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Assessing the first MSFD Implementation Cycle in Greece under Biodiversity and Contaminants Descriptors

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Abstract: The present work constitutes an assessment of the first implementation cycle of the Marine Strategy Framework Directive 2008/56/EC in Greece by focusing on biodiversity and contaminants, i.e., Descriptors 1 (biodiversity), 4 (food webs), 6 (seafloor integrity), 8 (contaminants), and 9 (contaminants in seafood), and by following the directive's requirements regarding Articles 8-Initial Assessment, 9-Definition of Good Environmental Status, 10-Establishment of Environmental Targets, 11—Monitoring Programmes, and 13—Programmes of Measures. In this study, the analysis that was conducted investigated the integration of the Com Dec 2010/477/EU criteria and the indicators that have been applied for each descriptor and the approaches and standards that have been used in order to determine the adequacy of the directive's implementation towards the achievement of GES, the consistency of Articles 8, 9, 10, 11, and 13, and the integration of existing EU legislation and regional/ international agreements or policies as well as the level of coherence among EU Mediterranean MSs. Overall, Greece addressed the requirements of Articles 8, 9, and 10 rather inadequately for D1, D4, D6 and partially adequately for D8, D9, integrating existing legislation to a certain extent. The implementation of Article 11 was satisfactory for all of the descriptors regarding monitoring the needs and the progress towards GES, whereas the measures that were established under Article 13 need to be improved in the forthcoming update.

Keywords: Marine Strategy; EU legislation; policy integration; Barcelona Convention; Mediterranean; GES

1. Introduction

The Marine Strategy Framework Directive (MSFD) [1] was introduced in 2008 and had the ultimate goal of achieving Good Environmental Status (GES) for European marine waters by 2020 and of protecting the marine resources that form the basis of human economic and social activities. The MSFD forms the environmental pillar of the Integrated Maritime Policy and entails that EU Member States (MSs) adopt all of the requisite measures in order to achieve its objectives. Accordingly, every six years, the EU MSs are obliged to assess the environmental status of their marine environment (Article 8), define the GES of the waters in their specific country (Article 9), and set environmental targets (Article 10). Monitoring Programmes (Article 11) were intended to be established and to become operational by the year 2014, with the expectation that they be updated at least every six years. Another expectation was that Programmes of Measures (Article 13) would be set by 2015, become operational by 2016 and be revisited every six years [1]. Claussen et al. [2] depicted the management cycle of the MSFD as a cyclical process, the first cycle of which was initiated in 2012, with the second cycle being initiated in 2018.

Eleven descriptors constitute the foundation of the MSFD, which address key features or processes that are related to the marine environment; descriptors 2, 3, 5, 8, 9, 10, and 11 address anthropogenic pressures; descriptors 1 and 6 depict the structure of the marine environment; and descriptor 4 depicts the functioning of marine ecosystems [3]. The first MSFD implementation cycle was complemented by Commission Decision 2010/477/EU [4],



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Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https:// creativecommons.org/licenses/by/ 4.0/). which outlined the criteria and methodological standards for the good environmental status of marine waters, providing a framework on which MSs could assess the environmental status of their marine waters and on which they could determine GES, while subdividing the 11 GES descriptors into 29 criteria and 56 associated indicators. These criteria and indicators guided the MSs in deciding upon the characteristics of the ecosystem features that were to be used when assessing the status of the individual marine environments. Com Dec 2010/477/EU was revised in 2017 and was repealed by Com Dec 2017/848/EU [5].

The MSFD necessitates that the MSs plan their marine strategies by adopting an ecosystem-based approach for the management of human activities while ensuring the sustainability of the goods and services that are provided by marine ecosystems [1]. The Ecosystem Approach (ECAP) for the management of human activities is fundamental to national and regional environmental commitments, and in order to safeguard and to restore ecological functions, it requires cross-sectoral, and in some cases cross-boundary, measures [6].

Bigagli [7] demonstrated that the MSFD forms the first legislative item that stipulates a complex management system for EU marine waters; additionally, under the MSFD, marine regions and sub-regions are determined based on bio-geographical characteristics and can be also regarded as marine social–ecological systems. Moreover, according to Borja et al. [8], the standards that are set by the MSFD enable the development of sustainable marine ecosystems and provide the overarching criteria that the economic activities that occur in the marine space should comply with. Thus, the MSFD is innovative in terms of environmental policy, as it fosters an integrative, holistic ecosystem approach to the marine environment and considers it to be a functional unit with complex interactions [9], constituting a powerful legislative instrument for integrated marine management in the European regional seas by encompassing existing EU legislations that are relevant to the marine realm [10].

The extensive material concerning marine waters that has been gathered by the EU MSs over the course of MSFD implementation constitutes an open access, well-structured, and manageable information tank that can be used by all of those who are involved in marine environment management and planning processes [11,12]. Nevertheless, adequacy and coherence constitute important traits of proper MSFD implementation, requiring MSs to act in a coordinated manner by exchanging best practices, aligning approaches, and establishing common thresholds regionally and/or sub-regionally [13]. In addition, the number of quantitative assessments or assessments that aggregate the different criteria and/or descriptors remains low. This lack of holistic and/or quantitative approaches could be attributed to the insufficiency of tools that support the aggregation of information at the spatial and temporal scales and the integration of various indicators [14]. As the MSFD follows ECAP, it should not only provide holistic assessments, but it should also integrate relevant sectorial policies, aligning and coordinating with policies that are essential for the MSFD to achieve its objectives at both the national and EU levels [10]. As mentioned by Gorjanc et al. [15], the MSs should exploit the various mechanisms that already exist, such as multilateral commissions, regional strategies, working groups within the EU, and the Regional Sea Conventions, to coordinate their efforts in order to achieve appropriate MSFD implementation and to achieve the objectives that have been introduced by the directive.

In Greece, the MSFD was initiated after its transposition into Greek law in 2011, although the transposition should have been in place by 15 July 2010. The first implementation cycle began in 2012 and ended in 2017. The first step was performed in 2012 and involved Article 8, Initial Assessment of the Environmental Status of Marine Waters and Impact of Human Activities, (8a/8b/8c); Article 9, the Determination of GES of Marine Waters; and Article 10, the Establishment of Environmental Targets and Associated Indicators. In 2016, Article 11, Monitoring Programmes, was addressed, whereas the requirements stipulated in Article 13, Programmes of Measures, were met in 2017 (Figure 1).



Figure 1. The 1st MSFD implementation cycle in Greece (modified from [2]).

In Greece, the MSFD implementation process entailed the introduction of several acts [16]: (1) the directive transposition of the MSFD into the Greek national legislation in June 2011 with Law 3983/2011, which was published in Official Government Gazette (O.G.G.) A144 (17 June 2011), when the Special Secretariat for Water from the Ministry of Environment and Energy was also assigned as the Competent Authority responsible for the implementation of the MSFD in Greece; (2) the regulation of the National Marine Environment Strategy Committee with Ministerial Decision (M.D.) 160182, which was published in O.G.G. B3186 (30 December 2011) and was composed following M.D. 110428, which was published in O.G.G. 189 (11 April 2012); (3) the public information and consultation on marine strategies, which was published in O.G.G. B2377 (27 August 2012); (4) the approval of Environmental Targets and Indicators for marine waters with M.D.1175/2012, which was published in O.G.G. B2939 (02 November 2012); (5) the approval of Monitoring Programmes for the assessment of the environmental status of marine waters, which was published in O.G.G. B3799 (25 November 2016); (6) the assignment of Marine Water Quality Monitoring to the responsible bodies under Joint Ministerial Decision 26856/2017, which was published in O.G.G. B11 (11 January 2017); (7) the approval of Programmes of Measures to achieve or maintain GES in marine waters under the M.D. 142569/2017, which was published in O.G.G 4728 (29 December 2017); and (8) the amendment of 2008/56/EC ANNEX III according to directive 2017/845, which was published in O.G.G. 5728 (19 December 2018).

The marine waters of Greece, as defined in Law 3983/2011, lie within the marine region of the "Mediterranean Sea" (Article 5, Par.1) and fall into three subregions identified in the directive, namely the Adriatic Sea; the Ionian Sea and the Central Mediterranean Sea; and the Aegean-Levantine Sea (Figure 2). As the Greek seascape encompasses a huge variety of oceanographic, hydrological, biological, and chemical features, in 2012, assessment areas were defined in order to consider these specificities (Table 1) [17]. The delineation was made in order to implement the directive at the appropriate level by defining ecologically relevant areas to support the ecosystem-based approach that was mandated by the directive in a manner that was compatible with Articles 3 and 4(2). These assessment areas bear an ID for the needs that were determined by the reporting exercise that was conducted, and in 2018, they were used to denote the official Marine Reporting Units for Greece (Figure 2).



Figure 2. The geographical boundaries of the Greek assessment areas, as reported in 2012 [17].

Marine Region	Marine Subregion	Assessment Area	Marine Unit ID
Mediterranean Sea	Aegean-Levantine Sea	Aegean Sea North Aegean Sea Central Aegean Sea South Aegean Sea Levantine Sea Aegean-Levantine subregion	MAL-EL-AA-AE MAL-EL-AA-NA MAL-EL-AA-CA MAL-EL-AA-SA MAL-EL-AA-LE MAL-EL-MS-AL
	Ionian Sea and Central Mediterranean Sea	Ionian Sea and the Central Mediterranean Sea subregion	MIC-EL-MS-IO
	Adriatic Sea	the Adriatic Sea subregion	MAD-EL-MS-AD

Table 1. The identity of the Greek waters, as reported in 2012 [17].

2. Methodology

In this study, the data that were reported by Greece under Articles 8, 9, 10, 11, and 13 of the MSFD for Descriptors (D) 1 (biodiversity), 4 (food webs), 6 (seafloor integrity), 8 (contaminants), and 9 (contaminants in seafood) were collected from the EIONET Central Data Repository [18], which is operated by the European Environment Agency (EEA) and that hosts data reports about the environment of the EU. The data that were processed were provided by Greece (EL) during the various stages of the 1st MSFD implementation cycle and were submitted electronically via the MSFD database reporting tool (in MS Access) and via the XML schemas that generate HTML factsheets and/or national text-based paper reports [19]. The data that were reported by other Mediterranean EU MSs, i.e., Spain (SP), France (FR), Italy (IT), Malta (MT), Slovenia (SI), Croatia (HR), and Cyprus (CY), were also found on EIONET and were analysed in order to perform a comparative analysis at the Mediterranean level.

During the first MSFD Implementation Cycle, ANNEX Part B of Com Dec 2010/477/EU [4] provided the MSs with the criteria that were to be used to assess the extent to which GES was being achieved, specifying that the required assessment methodologies had to be based upon relevant and already existing community legislation as well as approaches that had been developed under the Regional Sea Conventions (RSC). Concentrating on D1, D4, D6, D8, and D9, the present analysis investigated the integration of the Com Dec 2010/477/EU criteria and the indicators that were applied for each descriptor and the approaches and standards that were used in order to determine the adequacy of how the directive was implemented, the consistency of Articles 8, 9, 10, 11, and 13, and the integration of existing European legislation, policies, regional, and/or international agreements as well as the level of coherence that was achieved among the Mediterranean MSs.

Descriptors D1, D4, and D6 were focused upon in this study because as state descriptors, they depict the status of the marine environment. Herein, they are referred to as Biodiversity Descriptors, as they are all related to biodiversity components, and on many occasions, the MSs (e.g., SP, FR, EL) address them collectively while implementing the various steps of the directive. Descriptors 8 and 9 were selected from the various pressure descriptors, as they denote the impact of human activity on both the environment and on functional groups, on fish and seafood in particular. Herein, they are referred to as Contaminants Descriptors. In addition, these two sets of descriptors differ in how they were addressed, so the ways in which they contrast is of interest when considering the adequacy of the level of implementation as well as the adequacy of the implementation of the directive as a whole.

3. Results

The results of the analysis are presented according to MSFD directive and are divided into the Biodiversity and Contaminants Descriptors.

3.1. Article 8 Initial Assessment

3.1.1. Biodiversity Descriptors (Art 8_8a)

The initial assessment according to Article 8a_Features was conducted by Greece jointly for all of the three biodiversity descriptors, reporting on habitats, species, and functional groups, and to a limited extent, on ecosystems at the marine subregion level [17]. The seabed habitat types shallow sublittoral sand/mud/mixed sediment/coarse sediment and shelf sublittoral mud/sand/mixed sediment/coarse sediment were reported under Com Dec 2010/477/EU criteria 1.4, habitat distribution; 1.5, habitat extent; and 1.6/6.2, habitat condition. Posidonia oceanica meadows and Maerl-type sediments were the predominant habitats that were mentioned. The assessment was mainly qualitative; however, certain thresholds were set according to the Water Framework Directive (WFD) [20]. The level of disturbance and the percentage of habitats that were impacted were mentioned as knowledge gaps. Overall, seabed habitats were better addressed than water column habitats. In addition, Greece reported upon the following species qualitatively: baleen whales, toothed whales, turtles, seals, and inshore pelagic-feeding birds, under Com Dec 2010/477/EU indicators: 1.6.1, Condition of the typical species and communities; 1.6.2, Relative abundance and/or biomass; and 4.3.1, Abundance trends of functionally important selected groups/species, as well as under the following certain species features: Balaeptera physalus, Delphinus delphis, Monachus monachus, Caretta caretta, and Larus audouinii, under Com Dec 2010/477/EU criteria: 1.1, Species distribution, 1.2, Population size; and 1.3, population condition, providing descriptive information on species abundance and condition. Finally, the benthic and pelagic ecosystems were reported upon, but limited description was given in terms of ecosystem structure and functioning.

As far as relevant community legislation is concerned, the WFD was mentioned, as well as the Habitats [21] and Birds Directives [22], but these were not discussed as broadly as anticipated, whereas other international agreements were not integrated.

The main pressures that were reported to be impacting the Greek habitats and species as well as the habitat and species features that were determined under D1, D4, D6, included physical loss, physical damage, eutrophication, the introduction of hazardous substances, NIS, litter, and the extraction of species, which are ranked according to gravity. However, there were not enough data on the extent of habitat loss and damage. The status was not assessed, and threshold values were not set either. Finally, the distribution and frequency of occurrence, population growth, and trends in colonization as well as the relationships between invasive and native species for the 193 NIS that were also reported by EL under Art 8a were not provided.

At the Mediterranean level, the MSs reported physical loss, physical damage, and eutrophication as the main pressures on their local habitats. Fisheries, ports, dredging, offshore structures, urban activities, and aquaculture were determined to be the main activities that were responsible for the pressures that had been induced (Figure 3) [23].



Figure 3. Main pressures impacting habitats and relevant activities reported under biodiversity descriptors by Mediterranean MSs in 2012.

According to Article 12, Technical Assessment [24], the Initial Assessment for D1, D4, and D6 that was conducted by Greece was considered inadequate, as the information that was provided was limited and qualitative in nature.

3.1.2. Contaminants Descriptors (Art 8_8b)

The initial assessment following Article 8b_Pressures for Contaminants Descriptors, was conducted at the assessment area level (North, South and Central Aegean Sea, Ionian, Adriatic and Levantine Sea); however, for Com Dec 2010/477/EU criteria 8.1, Concentration of contaminants; 8.2, Effects of contaminants; and 9.1, Levels, number and frequency of contaminants, different amounts of data were available for each assessment area [17].

Greece defined the different sources of contamination by hazardous substances, namely industries, shipping, wastewater treatment, oil extraction, metal discharge, and atmospheric deposition; however, Greece did not provide any quantification regarding the input loads. The assessment involved synthetic (PAHs, PCBS, DDTs, and Drins) and non-synthetic (Cd, Pb, Cu, Zn, Hg, and petroleum hydrocarbons) substances as well as radionuclides (¹³⁷Cs) in all matrices, i.e., water, sediment, and biota (mussels and fish), as relevant, and threshold vales were provided. The impacts on marine organisms and functional groups were not adequately addressed, as data gaps were acknowledged. However, it was determined that GES had been achieved and that only a proportion of about 1–5% of the marine ecosystems continued to be non-GES, with that 1–5% representing hot spot areas. Finally, Greece reported on acute pollution events under criterion 8.2, where the MS provided data on the number, location, and extent of these pollution events. For D9, the concentration levels in fish and shellfish were assessed based on the regulatory levels set in Regulation 1881/2006 [25].

According to Article 12, Technical Assessment [24], the initial assessment conducted for D8 and D9 is considered partially adequate since despite a number of important data gaps, Greece assessed the concentration levels for all of the necessary substances in detail and in relation to GES.

3.1.3. Economic Social Analysis (Art 8_8c)

In the Socioeconomic Analysis that was conducted in Article 8c, Greece only reported on fisheries, aquaculture, ports, shipping, tourist recreation, and use of beaches for recreation as the various marine activities that were taking place in the country. These major economic activities were found to have an impact on various biodiversity components in Greece and generated significant pressure [17], and they were also the same activities that were the most commonly reported upon by the other Mediterranean MSs, with the exception of Italy (Figure 4) [23].



Figure 4. Marine economic activities reported by Mediterranean MSs under Art 8c in 2012.

3.2. Article 9 Definition of GES

3.2.1. Biodiversity Descriptors

Following the requirements of Article 9 that GES be defined, under D1, Greece provided specific definitions (Supplementary Materials) that were related to all seven Com Dec 2010/477/EU criteria but that were related to none of the indicators, including *Posidonia oceanica* and *Caretta caretta*, in the definitions and stated how attributes of these habitats and species would be maintained in order to achieve GES. For D4, GES was defined integrating criteria that were similar to those of Com Dec 2010/477/EU, but no indicators were represented here either, whereas for D6, Greece defined GES by integrating one Com Dec 2010/477/EU criterion and two indicators (Figure 5).

At the Mediterranean level, all of the MSs defined GES following the Com Dec 2010/477/EU criteria and indicators, with the exception of CY, who formulated its own definitions, while SP, IT, SI, and HR also included Posidonia oceanica and Caretta caretta in their definitions. The number of criteria and indicators that was used for the definition of GES denotes the availability of data concerning a particular descriptor and the level of detail to which a descriptor is addressed. For D1, FR, IT, and SP defined GES using both criteria and indicators in their GES definitions, and SI, HR, and EL addressed all of the criteria, whereas CY only defined GES at the descriptor level in 2012. Concerning D4, MT and CY where the two MSs in the Mediterranean region that did not provide any GES definitions. FR, IT, and SI used both the Com Dec 2010/477/EU criteria and the indicators, whereas SP, HR, and EL only used the criteria for their definitions. For D6, SP, FR, EL, and CY defined GES at both the criterion and indicator levels, whereas MT, SI, and HR defined GES at the criterion level only. FR applied the criteria and indicators for D1, D4, D6, representing the greatest extent of inclusion among the Mediterranean MSs. The percentages accompanying the various criteria and indicators indicate their applicability in the implementation of the Article. Criteria 1.1/1.2/4.2/4.3/6.2/6.1 as well as indicators 4.2.1/6.1.2 were the most commonly applied (Figure 5). Overall, the indicators for D1, D4,



and D6, those for D1 in particular, could not be addressed by most of MSs either because there were no data available or because of their incomprehensibility.

Figure 5. Application of Com Dec 2010/477/EU criteria (C) and indicators (I) in Art 9 for biodiversity descriptors by Mediterranean MSs in 2012.

Greece's approach to D1, D4, and D6 GES definitions was qualitative. At the Mediterranean level, for D1, only 25% of the MSs (SI, SP) defined GES quantitatively, providing threshold values and baselines on various aspects of seabed habitats. For D4 and D6, all of the MSs defined GES qualitatively [23].

The integration of existing legislation was not adequate, as although Greece mentioned endangered/protected species in its GES definitions, the relevant Habitats Directive was not specified, nor was the Barcelona Convention mentioned in the regional cooperation framework. At the Mediterranean level, the integration of relevant legislation was specified

by SP, FR, IT, MT, SI, and HR, whereas regional cooperation was mentioned through the Barcelona Convention, ACCOBAMS, and ICCAT.

Overall, the level of coherence among the Mediterranean MSs regarding the GES definition for D1, D4, and D6 was low. According to Article 12 of the Commission assessment [24], the GES definitions that were provided by Greece for D1 and D4 were partially adequate, whereas the MS's definition of D6 was adequate. The implementation of Article 9 for D1, D4, and D6 was rarely considered to be adequate in Article 12 assessment across the Mediterranean, with SP being the only MS to provide an adequate implementation of D1, and FR being the only country to adequately implement D4 [23].

3.2.2. Contaminants Descriptors

Greece determined GES (Supplementary Materials) for D8 by incorporating the two Com Dec 2010/477/EU criteria and one of the three indicators, whereas GES was defined for D9 by integrating the definitions of the Com Dec 2010/477/EU criterion and two indicators. At the Mediterranean level, the integration of the Com Dec 2010/477/EU criteria and indicators while defining GES was high. For D8, FR and HR used all of the criteria and indicators, whereas SP, IT, MT, SI, and EL used most of them. However, CY only defined GES for D8 at the descriptor level in 2012. For D9, SP, FR, IT, MT, HR, and EL integrated both the criteria and the indicators. For the same descriptor, SI only defined GES at the criterion level, and CY only described it at the descriptor level (Figure 6) [26].





Figure 6. Application of Com Dec 2010/477/EU criteria (C) and indicators (I) in Art 9 for contaminants descriptors by Mediterranean MS in 2012.

Greece defined GES for D8 and D9 quantitavely, using threshold values and baselines in the definitions of GES for all of the substances and matrices that were reported in the initial assessment, integrating the WFD [20], EQSD [27], 1881/2006 [25], and 2006/118/EC [28]. At the Mediterranean level, the approach to the Contaminants Descriptors was quantitative among all of the MSs, except for CY, who defined GES qualitatively for D8. Existing regulations were integrated as well as 1259/2011/EU [29], amending 1881/2006 and the Barcelona Convention MEDPOL Background Concentrations [13]. Thus, it can be concluded that data are available for D8 and D9 and that the level of existing policy integration is high, as is the level of coherence for both descriptors at the Mediterranean level.

Under Article 12, the Commission assessed Greece's implementation of Article 9 as partially adequate for both D8 and D9 [24]; this was also the case for all of the Mediterranean EU MSs. However, the definitions that were provided by FR were considered to be adequate for both D8 and D9, the definitions of SP were assessed as being adequate for D9, and the definitions that were provided by CY were considered to be inadequate for D8 [26].

3.3. Article 10 Establishment of Environmental Targets

3.3.1. Biodiversity Descriptors

The environmental targets and the associated indicators that were established by Greece for the Biodiversity Descriptors in 2012 referred to all of the Greek assessment areas. Greece established five environmental targets and four associated indicators to address D1, most of which addressed specific species and habitats (*Monachus monachus, Caretta caretta, Posidonia oceanica,* Maerl-type areas). For D4, one environmental target and one associated indicator were established, both of which focuses on demersal fish. Concerning D6, two environmental targets and one associated indicator were established. Overall, the targets for biodiversity were mainly state and monitoring of related to conservation and mapping (Supplementary Materials).

At the Mediterranean level, IT, MT, SI, HR, EL, and CY defined their targets for biodiversity descriptors separately, while FR and SP handled D1, D4, and D6 together, with FR assembling targets according to ecosystem components (e.g., habitats, fish, mammals, birds). CY and MT did not establish environmental targets for D4, possibly because this particular descriptor posed difficulties in terms of its application. The number of targets varied significantly for the biodiversity descriptors (Figure 7).



Figure 7. Environmental targets and associated indicators for biodiversity descriptors established by Mediterranean MSs in 2012.

Greece related the established environmental targets and the associated indicators to most of the Com Dec 2010/477/EU criteria and indicators (Figure 8). Although SP and FR established a great number of targets, they did not relate them to Com Dec 2010/477/EU, and in most cases, they characterised those criteria and indicators as "GES other". EL and SI were the MSs who related their targets to Com Dec 2010/477/EU the most extensively. The interrelation of environmental targets and the associated indicators to the Com Dec 2010/477/EU criteria and indicators shows the specificity of the targets and the associated indicators, whereas the width of the curves demonstrates the extent to which Com Dec 2010/477/EU was applied. Thus, D4 and D6 were mainly addressed at the descriptor level with more generic targets, while criteria 4.2/6.1/6.2 and indicators 4.3.1/6.1.2 were the ones that were more related to the targets and their associated indicators. For D1, the

targets were more specifically related to the Com Dec 2010/477/EU criteria and indicators. Criterion 1.2 and indicators 1.6.1/1.2.1 were the targets that were integrated the most frequently, whereas criterion 1.7 and indicator 1.7.1, which refer to ecosystem structure and its components, were not applied at all (Figure 8).



Figure 8. Interrelation of 2012 established environmental targets and associated indicators with Com Dec 2010/477/EU criteria and indicators for biodiversity descriptors (MT and CY did not establish targets for D4).

The targets for D1 were state, impact, pressure, and policy/legislation, with state and impact targets dominating. Most state targets aimed at maintaining or improving the condition of specific ecosystem components, while the impact targets focused on reducing the impacts of pressures. The main three species groups, fish, birds, and mammals, were addressed by most of the MSs, whereas GR, IT, SI, HR, and SP included reptiles and turtles as well. All of the MSs addressed benthic habitats or the condition of the benthic community, whereas specific sensitive/threatened species and habitats such as *Posidonia*

Regarding D1, 62% of the MSs (SP, FR, HR, MT, EL) established qualitative targets, 13% (CY) established quantitative targets, while 25% (IT, SI) set both qualitative and quantitative targets. All of the MSs set qualitative targets for D4, with SI also setting one quantitative target that included both baselines and threshold values. Concerning D6, 62% of the MSs (SP, FR, SI, MT, EL) established qualitative targets; 25% (IT, HR) established both qualitative targets; and quantitative targets, providing thresholds and baselines for the quantitative targets; and 13% (CY) quantitatively approached D6 by providing threshold values only [27].

oceanica (EL, FR, SI, MT) and Caretta caretta (EL, IT, SI, HR) were addressed often [23].

As far as existing policy integration was concerned, EL did not refer to any legislation. Nevertheless, at the Mediterranean level, existing legislation was integrated. For D1, the Habitats Directive (HD) [21] was mentioned specifically by SP, IT, SI, FR, and HR, whereas SP, SI, and MT referred to the Birds Directive (BD) [22]. Finally, SP, FR, and SI mentioned the Barcelona Convention. For D4, HR referred to ICCAT, and IT referred to the BD. For D6, IT, HR, and MT mentioned the HD, the WFD, and several EU regulations, whereas HR made a reference to the Barcelona Convention and the GFCM.

Overall, coherence was low across the Mediterranean region given the differences in the number of targets that were established, the application of the Com Dec 2010/477/EU criteria and indicators, and the approaches and integration of existing policy items. Finally, although the targets were specific (S) and realistic (R) in most cases, they were not SMART [30], as they were not measurable (M), time bound (T), and could not be characterised as being especially ambitious (A).

According to the Article 12 Commission Assessment [24], the environmental targets and the associated indicators for D1, D4, and D6 that were set by Greece were inadequate. The same applied to the other Mediterranean MSs, where the targets that were set to achieve GES were rarely considered to be adequate (the Spanish D1 targets), and in some cases, they were considered to be partially adequate (the French D1, D4, D6; the Spanish D6; the Slovenian D1 targets) [13].

3.3.2. Contaminants Descriptors

The environmental targets and the associated indicators that were established in 2012 by Greece for the Contaminants Descriptors (Supplementary Material) concerned all of the Greek assessment areas. One environmental target and two associated indicators were established for D8 and D9, whereas the targets and indicators were state, monitoring, and impact (Supplementary Materials).

At the Mediterranean level, the analysis of the environmental targets and associated indicators that were established by the MSs under D8 and D9 showed significant differences in terms of the implementation of Article 10, as the number of targets and associated indicators varied considerably. In general, most of the MSs, with the exception of SP and FR, established a limited number of environmental targets and associated indicators, whereas IT did not set any targets or indicators for D9 (Figure 9) [13].



Figure 9. Environmental targets and associated indicators established by Mediterranean MSs for D8 and D9 in 2012.

For the Contaminants Descriptors, Greece related the established environmental targets and the associated indicators to all of the Com Dec 2010/477/EU criteria and indicators (Figure 9). At the regional level, EL, SP, and SI were the MSs that related their targets to Com Dec 2010/477/EU the most extensively, whereas for the rest of the MSs, only limited integration was achieved. CY established targets at the descriptor level only, whereas FR used the criteria that were characterised as GES other, thus not related to Com Dec 2010/477/EU. The interrelation of environmental targets and their associated indicators were slightly more specific than those that were established for D9. The width of the curves demonstrates that criteria 8.1/9.1 and indicators 8.1.1/9.1.1 were applied the most often among the D8 and D9 criteria and indicators (Figure 10).



Figure 10. Interrelation of established environmental targets and associated indicators with Com Dec 2010/477/EU criteria and indicators for Contaminants Descriptors (IT did not establish targets for D9) in 2012.

Greece set state, monitoring, and impact targets for D8 and D9 (Supplementary Materials). At the Mediterranean level, for D8, the dominant types of targets that were established by the MSs were state (29.8%) and pressure (21.3%), both of which outweighed monitoring (17%) and knowledge (14.9%), whereas awareness and legislation were considered the least often (2.1%). The D9 targets were state (29%), pressure (25.8%), monitoring (12.9%), knowledge (16.1%), awareness (3.2%), policy (6.5%), and legislation (3.2%) related, with state and pressure outweighing the others as well (Figure 11) [13].



Figure 11. Type of environmental targets and associated indicators established by Mediterranean MSs for Contaminants Descriptors in 2012.

Greece approached D8 quantitatively, providing no threshold values or baselines, whereas the D9 targets were quantitative, integrating existing legislation and, more precisely, the EU 1881/2006 [25] regulatory levels. At a regional level, for D8, 50% of the MSs (IT, MT, SI, HR) established targets against specific reference levels (e.g., WFD, EQSD), 25% (FR, EL) established qualitative targets, and 25% of the MSs (SP, CY) set both qualitative and quantitative targets. Under D9, most of the MSs (SI, HR, EL, CY) established quantitative targets that referred to the Commission Regulation 1881/2006 and its amendment, either directly or indirectly, 28% (FR, MT) set qualitative targets, and 14% (SP) established both qualitative targets [13].

The most prominent legislation items were incorporated in the targets that were set by Greece (e.g., WFD, Regulation 1881/2006). Although there was a reference to the Horizon 2020 initiative for depolluting the Mediterranean, there was no reference to the Barcelona Convention or to other international agreements, whereas no targets were set at the subregional level, which would have been necessary to address any existing transboundary issues.

Overall, the environmental targets that were set for the Contaminants Descriptors by Greece did not specifically address pressures and their impacts, as mentioned in the initial assessment. Although the D9 targets were specific and measurable and thus operational, there was no reference to them being achievable, realistic, or time-bound (SMART) [30]. The D8 targets and indicators could probably be considered specific and measurable, but whether they were achievable or realistic cannot be assessed, as they were not established against certain thresholds, nor were they time bound. Therefore, the D8 and D9 targets could not be considered SMART.

According to the Article 12 Commission Assessment [24], the environmental targets that were set by Greece were considered to be inadequate to reach GES for D8 and were found to be partially adequate for D9. At the Mediterranean level, there was no MS whose targets were considered to be adequate for either D8 or D9. The targets and indicators for SP, FR, and SI under D8 as well as those for SP, SI, and EL for D9 were considered to be partially adequate. In all other cases, they were considered to be inadequate [13].

3.4. Article 11 Monitoring Programmes

The Greek MSFD Monitoring Programmes that apply to the Greek territorial waters were defined by M.D. 126635/2016 and include the sampling network and related sampling frequency for the environmental indicators of the 11 MSFD Descriptors. Following MSFD Article 11 requirements for Monitoring Programmes, the Greek MSFD monitoring network constitutes a combination of new monitoring activities as well as existing ones deriving from the other legal obligations of Greece [1]. Thus, it integrated five existing networks that were already operating under relevant EU legislation as well as a new network that was deployed for the open sea MSFD needs [31]. The existing networks include: the WFD

coastal water bodies network, which focuses on Biological Quality Elements for D1 and D6 as well as for D5 and D8, physical, chemical, and biological status; the marine Natura-2000 network for D1, assessment of habitats and species status; the MytiMED network for D8 and D9 and that also addresses UNEP/MAP-MEDPOL monitoring requirements; the Data Collection Framework (DCF) network for the evaluation of D3, D4, and D6; the POSEIDON network, which provides real-time measurements of oceanographic parameters, for D7, D11, and D5. Finally, the new MSFD open sea network focuses on parameters that are not covered by existing networks, addressing D1 and D5, D7, and D8 (Figure 12).



Figure 12. The Greek MSFD monitoring network integrating the data collection frameworks and the Natura 2000, WFD, Mytimed, Poseidon, and open sea MSFD networks.

3.4.1. Biodiversity Descriptors

Overall, the biodiversity Monitoring Programme for Greece was composed of 14 subprogrammes [31] that were linked to the D1, D4, D6 Com Dec 2010/477/EU criteria and environmental indicators as well as the relevant Legislation and/ or Regional Agreements (Supplementary Materials). All of the Com Dec 2010/477/EU criteria were addressed with a subprogramme, except for 6.2, as well as several indicators, while the existing monitoring obligations of HD and BD (sea mammals, reptiles and birds), WFD (benthic communities, marine angiosperms, macro-algae and macro-invertebrates), and DCF under the EU Common Fisheries Policy (fish and cephalopods) and the EU Mediterranean Fisheries Regulation 1967/2006 were related to the appropriate subprogrammes (Supplementary Materials). The new monitoring requirements for marine communities that were outlined by the MSFD (e.g., Maerl type benthic communities and planktonic communities) were also included.

Through the integration of the HD, BD, WFD, and DCF networks in the Monitoring Programmes, there was adequate coverage of the coastal areas, while the additional open sea MSFD sampling sites covered open sea areas to a certain degree but not extensively.

The monitoring frequency for the environmental indicators that were included in the subprogrammes differed according to the monitored indicator [31]: 1 time/year (1.1.1, 1.1.2, 1.1.3, 1.1.5, 1.2.1, 1.2.2, 1.2.3, 1.2.5, 1.3.1, 1.3.2, 1.3.3, 1.3.5, 4.1.1, 4.2.1, 4.3.1); 1 time/2 years (1.7.1, 1.7.3); 1 time/4 years (1.1.4, 1.2.4, 1.3.4, 1.4.1, 1.4.2, 1.5.1, 1.5.2, 1.6.1, 1.6.2, 1.6.3); 1 time/6 years (6.1.1).

Regarding D4, the necessary data were collected under the D3 subprogrammes in the framework of the DCF network in the FAO GFCM geographical subareas falling in the Greek territorial waters, i.e., GSA20 (Eastern Ionian Sea) and GSA22-23 (Aegean and Cretan Sea) [32]. In addition, as anticipated, D4 overlaps with D1 in terms of the biodiversity of fish and cephalopods (subprogramme 1.5) and in terms of the composition of planktonic

communities (subprogramme 1.9). Although criterion 6.2 and its related indicators were not addressed, D6 Monitoring programmes were linked to the DCF programme that concerns impact by trawling on Maerl habitat types and the WFD monitoring programme that concerns the assessment of the condition of benthic communities.

According to the assessment for Article 12 [33], the Monitoring Programmes for mammals, reptiles, and cephalopods as well as water column and seabed habitats were likely to address the monitoring needs for the assessment of progress towards the achievement of GES but were not likely to include the monitoring needs of fish, as the implementation of the DCF network was mentioned to have been compromised.

3.4.2. Contaminants Descriptors

The contaminants Monitoring Programme for Greece was composed of two subprogrammes that were linked to the D8 and D9 Com Dec 2010/477/EU criteria and environmental indicators. These subprogrammes were related to the monitoring obligations of the WFD and the Mytimed network and the continuous monitoring of fish and seafood under the network of the Greek health authorities for seafood control [31]. Additionally, data collection is conducted in the MSFD open sea network, whereas the requirements for UNEP/MEDPOL were integrated in the Monitoring Programme. Synthetic contaminants and heavy metals are monitored in marine water and sediment, as are the effects of pollutants in marine organisms (Supplementary Materials). Although radionuclides were mentioned in the GES definition for D8, they were not included in the Monitoring Programme for contaminants.

The monitoring frequency for the environmental indicators that were included in the subprogrammes [31] were: 2 times/year or 1time/6 years (8.1) for operational and surveillance WFD stations, accordingly, and 1 time/2 years (8.1.1) in MSFD stations; 1 time/6 years (8.2.1 and 8.2.2) in the Mytimed network; and continuously (9.1.1 and 9.1.2).

The monitoring network for D8 provides sufficient spatial coverage that comprises sampling stations from the WFD coastal sites, open sea MSFD sites, and the MytiMED network for biota collection. Acute pollution events require more frequent monitoring in case of occurrence. Regarding the monitoring network for D9, the spatial coverage or frequency is not mentioned in the Monitoring Programme.

Overall, according to the Article 12 assessment [33], the Greek Monitoring Programme for D8 had the potential to ensure the coverage of the monitoring needs for the assessment of the progress towards achieving GES, but the same cannot be said for D9.

3.5. Article 13 Programmes of Measures

Greece confirmed the national PoM on December 2017 with M.D. 142569/2017 and reported it to the EU Commission on 11th January 2018 through a paper report [34]. Overall, the PoM included a total of 106 measures for the different MSFD descriptors, of which 65 were existing and 41 were new (Figure 13).



Figure 13. Existing and new measures per descriptor contained in the PoM as reported by Greece in the first MSFD cycle.

3.5.1. Biodiversity Descriptors

Greece presented a total of 39 measures for the biodiversity descriptors applying to the Adriatic Sea, Mediterranean Central-Ionian Sea, and Aegean-Levantine Sea marine subregions, of which 25 were existing and 14 were new [34] (Supplementary Materials). The measures for D4 were identical to the measures for D3. Regarding the implementation zone, coastal waters were addressed with 39 measures, territorial waters were addressed with 33 measures, transitional waters were represented with 8 measures, and the terrestrial part of Greece was represented with 8 measures as well. The measures apply to all ecological components, with 87% of the measures addressing fish, 36% addressing macroalgae, 33% addressing benthic invertebrates, 20.5% addressing birds, 18% addressing reptiles, and 18% addressing marine mammals. In relation to habitats, 92% of the measures concerned water column habitats, 84.6% concerned seabed habitats, and 17.9% concerned coastal habitats, with Posidonia oceanica beds and reefs and Maerl beds being the main sensitive habitats that were addressed, as they were considered in 41% and 25.6% of the measures, respectively (Figure 14a). Finally, 76.9% of the Greek measures that were established under D1, D4, and D6 concerned spatial protection, relating to MPAs, National Parks, Natura 2000 sites, and Fishery Restriction Areas (Figure 14b). Compared to the measures that were established at the Mediterranean level the Greek measures presented a higher percentage of measures focusing on *Posidonia* beds and reefs and Maerl beds (Figure 14a), whereas in terms of Marine Protected Areas (MPAs), Natura 2000 sites, and Fishery Restriction Areas, other MSs provided more measures [35], (Figure 14b).



Figure 14. (**a**) Habitats to which the Greek and Mediterranean MS measures apply. (**b**) MPAs to which the Greek and other Mediterranean MS measures apply.

The Greek PoM integrated measures and actions under national, European, and regional legislative instruments [34]: HD (92/43/EEC), BD (2009/147/EC), WFD (2000/60/EC), Regulation (EC) No 199/2008 for the collection, management, and use of fishing data, Regulation (EC) No 1967/2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea, Regulation (EU) No 1380/2013 on the Common Fisheries Policy (CFP), the Barcelona Convention UNEP/MAP, ACCOBAMS, the Ramsar Convention, and the Convention for Biodiversity. Additionally, the Greek PoM integrated national strategies and decisions (mainly joint ministerial decisions) as well as the results of research projects.

The measures that were established under the biodiversity descriptors addressed the main activities that were designated by Greece in the initial assessment as being generators of pressures [34]; fisheries, aquaculture, tourism, urban activities, industry, shipping and ports, and research and survey (Figure 15). Agriculture, which was determined to be accountable for eutrophication phenomena, was not addressed by measures that were created under the biodiversity descriptors, but it was addressed under D8 and D5. Offshore structures and dredging are not common in the Greek marine environment; thus, no related measures were established. At the Mediterranean level, the activities that were addressed

Activities addressed by D1_D4_D6 PoMs Research, survey & ... Military operations Tourism & leisure activities Tourism & leisure. Waste treatment & disposal Industrial uses Urban uses Transport – land Transport – air Transport - shipping Transport infrastructure Forestry Agriculture Aquaculture – freshwater Aquaculture - marine,... Hunting and collecting for. Marine plant harvesting Fish and shellfish. Transmission of electricity. Non-renewable energy. Renewable energy. Extraction of water Extraction of salt Extraction of oil and gas,. Extraction of minerals.. Restructuring of seabed ... Offshore structures (other ... Coastal defence & flood .. Canalisation & watercourse. Land claim 20 40 60 80 100 120 140 160 n

via measures that related to the biodiversity descriptors were also fisheries aquaculture, tourism, shipping, waste treatment, industry, and research and survey (Figure 15) [35].

Figure 15. Established measures under Biodiversity Descriptors addressing activities generating pressures for Greece and Mediterranean MSs.

According to Article 16 assessment [36], the Greek PoM for D1, D4, and D6 did not address the MSFD needs to progress towards GES; GES was partially addressed for seabed habitats, fish and cephalopods, mammals, and reptiles; it was not addressed for water column habitats, and it could also not be assessed for birds.

3.5.2. Contaminants Descriptors

Greece presented a total of 15 measures for Contaminants Descriptors, 10 measures for D8 (of which 7 existing and 3 new) and 5 measures for D9 (4 existing and 1 new), all of which applied to all of the marine sub-regions [33] (Supplementary Materials). Regarding the implementation zone, coastal waters were addressed with 14 measures, territorial waters were addressed with 13 measures, and transitional waters were addressed with 9 measures. The measures applied to all of the ecological components, with 93% of the measures addressing fish and benthic invertebrates, 86% addressing cephalopods, and 60% addressing marine mammals, reptiles, birds, and macroalgae. Concerning habitats, 86% of the measures concerned water column and coastal habitats, and 60% concerned seabed





habitats. At the Mediterranean level, the measures addressing water column and seabed habitats outweighed those addressing coastal habitats in number (Figure 16) [37].

Figure 16. Habitats to which the Greek and Mediterranean MSs' measures established under Contaminants Descriptors apply.

Although not clearly defined in all of the measures, the Greek PoM for the Contaminants Descriptors integrated actions that were under national and European legislation: WFD; REACH; CFP; Directive 94/22/EC on authorizations for the prospection, exploration and production of hydrocarbons; Directive 2012/18/EU on major accidents involving dangerous chemicals; the Nitrates Directive; the Waste Directive; UWWTD; the Port Reception Facilities Directive (2000/59/EC); the Integrated Pollution Prevention Control Directive (96/61/EC); Regulation 1881/2006; and Regulation 1379/2013 discussing the markets in fishery and aquaculture products as well as national legislation. The measures were also linked to existing international agreements such as IMO-MARPOL (Ballast Water, Oil Pollution Response) and the Barcelona Convention and its protocols (Dumping Protocol/LBS/Emergency Protocol).

The measures that were established under the Contaminants Descriptors addressed the main activities that were designated in the initial assessment as being generators of pressures (Figure 17): shipping and ports, tourism, wastewater treatment, industry, urban activities, transport, agriculture, military operations, research and survey, fisheries, and aquaculture. At the Mediterranean level, the activities that were the most addressed by the proposed measures under the Contaminants Descriptors were also shipping, tourism, industrial uses, wastewater treatment, fisheries, urban uses, and aquaculture, all of which were also considered to be activities sources of hazardous compounds at this level (Figure 17) [37].

According to Article 16 assessment [36], the Greek PoM for D9 addresses the MSFD needs to progress towards GES, whereas for D8, it only does so partially.

Overall, regarding both the biodiversity and contaminants measures, although the bodies who were determined to be responsible for MSFD measures were not designated in the Greek PoM, the level of coordination for the implementation of the measures nationally was considered quite satisfactory, as the Competent Authority for the implementation of the MSFD was the Ministry of Environment and Energy, who was designated as the Competent Authority for the WFD and the Habitats and Birds Directives as well, under which a significant number of measures was established. Additionally, the Ministry of Maritime Affairs, Fisheries, and Island Policy, the Ministry of Tourism, and the Ministry of Rural Development and Food, were also involved in the measures implementation. Finally, regional cooperation was enabled with the integration in the Greek PoM of regional and international processes, such as the Barcelona Convention, ACCOBAMS, and GFCM as well as international environmental monitoring networks (MytiMED) [34].



Figure 17. Measures addressing activities for Greece and Mediterranean MSs under Contaminants Descriptors.

4. Discussion

The analysis that was conducted in the framework of this study identified certain inconsistencies between the data that were provided by Greece in the national text-based paper report [17] and the reporting sheets used in the 2012 reporting exercise following Articles 8, 9, and 10 [18], which probably resulted due to the volume of data and the complexity of the reporting scheme. Such inconsistencies as well as inadequate or inappropriate reporting were highlighted for other Mediterranean MSs as well while visiting their data to perform the comparative analysis. Additional difficulty was generated due to the delivery of some the MSs' National Paper Reports in the national languages (SP, FR, IT, SI, HR) [27].

The implementation of Article 8, which Greece performed in 2012, revealed the difficulties in addressing t Biodiversity Descriptors. The data that were provided were limited and were only able to allow a qualitative assessment of the status of habitats, species, and functional groups, leading to the inadequate implementation of the directive. Additionally, the absence of suitable reference conditions and threshold values did not enable quantitative environmental assessments [38]. In contrast, for the Contaminants Descriptors, the more detailed data that were provided, and the use of thresholds that were either based on existing legislation or that were newly suggested allowed for a quantitative assessment of the status despite identified gaps, and thus, a partially adequate implementation of the directive was achieved. The higher data availability for the Contaminants Descriptors as well as the nature of the elements that were described also enabled a more detailed assessment in terms of scale, as the results were reported at the level of assessment areas. Overall, during the second implementation cycle, the data that were provided by EL under Article 8 regarding the biodiversity descriptors [11,39] were more detailed and of better quality, allowing for more thorough assessments. In addition, for both the biodiversity and contaminants descriptors, the 2018 assessment was based on more recent data due to the operation of the national WFD Monitoring Programme, which enabled the collection of data and allowed for a more extensive and up to date assessment of the status of the marine environment [11,39]. The same progress in terms of the quality of the reported data was attested at the European level, especially for D1, biodiversity [40], in the second MSFD implementation cycle, although EL was not considered in this assessment report because in 2018 it did not report in electronic format [40,41]. Nevertheless, in both MSFD implementation cycles, only a limited number of MS delivered quantitative assessments or assessments following a holistic approach that aggregated the different criteria and/or descriptors [14,42].

Regarding Article 9, for Biodiversity Descriptors, Greece mostly determined GES (Supplementary Materials) according to the Com Dec 2010/477/EU criteria as well as to the indicators, although to a more limited extent. For Contaminants Descriptors, the GES definitions applied both the Com Dec 2010/477/EU criteria and indicators. The implementation of the Article was partially adequate for both the biodiversity and contaminant descriptors, except for D6, which was inadequate. For the biodiversity descriptors, the use of indicators for GES definition was also rare at the Mediterranean level. Despite the use of Com Dec 2010/477/EU, a consistent GES determination among Mediterranean MSs was not achieved [13,27], which was also identified across the EU [30]. According to the European Commission's assessment and guidance (2014) [30], the GES determinations varied considerably, and more efforts were needed to achieve GES in EU marine waters. In addition, the MSs' determination of GES was general, making it difficult to determine whether GES was attained or not. The unsatisfactory implementation of the directive was largely attributed to the fact that Com Dec 2010/477/EU did not pinpoint criteria and methodological standards in enough detail for certain descriptors, including Biodiversity Descriptors. This led to the revision of Com Dec 2010/477/EU and its amendment with Com Dec 2017/848/EU [5]. Despite the heterogeneity that was highlighted in the analysis, D8 and D9 were addressed more satisfactorily, especially since the threshold values were suggested by most of the MSs for the different matrices (water, sediment, biota). However, efforts are needed during the next directive implementation cycles in order to fully address the primary and secondary criteria of Com Dec 2017/848.

Existing EU legislation and international agreements were not systematically integrated into the Greek GES definitions, especially those relating to D1, D4, and D6, as was also concluded by Paramana et al. [13,27] regarding the implementation of MSFD Article 9 by the Mediterranean MSs for biodiversity and contaminants descriptors.

The environmental targets that were established by the MSs differed considerably in terms of both number and approach, revealing low coherence in the ways in which the Article was implemented. However, neither the Greek targets (Supplementary Materials) (with the exception of those for D9) nor those of other Mediterranean countries were considered to be adequate to lead to the achievement of GES [13,27], as they were not SMART, i.e., they were not specific, measurable, ambitious, relevant, and time bound. Greece set environmental targets and associated indicators that were in accordance with Com Dec (EU) 2010/477 to a great extent; however, these targets and indicators did not relate directly to Articles 8 and 9. Additionally, some targets were generic, with some coming close to GES definitions, but did not address particular pressures and impacts and thus human activities (SPECIFIC/ RELEVANT). The Greek targets were approached in a qualitative way, exhibiting a considerable lack of thresholds and baselines, and therefore, they were not directly MEASURABLE. Additionally, there was no specific timeframe set for the

achievement of the target (TIME BOUND). Finally, most of the targets were not innovative or AMBITIOUS. In the 2nd MSFD implementation cycle in Greece, the established environmental targets and the associated indicators were not updated [39]. At the Mediterranean level, Paramana et al. [13,27] showed that the establishment of environmental targets exhibited similar weaknesses for both the Biodiversity and Contaminants descriptors. The low interrelation of the environmental targets and the associated indicators shows the lack of specificity of the targets and the associated indicators and is indicative of the inadequacy of Article 10 implementation across the Mediterranean. Finally, the lack of regional and/or subregional environmental targets is solved by the Mediterranean MSs in order to address issues of transboundary nature and to achieve GES at a regional/subregional level is indicative of the low coordination level.

The Monitoring Programmes that were established in Greece were considered to be adequate to monitor the state of the marine environment and its ecological components as well as the pressures induced on it by human activities [36]. Nevertheless, more monitoring stations should be included in the Greek MSFD monitoring network, especially in the MSFD open sea network concerning the open sea waters in order to provide more detailed data and to enable more thorough approaches.

Most of the measures that were established in the Greek PoM for both the Biodiversity and Contaminants descriptors (Supplementary Materials) were already existing representing 64% and 73% of the measures that were outlined, respectively, similarly to what was attested at Mediterranean level for a different set of MSFD descriptors [43]. Fish, cephalopods, marine mammals, reptiles, and birds constitute the ecological components that were addressed the most often by the Greek measures, which was also the case at the Mediterranean level [43]. However, Greece included benthic invertebrates and macroalgae in its PoM, which comprised a number of measures addressing seabed habitats. The measures that were established under the descriptors in question addressed the main activities that were designated as being generators of pressures in the initial assessment, whereas key policy frameworks were indicated either explicitly or indirectly. The Greek PoM followed the same trend as most of the Mediterranean MSs regarding the provision of information on financing and sustainability of the measures, which was scarce, something that could probably be attributed to the unavailability of a relevant and concrete CEA/CBA methodology to provide such information [43]. Moreover, the absence of quantitative linkage to GES in most measures as well as the lack of information on the implementation level of already existing measures that had been established and implemented under other directives did not allow for a determination of whether the desired goal could be attained. Additionally, certain measures, especially those referring to the acquisition of knowledge of the monitoring of data, could not be considered as measures per se, since their intentions are to provide information on the status of the marine environment but cannot actually lead to the MSFD objective, i.e., the achievement or maintenance of GES. Finally, the lack of financial information, such as cost-benefit (CBA) and cost-effectiveness (CEA) analyses relating to the PoM as well as the absence of time framework did not reinforce the reliability of the measures or their sustainability. Finally, it could be alleged that the measures were not especially innovative so as to introduce a breakthrough in a persistent way (e.g., hot spot areas), and many issues were left unaddressed (e.g., transboundary pressures).

5. Conclusions

In Greece, the MSFD has acted as a driver of organizing status assessments and monitoring actions, while responding to its requirements has resulted in more attention being given to the marine environment. The following conclusions can be drawn from the present study:

 The first MSFD Implementation Cycle was successfully concluded in terms of responding to obligations, even if those obligations were not always responded to on time or in full.

- The assessments and GES definitions that were provided (Art 8/Art 9) were rather generic, especially for the biodiversity descriptors, indicating that the data were unavailable or fragmented, and there was also a lack of threshold values. However, in the second cycle assessment (2018), better quality data were used due to the operation of the national WFD Monitoring Programme, which allowed a more extensive and up to date assessment of the status of the marine environment.
- As most Mediterranean MSs, Greece was not able to produce precise GES definitions or establish specific targets interrelating them to Com Dec 2010/477/EU and using its criteria and indicators fully.
- As was the case for most of the Mediterranean countries, a lack of data, the absence of threshold values, and a lack of regional/subregional coordination were the main impediments for Greece in the implementation of the directive.
- Similar to the majority of Mediterranean MSs, Greece did not establish a PoM that was supported by financial information or cost-benefit analyses.
- o In the next MSFD implementation cycle, it will be necessary for Greece to:
- Fully address the primary and secondary criteria of Com Dec 2017/848 based on the data that were delivered during the operation of the Greek MSFD monitoring network, produce quantitative assessments, and have a holistic approach aggregating the different criteria and/or descriptors.
- Establish SMART targets by addressing pressures and impacts and thus human activities, indicating desired values to be achieved by the indicators and specific timeframes as well as regional and/or subregional environmental targets to achieve GES at the regional/subregional level.
- o Systematically consider and integrate existing EU legislation and international agreements.
- Establish measures that can be quantified in the imminent PoMs upgrade, which is expected to be conducted in 2021/2022, in order to be able to assess their effectiveness in preventing or mitigating the impacts of the human activities occurring in the country's territorial waters as well as in the subregions/region [44].
- Adopt novel, transboundary measures established together by other Mediterranean MSs in order to address transboundary issues, such as pollution and marine litter.

Therefore, there is still, a long way to go in order to regulate the activities that are taking place in the marine realm in a fully sustainable manner and to achieve the MSFD objectives in the Mediterranean context. The cross-border nature of marine features and pressures on the marine environment as well as other transboundary issues to be addressed require that protection and/ or mitigation measures are adopted at the regional level, and from this perspective, more regional coordination is required. Such an outcome would require a harmonized integration and proper implementation of other existing policy items relating to the marine environment, with Marine Spatial Planning constituting a vital contributor [11]. In addition, more effort needs to be put into Common MSFD Implementation/expert working groups and regional processes in order for the Mediterranean MSs to achieve an adequate implementation of the directive (e.g., better integration of data at the descriptor level [42], use of tools to aggregate information from various spatial and temporal scales and to integrate diverse indicators [45]), and become subregionally/regionally coherent, harmonising the actions that are required so as to contribute to GES achievement in a broader, Mediterranean context, in coordination with other EU MSs as well as with non-EU countries in the marine region.

To this end, Greece and the other Mediterranean MSs should adopt the methodologies and recommendations that have been developed within the framework of European research projects focusing on assisting MSs into developing coherent ways in which the MSFD can be implemented, such as ActionMED (No.11.0661/2015/712631/SUB/ENVC2), MED-CIS (No. 110661/2016/748067/SUB/ENV.C2), MEDREGION (No. 110661/2018/794286/ SUB/ENV.C2), ABIOMMED (No. 110661/2020/839620/SUB/ ENV.C.2). Article 23 [1] indicates the obligation of reviewing the directive, scrutinising the Marine Strategy Framework Directive 2008/56/EC, which was amended by Directive (EU) 2017/845 [46] and that is guided by Com Dec 2017/848 [5]. Assessments concerning individual MS regarding the MSFD implementation cycles such as what was achieved in the present work, regional assessments conducted by the JRC [47], JRC reviews, and analyses of the Member State reports, e.g., [40,41], the Commission Report on the Implementation of the MSFD adopted in June 2020 [42], as well as the results of MSFD implementation research projects constitute the necessary building blocks for such a review process.

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