published from 2010 onwards were chosen to ensure that the findings accurately represent contemporary practices, recent technological developments, and the latest insights in fish welfare. All studies identified through the literature search underwent screening for duplicate removal and assessment of relevance to the search criteria. The primary inclusion criteria for the study were:

- a) the involvement of one of the species under consideration.
- b) the provision of information regarding the rearing environment, and
- c) the provision of information and measures related to welfare indicators.

This selection encompassed both environmental and fish-based measures, addressing a comprehensive array of indicators relevant to fish welfare, including water quality parameters, behavior, growth, health status, and stress responses. Each potential operational welfare indicator (OWI) was assessed for its significance to fish welfare and feasibility in the aquaculture context.

A key consideration in selecting OWIs was their ease of implementation, both from the NCAs officers' point of view but also for non-specialized fish farm personnel. This emphasis on practicality ensured that the indicators chosen were not only scientifically valid but also actionable and easy to integrate into inspections. Indicators that required minimal specialized knowledge or advanced equipment were prioritized. For example, environmental indicators (e.g., water temperature, pH levels, dissolved oxygen) and basic fish-based observations (e.g., body condition, feeding behavior) were favored for their applicability and the potential to be monitored by aquaculture workers without extensive technical training.

Consequently, data mining was undertaken to analyze large datasets relevant to aquaculture welfare, involving extracting the trends, identifying the patterns, and discerning species-specific welfare needs from past research and industry practices.

## Specificity

The European seabass and the common carp possess distinct environmental, physiological, and behavioral requirements that must be incorporated into the OWIs. Factors such as water temperature preference and tolerance, feeding practices, and operational practices vary between the two species. The OWIs therefore accounted for these differences to ensure they are truly useful and efficient in enhancing welfare for each species.

## OPERATIONAL PRACTICES

### A. The case of European sea bass

Defining the boundaries of key activities, such as live fish transportation and fish harvest, is essential. Clear definitions and descriptions of the main implementation steps allow for the identification of factors that positively or negatively affect fish welfare, as well as welfare indicators linked to the animals' emotional state.

In European seabass farming, live fish transport typically occurs at the end of the weaning period when fish weighing 2 to 20 g are moved from land-based facilities (hatcheries or pre-fattening units) to open sea cages for on-growing. **Figure 2** outlines the steps involved in live fish transportation. Preparations begin with **grading** the fish to ensure uniform size, minimizing the risk of cannibalism between individuals of significantly different sizes. **Fasting** is necessary to lower fish metabolism, reducing the impact on water quality in the small transport containers. **Weighing** the fish is the practice used for counting them, determining the number of transport loads, and selecting appropriate containers. It also serves commercial purposes. Fish are transferred to mobile containers fitted onto road trucks, either using **nets or pumps**. The duration of **transportation** is critical and can range from a few hours to several days. To minimize fish metabolism during transit, water in the containers is often cooled. **Acclimatization** is necessary when transporting fish to distant locations where the receiving water temperature differs significantly ( $> 4^{\circ}\text{C}$ ) from the dispatching water. Post-transport **monitoring** of fish behavior for 1-3 days after arrival at the farm is crucial to confirm the success of the transportation process.

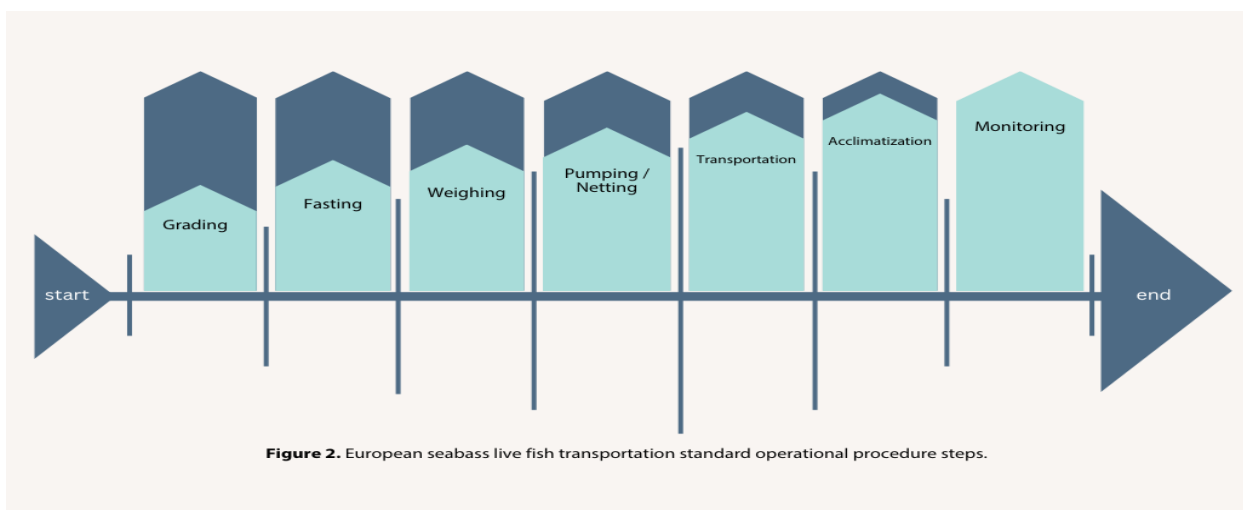


Figure 2. European seabass live fish transportation standard operational procedure steps.

The harvest of European seabass takes place at the end of the on-growing phase when the fish reach the desired market size. For European seabass and other marine fish species, harvesting involves killing the fish, which is typically carried out at sea near the floating rearing cages. The preparation for harvesting begins with fasting the fish to clear their intestines of feed residues and metabolic waste. This fasting period can last several days, depending on the farmer's sales plan.

The harvesting process starts by lifting the nets and placing a harvest net inside the cage to isolate a portion of the biomass for harvesting. Using gentle movements, workers separate the targeted fish and gradually reduce the available swimming space, causing the fish to crowd together. This crowding allows the fish to be captured either with a net or through pumping. The next step involves transferring the fish into tanks filled with slurry ice, where they are killed by a rapid drop in water temperature. Recently, the use of electric stunners has become more common in European seabass farms. In this method, fish are either guided directly into an electric field for stunning, dewatered, and then submerged in slurry ice to be killed (wet electric stunning), or dewatered first, then stunned in an electric field, and finally submerged in slurry ice. **Figure 3** illustrates the various steps involved in the European seabass harvesting process.

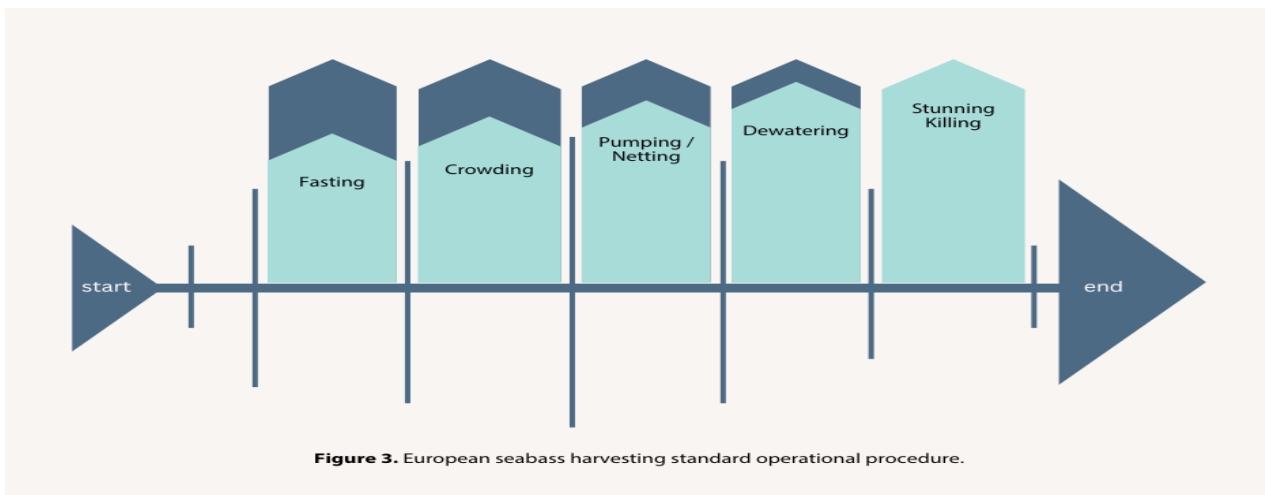
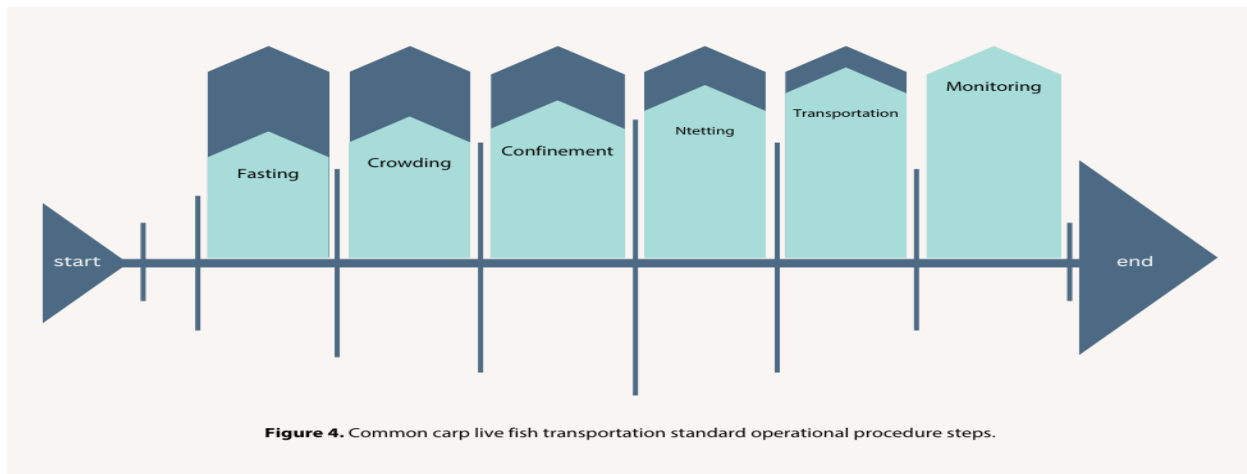


Figure 3. European seabass harvesting standard operational procedure.

## B. The case of common carp

Live fish transportation in case of common carp happens at the end of larvae stage, where the fish are transferred to on-growing ponds. Fingerlings are transferred to the new ponds at a weight of 0.1 to 0.2 g. Plankton availability is critical at this stage. Transportation practices such as fasting, crowding, confinement, netting, transfer to novel tanks, altered water quality parameters, unloading transportation vehicles and transfer to the on-growing ponds, are the main steps for standard operational procedure of common carp live transport, presented in **Figure 4**.



**Figure 4.** Common carp live fish transportation standard operational procedure steps.

Farmed carp are marketed in two main ways: either live or slaughtered. For slaughtered fish, harvesting involves lowering the water level and concentrating the fish at the pond outlet (monk), which increases fish density and stress levels. For human consumption, the fish are killed by bleeding after being stunned using percussion or electrical current. However, combining both methods is recommended to ensure the fish are rendered insensible.

**Harvest** starts by **decreasing the quantity of feed provided**; by the end of September, fish are fed using up the rest of the feed that remains in the feeding plan. **Harvest** usually begins in mid-October, in larger farms with many ponds, all yearlings of carp are caught in autumn for wintering in wintering ponds. In smaller farms, it is usually in November, but in all cases the water temperature in the pond needs to be as low as possible, preferably below 10 - 15°C. In Central Europe this is usually done from early October to mid-November.

Before slaughter, the fish are crowded at high densities in a fishing spot, which is the deepest part of the pond in front of the lowering monk, with a running water that provides the fish with the best conditions

for harvesting (**Figure 5.1**). Harvest is carried out using **nets** (trawls), which size and mesh diameter depends on the size of the fish to be caught and species diversity. The ponds can be equipped with traps where the fish is caught. The trap is a scrubber behind the drain monk, outside the pond with a freshwater supply. Fish, after a short drain (dewatering) and several minutes of rinsing the gills, are manually or mechanically placed into transport tanks. Upon collecting the fish, the fish that have been skimmed off are sorted and graded. **Grading** involves separating the fish into by species and by size, weighing and counting, and it happens outside the water. The weighing of fish should be done at 50 kg at a time without water, taking into account the 2% loss due to emptying of gut.

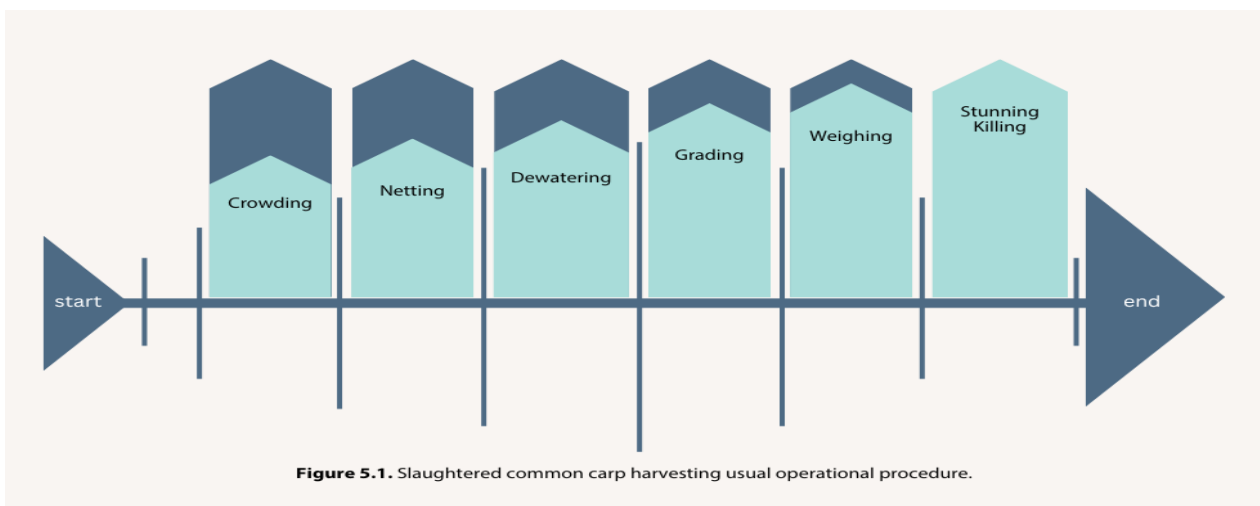


Figure 5.1. Slaughtered common carp harvesting usual operational procedure.

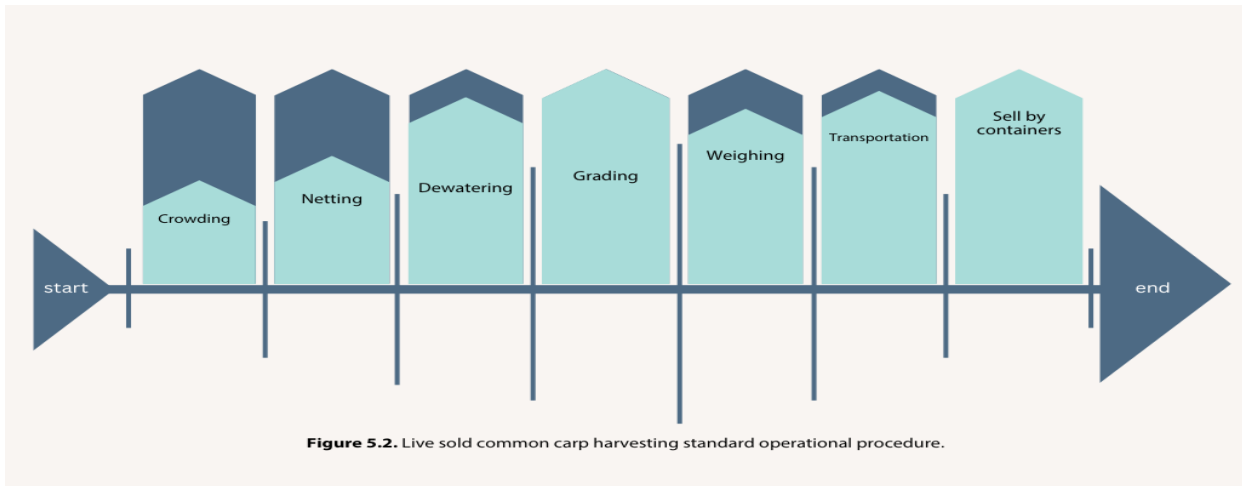
Fish are then **transported** to storage facilities where they stay for several weeks until sale. Transport is done using transport tanks, on a volume of 1500 - 2000 liters. Fish transport tanks should be equipped with an oxygen supply, although when transporting to storage/ wintering ponds is very short (up to 1 hour) transport and no oxygen supply is necessary. The ratio of water to fish is as 1:3 and the loading time should be no longer than 15 minutes. The density of fish depends on the duration of transport and the conditions of harvesting, and is usually in the range of 500 - 1000 kg/ tank (330kg/m<sup>3</sup> - 500 kg/m<sup>3</sup>).

During unloading from transport tanks, fish should be released from a low height directly into water of similar temperature, preferably sliding down a chute from the means of transport

During long distance transport in summer, tanks of 2000-2300 l are used, with fish load <1000 kg (e.g., 800 kg of fish and 1400 l of water). The water temperature is critical during this time, and must be below 18-20°C for any 24 h transportation. Winter transport uses the same volume of tanks, but fish load can

be >1000 kg. Water temperature 3-5°C, 1250 kg of fish per 1000 l of water for 24h transport is a standard. If transport over 24h is necessary, overflowing (water change) needs to be done.

In the case that common carp is marketed live, fish is transferred to containers sorted by size and transported to local markets live (**Figure 5.2**). Fish are sold to the consumers live.



## OPERATIONAL WELFARE INDICATORS (OWIs)

The selected OWI are meticulously vetted, actionable, and customized for each species of interest: European seabass (ESB) and common carp (CC) to assess the welfare of fish during transport and harvest, and provide evaluations in actual aquaculture operations, based on scientific evidence, relevance to industry contexts, and feasibility for NCAs.

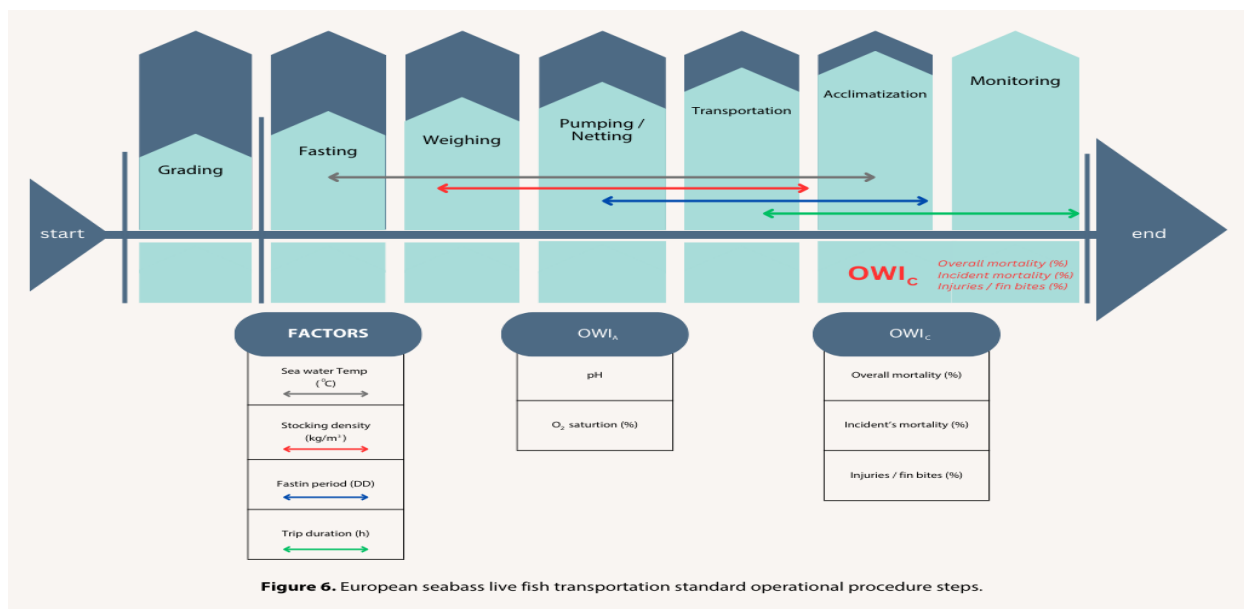
The OWIs must be reliable, sufficiently clear, repeatable and easy to use by aquaculture staff without necessitating substantial specialist expertise or expensive apparatus. OWIs are scalable and will encompass metrics such as physical condition grading, water quality benchmarks, behavioral observation techniques, or basic health assessments. Ensuring practical application implies that NCAs may incorporate these indications into their routine practices, thereby improving welfare monitoring effortlessly.

Every indicator was previously subjected to a validation process to confirm that it correctly represents the species' welfare state and to provide actionable insights. Valid, reliable, repeatable and measurable indicators provide aquaculture professionals with explicit information derived from the welfare evaluation.

## A1. European seabass live fish transportation

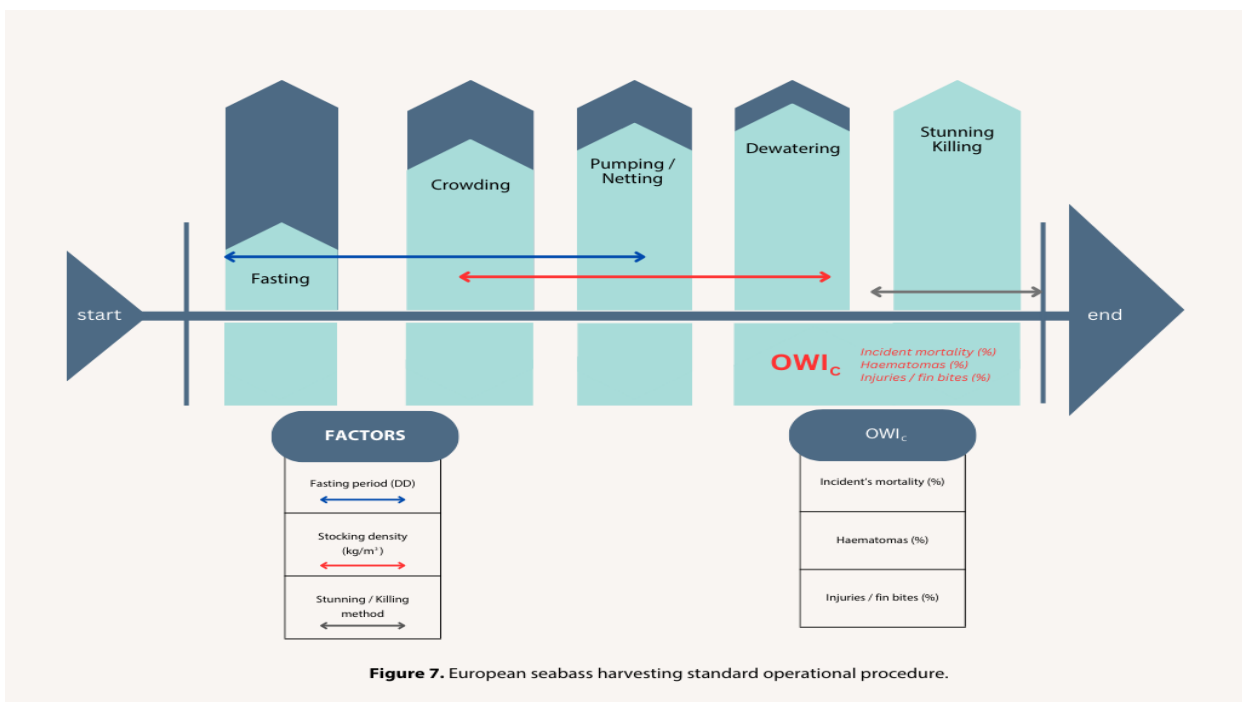
The primary challenges identified for welfare of farmed European seabass during transportation resulted by factors such as fasting duration, stocking density, sea water temperature and total transport duration. During the live fish transportation process there are welfare indicators used to estimate the affective state of welfare such as pH and O<sub>2</sub> saturation of sea water inside closed containers. Fish are crowded in closed containers during their transportation.

Indicators used to estimate the consequences of possible negative type, in such case welfare impacts results in the overall mortality and/ or the specific incident mortality. In addition, indicators such as injuries or fins bites can be used to estimate the possible negative welfare impacts of live fish transportation. **Figure 6** presents the factors (F) and the welfare indicators expressing fish affected state (OWI<sub>A</sub>) or welfare indicators assessing welfare consequences (OWI<sub>C</sub>) in the live transport of European seabass.



## A2. European seabass harvesting

The primary challenges identified for welfare of farmed European seabass during harvesting resulted by factors such as fasting duration, stocking density, and stunning/ killing method used. During the harvesting process there are welfare indicators used to estimate the possible negative welfare impacts such as incident mortality, percentage of fish expressed hematomas and injured fish. **Figure 7** presents the factors (F) and the welfare indicators assessing welfare consequences (OWI<sub>C</sub>) in the harvesting of European seabass.



## B1. Common carp live fish transport

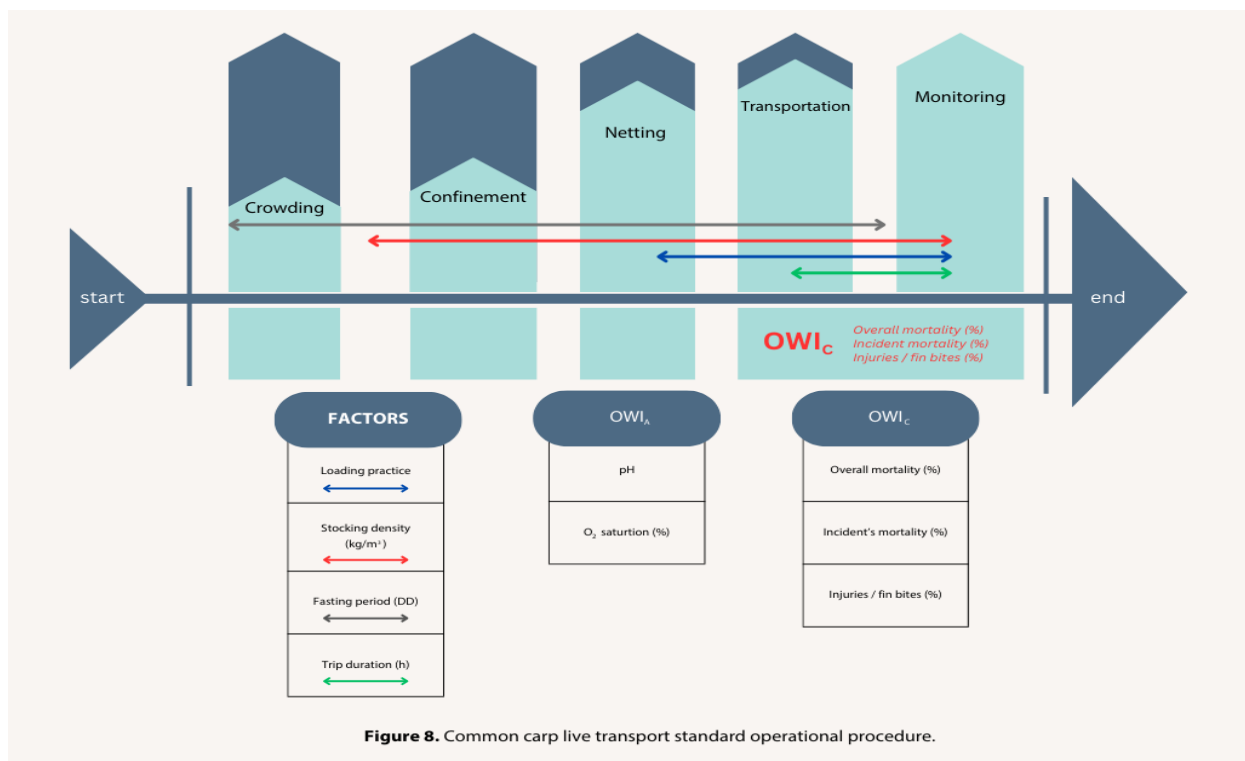
Key concerns in carp welfare during the transport are water shortages, pollution and deteriorated water quality, the need for a proper framework to identify and manage diseases, problems with predators, and insufficient regulations for farming and transport.

The most important potential causes of welfare loss during transportation are the following:

- No water change is done in transport that is longer than 24h (89.47%)
- The fish are poured from loading tanks to transport tanks from a large height (89.47%)
- Increased ammonia level during the transport (89.47%)
- Fish are shaken and bumped to tank walls during loading (84.21%)

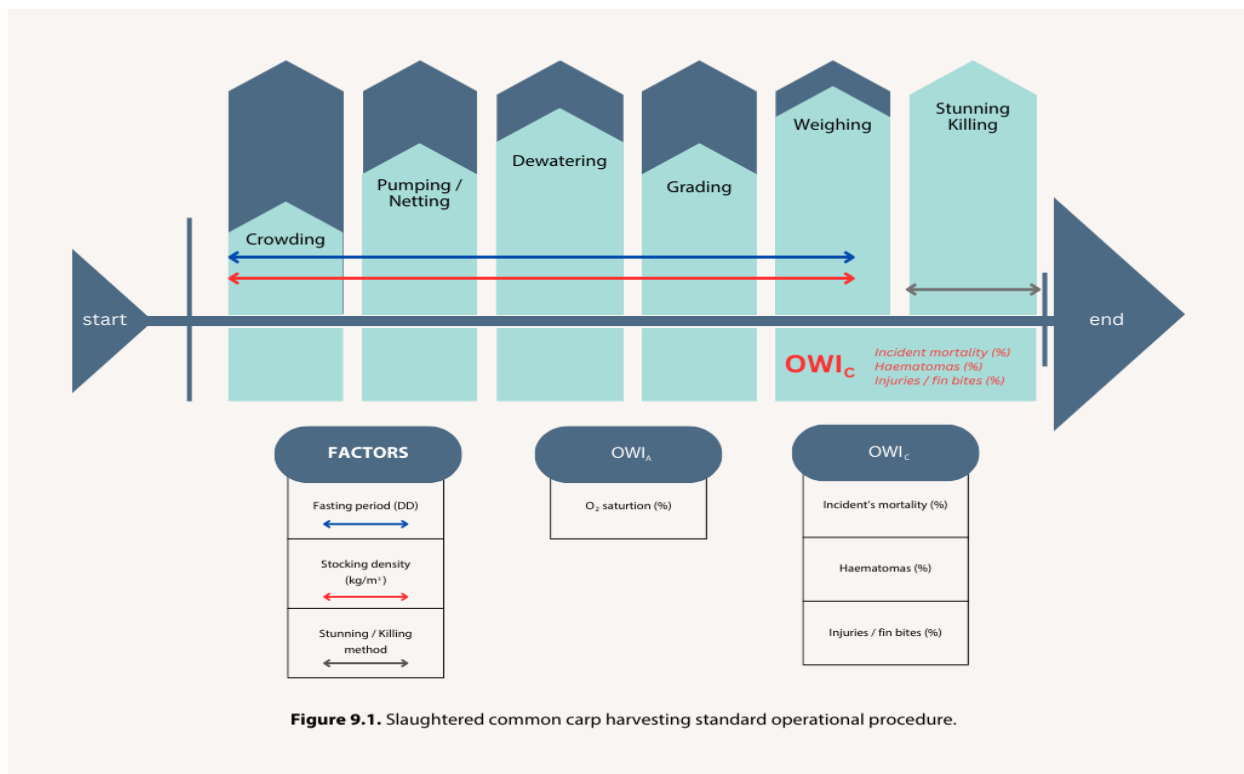
While the least important was that “the fish loading time is longer than 15 min”.

**Figure 8** presents the factors (F) and the welfare indicators expressing fish affected state ( $OWI_A$ ) or welfare indicators assessing welfare consequences ( $OWI_C$ ) in the live transport of common carp.



## B2. Common carp harvesting

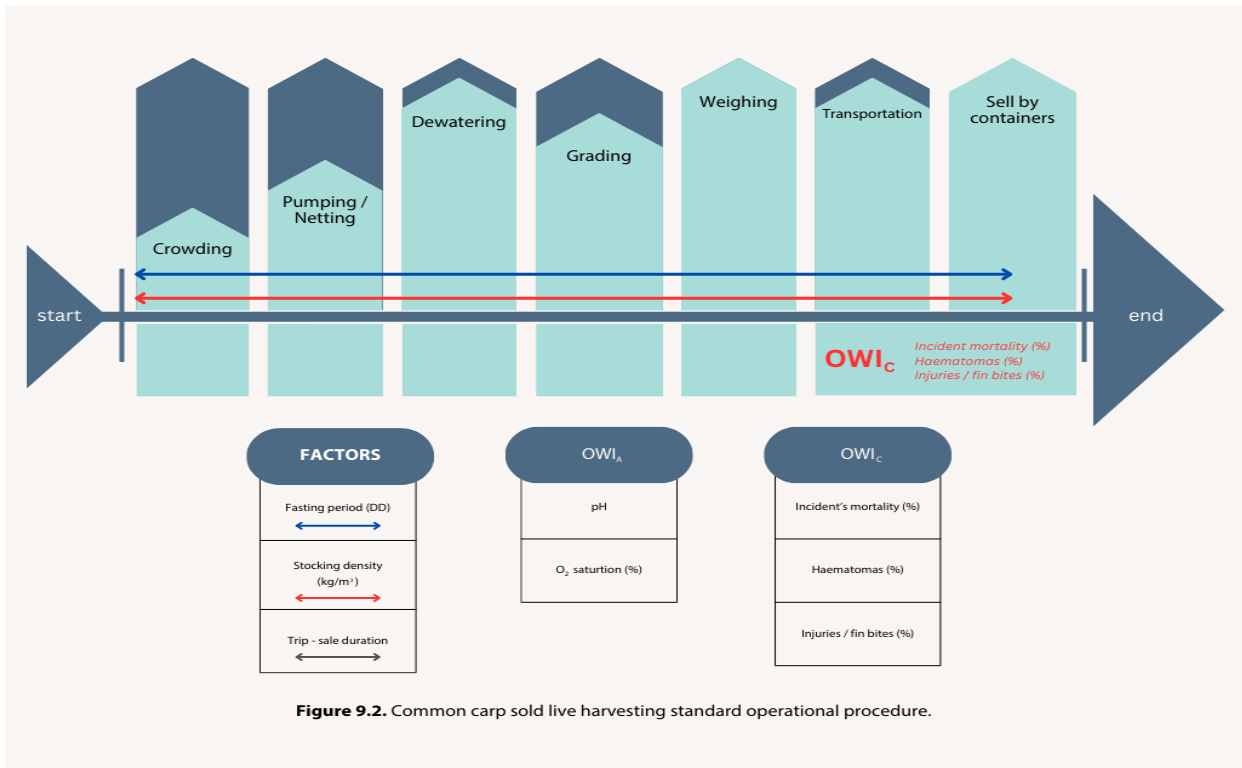
Key concerns in carp welfare during the harvest are water shortages, pollution and deteriorated water quality, challenges with stunning practices, and insufficient regulations for farming and transport. There are two different ways of marketing common carp in areas of Central Europe such as Czech Republic and Poland. Common carp is marketed either slaughtered or live to final consumers. **Figure 9.1** presents the standard operating procedure for common carp marketed as slaughtered.



In several areas of Central Europe, the sale of live common carp at farmers' markets is a cherished tradition, particularly during the festive season. This practice is deeply rooted in the region's cultural and culinary heritage, symbolizing abundance and prosperity. Fishmongers set up stalls in bustling markets, where live common carp are displayed in large plastic containers filled with water. These containers are carefully organized by size to cater to different consumer preferences.

The carp are transported to the markets under strict handling procedures to ensure their vitality and freshness. Consumers select their fish from the lively tanks, appreciating the spectacle as much as the purchase itself. For many this is part of holiday preparations, especially in the days leading up to Christmas.

The tradition is closely tied to the Christmas Eve dinner, where carp is a centerpiece in many households. Recipes vary by country and family, but the fish is typically prepared fried, baked, or served in soups. Before cooking the carp, families keep the carp alive in bathtubs at home for a couple of days to remove the muddy off-flavor, a practice that has become both a point of nostalgia and a topic of debate in modern times. **Figure 9.2** presents the standard operating procedure for common carp sold live.



## CONCLUSIONS

This study offers a comprehensive analysis of welfare metrics during transportation and harvesting for the farmed common carp and European seabass to serve NCA as a basis for ongoing evaluations. For both species either in case of transportation or the case of harvesting Operational Welfare Indicators assessing welfare consequences ( $OWI_C$ ) are "Overall mortality", "Incident mortality and "Injuries/Fin bites" of individual animals. More on that Operational Welfare Indicators expressing fish affected state ( $OWI_A$ ) are pH and  $O_2$  saturation (%) of water in the containers resulted by water exchange, stocking density and trip duration.

As the system becomes applied and used, the index will possibly undergo continual updates and refinements to integrate new data and insights, thereby ensuring its relevance and alignment with evolving circumstances.

## About EURCAW-Aqua

EURCAW-Aqua is the European Union Reference Centre for the welfare of aquatic animals. It focuses on farmed fish (rainbow trout, common carp, Atlantic salmon, European seabass, gilthead seabream) welfare, and covers the entire life cycle of fish from the early ontogenetic stages to the end of life. EURCAW-Aqua will also review the welfare of cephalopods and decapod crustaceans. Furthermore, during the development of new aquatic organisms farming operations, the welfare of any novel/emerging fish species will be evaluated upon specific queries arisen either by the European Commission Services or the Member States' Competent Authorities (CA's).

EURCAW-Aqua supports:

- Inspectors of CA's;
- Aquatic animals welfare policy workers;
- Bodies supporting CA's with science, training, and communication.

## Website and contact

EURCAW-Aqua's website <https://www.eurcaw-aqua.eu> offers relevant and actual information to support enforcement of aquatic animals' welfare legislation. Are you an inspector or aquatic animals welfare policy worker, or otherwise dealing with advice or support for official controls of aquatic animals' welfare? Your question is our challenge! Please, send us an email with your question and details and we'll get you in touch with the right expert.



[info@eurcaw-aqua.eu](mailto:info@eurcaw-aqua.eu)



<https://www.eurcaw-aqua.eu>

## Services of EURCAW-Aqua

### • Legal aspects

European fish welfare and farmed aquatic animals legislation that has to be complied with and enforced by EU Member States.

### • Welfare indicators

Fish and decapod crustaceans' welfare indicators, including resource based, management based, group and individual animal-based indicators, that can be used to verify compliance with the EU legislation.

### • Training

Training activities and training materials for inspectors, including bringing forward knowledge about ambivalence in relation to change.

### • Good practices

Good and best practice documents visualising the required outcomes of EU legislation.

### • Demonstrators

Farms, transport companies and relevant stakeholders demonstrating good practices of implementation of EU legislation.

## Partners

EURCAW-Aqua receives its funding from DG SANTE of the European Commission, as well as the national governments of the three partners that form the Centre:

- University of Crete, Greece
- Biology Centre CAS, Czech Republic
- Universitat Autònoma de Barcelona, Spain