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Summary

The present Deliverable 3.6 is released within WP3 *Boosting Fish Health at all Lifecycle Stages* for the Task 3.5 *Welfare Evaluation*.

Following an overview to fish welfare in aquaculture in the framework of EU policies and governance, industry sector and society, D3.6 presents the process of selection and validation of a list of Operational Welfare Indicators (OWIs) for European sea bass and gilthead sea bream by the PerformFISH Consortium. A tool to assess and score the overall welfare of sea bass and sea bream (BBW-Tool) has been developed to be applied at different life stages and farming systems during the grow-out cycle. This tool is based on direct (animal-based) and indirect (environmental/management based) OWIs covering different welfare needs.

A first benchmarking of welfare of about 49 million of EU farmed sea bass and sea bream was performed based on production datasets provided by the companies and LTPs of PerformFISH Consortium through the PerformFISH Gateway D4Science (WP7; DL7.1)¹. Acquisition of additional data on selected OWIs, which initially stopped in February 2020 due to Covid-19 pandemic, is now on going and the benchmark of welfare of sea bass and sea bream for the MMFF sector will be updated by the end of the project.

The developed welfare scoring tool aims at assisting the MMFF industry and other stakeholders within the Green Transition, dealing with the objectives of the new Strategic guidelines for sustainable and competitive EU aquaculture. The tool can be implemented with new OWIs based on scientific findings and technological innovation.

¹ <https://performfish.d4science.org/>

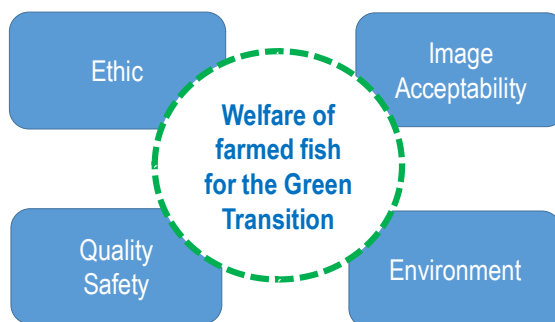
1 Introduction

Animal welfare represents a key issue in global (UN Agenda 2030; OIE) and EU strategies for the sustainable and competitive development of food production, including aquaculture (European Green Deal; Farm to Fork Strategy; EFSA strategy 2020; EC Food 2030). Achieving the **Sustainable Development Goals (SDGs) of the United Nations Agenda 2030**, can drive to an improvement of animal welfare as 66 out of 169 SDGs targets are considered relevant to this issue, in particular those of SDG 12 «responsible production and consumption» and SDG 14 «life below water» which have strong mutual synergies.

Other international experts belonging to the *“fishwelfareinitiative”* claim fish welfare needs to be an integral part of aquaculture operations worldwide to achieve the SDGs².

In the framework of the **F2F Strategy-Building a healthy and fully sustainable food system**, the Commission recognized that *“better animal welfare improves animal health and food quality, reduces the need for medication and can help preserve biodiversity. It is also clear that citizens want this. [...]The Strategic Plans and the new EU Strategic Guidelines on Aquaculture will support this process. The Commission will also consider options for animal welfare labelling to better transmit value through the food chain”*³, enabling consumer choice whilst offering farmers incentives for improving animal welfare.

The new **Strategic guidelines for a more sustainable and competitive EU aquaculture for the period 2021 to 2030** highlight the need to improve the health and welfare of farmed fish to deal with the green transition, due to the increasing public interest and benefit for the industry and the environment. Specific attention is paid on **setting common, validated, species-specific, and auditable fish welfare indicators**⁴.



² <https://www.fishwelfareinitiative.org/sdgs>

³ COM(2020)381 final

⁴ COM(2021)236 final

A set of suitable OWIs is thus a useful tool to:

- i) assess and benchmark fish welfare by farmers and health managers
- ii) improve husbandry practices and standards of production
- iii) comply with legal framework
- iv) assist competent authorities and auditors
- v) increase public positive perception of aquaculture

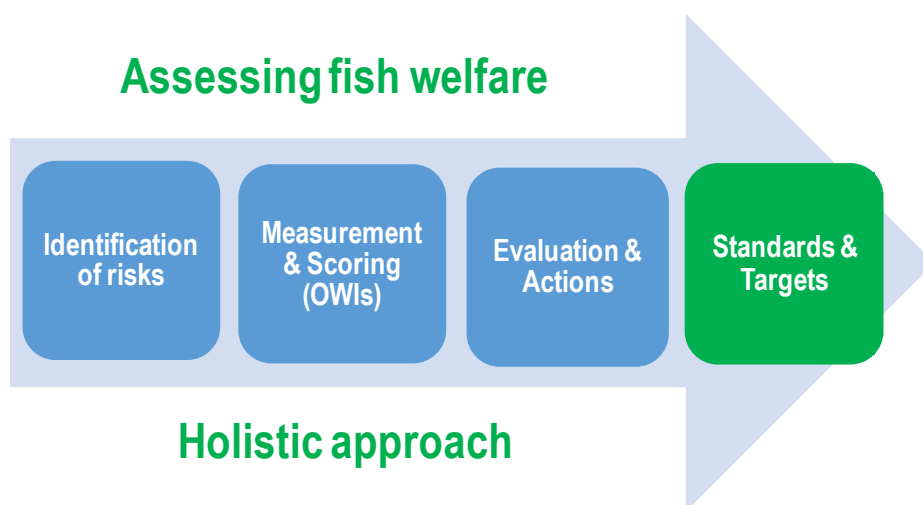
OWIs have been defined as “*observations or measurements that provide information about the extent to which the animal’s welfare needs are met and can realistically be used on the farm*” (Noble et al., 2018).

Some OWIs (and reference values) have been identified for farmed salmonids (Noble 2018, 2020), but are still to be defined and validated for sea bass and sea bream (EFSA, 2008; 2009).

Over a billion of sea bass and sea bream are harvested every year⁵ and a robust and feasible fish welfare evaluation system is highly necessary. The aim of PerformFISH within “Task 3.5: Welfare Evaluation (WP3)”, is to **develop a user-friendly welfare scoring tool based on OWIs to assess and benchmark the welfare of sea bream and sea bass in different farming systems.**

The present deliverable describes the process for the identification and implementation of animal-based and environmental/management-based OWIs for sea bass and sea bream and the methodology applied to develop a tool, hereinafter referred to the *sea Bass & Bream Welfare Tool (BBW-Tool)*, to score the level of overall welfare of group of farmed fish during the grow out phase.

The PerformFISH approach to fish welfare was shared with the Aquaculture Advisory Council (Focus Group on Fish Welfare, 2020), and received positive feedback from the Industry/Associations and NGOs. The Federation of Veterinarians of Europe (FVE) also endorsed the methodology to aid competent authorities within the application of the Animal Health Law. The PerformFISH ambition is to implement the Welfare BBW-Tool as a reference system to evaluate welfare in sea bream and sea bass in European and Mediterranean aquaculture.



⁵ www.fishcount.org.uk

2 Materials and methods

2.1 Systematization of welfare knowledge for sea bass and sea bream

The extensive review on welfare of sea bass and sea bream (Task 3.5.1) was completed in M36. The systematization of welfare knowledge allowed the selection of the most promising indicators to develop Operational Welfare Indicators (OWIs) for sea bass and sea bream. It includes:

- **Scientific papers**

Collection and analysis of peer-reviewed papers on sea bass and sea bream published in scientific repositories from late '80s onwards. Papers have been chosen based on cross queries of selected key words (e.g. welfare, well-being, stress, cortisol, behaviour, coping style, health, performances, European sea bass, *Dicentrarchus labrax*, Gilthead sea bream, *Sparus aurata*) found in title, key words, abstracts. Those papers reporting relevant results for fish health and welfare have been further selected.

- **EU research projects focusing on animal welfare**

Public technical reports/deliverables came out from EU research projects focused on welfare indicators in farmed fish (e.g. WEALTH, WELFISH, BENEFISH, COPEWELL, AQUAEXCEL) and other livestock productions (e.g. Welfare Quality®, AWIN) were consulted.

- **Legal framework & Official technical papers**

The systematization of knowledge has further included the **consultation of current legislation, recommendations** and **technical documents** for sea bass, sea bream and salmonids, including OIE Aquatic Code, EU recommendations, EFSA opinions, AAC position papers, Technical guidelines and Codes of Conduct (FAO, FEAP).

- **Standard of production & benchmarking systems**

Certification schemes (RSPCA, ASC, Global GAP, BAP GAA, FOS, Organic), Benchmarking systems (GAPI, GSSI), Welfare Handbook for Atlantic salmon and rainbow trout (Noble et al., 2018; 2020) have been considered with special regard to direct (animal-base) and indirect welfare indicators potentially useful for MMFF sector.

2.2 OWIs validation

The choice of OWIs and the validation by PerformFISH Consortium have been performed in task 3.5.2 through several steps:

- **Validation of Welfare Key Performance Indicators (W-KPIs) (WP7; Task 7.1)**

During the first period (M1-M18), a first set of welfare indicators for sea bass and sea bream proposed by P20 was approved by the PerformFISH consortium (Rome meeting, November 2017); it consisted of 28 WE-KPIs, 75% of them were animal-based indicators and 25% were indirect indicators. Most of the selected WE-KPIs were already in use in one or more aquaculture certification schemes.

Out of 28 KPIs, a total of **9 WE-KPIs were selected at “A-level” as ready to use**, taking into account their robustness, repeatability, cost-effectiveness and feasibility. 19 WE-KPIs were selected at “B-level”, as relevant KPIs to be implemented during the project (e.g. severity of injuries, degree of parasite infestation, abnormal behaviour) within the scope of WP3 - task 3.5.

- **Technical questionnaires for Producer Associations and the LTPs**

Two questionnaires (A, B) were developed to implement the OWIs list:

Questionnaire A was submitted to the five Producer Associations and Questionnaire B to aquaculture companies involved as LTPs in PerformFISH.

Questionnaire A requested information from the Associations on fish welfare in respect to the national legal framework, provisions and recommendations from national Competent Authorities, Code of Conduct and Guidelines at country level. It also contained questions on sea bass and sea bream welfare at farming, transport and slaughter.

Questionnaire B for Companies aimed to acquire information related to main fish welfare topics (Farming system, Stocking density, Handling, Grading, Environmental monitoring, Feeding, Transport, Harvesting, Slaughter, Emergency killing, Staff training, Certification schemes) and related direct and indirect indicators.

- **Validation of selected OWIs through a Welfare Survey**

An **on-line welfare survey** using the Survey Monkey Platform was launched in July 2019 within the PerformFISH Consortium in order to identify most suitable OWI to assess sea bass and sea bream welfare on farm.



The complete list of OWIs was defined on the basis of the results of the systematization of knowledge in task 3.5.1, consultations on KPIs in Task 7.1 and expert judgments.

The survey was prepared by ISPRA in collaboration with UAB, ULPG and API and was available online from July to October 2019. Consultation was open only to scientists, farmers and producer's Associations belonging to PerformFISH Consortium.

The **48 OWIs** proposed in the survey cover **9 different areas of fish welfare**:

1. HEALTH (N=8)
2. GROWTH (N=3)
3. BEHAVIOR (N=5)
4. HOUSING (N=7)
5. TRANSPORT (N=8)
6. HARVEST (N=5)
7. STUNNING/SLAUGHTER (N=8)
8. STAFF TRAINING (N=2)
9. COMPLIANCE WITH OIE AND EU RECOMMENDATIONS (n=2)

The set of OWIs included **animal-based indicators (46%)** and **indirect indicators (54%)** related to environment and husbandry management and practices. Some OWIs are **quantitative indicators**, providing numerical values for welfare scoring and other OWIs are **qualitative indicators**, related to the use of best management practices during farming, transport and slaughter.

The suitability of each OWI was scored according to the following OWI attributes: Informative, Reliable, Cost effective, Labour effective, Repeatable, Comparable, Easy to apply. Experts were asked to **score the overall suitability of each OWI** as low, medium, high. No answer was also an option if the expert did not have knowledge/expertise to provide an answer.

Most of OWIs (80%), selected through surveys and consultations, for sea bass and sea bream were already included into certification schemes and are in use for farmed Atlantic salmon and rainbow trout. However, threshold values for several welfare indicators were often missed, in particular for sea bass and sea bream.

2.3 OWIs Implementation

For the development of a **welfare scoring system for sea bass and sea bream (BBW-Tool)** the composite indicators approach has been applied, which consists in a wise aggregation of a certain number of elementary indicators representing different issues of the same multi-dimensional phenomenon. Composite indicators, if appropriately constructed, provide useful tools to improve governance actions and monitor their results.

The Adjusted Mazziotta–Pareto Index (AMPI) is one of the most used composite indicators. This tool is applied in several fields to measure complex multidimensional phenomena in the field of quality of life and well-being of citizens, environment, food sustainability and for monitoring EU Member States score on SDGs of the Agenda 2030.

AMPI is a composite index used to summarize a set of indicators that are assumed to be non-substitutable, i.e. all components have the same relevance (non-compensatory approach). It requires data normalization and equal weighting of the indicators (Mazziotta and Pareto 2016). Based on the above considerations, AMPI has been chosen as the most promising methodology to build a scoring tool for welfare of sea bass and sea bream according to the 24 OWIs selected by PerformFISH consortium, hereafter BBW-Tool. This method allows farmers

and other operators (e.g. auditors, competent authority) to easily identify batches and farms that have a higher (values above 100) or a lower (values below 100) level of animal welfare than the average resulting in an easy interpretation of the comprehensive welfare status.

Regarding sea bream, a first list of 21 potential OWIs has been proposed within H2020 MedAID; OWIs are scored on a 0-2 scale in respect to qualitative and quantitative variables (Roque et al., 2020). More recently the Salmon Welfare Index Model (SWIM 1.0; Folkedal et al., 2016) was adapted and tested for welfare assessment for sea-caged European sea bass (Yildiz et al., 2021).

Summarizing, **the BBW-Tool is based on the following:**

- Selection and validation of suitable direct (animal-based) and indirect (environmental/management based) OWIs for sea bass and sea bream by PerformFISH Consortium
- Application of AMPI multi-dimensional composite indicator, combining quantitative and qualitative OWIs
- Development of W-Index by species in a range between 70-130
- Score and comparisons of fish population well-being at batch and farm level within the grow out phase.

In order to show the application and the benefit of the proposed BBW-Tool, the AMPI method is applied separately by species at batch and farm level. The parameterization of batch and farm has been previously validated by ISPRA together with the industry within DL7.1- *Set of KPIs for Mediterranean Marine Fish Farming (MMFF) Sector*⁶

Batch level: data recorded for 1 single production batch is a group of fish, ideally homogeneous for size and source, stocked in grow out within 2 weeks and managed in one or more rearing units until the end of the grow out cycle and harvest. The number of batches to monitor for KPIs should be representative of the farm production.

Farm level: data recorded for several production batches (aggregated batches) as groups of individual batches reared in multiple rearing units which data are submitted aggregated, according to the stocking period (1st - 4th Quarter).

⁶ <http://performfish.eu/deliverables/>

				BB	BC	BD	BE	BF	BG	BH	
				Fish management							
Authors (all)	Year	Title	Journal	Farming system	Stocking density	Rearing volume	Confinement	Crowding	Grading	Handling	Anesthetic use
				FM-Fa	FM-St	FM-Re	FM-Co	FM-Gr	FM-Ha	FM-An	
Tandler, A., Hattel, M., Wilks, M.	1985	Effect of environmental temperature	Aquaculture	0	0	0	0	0	0	0	0
Wajsbrot, N., Gazitib, A., Krom, I.	1991	Acute toxicity of ammonia to juvenile	Aquaculture	0	0	0	0	0	0	0	0
Wajsbrot, N., Gazitib, A., Djaman, A.	1993	Chronic toxicity of ammonia to juvenile	Journal of Fish Biology	0	0	0	0	0	0	0	0
Newberry, R.C.	1995	Environmental enrichment in trout	Applied Animal Behaviour	0	0	0	0	0	0	0	0
Person-Le Ruyet, J., Charoiz, H.	1995	Comparative acute ammonia toxicity	Aquaculture	0	0	0	0	0	0	0	0
Sunyer, J.O., Gómez, E., Navaric, J.	1995	Physiological responses and degeneration	Canadian Journal of Fish and Aquatic Sciences	0	0	0	0	0	0	0	0
Andrades, J.A., Becerra, J. And	1996	Skeletal deformities in larval, juvenile	Aquaculture	1	0	0	0	1	0	0	0
Tort, L., Sunyer, J.O., Gómez, E.	1996	Crowding stress induces changes in	Veterinary Immunology and Zoology	0	0	0	0	0	0	0	0
Moliner, A., Gómez, E., Balazs, G.	1997	Stress by fish removal in the fish	Journal of Applied Aquaculture	0	1	0	0	0	0	0	0
Canario, A.V.M., Condega, J.,											
Henrique, M.M.F., Gomes, E.F.											
Tort, L., Rollant, J. And Rovito, A.											
Arends, R.J., Mancera, J.M., M.											
Montero, D., Blazet, V.S., Sor.											
Montero, D., Izquierdo, M.S., I.											
Montero, D., Manero, M., Izquierdo, M.S., I.											
Berkás, E., Vall, A.E. and Prada, R.											
Rollant, J., Balm, P.H.M., Rueda, J.											
Koven, W., Barr, Y., Lutzky, S.,											
Montero, D., Tort, L., Robaina, J.											
Druño, J., Esteban, M.A. and											
Rollant, J., Balm, P.H.M., Pérez, J.											
Tort, L., Montero, D., Robaina, J.											
Andrew, J.E., Noble, C., Kadis, S.											
Druño, J., Esteban, M.A. and											
Druño, J., Esteban, M.A. and											
Goldan, D. and Popper, D.											
Hernández, A. and Tort, L.											
Montero, D., Kalnovski, T., Ob.											
Druño, J., Esteban, M.A. and											
Pascual, P., Pedrajas, J.R., To.											
Bressler, K. And Ron, B.											
Cuesta, A., Meseguer, J. and B.											
Gómez-Requena, P., Mingari, S.											
Tort, L., Balm, P.H.M., Rueda, J.											

Figure 2. Sea bass and sea bream Welfare Database (WDB)

Table 1. Categories of welfare indicators for sea bass and sea bream included in the WDB

Behaviour	Physical	Immunological
<ul style="list-style-type: none"> Swimming Escape Feeding Social Consciousness Anesthesia Indices of electrical activity 	<ul style="list-style-type: none"> Health Histology 	<ul style="list-style-type: none"> Non-specific Specific
Production <ul style="list-style-type: none"> Growth Feed efficiency Health 	Physiological <ul style="list-style-type: none"> Hormonal Hydromineral Metabolic Haematological Enzymatic Neurotransmitters 	Molecular gene expression <ul style="list-style-type: none"> Metabolism Health

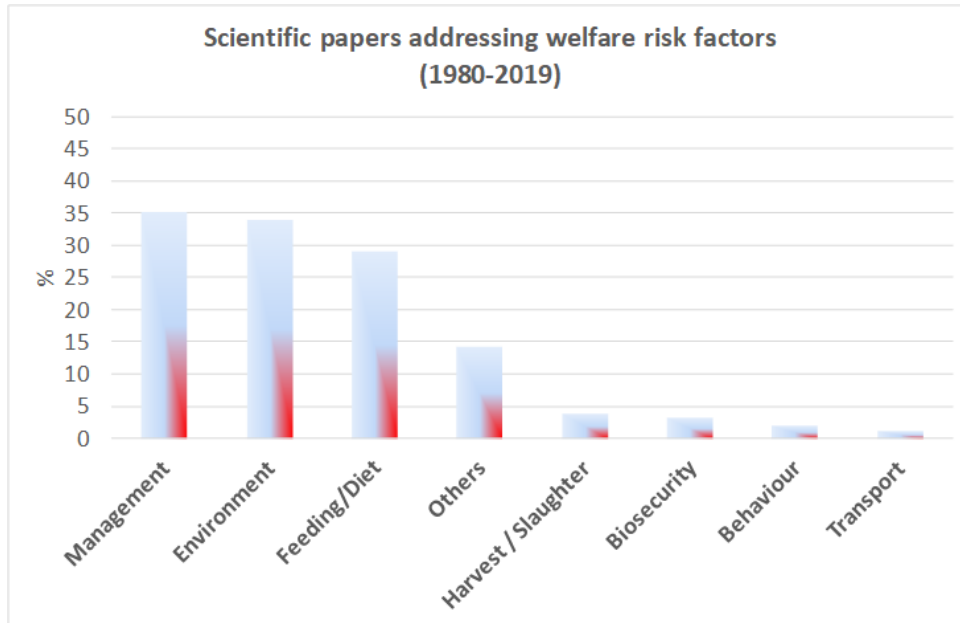


Figure 3. Scientific studies (%) investigating different welfare risk factors in sea bass

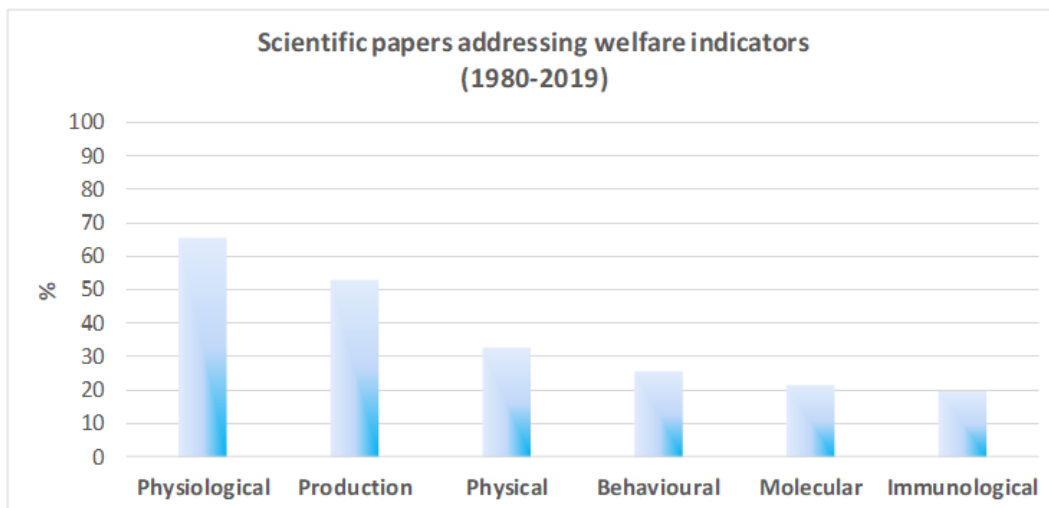


Figure 4. Scientific studies (%) investigating welfare according to the six categories of welfare indicators in sea bass

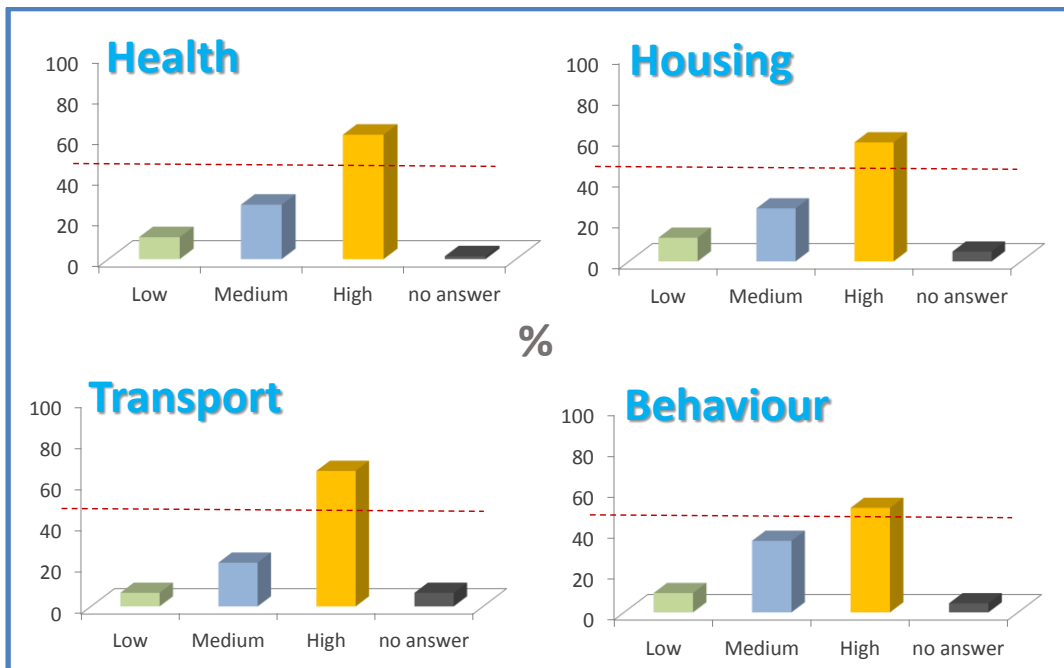
3.2 OWIs data collection

3.2.1 Welfare Key Performance Indicators (W-KPIs)

The collection of data useful for assessing welfare of sea bass and sea bream was started by PerformFISH companies using the set of 9 Welfare Key Performance Indicators (W-KPIs) validated by the Consortium in Task 7.1.

3.2.2 Results from Welfare Survey

PerformFISH consortium participated actively in the survey, providing at least one expert judgments from scientists, industry (e.g. managers, biologists, farm veterinarians) and representatives of Producer’s Associations belonging to PerformFISH consortium, for a total of 36 full filled surveys. **Most of PerformFISH OWIs proposed by P20 (n=48) were judged suitable for sea bass and sea bream** (Figure 5). In particular, high suitability was given to health, housing, harvest and transport OWIs. Health Management Plan, BPs and Staff training resulted highly recommended. Abnormal feeding/swimming behaviour are considered suitable qualitative OWIs. SGR can be an informative OWI if tailored to Mediterranean climate zones (Petochi et al., 2019).



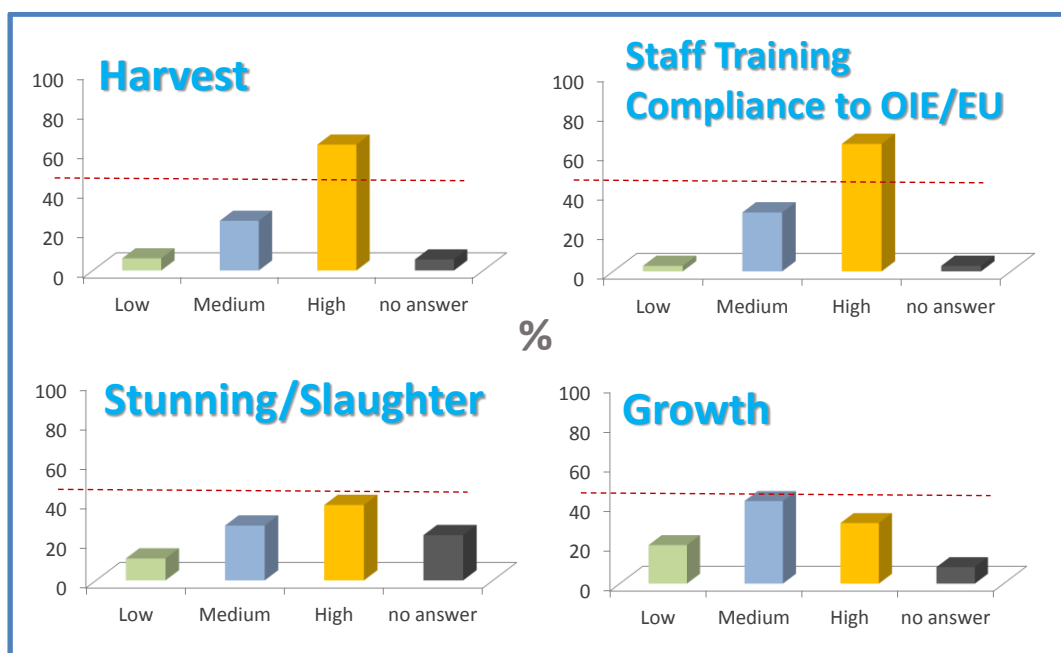


Figure 5. Suitability (%) of OWIs according to the welfare area

The score of stunning/slaughtering OWI indicated that there is still a lack of knowledge and uncertainty for the choice of OWI at stunning and slaughter in these species. Even if the PerformFISH welfare scoring system is focused on the farming cycle, the grow-out phase from stocking (>2g fish) to harvesting, however few OWIs for stunning/slaughter have been also included in the survey in order to get the perception of different stakeholders represented in the PerformFISH consortium and contribute to the debate on this issue in the MMFF sector. Indeed, with respect to sea bass and sea bream, the OIE standards for slaughter are still not achieved as asphyxia in ice or ice slurry is still commonly practiced (EU, 2017). On this issue the EU Commission highlighted the need for further research to tailor dedicated stunning/slaughtering methods for these species⁷.

The results of the survey provided a good picture of the perception of MMFF sector, which strongly recommended i) the use of Code of Conduct and Best Practices and ii) new research for the validation of reliable OWIs at slaughter, not yet available for sea bass and sea bream.

⁷ COM(2018) 87 final

3.3 OWIs Implementation

3.3.1 The OWIs used for the BBW-Tool

Based on the level of suitability scored for each OWI by the industry and academy in the PerformFISH survey (3.2.2), a subset of **24 OWIs was selected**. **The BBW-Tool includes:** 9 welfare KPI already validated with the industry (WP7, Task 7.1) and 15 OWIs selected in the survey and expert judgment (Figures 6, 7, 8). For most of the selected OWIs, a consensus on the suitability of OWIs was evident from the academic and industry stakeholders of PerformFISH consortium (Figure 7).

The BBW-Tool is based on non-invasive procedures since no live fish need to be sampled or sacrificed to apply it, also saving time for the group welfare assessment.

Few OWIs dealing with skin, fin condition and discharged fish at slaughter are measured only at the end of the grow out phase. These indicators are useful to identify any problems occurred both during the harvesting/slaughtering phase and the grow-out phase and to take actions for improvements. At the end of cycle, data can be more easily acquired without invasive procedures on a significant number of fish.

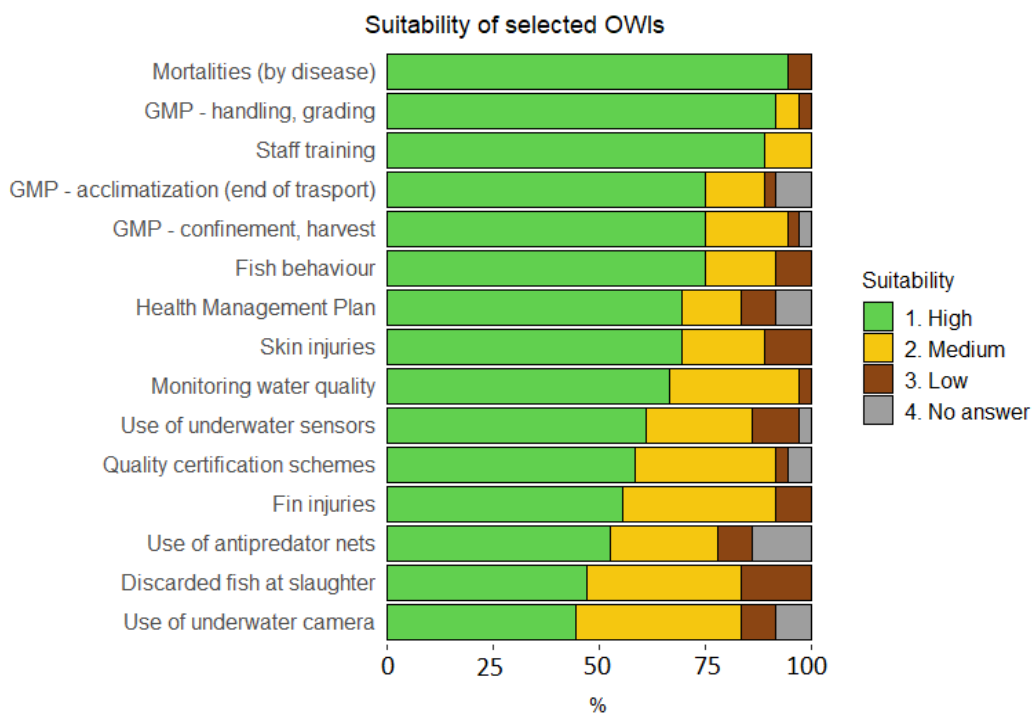


Figure 6. Suitability of the 15 OWIs for the BBW-Tool selected through the survey

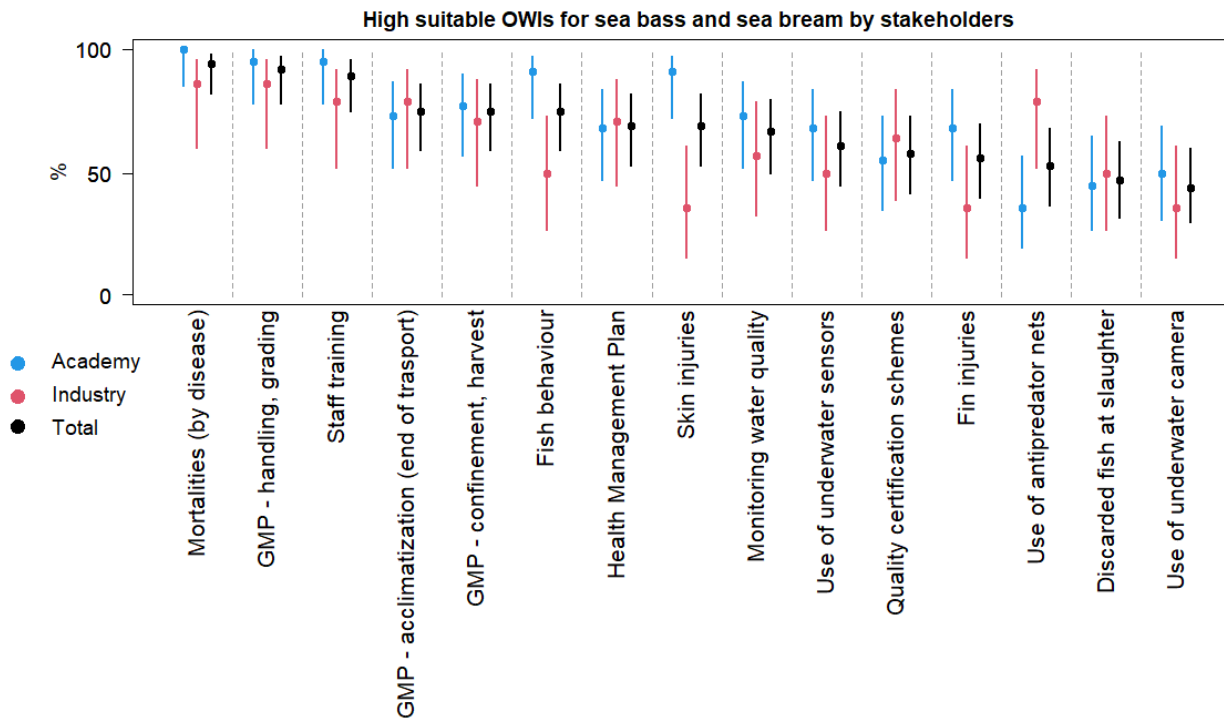


Figure 7. Percentage of high suitability of the 15 selected OWIs for the BBW-Tool according to PerformFISH stakeholders belonging to academy and industry

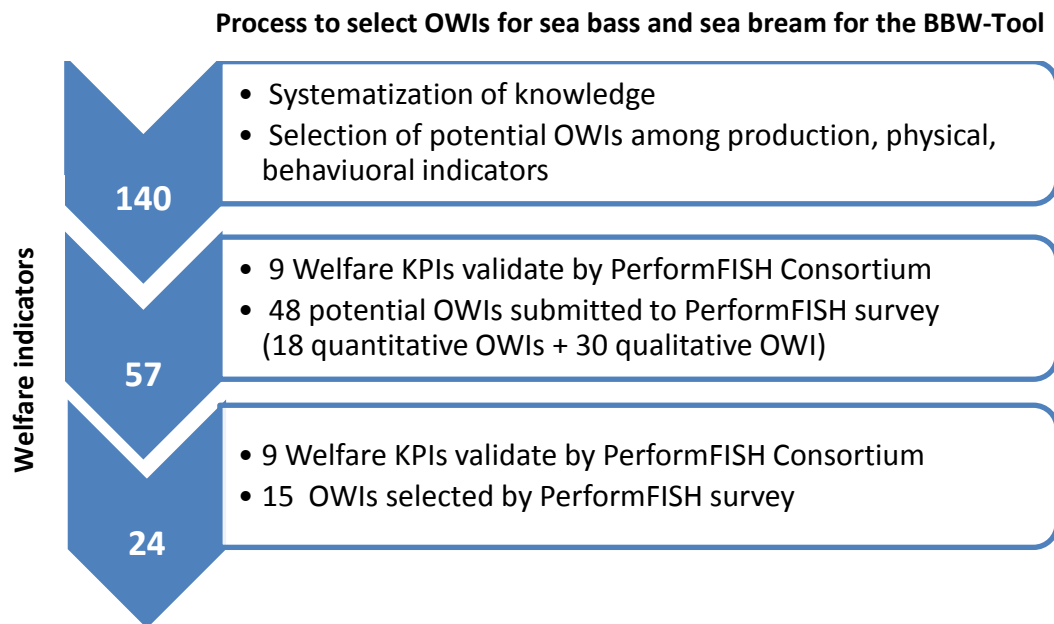


Figure 8. Process to select OWIs for sea bass and sea bream for the BBW-Tool

3.3.2 Welfare score of sea bass and sea bream

In order to test the methodology for exploring possible differences among production phases along the farming cycle, the initial phase (stocking-50g) and the whole cycle (stocking–harvest) were selected. The industry has identified the initial phase as one of the most critical phases for fish welfare during grow out, as this includes the acclimation of juveniles following transport and stocking. If not properly managed, this phase can be highly stressful for fish, potentially resulting in high mortality. Indeed, a larger number of W-KPIs validated by the consortium refers to this phase (see DL 7.1)⁸.

Present results are based on a dataset made available in PerformFISH VRE by LTPs belonging to the Consortium (Table 2). The BBW-Tool has been tested separately for sea bass and sea bream farmed in sea cages. Comparisons of individual closed batches from stocking to harvest within the period 2016-2020 as well as of farms using aggregated data have been carried out on a subset of quantitative OWIs.

Table 2. Data source acquired from PerformFISH VRE to test the BBW-Tool on sea bass and sea bream during the grow out phase

Data source to test BBW-Tool	Sea bass	Sea bream
Companies (n)	6	5
Farms (n)	12	10
Batches (n)	61	54
Rearing Units (n)	151	182
Stocked fish represented (Millions)	22	27

Consistently with the assumption of the model, W-Index values for all batches and farms fall in the range 70–130. An example of the application of the model at farm level is shown in Figure 9. For sea bass most of the farms show improvement or worsening of W-Index between the two phases. Similar results were observed for sea bream.

⁸ WP7 DLs available at <http://performfish.eu/deliverables/>

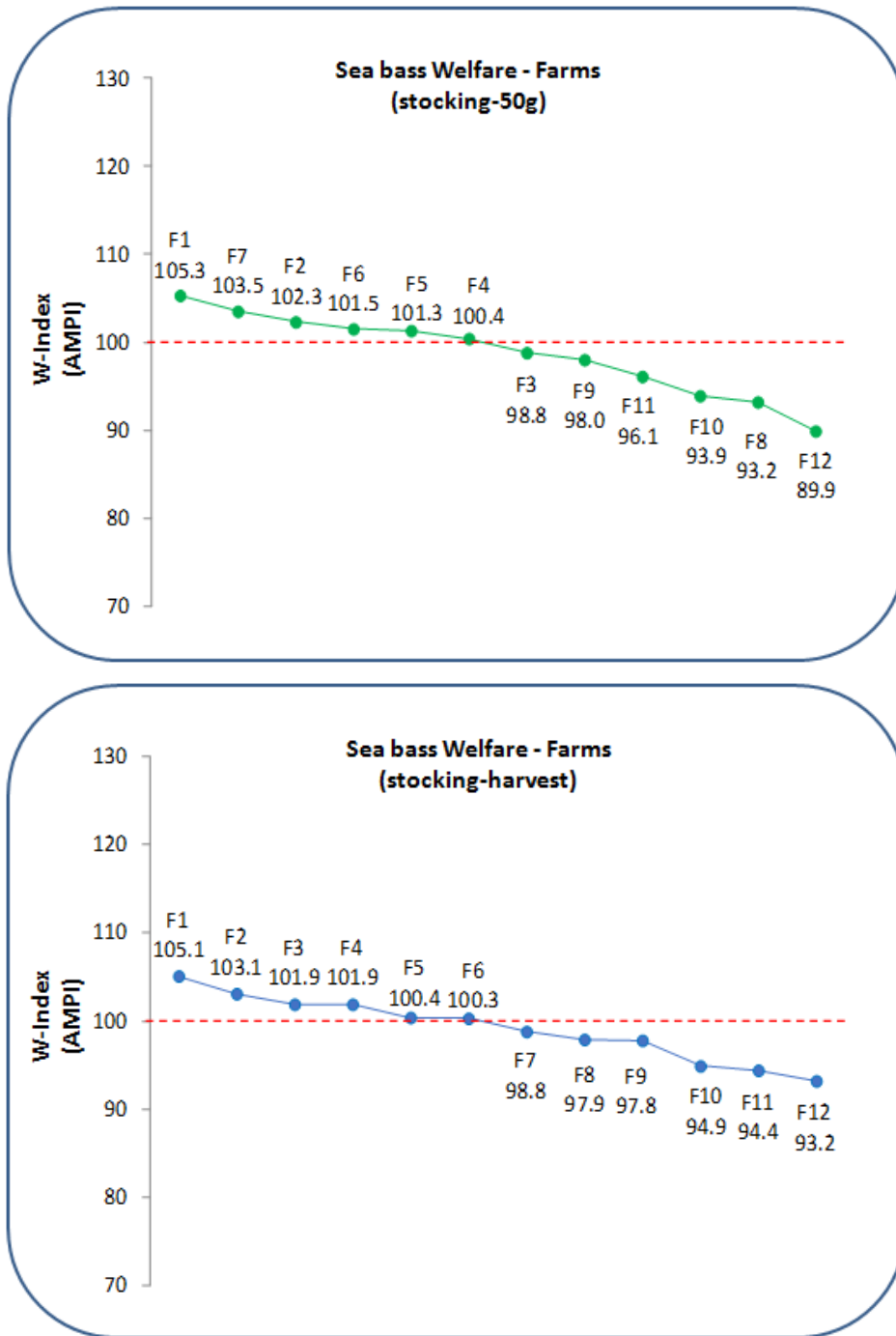


Figure 9. W-Index of sea bass farms for the initial grow out phase (top) and the whole cycle (bottom)

4 Conclusions

In line with the current needs and goals stated in the new Strategic guidelines for a more sustainable and competitive EU aquaculture for the period 2021 - 2030, D3.6 contributes to assessing and improving the overall well-being of sea bass and sea bream farmed by the MMFF sector. A tool for measuring the level of welfare of farmed sea bass and sea bream, namely BBW-Tool, has been developed and tested on the grow-out phase (stocking-harvesting). This tool is based on suitable and auditable 24 OWIs, validated by PerformFISH consortium and production data provided by LTPs.

The BBW-Tool synthesizes the OWIs data related to different animal welfare areas for a large population of sea bass and sea bream, into an easy interpretable multidimensional W-Index, useful to rank farming units according to their welfare level and to find room for improvements. As shown, the BBW-tool is further flexible and adaptable since it can be applied on a subset of OWIs.

Results demonstrate the appropriateness of the proposed BBW-Tool that enables to make robust and repeatable assessments and comparisons on the level of welfare of sea bass and sea bream across grow-out units, production phases and farming area. The BBW-Tool represents a promising non-invasive methodology to assess and score the well-being of farmed sea bass and sea bream for the following purposes:

- I. **“Company self-evaluation” within own farms and batches**
- II. **“Industry sector benchmarking” at country and area level**
- III. **“External audits” by competent authorities and/or certification bodies**
- IV. **“Code of Conduct” implementation**
- V. **“EU fish welfare labelling”**
- VI. **“Improve social acceptability” of MMFF products**

The BBW-Tool can be implemented with further OWIs based on scientific and technological advancements in coming years. Species-specific, validate and auditable OWIs addressing sea bass and sea bream welfare during transport and at slaughter can be included in the BBW-Tool following EU recommendations and implementation of legal framework. A wider use of tools for real time monitoring of farming conditions (e.g. environment, behaviour, health, biomass) is expected to increase in the MMFF sector, contributing to expand the **“precision farming”** and to improve the well-being of sea bass and sea bream. In this scenario, the digitalization of aquaculture will increase the sector’s efficiency also in terms of animal welfare. Promising indicators related to animal welfare needs or positive stimuli for the fish under farming conditions (e.g. environmental enrichment) may be included in the model according to new scientific evidence and largescale trials on sea bass and sea bream.

The BBW-Tool is not intended to replace the need for regular inspections by fish veterinarians or other fish health experts, but it can be an aid tool to implement such activities.

The BBW-Tool can be tailored to assess the welfare also in other fish species by selecting/modifying the set of OWIs.

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