

# Action D.6. Evaluation of the actions impact on ecosystem services

MAR MENOR

(SPAIN)

*Project responsible*

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## Executive summary

This report presents the results of Action D.6, evaluating the impact of the LIFE TRANSFER project on the ecosystem services in the Mar Menor coastal lagoon (SE Spain). The assessment focused on the effects of two macrophyte species transplantation (*Cymodocea nodosa* (Ucria) Ascherson, 1870 and *Ruppia cirrhosa* (Petagna) Grande, 1918), following the standardized EU MAES methodology and the CICES v5.2 Ecosystem services classification.

The assessment of the evaluation on the ecosystem services followed the next approach: (1) Identification of the target ecosystem and its initial condition (established based on ex-ante monitoring program within the LIFE TRANSFER project). (2) Selection and measurement (when possible and based on available monitoring data) of relevant ecosystem services based on the MAES framework. (3) Normalization of the values of ecosystem services and their inclusion in the matrix.

In the Mar Menor lagoon, the project successfully enhanced the ecosystem state from a regression to one of active recovery in terms of macrophyte seagrass. The core achievement was the significant expansion of seagrass meadows reached by means of transplant actions, with a final success rate of 88 % for *C. nodosa*, and 35 % for *R. cirrhosa*.

The seagrass transplantation and consequent restoration led to improvements across multiple ecosystem services categories. For the case of regulation and maintenance services, in the Mar Menor it has been documented an increase in the density and richness of benthic invertebrates, together with the presence of indicator fish species. These results confirm that the function of the restored area acts as a nursery and refuge habitat. Different ecological quality indices (MaQI, M-AMBI or BITS) showed an improvement in the transplanted areas, indicating a healthier status. Regarding to the environmental condition, it is shown that successful transplantation in the Mar Menor areas showed increased organic matter in sediments, which improves soil structure and nutrient cycling.

For the case of cultural services, despite they were not directly measured by any indicator, the LIFE TRANSFER project, in the Mar Menor, indirectly enhanced services related to science and education through dedicated training, knowledge exchange, and dissemination activities either for Natura 2000 technicians, students, and local population. Moreover, restoration of meadows in the selected area, enhanced the attractiveness of the ecosystem for tourism and recreational activities, together with its aesthetic potential.

The LIFE TRANSFER project has successfully demonstrated that seagrass restoration in the Mar Menor lagoon delivers ecological benefits. The project has enhanced a suite of

regulating, maintenance, and cultural ecosystem services, contributing to the long-term ecological resilience and socio-economic value of this Natura 2000 site.

## Introduction

This report reports the results of Action D6 "Evaluation of the actions impact on ecosystem services" in the Mar Menor, as foreseen in the application form using data from monitoring actions and other data that have been specifically collected.

The area considered is the coastal lagoon of the Mar Menor (ES6200030, ES0000260), located in the southeast of the Iberian Peninsula, Region of Murcia, Spain.

## Methodology

The method used for the assessment of ecosystem services, hereinafter SE, followed the guidelines "Assessing ecosystems and their services in LIFE projects a guide for beneficiaries" which in fact propose the MAES methodology - Mapping and Assessment of Ecosystems and their Services. In summary, the mapping and evaluation of the ES followed a different and sequential phased approach:

1. Identification of relevant ecosystems and evaluation of their conditions.
2. Selection and quantification of relevant ecosystem services.
3. Normalization of the values of ecosystem services and their inclusion in the matrix.

In the present report the most recent CICES (Common International Classification of Ecosystem Services) classification (version 5.2) was used according to the guidelines, so that the groups of ecosystem services: Provisioning, Regulation & Maintenance, Cultural services.

## Initial condition and ecosystem identification

- **Ecosystem:** Mar Menor coastal lagoon (Murcia, Spain) (ES6200030, ES0000260)
- **Ecosystem tipe (MAES<sup>1</sup>):** Marine inlets and transitional waters.
- **Ecosystem code:** TC

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<sup>1</sup> Maes J, Teller A, Erhard M, Grizzetti B, Barredo JI, Paracchini ML, Condé S, Somma F, Orgiazzi A, Jones A, Zulian A, Petersen JE, Marquardt D, Kovacevic V, Abdul Malak D, Marin AI, Czúcz B, Mauri A, Löffler P, Bastrup-Birk A, Biala K, Christiansen T, Werner B (2018) *Mapping and Assessment of Ecosystems and their Services: An analytical framework for ecosystem condition*. Publications office of the European Union, Luxembourg.

- **Target species:** *Cymodocea nodosa* (Ucria) Ascherson, 1870 and *Ruppia cirrhosa* (Petagna) Grande, 1918
- **Initial condition (2021):**
  - o Existing seagrass meadow status: Integrity threatened by human action.
  - o Potential seagrass meadow surface in the project: 1 000 m<sup>2</sup>
  - o Condition: “Poor” (Value 2 on 0-5 scale)
  - o Trend: “Regression”

## Ecosystem services selected

(based on LIFE guide Annex I, Table S5)

The ecosystem services produced by a lagoon are numerous; two criteria were applied for the selection: the principle of the benefits provided to people derived from the same definition of ecosystem services, and the restoration of the ecosystem functions contributed to the lagoon thanks to the work carried out by the LIFE TRANSFER project. In addition, the availability of indicators was taken into account among those made available by the guidelines "Assessing ecosystems and their services in LIFE projects a guide for beneficiaries".

A preliminary list of all possible Ecosystem Services (ES), provided by habitat 1150\* and supported by seagrass transplantation in Mar Menor, was defined with reference to the Common International Classification of Ecosystem Services (CICES v5.2) and to the MAES list of ES indicator for the specific ecosystem.

In a second phase, a selection of the most relevant (and quantifiable) ES have been identified in the context of LIFE TRANSFER project, in the Mar Menor lagoon (Spain). They have been identified considering the data collected in monitoring action (D.3) (specified as indicator) (**Table 1**).

**Table 1.** Ecosystem services relevant (and quantifiable) for the LIFE TRANSFER project. Ecosystem services were selected on the basis of the MAES list of indicators for the transitional water ecosystem. Details of ecosystem services and method for quantification are reported.

CICES V5.2 CODE	SECTION	DIVISION	GROUP	CLASS	INDICATOR
2.3.2.3	Regulation & Maintenance (Biotic/Biophysical)	Regulation of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining or regulating nursery populations and habitats or breeding grounds (Includes gene pool protection)	Improvement of biodiversity (algae, benthos, fish fauna): Richness and abundance indices
2.3.2.4				Maintaining or regulating refuge habitats	Extension of new seagrass meadows (m <sup>2</sup> ).  Improvement of conservation

CICES V5.2 CODE	SECTION	DIVISION	GROUP	CLASS	INDICATOR
					degree of habitat 1150*  Improvement of ecological status (EQS indices)
2.3.4.2			Regulation of soil quality	Decomposition and fixing processes and their effect on soil quality	Inorganic and organic carbon content in sediments. Total nitrogen, phosphorous in sediments.
2.3.4.3				Maintenance of soil structure by biological agents and ecological processes	Porosity, wet and dry density, humidity, percentage of fine fraction, and organic matter content in sediments
2.3.5.2			Water conditions	Regulation of the chemical condition of macronutrients in salt waters by living processes.	Total ammonium, oxidized nitrogen, dissolved inorganic phosphorus, and dissolved silicates in water matrix
3.1.1.1	Cultural (Biotic/Biophysical)	Physical and experiential interactions with natural environment	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting, i.e. broadly recreational activities	Elements of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions	By increasing the seagrass meadows coverage. Use of activities descriptor not measured in this case.
3.2.1.1		Intellectual and representative interactions with natural environment	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Elements of living systems that enable scientific investigation or the creation of traditional ecological knowledge, including the importance of	Promoting the interest in a Red Natura 2000 site (Mar Menor, Spain) by reserarch exchange meetings, dissemination

CICES V5.2 CODE	SECTION	DIVISION	GROUP	CLASS	INDICATOR
				between and within species genetic diversity	activities. (Action E)
3.2.1.2				Elements of living systems that enable education and training, including the importance of between and within species genetic diversity	Training and teaching activities among the dissemination activities (Action E).
3.2.1.4				Elements of living systems that enable aesthetic experiences	Dissemination activities for enhance the beauty of seagrass landscapes

### Regulation & Maintenance (Biotic/Biophysical) services

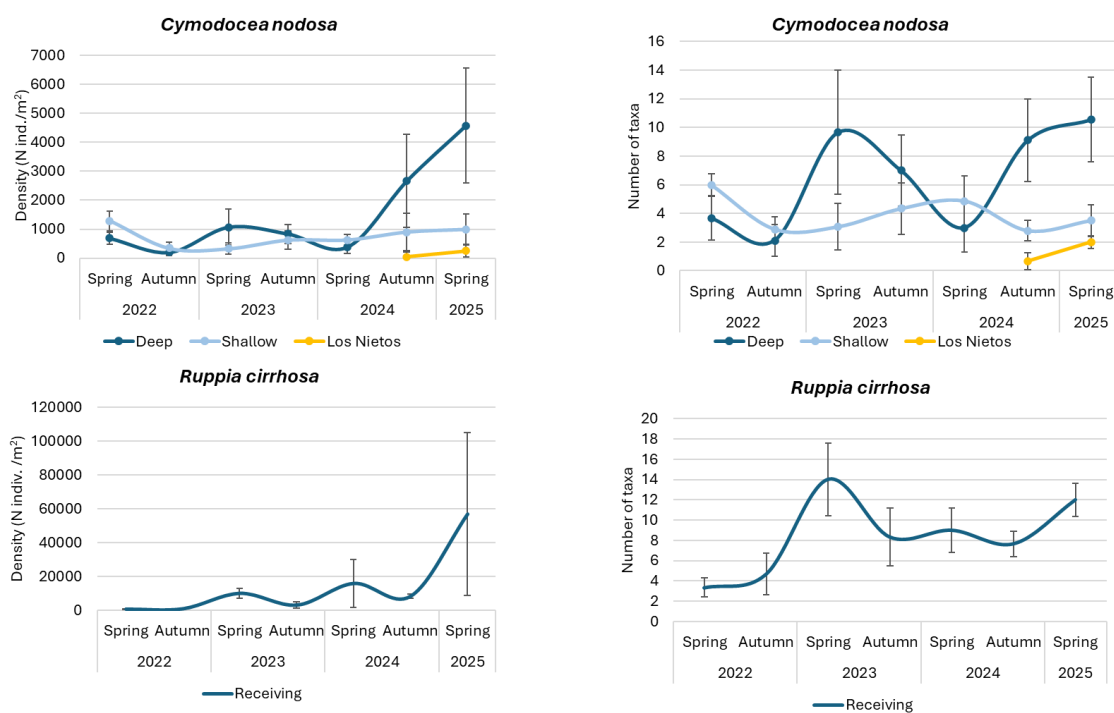
Within the framework of the LIFE TRANSFER project, in its action on the coastal lagoon of the Mar Menor (Spain), the seagrass meadows increased their extension as a result of the transplants carried out within action C.3 of the same project. By the end of the project, these phanerogam meadows accounted for 88 % and 35 % of the total transplanted in the first year for both species (*Cymodocea nodosa*: 900 m<sup>2</sup>; *Ruppia cirrhosa*: 35 m<sup>2</sup>) (CICES code: 2.3.2.4; **Table 1**) (**Figure 1**).



**Figure 1.** *C. nodosa* transplant station LUR4, in Los Urrutias. A particular case of success of transplant evolution, from 2022 (first transplant action) to 2025 (last monitoring period).

En consecuencia, los resultados del seguimiento llevado a cabo a lo largo del proyecto, en relación con las variables ambientales y los indicadores biológicos, mostraron un aumento de la biodiversidad tanto de macroinvertebrados bentónicos, macrófitos e ictiofauna asociados al hábita de fanerógamas marinas en ecosistemas de transición.

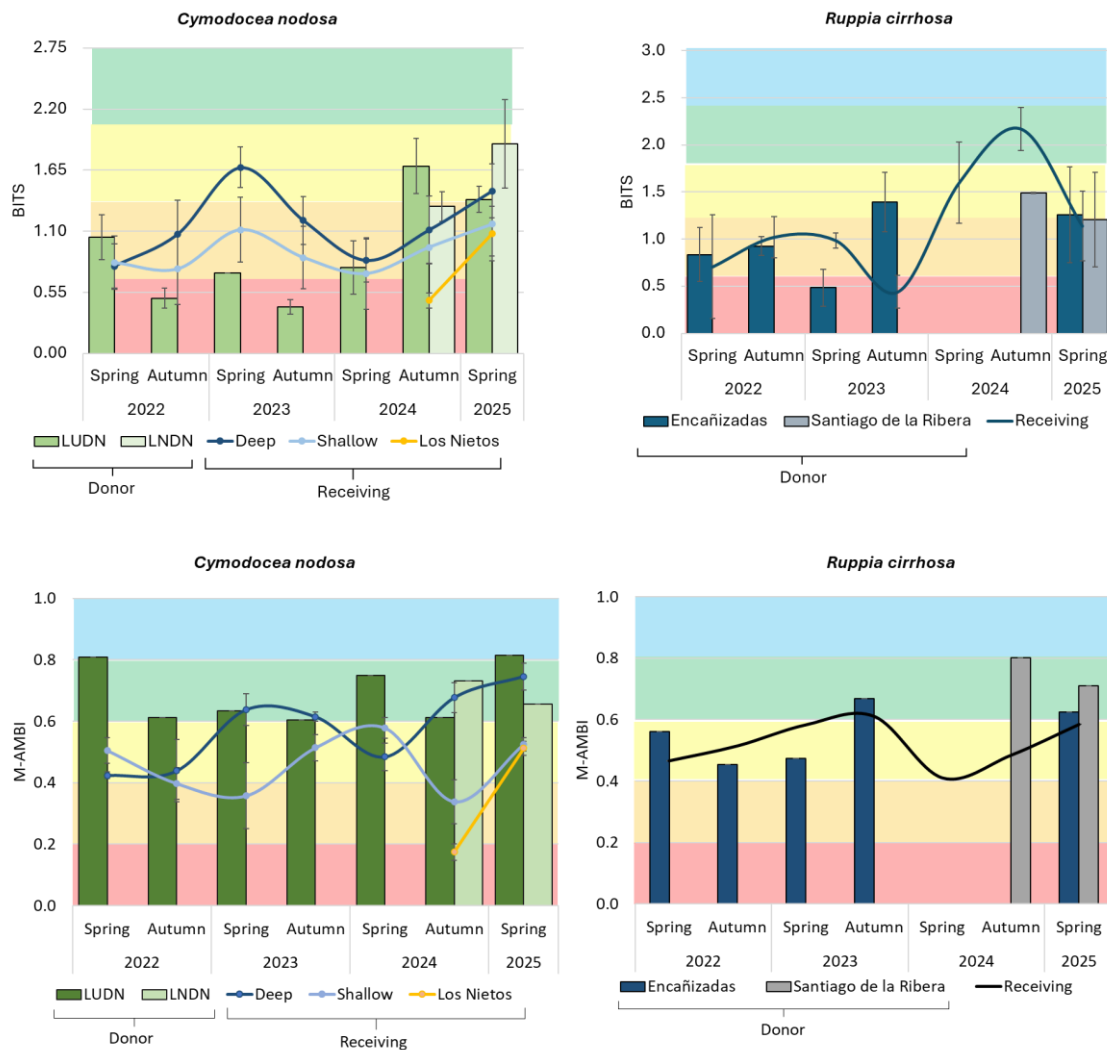
Desde el punto de vista biológico, los trasplantes exitosos del proyecto, llevaron consigo un aumento en el número de individuos de invertebrados bentónicos (**Figura 2**). Este mismo quedó directamente relacionado con el servicio ecosistémico 2.3.2.3: “Maintaining or regulating nursery populations and habitats or breeding grounds (Includes gene pool protection)” (**Table 1**).



**Figure 2.** Density of individuals (N indiv. / m<sup>2</sup>) and species richness (N taxa) identified in receiving sites of the different transplanted species: *C. nodosa* and *R. cirrhosa*, across the monitoring period (seasonally).

Subsequently, the progressive increase in indicator species associated with seagrass habitats, such as *Syngnathus abaster* Risso, 1827, *Syngnathus typhle* Risso, 1827, and *Syngnathus acus* Linnaeus, 1758, is a relevant ecological indicator of the success of transplantation and functional habitat recovery. Moreover, other species such as *Apricaphanius iberus* (Valenciennes, 1846) (Annex II Habitat Directive) was also observed in transplanted area. These species suggest an improvement in the structural complexity and shelter provided by the vegetation, directly correlated with the ES 2.3.2.3 code: “Maintaining or regulating nursery populations and habitats or breeding grounds (Includes gene pool protection)” (**Table 1**).

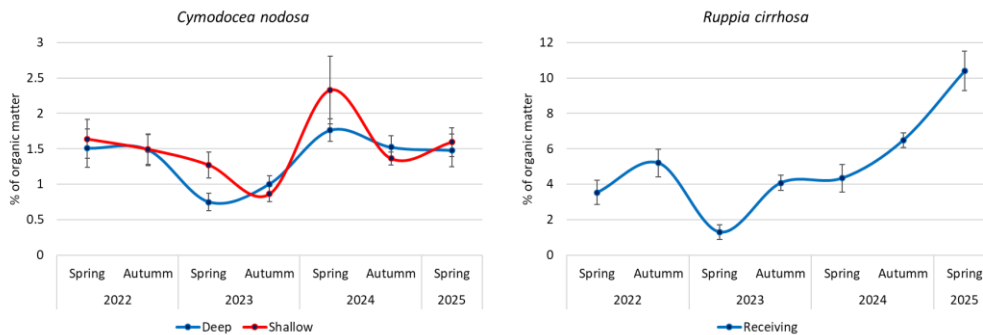
Although the number of macrophyte species and ichthyofauna was not directly increased, the improvement of the transplanted areas was observed in terms of the application of ecological quality indices: MaQI for macrophytes; M-AMBI and BITS for benthic invertebrates (**Figures 3 and 4**). The improvement in the values of these indices is associated with the Maintenance and Regulation service with CICES code 2.3.2.4: "Maintaining or regulating refuge habitats" (**Table 1**).



**Figure 3.** BITS (up) and M-AMBI (down) indices values estimated for each transplanted species sites, compared to control sites (donor), across the monitoring periods.

With respect to the physicochemical parameters, both of the water matrix and in the sediment, these were studied within the monitoring program of the environmental variables associated with the transplantation and monitoring of seagrass meadows in the Mar Menor. Some of them, as the organic matter content in sediments, increased in succeeded transplanted area, improving the ES 2.3.4.2 ("Decomposition and fixing processes and their effect on soil quality") and 2.3.4.3 ("Maintenance of soil structure by biological agents and ecological processes"). The monitoring of these and other water

matrix variables was important for the assessment of ecosystem services: 2.3.4.2.; 2.3.4.3: and 2.3.5.2: "Regulation of the chemical condition of macronutrients in salt waters by living processes" (**Table 1**).



**Figure 4.** Organic matter content (%) in sediments, in transplanted sites for each case of study: *C. nodosa* and *R. cirrhosa*, across the monitoring periods.

### Cultural (Biotic/Biophysical) services

In addition, other ecosystem services belonging to the cultural group were improved at the end of the project. However, the descriptors considered for them were not measured in quantitative terms, but were measured under observation conditions by the researchers and personnel involved in the project. On the other hand, those services in the group of interactions with the natural environment (code: 3.1.1.1: "Elements of living systems that enable activities promoting health, recuperation or enjoyment through active or immersive interactions") (**Table 1**), are considered an improvement given the tourist attraction for recreational activities such as snorkeling or diving, as well as bathing, in the study area.



**Figure 5.** Dissemination activities and technical training of seagrass transplantation, for other Natura 2000 technicians carried out in Mar Menor

On the other hand, actions within the framework of the LIFE TRANSFER project such as the dissemination and preparation of specialized technicians in other places of the

Natura 2000 Network in Spain, led to an improvement of the ecosystem services of the group of intellectual interactions and representative interactions with the lagoon ecosystem of the Mar Menor. (CICES code: 3.2.1.1: "Elements of living systems that enable scientific investigation or the creation of traditional ecological knowledge, including the importance of between and within species genetic diversity"; 3.2.1.2: "Elements of living systems that enable education and training, including the importance of between and within species genetic diversity"). In addition, these same informative activities favoured the enhancement of the habitat of seagrass meadows in the Mar Menor (CICES code: 3.2.1.4: "Elements of living systems that enable aesthetic experiences") (**Table 1**).

## Normalization of the values of ecosystem services and their inclusion in the matrix.

The normalization of the different values of the indicators used was carried out according to the estimated values for them in the control areas (natural donors sites) of the project. With this, the reference values of good conditions refer to those observed in these control areas (**Table 2, Table 3**).

**Table 2.** The normalised values (0 – 5) from the ecosystem services matrix can easily be translated into the values that are included in the KPI Webtool. Rate of change (%) refers to the degree of achievement of different descriptors variable respect to control area with natural donor meadows.

VALUE	DESCRIPTION	% RATE OF CHANGE
0	Without data / not relevant	0 – 15 %
1	Bad / not functional	16 – 35 %
2	Poor / defavourable	36 – 55 %
3	Moderate	56 – 75 %
4	Good	76 – 90 %
5	High	91 – 100 %

**Table 3.** Quantitative evaluation of ecosystem services according to CICES classification: monitoring values at control (C) and recipient (R) sites for *Cymodocea nodosa* (Cy) and *Ruppia cirrhosa* (Ru), and their normalization value tendency from 2021 to 2025, based on criteria of table 2.

CICES CODE	INDICATOR	VALUE 2021				VALUE 2025				NORMALIZED VALUE	
		Cy-C	Cy-R	Ru-C	Ru-R	Cy-C	Cy-R	Ru-C	Ru-R	Cy	Ru
2.3.2.4	New seagrass meadows (m <sup>2</sup> ).	-	0	-	0	-	900	-	35	0 → 4	0 → 1
	MaQI Index	0.85	0.35	0.85	0.55	0.85	0.85	0.85	0.85	2 → 5	3 → 5
	M-AMBI index	0.87	0.51	0.61	0.31	0.81	0.62	0.67	0.58	3 → 4	2 → 4
2.3.2.3	Benthic macrophytes species (sp)	6	17	9	9	5	13	8	3	5 → 5	5 → 2
	Benthic macroinvertebrate (sp)	17	6	9	4	27	12	18	17	1 → 2	2 → 5
	Fish species (sp)	14	14	-	8	11	10	-	4	5 → 5	3 → 2
2.3.4.2	Organic Carbon content (%)	0.7	0.67	1.54	0.47	0.19	0.14	3.13	2.86	5 → 4	1 → 5
	Inorganic Carbon content (%)	5.56	5.3	6.18	4.24	6.13	7.13	4.20	5.3	5 → 5	3 → 5
	Nitrogen in sediment (%)	0.12	0.07	0.11	0.07	0.03	0.02	0.16	0.17	3 → 5	3 → 5
	Density (Wet) g / cm <sup>3</sup>	1.32	1.53	0.82	0.99	1.38	1.58	1.01	1.01	5 → 5	2 → 5
	Density (Dry) g / cm <sup>3</sup>	1.50	1.31	0.81	0.96	1.38	1.59	1.10	1.01	4 → 5	5 → 5
	Inorganic Phosphorous (g / cm <sup>3</sup> )	116.8	77.2	134.1	141.9	81.05	58.2	196.6	513.1	3 → 3	5 → 5
2.3.4.3	Organic Phosphorous (g / cm <sup>3</sup> )	39.2	27.04	137.6	63.03	4.57	8.85	77.4	77.1	3 → 5	2 → 5
	Porosity (ml water / ml wet sed.)	0.46	0.86	2.07	1.07	0.19	0.71	1.73	0.64	5 → 5	2 → 2
	Wet density (g / cm <sup>3</sup> )	1.32	1.53	0.82	1.10	1.43	1.58	0.99	1.01	5 → 5	5 → 5
	Dry density (g / cm <sup>3</sup> )	1.31	1.5	0.81	0.97	1.43	1.58	1.1	1.01	5 → 5	5 → 5
	Humidity	0.35	0.56	2.57	1.72	0.13	0.45	1.05	0.62	5 → 5	3 → 3
	Organic matter content (%)	1.57	1.04	6.69	3.57	1.46	1.55	8.7	10.3	5 → 5	2 → 5
	Fine fraction (< 0.063 mm) (%)	3.81	1.68	7.87	4.62	4.61	6.75	42.7	41.58	2 → 5	3 → 5
2.3.5.2	Nitrate (µg at N – NO <sub>3</sub> /l)	BDL	7.4	0.7	0.21	2.14	1.44	11.09	0.08	2 → 5	5 → 5
	Nitrite (µg at N – NO <sub>2</sub> /l)	0.13	0.97	0.13	0.2	0.12	0.16	1.2	0.12	0 → 3	3 → 5
	Ammonium (µg at N – NH <sub>4</sub> /l)	BDL	1.24	0.54	1.07	0.86	1.22	3	5.67	0 → 3	2 → 2
	Silicate (µg at Si – SiO <sub>4</sub> /l)	6.22	3.58	1.72	15	27.43	24.5	35.9	28.6	5 → 5	0 → 5
	Phosphorous (µg at P – PO <sub>4</sub> / l)	0.12	0.19	0.17	0.31	0.12	0.10	0.20	0.31	3 → 5	2 → 3
	Total suspended solids (mg / l)	7	12.11	14	14	11.8	8.63	23.1	14.8	3 → 5	5 → 5

Table 4. Normalized value matrix (0-5) for each Ecosystem Services, for each transplanted area (*C. nodosa*, *R. cirrhosa*), based on data normalized in Table 3.

<b>CICES CODE</b>	<b>ECOSYSTEM SERVICE</b>	<b>C. Nodosa</b>	<b>R. Cirrhosa</b>
<b>2.3.2.4</b>	Maintaining or regulating nursery populations and habitats or breeding grounds (Includes gene pool protection)	2 → 4	2 → 3
<b>2.3.2.4</b>	Maintaining or regulating refuge habitats	4 → 4	3 → 3
<b>2.3.4.2</b>	Decomposition and fixing processes and their effect on soil quality	4 → 5	3 → 5
<b>2.3.4.3</b>	Maintenance of soil structure by biological agents and ecological processes	5 → 5	3 → 4
<b>2.3.5.2</b>	Regulation of the chemical condition of macronutrients in salt waters by living processes.	2 → 4	3 → 4
<b>3.1.1.1</b>	Elements of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions	3 → 4	2 → 3
<b>3.2.1.1</b>	Elements of living systems that enable scientific investigation or the creation of traditional ecological knowledge, including the importance of between and within species genetic diversity	2 → 5	2 → 5
<b>3.2.1.2</b>	Elements of living systems that enable education and training, including the importance of between and within species genetic diversity	2 → 5	2 → 5
<b>3.2.1.4</b>	Elements of living systems that enable aesthetic experiences	3 → 4	2 → 3