BIOF

Project Number: 18110-2

Project Acronym: SIMTAP

Project title: Self-sufficient Integrated Multi-Trophic AquaPonic systems for improving food production sustainability and brackish water use and recycling.

Periodic Technical Report
Part B

Period covered by the report: from [01 June 2019] to [30 November 2020]

Periodic report: [1st]

Contents

1. Explanation of the work carried out by the beneficiaries and overview of the progress

The international project entitled "Self-sufficient Integrated Multi-Trophic AquaPonic systems for improving food production sustainability and brackish water use and recycling - SIMTAP" was approved in November 2018 as part of the PRIMA (Partnership for Research and Innovation in the Mediterranean Area) call 2018 (Section 2) and started on 1 June 2019.

The project is coordinated by Prof. Alberto Pardossi of the University of Pisa (UNIPI), which participates in the project with two departments: the Department of Agricultural Sciences , Food and Environmental (DiSAAA), to which Prof. Pardossi belongs, and the Department of Veterinary Sciences (DiSVe), to which Prof. Carlo Bibbiani and Dr. Baldassare Fronte belong.

Other partners are the following:

- University of Bologna, Department of Agro-Food Sciences and Technologies, Bologna (Italy) (UNIBO; team leader: Prof. Daniele Torreggiani)
- University of Milan, Department of Environmental Sciences and Policies, Milan (UNIMI; team leader: Dr. Jacopo Bacenetti)
- INRAE-Agrocampus, SAS Sol Agro et hydrosystème Spatialisation, Rennes (France) (INRAE; team leader: Dr. Joel Aubin)
- Lycée de la Mer et du Littoral, Bourcefranc le Chapus (France) (LML; team leader: Dr. Vincent Gayet)
- Mediterranean Fisheries Research Production and Training Institute, Antalya (Turkey) (MEDFRI; team leader: Dr. Mehmet Ali Turan Koçer)
- Ministry for Agriculture, Fisheries and Animal Rights, Agriculture Directorate Marsa (Malta) (MAFA; team leader: Marcelle Agius)
- Korolev GmbH, Bonn (Germany) (KOROLEV; team leader: Dr. Rainer Linke)

In the proposal, the partner in Malta was Ministry for the Environment, Sustainable Development & Climate Change, and the team leader was Mr. Kyle Spiteri. Due to the reorganization of the Ministry, the name was changed in 2020.

The project obtained funding of approximately 953,000 euros.

The Covid-19 pandemic and the consequent lockdown and restrictions in 2020, and the lack of funds for the Italian partners (a results of slow procedure laid down by the NFB, the Ministry of University and Research, MUR) have delayed many project activities. On November 19, 2020, the General Assembly approved unanimously the Coordinator' proposal to modify the workplan and the deadline for several deliverables and one milestone, as reported in **Table 1**, **2** and **3**, respectively.

Table 1. Workplan (Gantt chart) of the SIMTAP project. The asterisks indicate the extension of the work package with respect to the workplan in the proposal.

SIMTAP GANTT CHART		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36
WP0	SIMTAP coordination and management																																				
T0.1	Technical coordination																																				
T0.2	Financial and administrative management																																				
T0.3	Quality assurance																																				
WP1	Ecosystem based approach for SIMTAP							*	*	*	*	*	*	*	*	*	*	*	*	*	*	E															
T1.1	Piloting activities							*	*	*	*	*	*	*	*	*	*	*	*	*	*	E															
T1.2	Study of the most suitable plants							*	*	*	*	*	*	*	*	*	*	*	*	*	*	E															
T1.3	Study of the dietary inclusion levels							*	*	*	*	*	*	*	*	*	*	*	*	*	*	E															
T1.4	Designing, building and trying out an integrated smart monitoring and control system							*	*	*	*	*	*	*	*	*	*	*	*	*	*	E															
WP2	Implementation and test of SIMTAP																															*	*	*	*	*	
T2.1	Pilot tests																															*	*	*	*	*	
T2.2	Testing SIMTAP or its specific parts																															*	*	*	*	*	
T2.3	Assessing and optimizing the energy efficiency																															*	*	*	*	*	
WP3	Integration of SIMTAP in current hydroponic systems to enhance market transferability and sustainability																															*	*	*	*	*	
T3.1	Studying and testing the algae and feeders production cycles using brackish water…																															*	*	*	*	*	
T3.2	Evaluating the final run-off from the SIMTAP system																															*	*	*	*	*	
T3.3	Development of a decision support system aimed at defining the optimal location of SIMTAP systems…																															*	*	*	*	*	
WP4	Assessing the quality of the food end-products																																		*	*	
WP5	Economic and environmental sustainability assessment																																				
T5.1	Global multicriteria assessment approach																																				
T5.2	Identifying the economic performances																																				
T5.3	Identifying the environmental performances																																				
T5.4	Emergy accounting																																				
T5.5	Identifying the social performances																																				
WP6	SIMTAP recommendations and guidelines																																				
T6.1	Guidelines and best practices																																				
T6.2	User's manual for SIMTAP																																				
WP7	Communication, dissemination and exploitation																																				
T7.1	Communication activities																																				
T7.2	Dissemination activities																																				
T7.3	Exploitation planning and IPR management																																				

Table 2. Deliverables of the SIMTAP project with the new expected date for some deliverables.

Code	Title	Related WP	Delivery date (month)	New delivery date (month)	Deliverable type	Status (completed, delayed, in progress)
D0.01	Project management tool (regularly kept updated)	0	1		Tool	Completed
D0.02	Financial and administrative guidelines	0	2		Working Paper	Completed
D0.03	Quality Assurance Plan	0	3		Working Paper	Completed
D0.04	Project's reports (Periodic reports and Final Report)	0	18 and 36		Report	Completed (18 M)
D1.01	SIMTAP design	1	5		Plan design	Completed
D1.02	Review paper on integrated smart monitoring and control systems (ISMaCS) for agri-food productions	1	3		Report	Completed
D1.03	ISMaCS design	1	5		Plan design	Completed
D1.04	SIMTAP prototypes in Italy, France, Turkey and Malta	1	6	21	Prototype	Completed (F, IT, TR) Delayed (M)
D1.05	Report on halophyte plant species for SIMTAP production	1	7		Report	Completed
D1.06	Report on algae species for SIMTAP production	1	3		Report	Completed
D1.07	Report on polychaetes and shellfish in a hypothetical SIMTAP system	1	7		Report	Completed
D1.08	Building, calibration and test of ISMaCS	1	7	21	Report	Delayed
D1.09	Report on ISMaCS calibration and test: report on the ISMaCS functions and quantification of the reliability of the system	1	7	21	Report	Delayed
D2.01	Report on system starting and biofilter conditioning	2	10	18	Report	Completes
D2.02	Report on dietary inclusion levels of polychaetes and/or shellfish	2	18	24	Report	In progress
D2.03	Report and protocol on microalgae, polychaetes, shellfish and halophyte plant production and culture in SIMTAP system	2	28	31	Report	
D2.04	Report on growth performances and welfare of European sea bass, gilthead sea bream and mullet during early growth stages	2	20	32	Report	
D2.05	Report on water and mass balance modelling	2	26	33	Report	
D2.06	Report on growth performances and welfare of European sea bass, gilthead sea bream and mullet during fattening growth stages	2	30		Report	
D2.07	Report about the assessment of solutions tested in WP1	2	30		Report	
D3.1	Report on the use of brackish water and/or exhausted nutrient solutions to grow algae, and halophytes; obtained biomass productions	3	30		Report	
D3.2	Report on the polychaetes and deposit/filter feeders productions	3	30		Report	
D3.3	Report on the water run-off and the amount of brackish water for replacement. Report on the reduction of the run-off of the cascade system compared with a standard hydroponic system	3	30		Report	
D3.4	Geodatabase of multicriteria analysis results in the countries involved	3	30		Dataset	
D3.5	Decision support system developed in a GIS Environment	3	30		Software	
D4.01	Report on fish fillet quality and safety and nutritional values	4	33		Report	
D4.02	Report on nutritional value and quality of halophyte plants	4	33		Report	

Code	Title	Related WP	Delivery date (month)	New delivery date (month)	Deliverable type	Status (completed, delayed, in progress)
D5.01	General report on methodology and definition of Baseline Scenario	5	7		Report	Completed
D5.02	LCC template and survey design	5	7		Template	Completed
D5.03	LCI template	5	7		Template	Completed
D5.04	Emergy template (common with LCA)	5	7		Template	Completed
D5.05	Social assessment template	5	7		Template	Completed
D5.06	Internal report about the subsidy possibilities	5	26		Report	
D5.07	LCC inventory	5	26	30	Dataset	
D5.08	Progress report on energy efficiency	5	26	30	Report	
D5.09	LCI database	5	26	30	Dataset	
D5.10	Emergy inventory	5	26	30	Dataset	
D5.11	Social assessment database	5	26	30	Dataset	
D5.12	LCC results	5	30	34	Report	
D5.13	LCA results	5	30	34	Report	
D5.14	Emergy results	5	30	34	Report	
D5.15	Social assessment	5	30	34	Report	
D5.16	General report on multicriteria performances of SIMTAP in different contexts	5	36		Report	
D5.17	Report for energy efficiency	5	36		Report	
D5.18	Internal report on environmental assessment	5	36		Report	
D6.01	Review of the main technical, socio-economic and environmental findings	6	28		Report	
D6.02	Identification of best practices and guidelines	6	30		Manual	
D6.03	Multicriteria analysis results	6	32		Report	
D6.04	Internal report	6	32		Report	
D6.05	First draft of the User’s manual	6	34		Manual	
D6.06	User’s manual	6	36		Manual	
D6.07	Video of presentation of the project	6	36		Video	
D7.01	Press releases	7	2		News Item/Press	In progress
D7.02	Communication Plan	7	2		Working Paper	Completed
D7.03	Project website & Facebook, Twitter and LinkedIn accounts	7	2		Website	Completed
D7.04	Project’s corporate identity set, presentation, promotional material, etc.	7	3		Website	In progress
D7.05	Plan for the dissemination and exploitation of results	7	7	24	Working Paper	Delayed
D7.06	Electronic newsletters	7	7		Newsletter	In progress
D7.07	Exploitation agreement	7	12	24	Working Paper	
D7.08	Joint papers published	7	12		Journal Article	
D7.09	Project video	7	24		Video	
D7.10	2 workshop proceedings and 1 conference proceedings	7	36		Conference Proceedings	

Table 3. Milestone of the SIMTAP project with the new expected date for one of them..

Number	Milestone Name	Due date (month)	New due date	Related WP
M1	Kick-off meeting	M1		WP0
M2	SIMTAP design	M4		WP1
M3	SIMTAP prototype	M6		WP1
M4	Economic, Environmental, Emergy and Social templates	M6		WP5
M5	Multicriteria Assessment Workshop	M6		WP5
M6	End of experiments on dietary inclusion levels of polychaetes and/or shellfish	M10		WP2
M7	Growth performance and welfare tests during early stages of finfish	M18		WP2
M8	Economic, Environmental, Emergy and Social templates completed by the partners	M25	**M29**	WP5
M9	End of: i) calibration and verification of water and mass balance models; ii) experiments on microalgae, filter/deposit feeders and halophyte plant production and culture; iii) growth performances and welfare experiments during fattening phase of finfish; iv) assessment of the efficiency of the systems and quantification of the performances	M30		WP2
M10	DSS developed	M30		WP3
M11	Set up of the cultivation of algae using brackish water resulting from a hydroponic cultivation and set up of the management of the run-off	M30		WP3
M12	Economic, Environmental, Emergy and Social analysis results	M36		WP5
M13	Final version of the user’s manual	M36		WP6
M14	Final version of Best practices and guidelines	M36		WP6
M15	Final conference	M36		WP7

1.1 Objectives

Table 4. Work performed and results achieved for the projects objectives as described in section 1.1 of the proposal

Objective	WP	Key performance indicator (KP1)	Work performed and results
SO1 - Designing a SIMTAP system with integrated smart monitoring and control system (ISMaCS) The project aims at designing SIMTAP systems to be implemented in different contexts in Mediterranean areas. The technological specifications of every component of the systems will be identified and reported in a document.	1	Executive project documents and technical specifications	The designs of the four SIMTAP systems set up in France, Italy, Malta and Turkey the smart monitoring were completed in due time.
SO2 – Development of four SIMTAP prototypes in different geographic contexts Four prototypes will be built in different Mediterranean countries (Italy, Turkey, France, and Malta) with diversified environmental and salinity conditions. Various combinations of inputs will be considered in order to optimize biomass production based on local specific features, opportunities and constraints	2	Set-up of the prototypes	Three SIMTAP systems were set up in France (INRAE, LML), Turkey (MEDFRI) and Italy (UNIPI, UNIBO) and were used for experiments in 2020. The construction of the system in Malta (MAFA) is still in progress.
SO3 - Evaluation of effectiveness, efficiency and performance of SIMTAP systems. The prototypes will be evaluated in terms of biomass, food and feed production, and waste production in comparison with conventional aquaculture and hydroponic systems	2	Food and feed productivity of the prototypes in comparison with currently available aquaculture and hydroponic systems	Results on fish growth performance at early and fattening stage in SIMTAP system are already or will be soon available (INRAE, LML, MEDFRI, UNIPI). Results on growth performance at fish early stage together with halophyte plant, microalgae, polychaetes as well as nutrient mass balance estimation in the SIMPTA systems installed in several countries will be carried out in 2021.
SO4 - Development of Decision Support System (DSS) for SIMTAP implementation DSS aimed at defining the optimal locations of SIMTAP systems in the different contexts will be developed in GIS environment with a multi-criteria approach. Moreover, in order to conduct a sustainability assessment, aggregating the different indicators proposed by the different methods (LCA, LCC, Emergy), a qualitative approach based on decision trees will be carried out, applying a decision support system software stemmed from DEX methodology	3-5	GIS tool to assess SIMTAP location. DEXi tool	INRAE developed the Dexi methodology adapted to SIMTAP systems and built the tools for data collection and calculation of indicators, and the structure of the decision trees.

Objective	WP	Key performance indicator (KP1)	Work performed and results
SO5 – Quality assessment of food products The objective is to assess the physical and chemical quality of food produced within the SIMTAP systems.	4	Chemical parameters of food products	Quality of crop plants grown in the SIMTAP prototype installed in Italy was assessed in a series of experiment conducted in 2020 by UNIPI. MEDFRI's studies on quality of fish and crop produced in SIMTAP system will be completed following the production in next period of the project.
SO6 - LCA of SIMTA. Life Cycle Assessment (LCA) will be carried out in order to assess environmental impacts from each SIMTAP system. Different parameters will be determined per unit of food produced to describe the use of resources and the environmental impacts.	5	LCA parameters	A data collection tool was developed by INRAE to collect the useful data for life cycle inventory.
SO7 - Economic assessment of SIMTAP. Life Cycle Cost (LCC) will be carried out in order to assess the economic performances of each SIMTAP system under investigation. LCC analysis will provide a detailed account of the total costs of a SIMTAP system over its expected life. European subsidy framework will be also investigated.	5	Cost and investment analysis	INRAE and UNIMI developed a form to collect economic data about production factors and the capital goods and revenues SIMTAP systems. An Excel-based tool for the calculation of the economic performances of the different SIMTAP systems was developed by UNIMI.
SO8 - Emergy accounting of SIMTAP. Emergy accounting (EA) will be carried out in order to complete the environmental assessment of each studied SIMTAP system.	5	Emergy parameters and indicators.	A tool was developed by INRAE to collect the useful data for Emergy accounting adapted to SIMTAP systems.
SO 9 - Social assessment of SIMTAP. Social Life Cycle Assessment (SLCA) will be carried out in order to assess the social performances from each SIMTAP system under investigation. Social indicators will be determined such as working hours, creation of new jobs and working opportunities, involvement of local population, improved working conditions.	5	Social indicators	INRAE and UNIMI developed **a** form to collect data to assess social sustainability of SIMTAP systems.
SO10 - Context of circular economy. The project output will be disseminated among the scientific community, economic operators and other stakeholders. Specific recommendations, guidelines, best practices, and training activities will be designed and developed in order to boost the exploitation of SIMTAP systems in the Mediterranean areas with the aim to create technical skills and job opportunities, and update trading system.	6-7	Dissemination events, technical documents (recommendations, guidelines, handbooks), training platforms and activities	Main results: project website; YouTube video of SIMTAP system in France; scientific publications.

1.2.1 Work Package 0

Title: SIMTAP coordination and management

WP Leader: UNIPI **WP Participants:** ALL

Start month: 01 **End month:** 36

Objectives: WP0 aims to develop an effective and comprehensive administrative, financial, technical and quality management in order to ensure the success of the project.

Task 0.1 Technical coordination (M1-M36). Task leader: UNIPI. Partners involved: ALL

The project coordinator organized the activities principally through e-email and web-conferences.

In 2019 and 2020, the following meetings were held:

1. June 26-27, 2019: Kick-off meeting, Pisa (Italy)
2. March 3, 2020: web-meeting organized by INRAE: workshop on multicriteria assessment
3. June 20 and October, 2020: web-meeting organized by INRAE; workshops on sustainability assessment (II).
4. November 19, 2020: web-meeting of the General Assembly.
5. December 9, 2020: web-conference organized by UNIPI, midterm report.

The Coordinator registered an account for the B2DROP service, which is provided via EUDAT and co-funded by the European Commission. The cloud (https://b2drop.eudat.eu/s/SEMsYjEEZmA463w?path=%2F) contains: the proposal and related documents; agenda, minutes, presentations and other documents of project meeting; deliverables; milestones; official documents (e.g. Consortium Agreement); tools and data (e.g. DEXI tool).

Five external scientific experts and representatives of governmental and civil society organizations with expertise in the thematic domains of SIMTAP were appointed as members of the Advisory Board (AB). The role of the AB is to advise the GA and SC on research design, implementation and analysis, the formulation of policy recommendations, and dissemination activities. The composition of AB is the following: Marco Fiori; Biagio Dimauro; Emmanuelle Roque d'Orbcastel; Klaus Ernicke; Tufan Eroldogan. A short CV of each member is reported in **Table 5.**

Task 0.2 Financial and administrative management (M1-M36). Task leader: UNIPI. Partners involved: ALL

The Coordinator provided information (Del. D0.1) on scientific and financial reports.

Task 0.3 Quality assurance (M1-M36). Task leader: UNIPI. Partners involved: ALL

The measures to be adopted within SIMTAP project to ensure quality of work and management are reported in the quality assurance plant (Del. D0.3).

Table 5. Members of the Advisory Board of SIMTAP.

Name and email address	Short CV
Marco Fiori [marco.fiori@coopitalia.coop.it]	Dr. Marco Fiori graduated in Law at the University of Bologna; buyer or manager of food sector at Lidl Italia, Salzam Emmezeta Group, Sma Gruppo Rinascente and then (since 2002) at Coop Italia (Bologna), since 2017 for the fish sector.
Biagio Dimauro [biagio.dimauro@regione.sicilia.it]	Dr. Biagio Dimauro, graduated in Agricultural Sciences, Regional Government of Sicily, Agriculture Division, expert on greenhouse horticulture and research project management. He was involved in the dissemination of FP/-EU Projects. He knows very well the greenhouse industry in Sicily, which is located in coastal areas (e.g. Vittoria, Pachino, Marsala) and increasingly uses hydroponic technology.
Emmanuelle Roque d'Orbcastel [emmanuelle.roque@ifremer.fr]	Dr. Emmanuelle Roque d'Orbcastel, Institut français de recherche pour l'exploitation de la mer (IFREMER), scientist, specialist in aquaculture, marine ecology and IMTA systems. https://annuaire.ifremer.fr/cv/17532/
Dr. Klaus Ernicke [klaus.ernicke@ernicke.com]	Klaus Ernicke, patent attorney in Augsburg (https://ernicke.com/en/) with intense experience on the protection of intellectual property and international patent applications.
Prof. Tufan Eroldogan [teroldogan@gmail.com, mtufan@cu.edu.tr]	Prof. Tufan Eroldogan, the University of Cukurova, Turkey. Master's degree in Aquaculture and Nutrition and PhD in Fish Nutrition, both from the University of Cukurova, Turkey. Postdoc studies at: Department of Aquaculture, The Volcani Center, Israel; Research Council of Norway; Department of Physiology Barcelona University. Research interests: fish nutrition, metabolism of lipids, fatty acid and omega-3, fish oil replacement and fatty acid metabolism in cultured aquatic species, fatty acid-micronutrients interactions, seafood quality. Experience in the field of nutrigenomic and proteomic. He was/is involved in many national and international research programs and has more than 70 publications.

1.2.1 Work Package 1

Title: Ecosystem based approach for SIMTAP

WP Leader: UNIPI **WP Participants:** ALL

Start month: 01 **End month: 06** (the end of this WP was postponed to M21)

Objectives: WP1 aims to: i) to design and build the SIMTAP prototypes and their monitoring and control systems in France, Italy, Malta and Turkey according to local constraints and the mutual interaction of each unit (aquaculture, hydroponic, photobioreactors for algae, filter/feeder modules etc.); ii) to identify on the basis of available literature and project partners' experience: the most suitable**.** hydroponic systems; the most suitable species of crop plant, algae, fish, polychaetes and other detritivore and filter feeder organisms (DFFO) for the SIMTAP system; the level of inclusion of DFFO, in place of fishmeal and fish oil, in the diet of fish reared in the SIMTAP systems.

Task 1.1 Piloting activity: Designing, building and first start of SIMTAP prototypes or specific sections of it, for their use under different Mediterranean climatic conditions, starting from the concept of the Patent Gebrauchsmusterschrift DE 20 2014 103 397 U1 2015.12.03 (M1-M6). Task leader: UNIPI /Partners involved: INRA, LML, MEDFRI, MESDC.

Three SIMTAP systems were built in France, Italy and Turkey. A sketch of the three systems is shown in Figs. **1-3** while a detailed description is reported in Del. 1.4. The MAFA SIMTAP system is under construction; it will be located in a greenhouse at the Agriculture and Innovation Research Hub, in Marsa. An experimental facility with recirculating seawater was also built in the spring 2020 at the University of Pisa for laboratory-scale experiments with DDFO.

Task 1.2 Theoretical study of the most suitable plants (edible and nutraceutical/pharmaceutical), algae, and live organisms to be integrated in the SIMTAP system (M1-M6) Task leader: UNIPI /Partners involved: INRA, MEDFRI.

Algae: Green microalgae and macroalgae (seaweeds), which will be cultured, respectively, in photobioreactors and plastic tanks in the SIMTAP prototype installed in Italy, were identified on the basis of on current literature and locally available organisms. Microalgae will be grown for feeding polichaetes while macroalgae will be grown to remove inorganic nitrogen from the effluents of the aquaculture sector. Many microalgal strains are appropriate for polychaetes feeding, e.e. *Dunaliella* sp., *Isochrysis* sp. *Chlorella vulgaris*, *Chlorella sorochiniana*, *Nannochloropsis oculata* and *Tetraselmis chuii*. Selected seaweed species were *Ulva rigida* C. Ag. and *Chetomorpha linum* (Müller) Kützingas. These species can be easily collected along the coast nearby Pisa, in particular in the shallow lagoon in Orbetello, where effluents from land-based aquaculture farms are discharged.

Plants

DEXi multi-criteria analysis was adopted by UNIPI for the selection of the most suitable plant species for the SIMTAP system. In the first instance, a survey was carried out with different researchers with expertise in the field to select the most important criteria for the evaluation. One simple tree structure which contained one root criterion ('Plant species selection'), four aggregated criteria, and four sub-criteria was created as a result of the survey. The weights assigned to the aggregated criteria, sub-criteria, and indicators were selected by a panel of experts considering the objectives of the SIMTAP project. Afterwards, an extensive literature analysis was conducted to identify the potential species and their features for the evaluation. Provided that suitable fish species for the SIMTAP system are euryhaline and can grow properly in a wide range of salinity, the same model was evaluated under two different scenarios (i.e. two different salinity levels): 10 and 35 g/L. Finally, the relevance of the model structure was evaluated by the sensitivity analysis, through the 'plus/minus-1' analysis. Fifteen salt-tolerant plant species were considered for the analysis. *S. europaea* L. and *P. oleracea* L. were selected as the most suitable crops for the SIMTAP system with high water salinity while at lower salinity level the best candidate species were five: *S. bigelovii Torr*, *S. europaea L*., *B. vulgaris* ssp. *Maritima* (L.) *Arcang*, *A. hortensis L*., and *P. oleracea L*. A manuscript to be submitted to an international journal is in progress.

Fish

In Integrated Multi-Trophic Aquaculture (IMTA), some organisms (fish, f.i.) generate produce wastes (uneaten feed, faeces etc.) that the extractive organisms convert into fertilizers, food and energy. Similarly, SIMTAP is a multi-trophic system where extractive species are crop plants (salt-tolerant glycophytes or halophytes), while in a marine IMTA shellfish and macroalgae are commonly used. The peculiar rearing environment of the SIMTAP systems drastically influences the generative and extractive species exploitable: the use of saline water (seawater or brackish water), the high stocking densities in fish section and reduced water renewal, and the possible interactions within different trophic levels. Thus, the biological characteristics of fish and other species to be cultured in SIMTAP systems should be assessed taking into account their complementarity and adaptability to the physical and technical traits of the considered system.

The study performed by UNIPI in 2020 aimed to identify the most suitable marine organisms for food production in the SIMTAP system under the typical environmental and market conditions of the Mediterranean area, through the creation of a decision model using DEXi software (DEXi_SIMTAP_Fish_1.0). A panel of experts of the University of Pisa, representatives of the main scientific sectors involved in the SIMTAP project (engineering, aquaculture, aquaponics, hydroponics, marine biology and animal nutrition) was selected in order to define and implement the decision model. Firstly, a comprehensive analysis of the available literature was carried out on fish species considered as relevant for the Italian SIMTAP production, the species selected were: Sturgeon (*Acipenser* spp), Meagre (*Argyrosomus regius*), European Sea Bass (*Dicentrarchus labrax*), Sharpsnut Sea Bream (*Diplodus puntazzo*), Mullet (*Mugil cephalus*), Common Octopus (*Octopus vulgaris*), Turbot (*Psetta maxima*), Greater Amberjack (*Seriola dumerili*), Sole (*Solea spp*), Gilthead Sea Bream (*Sparus aurata*), Shi Drum (*Umbrina cirrosa*). All these species can be found in the Mediterranean Sea. Based on collected data, the experts performed the SWOT analysis for identifying the most relevant species-related attributes to be considered in the decision process.

European Sea Bass and Gilthead Sea Bream were scored as "excellent" and appeared the most suitable fish species for the SIMTAP system.

This study is reported in the following publication: Rossi et al. (2021). *Selection of marine fish for Integrated Multi-Trophic Aquaponic production in the Mediterranean area, using DEXi multi-criteria analysis as innovative approach.* Aquaculture, 2021, 736402.

Detritivore and filter feeding organisms (DFFO)

A thorough literature survey was done by UNIPI to select the most appropriate DFFOs to be incorporated in the SIMTAP system. Main emphasis was given to locally available species to minimize the risk associated with introduced species. Three groups of DFFO were selected *viz*.: Polychaetes, Bivalves and Holothurians.

Several families of polychaetes (mostly in the families *Arenicolidae*, *Eunicidae*, *Glyceridae, Lumbrineridae, Nephtyidae*, and mainly *Nereididae*), are gaining popularity very rapidly owing to its commercial importance. Among the polychaete families, we focused on the *Nerididae* family and, especially on *Hediste diversicolor*, owing to its many advantages it has over other species, especially with respect to *Nereis virens*. *H. diversicolor* is a geographically widely distributed inhabitant of the intertidal zone of marine and brackish waters; it can be found as far north as Scandinavia and as far south as Morocco, in the cold and brackish Baltic Sea as well as in the hot and hypersaline lagoons of the Black Sea. It is known to tolerate a wide range of salinity down to 2-3‰ (euryhaline), whilst, *N. virens* is rarely found below 15‰ salinity (Jørgensen and Dales, 1957). However, the most conspicuous feature of *H. diversicolor* is the unique ability to obtain nourishment as a facultative filter-feeder (Riisgård 1991, Riisgård et al. 1992; Vedel and Riisgård 1993; Vedel et al.1994). In fact, *H. diversicolor* utilizes a variety of feeding strategies: i) as filter feeder feeding on diatoms and other micro-organisms (Harley 1950; 1953); ii) as deposit feeder feeding on sediments and particulate organic matters (Reise 1979; Cram and Evans, 1980); iii) as a scavenger feeding on the dead decayed matter (Olafsson and Parsson, 1986; Heip and Herman, 1979); iv) predator feeding on small meiobenthic organisms (Reise 1979; Witte and Wilde, 1979; Ratcliffe et al. 1981; Rönn et al. 1988). Moreover, on the reproductive front, *H. diversicolor* is typically atoquous *i.e.* the change of body form preliminarily to spawning resulting to a free-swimming epitoquous or 'heteronereid' form is absent (Dales 1950). Another important factor considering the breeding and production of Nereids is the sediment type, which provides shelter and act as breeding ground for these worms. *H. diversicolor* is known to tolerate in a wide range of sediment type and it was demonstrated that the size range of sediment tested (medium: 0.5-0.25mm and fine: 0.25-0.125mm) did not affect the growth of this species (Fidalgo e Costa 1999).

From amongst the available study on Bivalves, we selected *Mytilus galloprovincialis* and *Ruditapes philippinarium*. *M. galloprovincialis* is a native species of the Mediterranean coast and the Black and Adriatic Seas, though it considered as an invasive species outside its geographical range. Better growth, higher survival rate and faster metamorphosis were observed in *M. galloprovincialis* larvae cultured at 20°C or 24°C (Sánchez-Lazo and Martínez-Pita 2012) and a salinity within the range of 27 – 40 g/L. *R. philippinarum* is euryhaline; the spats are able to tolerate a wide range of salinity ranging from 14 – 33.5 g/L, with 20.5 g/L as the optimum (Lin et al. 1983).

Sea cucumbers are considered important processors of surface sediments in many coastal marine systems, as they play an important role in sustaining the health of marine ecosystems (Purcell 2010). Apart from nutrients redistribution, sea cucumbers also play an active role for ocean acidification buffering, due to ingestion and release of faecal matter and by their locomotion across the sea bed. Some species can facilitate calcification by organisms, such as corals, by increasing water alkalinity and dissolved inorganic carbon through their digestive processes and release of ammonia. Selected sea cucumber species were *Holothuria tubulosa* and *H. polii*. They are among the most common sea cucumbers species found in the Mediterranean Sea (Tortonese 1965).

Task 1.3 Theoretical study of the dietary inclusion levels of polychaetes and of other deposit/filter feeders, in place of fishmeal and fish oil, in diets of European sea bass and sea bream, mullets, etc. (M1-M6). Task leader. UNIPI/Partners involved: INRA, MEDFRI, MESDC.

Fishmeal (FM) and fish oil (FO) represent two of the main ingredients of marine fish feed owing to their optimal nutritional characteristics, in particular: high digestibility; high content of both proteins (62-72 % as-fed) and lipids (7.6-10.2 % as-fed in FM); complete aminoacidic spectrum and optimal fatty acids composition (NRC, 2011). However, these two ingredients represent also an important bottleneck to the development of sustainable aquaculture systems (Naylor et al., 2009, 2000). In the SIMTAP system, DFFOs play a pivotal role in keeping the quality of water and as partial substitute of FM and FO in fish feed. Any novel feed ingredient must be carefully evaluated regarding the gross biochemical composition, aminoacidic, and fatty acid profiles before its inclusion in fish diet, in order to allow optimal fish grown and development. For this evaluation, we considered the nutritional requirements of marine fish species selected in the Task 1.2: *Sparus aurata*, *Dicentrarchus labrax*, *Mugil cephalus*, *Diplodus puntazzo*, *Seriola dumerili*, *Umbrina cirrosa*, *Argyrosomus regius* and *Psetta maxima*. Then, a detailed review of the gross biochemical composition, aminoacidic and fatty acid profiles of some DFFO was carried out. The choice of DFFO included in this study is based on the results of the literature survey on polychaetes and shellfish (see Del. D1.07) and some experiments conducted at the University of Pisa (Task 2.1): *H. diversicolor*, *M. galloprovincialis*, *R. philippinairum*, and some Holothurians. Feed composition in terms of ingredients and biochemical composition was also reviewed. We focused on the gross biochemical composition, the amino acidic profile and the fatty acid profile. The results of this study are reported in the report entitled “Review on nutritional requirements of marine fish and biochemical composition of DFFOs for SIMTAP systems”. In order to determine the theoretical substitution rate of FM and FO in the diet of selected species at different growth stages, an electronic sheet (Excel, Microsoft) for feed formulation was built (see attachments). The database for this software is the open access International Aquaculture Feed Formulation Database (IAFFD, https://www.iaffd.com/).

Task 1.4 Designing, building and trying out an integrated smart monitoring and control system conceived specifically for SIMTAP systems, allowing the partners to have a remote access for data monitoring and download, and system control (M1-M6) Task leader: UNIBO/Partner involved: UNIPI.

The process of ISMaCS design included two main activities: study of the specific needs and requirements of the experimental sites and study and research on sensors and monitoring systems.

The first activity was carried out in continuous contact with the partners involved in the on-site experiments and has taken into consideration their feedback to iteratively revise and fine-tune the design of the system. The following issues have been taken into consideration: i) the specific characteristics of the experimental sites; ii) the planned activities; iii) the planned research and expected results. The second activity focused on the identification of the most suitable sensor systems and on the design and definition of the most effective, efficient and cost-effective solutions, specifically designed and built for the SIMTAP project. Since the market did not offer any commercial solution that meet the project requirements, the ISMaCS was designed, engineered and built as a system capable of measuring the main environmental outdoor and indoor data, DO, pH, EC, irradiance and other quantities, and to remotely send the acquired data in real time.

A prototype was built and, during the SIMTAP construction, installed in the UNIPI SIMTAP system for first tests and calibration. To run the tests, specific informatic codes were developed to remotely and automatically manage and process the data. The codes were then implemented in a routine procedure installed in the UNIBO servers. The codes were designed to be the base for the data analyses for the energy efficient assessments. At the same time, the management of data has been developed both in an UNIBO and a cloud server to allow all the partners involved in the project to remotely monitor the data in real time and to have a data backup for the project.

1.2.2 Work Package 2

Title: Implementation and test of SIMTAP

WP Leader: MEDFRI **WP Participants:** UNIPI; UNIBO; INRA UMR SAS; LML; MESDC

Start month: M7 **End month:** M30 (the end of this WP was postponed to M35)

Objectives: This WP aims to test and run SIMTAP systems installed in different environmental conditions. Other objectives are: i) to investigate diverse dietary inclusion levels of microalgae and deposit/filter feeders in diets for selected fish species; ii) to test growth performance of microalgae, deposit/filter feeders, finfish and halophyte plant species within the SIMTAP systems.

Task 2.1: Pilot Tests. Months (from 7 to 35). Task leader: MEDFRI **Participants:** UNIPI; INRA UMR SAS; LML; MAFA

2.1.1. Studies on system start-up and bioreactor conditioning in Turkey

SIMTAP prototype start up in Turkey was made on 1 June 2020 following preliminary tests during late May. A detailed description of the prototype is given in Del. 1.4. Because establishment of a nitrifying biofilm under saline conditions takes a relatively long period, ammonia chloride was added into recirculating water at various times to fasten bacteria growth and a commercial mixture of selected bacterial cultures was inoculated on 5 July 2020 according to the manufacturer's instruction. The results indicated a clear decrease in ammonia concentrations and a subsequent clear increase in nitrite concentrations following inoculation ammonia oxidizing bacteria over a period of one month under high temperature and salinity conditions. The complete acclimatization of nitrifying bacteria nearly took three months in the SIMTAP system. The study is reported in details in the Del. 2.1 (Report on system starting and biofilter conditioning).

2.1.2. Studies on the feasibility of growing gilthead seabream (*Sparus aurata*) juveniles using vegetable feed, supplemented with fresh mussel in France:

INRAE-LML tested the feasibility of growing gilthead seabream (*Sparus aurata*) juveniles using vegetable feed, (formulated without fishmeal and fish oil, and only composed of local vegetal raw materials) supplemented with fresh mussel (to balance the needs in micronutrient and fatty acids).

Three treatments were conducted. In the control treatment (C), the formulated feed delivered was a commercial feed, specific to marine fish at this stage of development (including marine ingredients). In the second treatment, "vegetal" (V), an experimental formulated feed was delivered and composed only of raw materials from plants, having the same chemical composition than the Control one in terms of total protein, total lipids and total digestible energy. In the last treatment, "mussel" (V+M), feed delivered was the same formulated feed than in the V treatment, supplemented with fresh flesh of mussel (shells were removed), on the basis of 1/6 of the energy supply of the feed intake. The quantity of mussels delivered was standardized according to the crude energy in mussel and in the feed from V. The fish were reared in a recirculating aquaculture system composed of three similar rearing tanks, corresponding each to one treatment. At the beginning of the experiment, 342 fish were stocked at a mean weight of 6.8 g, in each treatment. The fish were reared for 46 days.

The results suggested that seabream can be grown using feed formulated only with local vegetal raw materials and supplemented with fresh mussels, while keeping performances of growth and feed efficiency, like that of fish fed with usual feed (with fishmeal and fish oil).

2.1.3. Studies on microalgae culture in SIMTAP system by UNIPI in Italy

Microalgae are unicellular organisms that can be found both in marine and freshwater environments. In the SIMTAP system, the role of microalgae is twofold: i) they constitute feed rich in fatty acids, especially in omega-3, for the diet of DFFO, which in turn are used as feed for fish; ii) they perform wastewater phytoremediation (in particular as regards nitrogen and phosphorus) of the recirculating water in the aquaponic system or external wastewater (e.g. greenhouse runoff water) used to reintegrate the water losses due to the evapotranspiration.

In 2020, three experiments were performed on a laboratory scale and in sterile conditions using glass flasks placed in a growth chamber. Five marine algae strains were cultured in exp. 1: *Nannochloropsis* sp., *Dunaliella* sp, *Rhodomona*s sp, *Isochrysis* sp, *Tetraselmis* sp. *Nannochloropsis* sp. strain was provided by the Maricoltura di Rosignano Solvay (Livorno) company, while the other strains were donated by the Interuniversity Center of Marine Biology (CIBM) of Livorno. All marine strains had been grown in a specific growth medium (F medium) containing 65% of natural seawater (collected on the coast nearby Pisa) in distilled water (Guillard and Ryther, 1962). Therefore, in exp. 1 each strain was cultured in an F medium that was prepared adding 35 g/L of the synthetic sea salt Instant Ocean™ (IO) to distilled water. A second experiment was conducted using F medium containing natural sea water or two different artificial sea waters, which were prepared using IO or another synthetic sea salt (Red Sea Salt™). In both experiments, algae growth was monitored by determining the optical density (OD, i.e. the absorbance at 530) and the content of dry biomass, chlorophylls and carotenoids in the growth medium.

The two experiments revealed, unexpectedly, the toxicity of IO for all the algae strains tested, although *Dunaliella* sp. was slightly more tolerant to IO than the other strains. The reason of the toxicity of IO is not clear and a specific study will be carried out in 2021, also to evaluate the need to replace IO with RSS in laboratory cultures and in the photobioreactors of the SIMTAP system.

The third experiment with freshwater microalgae was carried out both in the laboratory (in the same conditions adopted for exps. 1-2) and in the SIMTAP photobioreactors under greenhouse. The freshwater algae were two strains of *Chlorella* sp. (SEC_LI_ChL_1) and C. *sorokiniana*, which belong to the algae collection of UNIPI, and *Chlorogonium* sp., which was kindly provided by the Department of Biology. SEC_LI_ChL_1 strain was isolated a few years ago from a pond in which the leachate of a municipal landfill flowed before the remediation treatment. *C. sorokiniana* strain was collected in 2019 at the mouth of the Barra Channel, which flows into Lake Massaciuccoli (Pisa). All strains were cultivated in a modified TAP medium (Andersen, 2005).

The experiment in photobioreactors was conducted in the period September-December 2020. The growth medium was prepared with commercial water-soluble fertilizers dissolved in drinking water. The growth of the SEC_LI_ChL_1 strain was reduced in the photobioreactors as compared to the laboratory culture, probably due to the different climatic conditions, in particular due to the lower irradiance in the greenhouse with respect to the laboratory.

In 2020, the strain of *Chlorella* SEC_LI_ChL_1 was also characterized. The molecular characterization was combined with observations under both optical and electron microscope (TEM) and with the determinations of some metabolic traits of algae cultures conducted under conditions of full (PPFD = 120 μmol/m^2.s) or reduced (PPFD = 60 μmol/m^2.s) autotrophy, heterotrophy and mixotrophy. The phylogenetic analysis revealed different placements within the *Chlorella-Micractinium* clade. In addition to some morphological-ultrastructural and metabolic features shared with other microalgae of the genus *Chlorella*, two peculiar characteristics were observed: the association with intracellular bacteria, never described before in these microalgae, and the presence of bicellular aggregates (also called 'doublets') not caused by cell division. This research is reported in a manuscript accepted by the international journal Algal Research.

2.1.4. Studies on crop production in SIMTAP system by UNIPI in Italy

Three experiments were conducted between October 2019 and August 2020 with different plant species, which were propagated by seed and grown in a closed-loop hydroponic system with a stagnant nutrient solution (floating system). To simulate the use of sea water, different amounts of IO were added to the control nutrient solution (total concentration of nutritive salts was about 2.6 g L-1). The IO concentrations tested in these experiments were as follows: 0 (IO-0), 10 (IO-10), 20 (IO-20) and 30 (IO-30) g/L. The species studied were: *Portulaca oleracea* L. (purslane); *Beta vulgaris* var. *cicla* (Swiss chard); *Beta vulgaris* subsp. *maritima* (sea beet); *Salicornia europaea* L. (glasswort). The first three species are glycophytes (like the vast majority of crop plants) with a high tolerance to salinity, while glasswort is an obligate halophyte (or eualophyte).

In exp. 1, which was conducted in autumn-winter season, crop yield decreased with increasing salinity in purslane and Swiss chard. While purslane did not tolerate salinities above 10 g/L, yield was around 2 kg/m^2 in Swiss chard at the highest salinities tested against against about 2 kg/m^2 in the control. Glasswort plants grew more in the grown in IC-enriched nutrient solutions than in the control; crop yield ranged between 7.2 and 11.2 kg/m^2 in saline cultures against 2.5 kg/m^2 in the control. In exp. 2, Swiss chard and sea beet were cultivated using nutrient solution containing 0 or 10 g/L IO with similar results to those found in exp. 1.

In exp. 3, different nutrient solutions were compared with different salinities (0, 10 and 35 g/L of IO or NaCl) and nitrate concentration (1 and 10 mM, corresponding to approximately 14 and 140 mg/L of N). The low N concentration was selected to simulate the limited nitrate supply that differentiated aquaponics and hydroponics; in the latter system, N concentration typically ranges from 5 to 15 mM. Low N concentration reduced significantly plant growth only in the two *Beta* species; in sea beet, however, this reduction was not observed in plants grown in salinized nutrient solution. The growth of glasswort was significantly greater when the high salinity was obtained using IO instead of NaCl. Daily uptake of nitrogen depended on plant species and salinity level, and ranged between 0.19 and 0.89 g/m^2 per day.

Based on the results of these experiments, it can be concluded that *S. europaea* is the crop plant that best adapts to the typical conditions of marine aquaponics. Glasswort is very interesting from a commercial point of view, as it already has an important market in some countries (France, Israel, Spain) and is increasingly present also in Italy as fresh vegetables**.** at prices as high as 9-10 €/kg. The consumption of glasswort is also promoted by gourmet cuisine and by its nutraceutical properties, although its consumption presents risks related to the high sodium content (it is also used as a substitute for table salt), oxalates and nitrates.

2.1.5. Studies on polychaete breeding and nutrition by UNIPI in Italy

In the SIMTAP system, the addition of DFFO capable of extracting the organic particulate matter as well as potential pathogenic microorganisms from the recirculating water can improve the quality of the aquatic environment and reduce the risk of disease outbreaks. Moreover, the inclusion of unicellular algae as feed for DFFO will augment the nutritional composition of these lower trophic organisms, which when fed by fish will led to the biomagnification of the polyunsaturated fatty acids (PUFAs). This will reduce the operation costs of SIMTAP system resulting from lower costs for water treatment and feed. In this context, a multifaceted research work was conducted in 2020 on the polychaeta *H. diversicolor* using juvenile worms obtained from laboratory cultures or both juvenile and adult worms collected in the wild.

The results of these experiments will be reported in **D3.02**.

2.1.6. Studies on evaluation of nutritional value of polychaete meal for European sea bass (*Dicentrarachus labrax*) and gilthead sea bream (*Sparus aurata*) in Turkey.

Since polychaete fed with fish wastes generated in the integrated system will be used for feeding fish again, its nutrition composition and nutritional value should be studied beforehand. For this reason, two experiments were planned in European sea bass and gilthead sea bream. Feed ingredients were obtained from the local market and their compositions were determined. Polychaete material was obtained from the Aegean Sea at different times as frozen or alive. Material arrived as frozen was dried in a freeze dryer whereas those arrived alive was dried in an oven at 65°C for one day. Following drying process, the two forms of polychaete meal (PM) were combined at ratio about 1:1 and included into the experimental diets.

European sea bass: PM was incorporated at 0%, 5, 10, 15 and 20 at the expense of fish meal and fish oil. The diets were formulated to be isoproteic (48%) and isolipidic (14%). The ingredients were thoroughly mixed and then deionized water was added until dough like consistency. The mixtures were extruded using a meat chopper at 2 mm diameter. The resulting pellets were broken into small pieces, dried at 65°C and stored in airtight bags until used.

Gilthead sea bream: PM inclusion levels are the same with sea bass diets. The diets were formulated to contain 48% protein and 12% lipid. Diet processing is also the same above.

Fish material used in the experiments were procured from a private farm. They were randomly allocated to 400 L-tanks and adapted to experimental conditions for 4 weeks. At the start of the experiments (05 November 2020), 10 fish with homogenous size were remained in the tanks. Initial average weights of sea bass and sea bream were 14.56±0.01 and 20.03±0.02 g respectively. Each experimental diet was tested triplicated tanks. Fish were fed until apparent satiation twice a day. Growth performance was monitored with biweekly weightings. The experiment lasted 6 weeks.

The results of these experiments will be reported in **D2.04**.

2.1.7. Studies on growth performance of gilthead sea bream (*Sparus aurata*) in relation to different replacement rates of commercial feed with mussels by UNIPI in Italy.

In order to reduce the use of commercial feed whose ingredients are frequently imported from all over the globe, the use of mussels reared "*in loco*" within the SIMTAP system may represent an interesting alternative. This is particularly true for carnivorous fish species such as Gilthead Seabream (*Sparus aurata*) and European Seabass (*Dicentrarchus labrax*). For this reason, an experiment was conducted in 2020 to investigate the fish growth performances in relation to different replacement rates of commercial feed with mussels.

To this purpose, 1243 Gilthead seabream (BW 4.9±1.1 g) were randomly allocated in six different tanks (420 L capacity each) and fed as follow (Feed/Mussels, dry weight ratio): 100/0% (control), 80/20%, 60/40%, 40/60%, 20/80% and 0/100%. The pellet diameter of the commercial feeds used (Optima, INVE Aquaculture, Belgium) were <1.2 mm until day 21, then 2 mm until the end of the trial. Frozen mussels (Chilean mussel, *Mytilus chilensis* o *Mytilus platensis*) were kindly donated by ARBI Company (Monsummano, Pistoia, Italy). Commercial feed was kindly provided by

INVE, Aquaculture Rosignano, Rosignano Solvay, Livorno, Italy), which also provided fish juveniles. Fish were fed three times per day (08:00 a.m., 10:30 a.m., and 01:00 p.m.); the feed was directly supplied while the frozen mussels were thawed, then minced with a mixer until reaching a 1-4 mm particle size and delivered to the fish tanks. Feed and mussel dry matter (DM) was 95% and 20%, respectively. Based on DM content, the daily feeding rate was 3% of the fish biomass throughout the experimental period and the total amount supplied every day was adjusted weekly according to the fish growth. Body weight (BW) and total length were measured in all fish individuals at the beginning and the end of the experiment. Moreover, BW and total length were weekly measured on 25 fish of each treatment. Weekly and cumulated Feed Conversion Rate (FCR) was calculated as follow:

$$FCR = \ diet\ supplied\ (g\ DW)/BW\ increase\ (g, wet\ weight)$$

Growth performances of the groups were compared taking into account the differences between groups in initial body weight; thus, the data were elaborated reducing the BW of each fish by the general mean of initial BW and then adding the group BW mean.

The results of these experiments will be reported in **D2.04**.

Task 2.2: Testing SIMTAP or its specific parts. Months (from 11 to 35). Task leader: MEDFRI Participants: UNIPI; INRA UMR SAS; LML; MAFA

2.2.1. Studies on fish growth performances at fattening stage in SIMTAP system in France: The French SIMTAP system (INRAE-LML) was tested from 9th June to 7th October 2020 in the facilities of LML. The system was developed with the aim to maximise the use of nutrients contained in the formulated feed delivered to seabream (*Sparus aurata*) in associating different species of different trophic levels. To limit environmental impacts related to the use of fishmeal and fish oil in the usual formulated feed, only local vegetal raw materials composed the formulated feed. In addition, fresh mussels, discarded from the market because of out of calibration, were supplied to balance micronutrient and fatty acids needs of fish, at a rate of 1/6 on the basis of the energy content of the formulated feed. The system was composed of 4 ponds, connected in cascade, to circulate the water by gravity, according to the following order:

- pond 7: 1387 seabreams were stocked at a mean weight of 210 g;
- pond 6: 700 oysters (*Crassostrea gigas*) and 875 shrimps (*Penaeus japonicus*) were stocked at a mean weight of 47.5 g and 0.52 g, respectively.
- pond 5: 1020 oysters and 1275 shrimps were stocked at a mean weight of 47.5 g and 0.52 g, respectively;
- pond 4: 11765 clams (*Ruditapes decussatus*) and 1400 shrimps were stocked at a mean weight of 3.4 g and 0.52 g, respectively.

From the pond 4, water was sent back to the pond 7 thanks to a pump. Initially, the pond 2 was supposed to receive the discharge water from the system during renewal of water. The nutrients contained in the discharge water should have been used for macro-algae growth (*Ulva*). In fact, since salinity remained at an appropriate level in the system, water was added from the inlet conduct (connected to the open sea) only to compensate evapotranspiration, avoiding discharge water toward the pond 2 and the surrounding environment. Therefore, this pond was considered more as a control pond (as well as the inlet channel).

During the experiment, fish growth was checked by sampling fish three times, the shrimp growth was checked once, and the bivalves were not controlled before the end. The water quality was recorded each week to control temperature, oxygen, pH, turbidity and salinity. These data were also collected punctually to check the quality of water in the fishpond when the temperature increased. Once a month, water was sampled in each pond to check the concentration in phytoplankton and nitrogen and phosphorus compounds. In addition, 24-h water sampling campaigns were conducted on two occasions to check the daily evolution of the parameters.

Good results were obtained for fish growth and feed conversion ratio, despite the lack of fish meal and fish oil in the feed. Without additional specific source of nutrients in the system, except than the feed supplied to the sea bream, the body growth of the other organisms reared were similar and even better (more specifically the filling ratio and survival rate of the molluscs) compared to their usual monoculture in ponds (based on expert experience). Since water was added in the system only to compensate evaporation and no water was discharged during the study, it resulted in the save of water and in the preservation of the surrounding environment.

Task 2.3: Assessing and optimizing the energy efficiency. Months (from 9 to 35). Task Leader: UNIBO **Participants:** UNIPI; INRA UMR SAS; LML; MAFA; MEDFRI

Due to the COVID restrictions – related in particular to delays in material deliveries and travel limitations – the Task 2.3 has experienced a remarkable delay. However, a few activities could have been carried out despite the restrictions. The work completed in the WP1, in particular the SIMTAP installations, the ISMaCS tests and the server availability, allowed to create informatics routines and codes to handle the collected data. Moreover, an analysis of the scientific literature allowed to identify possible methods to apply for an accurate data analysis.

Currently, UNIBO is assembling the ISMaCS and organizing their implementation on the experimental installations according to the pandemic restrictions and is testing and evaluating possible methodologies to be applied for the energy efficiency assessment.

1.2.4 Work Package 3

Title: Integration of SIMTAP in current hydroponic systems to enhance market transferability and sustainability.

WP Leader: UNIBO **WP Participants:** UNIBO, UNIPI, MAFA

Start month: 25 **End month: 30** (the end of this WP was postponed to M35)

The activities of WP3 will start in the next few months.

1.2.5 Work Package 4

Title: Assessing the quality of the food end-products

WP Leader: UNIPI **WP Participants: MEDFRI, LML, MESDC**

Start month: 16 **End month:** 33

The activities of WP3 will start in the next few months.

1.2.6 Work Package 5

Title: Economic, environmental and social sustainability assessment
WP Leader: INRAE **WP Participants:** ALL

Start month: M1 End month: M36

Objectives: The general objective of WP5 is to build an overall assessment of sustainability of the SIMTAP systems compared to standard systems. The methodology is based on Life Cycle Assessment (LCA) for environmental goals, Emergy accounting (EA) for energetic and sustainable goals, Life Cycle Costing (LCC) for economic goals, and Social LCA (SLCA) for social goals. In order to build an overview of the sustainability, these indicators as well as additional indicators of system efficiency are organized in a qualitative decision tree permitting to aggregate the indicators into principles of sustainability, using a participatory method (DEXI method). The responsibility of LCA, EA, and DEXI methods was carried out by INRAE and the responsibility of the LCC and SLCA was carried out by UNIMI. The both teams worked closely together on the different tasks, and involved all SIMTAP partners in the participatory process.

The operational objectives are: i) to implement tools such as economic models (e.g. LCC) and logic framework project planning concept that can assist farmers to improve their management and secure a sustainable income; ii) To identify the environmental performances of the whole integrated cycle respect to aquaculture + hydroponic and the main hotspots (processes mainly responsible of this impact) using the Life Cycle Assessment (LCA) approach and Emergy analysis. LCA and other energy and resource evaluation will be also done, and the results obtained will be compared thanks to a qualitative approach (decision trees DEXi software); hence the most suitable species and rearing conditions will be defined.

Task 5.1 Global multicriteria assessment approach (M1-M6; M26-M36) Task leader: INRA/Partners involved: UNIMI, MEDFRI.

The task 5.1 of the work package 5 aims to develop a global approach to assess sustainability of SIMTAP systems, in order to organize the different indicators resulting from environmental impacts assessment (Life Cycle Assessment and Emergy Assessment) and socio-economic impacts assessment (Social Life Cycle Assessment and Life Cycle Costing). A qualitative approach based on decision trees has been be carried out, applying a decision support system software called DEXi (https://kt.ijs.si/MarkoBohanec/dexi.html) stemmed from DEX methodology (Bohanec, 2003).

DEX for Decision Expert is a methodology that combines hierarchical multi-attribute model decision making with an expert systems approach based on qualitative attributes or also called criteria (Bohanec 2003; Craheix et al. 2015). All the attributes in the model are qualitative and represented by words (low, medium, high). DEXi allows the breakdown of a complex decision problem into smaller and less complex sub-problems (Bohanec, 2003; Craheix et al., 2015). Mobilizing a large reference literature as well as interviews of specialists, a wide list of principles, criteria and indicators of sustainability was proposed. According to the Dexi method, this list was prioritized and a decision tree linking all the different concepts was built, involving the different partners of the project and external advises. The different concepts were then weighted using a participatory process, to obtain the final DEXI tree. Different steps were achieved in order to conduct the application of Dexi method to Simtap project. All the process of construction the Dexi-aqua tree has been conducted up to the end. Therefore, different products have been obtained:

- a list of relevant and operational indicators for the assessment of the three pillars of the sustainable development (including those from LCA, LCC, SLCA and Emergy Accounting) adapted to aquaculture, with their thresholds values;
- three decision trees (one by sustainable pillar), organising the indicators and their aggregation and weighting;
- a template for the data collection and indicators calculation
- a guide to use the different tools.

The next step will consist in the validation, and adaptation of the Dexi-aqua trees, to the different production contexts. To do so, the assessment of reference systems to fix the last remaining points and generate reference values for the sustainability assessment of the SIMTAP new systems, will be perform by the project partners.

Task 5.2 Identifying the economic performances (M1-M6; M22-M36) Task leader: UNIMI/Partners involved: INRA, KOROLEV, MEDFRI.

Life-cycle analysis (LCA) does not account for economic aspects, and such analysis should therefore be considered together with a life-cycle cost analysis (LCC), which takes into account the costs of investment, energy, maintenance, and dumping the final waste product throughout the lifetime of a plant (Swarr et al, 2011). Life-cycle cost analysis (LCC) is an approach for evaluating all relevant costs over time of a project, product, or services. It takes into consideration all costs including first costs, such as capital investment costs, purchase, and installation costs; future costs, such as energy costs, operating costs, maintenance costs, capital replacement costs, financing costs; and any resale, salvage, or disposal cost, over the lifetime of the project or product. LCC is thus an engineering economic analysis approach useful for comparing the relative merit of competing project alternatives. LCC is not standardized like environmental LCA and many different conceptual frameworks to perform this analysis have been proposed in literature but the most common to date has been the use of cash flow models (Falcone et al., 2016). The latter approach was therefore selected to evaluate the economic performance of SIMTAP systems and to critically compare these with commercial aquaculture plants. In this task, regarding the Life Cycle Cost (LCC), to assess the economic performances from each SIMTAP system:

- A data collection form has been developed by for the gathering of the information about the different production factors (e.g. amount, specific costs) and the capital goods (investment, life span) as well as about the productive performances of the different SIMPTAP systems;
- the data collection form has been shared with the partners involved in WP2, WP3 and WP4. Contacts were established with some aquaculture plants located in the south of Tuscany and the list of economic data needed for the assessment of seabream and seabass production in inland aquaculture plants was discussed with plant managers;
- an Excel-based tool for the calculation, for the different SIMTAP systems, of NPV (Net Present Value), Internal Rate of Return (IRR) and Gross Added Value (GAV) was set-up

The next steps will consist in: (i) the collection, in cooperation with the partners, of the inventory data for LCC analysis for commercial aquaculture plants and for SIMTAP systems; (ii) processing of the collected data and analysis of the economic performances

Task 5.3 Identifying the environmental performances (M1-M6; M22-M36) Task leader: INRA/Partners involved: UNIMI, MEDFRI.

In this task, the Life Cycle Assessment (LCA) is the methodology selected to assess environmental impacts from each SIMTAP system studied. LCA is a standardized framework (ISO, 2006a; b) designed to estimate potential impacts associated with producing a product by quantifying and estimating resources consumed and compounds emitted into the environment during all stages of its life cycle, from raw material extraction up to the end-of-life (Guinée et al. 2002). Each substance emitted or consumed is assigned to one or more impact categories based on its potential environmental impact and information from scientific literature. The LCA performed in this study followed the main guidelines in the ILCD handbook (Joint Research Centre 2010). It is composed of four main steps: Goal and scope definition, Life Cycle Inventory (LCI), Life Cycle Impact Assessment, Results analysis. At this stage the work was focussed on the two first steps. The LCI template has been integrated to Dexi template since indicators from LCA are used in Dexi, to make data collection easier. A workshop was carried on October 9th, 2020 to present to all the partners the LCA methodology and the information expected to fill the LCI template. A LCI template, adapted to SIMTAP systems, has been established and sent to all partners who will fill it before the end of February 2021.

Task 5.4 Emergy accounting (M1-M6; M22-M36) Task leader: INRA

Here, the Emergy Accounting (EA) method was chosen in addition to LCA methodology to further assess environmental impacts from each studied SIMTAP system. EA (Odum and Odum,2003;) is a tool based on Energy Systems Theory (Odum, 1983), which was developed to integrate all system inputs (i.e. resources, services and commodities) using a common unit. Prior to carrying out the assessment, an inventory template has been established, gathering information on all the elements (inputs from nature and technosphere and outputs) involved in the production of all the products from each studied system. The EA template has been integrated to the global Dexi template to make data collection easier for the partners.

A dedicated workshop was carried on October 9th, 2020 to present to all the partners the environmental and sustainability assessment methodology (ie including EA, LCA and DEXI methods) and the information expected to fill the template. An internal course on LCA and Emergy accounting was also held for the project partners. An EA template integrated to the global DEXI template has been established. This template was specifically designed to fit SIMTAP systems. The global template has been forward to all partners who are expected to fill it before the end of February 2021.

Task 5.5 Identifying the social performances (M1-M6; M22-M36) Task leader: UNIMI/Partner involved: MEDFRI.

The aim of this task is to assess the social sustainability contributing to the full assessment of the SIMTAP systems. Social sustainability is one of the three pillars of sustainability also included within the global multicriteria assessment framework (Task 5.1). Unlike the latter, for this specific task the social results will be presented separately to better highlight the societal risks and benefits of the SIMTAP system. However, the inventory data needed for the two analyses (global multicriteria assessment and social life cycle assessment) concur. Therefore, the stakeholders, social themes and sub-categories relevant to the project from the social point of view were selected under the guidance of INRAE, also through surveys and frequent discussion (via email, video calls and on-line workshops) with the project members. This selection was made following the principles dictated by the UNEP (United Nations Environment Programme) Guidelines for SLCA (Guidelines for Social Life Cycle Assessment of Products), which have been adapted to the system under evaluation, thus inserting sub-categories of specific interest for aquaculture production while excluding some others considered not of interest. Starting from this, threshold values were attributed to each sub-category, based on scientific literature and experts' opinion, for their evaluation through performance references points. The data collection form has been developed for gathering information about the social relevant aspects of the different SIMTAP systems under evaluation. The data collection form has been shared with the partners involved in WP2, WP3 and WP4. Contacts were established with some aquaculture farms located in the south of Tuscany and the list of social figures needed for the assessment of seabream and seabass production in inland aquaculture plants was discussed with farm managers.

The next steps will consist in: i) definition of a method for aggregating and weighing the inventory data to better express the social results, in order to highlight the social hotspots and to compare in depth the SIMTAP systems and those with conventional production cycles. To do this, the aggregation and weighing methods proposed by the UNEP Guidelines will also be considered. These are currently under review and the updated version will be published in the next few months.

1.2.7 Work Package 6

Title: SIMTAP recommendations and guidelines.

WP Leader: UNIMI **WP Participants: ALL**

Start month: 18 **End month:** 33

Objectives: WP0 aims to assess the quality of the food products (plants and fish) in SIMTAP systems. Seven deliverables are foreseen for this WP.

The work has started recently and there are still no important results to include in this report.

1.2.8 Work Package 7

Title: Communication, dissemination and exploitation.

WP Leader: UNIBO **WP Participants:** ALL

Start month: 1 **End month:** 36

Objectives: WP7 aims principally at i) disseminating the project results to the scientific community, stakeholders in the sector of aquaculture and food production and the general public.

Task 7.1 Communication activities (M1-M36) Task leader: UNIBO/Partners involved: ALL.

A detailed Communication Plan was written. The communication plan (CP) aims at enhancing the visibility of SIMTAP project and arising public awareness on the research goals and expected results. Project consortium members ensure that the project is and will be adequately promoted through the following different means and through the involvement of adequate media experts.

The communication started with the kick-off meeting of the project and has been carried on with activities that took place during the whole project period.

A common public image/branding for SIMTAP allows an easier identification by the public and ensures visibility and recognition. Therefore, project logo (see report cover) and common graphics for the project template (e.g., presentation, template, report, etc.) and any published or publicly presented material (e.g., brochures, leaflets, flyers, posters, etc.) has been created. Moreover, an institutional presentation template, containing basic information about the SIMTAP project has been developed, to act as a basis for relevant communication activities.

The Website for the SIMTAP Project was created and it is still updated every few weeks and at every important even. The site is visible at the following url: https://www.simtap.eu/index.php

SIMTAP Project profiles have been created also on Social Networks as follows:

- Facebook: https://www.facebook.com/SimtapProject
- Twitter: https://twitter.com/ProjectSimtap
- YouTube: https://www.youtube.com/channel/UC2olupsbww4iynNop-RgH_Q

- ResearchGate: https://www.researchgate.net/project/SIMTAP-Self-sufficient-Integrated-Multi-Trophic-AquaPonic-systems-for-improving-food-production-sustainability-and-brackish-water-use-and-recycling

At the beginning of the project, TV broadcastings were done, and they can be watched at the following Web sites:

- http://futuro24.blog.rainews.it/2019/05/31/futuro24-tecnologie-per-unagricoltura-sostenibile/
- https://www.youtube.com/watch?v=umHouF6tsKc&feature=emb_logo

Task 7.2 Dissemination activities (M1-M36) Task leader: UNIPI /Partners involved: all

Project consortium members ensure that project results are adequately disseminated through different means, in particular: i) publication of joint scientific papers on peer reviewed journals using Gold and/or Green Open Access approach; at the moment, three papers were published, one was accepted and other manuscripts are in progress; ii) dissemination events; iii) newsletter; iv) training sessions for stakeholders, which will be organized towards the end of the project participation of consortium members in events where the research performed can be presented.

Due to the Covid-19 pandemic situation very few on-line events were organized:

- BRIGHT-NIGHT "Brilliant Researchers Impact on Growth Health and Trust in research" at UNIBO. https://www.nottedeiricercatori.it/
- IEEE MetroAgriFor 2020 Workshop. Virtual Conference | 4-6, November 2020. https://ieeexplore.ieee.org/xpl/conhome/9276490/proceeding
- International Conference on Environmental Science & Technology, 4-7 September 2019, Rhodes, Greece. https://cest2019.gnest.org/proceedings

Publications:

- Bacenetti et al. (2019), *Approaches to tackle emerging challenges in European aquaculture*. 16th International Conference on Environmental Science & Technology, 4-7 September 2019, Rhodes, Greece.
- Barbaresi et al. (2020), *A Smart Monitoring System for Self-sufficient Integrated Multi-Trophic AquaPonic*. Proceedings of IEEE MetroAgriFor 2020 Workshop.
- Ciurli et al. (2021), *Multidisciplinary integrated characterization of a native Chlorella-like microalgal strain isolated from a municipal landfill leachate*. Algal Research (accepted).
- Rossi L. Bibbiani C., Fierro-Sañudo J.F., Chinoilema Maibam C., Incrocci L., Pardossi A., Fronte B. (2021). *Selection of marine fish for Integrated Multi-Trophic Aquaponic production in the Mediterranean area, using DEXi multi-criteria analysis as innovative approach.* Aquaculture, 2021, 736402. https://doi.org/10.1016/j.aquaculture.2021.736402.

Task 7.3 Exploitation planning and IPR management (M1-M36) Task leader: UNIPI /Partners involved: all

A solid plan for commercially exploiting the project results by the whole consortium or by one or partners was foreseen at month 7 (Del. 07.05); however, due to the delay of the project activities, it has been postponed to month 24, when an exploitation agreement /Del. 07.07) will be signed.

1.3 Impact

The information on section 2.1 of the proposal submitted (how your project will contribute to the expected impacts) is still relevant or needs to be updated. Include further details in the latter case.

2. Update of the plan for exploitation and dissemination of result (if applicable)

Due to the delay of much of the project activities, the plan for the dissemination and exploitation of results (Del. D7.05) and the exploitation agreement (Del. D707) have not yet prepared or achieved. The new deadline for this achievement is the end of May 2020 (M24).

3. Update of the data management plan (if applicable)

Not applicable

4. Follow-up of recommendations and comments from previous review(s) (if applicable)

Not applicable

5. Deviations from the proposal submitted (if applicable)

The workplan reported in the proposal was modified because most of the partners are significantly behind the schedule due to problems with the NFB (in Italy and in Germany) and the pandemic.

According to the Consortium Agreement, the new workplan with extended duration of WP2-4 and the new schedule of some deliverables was approved by the General Assembly, which met online on 19 November 2020.

5.1 Tasks

The set-up of the SIMTAP prototype at the University of Pisa was delayed by 9 months due to the lack of funds (a results of slow procedure laid down in Italy) and then to the pandemic and the lockdown between March and June 2020, which hampered the construction of the prototype by the company selected at the end of 2019 and restricted the access of the UNIPI staff to laboratories and experimental facilities. The installation of the prototype at MEDFRI campus was also delayed due to extension of building by sub-contractor and then the installation was behind the schedule in the pandemic period. These delays were affected the activities of WP2.

These delays have affected the activities foreseen in WP1 (task 1.4, ISMaCS installation and testing) and WP2 (tasks 2.1, 2.2. and 2.3), and may affect WP3 (task 3.1, 3.2 and 3.3) in 2021.

5.2 Use of resources

There were deviations of the use of resources reported in the proposal as regard UNIPI, UNIBO and INRAE (**Table 6**):

UNIPI: - The cost of the SIMTAP prototype installed in Pisa was lower than the expected ones; on the contrary, more consumables than it was foreseen are necessary for the experiments performed to test the whole system (f.i. for laboratory analysis; purchase of fish juveniles). Therefore, the funds for “Travel and subsistence” and “Equipment” were reduced to balance the extra costs for “Consumables”, without any variation of the total UNIPI budget.

UNIBO: Due to the urgency of activities related to the ISMaCS, after a careful analysis of monitoring systems available on market and meetings with partners (activities planned in the Task 1.4), UNIBO directly built the largest part of the components of the ISMaCS; for the data collection only (server and cloud), commercial solutions were chosen. This ISMaCS design allowed more precise and adaptable systems, better meeting the project needs. This solution entailed to use more resources allocated for “Consumables” and, consequently, just a small part of “Equipment” funds has been spent. Moreover, the COVID-19 restrictions reduced the possibility to participate to conferences, therefore the funds for “Other costs” category are reduced. Finally, the reduction of “Equipment” and “Other costs” funds, balance the extra costs needed for “Consumables”. Despite these transfers in cost categories, the total of UNIBO budget does not require any adjustment.

INRAE: For the next period a change of 15000 € is required between the line “Travel & subsistence” and the line “other costs”, due to the lack of traveling caused by the Covid crisis and permitting to cover the increase in chemical analysis number due to a new experimental cycle. This request is in progress at ANR.

MEDFRI: The Turkish lira has lost value about twice against the Euro in the two years since the project proposal. For this reason, the MEDFRI’s budget allocated to the organization of meetings and symposia in the last year of the project has also lost value by half. Therefore, there can be a need for additional funding to participation of the meeting and symposium for the next period.

UNIMI: no funds were received from the Italian Ministry as well as no fund anticipation was granted by the University. Consequently, until now, the expenses for the participation to the kick-off meeting in Pisa as well as for the technical visits carried out in aquaculture farms (total amount about 5,500 €) were anticipated using, temporarily, other funds of the research group.

Table 6: SIMTAP budget: total expected costs, actual costs (month 18) and deviations.

PARTNER		Personnel costs						Consumables	Travel & subsistence	Equipment	Other costs	Overheads	TOTAL
		Permanent staff (€)	**person month (months)**	**Temporary staff except PhD (€)**	**person month (months)**	**PhD (€)**	**person month**						
UNIPI	Expected (E)	157,309	28.0	75,600	36,0	-	-	35,000	20,000	15,000	14,000	96,454	413,363.00
	Actual (A)	71,890	10,4	26,000	13,0	-	-	7,839	694	9.300	5,057	43.975	164.755
	A/E %	45.7%	37.1%	34.4%	36.1%	-	-	22.4%	3.5%	62.0%	36.1%	45.6%	39.8%
	Deviation	157,309	28.0	75,600	36,0	-	-	**50,000**	**10,000**	**10,000**	14,000	96,454	413,363.00
UNIBO	Expected (E)	68,897	11.2	50,000	24	-	-	9,000	18,000	20,000	6,000	41,449	213,346.08
	Actual (A)	23,846.91	4.2	13,017.63	7	-	-	14,961.16	1,118.37	4,522.36	0	17,313.90	74,780.33
	A/E %	34.6%	37.5%	26.0%	29.2%	-	-	166.2%	6.2%	22.6%	0.0%	41.8%	35.1%
	Deviation	68.897	11.2	50.000	24	-	-	**22.000**	18.000	**9.000**	**4.000**	41.449	213.346.08
UNIMI	Expected (E)	36,309	7.6	37,800	18.0	-	-	0	11,000	0	0	26,033	111,142.52
	Actual (A)	26,366	4.5	0	0	-	-	0	5,5000	0	0	0	31,866
	A/E %	72.6%	59.2%	0%	0	-	-	0	50.0%	0	0	0%	28.6%
	Deviation	-	-	-	-	-	-	-	-	-	-	-	-
INRAE	Expected (E)	141,677	22.0	33,908	9.0	-	-	8,127	24,800	0	34,000	8,855	251,367
	Actual (A)	77,077	10.0	27,114	9.0	-	-	6,962	5,050	0	11,000	4,010	131,213
	A/E %	54%	45%	80%	100%	-	-	86%	20%		32%	45%	52%
	Deviation	141,677	22.0	33,908	9.0	-	-	**23,127**	**9,800**	-	34.0	8,855	109,690
LML	Expected (E)	28,648	12	3,465	6	-	-	26,367	965	2,000	0	2,851	64,294
	Actual (A)	14,324	6	0	0	-	-	6,562	0	1,567	0	0	22,453
	A/E %	50.0%	50.0%	0.0%	0.0%	-	-	24.9%	0,0%	78.4%	-	0.0%	34.9%
	Deviation	-	-	-	-	-	-	-	-	-	-	-	-

PARTNER		Personnel costs						Consumables	Travel & subsistence	Equipment	Other costs	Overheads	TOTAL
		Permanent staff (€)	person month (months)	Temporary staff except PhD (€)	person month (months)	PhD (€)	person month						
MEDFRI	Expected (E)	0	57	27.360	72	-	-	36.000	11.800	91.200	29.800	0	196.160
	Actual (A)	0	24	10.931	25	-	-	6.768	3.033	36.255	24.654	0	81.641
	A/E %	-	42,1	40,0	34,7	-	-	18,8	25,7	39,8	82,7	-	41,6
	Deviation	-	-	-	-	-	-	-	-	-	-	-	-
MAFA	Expected (E)	19,000	36.0	40,000	36.0	-	-	10,000	4,000	47,000	25,000	5,000	150,000
	Actual (A)	0	0	0	0	-	-	0	0	0	0	0	0
	A/E %	0%	0%	0%	0%	-	-	0%	0%	0%	0%	0%	0%
	Deviation	-	-	-	-	-	-	-	-	-	-	-	-
KOROLEV	Expected (E)	15,000	8.0	0	0.0	-	-	3,000	5,000	0	4,000	3,000	30,000.00
	Actual (A)	0	0	0	0	-	-	0	0	0	0	0	0
	A/E %	0%	0%	0%	0%	-	-	0%	0%	0%	0%	0%	0%
	Deviation	-	-	-	-	-	-	-	-	-	-	-	-

Brief description of actual costs

UNIPI

- Consumables: sand [1,439 €]; synthetic sea salt [5,014 €]; miscellany for prototype [1,384 €]
- Equipment [depreciation]: SIMTAP prototype [51611 €]; hand-held meter for dissolved oxygen [759 €]; shelf for polychaetes lab. [481 €]
- Non-permanent staff: postdoc salary [24.000 €]
- Travels: meeting in Montpellier; travel to Rennes [cancelled due to the pandemic; travel to Villafranca
- Other costs: kickoff meeting [1416 €]; website [2420 €]; contract for prototype maintainance [1200 €]

UNIBO

- Consumables: Sensors for parameters measurement and recording [3.274,08€]; Electronic System [11.306,96€]; Electronic Material [380,12€]
- Travel and subsistence: Kickoff meeting in Pisa June 2019 [444,98€]; Rennes Visit Torreggiani Daniele March 2020 [230,59, €]; Rennes Visit Alberto Barbaresi March 2020 [287,6€]; Pisa Visit Alberto Barbaresi July-August 2020 [156,10€].
- Equipment: Hard disks [€491,6]; Software licence Rhinoceros 6 [€237,9]; DELL Server [€3701,48]; Router [€91,38].

INRAE

- Consumables: Experimental feed [4464.00 €]; miscellany [2497.76 €];
- Travel and subsistence: Kickoff meeting in Pisa [771.10 €]; Experiment in Bourcefranc [4278.65 €];
- Other costs: Hydraulic consultancy [1000.00 €]; Consultancy multicriteria assessment [10000.00 €] ;

LML

- Temporary staff except PhD: gratification trainee March to August 2021.
- Consumables: purchase of animals
- Equipment: pump and blower.

MEDFRI

- Consumables: Biofilter carrier [1.990,2; €]; Polychaete culture tanks [2.132,5; €]; Pneumatic parts [507,7; €]; Pipes and plumbing [2.137,4; €]
- Travel and subsistence: Kickoff meeting in Pisa, June 2019 [1.862,4 €]; Prototype travel and studies [1.170,3; €]
- Equipment: SIMTAP prototype [21.948,3; €]; Lab equipment [14.306,5; €]
- Other costs: Building sub-contract [24.654,4; €]

Notes: according to the Turkish national regulations [TÜBİTAK], the costs of the “permanent staff” involved in the project is paid by the government, not by the “resource management” under MEDFRI. Therefore, the costs in this “budget table” is kept equal to zero [0 €] even if 57 person months [PMs] are planned: in fact, participation into research activities is a responsibility of a researcher in a public institute depending on government salary.

5.2.1 Unforeseen subcontracting (if applicable)

Not applicable for all the partners

5.2.2 Unforeseen use of in-kind contribution from third party against payment or free of charges (if applicable)

UNIPI

The costs for the realization of the DFFO laboratory (see WP1, Task 1.1) were covered by other funds in the availability of the project coordinator. A research assistant (with MSc degree), Dr. Lorenzo Rossi, was appointed between November 2019 and October 2020 and the cost of the contract (namely, "borsa di ricerca" in Italian) was covered by the Coordinator's funds. A research fellow (post-doc) from Mexico, with a grant from CONACyT (Consejo Nacional de Ciencia y Tecnología Stato di San Paolo, Messico), was hosted between November 2019 and October 2020 was hosted at the University of Pisa to work on the SIMTAP project. Juveniles of Gilthead Seabream (*Sparus aurata*) were kindly donated by Maricoltura (INVE Aquaculture Research Centre; https://www.inveaquaculture.com), Rosignano Marittimo (Livorno, Italy). An agreement was signed in 2020 between UNIPI and the Blue Resolution association. ARBI, an Italian private company in the seafood sector headquartered in Monsummano, Pistoia, and the Scuola Superiore Sant'Anna, Pisa, belong to this association, which aims to identify and propose innovative solutions for defending the marine environment from pollution. In 2020, ARBI provided frozen seafood, free of charge, for the experiments on fish feeding. UNIPI will inform ARBI about the achievements of the project and will join ARBI's dissemination activities on the sustainability of fishery sector.

MEDRI

Juveniles of European sea bass (*Dicentrarachus labrax*) and Gilthead Sea bream (*Sparus aurata*) to study of evaluation of nutritional value of polychaete meal were supplied by Kılıç Deniz A.Ş. (https://www.kilicdeniz.com.tr/). Some of the polychaetes for the pre-experiments was donated by Körfez Av-Yem Dünyası (https://www.yemdunyasi.com/default.aspx) while some was supplied by a local supplier, covered by the Coordinator's funds.

List of attachments

(available at https://b2drop.eudat.eu/s/SEMsYjEEZmA463w/download)

Internal reports

- UNIPI: Internal report: Review on nutritional requirements of marine fish and biochemical composition of detritivore and filter-feeder organisms for SIMTAP systems.
- MEDRI: Report on system starting and biofilter conditioning.

Tools

- DEXi tool box and data.

Publications

- Bacenetti et al. (2019). *Approaches to tackle emerging challenges in European aquaculture*. 16th International Conference on Environmental Science & Technology, 4-7 September 2019, Rhodes, Greece. Reprint.
- Barbaresi et al. (2020). *A Smart Monitoring System for Self-sufficient Integrated Multi-Trophic AquaPonic*. Proceedings of IEEE MetroAgriFor 2020 Workshop. Reprint.
- Ciurli et al. (2021). *Multidisciplinary integrated characterization of a native Chlorella-like microalgal strain isolated from a municipal landfill leachate*. Algal Research (accepted). Post-print manuscript.
- Rossi L. Bibbiani C., Fierro-Sañudo J.F., Chinoilema Maibam C., Incrocci L., Pardossi A., Fronte B. (2021). *Selection of marine fish for Integrated Multi-Trophic Aquaponic production in the Mediterranean area, using DEXi multi-criteria analysis as innovative approach.* Aquaculture, 2021, 736402. https://doi.org/10.1016/j.aquaculture.2021.736402.

Dissemination material

- Presentation of SIMTAP to LML students.