

Organisation **CoLAB +ATLANTIC**



D11.5 NAUTILOS Socio- Economic Impact Assessment

Final version

Date: 22-07-2024

Doc. Version: 1.4

doi: 10.5281/zenodo.14283327



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101000825 (NAUTILOS). This output reflects only the author's view and the European Union cannot be held responsible for any use that may be made of the information contained therein.

Document Control Information

Settings	Value
Deliverable Title	D11.5 NAUTILOS Socio-Economic Impact Assessment - final
Work Package Title	Exploitation and Impact
Deliverable number	D11.5
Description	The deliverable presents the final version of the socio-economic impact assessment for NAUTILOS.
Lead Beneficiary	CEiiA
Lead Authors	Inês Magusteiro, Paula Salge, Luísa Barros and Pedro Gonçalo (CoLAB +ATLANTIC), Daniel Costa and Catarina Lemos (CEiiA)
Contributors	Andy Smerdon, Jana Fahning, Damien Malarde, Christos Tsabaris, Marco Mazza, Christophe Guinet, Tiago Bartolomeu, Francisco Vasconcelos, Peter Cristofolini, Bert van Bavel, Danilo Vrtačnik
Submitted by	Paula Salge (CoLAB +ATLANTIC)
Doc. Version (Revision number)	1.4
Sensitivity (Security):	Public
Date:	22/07/2024

Document Approver(s) and Reviewer(s):

NOTE: All Approvers are required. Records of each approver must be maintained. All Reviewers in the list are considered required unless explicitly listed as Optional.

Name	Role	Action	Date
Lazarina Dimitrova	Project Manager at Europroject	Review	21/06/2024
Gabriele Pieri	Review Team 2	Review	10/07/2024
Manolis Ntoumas	Review Team 2	Review	15/07/2024
Maria João Bebiano	Review Team 2	Review	18/07/2024

Document history:

The Document Author is authorised to make the following types of changes to the document without requiring that the document be re-approved:

- Editorial, formatting, and spelling
- Clarification

To request a change to this document, contact the Document Author or Owner.

Changes to this document are summarised in the following table in reverse chronological order (latest version first).

Revision	Date	Created by	Short Description of Changes
	07/08/2023	Inês Magusteiro	First iteration of document's index
1.0	20/06/2023	Inês Magusteiro	Document creation
1.1	14/06/2024	Paula Salge	Changes in the index and update of information
1.2	27/06/2024	Paula Salge	Changes after the first revision
1.3	12/07/2024	Paula Salge	Changes after the second revision
1.4	18/07/2024	Paula Salge	Changes after the final revision

Configuration Management: Document Location

The latest version of this controlled document is stored in <location>.

Nature of the deliverable		
R	Report	x
DEC	Websites, patents, filing, etc.	
DEM	Demonstrator	
O	Other	

Dissemination level		
PU	Public	x
CO	Confidential, only for members of the consortium (including the Commission Services)	

ACKNOWLEDGEMENT

This report forms part of the deliverables from the NAUTILOS project which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000825. The Community is not responsible for any use that might be made of the content of this publication.

NAUTILOS - New Approach to Underwater Technologies for Innovative, Low-cost Ocean Observation is an H2020 project funded under the Future of Seas and Oceans Flagship Initiative, coordinated by the National Research Council of Italy (CNR, Consiglio Nazionale delle Ricerche). It brings together a group of 21 entities from 11 European countries with multidisciplinary expertise ranging from ocean instrumentation development and integration, ocean sensing and sampling instrumentation, data processing, modelling and control, operational oceanography and biology and ecosystems and biogeochemistry such as water and climate change science, technological marine applications and research infrastructures.

NAUTILOS will fill in marine observation and modelling gaps for chemical, biological and deep ocean physics variables through the development of a new generation of cost-effective sensors and samplers, the integration of the aforementioned technologies within observing platforms and their deployment in large-scale demonstrations in European seas. The fundamental aim of the project will be to complement and expand current European observation tools and services, to obtain a collection of data at a much higher spatial resolution, temporal regularity and length than currently available at the European scale, and to further enable and democratise the monitoring of the marine environment to both traditional and non-traditional data users.

NAUTILOS is one of two projects included in the EU's efforts to support the European Strategy for Plastics in a Circular Economy by supporting the demonstration of new and innovative technologies to measure the Essential Ocean Variables (EOV).

More information on the project can be found at: <https://www.nautilus-h2020.eu/>.

COPYRIGHT

© NAUTILOS Consortium. Copies of this publication – also of extracts thereof – may only be made with reference to the publisher.

TABLE OF CONTENTS

I.	INTRODUCTION	9
1.	Objectives and Scope	9
2.	Characterization of NAUTILOS Beneficiaries	9
3.	Exploitation Strategy	10
II.	SOCIO ECONOMIC IMPACT ASSESSMENT	12
1.	Methodology	12
2.	Results and Analysis	23
III.	COST SAVINGS AND COMPETITORS ANALYSIS	37
1.	Methodology	37
2.	Results and Analysis	39
IV.	CONCLUSION	57
	APPENDIX 1: NAUTILOS MARINE TECHNOLOGIES	58
	APPENDIX 2: REFERENCES AND RELATED DOCUMENTS	59

EXECUTIVE SUMMARY

This deliverable presents the final version of the NAUTILOS Socio-Economic Impact Assessment, completed in the M45 of the project. It outlines the methodology used in the assessment and details the economic and social results and conclusions related to the exploitable NAUTILOS sensors and samplers.

The primary objective of the NAUTILOS Socio-Economic Impact Assessment is to create a tool for evaluating the socio-economic impact of NAUTILOS sensors and samplers, which will be useful both during the later stages of the project and throughout its exploitation phase, extending even beyond the project's conclusion. This assessment focuses on potential sales projections for 2029 and aims to provide insights into the contribution of NAUTILOS within Europe's Blue Economy value chain. The results are intended to aid in the development of future business cases and to inform policymakers about the strategic importance of enhancing Europe's competitiveness in developing ocean-observing instruments.

A comprehensive Input-Output model was developed to identify and estimate the direct, indirect, and induced economic impacts of the NAUTILOS technologies. This model is essential for understanding the broader socio-economic implications of exploiting NAUTILOS sensors and samplers.

Another aspect of the socio-economic assessment is the cost-saving analysis of NAUTILOS sensors and samplers. A global market search for available ocean instruments, including competitive technologies, was conducted using 2024 market data as a reference. This analysis, forming part of the NAUTILOS exploitation strategy (to be finalised in deliverable D11.7), indicates that the NAUTILOS technologies offer competitive advantages in terms of cost savings and market positioning.

The Socio-Economic Impact Assessment confirms the substantial impact of NAUTILOS cost-effective technologies on the European Blue Economy, and its potential to democratise and expand marine environment monitoring for all kinds of stakeholders with different aims. By providing a detailed analysis of the socio-economic impacts and cost savings, this assessment underscores the potential for NAUTILOS to foster a more competitive and sustainable market for oceanographic instruments in Europe, guiding future business strategies and policy decisions.

LIST OF FIGURES

Figure 1 - Distribution of NAUTILOS entities by type.....	9
Figure 2 - Distribution of NAUTILOS entities considered in this assessment by type of organisation .	11
Figure 3 - Print screen of the table of Input coefficients (2019) - Input coefficients [NAIO_10_COIN__custom_5726235].....	17
Figure 4 -Print screen of the table of Output multipliers (2019) - Output multipliers [NAIO_10_COOUT__custom_5726174].....	18
Figure 5 -Print screen of the Use table at basic prices (2019) - Use table at basic prices [NAIO_10_CP1610__custom_5726263].	19
Figure 6 - Print screen of the Symmetric input-output table at basic prices (industry) (2019).....	20
Figure 7 - Examples of Eurostat tables and matrices adapted and incorporated into the I-O Model..	21
Figure 8 - Example of one of the final calculation steps in the Input-Output model for the NAUTILOS case	22
Figure 9 - Fluorometric sensors (HESSO) socio-economic impact results.	23
Figure 10 – Dissolved Oxygen Data Logger (NKE) socio-economic impact results.	24
Figure 11 – Fluorescence Data Logger (NKE) socio-economic impact results.	25
Figure 12 - Silicate Electronic sensor (NKE) socio-economic impact results	26
Figure 13 - Microplastic sensors (NIVA & CSEM) socio-economic impact results.	27
Figure 14 – Passive device (AQUATEC) socio-economic impact results.	28
Figure 15 - Active Acoustic Profiling data logger (Aquatec) socio-economic impact results.	29
Figure 16 – Sampler for Nanoplastics and Microplastics (SCT) socio-economic impact results.....	30
Figure 17 – Deep Ocean CTD (UL-FE) socio-economic impact results.....	31
Figure 18 – Deep Ocean low-level radioactivity data logger (HCMR) socio-economic impact results.	32
Figure 19 - Non-invasive animal towed tagging system used for animals such as manta rays (CEiiA) socio-economic impact results.	33
Figure 20 - Oceanographic Satellite Relayed Data Logger Tag (CNRS) socio-economic impact results.	34
Figure 21 – NAUTILOS project socio-economic impacts results.	35

LIST OF TABLES

Table 1 - List of NAUTILOS exploitable results up to M45 (companies and countries) and respective target regions considered for the socio-economic analysis.	10
Table 2 - Economic impact associated with Imports and Exports values for each NAUTILOS technology	36
Table 3 - Social Impact associated with full-time job creation divided by gender and expected qualification for each NAUTILOS technology.....	36
Table 4– NAUTILOS Cost-Benefit Analysis Classification	37
Table 5 - Competitors analysis template table	38
Table 6 - Fluorometric DO Sensor (Hesso) & Dissolved Oxygen Data Logger Wisens TD-DO (NKE) cost-saving analysis.....	40
Table 7 - Fluorescence Data Logger WISENS TD - CHL-A (NKE) cost-saving analysis.	42
Table 8 - Silicate Electrochemical Sensor (NKE) cost saving analysis.....	43
Table 9 – Microplastic Sensors (NIVA + CSEM) cost saving analysis.....	44
Table 10 – Passive Device Click & Sound Recorder (Aquatec) cost-saving analysis.....	45
Table 11 – Active Acoustic Profiling Data Logger Aquascat Mk2 (Aquatec) cost-saving analysis.....	46
Table 12– Sampler for Nanoplastics and Microplastics (SCT) cost-saving analysis.	48
Table 13 – Deep Ocean CTD Sensor (UL-FE) cost-saving analysis.....	50
Table 14 – Deep Ocean Radioactivity Data Logger (HCMR) cost-saving analysis.	52

Table 15 – Non-Invasive Animal Towed Tagging System used for animals such as Manta Rays and Sharks | MAANTA (CEIIA) cost-saving analysis. 53

Table 16 – Oceanographic Satellite Relayed Data Logger (SRDL) from the Sea Mammal Research Unit Deployed on Southern Elephant Seal | Marine Animal-Borne Temperature-Salinity-Do Tag (CNRS) cost-saving analysis. 54

Table 17 – NAUTILOS Cost-Saving Results. 55

LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
CPA	Classification of Products by Activity
CTD	Conductivity, Temperature and Depth
GVA	Gross Value Added
ESA	European System of Accounts
EOV	Essential Ocean Variable
Eurostat	European Statistical Office of the European Commission
EU	European Union
EU-28	European Union including the 28 countries before the UK left in 2020
FTE	Full time equivalent
I-O	Input-Output
GA	Grant Agreement
MEMs	Micro-electromechanical system
NACE	Nomenclature of Economic Activities
PR	Periodic Report
SEIA	Socio-Economic Impact Assessment
TRL	Technology Readiness Level

I. INTRODUCTION

1. OBJECTIVES AND SCOPE

The NAUTILOS Socio-Economic Impact Assessment (SEIA) aims to develop a tool to be used during the later stages of the project and throughout its exploitation (even post-project) to assess the socio-economic impact of potentially exploitable NAUTILOS marine technologies, considering sales in 2029. By developing this assessment, the consortium will be able to understand the socio-economic impact of NAUTILOS in the Blue Economy value chain of Europe. This can support the development of future business cases and inform decision-makers about the importance of building a more competitive Europe in the development of ocean observing instruments for biogeochemical, biological, and deep-sea physical key ocean variables and micro/nano plastics.

The first version of the NAUTILOS SEIA (Deliverable 11.8) was delivered in M24 of the project and the content included the state-of-the-art regarding the theme and existing economic models, as well as a description of the methodology chosen to develop the assessment. This final report explains the input-output modelling tool and presents the direct, indirect, and induced economic impacts and social results related to the exploitable NAUTILOS sensors and samplers. Another aspect of the socio-economic assessment is the cost-saving analysis of NAUTILOS sensors and samplers. To achieve this goal, a global search of available instruments (including competitors, if existent) has been carried out in a major effort by the WP11 socio-economic team and sensor and sampler developers (using the 2024 market as a reference), which is considered as part of the exploitation strategy of the NAUTILOS project (to be finalised in deliverable D11.7). Based on the analysis of competitors and cost savings, it is possible to understand the contribution of the NAUTILOS project and to understand how and if the developed technologies present advantages on the global market.

2. CHARACTERIZATION OF NAUTILOS BENEFICIARIES

A comprehensive characterisation of the individual beneficiaries of the project was performed and presented in Deliverable D11.8 (Table 1). The consortium includes a total of 11 countries and no more than 4 members of the consortium per country (CoLAB +ATLANTIC is a Third Party to CEiiA). Also, there is a complementary distribution in terms of the types of entities involved, private or public sector, which can help ensure a diverse and effective dissemination and exploitation of results. A total of 9 (41%) public entities and 13 (59%) private entities (including 6 SMEs) are part of the NAUTILOS consortium (Figure 1).

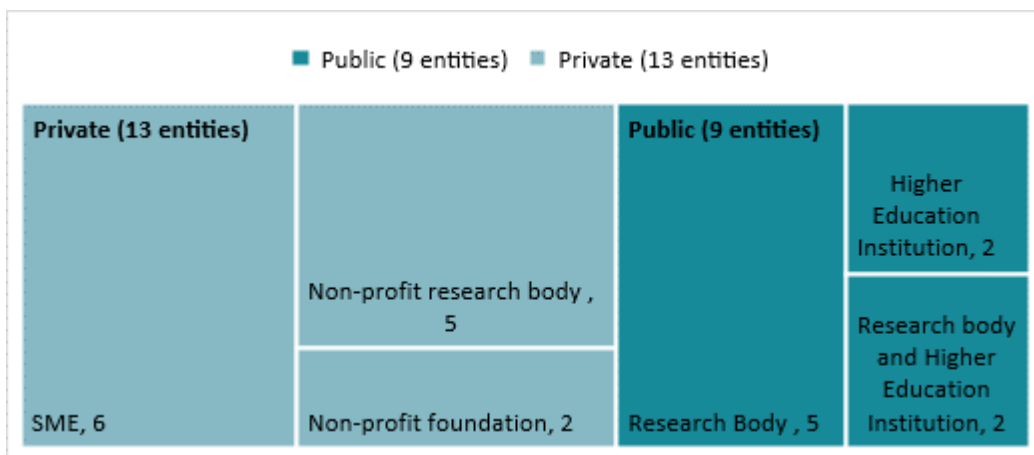


Figure 1 - Distribution of NAUTILOS entities by type.

This is important to be reported in the present deliverable since the type of entities in the consortium may influence the reality behind the socio-economic impacts of the project. For instance, companies (e.g. SCT) will directly commercialise the sensors and samplers developed, whereas instruments developed by non-private entities show here the potential commercial impact if a commercial partner is to be found by the end of the project (e.g. HESSO).

3. EXPLOITATION STRATEGY

As previously mentioned, the variety in terms of the types of entities involved is part of the complexity of the NAUTILOS project. The exploitation strategy of NAUTILOS, which will be presented in deliverable D11.7, details the specific exploitation plans defined for each partner responsible for developing each sensor, data logger, and sampler. By the end of the closure of this present deliverable, we can consider having 12 technologies (4 sensors, 5 data logger, 1 sampler and 2 tags) (Table 1, Appendix 1) as exploitable by 2029 to measure biological, chemical, and physical Essential Ocean Variables (EOVs) in addition to micro/nano-plastics, and two animal-borne tagging systems (animal-tags).

It is important to note that the Grant Agreement (GA) specifies that among sensors, samplers, and tags 14 marine technologies will be produced by the partners during the NAUTILOS project (Appendix 1). However, not all NAUTILOS technologies are intended to be exploited at the end of the project. Specifically, two sensors and one sampler developed by partner NIVA—namely the "Downward-looking multi/hyperspectral and laser-induced fluorescence sensors and cameras," the "Carbonate system/ocean acidification sensors," and the "Sampler for phytoplankton and other suspended matter"—are excluded from this assessment. These technologies were developed by NIVA for scientific purposes rather than for commercialisation. More details on the exploitable results of NAUTILOS will be presented in deliverable D11.7.

Table 1 - List of NAUTILOS exploitable results up to M45 (companies and countries) and respective target regions considered for the socio-economic analysis.

#	NAUTILOS Technology (sensor/data logger/sampler/tag)	Company and Country	Included in the Socio-economic impact assessment	Target region*
1	Fluorometric Dissolved Oxygen Sensor	HES-SO - Switzerland	Yes	EU
2	Dissolved Oxygen Data Logger Wisens TD-DO	NKE – France	Yes. It was considered two sensors, with separate assessments**	EU
3	Fluorescence Data Logger WiSens TD – Chl-a	NKE – France		EU
4	Silicate Electrochemical Sensor	NKE - France	Yes	EU
5	Microplastic sensors	NIVA - Norway + CSEM – Switzerland**	Yes**	Norway
6	Passive broadband acoustic recording sensor for noise monitoring	AQUATEC - United Kingdom	Yes. It was considered a single assessment	EU
	Passive acoustic event recorder (porpoise & dolphin clicks for abundance estimation)	AQUATEC - United Kingdom		EU
7	Active Acoustic Profiling Data Logger AQUAscet Mk2	AQUATEC - United Kingdom	Yes	EU
8	Submersible Sampler for Nanoplastics and Microplastics	SCT - Germany	Yes	EU
9	Deep ocean CTD Sensor	UL-FE - Slovenia	Yes	EU
10	Deep ocean radioactivity Data Logger	HCMR - Greece	Yes	EU

11	Non-invasive animal towed tagging system used for animals such as manta rays and sharks MAANTA	CEiiA - Portugal	Yes	EU
12	Oceanographic Satellite Relayed Data Logger (SRDL) from the Sea Mammal Research Unit deployed on southern elephant seal Marine animal-borne temperature-salinity-DO Tag	CNRS - France	Yes	EU

*In this case, the EU includes 28 countries, before the UK left in 2020.

** Detailed information is provided in Chapter II, 1.2.2 “Data Collection from Partners”.

NAUTILOS potentially exploitable marine technologies are produced by 10 entities, which are based in different countries, namely: France (CNRS and NKE), Germany (SCT), Greece (HCMR), Slovenia (UK-FE), Switzerland (HES-SO and CSEM), Norway (NIVA), Portugal (CEiiA) and United Kingdom (AQUATEC). Concerning the type of organisations, four entities (40%) are public (two Research bodies and two Research body and Higher Education Institutions), and six entities (60%) are private (1 non-profit foundation, 2 non-profit research bodies, and 3 small and medium size enterprises) (Figure 2).

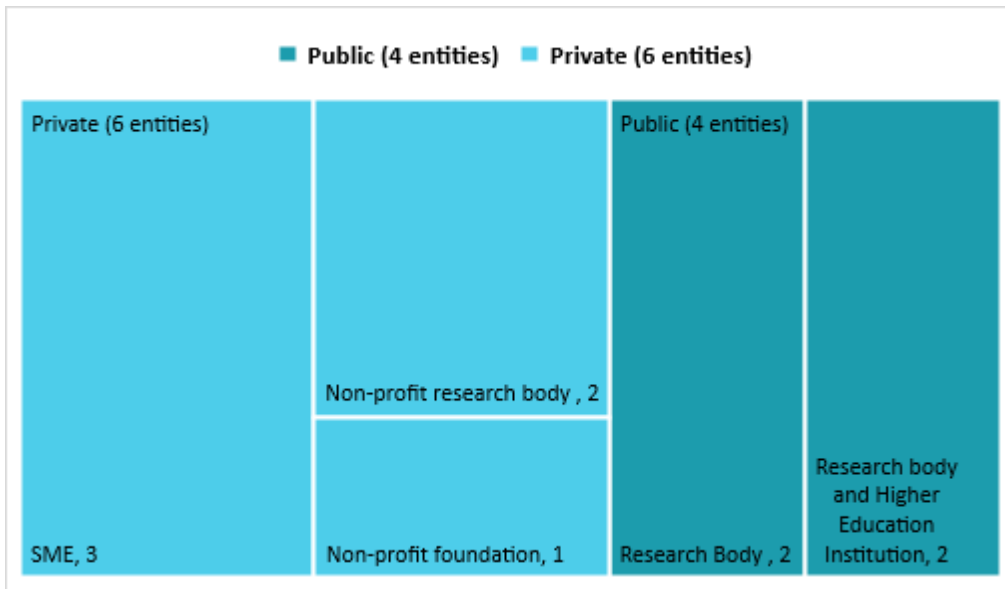


Figure 2 - Distribution of NAUTILOS entities considered in this assessment by type of organisation

The socio-economic impacts are estimated separately for each technology, as well as collectively for the entire NAUTILOS project. Thus, the socio-economic impact of the individual sales of the technologies developed by the partners in their geographical areas is estimated. For most of the technologies, namely, the ones produced in EU countries, the territory of the European Union (EU) (before 2020, including the United Kingdom) was assumed as the target geographical area for measuring impacts, except for the technologies developed outside the EU, i.e. Norway (Table 2). The methodology and results can be consulted in Chapter II.

Moreover, the cost-saving analysis is also presented separately for each technology. The methodology and results are detailed in Chapter III.

II. SOCIO ECONOMIC IMPACT ASSESSMENT

1. METHODOLOGY

1.1. INPUT-OUTPUT MODEL

The Input-Output Model (I-O Model), also known as the Leontief model, is widely used to study cross-sectoral relationships and the economic impact of activities in a region. Developed by Wassily Leontief, it examines how expenditure in one industry affects other sectors in a local economy, estimating **direct, indirect, and induced impacts**.

The I-O Model, an inter-industry model, identifies the structure and linkages within a regional economy, highlighting the importance of various industries and predicting economic consequences in terms of production, earnings, and employment. The I-O Model uses a matrix representation of a region's economy to predict the impact of changes in one industry on other industries, consumers, government, and foreign suppliers to the economy.

The total economic effects measure how the local economy is stimulated and are calculated by the sum of direct, indirect, and induced impacts. They are all the transactions attributable, either directly or indirectly, to the activities that are being measured. The I-O Model accounts for transactions among industries, governments, households, and trade, assessing the significance of industry linkages and the economic outcomes of changes in production, earnings, or employment.

The input-output framework in the European System of Accounts

The input-output framework of the European System of Accounts (ESA 1995) consists of three types of tables:

- Supply tables
- Use tables
- Symmetric input-output tables.

For the three types of tables, the same concepts and definitions apply to the whole system of accounts.

Supply and use tables are an integral part of the European System of Accounts (ESA 1995). The supply table provides a detailed picture of the supply of goods and services by domestic production and imports, whereas the use table shows the use of goods and services for intermediate consumption and final use (consumption, gross capital formation, exports) as well as how the components of value added (compensation of employees, other net taxes on production, consumption of fixed capital, net operating surplus) are generated by industries in the domestic economy.

Symmetric input-output tables are a transformation of the supply and use tables and therefore the classifications in the tables coincide. These classifications are also totally compatible with those used within the framework of the United Nations. The supply and use tables and input-output tables of the ESA 1995 relate products and industries. The classification used for industries is the 'General Industrial Classification of Economic Activities within the European Communities' (NACE) and the classification used for products is the 'Classification of Products by Activity' (CPA).

Symmetric input-output tables are the basis for input-output analysis. These tables can either be made based on an industry-by-industry or product-by-product classification, and the selection of the

appropriate type of table depends on the specific objective of the economic analysis. Whereas Industry-by-industry I-O tables are closer to statistical sources and actual market transactions, product-by-product I-O tables are believed to be more homogenous in terms of cost structures and production activities.

Output multipliers and Input coefficients ¹

The output multipliers matrix and the Input coefficients matrix are used to calculate indirect and induced effects in the economy. An output multiplier for an industry j is defined as the total value of production in all industries of the economy that is necessary for all stages of production in order to produce one unit of product j for final use.

An input coefficient shows the rate at which an input from a certain product i is transformed into outputs of a certain industry j .

1.2. ESTIMATION OF SOCIO-ECONOMIC IMPACTS OF NAUTILOS

1.2.1 ASSUMPTIONS

As previously mentioned, for the NAUTILOS' technologies produced in the EU countries, the EU territory (before 2020, including the United Kingdom) was assumed as the target region for measuring the socio-economic impacts of the project results. Therefore, with the present work and the results here introduced **it is possible to estimate the impacts of the project on the EU economy**. Since 2019 is the latest year for which all the necessary indicators are available in Eurostat (European Statistical Office of the European Commission, and our data source for the European region), data was aggregated from the 28 EU countries (before 2020), where the United Kingdom (UK) was still included.

While we are aware that the current year is 2024, it is important to highlight that the specialised matrices and tables developed by official entities (Eurostat) that are required for this I-O study (which detail the overall structure of the European economy's sectoral and industrial linkages) are only published every few years, with the last one being published at the end of 2023 but related to 2019. Although some years have passed, these are the only methodological tools available for the EU region and should therefore be used in the scope of this study. Nevertheless, it was considered to be reasonable to expect that the overall structure of the European industrial linkages has not shifted dramatically in only a few years until 2024. On the other hand, for the technologies developed in Norway, Norway was considered as the target region. In this case, the data source used to extract all the indicators was Statistics Norway, which is responsible for providing statistics on Norwegian society, all of which refer to the same reference year (2019).

To estimate the socio-economic impacts of the commercialisation of the NAUTILOS technologies, it was necessary to group them into a single Economic activity/Group of products, of which "Computer, electronic and optical products" (European Classification of Products by Activity, CPA) was considered to be representative of all NAUTILOS technologies. This means that to estimate the direct, indirect, and induced socio-economic impacts of NAUTILOS, the average values of the economy for this specific category of products were taken into account. It was assumed that all technology developers are in the average of the EU and Norwegian economies.

¹ Mahajan, S. et al. "Handbook on Supply, Use and Input-Output Tables with Extensions and Applications," . United Nations. 74 (1), 2018, Studies in Methods (Series F), 978-92-1-1

Information on the commercialisation of each NAUTILOS technology was collected from each technology developer and commercial partner (NAUTILOS partners, Table 1), and 2029 was defined as the year to assess the socio-economic impacts of the NAUTILOS technologies in the economy. At the time of writing this report, it was not expected that all the technologies will reach TRL of 9 by the end of the project and therefore a period of five years was considered reasonable for the technologies to reach the necessary maturity for commercialisation (TRL 9). As a reminder, the input-output methodology provides annual economic variables, i.e. it makes no assumption as to whether the products will be sold before or after that year, only the specific occurrence in that year (in the present work, sales in 2029).

The calculation of the variables required some basic and common assumptions and the use of the tools available during the development of this tool (in 2023/2024) to carry out the socio-economic impact assessment:

(i) the structure of the European economy and its fundamental industrial linkages (to assess how the indirect and induced impacts spread throughout the economy and its sectors) are based on the most recent relevant tables and matrices published by Eurostat in 2023 concerning 2019.

(ii) the specific NAUTILOS data needed to feed the model (e.g. expected prices for sensors, costs) was estimated by partners that develop and intend to commercialise NAUTILOS instruments.

(iii) the specific year of the analysis (i.e. results) is expected to be 2029 (which was also used as a reference to estimate the number of units sold).

When it comes to this last part, some additional simplifications had to be made. As was mentioned before, the choice of 2029 as the point in time for the analysis had to do with the fact that it was the more realistic year in which all sensors are expected to be commercially available (TRL 9). This means that in order to apply the I-O methodology to this analysis, it had to be done essentially with the present (the year 2024) in mind (given the year of the data feeding the model), except for the number of units sold, but with the expectation that these results will occur in 2029 (when all the sensors will be commercially available).

As such, all prices (including costs) were assumed to remain constant between now and 2029. While prices naturally will not remain stable between both years, this assumption avoids any unforeseen distortions in the analysis introduced by different price level changes between different goods and services across the European economy. At the same time, it also allows for a more meaningful cost-benefit comparison between NAUTILOS sensors and other currently commercially available solutions, as both have the same reference point for the comparison.

1.2.2 DATA COLLECTION FROM PARTNERS

As mentioned above, information regarding the estimated socio-economic impacts associated with the commercialisation of each NAUTILOS technology was collected from the partners. The information was requested mainly by email, but in some cases in dedicated meetings, and included **estimated production (sales) in 2029, purchases (supplies) needed to achieve sales in 2029, employment in 2029, potential customers or market sectors, and cost-savings associated with the technology compared to the competition.** This data collection was a long process that began in mid-2022 and was completed by the end of May 2024. It required a high level of engagement with all the partners responsible for developing the technologies and involved regular contact and meetings with them.

Throughout the process, there were some challenges which were mainly related to partners' difficulties in estimating the impacts of the commercialisation of their respective technologies. Many partners encountered difficulties in providing socio-economic information, attributing this challenge to the inherent uncertainty of predicting outcomes so far into the future, specifically for the year 2029. Some of them even felt that it was sometimes a kind of "guesswork". Research organisations and universities generally found it more difficult to provide such prognoses compared to companies, which may be because they do not consider selling their products directly, and by M45 commercial agreements were not settled for all of them (despite many being advanced and to be reported in deliverable D11.7). They are therefore uncertain about potential technology adopters. Others struggled to articulate how their technology would enter the market, primarily due to some delays in technical performance already reported in the scope of NAUTILOS Periodic Report (PR).

For some technologies, there was the need to make certain assumptions to estimate the socio-economic impacts. Those assumptions are explained below:

- **Passive broadband acoustic recording sensor for noise monitoring and Passive acoustic event recorder (porpoise & dolphin clicks for abundance estimation) - Aquatec**

After discussions with Aquatec's team, led by Andy Smerdon, the Project Coordinator, Gabriele Pieri, and the WP11 leader - Catarina Lemos, it was decided to consider only one single device/product to sell which is the Passive device, that has three software options (Sound Recorder, Click Recorder, Combination of both) installed. So, a single socio-economic analysis was considered and presented in the results section. It is important to note that this was assumed although the NAUTILOS proposal and project refer to the development of two passive sensors, inclusively as mentioned in Table 1. This is because there is a device with three operating options and the software cannot be sold without the hardware (device itself).

- **Fluorometric Sensor and Dissolved Oxygen Sensor - HES-SO**

Regarding this sensor, the assumption was related to the country of production. There was an agreement between HESSO, which is responsible for development, and NKE, to partner in the commercialization of the sensors. So, it is considered that NKE will be producing the sensor units in France instead of producing them in Switzerland, in the headquarters of HESSO.

- **Dissolved Oxygen (WiSens TD-DO) and Fluorescence (WiSens TD_Ch1-a) Data Loggers - NKE**

NKE proposed the development of two data loggers to measure Biogeochemical and Biological variables, namely Dissolved Oxygen and Fluorescence (Chlorophyll-a) sensors. However, in the GA, these two data loggers were grouped under the same development and integration task (*ST3.1.2 and T5.3 respectively*), which gave the impression that they were a single technology. As the two data loggers developed by NKE (WiSens) are to be commercialised, two separated assessments were performed.

- **Microplastic sensors - NIVA + CSEM**

For the microplastic sensors, Norway was considered the country of production, even though NIVA does not have any production sites for larger volumes. This decision was made because the NAUTILOS Input-Output model only includes data for the EU-28 and Norway, and no relevant data for Switzerland (where CSEM is based) was available for 2019, the reference year for other regions. In fact, the country of production has not yet been defined, as the technology is still in development and so far, only two RTOs (Research and Technology Organisation) are involved. For possible product development, a commercialization partner should be identified. Concerning this sensor, NAUTILOS PR redefined this project outcome and divided it into 3 different results: sampling unit (NIVA), sensor unit (CSEM), and Sampler and Sensor (full device from NIVA and CSEM). While the performance of the single modules has been demonstrated, the integration of all modules is still pending. For the present

socio-economic assessment, considering 2029 as a reference year, the full device is regarded as a single exploitable result, as originally outlined in the NAUTILOS proposal.

1.2.3 DATA SOURCES

a) Eurostat

To develop the Input-Output model and estimate the socio-economic impacts of the NAUTILOS technologies produced in the EU, several datasets from the European Statistical Office of the European Commission (Eurostat) were used to extract the necessary indicators for the estimations, namely:

1. Input coefficients² (Figure 3), output multipliers³ (Figure 4), and Use Table at Basic Prices⁴ (Figure 5), from the Database for ESA supply, use and input-output tables⁵.
2. Employment by gender, age and detailed economic activity (from 2008 onwards, NACE Rev. 2 two-digit level) – 1000⁶

All necessary indicators were extracted or derived from these datasets to estimate direct, indirect and induced impacts over the EU economy. The first was used to estimate impacts on production, gross value added (GVA), salaries, employment, and imports. The second was also used to estimate impacts on employment.

² [Statistics | Eurostat \(europa.eu\)](#)

³ [Statistics | Eurostat \(europa.eu\)](#)

⁴ [Statistics | Eurostat \(europa.eu\)](#)

⁵ [Database - ESA supply, use and input-output tables - Eurostat \(europa.eu\)](#)

⁶ [Statistics | Eurostat \(europa.eu\)](#)

	A	B	C	D	E	F	G	H	I	J
1	Data extracted on 10/04/2023 17:57:42 from [ESTAT]									
2	Dataset: Input coefficients [NAIO_10_COIN_custom_5726235]									
3	Last updated: 17/04/2020 23:00									
4										
5	Time frequency		Annual							
6	Unit of measure		Number							
7	Stock or flow		Total							
8	Geopolitical entity (reporting)		European Union - 28 countries (2013-2020)							
9	Time		2019							
10										
11	INDUSE (Labels)	Products of agriculture, hunting and r	Products of forestry, logging and relat	Fish and other fishing products; aquac	Mining and quarrying	Food, beverages and tobacco products	Textiles, wearing apparel, leather and	Wood and of products of wood and co	Paper and paper products	Printing and recording services
12	PROD_NA (Labels)									
13	Products of agriculture, hunting and r	0,13	0,05	0,01	0	0,2	0,01	0	0	0
14	Products of forestry, logging and relat	0	0,22	0	0	0	0	0,11	0,03	0
15	Fish and other fishing products; aquac	0	0	0,05	0	0	0	0	0	0
16	Mining and quarrying	0	0	0	0,08	0	0	0	0,01	0
17	Food, beverages and tobacco products	0,09	0	0,07	0	0,18	0,01	0	0	0
18	Textiles, wearing apparel, leather and	0	0	0,01	0	0	0,25	0	0,01	0
19	Wood and of products of wood and co	0	0,01	0	0	0	0	0,2	0,02	0
20	Paper and paper products	0	0	0	0	0,01	0,01	0,01	0,23	0
21	Printing and recording services	0	0	0	0	0	0	0	0,01	0
22	Coke and refined petroleum products	0,02	0,01	0,05	0,27	0	0	0	0	0
23	Chemicals and chemical products	0,05	0,01	0,02	0,01	0,01	0,05	0,03	0,05	0
24	Basic pharmaceutical products and ph	0	0	0	0	0	0	0	0	0
25	Rubber and plastic products	0,01	0	0,01	0	0,01	0,01	0,01	0,02	0
26	Other non-metallic mineral products	0	0	0	0,01	0,01	0	0,01	0	0
27	Basic metals	0	0	0	0,01	0	0	0	0	0
28	Fabricated metal products, except ma	0,01	0	0,01	0,01	0,01	0,01	0,01	0,01	0
29	Computer, electronic and optical prod	0	0	0	0	0	0	0	0	0
30	Electrical equipment	0	0	0	0	0	0	0	0	0
31	Machinery and equipment n.e.c.	0	0,01	0,01	0,02	0	0,01	0	0,01	0
32	Motor vehicles, trailers and semi-trail	0	0	0	0	0	0	0	0	0

Figure 3 - Print screen of the table of Input coefficients (2019) - Input coefficients [NAIO_10_COIN_custom_5726235]

	A	B	C	D	E	F	G	H	I	J	
1	Data extracted on 10/04/2023 17:53:46 from [ESTAT]										
2	Dataset: Output multipliers [NAIO_10_COOOUT_custom_5726174]										
3	Last updated: 17/04/2020 23:00										
4											
5	Time frequency	Annual									
6	Unit of measure	Number									
7	Stock or flow	Total									
8	Geopolitical entity (reporting)	European Union - 28 countries (2013-2020)									
9	Time	2019									
10											
11	INDUSE (Labels) Products of agriculture, f Products of forestry, logg Fish and other fishing pri Mining and quarrying Food, beverages and tob Textiles, wearing apparel Wood and of products of Paper and paper product Printing and recording										
12	PROD_NA (Labels)										
13	Products of agriculture, hunting and r	1,18	0,05	0,03	0	0,29	0,03	0,01	0,01	0,	
14	Products of forestry, logging and relat	0	1,29	0	0	0	0	0,18	0,06	0,	
15	Fish and other fishing products; aquac	0	0	1,06	0	0,01	0	0	0	0,	
16	Mining and quarrying	0,04	0,02	0,06	1,29	0,03	0,02	0,03	0,04	0,	
17	Food, beverages and tobacco product	0,14	0,01	0,1	0,01	1,26	0,02	0,01	0,01	0,	
18	Textiles, wearing apparel, leather and	0	0	0,02	0	0	1,34	0,01	0,02	0,	
19	Wood and of products of wood and co	0,01	0,01	0,01	0,01	0,01	0,01	1,26	0,04	0,	
20	Paper and paper products	0,01	0,01	0,01	0,01	0,03	0,02	0,02	1,31	0,	
21	Printing and recording services	0	0	0	0	0	0	0	0,01	1,	
22	Coke and refined petroleum products	0,05	0,03	0,09	0,41	0,03	0,02	0,03	0,03	0,	
23	Chemicals and chemical products	0,09	0,02	0,05	0,05	0,05	0,1	0,07	0,11	0,	
24	Basic pharmaceutical products and ph	0,01	0	0	0	0	0	0	0	0,	
25	Rubber and plastic products	0,02	0,01	0,02	0,02	0,03	0,03	0,02	0,04	0,	
26	Other non-metallic mineral products	0,01	0	0,01	0,02	0,01	0,01	0,02	0,01	0,	
27	Basic metals	0,01	0,01	0,01	0,03	0,01	0,02	0,02	0,02	0,	
28	Fabricated metal products, except ma	0,02	0,01	0,02	0,03	0,02	0,02	0,03	0,02	0,	
29	Computer, electronic and optical prod	0	0	0,01	0,01	0,01	0,01	0,01	0,01	0,	
30	Electrical equipment	0,01	0	0,01	0,01	0,01	0,01	0,01	0,01	0,	
31	Machinery and equipment n.e.c.	0,01	0,02	0,02	0,04	0,01	0,02	0,02	0,02	0,	
32	Motor vehicles, trailers and semi-trail	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,	

Figure 4-Print screen of the table of Output multipliers (2019) - Output multipliers [NAIO_10_COOOUT_custom_5726174].

	A	B	C	D	E	F	G	H	I	J
1	Data extracted on 10/04/2023 18:00:47 from [ESTAT]									
2	Dataset:	Use table at basic prices [NAIO_10_CP1610__custom_5726263]								
3	Last updated:	23/03/2023 23:00								
4										
5	Time frequency	Annual								
6	Unit of measure	Million euro								
7	Stock or flow	Total								
8	Geopolitical entity (reporting)	European Union - 28 countries (2013-2020)								
9	Time	2019								
10										
11										
12	INDUSE (Labels)	Crop and animal products	Forestry and logging	Fishing and aquaculture	Mining and quarrying	Manufacture of food products	Manufacture of textiles, wearing apparel, leather and other products	Manufacture of wood and wood products	Manufacture of paper and printing and reproduction	
13	PROD_NA (Labels)									
14	Products of agriculture, hunting and fishing	61 981,81	0,05	54,59	13,24	230 786,75	2 590,94	49,84	49,36	3,0
15	Products of forestry, logging and related products	695,73	12 091,33	17,78	57,82	437,49	9,9	15 676,59	5 750,7	20,0
16	Fish and other fishing products; aquaculture products	24,93	5,08	834,3	-0,05	5 310,31	8,07	0,13	0,16	
17	Mining and quarrying	1 445,46	36,4	73,04	16 227,85	3 048,45	360,75	83,4	1 539,89	71,0
18	Food, beverages and tobacco products	45 347	46,36	1 044,2	208,76	208 805,5	2 002,45	77,95	685,76	35,0
19	Textiles, wearing apparel, leather and other products	639,48	68,98	210,01	94,6	812,11	58 734,82	342,95	1 473,2	509,0
20	Wood and of products of wood and cork, except charcoal; wood charcoal	1 127	259,32	75,26	319,88	1 869,92	178,07	29 541,75	3 671,18	107,0
21	Paper and paper products	612,05	28	40,2	217,29	15 015,38	1 226,6	1 306,25	43 998,19	13 669,0
22	Printing and recording services	68,14	12,19	10,03	70,33	1 264,43	279,15	99,14	803,39	6 894,0
23	Coke and refined petroleum products	9 576,71	635,16	773,04	58 630,21	2 308,22	353,12	462,91	438,44	124,0
24	Chemicals and chemical products	24 009,84	230,02	297,43	1 598,41	9 714,13	9 845,33	4 155,61	8 658,47	3 206,0
25	Basic pharmaceutical products and pharmaceutical preparations	1 555,23	0,29	38,83	0,89	1 464,27	13,39	1,25	5,86	0,0
26	Rubber and plastic products	2 864,81	73,1	100,13	501,63	16 732,67	3 064,98	1 203,67	3 403,65	1 563,0
27	Other non-metallic mineral products	1 440,88	47,91	53,55	1 483,56	5 829,4	437,6	1 828,33	138,28	6,0
28	Basic metals	175,28	24,28	7,31	1 032,71	1 086,37	251,64	411,64	427,77	188,0
29	Fabricated metal products, except machinery and equipment	2 423,74	144,49	89,89	1 525,48	7 313,77	1 220,65	1 849,22	991,64	414,0
30	Computer, electronic and optical products	112,7	21,53	39,05	194,78	363,91	81,5	52,68	132,41	424,0
31	Electrical equipment	351,88	27,63	39,53	243,54	637,41	144,11	127,4	228,16	84,0
32	Machinery and equipment n.e.c.	2 194,28	488,51	128,33	4 374,74	3 521,63	1 086,49	468,1	1 010,53	679,0
33	Motor vehicles, trailers and semi-trailers	712,88	211,48	18,07	122,92	386,39	59,16	126,55	21,29	5,0

Figure 5-Print screen of the Use table at basic prices (2019) - Use table at basic prices [NAIO_10_CP1610__custom_5726263].

b) Statistics Norway

To comprehensively analyse the socio-economic impacts of the technologies developed in Norway and build the NAUTILOS input-output model tailored to the Norwegian context, datasets sourced from Statistics Norway⁷ were employed, namely the Symmetric Input-Output Table for 2019 (Figure 6). In addition, another dataset was integrated to estimate impacts on production, gross value added (GVA), employment, imports and salaries. The number of employment and earnings⁸ dataset was also used to extract indicators to estimate the impact on employment.

⁷ [Supply and Use and Input-Output tables \(ssb.no\)](https://ssb.no)

⁸ [12314: Employees, jobs, earnings, and earnings index, by industry division \(88 groups, SIC2007\) 2016K1 - 2023K3. Statbank Norway \(ssb.no\)](https://ssb.no)

21	A	B	C	D	E	F	G	H	I	J	K	L
22	UENUM:	IN	Date:	22 December 2021								
23												
24	Transaction	Uses			Transaction	P2	P2	P2	P2	P2	P2	P2
25	(3 quadrant)	#Res.			Reporting Sector:	S1	S1	S1	S1	S1	S1	S1
26					PRODUCTS (CPA*64)	Products of agriculture, hunting and related services	Products of forestry, logging and related services	Fish and other fishing products; aquaculture products: support services to	Mining and quarrying	Food products, beverages and tobacco products	Textiles, wearing apparel and leather products	Wood and of products and cork, except for articles of straw and
27					PRODUCTS (CPA*64)	R01	R02	R03	RB	R10_12	R13_15	R16
28					R01	147,93	3,39	3,26	6,37	3979,24	27,39	0,84
29	1				R02	16,59	173,06	0,16	0,20	0,16	0,01	237,03
30	1				R03	4,90	0,00	1300,88	4,24	3243,20	0,29	0,60
31	1				RB	19,17	0,95	50,40	1967,57	102,91	1,94	22,73
32	1				R10_12	721,19	0,52	2015,71	95,09	5961,32	14,89	39,87
33	1				R13_15	5,77	0,30	61,56	57,15	25,30	112,02	6,56
34	1				R16	3,48	0,04	8,34	11,91	10,96	0,30	574,02
35	1				R17	21,84	0,06	29,47	4,57	99,18	1,50	10,44
36	1				R18	0,58	0,01	4,01	1,62	4,07	0,47	1,10
37	1				R19							
38	1				R20							
39	1				R21	307,85	20,94	379,53	574,97	113,32	25,00	75,55
40	1				R22	47,88	4,77	36,40	86,98	294,93	6,31	20,78
41	1				R23	6,33	0,47	14,08	199,29	26,31	0,99	64,25
42	1				R24	0,20	0,02	10,42	341,94	3,97	11,31	30,78
43	1				R25	20,35	6,62	97,86	467,43	122,59	7,07	50,29
44	1				R26	4,86	3,50	24,04	116,59	9,76	4,46	4,28
45	1				R27	5,27	3,03	45,84	107,67	22,59	4,36	11,33
46	1				R28	7,48	8,04	232,00	1366,11	80,40	2,89	29,52
47	1				R29	0,17	0,11	1,06	31,97	2,28	0,10	0,53
48	1				R30	0,38	0,13	47,33	597,10	13,73	1,27	7,72
49	1				R31_32	2,37	0,60	17,47	10,35	9,19	15,20	5,75
50	1				R33	8,44	10,39	180,12	352,89	260,62	23,97	51,81
51	1				RD	94,55	10,02	53,91	412,78	190,61	6,66	35,46
52	1				R36	0,04	0,03	0,09	2,05	3,53	0,27	0,26

Figure 6 - Print screen of the Symmetric input-output table at basic prices (industry) (2019)

1.2.4 NAUTILOS INPUT-OUTPUT MODEL

The direct, indirect and induced impacts of the NAUTILOS project were estimated using an input-output model developed based on the data sources mentioned in the previous sections. Two different Input-output models were developed: one for the EU-28 and one for Norway. The estimated impacts, based on the Eurostat definition, were as follows:

- **Production** – represents the value of the output of an activity carried out under the control, responsibility and management of an institutional unit. This activity involves the use of resources such as goods, labour, capital, and services to produce goods and services.
- **Gross Value Added (GVA)** - defines the output value at basic prices less intermediate consumption valued at purchaser prices. In other words, it represents the extra value added to goods and services gained through the production process.

- **Employment Full-Time Equivalent (FTE)** - measures employees or students in a way that makes them comparable although they may work or study different numbers of hours per week. The unit is obtained by comparing the average number of hours worked by an employee or student with the average number of hours worker or student, valued at 40 hours per week.
- **Salaries** – consists of the total remuneration, in cash or kind, paid by an employer to an employee for the work performed by the latter during an accounting period.
- **Imports** – depicts the transactions of goods and services (sales, barter, gifts, or grants) from non-residents to residents.
- **Exports** – correspond to the transactions in goods and services (sales, barter, gifts, or grants) from residents to non-residents.

As mentioned earlier, average values of the Economy of EU-28 and Norway were used to determine impacts on each of the variables, being the estimated production in 2029 the basis for all the calculations, except for exports.

Constructing the I-O Model

The data collected (as mentioned previously) was adapted and incorporated as intermediary and/or auxiliary steps during the construction of the model, developed in the scope of the NAUTILOS project. These involved some important information such as, for example, the output multipliers matrix and the input coefficients matrix, both necessary to calculate indirect and induced effects in the economy (Figure 7). As a reminder, an output multiplier for an industry j is defined as the total value of production in all industries of the economy that is necessary for all stages of production in order to produce one unit of product j for final use. An input coefficient shows the rate at which an input from a certain product i is transformed into outputs of a certain industry j .

With the help of these coefficients (and some other variables), we are able to estimate, for example, how selling X euros worth of an optical sensor leads to Y euros of sales in all the supplying sectors (i.e. indirect impacts in sectors such as, for example, metal structures or glass production) or Z euros of salaries in all the economy (i.e. induced impacts).

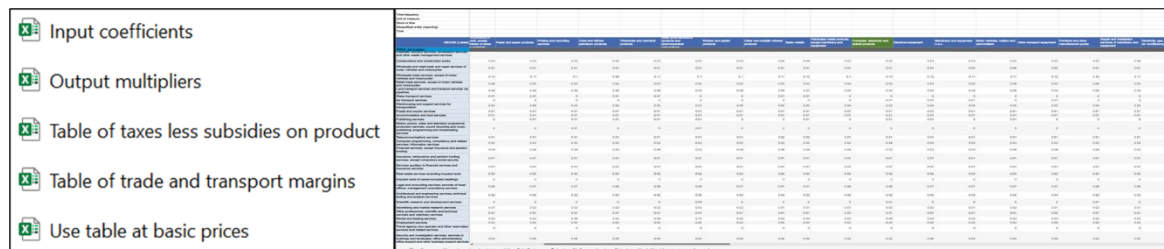


Figure 7 - Examples of Eurostat tables and matrices adapted and incorporated into the I-O Model.

2. RESULTS AND ANALYSIS

2.1 SOCIO-ECONOMIC IMPACTS OF EACH TECHNOLOGY

I) FLUOROMETRIC DISSOLVED OXYGEN SENSOR (HES-SO)

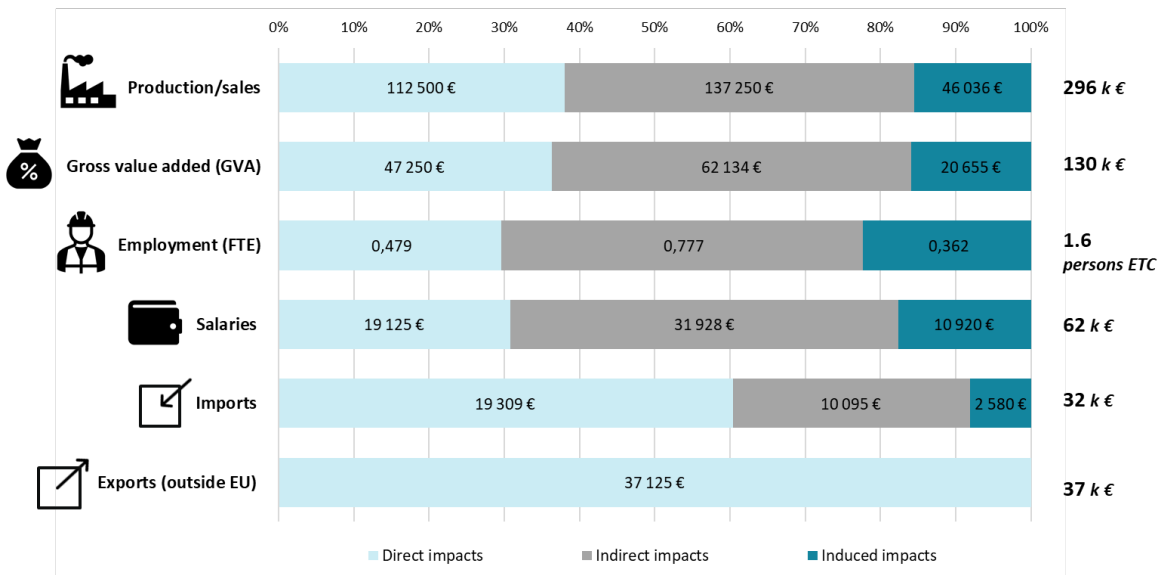


Figure 9 - Fluorometric sensors (HESSO) socio-economic impact results.

Regarding HESSO's Fluorometric sensors, the estimated partner turnover in 2029 is about 113,000 euros (Figure 9).

Considering all the broader socioeconomic influences, which encompass both indirect and induced impacts, it becomes evident that this economic activity has a substantial influence throughout the entire value chain. Specifically, the overall production in the economy is anticipated to amount to approximately 296,000 euros, with the Gross Value Added (GVA) expected to represent about 44% of that figure, totalling around 130,000 euros. Moreover, the upstream effects are prominently observed in terms of wages, with indirect effects contributing more than half of the total value.

When considering only the direct impacts, it's important to highlight again that this particular device is projected to yield a relatively substantial margin, as indicated by its Gross Value Added (GVA), constituting approximately 41% of its turnover. Additionally, this level of sales is anticipated to support approximately 0.5 full-time equivalent (FTE) jobs, while exports outside the EU are also substantial, amounting to roughly one-third of the turnover.

II) DISSOLVED OXYGEN DATA LOGGER | WISENS TD -DO (NKE)

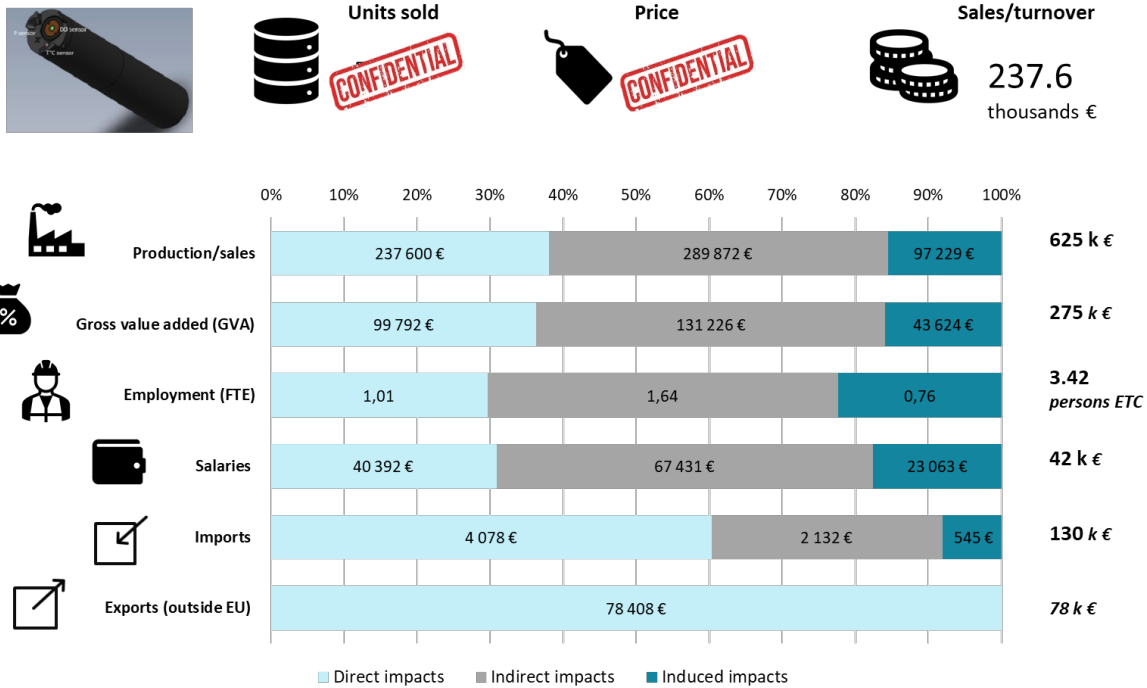


Figure 10 – Dissolved Oxygen Data Logger (NKE) socio-economic impact results.

Regarding NKE’s Dissolved Oxygen Data Logger, the partner expects a turnover of 237,600 euros in 2029 (Figure 10).

Taking into account the wider socioeconomic influences, including both indirect and induced impacts, it's clear that this economic activity has a significant impact across the entire value chain. Overall production in the economy is expected to reach approximately 625,000 euros, with the Gross Value Added (GVA) making up about 44% of that, totalling around 275,000 euros. Notably, the upstream effects, especially in terms of wages, are significant, with indirect effects contributing more than half of the total value.

Focusing solely on the direct impacts, it's worth emphasising again that this specific device is projected to yield a substantial margin, with its Gross Value Added (GVA) constituting approximately 41% of its turnover. Furthermore, this level of sales is expected to support approximately 1,01 full-time equivalent (FTE) jobs, and exports outside the EU are also significant, making up roughly one-third of the turnover.

III) FLUORESCENCE DATA LOGGER | WISENS TD – CHL-A (NKE)

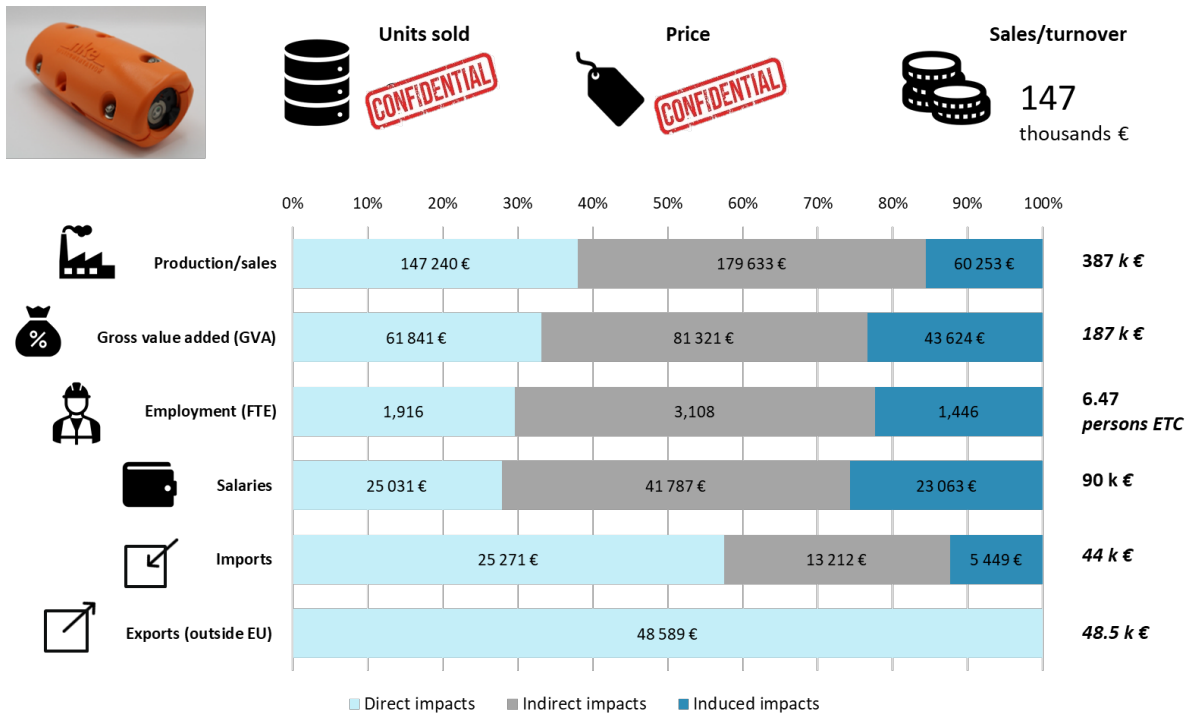


Figure 11 – Fluorescence Data Logger (NKE) socio-economic impact results.

Concerning the Fluorescence data logger WiSens TD-Chl-a, NKE estimates that the sales in 2029 will result in a total revenue of 147,000 euros (Figure 11).

Considering broader economic factors, including both indirect and induced impacts, it's estimated that the production in the economy related to these sensors will reach around 387,000 euros, with Gross Value Added (GVA) making up about 48% of that sum, totalling approximately 187,000 euros. Additionally, indirect effects, particularly in terms of wages, contribute about half of the total value.

Focusing solely on the direct impacts, it's worth noting again that these data loggers are expected to generate a considerable margin, with their Gross Value Added (GVA) representing approximately 41% of their turnover. Furthermore, the sales of these sensors are projected to support around 1.9 full-time equivalent (FTE) jobs, and exports outside the EU are significant, accounting for one-third of the revenue.

IV) SILICATE ELECTROCHEMICAL SENSOR (NKE)

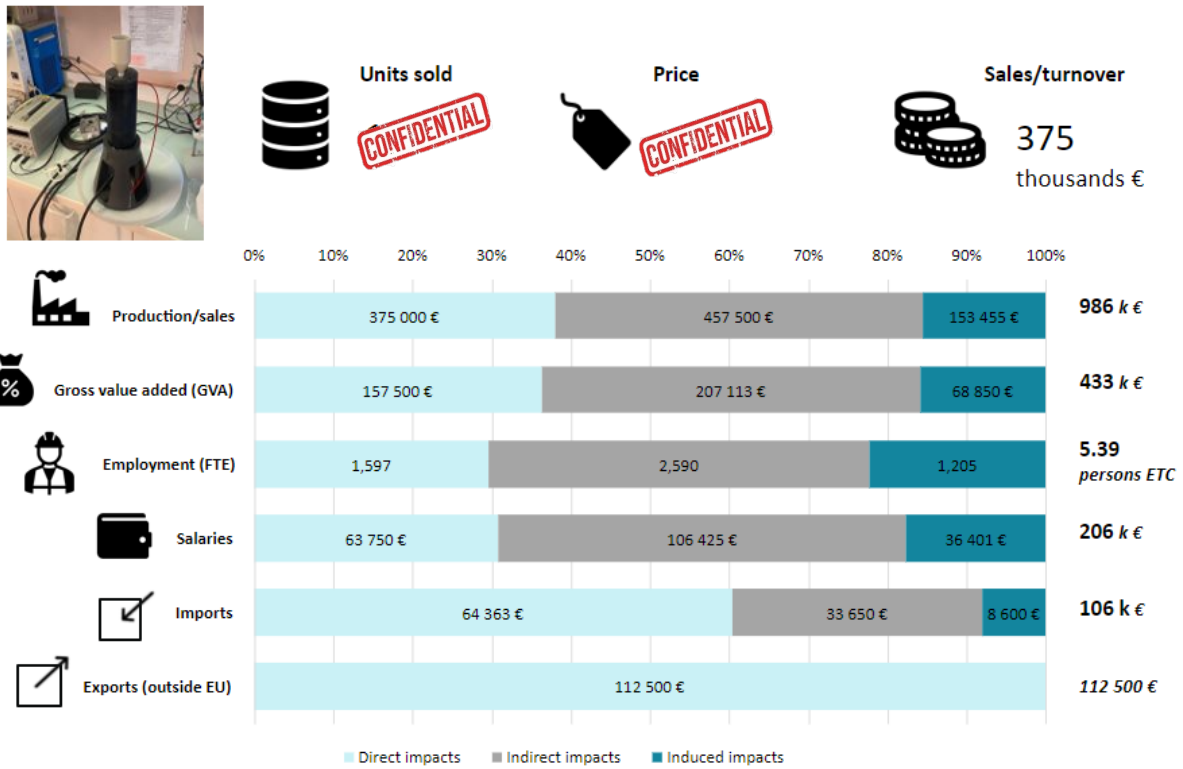


Figure 12 - Silicate Electronic sensor (NKE) socio-economic impact results

Regarding NKE’s Silicate Electronic sensor, the projected turnover in 2029 is estimated to be 375,000 euros (Figure 12).

Considering broader economic factors, including both indirect and induced impacts, it's estimated that the production in the economy related to these sensors will reach around 986,000 euros, with Gross Value Added (GVA) making up about 52% of that sum, totalling approximately 433,000 euros. Additionally, indirect effects, particularly in terms of wages, contribute more than half of the total value.

Focusing solely on the direct impacts, it's worth noting again that these sensors are expected to generate a considerable margin, with their Gross Value Added (GVA) representing approximately 42% of their turnover. Furthermore, the sales of these sensors are projected to support around 1.6 full-time equivalent (FTE) jobs, and exports outside the EU are significant, accounting for approximately one-third of the revenue.

V) MICROPLASTIC SENSORS (NIVA+CSEM)

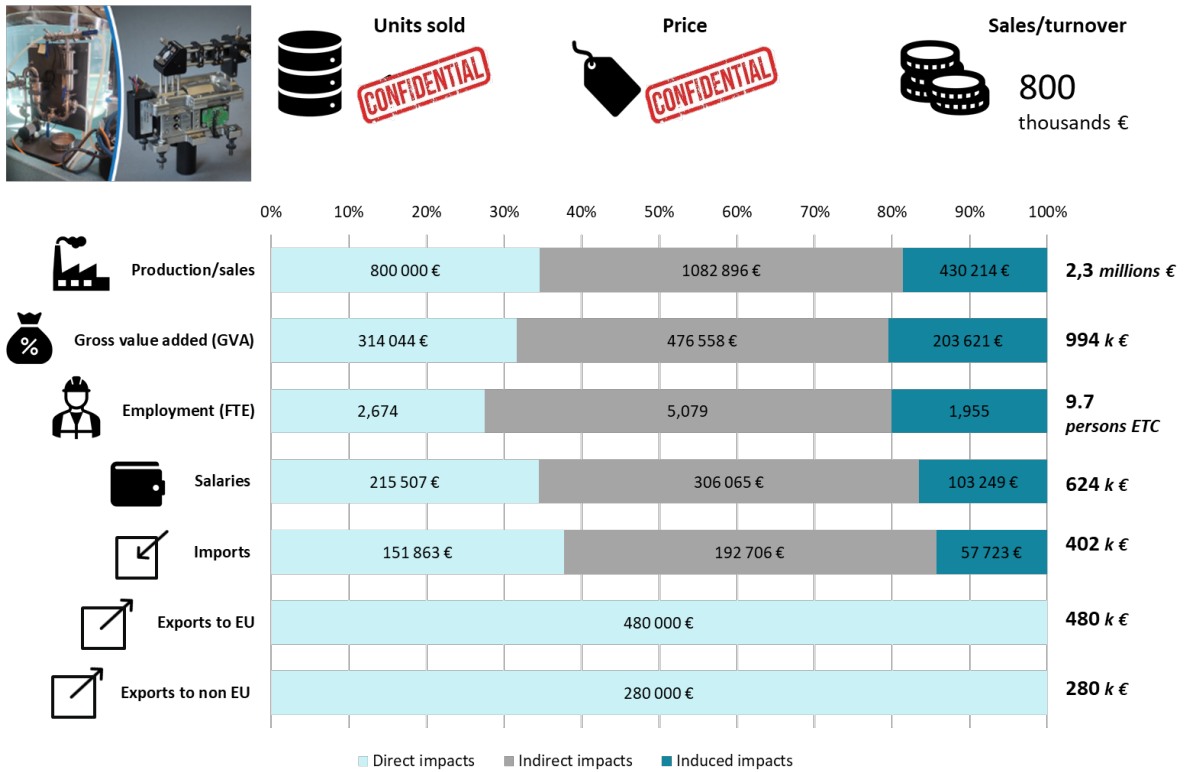


Figure 13 - Microplastic sensors (NIVA & CSEM) socio-economic impact results.

Concerning NIVA/CSEM’s Microplastic sensors, the partner estimates that the sales in 2029 would generate a total revenue of 800,000 euros (Figure 13).

Considering broader economic factors, encompassing both indirect and induced impacts, the overall production related to these sensors in the economy is estimated to reach approximately 2,300,000 euros. Gross Value Added (GVA) contributes about 43% of this total, amounting to around 994,000 euros, with indirect effects, particularly in wages, making up more than half of the total value.

Looking specifically at the direct impacts, it's important to highlight once more that these sensors are expected to yield a significant margin. Their Gross Value Added (GVA) accounts for approximately 39% of their revenue. Additionally, the sale of these sensors is forecasted to support approximately 2.7 full-time equivalent (FTE) jobs, and exports outside the EU are substantial, making up more than one-third of the revenue.

VI) PASSIVE DEVICE | CLICK AND SOUND RECORDER (AQUATEC)

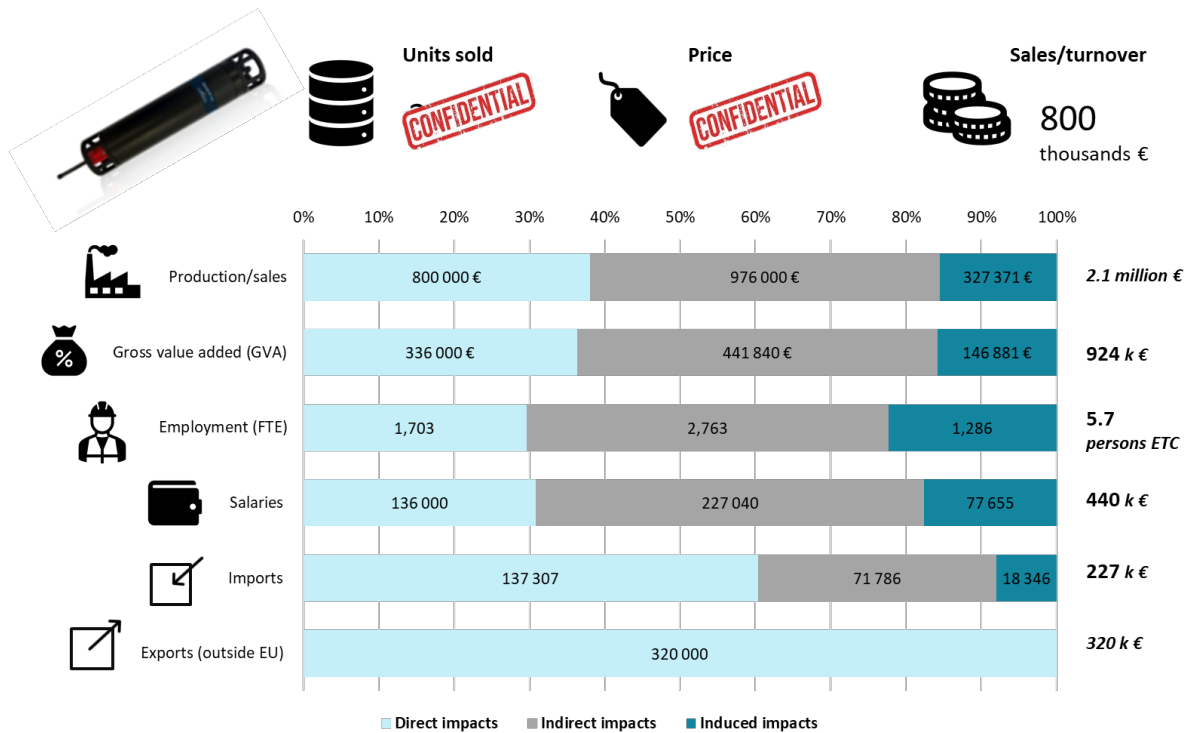


Figure 14 – Passive device (AQUATEC) socio-economic impact results.

Concerning Aquatec’s Passive device, Click and Sound Recorder, the sales projections made by the partner indicate the turnover will reach 800,000 euros in 2029 (Figure 14).

Taking into account the broader socioeconomic impacts, including both indirect and induced impacts, it becomes evident that this economic activity exerts significant influence across the entire value chain. Overall production in the economy is expected to reach approximately 2,100,000 euros, with Gross Value Added (GVA) constituting about 44% of that figure, totalling around 924,000 euros. Notably, the upstream effects are particularly apparent in terms of wages, with indirect effects contributing more than half of the total value.

When focusing solely on the direct impacts, it's worth emphasising once more that this specific device is anticipated to generate a considerable margin, with its Gross Value Added (GVA) representing approximately 42% of its turnover. Furthermore, this level of sales is expected to sustain approximately 1.7 full-time equivalent (FTE) jobs, and exports outside the EU are also considerable, accounting for more than one-third of the turnover.

VII) ACTIVE ACOUSTIC PROFILING DATA LOGGER | AQUASCAT MK2 (AQUATEC)

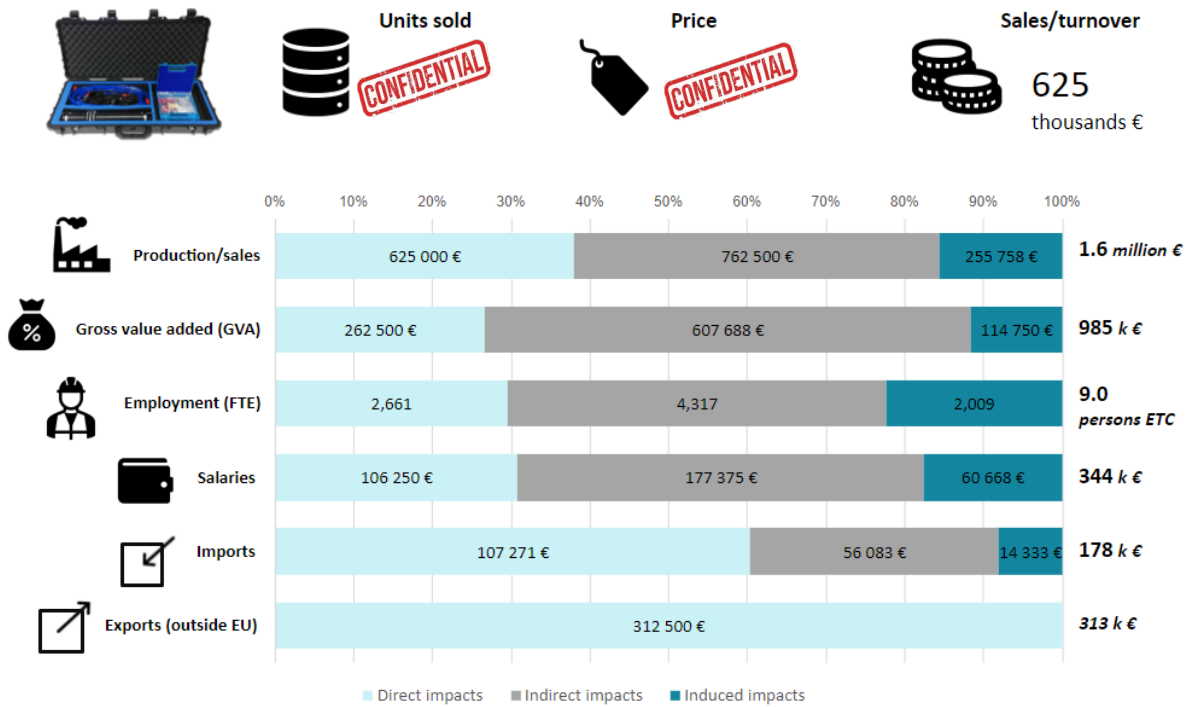


Figure 15 - Active Acoustic Profiling data logger (Aquatec) socio-economic impact results.

Regarding Aquatec’s Active Acoustic Profiling data logger, AQUAscet Mk2, the partner's total turnover in 2029 is expected to be about 625,000 euros (Figure 15).

Considering the wider socioeconomic impacts, which include both indirect and induced effects, it's clear that this economic activity significantly influences the entire value chain. Overall production in the economy is forecasted to be around 1,600,000 euros, with Gross Value Added (GVA) making up about 62% of that, totalling approximately 985,000 euros. Notably, the upstream effects, especially in terms of wages, are significant, with indirect effects contributing more than half of the total value.

When focusing solely on the direct impacts, it's important to highlight once again that this specific device is expected to yield a substantial margin, with its Gross Value Added (GVA) representing approximately 42% of its turnover. Additionally, this level of sales is projected to support approximately 2.6 full-time equivalent (FTE) jobs, and exports outside the EU are also significant, constituting half of the turnover.

VIII) SUBMERSIBLE SAMPLER FOR NANOPLASTICS AND MICROPLASTICS (SCT)

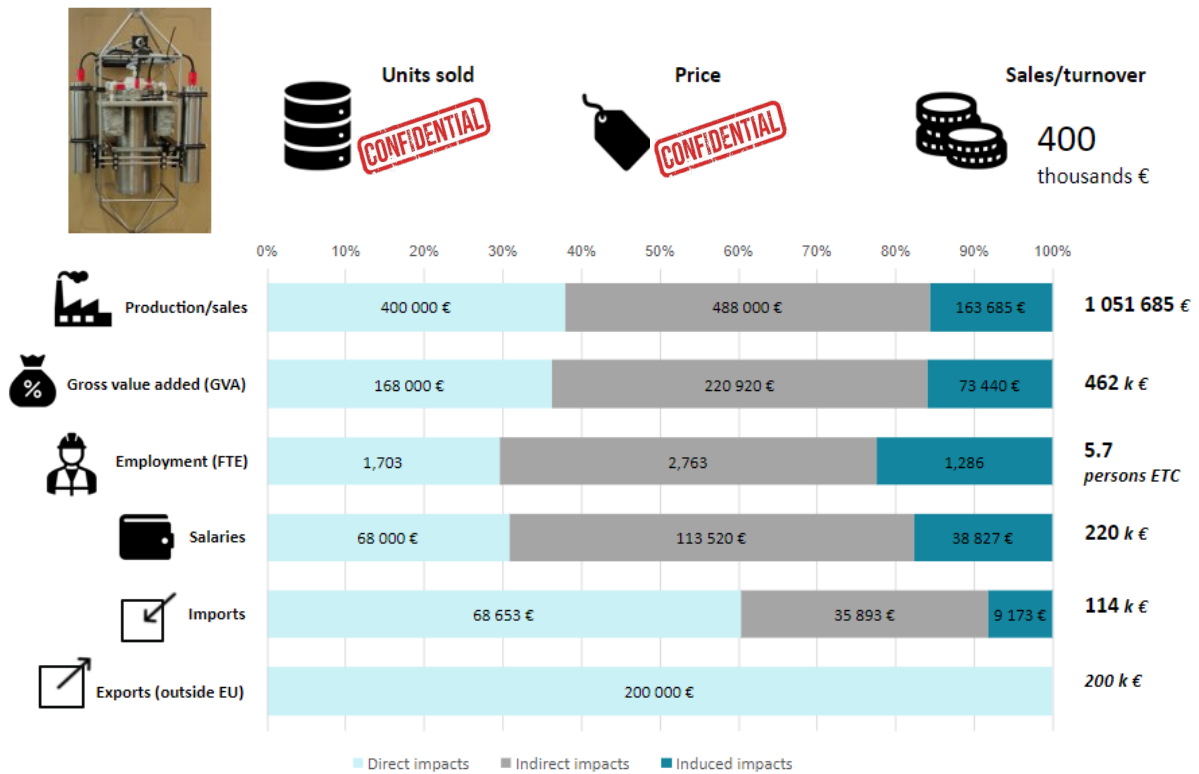


Figure 16 – Sampler for Nanoplastics and Microplastics (SCT) socio-economic impact results.

Regarding the Sampler for Nanoplastics and Microplastics, the sales made by SCT in 2029 are expected to result in a total turnover of 400,000 euros (Figure 16).

Looking at the broader socioeconomic effects, which encompass both indirect and induced impacts, it's evident that this economic activity has a significant influence throughout the entire value chain. The overall production in the economy is expected to reach about 1,051,000 euros, with Gross Value Added (GVA) accounting for approximately 46% of that, totalising around 462,000 euros. Particularly noteworthy are the upstream effects, especially regarding wages, where indirect impacts contribute about half of the total value.

When focusing solely on the direct effects, it's worth emphasising once more that this particular device is anticipated to generate a substantial margin, with its Gross Value Added (GVA) representing approximately 42% of its turnover. Moreover, this level of sales is estimated to sustain approximately 1.7 full-time equivalent (FTE) jobs, and exports outside the EU are also significant, comprising half of the turnover.

IX) DEEP OCEAN CTD SENSOR (UL-FE)

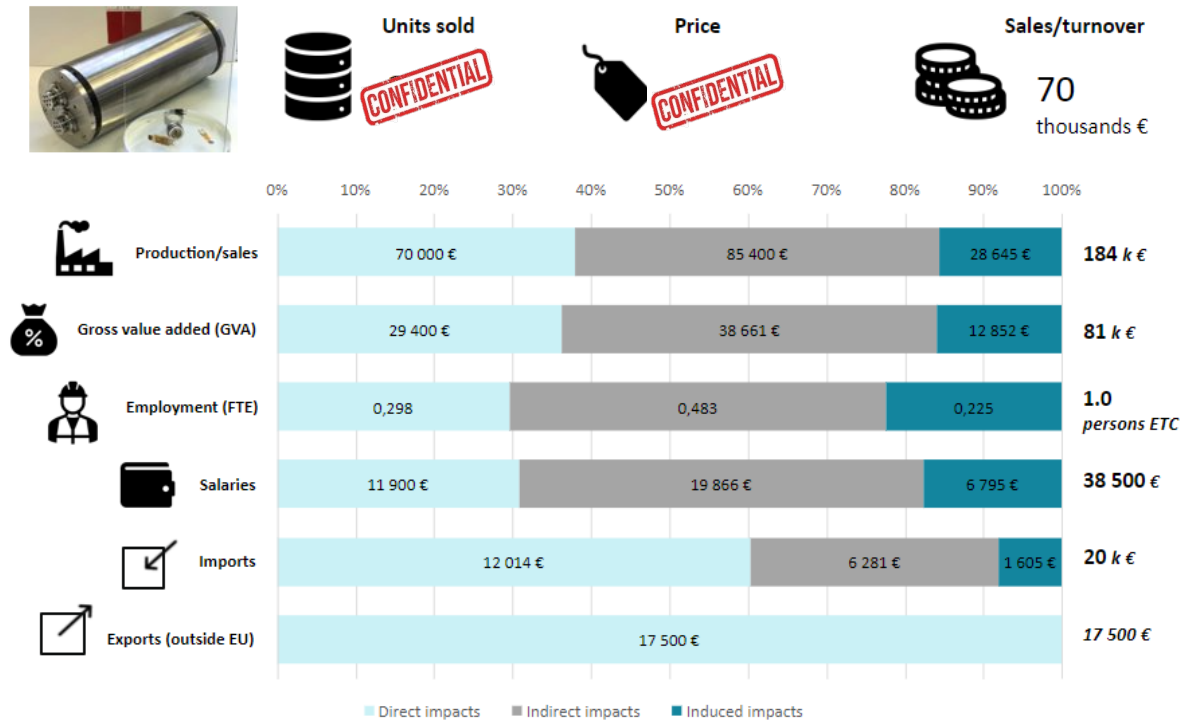


Figure 17 – Deep Ocean CTD (UL-FE) socio-economic impact results.

As for UL-FE’s Deep Ocean CTD, the partner sales projections indicate that the total turnover will in 2029 reach 70,000 euros (Figure 17).

Considering the broader socioeconomic impacts, which include both indirect and induced effects, it's clear that this economic activity has a significant influence across the entire value chain. The overall production in the economy is expected to reach approximately 184,000 euros, with Gross Value Added (GVA) constituting about 44% of that figure, totalising around 81,000 euros. In terms of wages, the indirect impacts contribute to about half of the total value.

When focusing solely on the direct effects, it's important to highlight once more that this specific device is expected to generate a significant margin, with its Gross Value Added (GVA) representing 42% of its turnover. Additionally, this level of sales is estimated to sustain approximately 0.3 full-time equivalent (FTE) jobs, and exports outside the EU are also significant, comprising one-quarter of the turnover.

X) DEEP OCEAN RADIOACTIVITY DATA LOGGER (HCMR)

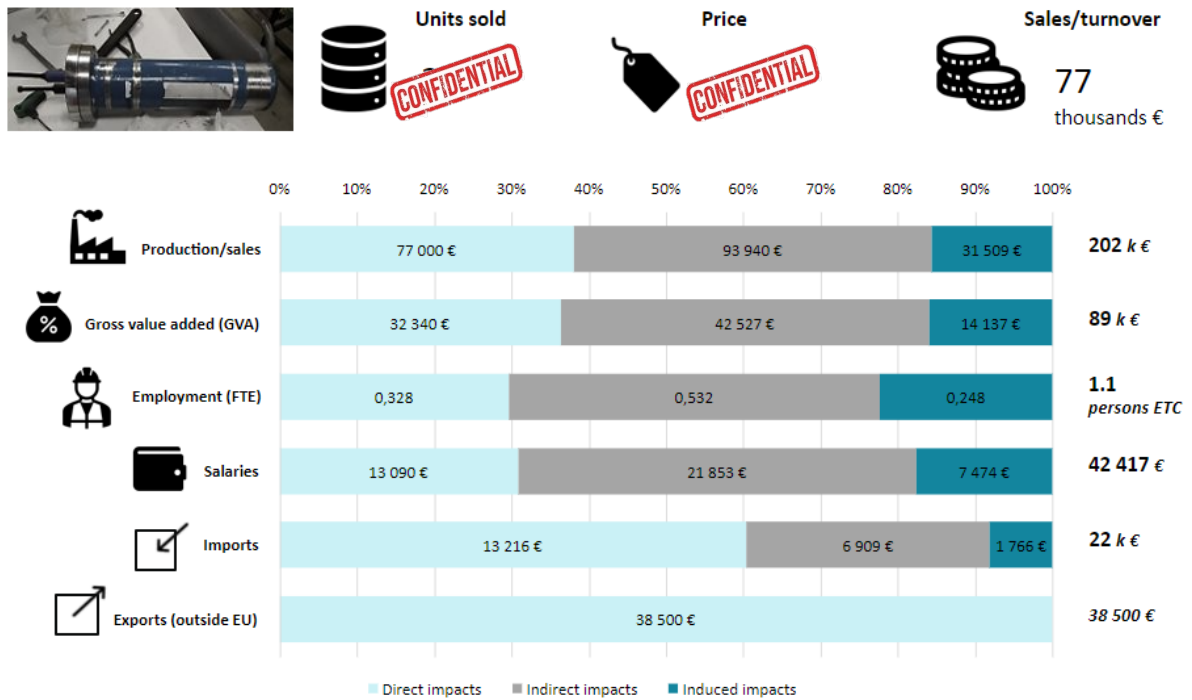


Figure 18 – Deep Ocean low-level radioactivity data logger (HCMR) socio-economic impact results.

As for HCMR’s Deep Ocean low-level radioactivity data logger, the partner estimates that the sales in 2029 will generate a revenue of 77,000 euros (Figure 18).

The overall production in the economy is expected to reach approximately 202,000 euros, with Gross Value Added (GVA) constituting about 44% of that figure, totalising around 89,000 euros. In terms of wages, the indirect impacts contribute to about half of the total value.

When focusing solely on the direct effects, it's important to highlight once more that this specific device is expected to generate a significant margin, with its Gross Value Added (GVA) representing 42% of its turnover. Additionally, this level of sales is estimated to sustain approximately 0.3 full-time equivalent (FTE) jobs, and exports outside the EU are also significant, comprising half of the turnover.

XI) NON-INVASIVE ANIMAL TOWED TAGGING SYSTEM USED FOR ANIMALS SUCH AS MANTA RAYS AND SHARKS | MAANTA (CEiIA)

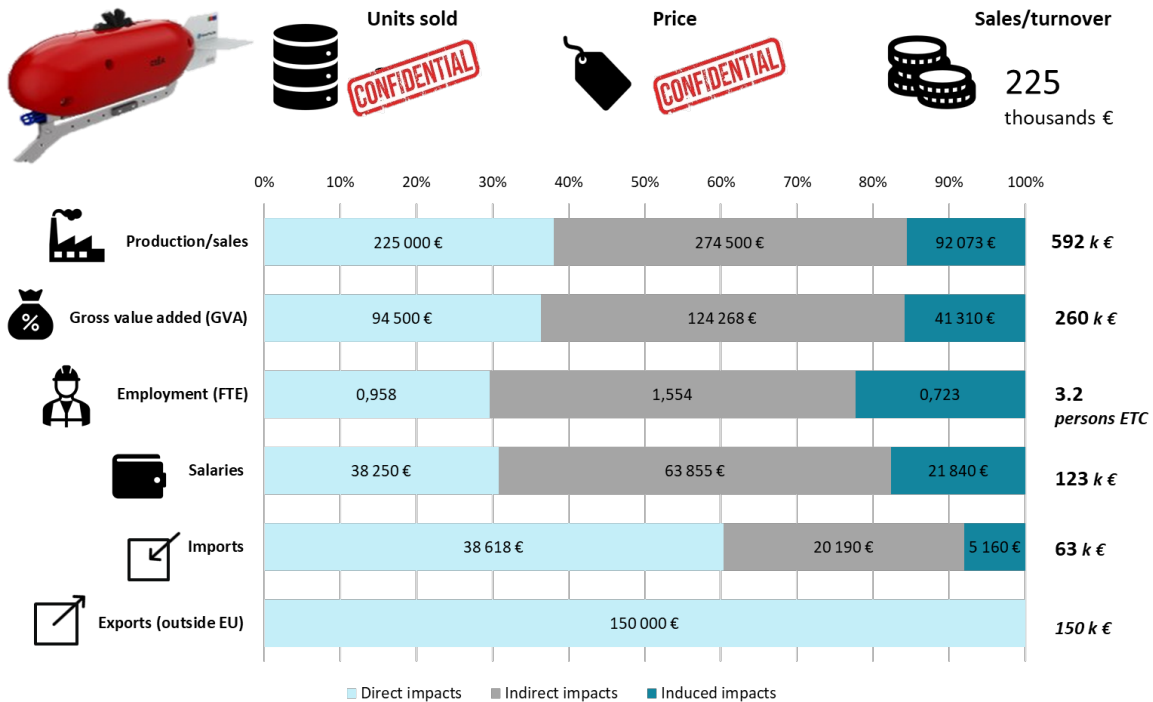


Figure 19 - Non-invasive animal towed tagging system used for animals such as manta rays (CEiIA) socio-economic impact results.

As for the non-invasive animal towed tagging system, MAANTA, used for animals such as manta rays and sharks, CEiIA expects that sales in 2029 will result in a turnover of 225,000 euros (Figure 19).

When accounting for the total socioeconomic impacts, which also include indirect and induced effects, one can see that this economic activity leaves a more significant mark on the whole value chain, which is to be expected given the technological complexity and high added value associated with some of the upstream sectors. In fact, total production in the economy is expected to be, in 2029, about 592,000 euros and the GVA is also expected to be about 44% of that value, reaching about 260,000 euros. The upstream effects are also particularly visible when it comes to salaries, where indirect effects account for more than half of the total value.

When focusing solely on the direct effects, it is worth noting once more that such a device is expected to have a fairly high margin when measured by the GVA, which represents about 42% of turnover. Also, this volume of sales is expected to sustain about 1 job (measured in FTE) and exports outside the EU are also relevant, at about 2/3 of turnover (66.6%).

XII) OCEANOGRAPHIC SATELLITE RELAYED DATA LOGGER (SRDL) FROM THE SEA MAMMAL RESEARCH UNIT DEPLOYED ON SOUTHERN ELEPHANT SEAL | MARINE ANIMAL-BORNE TEMPERATURE-SALINITY-DO TAG (CNRS)

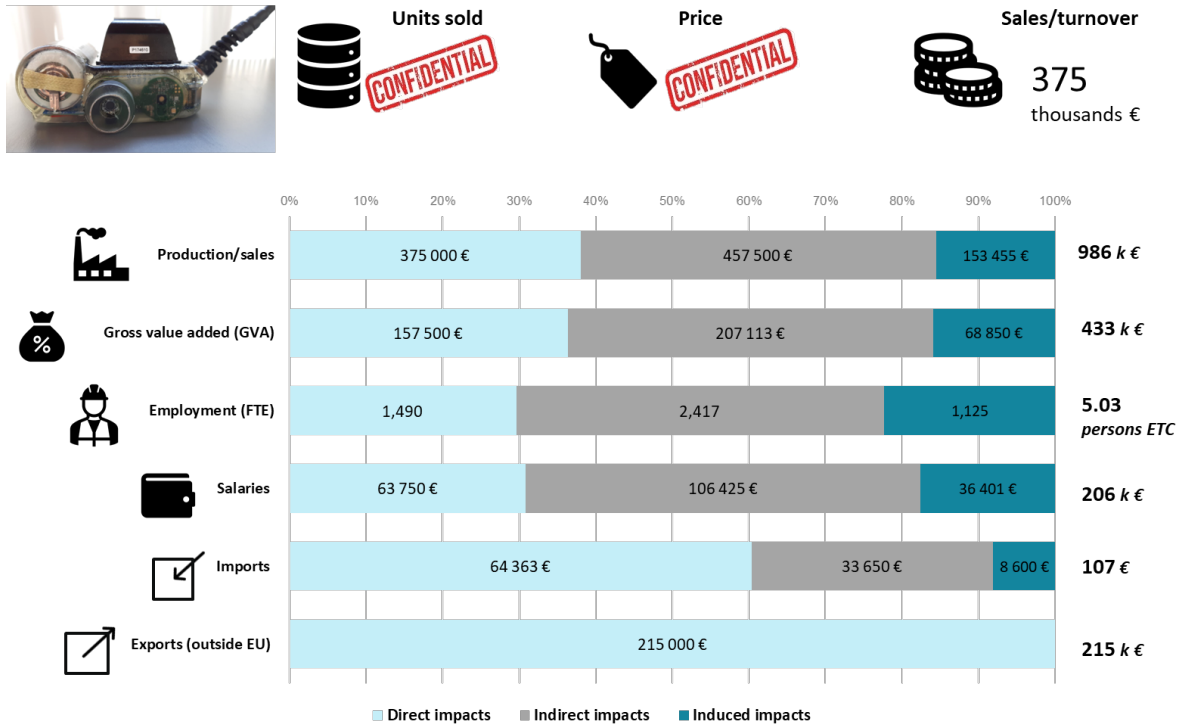


Figure 20 - Oceanographic Satellite Relayed Data Logger Tag (CNRS) socio-economic impact results.

As for CNRS's Oceanographic Satellite Relayed Data Logger Tag, the partner goal is to reach a total turnover of 375,000 euros in 2029 (Figure 20).

The overall production in the economy is expected to reach approximately 990,000 euros, with Gross Value Added (GVA) constituting about 44% of that figure, totalling around 434,000 euros. In terms of wages, the indirect impacts contribute to about half of the total value.

When focusing solely on the direct effects, it's important to highlight once more that this specific device is expected to generate a significant margin, with its Gross Value Added (GVA) representing approximately 42% of its turnover. Additionally, this level of sales is estimated to sustain approximately 1.5 full-time equivalent (FTE) jobs, and exports outside the EU are also significant, comprising more than half of the turnover.

2.2 SOCIO-ECONOMIC IMPACTS OF NAUTILOS

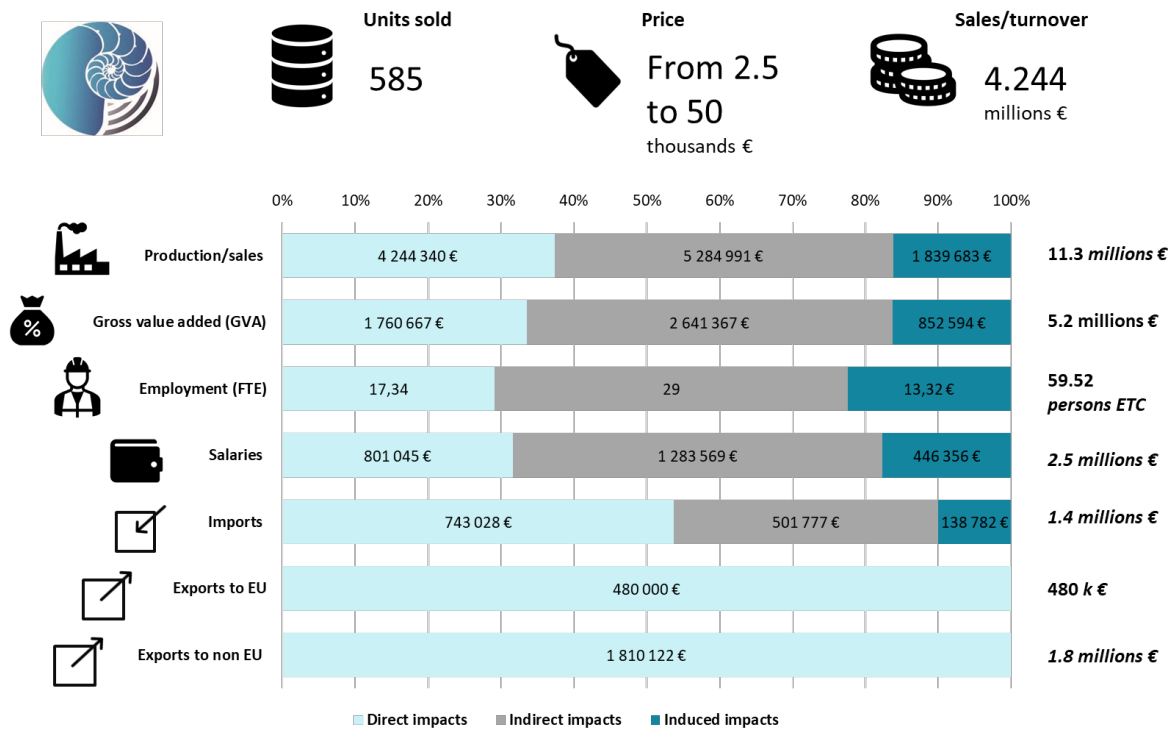


Figure 21 – NAUTILOS project socio-economic impacts results.

The NAUTILOS project emerges as a pivotal contributor to Europe's Blue Economy, poised to revolutionise marine observation capabilities with its innovative sensors and samplers. **The economic forecast reveals promising prospects, with an anticipated sale of 585 units in 2029, generating a projected revenue of 4,244,000 euros (Figure 21).** This financial impact extends far beyond direct sales, permeating through the entire economic ecosystem.

The socio-economic analysis underscores NAUTILOS' broader influence, where **total economic production is projected to reach 11,369,000 euros**, with a substantial Gross Value Added (GVA) of 5,254,000 euros, representing 46% of total production. Notably, indirect effects, particularly in terms of job creation and salary contribution, play a significant role, highlighting NAUTILOS' multiplier effect within the European market. Direct economic impacts are equally impressive, with NAUTILOS technologies expected to contribute 41% of their turnover as GVA, supporting approximately 17 full-time equivalent (FTE) jobs. Moreover, exports outside the EU are projected to constitute 42% of the turnover, indicating the project's global relevance and competitiveness.

Table 2 presents an overview of the import and export values for each NAUTILOS technology. It shows the financial transactions related to the international trade of these technologies, reflecting their global market presence and economic impact. Import values indicate the cost of acquiring components or materials necessary to produce each sensor, sampler and tag, highlighting dependencies on foreign suppliers. Conversely, export values represent the revenue generated from selling NAUTILOS technologies to markets outside the European Union (EU), demonstrating the project's competitiveness and ability to penetrate international markets. These import and export figures are key indicators of NAUTILOS' economic footprint and its role in advancing Europe's position in marine technology innovation and global trade.

The partners were also asked to estimate what they consider could be the distribution of direct job creation when it comes to gender and qualifications (Table 3). Information requested included the

male/female split and the BSc/MSc/PhD split. While this profile of jobs created may not directly match the one from the Input-Output model, due to considerations that had to be taken into account to use such methodology (as was explained in the methodological section), this exercise was above all relevant to identify the spread of male/female jobs and qualifications, in particular, if jobs would consider employees with BSc, MSc or PhD. This information is nonetheless relevant to have a better idea of the possible broader lasting social impact of the project and how it could be distributed.

Table 2 - Economic impact associated with Imports and Exports values for each NAUTILOS technology

NAUTILOS TECHNOLOGIES (Developer- Country)	ECONOMIC IMPACT	
	IMPORTS	EXPORTS
Fluorometric Sensors/dissolved oxygen (HESSO- CH)	31 984 €	37 125 €
Dissolved Oxygen Data Logger WiSens TD-DO (NKE- FR)	6 755 €	78 408 €
Fluorescence Data Logger WiSens TD-Chl-a (NKE- FR)	43 932 €	48 589 €
Silicate Electrochemical Sensor (NKE- FR)	106 613 €	112 500 €
Microplastic sensors (NIVA- NO + CSEM- CH)	402 292 €	280 000 €
Passive broadband acoustic recording sensor for noise monitoring and acoustic event recorder Sound and click recorder (Aquatec- UK)	227 439 €	320 000 €
Active Acoustic Profiling Sensor AQUAscat Mk2 (Aquatec- UK)	177 687 €	312 500 €
Submersible Sampler for Nanoplastics and Microplastics (SCT- DE)	113 719 €	200 000 €
Deep ocean CTD Sensor (UL-FE- SI)	19 900 €	17 500 €
Deep ocean radioactivity data logger (HCMR- EL)	21 891 €	38 500 €
Non-invasive animal towed tagging system used for animals such as manta rays and sharks MAANTA (CEiiA- PT)	63 968 €	150 000 €
Oceanographic Satellite Relayed Data Logger (SRDL) from the Sea Mammal Research Unit deployed on southern elephant seal (CNRS- FR)	106 612 €	215 000 €
NAUTILOS TOTAL	1 322 792 €	1 810 122 €

Table 3 - Social Impact associated with full-time job creation divided by gender and expected qualification for each NAUTILOS technology

NAUTILOS TECHNOLOGIES (Developer- Country)	Social				
	Males	Females	Qualifications		
			BSc	MSc	PhD
Fluorometric Sensors/dissolved oxygen (HESSO- CH)	50%	50%	50%	50%	-
Dissolved Oxygen Data Logger (NKE- FR)	50%	50%	50%	50%	-
Fluorescence Data Logger (NKE- FR)	50%	50%	50%	50%	-
Silicate Electrochemical Sensor (NKE- FR)	100%	-	-	100%	-
Microplastic sensors (NIVA- NO + CSEM- CH)	60%	40%	40%	40%	20%
Passive broadband acoustic recording sensor for noise monitoring and acoustic event recorder (sound and click recorder) (Aquatec- UK)	50%	50%	100%	-	-
Active Acoustic Profiling Data Logger (Aquatec- UK)	33%	67%	33%	-	33%
Sampler for Nanoplastics and Microplastics (SCT- DE)	67%	33%	33%	67%	-
Deep ocean CTD (UL-FE- SI)	100%	-	50%	50%	-
Deep ocean low-level radioactivity data logger (HCMR- EL)	50%	50%	-	50%	50%
Non-invasive animal towed tagging system used for animals such as manta rays and sharks (CEiiA- PT)	67%	33%	50%	33%	17%
Oceanographic Satellite Relayed Data Logger (SRDL) from the Sea Mammal Research Unit deployed on southern elephant seal (CNRS- FR)	-	100%	-	100%	-
NAUTILOS TOTAL	59%	41%	41%	44%	12%

III. COST SAVINGS AND COMPETITORS ANALYSIS

1. METHODOLOGY

NAUTILOS aims to fill in marine observation and modelling gaps for biogeochemical, biological and deep ocean physics essential ocean variables and micro-/nano-plastics, by developing a new generation of cost-effective sensors and samplers. Hence, another critical component of the socio-economic assessment was evaluating how NAUTILOS' technologies contribute to significant cost savings.

A comprehensive competitor/market analysis was carried out in order to conduct the cost savings analysis. The analysis describes competitors offering products (or services where a product is unavailable) similar to the NAUTILOS technology and is based on what is currently available (2024) on the global market.

Competitors were first identified through consultation with NAUTILOS technology developers. Secondly, a global online search was conducted to identify companies producing similar technologies as competitors, prioritising commercially available products and Europe based companies. Additionally, available web databases built by the scientific community, such as ESONET yellow pages (esonetyellowpages.com) were also used as information source. Where no commercial alternatives were found, technologies developed for research or prototypes were also considered. When information was provided by partners, additional contact was made with potential competitors to obtain technical specifications and to request quotes. In total, more than 30 price quotations were requested, and these values were used to conduct the cost-saving analysis and classify the NAUTILOS technologies according to their benefit. In compliance with data protection regulations, competitor prices will not be presented in this report. It is important to emphasise that the aim of the cost-saving analysis is not to devalue what is produced by competitors but rather to highlight the qualities and advantages of the technologies developed by the NAUTILOS project.

This activity was previously to be considered as part of deliverable D11.7, but it was decided to describe it in the present deliverable as it is critical to the assessment of cost savings. The analysis presented here was limited to a maximum of four competitors per sensor.

A comprehensive comparative analysis was conducted for each NAUTILOS' technology against its competitors, resulting in each one receiving a classification, whose definition is presented in Table 4. In general, NAUTILOS' products demonstrate at least one advantage over competitors, as outlined in their respective sections.

Table 4– NAUTILOS Cost-Benefit Analysis Classification

Classification	Description
New to Market	No equivalent or comparable competitor on the market.
Improved Technology	Other comparable sensors are available on the market. It is considered improved Technology if the benefits/technical features of the NAUTILOS sensors are considered best-fit for ocean monitoring.
Cheaper in Class	Other comparable sensors are available on the market, with similar technical features, but for a higher cost.

Table 5 provides a template for the market study, which was conducted to identify the competitive landscape and to facilitate comparisons between the identified technologies and NAUTILOS' sensors.

The table offers a clear and concise explanation of the methodology employed, thus ensuring that the information presented is readily comprehensible. It should be noted that neither the prices of NAUTILOS technologies nor those of competitors are included in this report; instead, cost savings are presented in estimated ranges of euros.

Table 5 - Competitors analysis template table

	Sensor	Company (Country)	Technical Information					Main differentiating features	Price	Cost Savings / Benefits
			Measured Parameters and estimated sensitivity	Overall dimensions	Communication protocols/data sharing	Max depth	Input Power/ Energy Consumption / Mission Duration			
NAUTILOS	Nautilus Sensor	Nautilus Partner	Ocean variable	X mm length x X mm diameter	Examples: - USB - WiFi	X m	_ W	Examples: - precise measurements - Compact - Low power consumption	CONFIDENTIAL	New to Market Improved Technology Cheaper in Class = € Y - € X
Competitor 1	Sensor 1	Y company ()	Ocean variable	Y mm length x Y mm diameter	Examples: - RS-232 - RS-485	Y m	_ days _ years	Comparable Competitor	CONFIDENTIAL	= € Y - € X (Y bigger -> positive cost saving range)
Competitor 2	Sensor 2	Z company ()	Ocean variable	Z mm height x Z mm width x Z mm length	Examples: - internal battery	Z m	Power supplied at _ to _ V, _ mA	Non-Comparable Competitor	CONFIDENTIAL	= € Z - € X (Z smaller -> negative cost saving range)

2. RESULTS AND ANALYSIS

The cost-saving analysis and classification for each NAUTILOS technology compared to other commercial sensor manufacturers are presented in the following sections.

I) FLUOROMETRIC DO SENSOR (HES-SO) & DISSOLVED OXYGEN DATA LOGGER | WISENS TD-DO (NKE)

The technologies developed by *NKE* and *HESSO* use an optical technique to determine the concentration of dissolved oxygen in seawater but measure it using different methods (*NKE* uses fluorescence intensity, while *HESSO* is based on fluorescence lifetime). In addition, the *NKE* data logger is a standalone device while the other is a sensor adaptable to oceanographic data loggers such as WiMo platform developed by *NKE*. The competitors have been divided into two groups, which are presented in the same table, as they share the same market. Table 6 shows the price range and characteristics of each instrument. The "Fluorometric Sensors/Dissolved Oxygen (HESSO)" was classified as "**Cheaper in Class**". The "Dissolved Oxygen Sensor | WiSens TD-DO (NKE)" was classified as "**Improved Technology**".

- NAUTILOS sensor 1: Fluorometric Sensors/Dissolved Oxygen (HES-SO)



The main improvement of NAUTILOS' "Fluorometric Sensors/Dissolved Oxygen" (HES-SO) compared to the other competitors comes from the method used to measure dissolved oxygen, mainly because it requires total darkness in the sample. As such, the sensor eliminates the need for a selective optical filter to remove the contribution of the excitation light. In addition, this sensor distinguishes itself in its precise measurements, boasting the best resolution. In terms of sensor competitors, there are two offerings from EU companies, one manufacturer from the USA and one from Japan. Comparing them to *HES-SO's* sensor, the latter provides the best measurement resolution but, at the same time, also has the lowest depth rating and average energy consumption. Nevertheless, NAUTILOS' sensor is the cheapest in the market.



- NAUTILOS Data Logger 2: Dissolved Oxygen Data Logger | WiSens TD-DO (NKE)

The "WiSens TO-DO (NKE)" data logger can work at lower ocean depths and be deployed independently, either in a standalone configuration, only recording data, or connected to a transmitter. The data logger competitors 1 (from *PyroScience*) and 2 (from *RBR*) provide more precise measurements than *NKE's* data logger, with the drawback of being more expensive. Additionally, data logger competitor 1 has a lower depth rating, only capable of water surface operations, and data logger competitor 2 does not have an internal battery, relying on external power to function. The final competitor, the *miniDOT Logger*, offers the more affordable option currently available on the market. It is designed for use in surface water operations and is capable of long deployments. However, it does not transmit the data it records, necessitating its recovery and consequently increasing the cost of its operation. NAUTILOS' data logger for measuring

dissolved oxygen is considered the most suitable for ocean monitoring with autonomous logging, an internal battery to provide power and a depth rating of up to 600 m.

Table 6 - Fluorometric DO Sensor (Hesso) & Dissolved Oxygen Data Logger | Wisens TD-DO (NKE) cost-saving analysis.

	Sensor	Company (Country)	Technical Information					Main differentiating features	Price	Cost Savings / Benefits
			Measured Parameters and estimated resolution	Overall dimensions	Communication protocols /data sharing	Max depth	Input Power / Mission Duration			
NAUTILOS Sensor 1	Fluorometric Oxygen Sensor	HES-SO (CH)	Dissolved oxygen concentration resolution: 0.001 mg/L	90 mm height x 20 mm diameter	- RS-232 - RS-485	250 m	Power supplied at 12 V, 70 mA average current consumption	- Streamlined process - High-resolution - Sensor only	CONFIDENTIAL	Cheaper in Class
Competitor Sensor 1	WiMo Dissolved Oxygen Sensor	NKE (FR)	-Dissolved oxygen concentration resolution: 0.025 mg/L -Temperature	155 mm height x 25 mm diameter	- Modbus RTU - RS-485 with adaptor Mosens	250 m	Power supplied at 9 - 16 V; 80 mA	- Compact - Less precise measurements - Sensor only	CONFIDENTIAL	0 € - 500 €
Competitor Sensor 2	Oxygen sensor 4835	Aanderaa (NO)	Absolute oxygen concentration resolution: 0.003 mg/L	86 mm height x 36 mm diameter	- AiCaP CANbus - RS-232	300 m	Power supplied at 5 to 14 V, 1200 mA average current consumption	- Compact - Precise Measurements - Sensor only	CONFIDENTIAL	0 € - 500 €
Competitor Sensor 3	SBE 63	Seabird (USA) 	Dissolved oxygen concentration resolution: 0.007 mg/L	100 mm height x 59 mm diameter	- RS-232	7000 m	Power supplied at 6 - 24 VDC; 35 mA	- Bio-fouling resistant - Sensor only	CONFIDENTIAL	7 000 € - 9 000 €
Competitor Sensor 4	RINKO II	JFE Advantech Co. (JPN) 	Dissolved Oxygen concentration resolution: 0.003 mg/L	185 mm height x 54 mm diameter	- RS-232C (CAR) - RS-485 (CAD)	1000 m	Power supplied at 12 - 24 VDC; 35 mA	- Phosphorescence - Fast-response - High-accuracy - High-resolution - Sensor only	CONFIDENTIAL	5 000 € - 7 000 €







NAUILOS Data Logger 2	WiSens TD – DO	NKE (FR)	- Dissolved Oxygen concentration resolution: 0.01 mg/L - Temperature - Pressure	220 mm height x 45 mm diameter	- Internal Memory - WiFi	600 m	Lithium batteries (3.6 VDC)	- Luminescence quenching sensor - Independent but transmitter compatible - Data logger	CONFIDENTIAL	Improved Technology
Competitor Data Logger 1	APHOX-L- O2 + OXCAP- SUB	PyroScience (DE)	Dissolved oxygen concentration resolution: 0.005 mg/L	338.5 mm height x 63 mm diameter	- USB 2.0 - 4 GB internal storage	100 m	Rechargeable LiPo battery, 1250 mAh	- Precise Measurements - Sensor cap and logger separate (modular)	CONFIDENTIAL	500 € - 1 000 €
Competitor Data Logger 2	RBRcoda ³ T.ODO	RBR (CA) 	-Dissolved oxygen concentration resolution: 0.056 mg/L -Temperature	125 mm height x 28 mm diameter	- RS-232	6000 m	Power supplied at 12 V, 34 mA for average current consumption	- High optical stability - Low Power consumption - Data logger	CONFIDENTIAL	3 000 € - 5 000 €
Competitor Data Logger 3	miniDOT Logger	Precision Measurement Engineering (USA) 	-Dissolved oxygen concentration resolution: 0.01 mg/L -Temperature	187.3 mm height x 49.5 mm diameter	- Internal SD card - USB cable	300 m	- 2 AA lithium batteries - 1 year	- No transmission of data - Long deployments - Data logger	CONFIDENTIAL	-5 000 € - -2 000 €

*Value in red is a negative cost saving.

II) FLUORESCENCE DATA LOGGER | WISENS TD - CHL-A (NKE)

Table 7 shows three competitors of this data logger already available in the market, as well as the main characteristics of each one. The analysis classified this data logger as **“Improved Technology”**.

Table 7 - Fluorescence Data Logger | WISENS TD - CHL-A (NKE) cost-saving analysis.

	Sensor	Company (Country)	Technical Information					Main differentiating features	Price	Cost Savings / Benefits
			Measured Parameters and estimated sensitivity	Overall dimensions	Communication protocols/data sharing	Max depth	Energy Consumption / Mission Duration			
NAUTILOS	WiSens TD – Chl-a	NKE (FR)	- Chlorophyll-a sensitivity: 0.03 µg/L - Temperature - Pressure	220 mm height x 45 mm diameter	- Internal Memory - WiFi	600 m	Lithium batteries (3.6 VDC)	- Precise measurements - Independent but transmitter compatible		Improved Technology
Competitor 1	EXO1	YSI (USA) 	- Chlorophyll-a sensitivity: 0.01 µg/L - Temperature - Pressure	647.7 mm height x 47 mm diameter	- 512 MB total memory - RS-485 or RS-232 - USB - Bluetooth	250 m	2 D-cell batteries 90 days	- Precise measurements - Unattended logging		8 000 € - 10 000 €
Competitor 2	TriLux	Chelsea Technologies (UK)	- Chlorophyll-a sensitivity: 0.1 µg/L - Phycoerythrin - Turbidity	140 mm height x 26.5 mm diameter	- RS-232 or RS-422 - SDI-12 - Analogue	2000 m	1 W 11 to 25 VDC (input power)	- Compact - Autonomous deployments (power required) - Easy integration in a larger system		-100 € - -1 000 €
Competitor 3	Eco FLB	Wet Labs (USA) 	- Chlorophyll - Phycoerythrin sensitivity: 0.02 µg/L	127 mm height x 63 mm diameter	- 108 000 sample data memory - RS-232 - Analogue	600 m	6 lithium batteries (9 VDC)	- Compact - Autonomous logging - Precise measurements		8 000 € - 10 000 €


*Value in red is a negative cost saving.

The first and third competitors, made by the American *YSI* and *Wet Labs* respectively, are almost three times more expensive than NAUTILOS' data logger. *NKE's* data logger provides less precise measurements with a lower sensitivity but is smaller and is rated for a higher ocean depth, characteristics that widen the range of ocean monitoring scenarios where it can be deployed. On the other hand, the *TriLux* logger is cheaper, smaller and higher depth-rated, however, it demonstrates a lower sensitivity, and it does not determine either temperature or pressure. In addition, it is not manufactured with an internal battery and requires an external power supply for autonomous deployment.

III) SILICATE ELECTROCHEMICAL SENSOR (NKE)

Currently, there is only one competing sensor on the market that can directly analyse the concentration of silicate in seawater, most others are sample-dependent. In this analysis, both instruments were considered as possible competitors, as shown in Table 8. The analysis classified this sensor as **“Improved Technology and Cheaper in Class”**.

Table 8 - Silicate Electrochemical Sensor (NKE) cost saving analysis.

	Sensor	Company (Country)	Technical Information					Main differentiating features	Price	Cost Savings / Benefits
			Measured Parameters	Overall dimensions	Communication protocols/data sharing	Max depth	Energy Consumption/ Input Power/ Mission Duration			
NAUTILOS	Silicate Electrochemical Sensor	NKE (FR)	Silicate concentration Temperature	250 mm height x 90 mm diameter	- RS-232	1000 m	Power supplied at 12 VDC	- Electrochemical detection - Fast measurements - Less maintenance required	CONFIDENTIAL	Improved Technology and Cheaper in Class
Competitor 1	Lab-on-chip Chemical Sensors	Clear Water Sensors (UK)	Silicate concentration	560 mm height x 150 mm diameter	- RS232 and RS485 - User-programmable via USB	6000 m	- 1.92 W - 1 year	- Use of chemical reagents - Limited by reagents canisters	CONFIDENTIAL	4 000 € - 6 000 €
Competitor 2	Trilogy Laboratory Fluorometer + Silicate Absorbance Module	Turner Designs (USA) 	Silicate concentration	213.9 mm height x 265.2 mm width x 328.2 mm length	- RS-232 - USB	NA	100 to 240 VAC Universal Power	- Not a sensor - Requires sample (additional costs per measurement) - Laboratory chemical reagents and process	CONFIDENTIAL	-17 000 € - -19 000 €






*Value in red is a negative cost saving. Grey competitor is not comparable.

The second competitor *Turner Designs*, from the USA, does not present comparable competition since it is a laboratory fluorometer rather than a sensor. This method, which is the most common way to measure silicate concentration in the ocean, requires the collection of water samples *in situ* resulting in additional costs with every new set of measurements. Compared to the remaining competitor, the *Lab-on-chip Chemical Sensor*, NAUTILOS' sensor can provide faster measurements while, at the same time, requiring less maintenance. This is because it does not rely on chemical reagents that are typically consumed with each measurement. This innovative approach not only accelerates the measurement process but also minimises operational costs, making NAUTILOS the best choice for silicate monitoring applications.

IV) MICROPLASTIC SENSORS (NIVA + CSEM)

The competitors and cost-savings analysis considered two competitors for this sensor, presented with the corresponding characteristics in Table 9. As such, the analysis classified this sensor as **“New to Market”**.

Table 9 – Microplastic Sensors (NIVA + CSEM) cost saving analysis.

	Sensor	Company (Country)	Technical Information					Main differentiating features	Price	Cost Savings / Benefits
			Measured Parameters	Overall dimensions	Communication protocols/data sharing	Max depth	Input Power			
NAUTILOS	Microplastic Sensor	NIVA & CSEM (NO & CH)	Microplastic particles in surface water: particle count, size Fluorescent emission intensity	FerryBox ready housing: 300 mm height x 400 mm width x 180 mm length	- Ethernet - Satellite internet	Water Surface	Power supplied at 24 V; 3 A	- Compact - Portable - Suitable for on-site measurements		New to Market
Competitor 1	MacroRAM	Horiba (JPN) 	Chemical analysis of the water sample	381 mm height x 432 mm width x 432 mm length	- Integral software - USB	NA	Universal AC single-phase input power; 100-240 V AC; line frequency 50 – 60 Hz	- Identifies the polymers present in the sample - Requires water sample		70 000 € - 90 000 €
Competitor 2	INVENIO FTIR Spectrometer	Bruker (USA) 	Chemical analysis of the water sample	267 mm height x 340 mm width x 340 mm length	- Integral PC-panel - Wireless connection and data export	NA	Universal AC single-phase input power; 100-240 V AC	- Identifies the polymers present in the sample - Requires water sample		100 000 € - 120 000 €


*Grey competitors are not comparable.

The analysis identified only two non-comparable competitors, both located outside Europe, offering laboratory equipment that requires *in situ* water sampling to be externally provided, as the equipment needs dry conditions to function. Their systems employ different spectroscopic methods to analyse samples, providing extensive information about the chemical composition of the different plastics present in seawater specimens (the most common way to study ocean microplastics already available in the market). NAUTILOS' sensor provides a new market approach to the study of microplastics, by creating the opportunity to perform the measurements on-site, making it cheaper and faster to obtain relevant data.

V) PASSIVE DEVICE | CLICK & SOUND RECORDER (AQUATEC)

The market has many acoustic sensors however these usually specialise in either animal sounds and clicks or underwater noise, with sensors that can reliably detect both being much rarer. This analysis identified three competitors that can be seen in Table 10, along with the main characteristics of each one. This data logger was classified as “Cheaper in Class”.

Table 10 – Passive Device | Click & Sound Recorder (Aquatec) cost-saving analysis.

	Sensor	Company (Country)	Technical Information					Main differentiating features	Price	Cost Savings / Benefits
			Measured Parameters and estimated sensitivity	Overall dimensions	Communication protocols/data sharing	Max depth	Energy Consumption / Mission Duration			
NAUTILOS	Passive Acoustic Data Logger	Aquatec (UK)	Broadband Underwater Sound, Noise monitoring, Click recorder	460 mm length x 98 mm diameter	- USB - Internal memory	1000 m	Rechargeable batteries	- Broad Bandwidth (5 Hz up to 150 kHz)	CONFIDENTIAL	Cheaper in Class
Competitor 1	icListen HF	Ocean Sonics (CA) 	High-frequency underwater sounds sensitivity: -173 dB re V/μPa	318 mm length x 48 mm diameter	- Ethernet - 512 GB internal storage	3500 m	- External Power 2.4 W - Internal battery life 8 h	- Can be linked with other sensors to form an array	CONFIDENTIAL	10000 € - 12000 €
Competitor 2	Porpoise 84D	RS Aqua (UK)	Marine mammal clicks, noise pollution and noise source localization	232 mm length x 70 mm diameter	- Ethernet - USB - Internal storage 8 TB	2500 m	- 300 mW - 84 D-cell lithium battery pack - 1.5 years	- Large data capacity - Capable of long deployments	CONFIDENTIAL	16000 € - 18000 €
Competitor 3	DeepF-POD	Chelonia (UK)	Animal echolocation clicks	710 mm length x 100 mm diameter	-Removable 32 GB micro-SD card	2000 m	- Battery pack of 10 D-cells - 8 months	- Animal click detection - Ignores non-animal sounds	CONFIDENTIAL	500 € - 1000 €








*Grey competitors are not comparable.

The two grey competitors do not possess the full capacities of NAUTILOS’ data logger (underwater sound and animal click recorder), as such they are not considered comparable competitors. The first one, from the *Ocean Sonics*, only captures underwater sounds without distinction. The other competitor, *Chelonia* of the United Kingdom, filters out any sounds that are not from animals. The main advantage that the NAUTILOS sensor has is its high precision when identifying the point of origin of every sound it captures, along with its large frequency range and reduced cost. The *RS Aqua’s* sensor, on the other hand, provides comparably less accurate data but is capable of long deployments. However, this advantage comes coupled with a significant increase in the price of the sensor and for that reason NAUTILOS sensor is considered cheaper in class.

VI) ACTIVE ACOUSTIC PROFILING DATA LOGGER | AQUASCAT Mk2 (AQUATEC)

Table 11 shows four competitors of this data logger already available in the market, as well as the main characteristics of each one. The analysis classified this data logger as **“Improved Technology and Cheaper in Class”**.

Table 11 – Active Acoustic Profiling Data Logger | Aquascats Mk2 (Aquatec) cost-saving analysis.

	Sensor	Company (Country)	Technical Information				Main differentiating features	Price	Cost Savings / Benefits	
			Measured Parameters and estimated sensitivity	Overall dimensions	Communication protocols/data sharing	Max depth				Energy Consumption / Mission Duration
NAUILOS	Active Acoustic Profiling Data Logger	Aquatec (UK)	Acoustic backscatter from suspended matter Suspended sediment profile	500 mm height x 80 mm diameter	Internal memory	6000 m	Rechargeable or primary batteries -1.7W (1 month on internal batteries)	- High resolution - Particle size and load profiling - Direct measurement		Improved Technology and Cheaper in Class
Competitor 1	Origin 600 ADCP	Sonardyne (UK)	Acoustic Doppler effect	308 mm height x 290 mm diameter	1 TB internal memory	150 m	- 600 mW (pinging) - 3 months	- Estimated profile results - Provides no details of suspended material - Data must be processed		4000 € - 6000 €
Competitor 2	LISST-ABS	SEQUOIA (USA) 	Acoustic Backscatter from Sediment Suspended matter concentration	336.5 mm height x 50.8 mm diameter	- External datalogger - Underwater connector (SDI-12, RS232)	100 m	Supply voltage: 10 to 18 V Current drain: 105 mA	- Single-point measurement - Lower detail of suspended material - Simple post-processing software		-15000 € - -17000 €
Competitor 3	Workhorse II Sentinel ADCP + ViSea PDT (software)	Teledyne RDI (CA) 	Acoustic Doppler effect Echo intensity	420 mm height x 228 mm diameter	- RS-422 - RS-232 - 4 Gb internal memory	200 m	Power supplied at 20 - 50 VDC	- Estimated particle size profiling - Data must be processed by a third-party software		2000 € - 4000 €
Competitor 4	Signature 1000	Nortek (NO)	Acoustic Doppler effect Echo intensity	212 mm height x 142 mm diameter	- RS-422/RS-432 - Ethernet - 128 Gb internal memory	300 m	15 mW	- Direct concentration measurement - Estimated particle size profiling - Must be calibrated for different particle sizes		6000 € - 8000 €

*Value in red is a negative cost saving. Grey competitor is not comparable.



The grey competitor, *SEQUOIA*, is incapable of performing automated profiles of the water column, executing only single-point measurements, thus being considered a non-comparable competitor. This difference means that for the two to obtain equivalent results the *LISST-ABS* sensor would have to be deployed thousands of times, making it impossible to form a fair comparison. The other competitors under analysis in the present study are only capable of providing estimated results based on an extrapolation from the measured data. This generates more uncertainties because of the calibration of the software, which most of the time already requires an average particle size to correct.

NAUTILOS data logger, in contrast, allows for direct measurement of suspended matter to make its profile, making it more accurate, without requiring analysis of additional measurements/data. Moreover, it is the only competitor to work over 300m depth. All these excellent features for a cheaper price when compared to similar products.

VII) SAMPLER FOR NANOPLASTICS AND MICROPLASTICS (SCT)

The market has numerous samplers available, specialising in the collection and study of different materials that are suspended in the ocean. However, there are significantly fewer ones that can collect microplastics autonomously without contaminating the sample, invalidating it for data collection. As such, four competitors were identified to demonstrate the overall market, as seen in Table 12, along with their main characteristics. The analysis classified this sampler as “Improved Technology”.

Table 12– Sampler for Nanoplastics and Microplastics (SCT) cost-saving analysis.

	Sensor	Company (Country)	Technical Information					Main differentiating features	Price	Cost Savings / Benefits
			Measured Parameters and mesh size	Overall dimensions	Communication protocols/data sharing	Max depth	Energy Consumption / Mission Duration			
NAUILOS	SuNaMips	subCtech (SCT) (DE)	Microplastic water samples Mesh: 0.03 mm	850 mm height x 350 mm width x 350 mm length	- Internal memory - USB	600 m	6 months	- Stand-alone - Automated sampler - Independent multisampling - Sample contamination proof	CONFIDENTIAL	Improved Technology
Competitor 1	Particle and Phytoplankton Sampler	McLane (USA) 	Collection of particles, diverse suspended matter	430 mm height x 430 mm width x 1650 mm length	- USB - RS-232 - RS-485	5500 m	14 months	- Sample containers not suitable for microplastic collection	CONFIDENTIAL	8 000 € - 10 000 €
Competitor 2	Plastic particle pump	KcDenmark (DK)	Plastic particles, plankton	1370 mm height x 600 mm width x 600 mm length	Cable to the control box	40 m	0,75 kW	- Single sample only - Platform dependant	CONFIDENTIAL	-30 000 € - -35 000 €
Competitor 3	Microplastic sampler	OSIL (UK)	Water sample	1500 mm height x 315 mm diameter	NA	5000 m	NA	- Single sampling - Vessel (with crane) dependent - No direct filtration	CONFIDENTIAL	-30 000 € - -35 000 €
Competitor 4	Ascension Microplastic Depth Sampler	Ocean Diagnostics (CA) 	Microplastic water samples Depth, temperature, salinity, volume Mesh: 0.01 mm	300 mm height x 188 mm diameter	- Communication tether - Bluetooth	400 m	266 W-Hr. LIPO battery (3 hours at max pump throttle)	- Lower-graded Materials - Multisampling - Programmable sample routines - Ship-based deployment	CONFIDENTIAL	-10 000 € - -13 000 €

*Value in red is a negative cost saving. Grey competitors are not comparable.

The grey competitors lack the same capabilities as the NAUTILOS' sampler, rendering them unsuitable competition. The most prominent factors considered were suitability for ocean monitoring (mission duration and autonomous sampling), filtration and multisampling capability.

In the case of the *McLane sampler*, the holders are designed for the collection of suspended matter and phytoplankton samples, as such it was not prepared to be used for the study of microplastics. Because of this characteristic, it is considered a non-comparable competitor.

The second competitor *KcDenmark* can provide only a single sample at a time, which is not ideal for ocean monitoring. This difference means that to obtain the same number of samples at different ocean depths, this sampler would have to be deployed multiple times compared to a single descent of the *SuNaMips*.

Lastly, *OSIL's* sampler, also a non-comparable competitor, requires a sizable vessel equipped with a crane for it to function. Furthermore, there are no filters, and the only form of filtration is made by letting the microplastics and other suspended matter settle at the bottom of the sampler body and then removing the top layer of water (90% of the collected sample). This method requires the sampler to be upright after recovery and to remain undisturbed.



Different from the others, the fourth competitor, from *Ocean Diagnostics*, can be applied in a similar configuration as the NAUTILOS sampler, however, its lower battery capacity imposes some disadvantages upon it, restricting the volume of water that can be sampled and the duration of the mission, this being one of the most relevant features because it is determinant in case of an offshore buoy deployment (NAUTILOS case study). This characteristic makes this competitor more suitable for ship-based deployments, performed by one or two operators, and for studies along the coastal regions.

Another difference between NAUTILOS and Competitor 4 is the materials that they are made of, more specifically the ones that are in contact with the sample and how they affect it. NAUTILOS sampler utilises metal or high-performance plastics to guarantee that there is no contamination of the sample, meaning that there is no transfer of particles from the holder to the water to be studied. On the other hand, the *Ascension* sample containers are made of lower-graded plastics, namely Polypropylene, a more economic and lighter material. As such, NAUTILOS' sampler is heavier, but this fact can be easily overcome by using extra floating devices such as buoyancy spheres.

VIII) DEEP OCEAN CTD SENSOR (UL-FE)

Table 13 shows four competitors of this sensor already available in the market, as well as the main characteristics of each one. The analysis classified this sensor as “Cheaper in Class”.

Table 13 – Deep Ocean CTD Sensor (UL-FE) cost-saving analysis

	Sensor	Company (Country)	Technical Information					Main differentiating features	Price	Cost Savings / Benefits
			Measured Parameters and estimated resolution	Overall dimensions	Communication protocols/data sharing	Max depth	Energy Consumption / Mission Duration			
NAUILOS	Deep ocean CTD	UL-FE (SI)	Conductivity (0.01 mS/cm), Temperature (0.01 °C), Depth (0.1 bar)	302 mm length x 120 mm diameter	- RS-485 - RS-232	2000 m	- no standalone battery	- Low power consumption - All-in-one sensor unit	CONFIDENTIAL	Cheaper in Class
Competitor 1	CTD 48	Sea and Sun Technology (DE)	Conductivity (0.01 mS/cm), Temperature (0.005 °C), Depth (0.4 bar)	240 mm length x 48 mm diameter	- RS-485 - RS-232 - FSK	2000 m	- 0.5 W - no standalone battery	- Low power consumption - Separate conductivity and temperature sensor	CONFIDENTIAL	3 000 € - 5 000 €
Competitor 2	Midas CTD	Valeport (UK)	Conductivity (0.002 mS/cm), Temperature (0.005 °C), Depth (0.2 bar)	750 mm height x 140 mm width x 120 mm length	- RS-485 - RS-232 - FSK	2000 m	- 0.6 W - Lithium battery (250 hours operation)	- Low power consumption - Separate conductivity and temperature sensor - Autonomous operation	CONFIDENTIAL	12 000 € - 14 000 €
Competitor 3	Hybrid CTD	D2 Incorporated (USA) 	Conductivity (0.0004 mS/cm), Temperature (0.0002 °C), Depth (0.34 bar)	127 mm height x 76.2 mm width x 330.2 mm length	- USB - RS-232 - RS-485	3400 m	- 50 mW - Lithium battery	- Separate conductivity and temperature sensor - Water flow rate independent - Autonomous operation	CONFIDENTIAL	5 000 € - 8 000 €
Competitor 4	SBE 37-SIP MicroCAT	Seabird (USA) 	Conductivity (0.0001 mS/cm), Temperature (0.0001 °C), Depth (0.4 bar)	489 mm length x 66.3 mm diameter	- 530 000 internal memory - RS-232 - RS-485	2000 m	Power supplied at 9 - 24 VDC; 0.25 A	- Depth/pressure sensor is not integrated by default - Separate conductivity and temperature sensor	CONFIDENTIAL	9 000 € - 11 000 €


The main distinguishing feature of NAUTILOS' "Deep Ocean CTD" is the microfabricated sensors for measuring conductivity, temperature and pressure. Conductivity and temperature sensors were fabricated using MEMS (micro-electromechanical system) technology, which allows for the integration of temperature and conductivity sensors on the same electronic board. This feature makes the sensor more reliable, with more cost-effective production and maintenance, due to the reduction of internal electrical connections, meaning that there are fewer points of possible failure. This also proves beneficial in reducing the size of the CTD, making integration easier.

Two North American and two European competitors were considered and, every single one is more expensive than NAUTILOS' CTD. Still, at the same time, the competitors also provide precise measurements with better resolution. Some competitors can also operate independently, with a programmable sampling cycle, due to having a battery pack, either integrated into the CTD or as an optional accessory that is connected externally. The cost effectiveness of the NAUTILOS CTD broadens the amount of possible applications, because of its accessibility.

IX) DEEP OCEAN RADIOACTIVITY DATA LOGGER (HCMR)

The market for ocean radioactivity sensors is relatively limited in scope and because of that, only two competitors were identified. Both are shown in Table 14, along with their characteristics. This data logger was classified as **“Improved Technology and Cheaper in Class”**.

Table 14 – Deep Ocean Radioactivity Data Logger (HCMR) cost-saving analysis.

	Sensor	Company (Country)	Technical Information					Main differentiating features	Price	Cost Savings / Benefits
			Measured Parameters and estimated sensitivity	Overall dimensions	Communication protocols/data sharing	Max depth	Energy Consumption / Mission Duration			
NAUTILOS	Deep ocean low-level radioactivity Data logger	HCMR (EL)	Gamma-ray emitters	420 mm height x 150 mm diameter	- Ethernet and WIFI (option 1) - USB and WIFI (option 2)	3000 m	- 2.2 W - 25 days	- Temperature fluctuation resistant - Longer-lasting battery - Installation adaptability - Stand-alone	CONFIDENTIAL	Improved Technology \ Cheaper in Class
Competitor 1	TUNA	ENVINET (DE)	Spectroscopic Gamma Detection	570 mm height x 150 mm diameter	- RS 232 - Ethernet - WI-FI	2650 m	- 2.2 W - 5 days	- Platform-dependent or stand-alone (sea lander)	CONFIDENTIAL	5000 € - 8000 €
Competitor 2	AT6104DM Spectrometer	ATOMTEX (BY) 	Spectroscopic Radiation Detection	510 mm height x 130 mm diameter	- RS485 - Bluetooth - Internal memory (stores 140,000 measurements)	500 m	9 h (continuous operation)	- Low depth - Operator required	CONFIDENTIAL	-12000 € - -14000 €



*Value in red is a negative cost saving. Grey competitor is not comparable.

The grey competitor, from the *ATOMTEX*, is an immersion spectrometer, which requires the input of two operators to submerge and collect data. This characteristic coupled with its lower depth rating and mission duration, renders it a non-comparable option. On the other hand, the *ENVINET* sensor presents similar characteristics to the *NAUTILOS* one however, the latter has some capabilities that set it apart. The main ones are its adaptability to different applications and installation methods and its longer-lasting deployment.

X) NON-INVASIVE ANIMAL TOWED TAGGING SYSTEM USED FOR ANIMALS SUCH AS MANTA RAYS AND SHARKS | MAANTA (CEiIA)

The market already has multiple tagging devices for larger marine animals available, however, none of them include an O2 sensor, with other sensors such as CTDs being much more common. As such, only two competitors that could possibly provide the same type of data were identified, both outside of Europe. These are shown in Table 15, along with their characteristics. MAANTA was classified as “New to Market”.

Table 15 – Non-Invasive Animal Towed Tagging System used for animals such as Manta Rays and Sharks | MAANTA (CEiIA) cost-saving analysis.

	Sensor	Company (Country)	Technical Information					Main differentiating features	Price	Cost Savings / Benefits
			Measured Parameters and estimated sensitivity	Overall dimensions	Communication protocols/data sharing	Max depth	Energy Consumption / Mission Duration			
NAUILOS	MAANTA Animal tag	CEiIA (PT)	Dissolved Oxygen, Depth, Temperature, Acceleration, Orientation, Velocity	155 mm height x 120 mm width x 375 mm length	- ARGOS Satellite position tracking - Internal memory card	2000 m	7 days	- Non-invasive - Stand-alone - Towed - Modular	CONFIDENTIAL	New to Market
Competitor 1	SPOT-253	Wildlife Computers (USA) 	Location, Temperature, wet/dry, Depth, Light	50 mm height x 40 mm width x 153 mm length	- ARGOS Satellite system	2000 m	300 days	- Invasive - Modular sensor package	CONFIDENTIAL	6000 € - 8000 €
Competitor 2	ORI1300-3MPD3GT	Little Leonardo (JPN) 	Velocity 3-axis acceleration 3-axis magnetic field Depth Temperature	83.5 mm height x 16.5 mm diameter	- Via an interface box with a logger cable - 512 Mbit internal memory	1300 m	21 days	- Non-invasive - Towed - Suction Cup - Less modular sensor package	CONFIDENTIAL	6000 € - 8000 €

*Grey competitors are not comparable.

The grey competitor, *Wildlife Computers* from the USA, has an invasive deployment method, an anchor that pierces the skin or fin of the animal. The invasiveness of a tag, including its deployment, is undesirable because it affects the animal's behaviour for some time, affecting the quality of the data gathered during the mission. Such a situation is particularly relevant when studying specific and brief moments (e.g. just before giving birth). Therefore, given the focus on the quality and pertinence of the data, invasive tags can be considered non-comparable in this analysis.



The other competitor, the *Little Leonardo's* tag, compared with *CEiiA's* device, not only is it higher priced but is also rated for lower depths. *CEiiA's* tag capability to hold at higher ocean depths allows it to follow and monitor animals in their entire region of activity (which reaches 2000 m for many species). It is also relevant to mention that while this tag has a longer maximum mission duration, this aspect is not always critical for many of the missions undertaken, especially in cases where the goal is to tag a migratory animal during its stay in the vicinity before it leaves the area (which would also make tag recovery significantly more expensive).

Most importantly, *MAANTA* and *SPOT-253* have a flexible sensor package, meaning that swapping the sensors that integrate the tags is an easy process that does not require extensive work. This feature means that the integration of a dissolved oxygen sensor in a tag is a non-issue that can be quickly done, with small additional costs.

XI) OCEANOGRAPHIC SATELLITE RELAYED DATA LOGGER (SRDL) FROM THE SEA MAMMAL RESEARCH UNIT DEPLOYED ON SOUTHERN ELEPHANT SEAL | MARINE ANIMAL-BORNE TEMPERATURE-SALINITY-DO TAG (CNRS)

The study of dissolved oxygen and its effect on animal behaviour is a relatively new concept. For this reason, only one competitor was ever designed and tested. It can be seen in Table 16 with its characteristics. NAUILOS' tag was classified as **"New to Market"**.

Table 16 – Oceanographic Satellite Relayed Data Logger (SRDL) from the Sea Mammal Research Unit Deployed on Southern Elephant Seal | Marine Animal-Borne Temperature-Salinity-Do Tag (CNRS) cost-saving analysis.

	Sensor	Company (Country)	Technical Information					Main differentiating features	Price	Cost Savings / Benefits
			Measured Parameters and estimated sensitivity	Overall dimensions	Communication protocols/data sharing	Max depth	Energy Consumption / Mission Duration			
NAUILOS	Oxygen Sensor Tag	CNRS (FR)	Oxygen in addition to pressure, temperature and salinity	80 mm height x 80 mm width x 105 mm length	-Argos satellites -SD card	2000 m	- Lithium battery - 5 months	Similar characteristics		New to Market
Competitor 1	mrPAT + mini-DO	Wildlife Computers + Loligo Systems (USA + DK) 	Temperature, Tilt and dissolved oxygen	170 mm length x 60 mm diameter	-Argos satellites -Wildlife Computers Data Portal (recovery and analysis)	2000 m	730 days	- Similar characteristics - Not commercially available	NA	NA

*Grey competitor is not comparable.

The grey competitor, created by the collaboration of *Wildlife Computers* with *Loligo Systems*, presents similar characteristics to NAUTILOS' tag, however, it is not commercially available. It was developed as a unique prototype for a research project and has not been commercially released to the market since the conclusion of the data collection. Furthermore, the tag was initially developed for use with sharks, not seals like NAUTILOS'. Therefore, additional modifications would be necessary to adapt the already modified device for use as a seal tag. In consequence, *CNRS*' tag will be the first long-term deployment seal tag for the study of dissolved oxygen to be readily available for purchase.

XII) NAUTILOS COST-BENEFIT RESULTS

Table 17 comprehensively summarizes all NAUTILOS technologies and their cost-benefit classifications. **NAUTILOS will introduce three new sensors to the market ("New to Market"), including one specifically designed for micro/nano plastic detection and analysis, as well as two innovative animal-borne tags.**

In terms of market price, **three NAUTILOS sensors are considered the most cost-effective in comparison to similar sensors with similar technical features already available on the market ("Cheaper in Class")**. These sensors offer improved performances at a competitive price, providing good value for money. In terms of technological development and high performance, **two NAUTILOS ocean monitoring sensors and one micro/nano plastic sampler are considered "Improved Technology"**. They can be recognised as an improved option in their categories based on various criteria, such as accuracy, reliability, durability, and technical innovation. Finally, three NAUTILOS sensors combine the advantage of being the most affordable on the market with top performance, offering advanced features and capabilities not found in other sensors.

Table 17 – NAUTILOS Cost-Saving Results.

Producer (Country)	HES-SO (CH)	NKE (FR)	NKE (FR)	NKE (FR)	NIVA & CSEM (NO & CH)	AQUATEC (UK)	AQUATEC (UK)	SubCTech (SCT) (DE)	UL-FE (SI)	HCMR (EL)	CEiiA (PT)	CNRS (FR)
Technology	Fluorometric Oxygen Sensor	WiSens TD – DO	WiSens TD – Chl-a	Silicate Electrochemical Sensor	Microplastic Sensor	Passive Acoustic Data Logger	Active Acoustic Profiling Data Logger	SuNaMips	Deep ocean CTD	Deep ocean low-level radioactivity Data Logger	MAANTA Animal tag	Oxygen Sensor Tag
Cost-Benefit Classification	Cheaper in Class	Improved Technology	Improved Technology	Improved Technology \ Cheaper in Class	New to Market	Cheaper in Class	Improved Technology \ Cheaper in Class	Improved Technology	Cheaper in Class	Improved Technology \ Cheaper in Class	New to Market	New to Market

In what concerns cost-savings, and as reported above, it was decided in this present public deliverable not to disclose economic information from project partners and competitors, despite the detailed market analysis performed. Although it is difficult to present conclusions about cost savings, we can conclude from the proposed classification that 100% of NAUTILOS technologies offer benefits to the market, as at least 75% of them are cheaper than comparable competitors (while the remaining 25% offer benefits/technical features that are considerably better for ocean monitoring). Considering all sensors that are cheaper than comparable competitors, the minimum cost-saving is 93 Euro, and the maximum is 16 340 Euro.

IV. CONCLUSION

The NAUTILOS Socio-Economic Impact Assessment was an important exercise to validate the transformative force of the project, and its potentially exploitable results, within the European Blue Economy, redefining ocean and environmental data collection and monitoring with its innovative and cost-effective sensors and samplers.

The development of the Input-Output model and the calculation of the socio-economic variables were based on key assumptions and the tools made available during 2023/2024. The structure of the European economy and its primary industrial linkages were analysed using Eurostat 2023, which reflects data from 2019. This analysis was crucial to evaluate how indirect and induced impacts permeate the economy and its sectors. Additionally, specific NAUTILOS data, such as expected sensor prices and costs, were estimated by partners involved in the development and future commercialisation of NAUTILOS instruments. The analysis focused on the year 2029, which was also used as a reference to estimate the number of units expected to be sold.

The results showed that the projected economic impact is highly promising, with an expected sale of 585 units of sensors, samplers, and tags by 2029, generating a projected revenue of 4,244,000 euros (direct sales). This financial impact extends well beyond direct sales, influencing the entire economic ecosystem of ocean observation and monitoring. **The socio-economic analysis highlights the far-reaching impact of NAUTILOS, with total economic production projected to reach 11,369,000 euros (over the total budget of NAUTILOS) and a significant Gross Value Added (GVA) of 5,254,000 euros, representing 46% of total production.**

The social impact is equally impressive. NAUTILOS technologies are expected to generate and support approximately 17 full-time equivalent (FTE) jobs in 2029, employing highly qualified resources (41% BSc, 44% MSc) with different aptitudes and backgrounds. Moreover, the project is committed to promoting gender balance within its workforce, expecting 59% male jobs and 41% female jobs.

Every technology developed in the scope of the NAUTILOS project has shown to be an important addition to the global market in its own way, either by elevating the capabilities of what can easily be commercially obtained or by providing a cheaper alternative, expanding access to a wider array of potential customers. Some companies introduced entirely new ocean monitoring solutions to the global market. The market relevancy of NAUTILOS proven by the Cost Savings and Competitors' Analysis, represents a positive progression of the project towards its initial goals and objectives.

NAUTILOS technologies have great potential to foster a more competitive and sustainable market for oceanographic instruments in Europe and beyond, guiding future business strategies and policy decisions.

In conclusion, the NAUTILOS project is not only advancing technological frontiers in ocean observation and monitoring but also promises substantial economic and social benefits. By developing cost-effective, high-performance sensors and samplers, NAUTILOS is enhancing Europe's competitive edge in marine technology and fostering ocean sustainability growth. The project's contributions are crucial for building a more competitive Europe, supporting the Blue Economy, and enabling comprehensive and accessible monitoring of the marine environment for both traditional and non-traditional data users.

APPENDIX 1: NAUILOS MARINE TECHNOLOGIES

Nautilus Technologies Grant Agreement	Deliverable 11.5	Developer	Technology Class	Notes
Fluorometric Sensors/dissolved oxygen	Fluorometric Dissolved Oxygen Sensor	HES-SO	Sensor	
Dissolved Oxygen and Fluorescence Sensors	Dissolved Oxygen Data Logger Wisens TD-DO	NKE	Data Logger	<i>See Chapter II, 1.2.2 "Data Collection from Partners"</i>
	Fluorescence Data Logger WiSens TD – Chl-a	NKE	Data Logger	
Silicate Electrochemical Sensor	Silicate Electrochemical Sensor	NKE	Sensor	
Microplastic sensor	Microplastic sensor	NIVA + CSEM	Sensor	
Passive broadband acoustic recording sensor for noise monitoring	Passive broadband acoustic recording sensor for noise monitoring and acoustic event recorder (sound and click recorder)	AQUATEC	Data Logger	<i>See Chapter II, 1.2.2 "Data Collection from Partners"</i>
Passive acoustic event recorder (porpoise & dolphin clicks for abundance estimation)				
Active Acoustic Profiling Sensor	Active Acoustic Profiling Data Logger AQUAscat Mk2	AQUATEC	Data Logger	
Sampler for Nanoplastics and Microplastics	Submersible Sampler for Nanoplastics and Microplastics	SCT	Sampler	
Deep ocean CTD	Deep ocean CTD Sensor	UL-FE	Sensor	
Deep ocean low-level radioactivity sensor	Deep ocean low-level radioactivity Data Logger	HCMR	Data Logger	
Animal-borne instruments	Non-invasive animal towed tagging system used for animals such as manta rays and sharks MAANTA	CEiiA	Tag	
	Oceanographic Satellite Relayed Data Logger (SRDL) from the Sea Mammal Research Unit deployed on southern elephant seal Marine animal-borne temperature-salinity-DO Tag	CNRS	Tag	
Downward looking multi/hyperspectral and laser induced fluorescence sensors and cameras	<i>Not considered in this SEIA</i>	NIVA	Sensor	<i>See Chapter I, 3.0 "Exploitation Strategy"</i>
Sampler for phytoplankton and other suspended matter	<i>Not considered in this SEIA</i>	NIVA	Sampler	
Carbonate system/ocean acidification sensors	<i>Not considered in this SEIA</i>	NIVA	Sensor	

APPENDIX 2: REFERENCES AND RELATED DOCUMENTS

ID	Reference or Related Document	Source or Link/Location
1	NAUTILOS Grant Agreement	NAUTILOS GoogleDrive
2	NAUTILOS Annex I to the Grant Agreement Part B	NAUTILOS GoogleDrive
3	D11.1. NAUTILOS Exploitation Strategy	NAUTILOS GoogleDrive
4	D11.8. NAUTILOS Socio-Economic Impact Assessment	NAUTILOS GoogleDrive
5	Aanderaa – Oxygen sensor 4835	https://www.aanderaa.com/oxygen-sensors
6	Seabird – SBE 63	https://www.seabird.com/sbe-63-optical-dissolved-oxygen-sensor/product?id=60762467729
7	JFE Advantech Co. – RINKO II	https://www.jfe-advantech.co.jp/eng/products/ocean-rinko.html
8	PyroScience – APOX-L-O2	https://www.pyroscience.com/en/products/all-meters/aquaphox-l-o2
9	RBR - RBRcoda ³ T.ODO	https://rbr-global.com/products/sensors/rbrcoda-todo/
10	PME – miniDOT Logger	https://www.pme.com/products/minidot
11	YSI – EXO1	https://www.ysi.com/exo1
12	Chelsea Technologies – TriLux	https://chelsea.co.uk/products/trilux/
13	ClearWaters Sensors – Lab-on-chip Chemical Sensors	https://www.clearwatersensors.com/silicate-sensor/
14	Turner Designs – Trilogy Laboratory Fluorometer	https://www.turnerdesigns.com/trilogy-laboratory-fluorometer
15	Horiba - MacroRAM	https://www.horiba.com/int/scientific/products/detail/action/show/Product/macroramtm-805/
16	Bruker – INVENIO FTIR Spectrometer	https://www.bruker.com/en/products-and-solutions/infrared-and-raman/ft-ir-research-spectrometers/invenio-ft-ir-spectrometer.html
17	Ocean Sonics – icListen HF	https://oceansonics.com/iclisten-hf/
18	RS Aqua – Porpoise 84D	https://rsaqua.co.uk/product/porpoise-84d/
19	Chelonia – DeepF-POD	https://www.chelonia.co.uk/fpod_home_page.htm
20	Sonardyne – Origin 600 ADCP	https://www.sonardyne.com/products/origin-600-adcp/

21	SEQUOIA – LISST-ABS	https://www.sequoiasci.com/product/lisst-abs/
22	Teledyne RDI – Workhorse II Sentinel ADCP	https://www.teledynemarine.com/en-us/products/Pages/workhorse-sentinel-adcp.aspx
23	Nortek – Signature 1000	https://www.nortekgroup.com/products/signature-1000
24	McLane – Particle and Phytoplankton Sampler	https://mclanelabs.com/phytoplankton-sampler/
25	KcDenmark – Plastic particle pump	https://www.kc-denmark.dk/products/microplastic-particle-pump/plastic-particle-pump.aspx
26	OSIL – Microplastics Sampler	https://osil.com/product/microplastics-sampler/
27	Ocean Diagnostics – Ascension Microplastics Depth Sampler	https://oceandiagnostics.com/microplastics-sampling
28	Sea and Sun Technology – CTD 48	https://www.sea-sun-tech.com/product/multiparameter-probe-ctd-48/
29	Valeport – Midas CTD	https://www.valeport.co.uk/products/midas-ctd/
30	D2 Incorporated – Hybrid CTD	https://www.d-2.com/?page_id=861
31	RBR - RBRconcerto ³ C.T.D	https://rbr-global.com/products/standard-loggers/rbrduo-ct/
32	ENVINET - TUNA	https://scientaenvinet.com/en/products/tuna
33	ATOMTEX - AT6104DM Spectrometer	https://atomtex.com/en/at6104dm-at6104dm1-spectrometers
34	Wildlife Computers – SPOT-253	https://wildlifecomputers.com/our-tags/spot-argos-satellite-tags/
35	Little Leonardo – ORI1300	http://l-leo.com/eng/data-logger
36	Wildlife Computers – mrPAT	https://wildlifecomputers.com/our-tags/pop-up-satellite-tags-fish/mark-report-pat/
37	Animal tag prototype (CNRS competitor)	https://animalbiotelemetry.biomedcentral.com/articles/10.1186/s40317-015-0088-x