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**Deliverable 1.1.1  
BlueDiversity Database**

**Activity 1.1 – State of the art context  
analysis  
(Version 1.0 – February 2025)**

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## BlueDiversity

Shared BLUE knowledge and skills to sustain BIODIVERSITY in mariculture

### Project Details

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## REVISION TABLE

Version	Name(s)	Date	Description
V 0.1	Maurizio Pinna, Valeria Specchia	September 2024	BlueDiversity Database template for data collection discussed among LP1, PP7 and all PPs.
V 0.2	Maurizio Pinna, Valeria Specchia	October 2024	BlueDiversity Database template shared with all Pilot Areas.
V 0.3	Maurizio Pinna, Valeria Specchia	January 2025	BlueDiversity Database internally reviewed
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V 0.5	Maurizio Pinna, Valeria Specchia	February 2025	BlueDiversity Database results revised by consortium
V 1.0	Maurizio Pinna, Valeria Specchia	February 2025	Deliverable submission

### DISCLAIMER NOTE

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## ABOUT THE **BlueDiversity** PROJECT

The **BlueDiversity** project is part of the Interreg Italy-Croatia 2021-2027 Programme, co-funded by the European Union. The **BlueDiversity** project's priority is priority 2 (Green and resilient shared environment). The Specific Objective is SO2.2: improve the protection and preservation of nature, biodiversity and green infrastructure, including in urban areas, and reduce all forms of pollution. In light of this, the **BlueDiversity** project aims at enhancing the ecosystem services-based practices, which allow the sustainment of local ecosystems' preservation through reducing human activities' impacts on biodiversity, while enhancing and developing economic and territorial opportunities.

To achieve the project's objectives, the Project Partners have the need to assess the State of the Art about the main biodiversity threats identified in the pilot areas, by analysing biodiversity, non-indigenous species, marine litter, and lagoon litter. The State-of-the-Art analysis will also target, experiment and screen existing practices, innovations, resources available and attitudes of the ecosystem services end users in the context of the Adriatic Sea.

The Adriatic socio-eco-cultural features represent the common thread for the project actions, bringing relevant stakeholders of the blue economy and blue research to work together towards best and innovative practices with the common scope to develop a green and sustainable transition in the blue sector. In particular, the **BlueDiversity** project targets small and medium enterprises aiming to establish "living laboratories", providing institutional support on the one hand, and placing them as didactic examples at the much-needed interface with schools and younger generations, enhancing the framework of the blue economy with a multilateral approach that includes institutional actors and citizens.

The Adriatic Sea, shared by Italy and Croatia, represents one of the best examples of natural backgrounds in ecological terms, where the dynamics of co-creation, based on an intertwinement of tradition and innovation, can be established. The project aims to develop pilot activities that will experiment with innovative fishing gear to tackle the presence of non-indigenous species that seriously threaten the Adriatic coasts' aquatic ecosystems.

The **BlueDiversity** project is modular, aiming at fully replicable successful experiences, representing the actions' legacy and the core of a shift towards the blue economy. Such elements will be strategically disseminated targeting different institutional and non-institutional entities focusing on the capitalization of the knowledge, know-how and innovative instruments developed throughout the project and aimed at building a sound ground for future major innovative developments.



#### D 1.1.1 - EXECUTIVE SUMMARY

The **BlueDiversity** project is aimed at preserving ecosystem services through enhanced management strategies along the coasts of Italy (Veneto, Marche, and Apulia) and Croatia (Splitsko-dalmatinska županija and Dubrovačko-neretvanska županija). The project's key deliverable, the “BlueDiversity Database” (Deliverable 1.1.1), serves as a comprehensive analysis tool to support decision-making regarding biodiversity conservation and ecosystem services preservation. By gathering and assessing data from various sources, the BlueDiversity database aims to answer crucial questions about what is being done—and what more can be done—to preserve and improve the health of coastal ecosystems.

A key goal of **BlueDiversity** is not only to collect data but also to engage stakeholders like local authorities, and the public. It strives to foster greater awareness of biodiversity issues and the challenges facing coastal and marine ecosystems, encouraging the sharing of insights from various actors involved. The database also serves as an open-access tool, designed to be a valuable resource for stakeholders across the Mediterranean region. The results will be widely disseminated, offering a deeper understanding of biodiversity and environmental conditions in the pilot areas, ultimately contributing to informed decision-making on ecosystem management.

The **BlueDiversity** database is built from a wealth of data spanning biodiversity occurrences and abiotic environmental parameters. It contains a total of 3,623 biodiversity observations, 264 data points concerning abiotic conditions in the water column, and 79 observations of sedimentary abiotic parameters. While this dataset is already rich in information, one of the standouts features of the **BlueDiversity** database is its dynamic, “living” nature, designed to be continuously updated with new data as it is collected from ongoing research and field activities. This ensures that the database will remain relevant and useful for both short- and long-term monitoring of ecosystems.

To ensure the consistency and interoperability of the biodiversity data, the **BlueDiversity** database follows the internationally recognized Darwin Core Occurrence standard, which allows the sharing of biological data in a consistent and structured format. This approach ensures that all observations from the pilot areas, whether collected through field research, scientific literature, or grey literature, are aligned under a common standard for classification and reporting. The dataset includes vital taxonomic details like the scientific names, kingdom, phylum, family, and genus of the species recorded, and ecological characteristics like habitat type. The database also incorporates essential fields such as “organismRemarks” and “establishmentMeans,” which describe the protection level of species and their native or non-indigenous status. This inclusion is especially valuable for understanding species dynamics, including the impact of non-indigenous species on local ecosystems, which is an increasing concern for marine and coastal conservation efforts.

The environmental data for the water column and sediments were compiled following the EU Water Framework Directive (2000/60/EC), which provides a regulatory framework for the protection of water quality across European Union member states. These datasets play a crucial role in assessing



and monitoring water quality and its effects on coastal and marine biodiversity. The framework aims to prevent the deterioration of aquatic ecosystems, improve the status of water bodies, and protect groundwater resources. This regulatory compliance ensures that the collected data aligns with established environmental quality standards, such as those defined under the European Water Framework and the Directive on Environmental Quality Standards for Water (2008/105/EC).

Similarly, the abiotic data for sediments were collected in accordance with the EU's focus on sediment monitoring, as outlined by the Water Framework Directive. These parameters are vital for understanding the presence and accumulation of harmful substances, including pollutants and priority substances, in marine and coastal environments. Sediment monitoring also provides valuable insights into long-term environmental trends, contributing to a better understanding of ecosystem health and supporting the identification of effective control measures for environmental pollution.

Beyond the data collection and analysis, the **BlueDiversity** project serves as a catalyst for the promotion of sustainable blue economy practices across the Adriatic region. The Adriatic Sea, which borders both Italy and Croatia, offers a unique setting for such an initiative due to its rich biodiversity and the presence of important coastal and marine ecosystems. The project's aim is to bridge the gap between innovation and tradition by fostering collaboration among stakeholders, including policymakers, researchers, local communities, and the private sector. By applying knowledge and innovative technologies, the BlueDiversity project supports the development of green practices that protect marine ecosystems while also creating new economic opportunities in the region. This initiative is part of a broader effort to build a sustainable, ecosystem-based approach to managing coastal and marine resources.

The **BlueDiversity** project's pilot areas, which include protected marine areas and biodiversity hotspots, serve as "living labs" for testing and demonstrating innovative management practices. These areas are seen as critical to the long-term preservation of marine biodiversity and the development of blue economy strategies that can be replicated across other regions facing similar challenges. In conclusion, the **BlueDiversity** project represents a critical step toward improving the management and preservation of coastal and marine ecosystems. By providing an evolving, open-access database and promoting sustainable blue economy practices, the project lays the groundwork for a greener, more sustainable future for coastal regions in both Italy and Croatia

#### D 1.1.1 - LINKS WITH OTHER PROJECT ACTIVITIES

Work Package 1 (State of the Blue Art) provides a foundational understanding of the current state of coastal ecosystems and biodiversity in the **BlueDiversity** project's Pilot Areas. This WP lays the groundwork for future research initiatives and methodologies aimed at enhancing marine and coastal ecosystem preservation.



Deliverable 1.1.1 - **BlueDiversity** Database, is a pillar output of WP1 and serves as a critical resource for the entire **BlueDiversity** project. It includes comprehensive data on biodiversity occurrences and abiotic conditions in the water column and sediments, providing a dynamic and up-to-date resource for stakeholders and decision-makers.

The **BlueDiversity** Database has substantial implications for the other three work packages of the project. WP2 (Blue Initiative) leverages the **BlueDiversity** database as a critical tool for advancing innovative practices related to sustainable marine resource management, enhancing the overall blue economy in the Adriatic region.

WP3 (Blue Education, Training and Culture) draws upon the database to inform educational programs, training initiatives, and awareness-raising campaigns aimed at equipping local communities and stakeholders with the knowledge and skills needed to engage in blue economy practices.

WP4 (Blue Capitalisation) utilizes the data to support the replication and scalability of successful practices, ensuring that the lessons learned from the **BlueDiversity** Pilot Areas can be applied to other regions facing similar environmental challenges.



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 **BlueDiversity**



## 1. DELIVERABLE 1.1.1 - INTRODUCTION

### 1.1. DELIVERABLE OVERVIEW

#### 1.1.1. OBJECTIVES

This document represents a key pillar for the BlueDiversity project. The scope of Deliverable 1.1.1 “BlueDiversity Database” encompasses the analysis and assessment of the State of the art to answer the question “What is being done/what can be done to enhance skills of ecosystem services preservation?” while identifying strategies to act and tackle current challenges on Italian (Veneto, Marche and Apulia) and Croatian (Splitsko-dalmatinska županija and Dubrovačko-neretvanska županija) shores providing direct users of ecosystem services with updated and evidence-based data and strategies.

This key document aims at engaging the PPs’ stakeholders’ network, target groups, relevant actors and the general public on awareness-raising actions, as well as on presenting their own perspective over challenges and issues as perceived by them. Also, the results of this analysis will be disseminated to stakeholders, local public authorities and private actors as well as the public as an open-access database describing the biodiversity and environmental features of the Pilot Areas included in the **BlueDiversity** project.

#### 1.1.2. KEY FINDINGS

The biodiversity and the abiotic datasets constituting the **BlueDiversity** database were uploaded from all Pilot Areas. The database consists of 3623 observations concerning biodiversity data, 264 observations concerning abiotic parameters from the water column, and 79 observations concerning abiotic parameters from the sediments.

Although a lot of information was covered within the database, one of the main purposes of the **BlueDiversity** database is to be a “living” dynamic database, where every new information can always be uploaded by adding a new row, as well as all the new data collected during the **BlueDiversity** samplings and activities in all the Pilot Areas.

#### 1.1.3. LIMITATIONS

Although the biodiversity occurrence dataset presents a total of 3,623 observations and has been thoroughly completed across all its main aspects, the abiotic dataset remains an area that could benefit from further enhancement across all Pilot Areas. While significant progress has been made,



there is still considerable room for improvement, particularly in terms of filling gaps in data coverage and expanding the temporal and spatial resolution of the available measurements.

In contrast to the comprehensive and readily accessible biodiversity data found in both scientific and grey literature, the availability of detailed abiotic information, particularly for coastal and marine environments, often remains limited. This scarcity poses a limitation for environmental monitoring and management. Coastal and marine ecosystems are dynamic and complex, influenced by a variety of abiotic factors such as water temperature, salinity, nutrient levels, pH, and sediment composition. However, unlike biodiversity data, which is usually extensively documented in scientific and grey literature, abiotic data tends to be less consistently reported and may lack the depth required to fully understand the underlying environmental processes that influence these ecosystems.

## 1.2. MATERIALS AND METHODS

### 1.2.1. DATA COLLECTION AND ORGANISATION

Biodiversity data were collected and organized following the [Darwin Core](#) (DwC) Occurrence standard to ensure interoperability and consistency in occurrence records from all the Pilot Areas (Table 1). The dataset compilation includes data deriving from grey and scientific literature research, NATURA 2000 Standard Data Forms, as well as in-situ activities to ensure comprehensive coverage of occurrence records and associated metadata.

To ensure consistency in classification, standardised taxonomic references were applied using specific databases for different organism groups. Specifically, the [Algaebase](#), [GBIF](#), and [WORMS](#) databases were utilized.

**Table 1.** Darwin Core terms used for the biodiversity dataset construction.

Column label	Column description
taxonID	An identifier for the set of taxon information
occurrenceID	An identifier for the Occurrence
scientificName	The full scientific name, with authorship and date of information
kingdom	The full scientific name of the kingdom in which the taxon is classified
phylum	The full scientific name of the phylum in which the taxon is classified
class	The full scientific name of the class in which the taxon is classified
order	The full scientific name of the order in which the taxon is classified
family	The full scientific name of the family in which the taxon is classified
genus	The full scientific name of the genus in which the taxon is classified
taxonRank	The taxonomic rank of the most specific name in the scientificName



country	The name of the country or major administrative unit in which the observation occurred
countryCode	The standard code for the country in which the Location occurs
locality	The specific description of the protected area (e.g., NATURA 2000) in which the observation occurred
decimalLatitude	Geographic latitude in decimal degrees
decimalLongitude	Geographic longitude in decimal degrees
geodeticDatum	Spatial reference system (WGS84)
habitat	A description of the habitat in which the observation occurred
organismRemarks	A description of the protection level for the observed species
establishmentMeans	Statement about whether or not an organism has been introduced to a given locality through the direct or indirect activity of modern humans
bibliographicCitation	A bibliographic reference for the resource
basisOfRecord	The specific nature of the data record

### 1.2.2. ENVIRONMENTAL DATA COMPILATION

Abiotic parameters for both the water column and sediment were compiled according to the most recent legislative frameworks, including the European Union's Water Framework Directive (WFD). These regulations define the necessary standards for monitoring coastal and marine ecosystems, ensuring compliance with environmental assessment guidelines.

### 1.2.3. DATA PROCESSING AND VISUALIZATION

The collected data were structured in the **BlueDiversity** database for both ease of access and analysis. Charts and graphical representations were created using Microsoft Excel to illustrate trends and patterns within the dataset. Excel functions were employed for basic statistical analysis and visualization, ensuring clear interpretation of results.

Taxonomy heat trees were generated using [Metacoder](#), an [R](#) package for visualisation and manipulation of community taxonomic diversity data.



## 2. SELECTION OF PILOT AREAS

The **BlueDiversity** project was structured to be a modular and dynamic project. One of the key objectives of this project is to generate, reach, live and have the possibility to share and replicate successful experiences, representing a legacy of actions and the core of a real, concrete shift towards the application of the blue economy concept in its most sustainable forms. The **BlueDiversity** results are intended to be strategically disseminated involving institutional and non-institutional entities whose focus relies on the capitalisation of knowledge, know-how and exploitation of innovative instruments and technologies developed throughout the project and aiming at building a sound ground for future major innovative developments.

To reach such objectives, the **BlueDiversity** project finds one of its main targets in enhancing the ecosystem services-based practices. Such practices allow to sustain the local ecosystems' preservation by reducing the pressures on biodiversity deriving from human activities while, at the same time, enhancing and developing economic opportunities on the territory.

The Adriatic Sea, which touches the coasts of both Italy and Croatia, represents a virtuous example of natural backgrounds in ecological terms. Here, the dynamics of co-creation can be established based on the intertwinement of innovation and tradition. The Adriatic socio-eco-cultural characteristics are able to bring relevant stakeholders of the blue economy and blue research to work side by side for the common scope of developing a green and sustainable transition in the blue economy throughout the development of innovative and best practices.

In light of this, the **BlueDiversity** Project Partners need to assess the State of the Art about the main biodiversity threats by analysing biodiversity, non-indigenous species, marine litter, and lagoon litter. For doing this, the Project Partners identified six Pilot Areas, mainly represented by protected areas, coastal and marine areas representing important biodiversity hotspots, and marine coastal areas where the blue economy represents a true and actual reality. These living labs represent the foreground for the development of the project's main objectives, from biodiversity conservation to technological development.

Specifically, the Pilot Areas are distinguished as follows:

- LP1 (University of Salento) - Aquatina di Frigole and Ionian Sea mariculture
- PP2 (Sea and karst) - Cetina River and Estuary; Pantan Coastal Lagoon; Uvala Vrulja kod Brela
- PP4 (Institute of Oceanography and Fisheries) - Neretva Delta
- PP5 (Public Institution for the Management of Protected Natural Areas of Dubrovnik-Neretva County) - Mali Ston Bay
- PP6 (Blue Marine Service) - Coast of San Benedetto del Tronto - Natural Reserve Sentina
- PP7 (University of Padua) - Venice Lagoon



### 3. BLUE DIVERSITY DATABASE

The **BlueDiversity** dynamic database is a constantly evolving database divided into three main datasets: biodiversity dataset; abiotic dataset for the water column; and abiotic dataset for the sediments. All datasets were filled in by the Project Partners referring to the selected Pilot Areas. An excel file whose three sheets represent the three datasets constitutes the **BlueDiversity** database, available in the project's shared folder at the following [link](#).

The link is not publicly accessible, but permission to access can be obtained by contacting the reference person, represented by Prof. Maurizio Pinna ([maurizio.pinna@unisalento.it](mailto:maurizio.pinna@unisalento.it)) by personal identification, institutional or enterprise identification, as well as providing all information concerning the intended use of the data contained in the **BlueDiversity** database.

#### 3.1. BIODIVERSITY DATA

The collection of biodiversity data in the **BlueDiversity** database is organised according to the Darwin Core Occurrence Dataset standards. Specifically, the Darwin Core represents a standard maintained by the [Darwin Core Maintenance Interest Group](#). Darwin Core Archives include a standardised glossary of terms (in other contexts, these might be called properties, elements, fields, columns, attributes, or concepts) intended to facilitate the sharing of information about biological diversity through the provisioning of shared identifiers, labels, and common definitions.

The Darwin Core Occurrence Dataset for the biodiversity data collection in **BlueDiversity** is primarily based on taxa and their occurrence in the Pilot Areas as documented by observations, specimens, samples, and scientific or grey literature information.

Given the database purpose of representing the baseline information for the **BlueDiversity** Pilot Areas, two specific fields of the biodiversity dataset are included: "organismRemarks" and "establishmentMeans", respectively related to the protection level of a species or the *Native* or *Alien* state of a species. To establish such descriptions, the [Bern Convention](#), [EU Birds Directive](#), [EU Habitats Directive](#), [Regulation of strictly protected species](#), and the [IUCN Red List](#) of threatened species were consulted to identify protected species, while the [European Alien Species Information Network](#) (EASIN) database was queried to identify native, alien and cryptogenic species.

#### 3.2. ABIOTIC DATA FOR THE WATER COLUMN

The collection of abiotic data for the water column in the **BlueDiversity** database is organised according to the main references deriving from the [Directive 2000/60/EC](#) of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action



in the field of water policy, in accordance with the [Directive 2008/105/EC](#) of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy. The purpose of the Water Framework Directive is in fact to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater which:

- Prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems;
- Promotes sustainable water use based on a long-term protection of available water resources;
- Aims at enhanced protection and improvement of the aquatic environment, inter alia, through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances;
- Ensures the progressive reduction of pollution of groundwater and prevents its further pollution, and contributes to mitigating the effects of floods and droughts.

### 3.3. ABIOTIC DATA FOR THE SEDIMENTS

Also concerning the collection of abiotic data for the sediments in the **BlueDiversity** database, the dataset was organised according to the main guidelines deriving from the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, in accordance with the Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy.

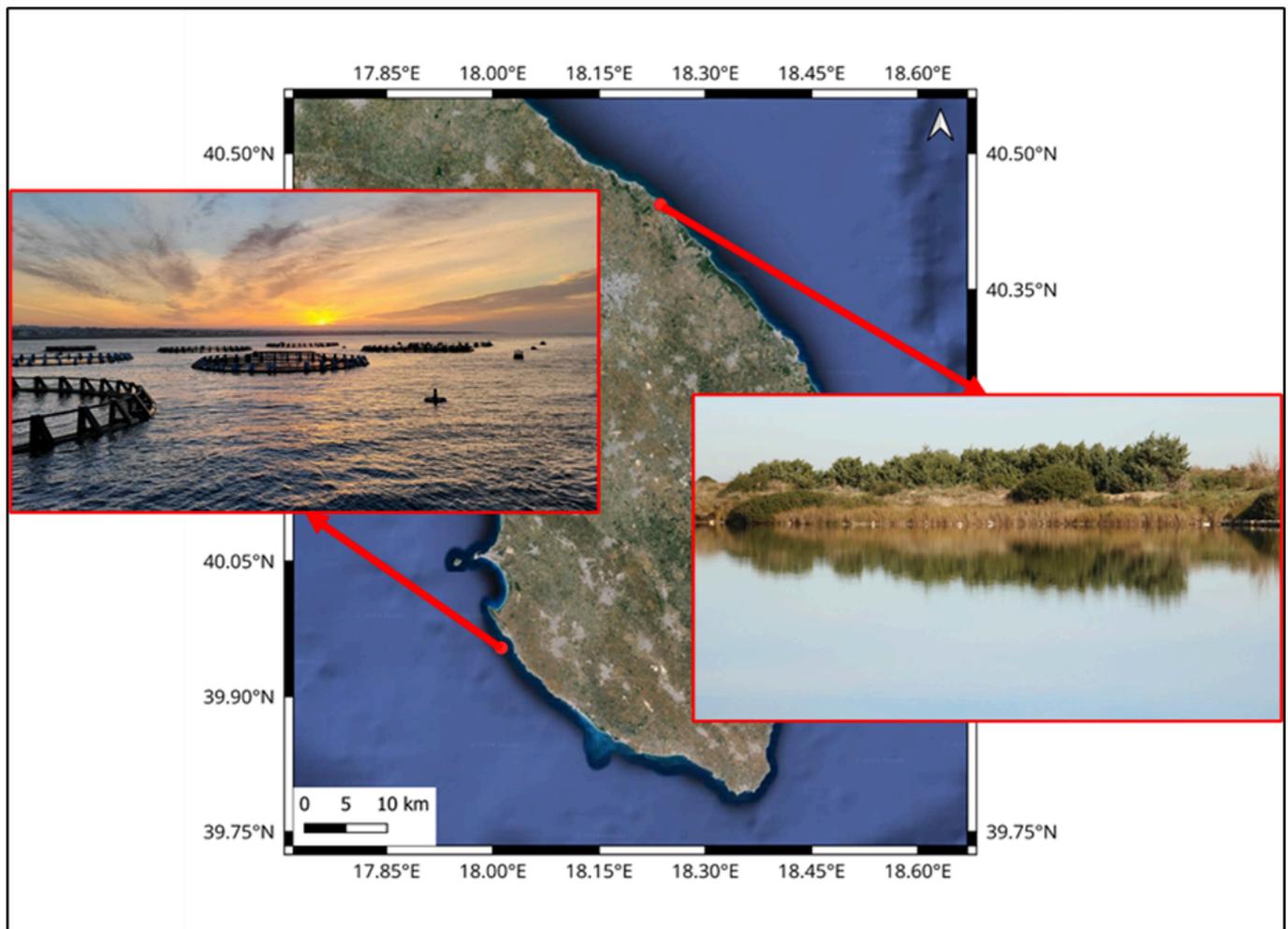
Particularly, the latter specifies that member States should improve the knowledge and data available on sources of priority substances and ways in which pollution occurs in order to identify targeted and effective control options. Member States should, inter alia, monitor sediment and biota, as appropriate, at an adequate frequency to provide sufficient data for a reliable long-term trend analysis of those priority substances that tend to accumulate in sediment and/or biota.



## 4. RESULTS FROM PILOT AREAS

### 4.1. AQUATINA DI FRIGOLE AND IONIAN SEA MARICULTURE

Aquatina di Frigole and Ionian Sea mariculture (Figure 1) is divided into two separate zones: the NATURA 2000 Site “Aquatina di Frigole” (IT9150003) on the Adriatic Sea coast, and the Ionian Sea mariculture on the Ionian Sea coast.



**Figure 1.** Aquatina di Frigole and Ionian Sea mariculture.

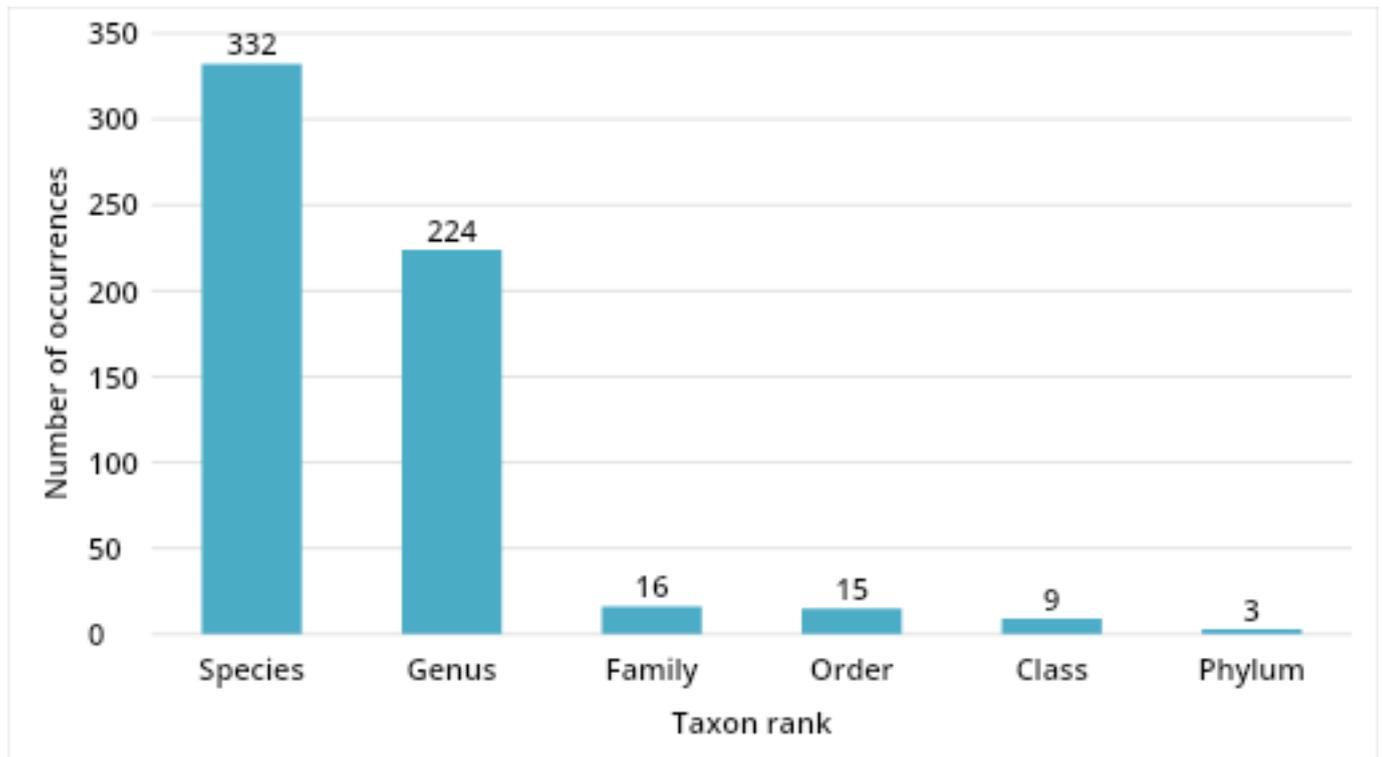
In the Aquatina di Frigole and Ionian Sea Mariculture Pilot Area, a total of 599 occurrences were documented throughout the study. These occurrences were classified at various taxonomic levels, reflecting differences in the resolution of species identification. Specifically, 332 occurrences were successfully annotated at the species level, providing the highest degree of taxonomic precision. An additional 224 occurrences were identified at the genus level, while 16 were classified up to the



## Italy – Croatia



family level. Furthermore, 15 occurrences were resolved at the order level, 9 at the class level, and the remaining 3 were assigned only to the phylum level. The distribution of taxonomic identifications is illustrated in Figure 2.



**Figure 2.** Number of occurrences per taxon rank for the Aquatina di Frigole and Ionian Sea mariculture Pilot Area.

A total of 43 occurrences within the Pilot Area correspond to species that are classified as protected (Figure 3). These species span a diverse range of taxonomic groups, including birds, reptiles, amphibians, fish, and marine plants, highlighting the ecological significance of the Aquatina di Frigole and Ionian Sea Mariculture Pilot Area.

Among the protected species identified are several waterfowl and wading birds, such as *Anas acuta*, *Anas crecca*, *Anas platyrhynchos*, *Ardea purpurea*, *Ardeola ralloides*, *Aythya nyroca*, *Botaurus stellaris*, *Chlidonias hybrida*, *Chlidonias niger*, *Circus aeruginosus*, *Circus cyaneus*, *Circus pygargus*, *Egretta alba*, *Egretta garzetta*, *Fulica atra*, *Gallinago gallinago*, *Gallinula chloropus*, *Himantopus himantopus*, *Ixobrychus minutus*, *Nycticorax nycticorax*, *Platalea leucorodia*, *Plegadis falcinellus*, *Recurvirostra avosetta*, *Sterna albifrons*, and *Sterna sandvicensis*.

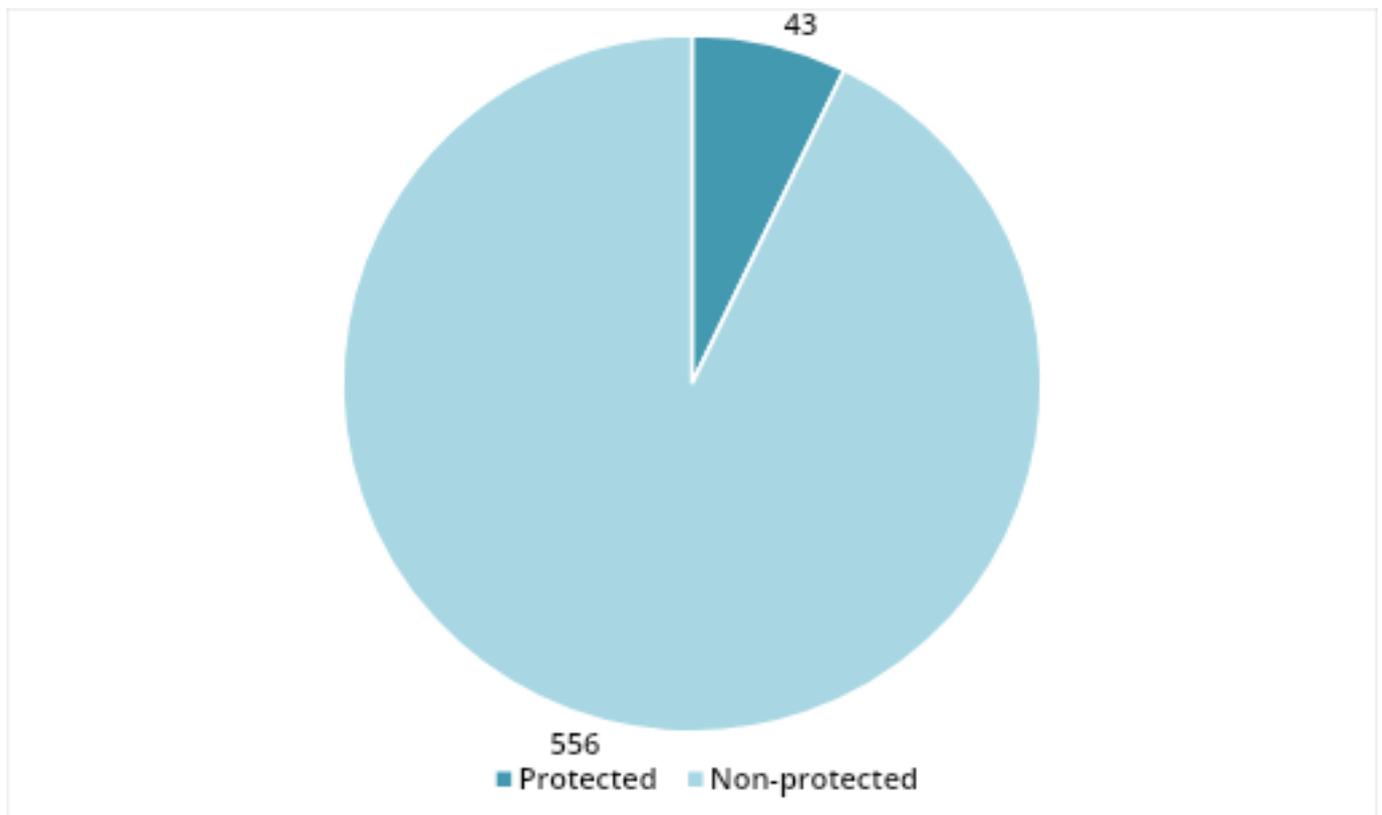


## Italy – Croatia



In addition, several reptiles and amphibians were documented, including *Coluber viridiflavus*, *Elaphe quatuorlineata*, *Elaphe situla*, *Emys orbicularis*, *Lacerta bilineata*, *Podarcis siculus*, and *Bufo viridis*. The study also recorded the presence of the rare damselfly *Coenagrion mercuriale*.

Among fish species, *Anguilla anguilla*, *Mullus barbatus*, *Pomatoschistus marmoratus*, and *Syngnathus acus* were identified. Meanwhile, ecologically important marine invertebrates and plants included *Cymodocea nodosa*, *Pinna nobilis*, *Posidonia oceanica*, and *Theodoxus prevostianus*.



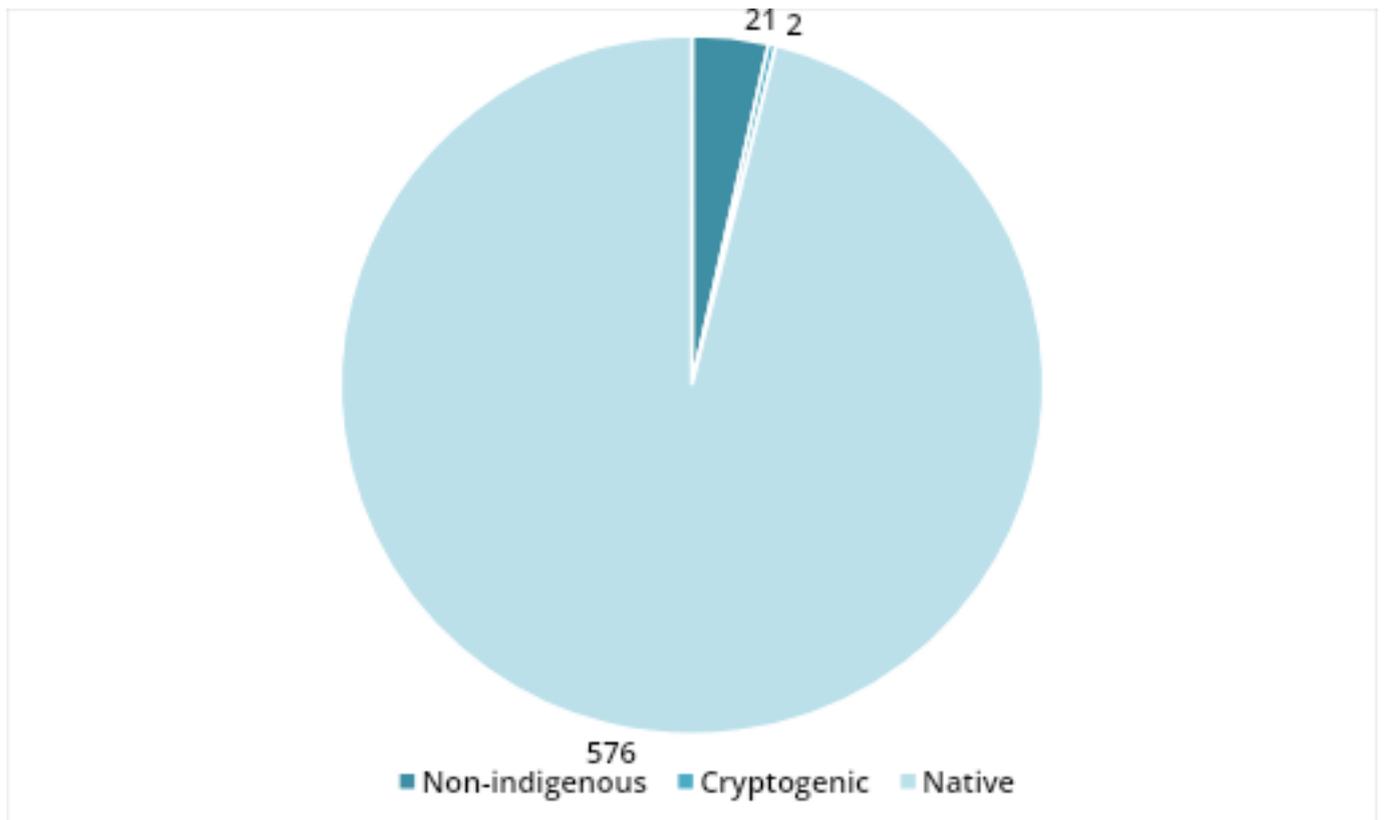
**Figure 3.** Number of occurrences according to the protection level for the Aquatina di Frigole and Ionian Sea mariculture Pilot Area.

Within the study area, a total of 21 occurrences were attributed to non-indigenous species, while 2 occurrences were classified as cryptogenic species (Figure 4). The presence of these species highlights the ongoing dynamics of biological invasions and their potential ecological impacts on native biodiversity.

The non-indigenous species identified span a variety of taxonomic groups, including tunicates (*Ascidella aspersa*, *Botrylloides leachii*, *Styela canopus*, *Styela plicata*), ctenophores (*Beroe ovata*, *Mnemiopsis leidyi*), mollusks (*Littorina obtusata*), crustaceans (*Callinectes sapidus*, *Palaemon elegans*, *Penaeus aztecus*), polychaetes (*Ficopomatus enigmaticus*, *Hydroides dianthus*, *Perinereis cultrifera*,



*Schistomeringos rudolphi*, *Terebella lapidaria*), and other invertebrates such as *Gammarus pulex*. Additionally, certain non-indigenous plant species (*Carpobrotus edulis*, *Cistus ladanifer*), annelids (*Dendrobaena octaedra*), gastropods (*Bulinus truncatus*), and ciliates (*Eutintinnus apertus*) were recorded.



**Figure 4.** Number of occurrences according to the establishment means for the Aquatina di Frigole and Ionian Sea mariculture Pilot Area.

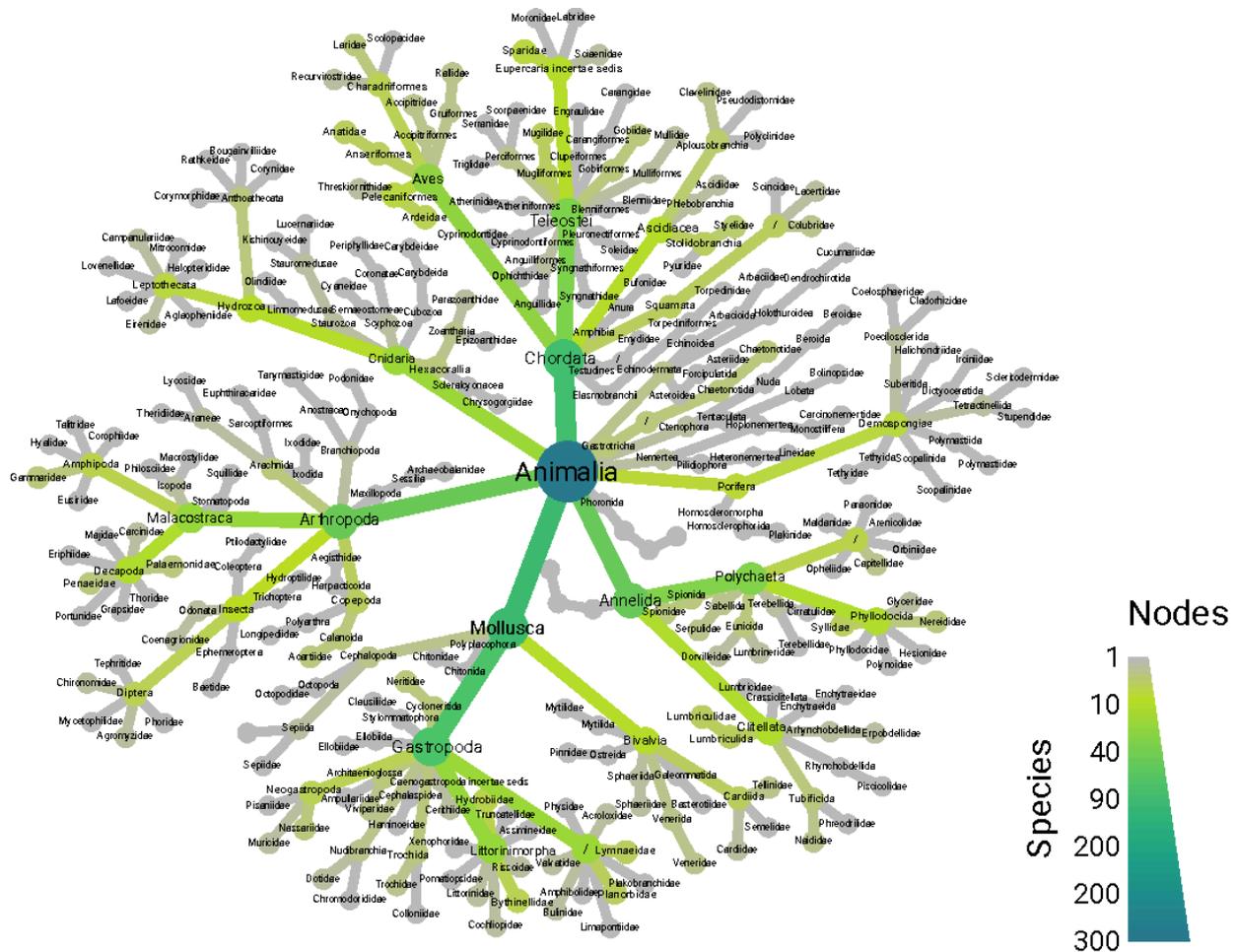
The recorded occurrences in the Aquatina di Frigole and Ionian Sea mariculture Pilot Area are distributed across multiple biological kingdoms, reflecting the diversity of life present in the region. The classification of these occurrences follows the taxonomic scheme outlined in Table 2, which provides a comprehensive overview of their distribution among different kingdoms.

**Table 2.** Kingdoms scheme for the Aquatina di Frigole and Ionian Sea mariculture Pilot Area.

Kingdom	Number of occurrences
Animalia	327
Plantae	87
Chromista	171
Bacteria	10

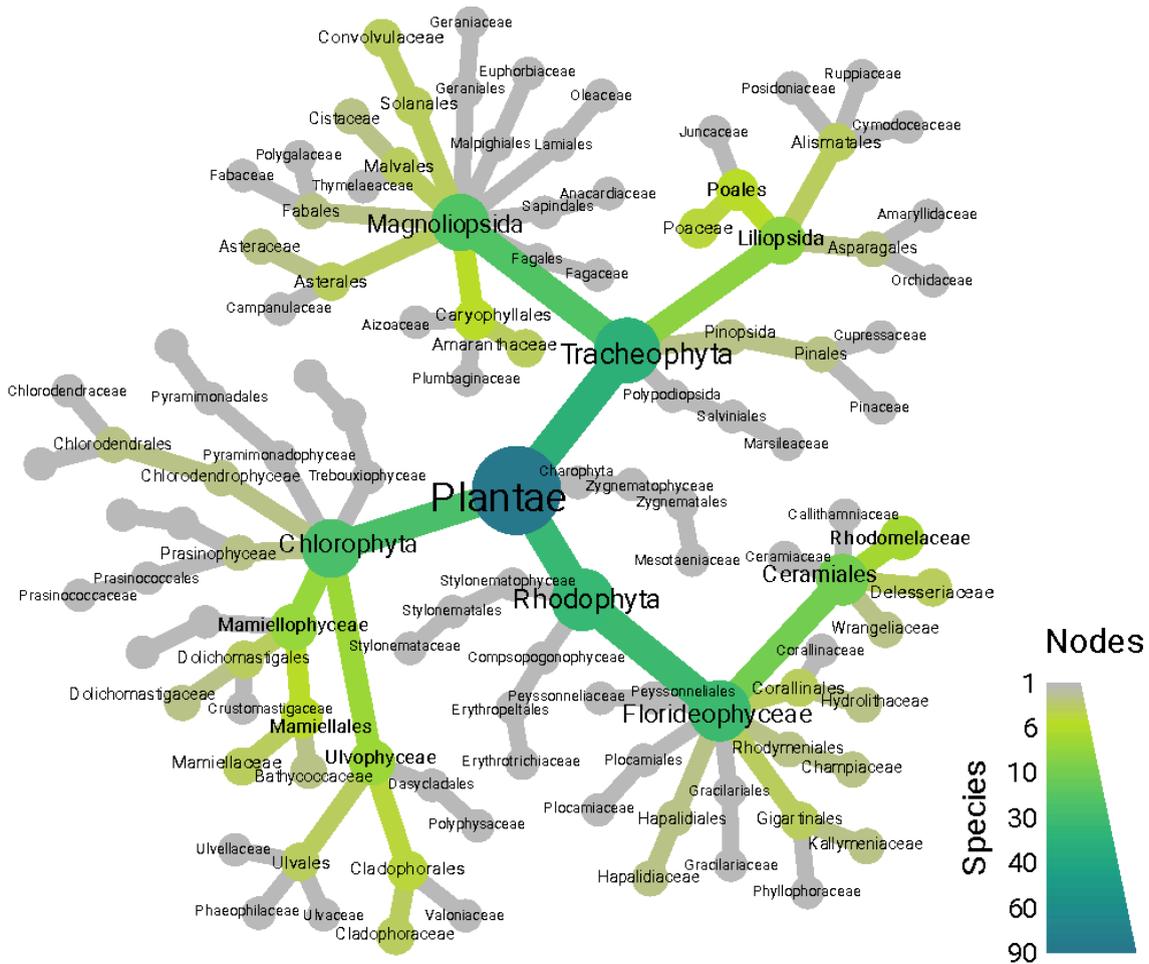


To visually illustrate the taxonomic composition within each biological kingdom, taxonomic heat trees were generated. These graphical representations depict the hierarchical structure of species belonging to different kingdoms, highlighting their distribution and relative abundance. The resulting visualizations are presented in Figures 5, 6, 7, and 8.



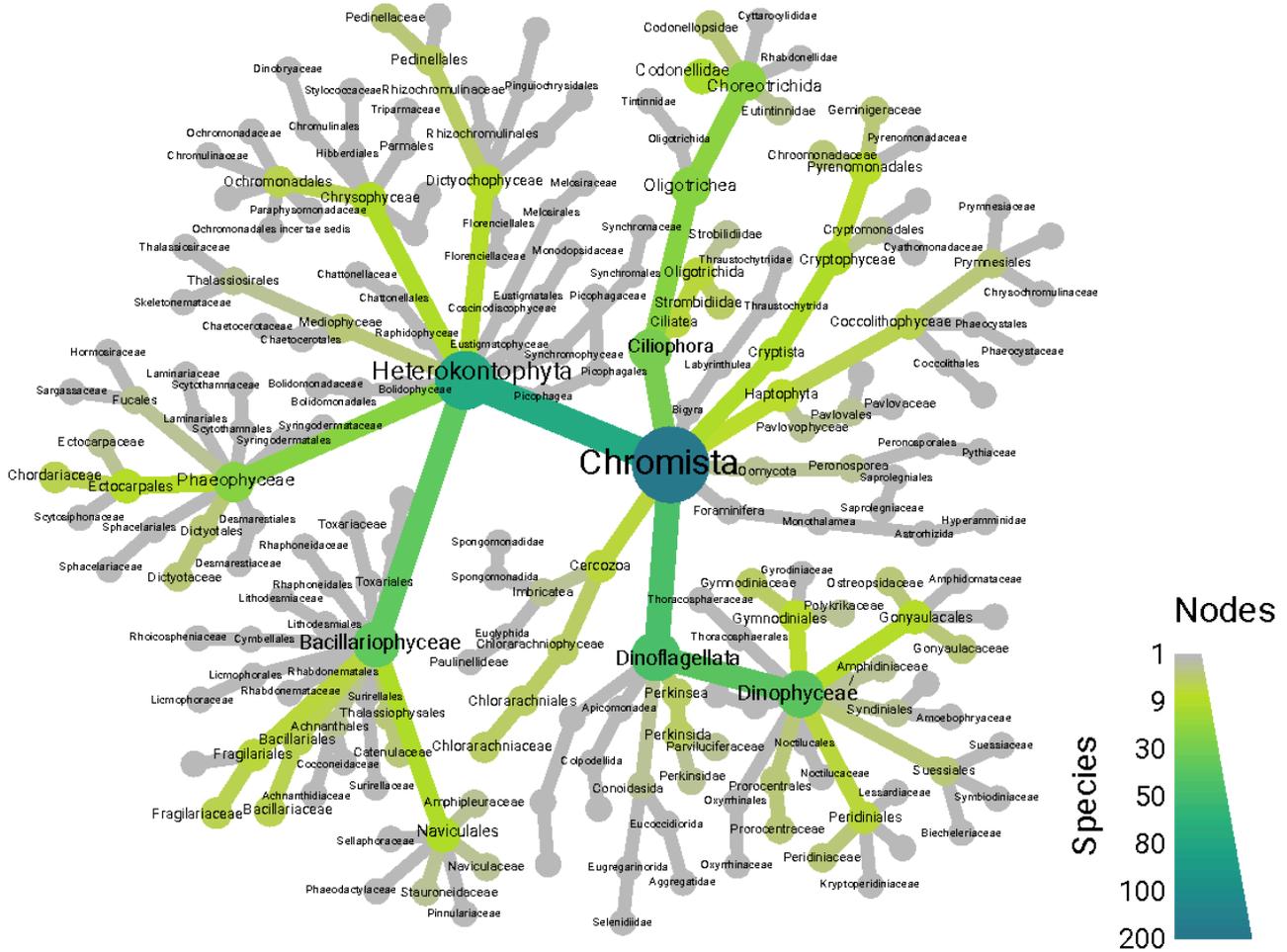
**Figure 5.** Heat tree representation of Aquatina di Frigole and Ionian Sea mariculture species that belong to the Animalia kingdom. The graph shows the classification until the family rank. Colour and size of the nodes are directly proportional to the number of species present in that taxon.





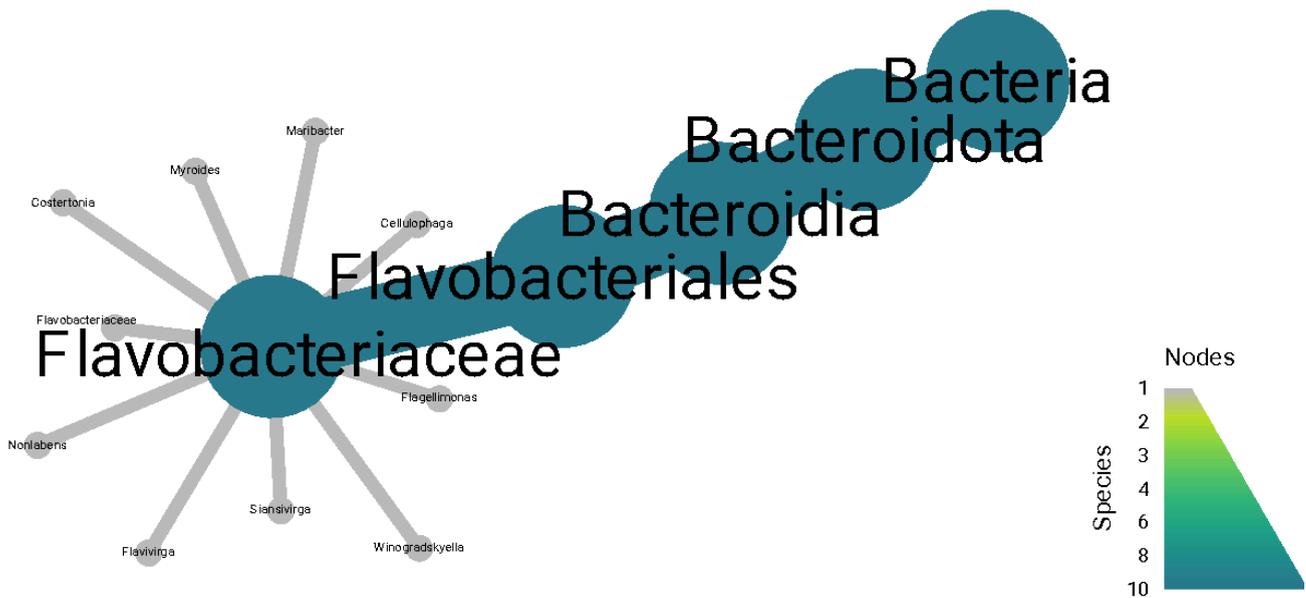
**Figure 6.** Heat tree representation of Aquatina di Frigole and Ionian Sea mariculture species that belong to the Plantae kingdom. The graph shows the classification until the family rank. Colour and size of the nodes are directly proportional to the number of species present in that taxon.





**Figure 7.** Heat tree representation of Aquatina di Frigole and Ionian Sea mariculture species that belong to the Chromista kingdom. The graph shows the classification until the family rank. Colour and size of the nodes are directly proportional to the number of species present in that taxon.

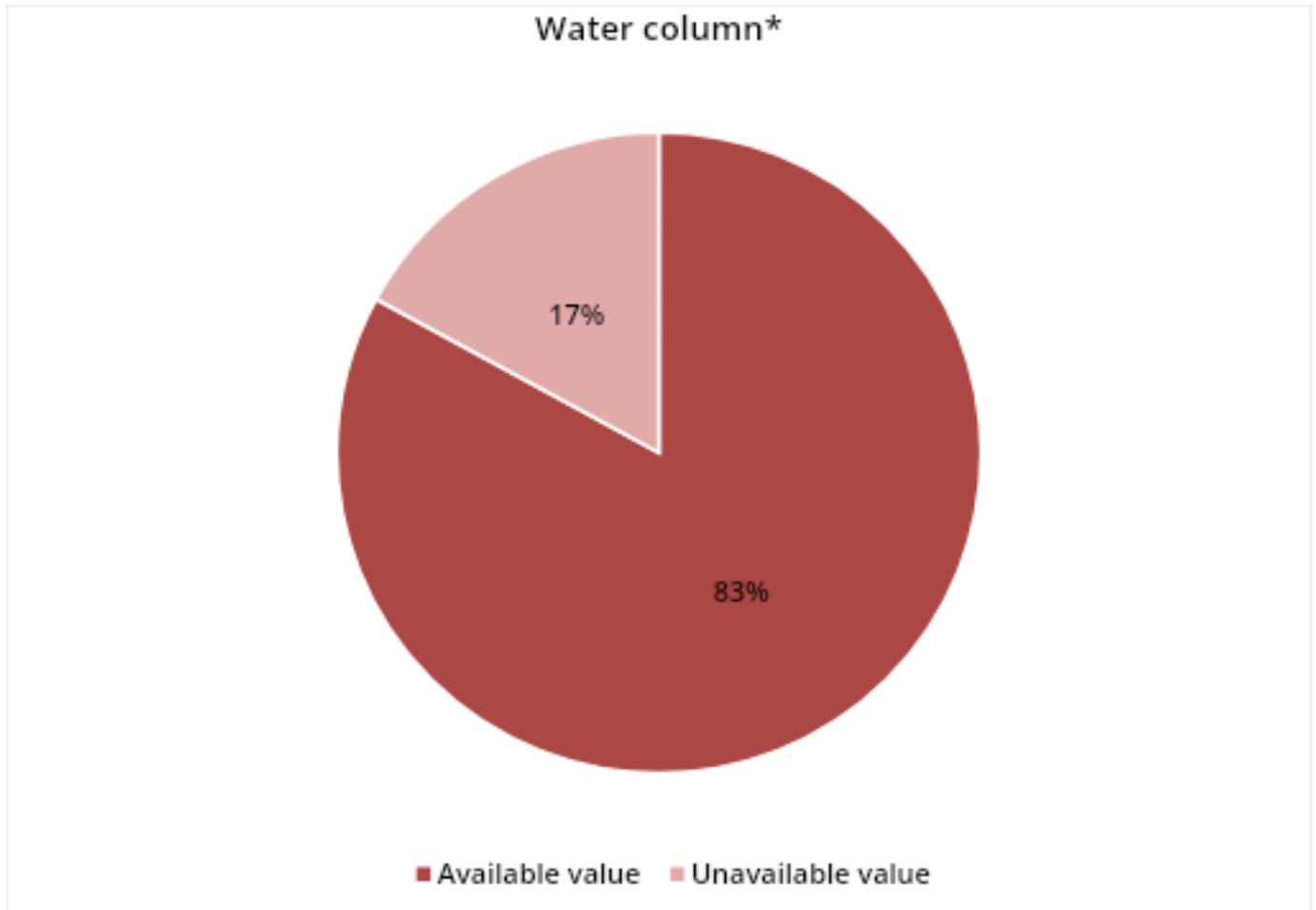




**Figure 8.** Heat tree representation of Aquatina di Frigole and Ionian Sea mariculture species that belong to the Prokaryota kingdom. The graph shows the classification until the family rank. Colour and size of the nodes are directly proportional to the number of species present in that taxon.

The database includes extensive abiotic data collected over multiple years, providing valuable insights into the environmental conditions of the Aquatina di Frigole and Ionian Sea mariculture Pilot Area. Specifically, a total of 51 observations have been recorded from the water column over an eight-year period, offering a long-term perspective on key physicochemical parameters such as temperature, salinity, dissolved oxygen, and nutrient concentrations (Figure 9). These data contribute to the understanding of water quality dynamics and potential environmental fluctuations over time.

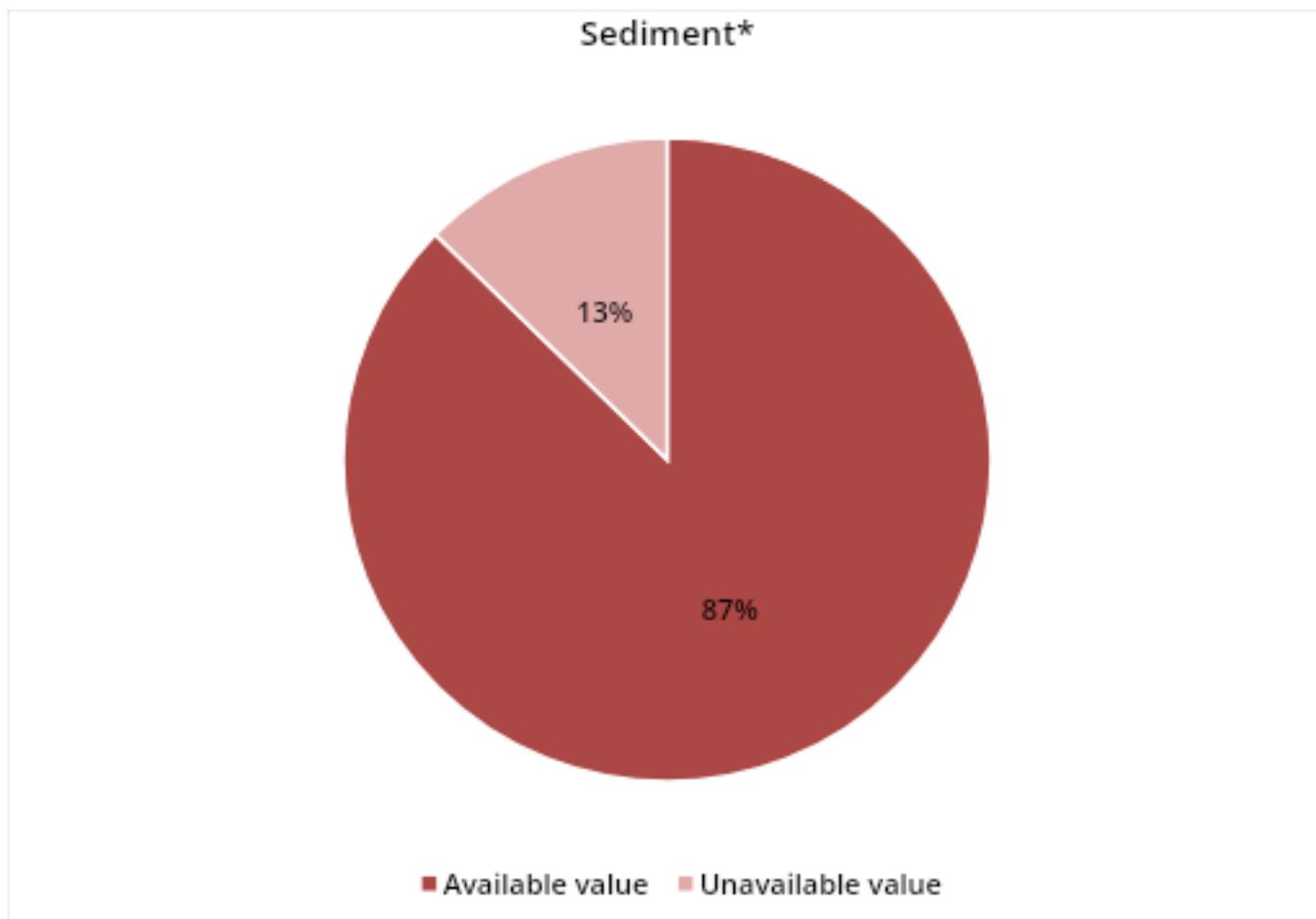




**Figure 9.** Percentage of available values from the abiotic dataset for the water column. \*Many values are represented by *m.l.q.* (a value lower than the instrument's qualification limit).

In addition to water column monitoring, 12 observations have been gathered from sediment analyses over a two-year period (Figure 10). These sediment records provide important information on substrate composition, organic matter content, and other geochemical properties that influence benthic ecosystems and habitat conditions. Together, these datasets serve as a foundation for assessing environmental variability, detecting trends, and supporting future conservation and management efforts in the study area.



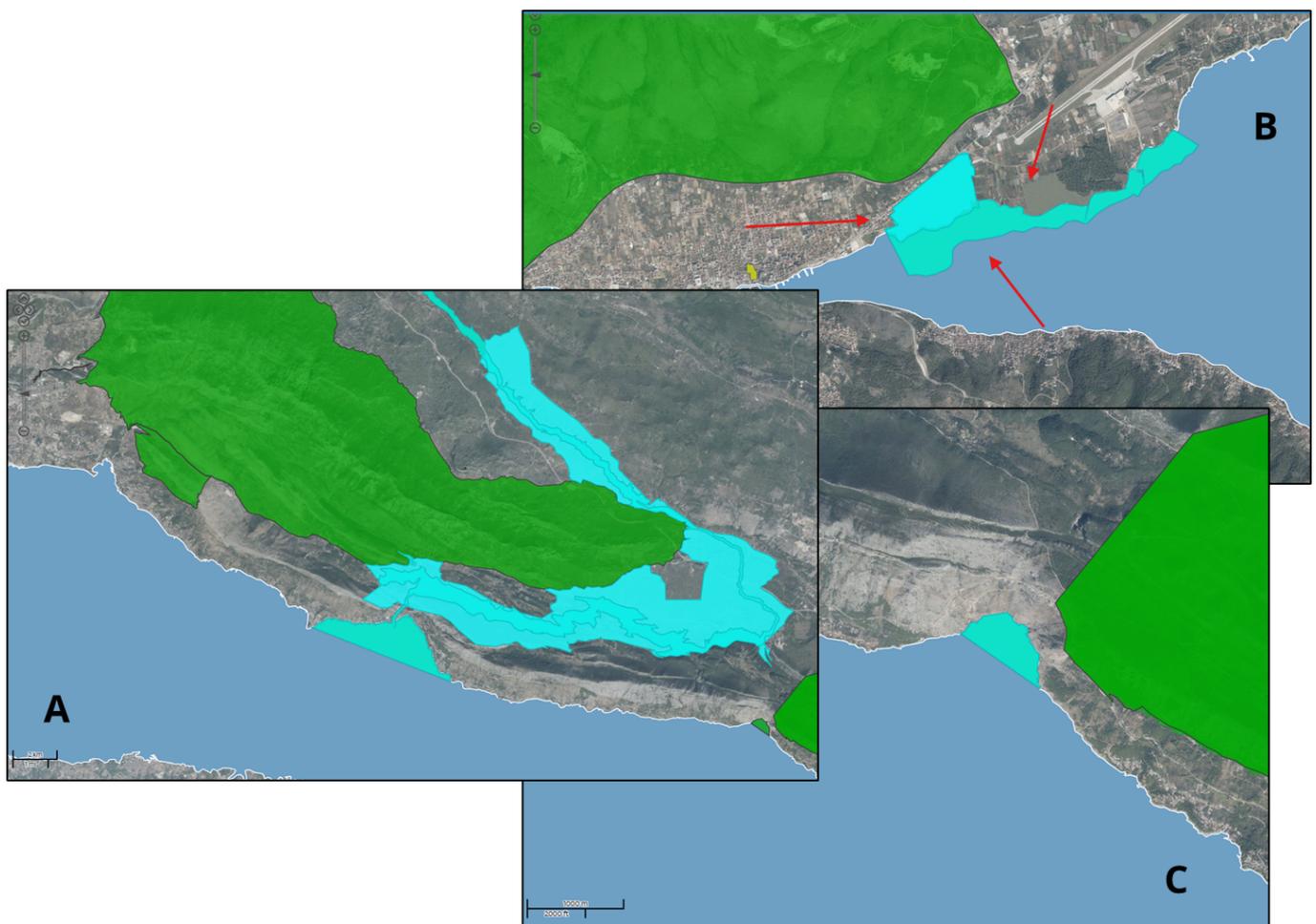


**Figure 10.** Percentage of available values from the abiotic dataset for the sediments. \*Results refer to the Ionian Sea mariculture part of the Pilot Area.



#### 4.2. CETINA RIVER AND ESTUARY; PANTAN COASTAL LAGOON; UVALA VRULJA KOD BRELA

The Cetina River and Estuary; Pantan Coastal Lagoon; Uvala Vrulja kod Brela Pilot Area (Figure 11) is divided into three sub-areas. Cetina River and Estuary is represented by the NATURA 2000 Site “Cetina Estuary” (HR3000126); the NATURA 2000 Site “Cetina River” (HR2000929); and the Protected Landscape “Canyon of the Cetina River”. Pantan Coastal Lagoon is represented by the NATURA 2000 Site “Pantan” (HR3000430); the NATURA 2000 Site “Pantan – Divulje” (HR3000459); and the Ornithological & Ichthyological Reserve “Pantan”. Finally, Uvala Vrulja kod Brela is represented by the NATURA 2000 Site “Uvala Vrulja – Brela” (HR3000123).

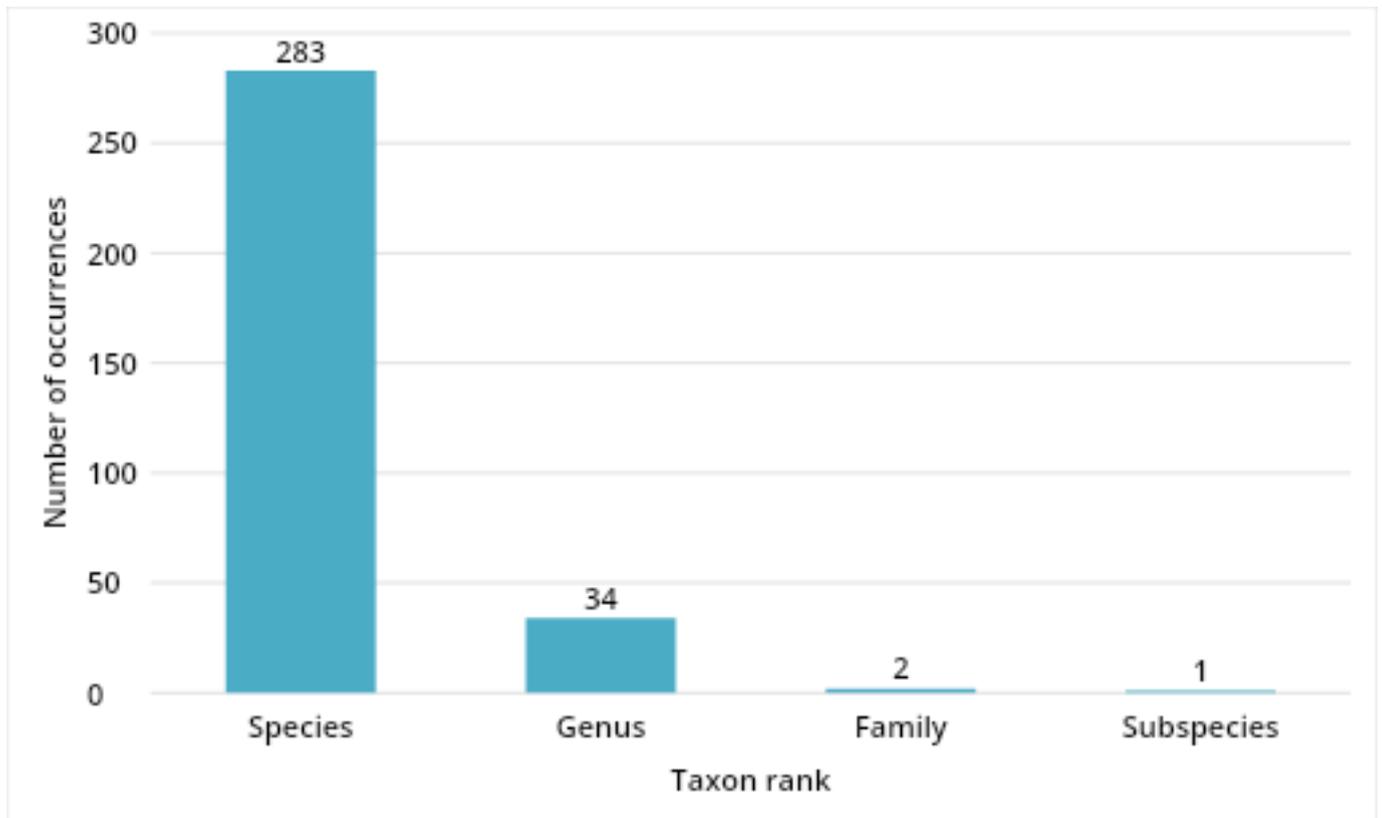


**Figure 11.** Cetina River and Estuary (A); Pantan Coastal Lagoon (B); Uvala Vrulja kod Brela (C).

A total of 320 occurrences were documented within the Cetina River and Estuary; Pantan Coastal Lagoon; and Uvala Vrulja Kod Brela Pilot Area, reflecting the region's biodiversity. Among these, 283 occurrences were identified at the species level, providing a high degree of taxonomic resolution. Additionally, 34 occurrences were classified at the genus level, while 2 were identified up to the



family level. Notably, 1 occurrence was annotated at the subspecies level, further refining the taxonomic detail. The distribution of these taxonomic classifications is visually represented in Figure 12.



**Figure 12.** Number of occurrences per taxon rank for the Cetina River and Estuary; Pantan Coastal Lagoon; Uvala Vrulja kod Brela Pilot Area.

Within the Cetina River and Estuary; Pantan Coastal Lagoon; and Uvala Vrulja Kod Brela Pilot Area, a total of 39 occurrences correspond to species classified as protected (Figure 13). These species span a wide range of taxonomic groups, including birds, fish, marine invertebrates, and aquatic plants, underscoring the ecological significance of the region and the necessity for conservation efforts.

Among the recorded protected species are several bird species, which play a crucial role in maintaining ecosystem balance. These include *Alcedo atthis*, *Cettia cetti*, *Corvus corone cornix*, *Emberiza cirulus*, *Falco tinnunculus*, *Gallinula chloropus*, *Larus fuscus*, *Monticola solitarius*, *Motacilla cinerea*, *Parus major*, *Passer domesticus*, *Phasianus colchicus*, *Rallus aquaticus*, *Sterna hirundo*, *Streptopelia decaocto*, *Sylvia atricapilla*, *Tachybaptus ruficollis*, and *Turdus merula*.



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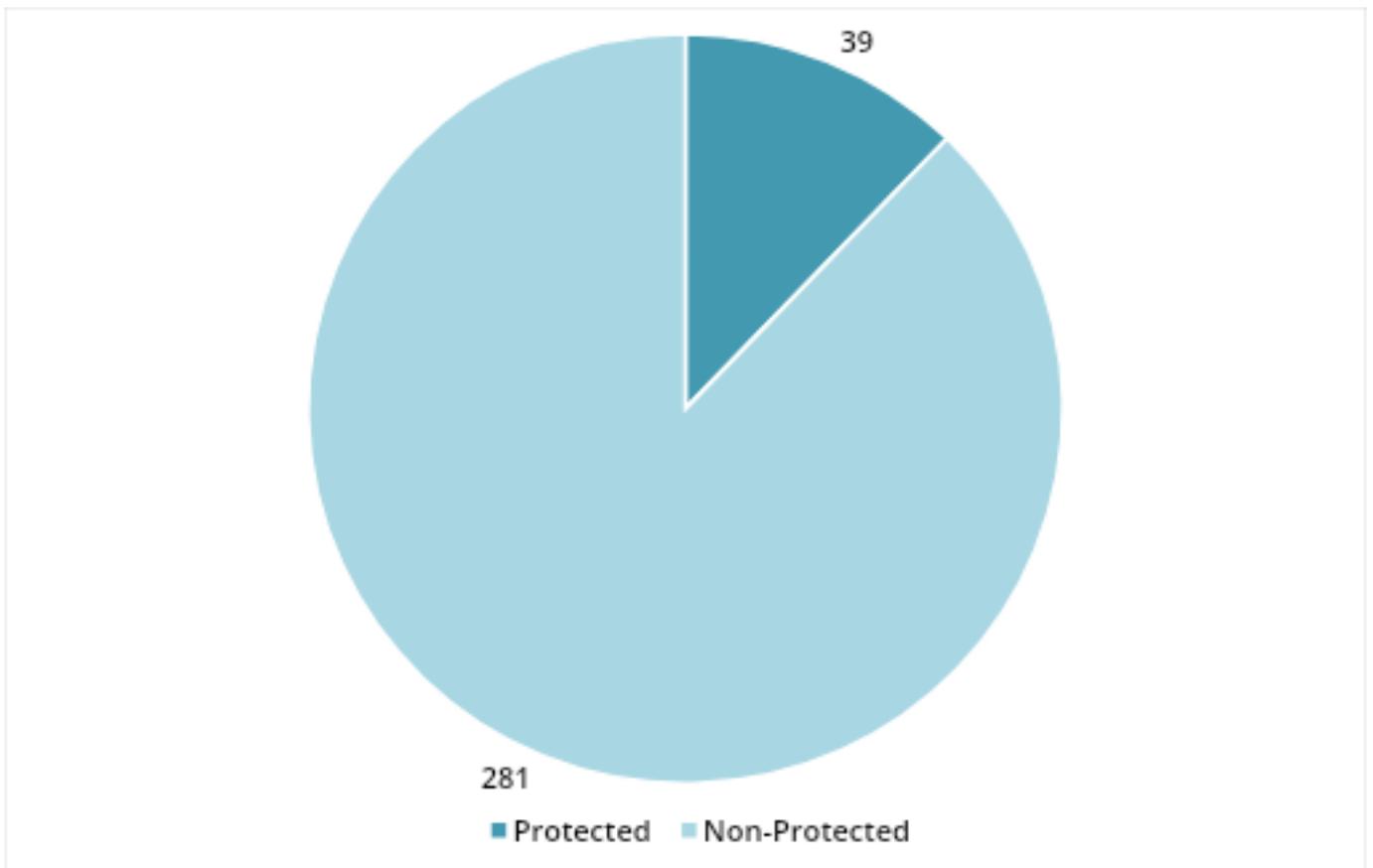


Several fish species were also identified among the protected occurrences, including *Aphanius fasciatus*, *Gobius cobitis*, *Hippocampus guttulatus*, *Mullus barbatus*, *Parablennius gattorugine*, *Pomatoschistus marmoratus*, and *Sardina pilchardus*.

Additionally, a variety of marine and freshwater invertebrates contribute to the biodiversity of the region. Notable species include *Acanthocardia paucicostata* (a bivalve mollusk), *Anemonia viridis* (snakelocks anemone), *Kirkegaardia heterochaeta* (a polychaete worm), *Paradiopatra bihanica* (another polychaete worm), *Pinna nobilis* (noble pen shell), and *Tethya aurantium* (a sponge species).

The study area is also home to important aquatic plants such as *Cymodocea nodosa* and *Zostera noltii*, both of which play a vital role in maintaining habitat structure and supporting marine biodiversity.

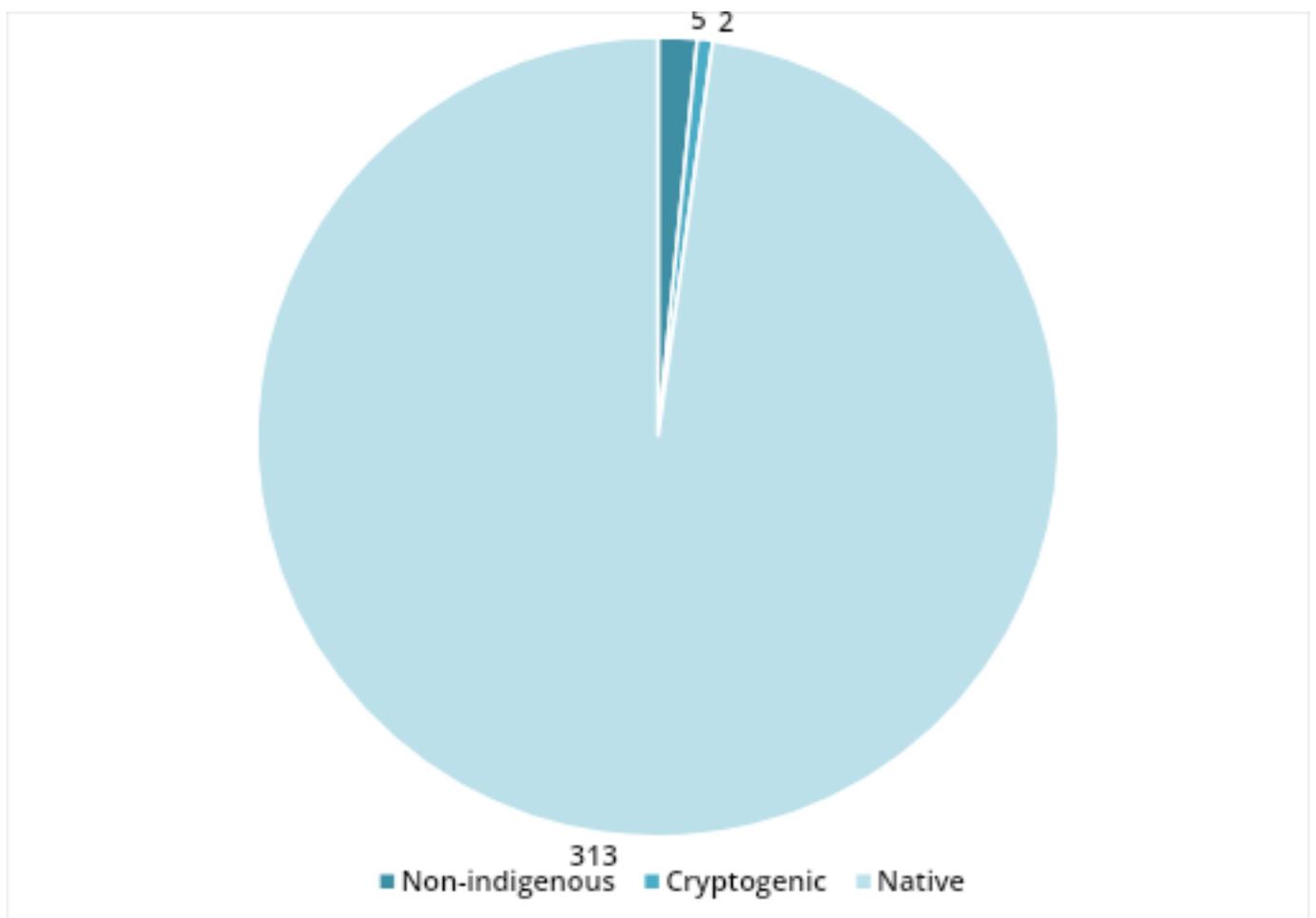
The presence of these protected species highlights the ecological richness of the region and underscores the importance of ongoing monitoring and conservation efforts to preserve its biodiversity.



**Figure 13.** Number of occurrences according to the protection level for the Cetina River and Estuary; Pantan Coastal Lagoon; Uvala Vrulja kod Brela Pilot Area.

The study identified a total of seven occurrences related to species with uncertain or non-native origins within the Cetina River and Estuary; Pantan Coastal Lagoon; and Uvala Vrulja kod Brela Pilot Area (Figure 14). Among these, five occurrences were attributed to non-indigenous species. Additionally, two occurrences were classified as cryptogenic species.

The recorded non-indigenous species span different taxonomic groups and include: *Phasianus colchicus*, *Streptopelia decaocto*, *Callinectes sapidus*, *Codium fragile*.



**Figure 14.** Number of occurrences according to the establishment means for the Cetina River and Estuary; Pantan Coastal Lagoon; Uvala Vrulja kod Brela Pilot Area.

The recorded occurrences within the Cetina River and Estuary; Pantan Coastal Lagoon; and Uvala Vrulja kod Brela Pilot Area span two biological kingdoms, illustrating the rich diversity of life across different ecological niches. These occurrences are classified according to the taxonomic scheme



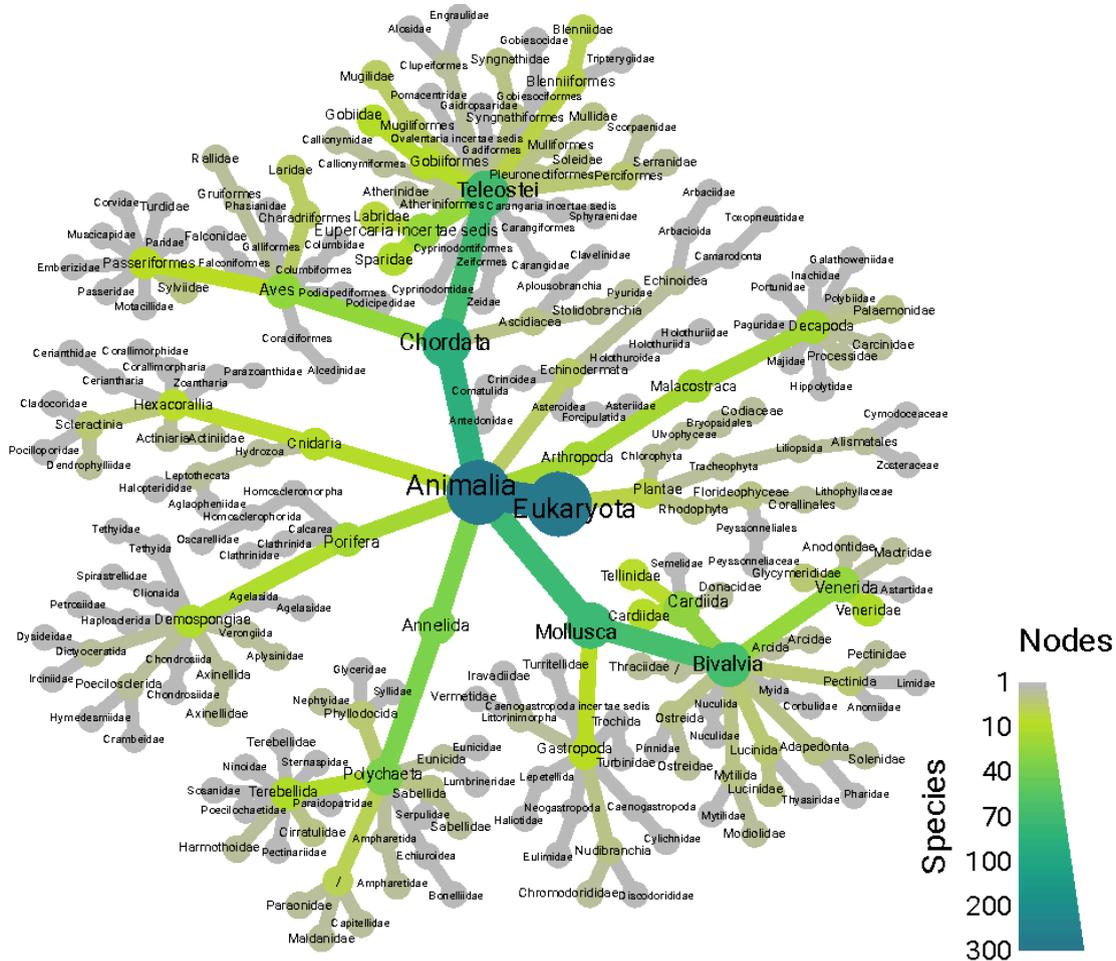
outlined in Table 3, which provides a comprehensive breakdown of species across the distinct kingdoms. This classification highlights the complexity of the region's biodiversity and the variety of organisms that contribute to the area's ecological framework.

**Table 3.** Kingdoms scheme for the Cetina River and Estuary; Pantan Coastal Lagoon; Uvala Vrulja Kod Brela Pilot Area.

Kingdom	Number of occurrences
Animalia	248
Plantae	7

A taxonomic heat tree was created to visually represent the species belonging to the Animalia kingdom within the study area. This graphical representation highlights the diversity and distribution of animal species, offering an intuitive way to understand their taxonomic relationships and relative abundance. The heat tree for the Animalia kingdom is presented in Figure 15, providing a clear, visual breakdown of species across different taxonomic levels within this kingdom.

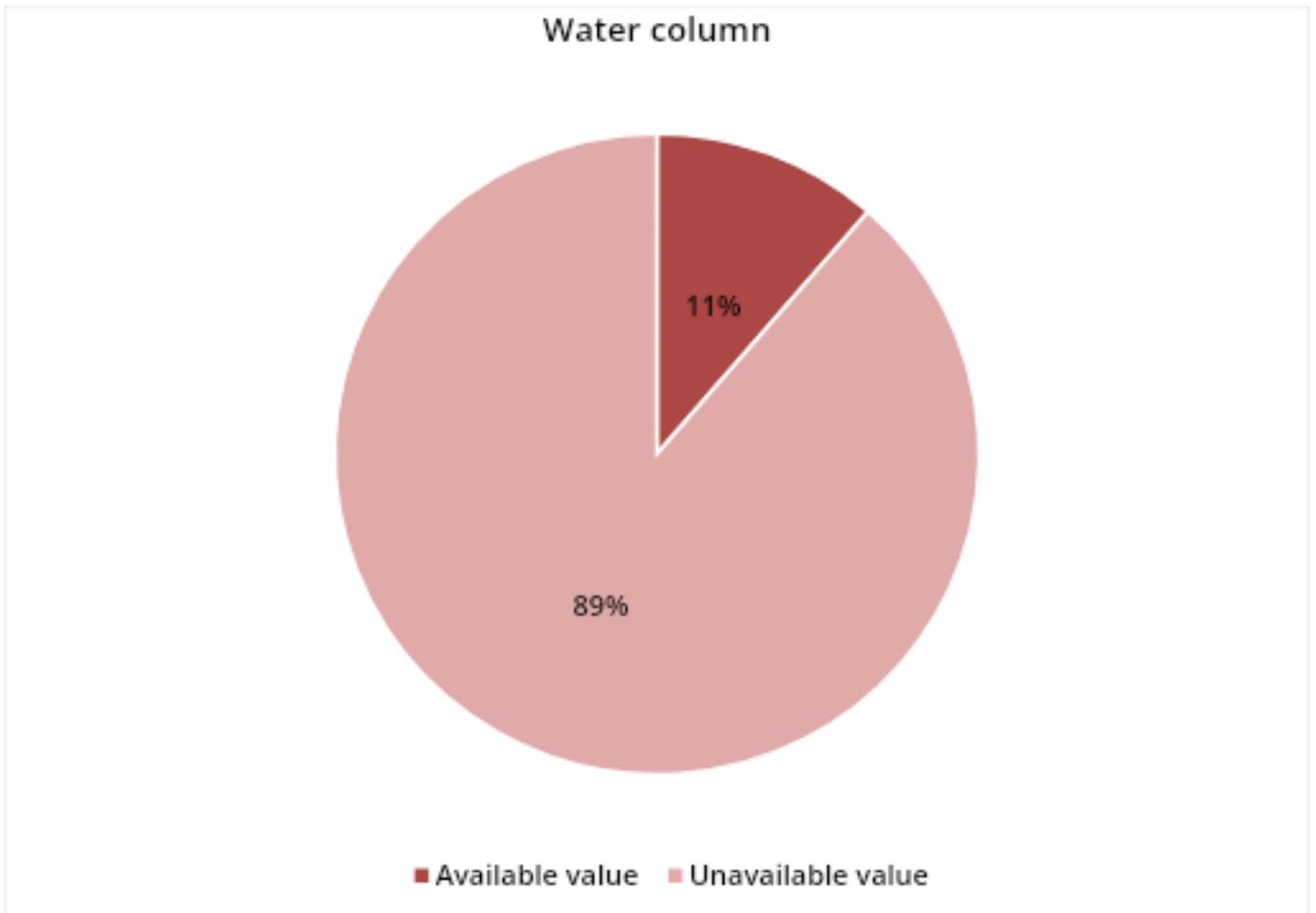




**Figure 15.** Heat tree representation of Cetina River and Estuary; Pantan Coastal Lagoon; Uvala Vrulja kod Brela species that belong to the Animalia kingdom. The graph shows the classification until the family rank. Color and size of the nodes are directly proportional to the number of species present in that taxon.

Regarding abiotic data, a total of 8 observations have been recorded from the water column over a span of 6 years, providing valuable insights into the physicochemical dynamics of the aquatic environment (Figure 16). These data are crucial for understanding the variability in key water parameters such as temperature, salinity, and nutrient concentrations across different time periods.

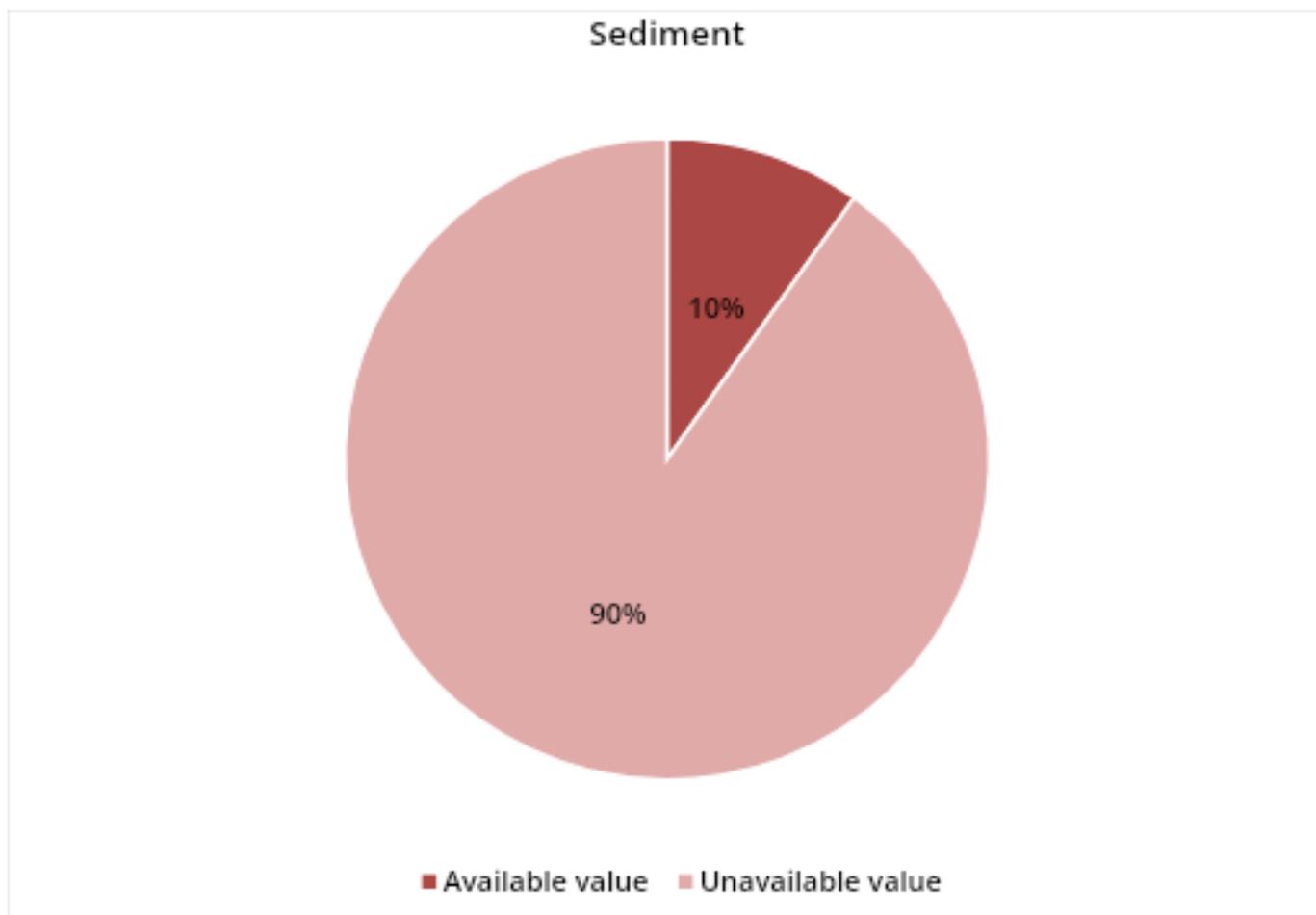




**Figure 16.** Percentage of available values from the abiotic dataset for the water column.

Additionally, 2 observations have been made from sediment analyses over a 2-year period (Figure 17), offering a snapshot of the benthic conditions and geochemical properties of the study area.





**Figure 17.** Percentage of available values from the abiotic dataset for the sediments.



### 4.3. NERETVA DELTA

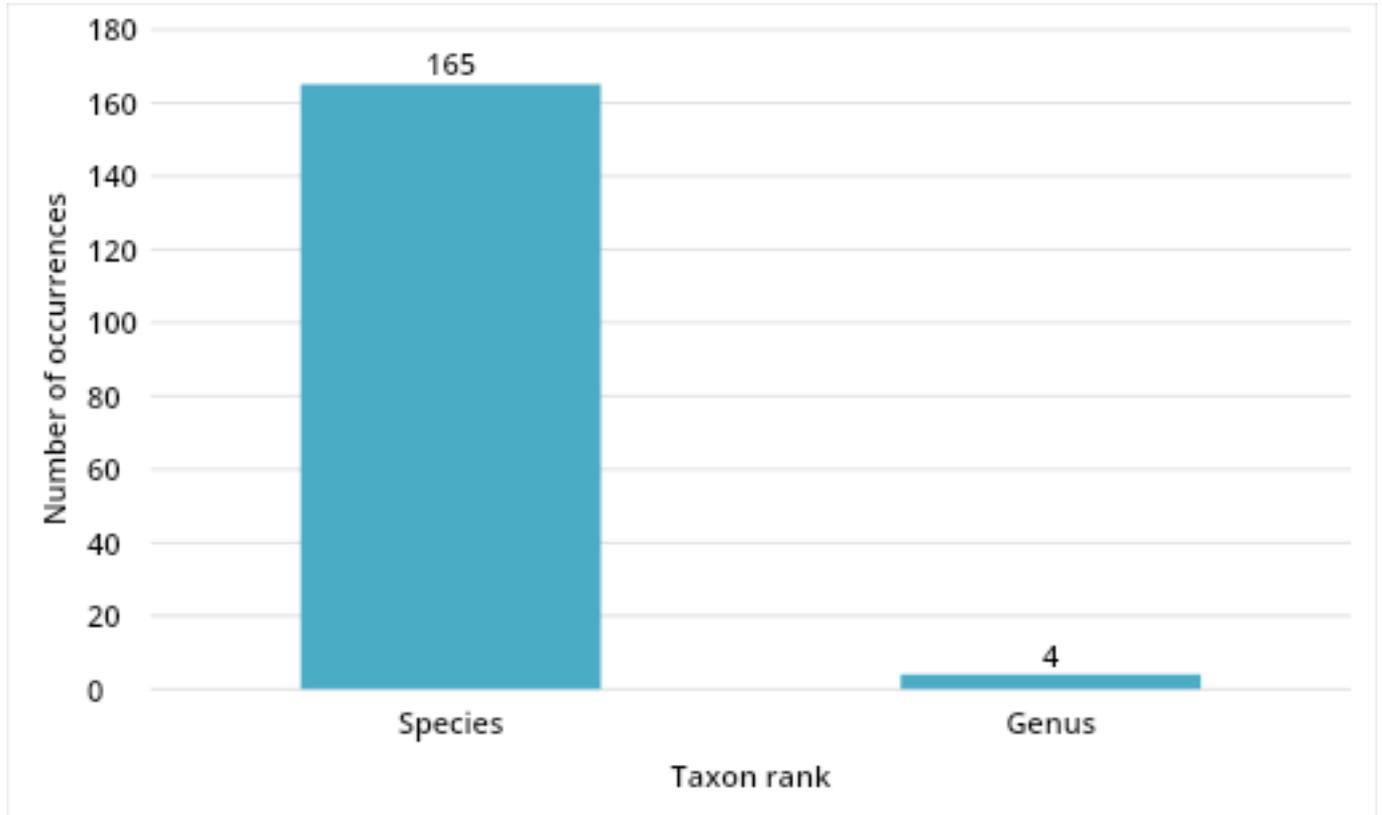
The Neretva Delta Pilot Area (Figure 18) is centred around the Neretva Estuary, which serves as the most critical nursery ground for marine fish and crustaceans along the Eastern Adriatic coast. This estuarine ecosystem plays a vital role in supporting the life cycle of various marine species, providing sheltered and nutrient-rich habitats essential for juvenile fish and crustaceans. The Neretva Estuary is therefore an ecologically significant area, contributing to the biodiversity and productivity of the broader marine environment in the region.



**Figure 18.** Neretva Delta.

In the Neretva Delta Pilot Area, a total of 169 occurrences were recorded, highlighting the area's rich biodiversity. Of these, 165 occurrences were identified at the species level, providing a high level of taxonomic detail, while the remaining 4 occurrences were classified at the genus level. This classification is visually represented in Figure 19, which further illustrates the distribution of these occurrences across various taxonomic groups.





**Figure 19.** Number of occurrences per taxon rank for the Neretva Delta Pilot Area.

Within the Neretva Delta Pilot Area, 33 occurrences are represented by species classified as protected (Figure 20). These species, spanning various taxonomic groups, are of particular ecological significance due to their vulnerable or threatened status, underscoring the importance of conservation efforts in the region.

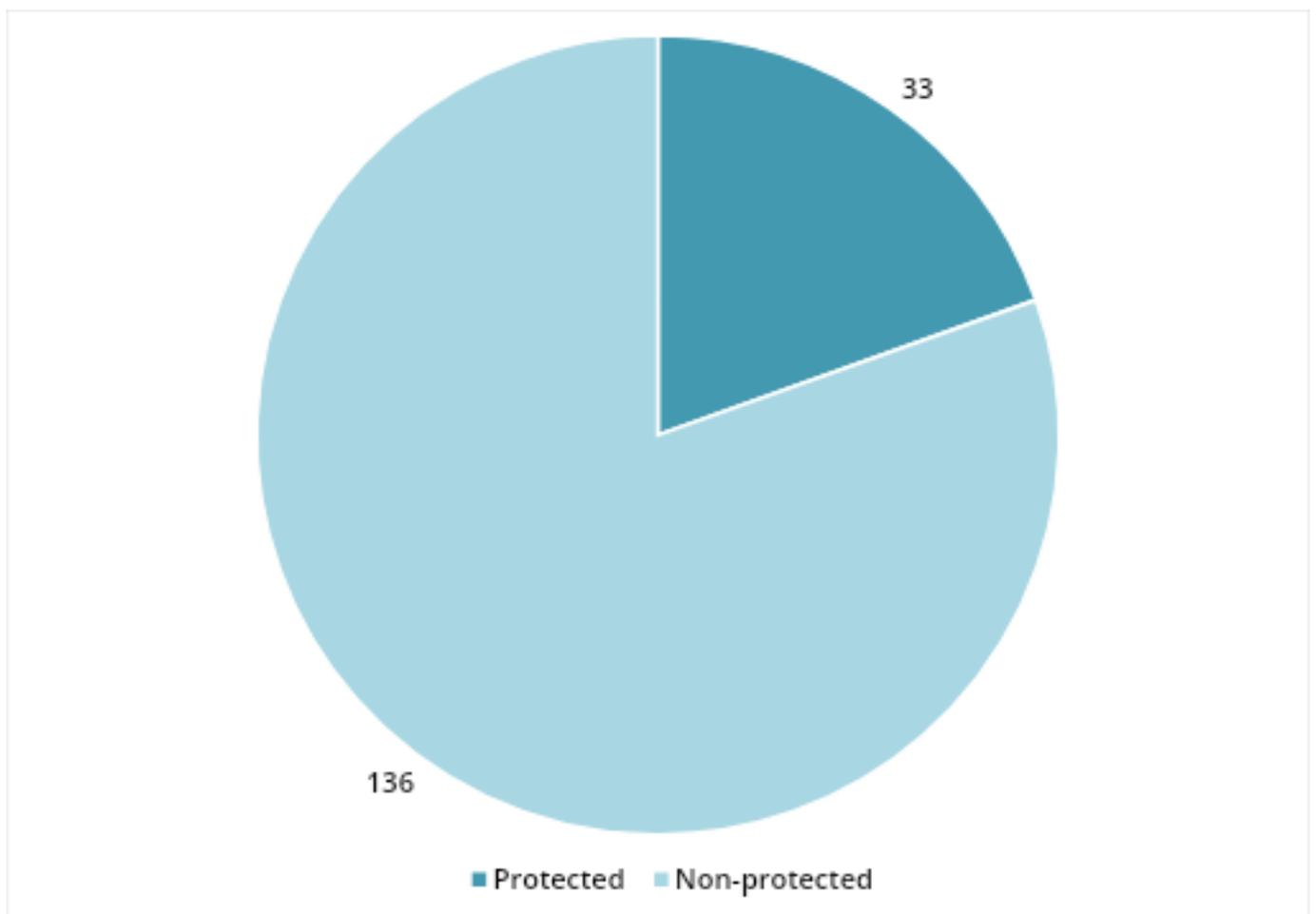
The protected species identified in this area include several bird species such as *Anas acuta*, *Anas crecca*, *Anas platyrhynchos*, and *Ardea purpurea*, all of which are vital for maintaining ecological balance in wetland ecosystems. Fish species, including *Anguilla anguilla*, *Aphanius fasciatus*, *Alburnus albidus*, *Alosa fallax*, and *Salmo marmoratus*, are also represented, demonstrating the estuary's importance as a crucial breeding ground.

In addition, several aquatic invertebrates, such as *Congerina kusceri* and *Kirkegaardia heterochaeta*, further highlight the region's biodiversity. The presence of key marine plants like *Cymodocea nodosa* and *Zostera noltii* underscores the ecological value of the submerged habitats within the Neretva Delta.



Other notable species include *Cynanchum acutum*, *Cyperus longus*, *Dorycnium rectum*, and *Eleocharis ovata*, which contribute to the diversity of the region’s wetland and aquatic ecosystems. The list also features *Pomatoschistus canestrinii* and *Mullus barbatus*, both of which play significant roles in the local food web.

The diversity of protected species in this area underscores the ecological importance of the Neretva Delta as a critical habitat for a wide variety of organisms, reinforcing the need for ongoing monitoring and protection to preserve the biodiversity of this unique ecosystem.

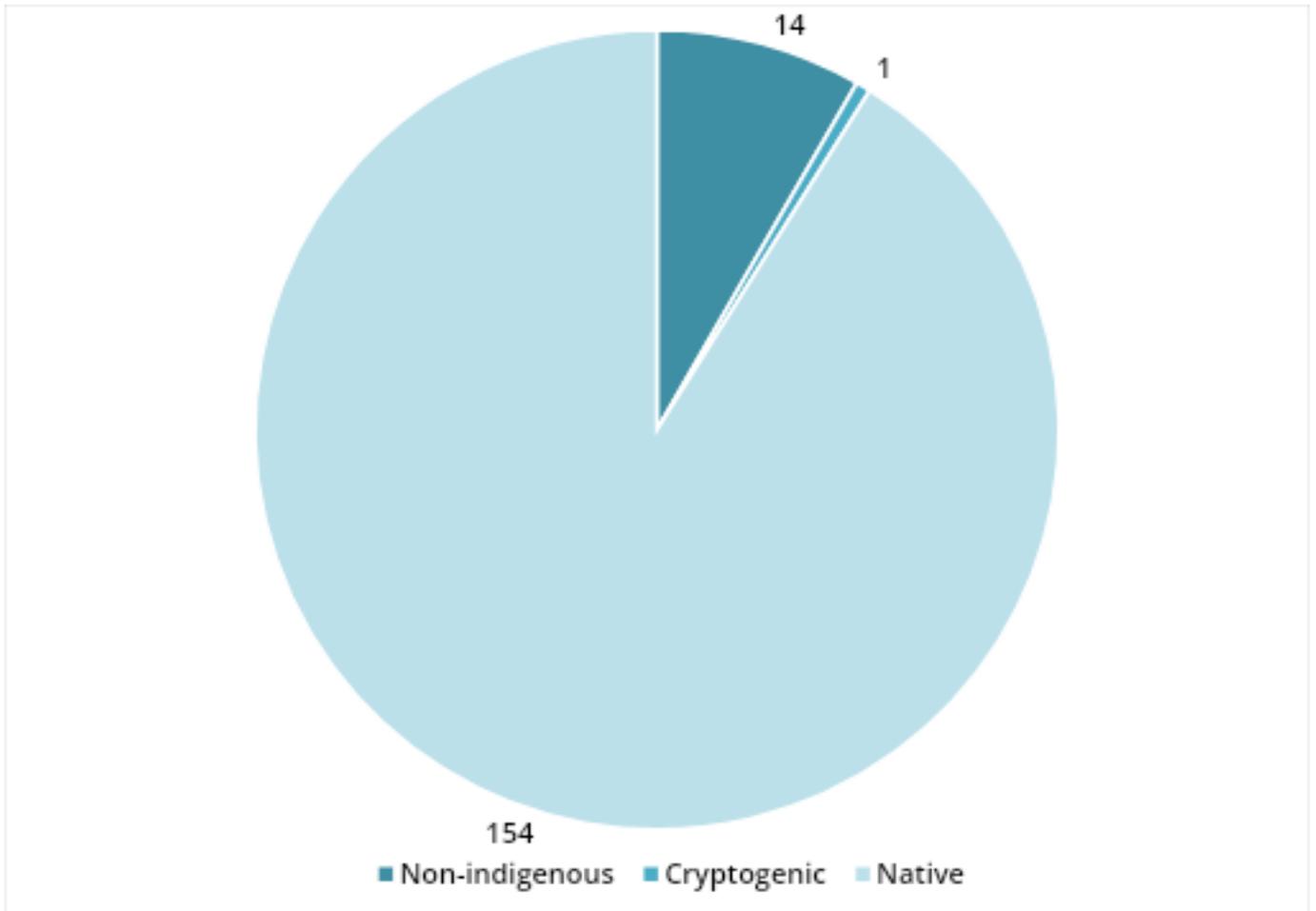


**Figure 20.** Number of occurrences according to the protection level for the Neretva Delta Pilot Area.

In the Neretva Delta Pilot Area, a total of 14 occurrences were recorded for non-indigenous species, with 1 occurrence classified as cryptogenic (Figure 21). These non-indigenous species include *Arcuatula senhousia*, *Callinectes sapidus*, *Egeria densa*, *Eleusine indica*, *Epinephelus aeneus*, *Esox lucius*, *Ficopomatus enigmaticus*, *Micropterus salmoides*, *Mnemiopsis leidy*, *Myriophyllum heterophyllum*,



*Paspalum paspalodes*, *Pseudocaranx dentex*, *Silurus glanis*, and *Synodontis eupterus*. The introduction of these species into the region can lead to various ecological impacts, such as competition with native species, habitat alteration, or changes in ecosystem dynamics.



**Figure 21.** Number of occurrences according to the establishment means for the Neretva Delta Pilot Area.

The recorded occurrences within the Neretva Delta Pilot Area are classified into two distinct kingdoms, as outlined in the taxonomic scheme presented in Table 4. This classification reflects the diverse range of life forms present in the area, highlighting the ecological complexity and variety of organisms inhabiting the region.

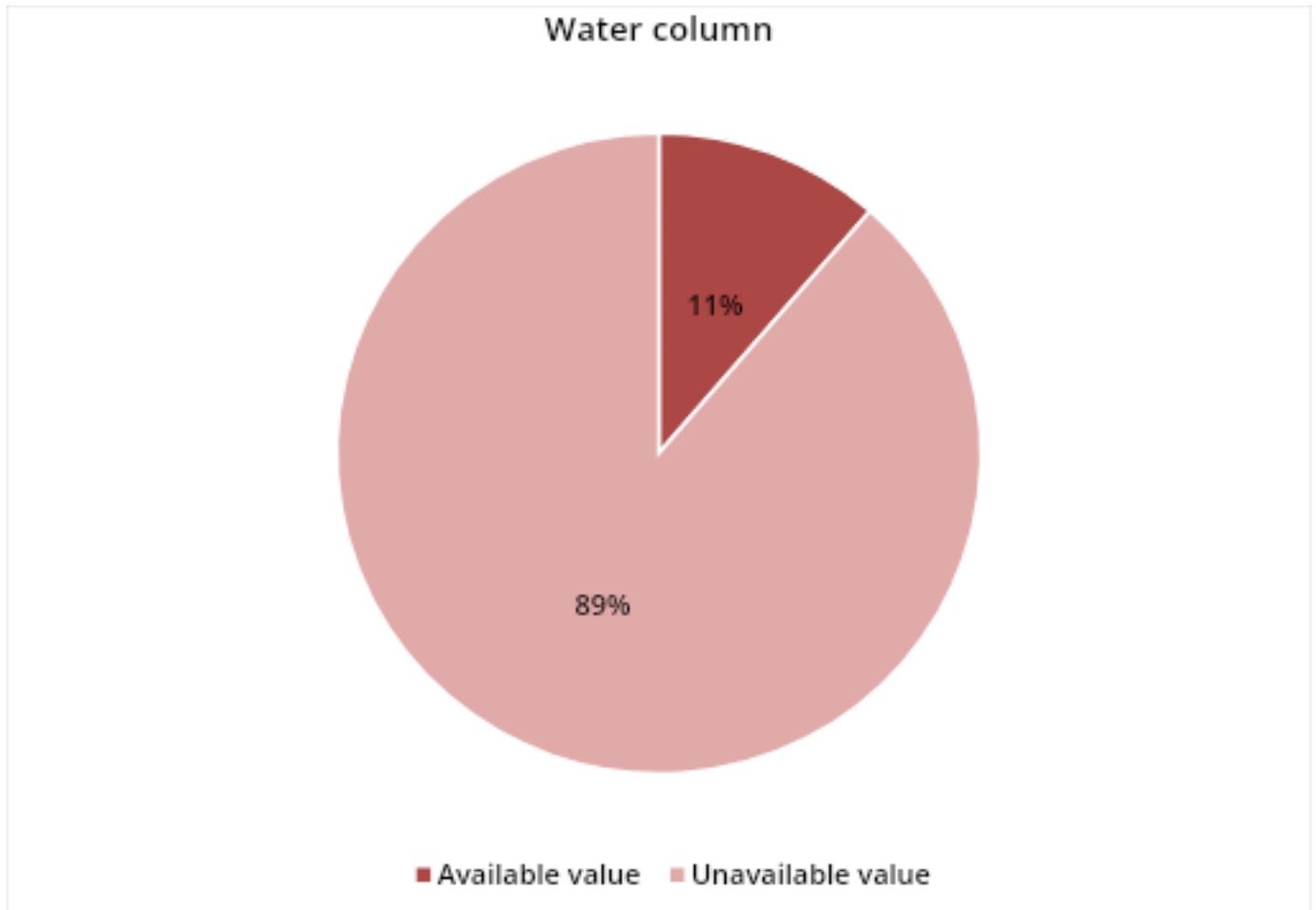
**Table 4.** Kingdoms scheme for the Neretva Delta Pilot Area.

Kingdom	Number of occurrences
Animalia	84
Plantae	72





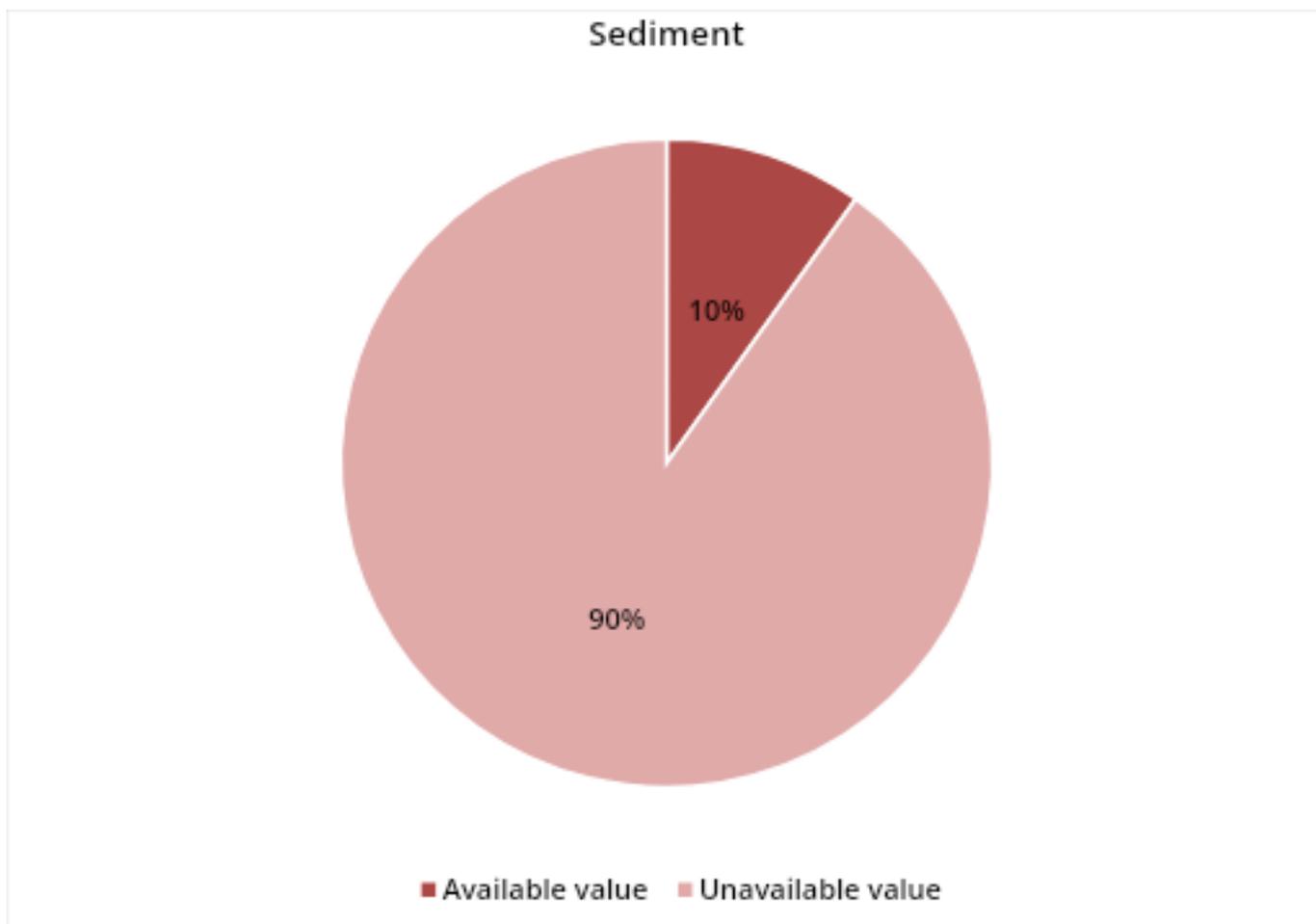
for understanding the dynamic nature of the water environment, capturing fluctuations in key physicochemical parameters such as temperature, salinity, dissolved oxygen levels, and nutrient concentrations. By tracking these variables over time, we gain a more comprehensive understanding of the factors influencing water quality, aquatic life, and overall ecosystem health in the region.



**Figure 23.** Percentage of available values from the abiotic dataset for the water column.

Furthermore, 4 observations from the sediments have been made over a period of 4 years (Figure 24). These sedimentary analyses provide invaluable data on the geochemical properties of the benthic environment, such as sediment composition, organic matter content, and trace element concentrations. Sediment analysis is key to understanding the processes occurring beneath the water surface, including nutrient cycling, habitat structure, and the influence of sediment disturbance on local biota. The combination of water column and sediment data forms a holistic picture of the abiotic conditions in the Neretva Delta, essential for informed ecological management and conservation efforts in this unique and ecologically sensitive area.



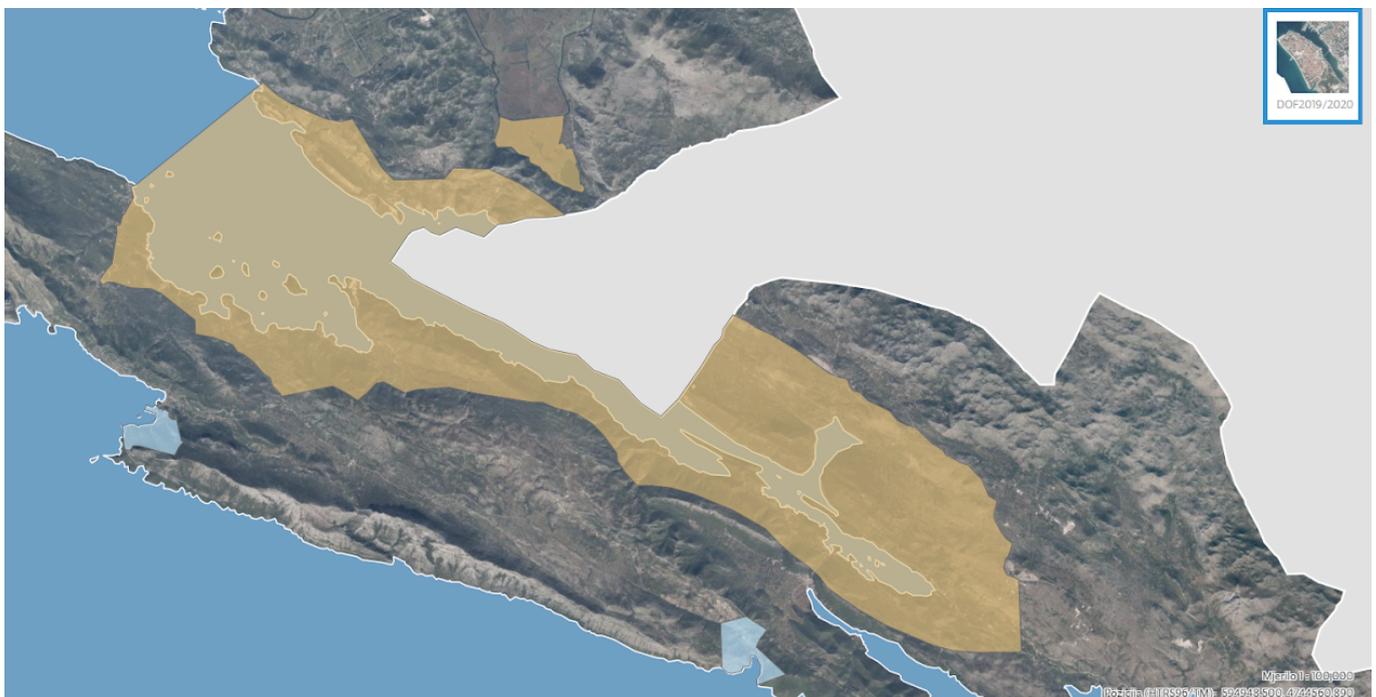


**Figure 24.** Percentage of available values from the abiotic dataset for the sediments.



#### 4.4. MALI STON BAY

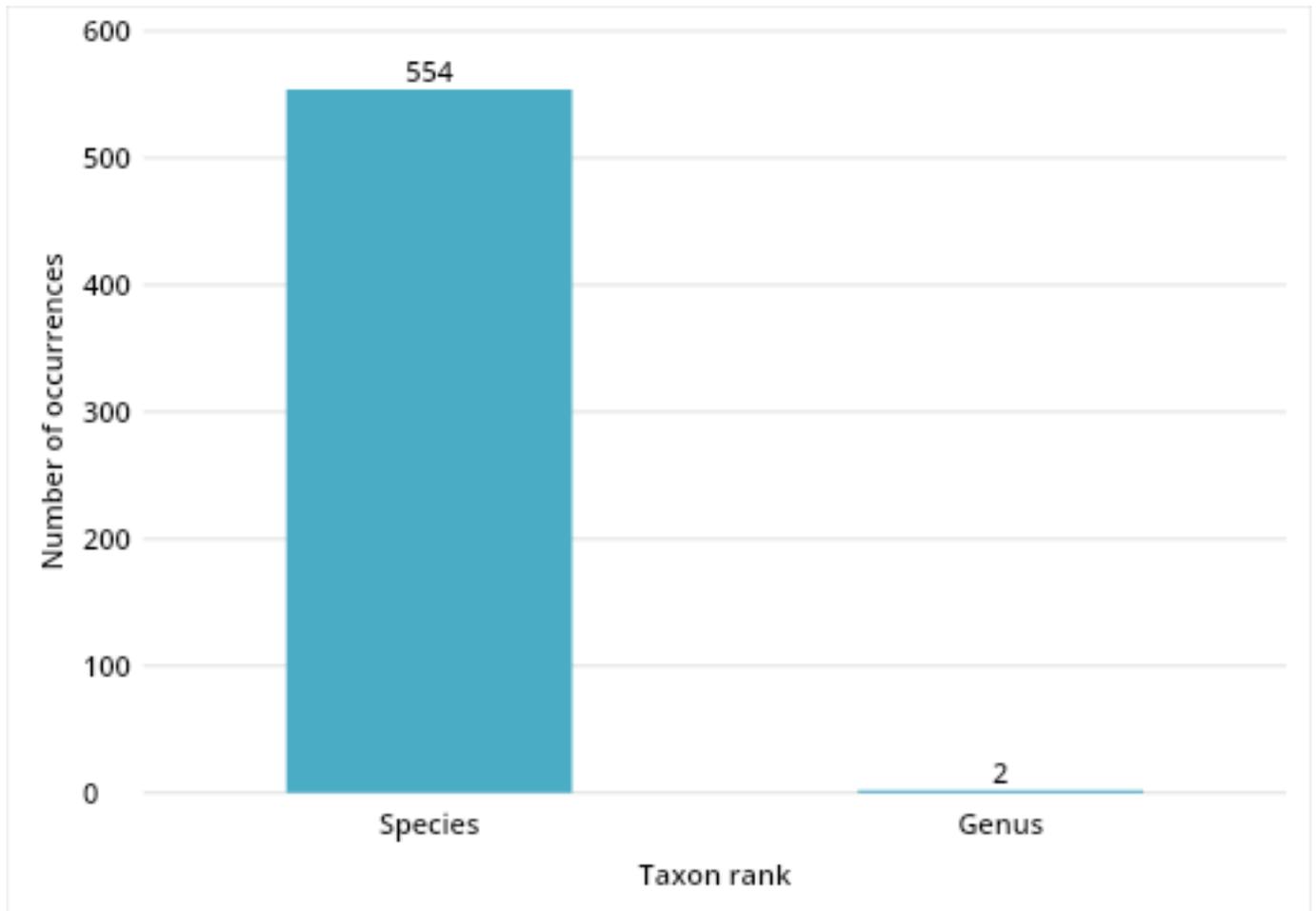
The Mali Ston Bay Pilot Area (Figure 25) is situated in the southern region of the Croatian Adriatic Sea, located between the mainland and the Pelješac Peninsula. This bay extends into the Neretva River channel, linking it to a broader network of marine and freshwater ecosystems. The geographical positioning of Mali Ston Bay is of ecological importance, as it acts as a transitional zone where the marine influences of the Adriatic Sea meet the freshwater inputs from the Neretva River. This convergence creates a unique environmental gradient, supporting a diverse range of habitats and species that thrive in both brackish and marine conditions.



**Figure 25.** Mali Ston Bay.

In the Mali Ston Bay Pilot Area, a total of 556 occurrences were recorded, reflecting the rich biodiversity present within this unique ecosystem (Figure 26). Of these, 554 occurrences are annotated at the species level, providing detailed insights into the individual species that inhabit this coastal region. This high level of species-specific data enables a precise understanding of the composition and distribution of the local biota. Additionally, 2 occurrences were annotated up to the genus level, indicating that while the majority of the occurrences have been identified to species, a small proportion could not be fully classified beyond the genus level, suggesting the potential for further study or the presence of species with similar morphological characteristics. The comprehensive data collected from these occurrences offers a clear picture of the biological diversity within the area, contributing to ongoing ecological research and conservation efforts aimed at preserving the health and integrity of the Mali Ston Bay ecosystem.





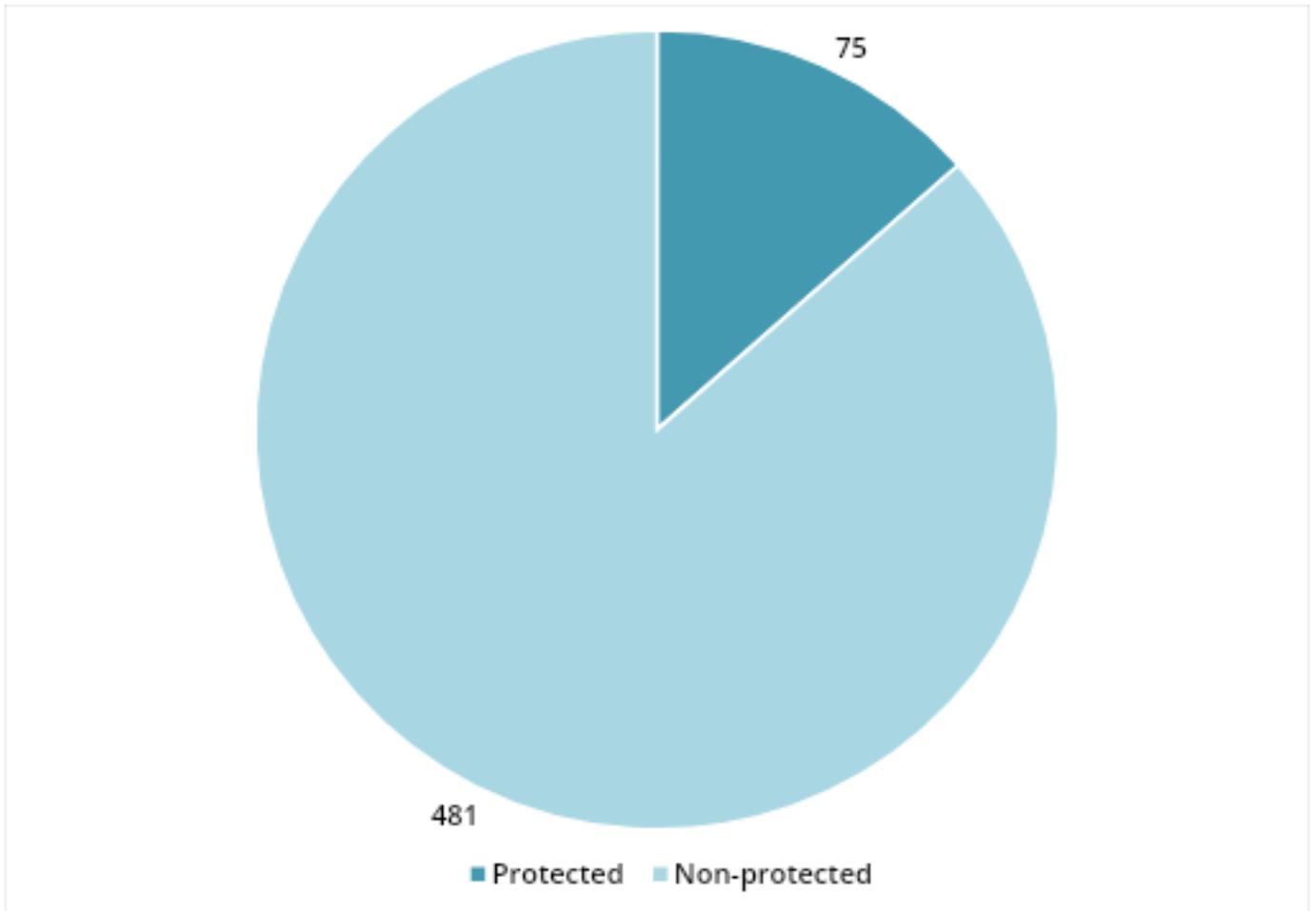
**Figure 26.** Number of occurrences per taxon rank for the Mali Ston Bay Pilot Area.

In the Mali Ston Bay Pilot Area, a total of 75 occurrences are represented by species classified as protected (Figure 27). These species are of significant ecological importance due to their vulnerable or threatened status and their crucial roles in maintaining the health and functionality of coastal and marine ecosystems. The list of protected species includes various marine plants such as *Cymodocea nodosa*, *Cystoseira compressa*, *Cystoseira corniculata*, *Cystoseira crinitophylla*, *Cystoseira foeniculacea*, and *Posidonia oceanica*, all of which contribute to the formation of vital underwater habitats, such as seagrass meadows and macroalgal beds, that provide shelter and food for numerous marine organisms.

Additionally, several invertebrates, including *Geodia cydonium*, *Lithophaga lithophaga*, *Pholas dactylus*, and *Pinna nobilis*, are protected due to their roles in benthic ecosystems and their sensitivity to environmental disturbances. The presence of *Hippocampus guttulatus*, a species known for its vulnerability to habitat loss and overfishing, further emphasizes the importance of



conservation efforts in this region. Other protected species such as *Sarcotragus foetidus*, *Sarcotragus spinosulus*, *Savalia savaglia*, and *Tethya aurantium* are significant for their ecological functions, contributing to the structural complexity and biodiversity of the region’s ecosystems.



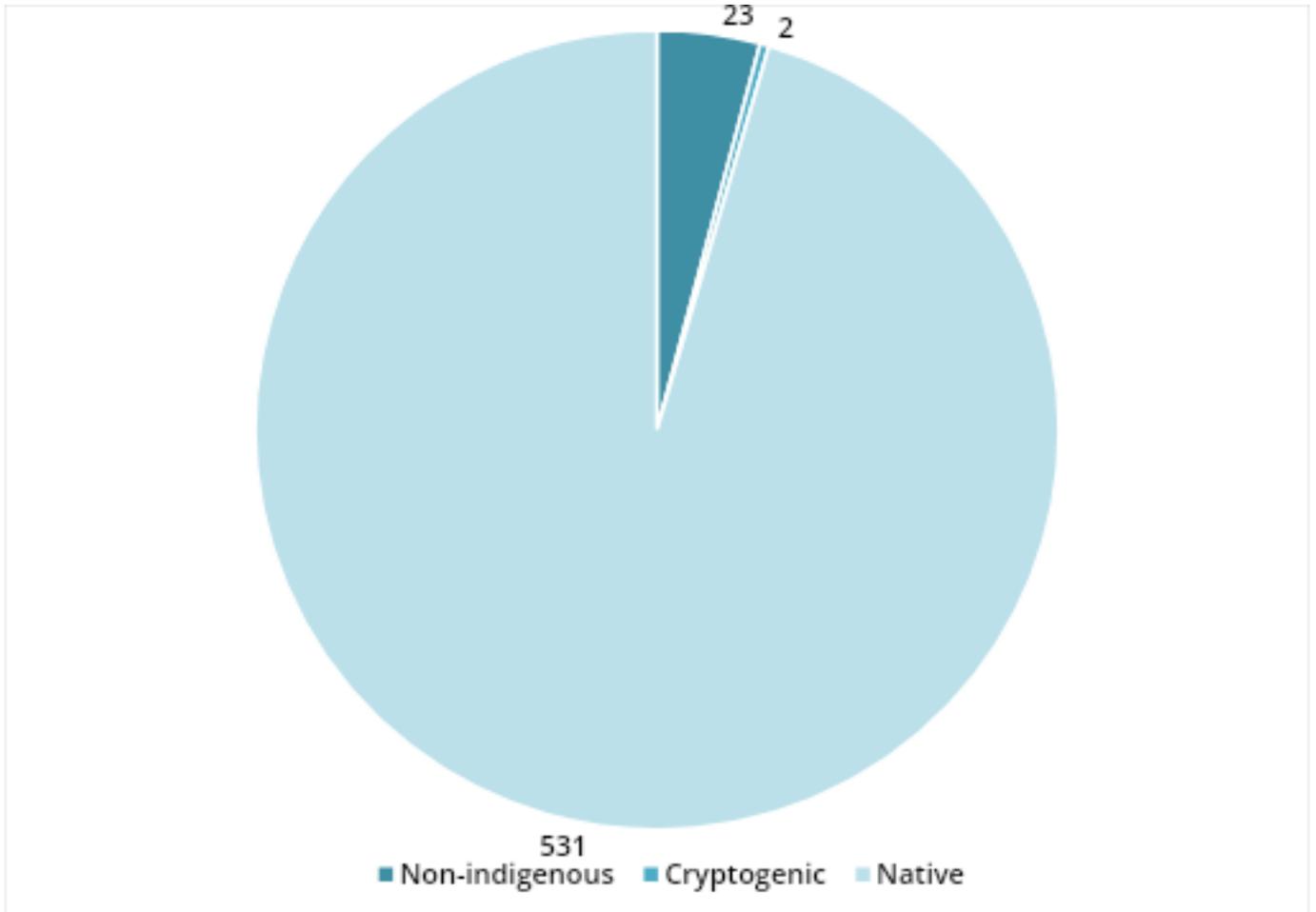
**Figure 27.** Number of occurrences according to the protection level for the Mali Ston Bay Pilot Area.

In the Mali Ston Bay Pilot Area, a total of 23 occurrences are attributed to non-indigenous species, while 2 occurrences are classified as cryptogenic (Figure 28). The non-indigenous species recorded in this area include *Amathia verticillata*, *Asparagopsis armata*, *Botrylloides leachii*, *Bursatella leachii*, *Caulerpa cylindracea*, *Melibe viridis*, *Paraleucilla magna*, and *Styela plicata*.

These species are often characterized by their ability to thrive in new environments, sometimes leading to changes in the structure and functioning of the ecosystem. For example, *Caulerpa cylindracea* is known for forming dense mats that can smother native seagrass beds, while *Styela plicata*, a colonial tunicate, can outcompete native filter-feeding species for space and food.



Interestingly, this is the sole Pilot Area in which *Callinectes sapidus* was not registered.



**Figure 28.** Number of occurrences according to the protection level for the Mali Ston Bay Pilot Area.

The occurrences recorded in the Mali Ston Bay Pilot Area are classified into three distinct biological kingdoms, as detailed in the taxonomic scheme presented in Table 5. This distribution reflects the diverse range of organisms inhabiting the area, each contributing to the ecological balance of the region. The presence of species from different kingdoms highlights the area’s rich biodiversity and its role as a dynamic ecosystem where complex interactions between plant, animal, and other life forms take place.

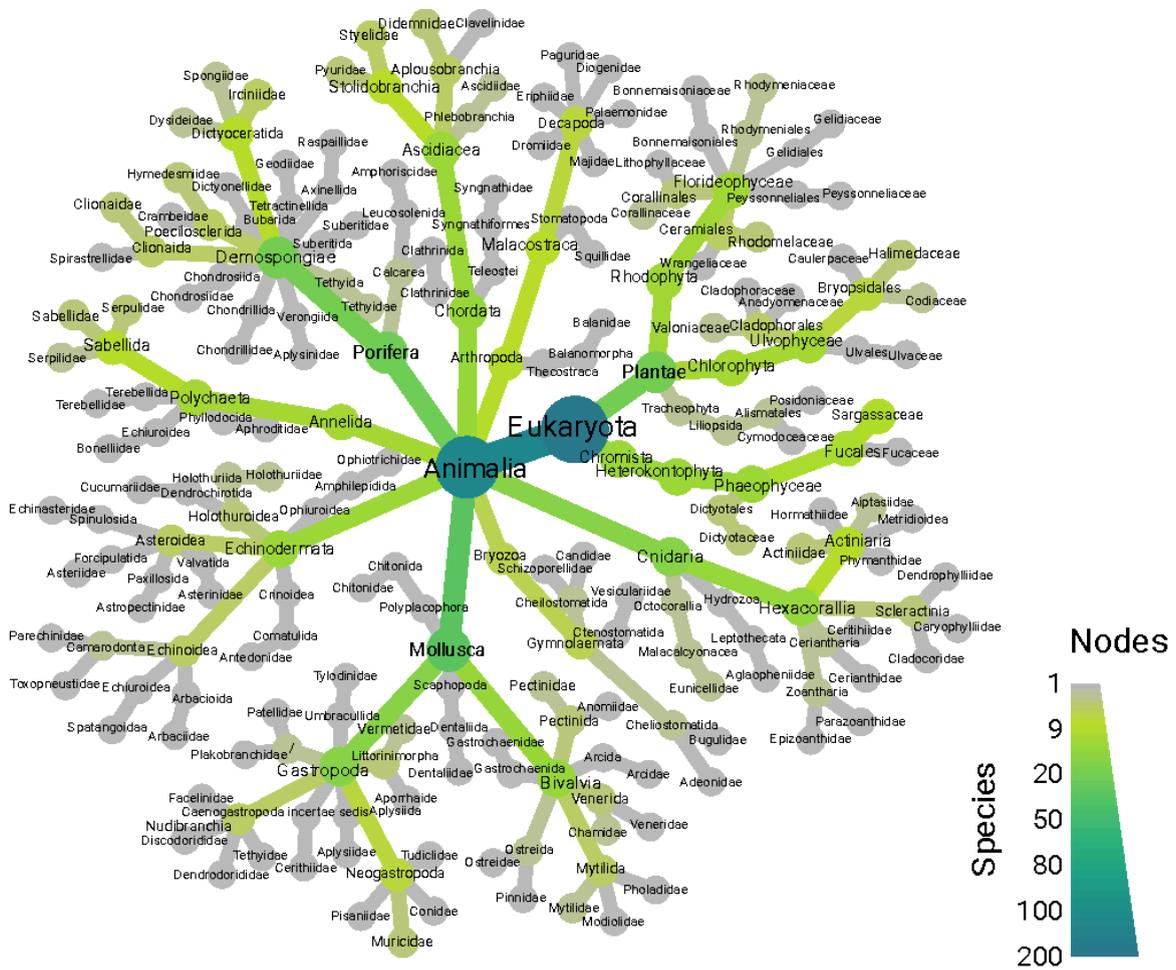
**Table 5.** Kingdoms scheme for the Mali Ston Bay Pilot Area.

Kingdom	Number of occurrences
Animalia	131
Plantae	24



Chromista	13
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A taxonomic heat tree was generated to visually represent the species belonging to the kingdoms Animalia, Plantae, and Chromista within the Mali Ston Bay Pilot Area (Figure 29). This graphical representation serves as a powerful tool for visualizing the distribution of species across these three kingdoms, offering a clear and concise overview of the biodiversity present in the area. The heat tree highlights the relative abundance and diversity of species within each kingdom, allowing for a deeper understanding of the ecological composition of the region.

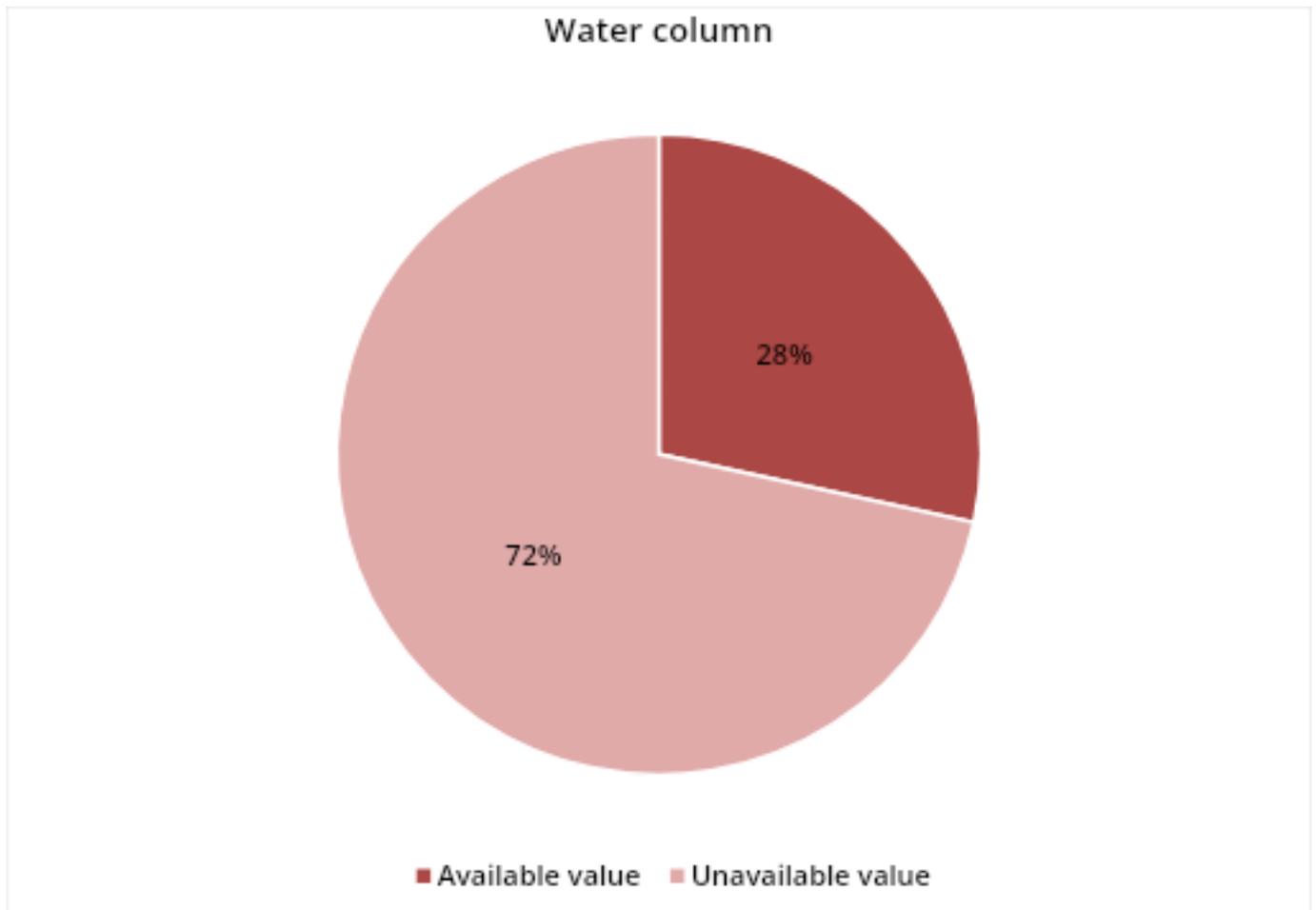


**Figure 29.** Heat tree representation of Mali Ston Bay species that belong to the Animalia, Plantae and Chromista kingdoms. The graph shows the classification until the family rank. Colour and size of the nodes are directly proportional to the number of species present in that taxon.

Regarding abiotic data, a total of 38 observations from the water column were recorded over a span of 15 years (Figure 30), providing valuable insights into the environmental conditions and



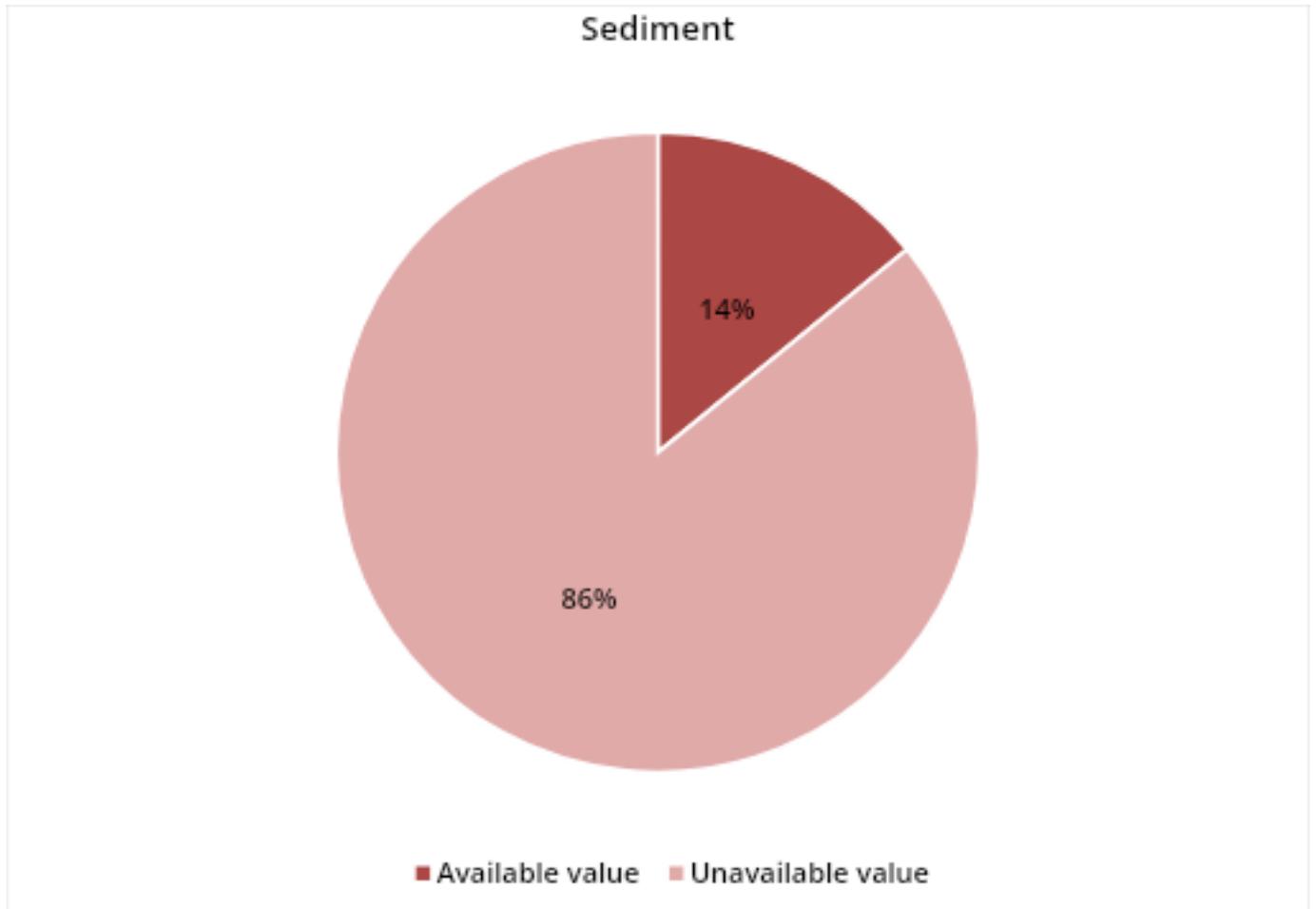
variations within this important coastal ecosystem. These long-term observations help to establish trends in factors such as temperature, salinity, and nutrient levels, which are crucial for understanding the ecological dynamics of the region.



**Figure 30.** Percentage of available values from the abiotic dataset for the water column.

In addition, 5 observations were gathered from the sediments over 6 years (Figure 31), offering essential information about the substrate composition and sediment characteristics that influence habitat quality and the distribution of benthic organisms. Together, these datasets contribute to a more comprehensive understanding of the abiotic factors shaping the Mali Ston Bay ecosystem and can inform management and conservation strategies aimed at maintaining the area's ecological health.





**Figure 31.** Percentage of available values from the abiotic dataset for the sediments.



#### 4.5. COAST OF SAN BENEDETTO DEL TRONTO - NATURAL RESERVE SENTINA

Coast of San Benedetto del Tronto - Natural Reserve Sentina Pilot Area (Figure 32) is included between the port of San Benedetto del Tronto (AP, Italy) and the coast up to the Tronto river, approximately 4 km south of the city.



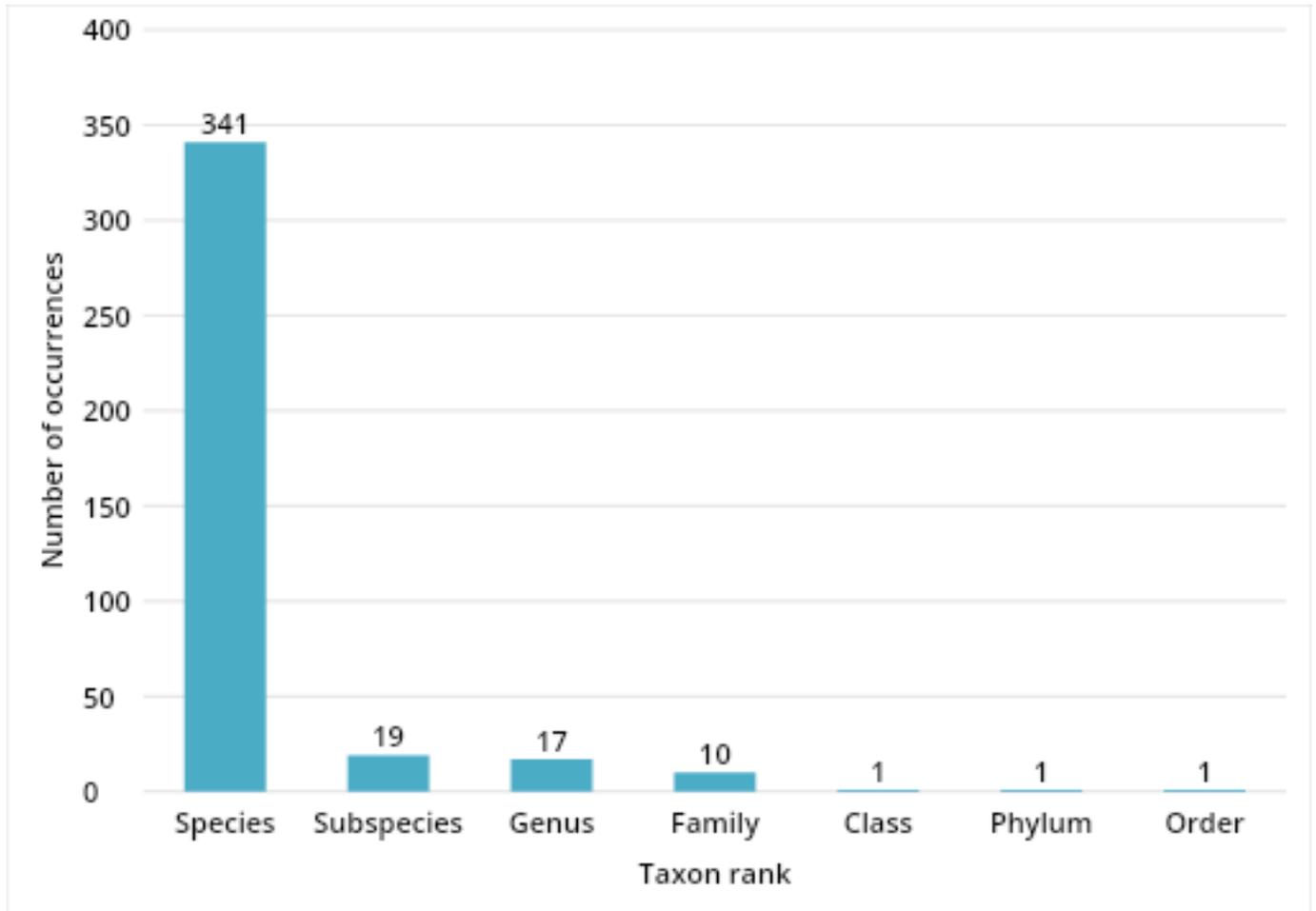
**Figure 32.** Coast of San Benedetto del Tronto - Natural Reserve Sentina.

In the Coast of San Benedetto del Tronto - Natural Reserve Sentina Pilot Area, a total of 390 occurrences were recorded, showcasing the rich diversity of species present in this protected coastal region (Figure 33). Among these occurrences, 341 have been annotated at the species level, providing a highly detailed understanding of the specific organisms that inhabit the area. This species-specific data is crucial for monitoring biodiversity and tracking changes in species composition over time. Additionally, 19 occurrences are identified at the subspecies level, offering a finer resolution of biodiversity.

The dataset also includes 17 occurrences annotated at the genus level, 10 at the family level, and 1 occurrence identified at the order level, further underscoring the complexity of the biological



community in the reserve. Notably, 1 occurrence is classified at the class level, and 1 at the phylum level, indicating that while most organisms have been identified to species, there remain some instances where classification could not reach the highest taxonomic resolution.

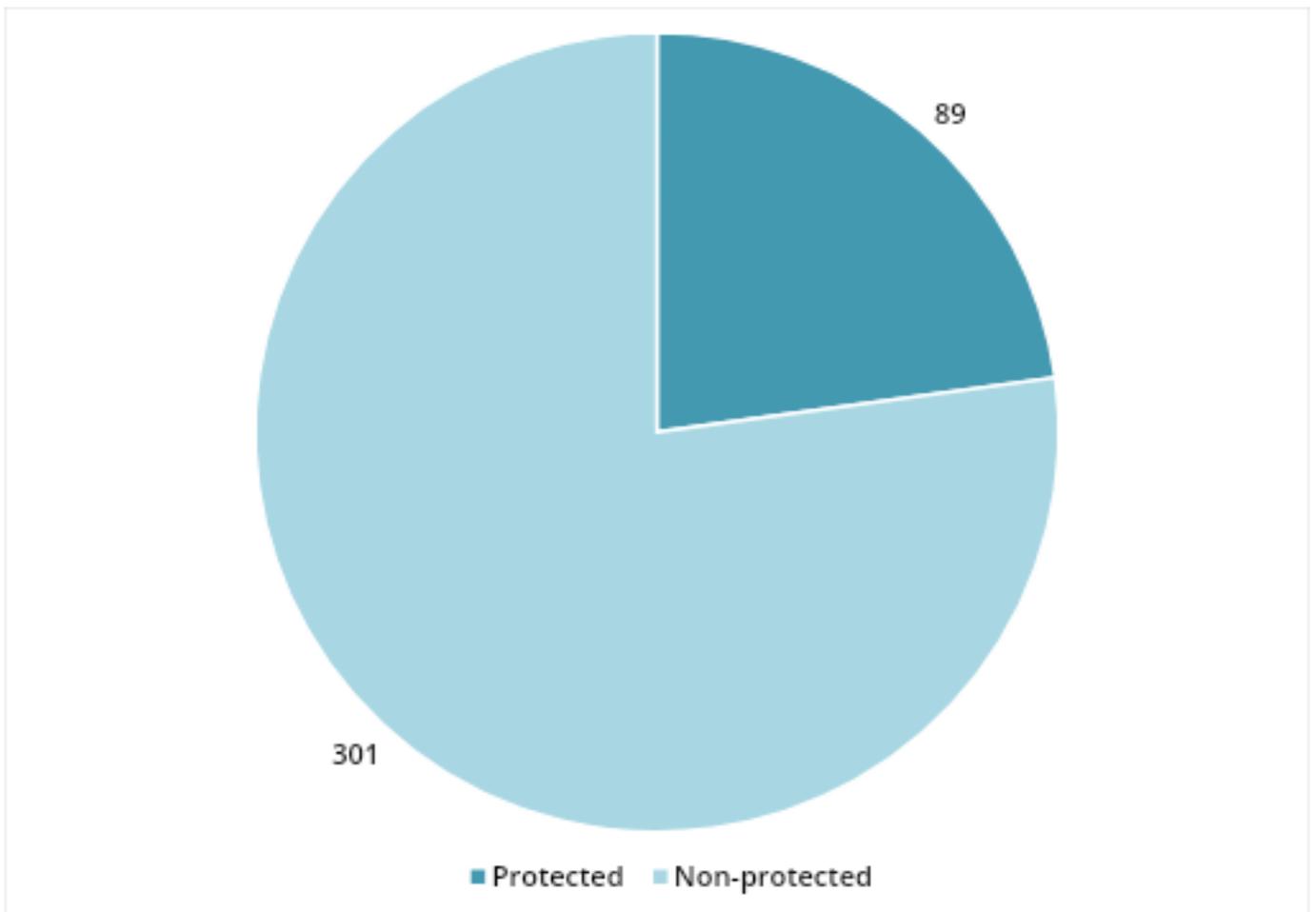


**Figure 33.** Number of occurrences per taxon rank for the Coast of San Benedetto del Tronto - Natural Reserve Sentina Pilot Area.

Regarding the protection level, a total of 89 occurrences within the Coast of San Benedetto del Tronto - Natural Reserve Sentina Pilot Area are represented by species that are protected under various national and international conservation frameworks (Figure 34). These protected species span a wide range of taxa, highlighting the ecological significance of the area and its role in safeguarding biodiversity. Among the protected species, birds are notably represented, including *Acrocephalus melanopogon*, *Acrocephalus scirpaceus*, *Alcedo atthis*, *Ardea cinerea*, *Ardeola ralloides*, and *Ciconia ciconia*.



In addition to birds, several fish species are also protected within the area, such as *Anguilla anguilla*, *Alosa fallax*, and *Sardina pilchardus*. These species are integral to the marine food web and are particularly sensitive to changes in water quality and habitat degradation. The reserve also provides refuge to other aquatic organisms, including *Caretta caretta* (loggerhead sea turtle) and *Hippocampus hippocampus* (seahorse), both of which face significant threats from human activities like overfishing and extensive coastal development.

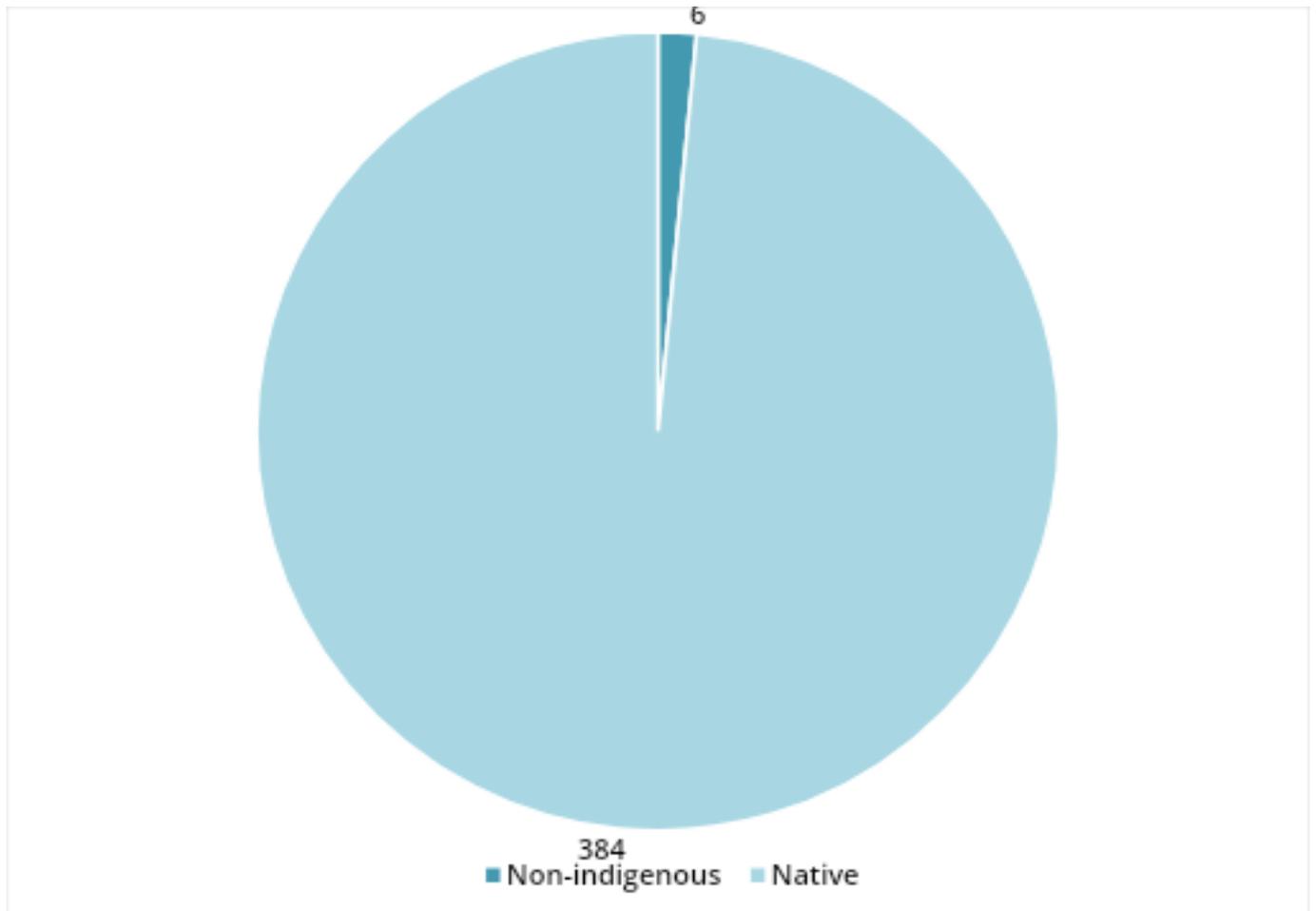


**Figure 34.** Number of occurrences according to the protection level for the Coast of San Benedetto del Tronto - Natural Reserve Sentina Pilot Area.

A total of 6 occurrences within the Coast of San Benedetto del Tronto - Natural Reserve Sentina Pilot Area are attributed to non-indigenous species, as shown in Figure 35. These species, introduced to the region either intentionally or accidentally, have established themselves within the local ecosystem, contributing to shifts in ecological dynamics.



The non-indigenous species recorded include *Anadara inaequalvis* (a bivalve species), *Atriplex portulacoides* (an invasive plant), *Callinectes sapidus*, and *Chelidonichthys lucerna*.



**Figure 35.** Number of occurrences according to the establishment means for the Coast of San Benedetto del Tronto - Natural Reserve Sentina Pilot Area.

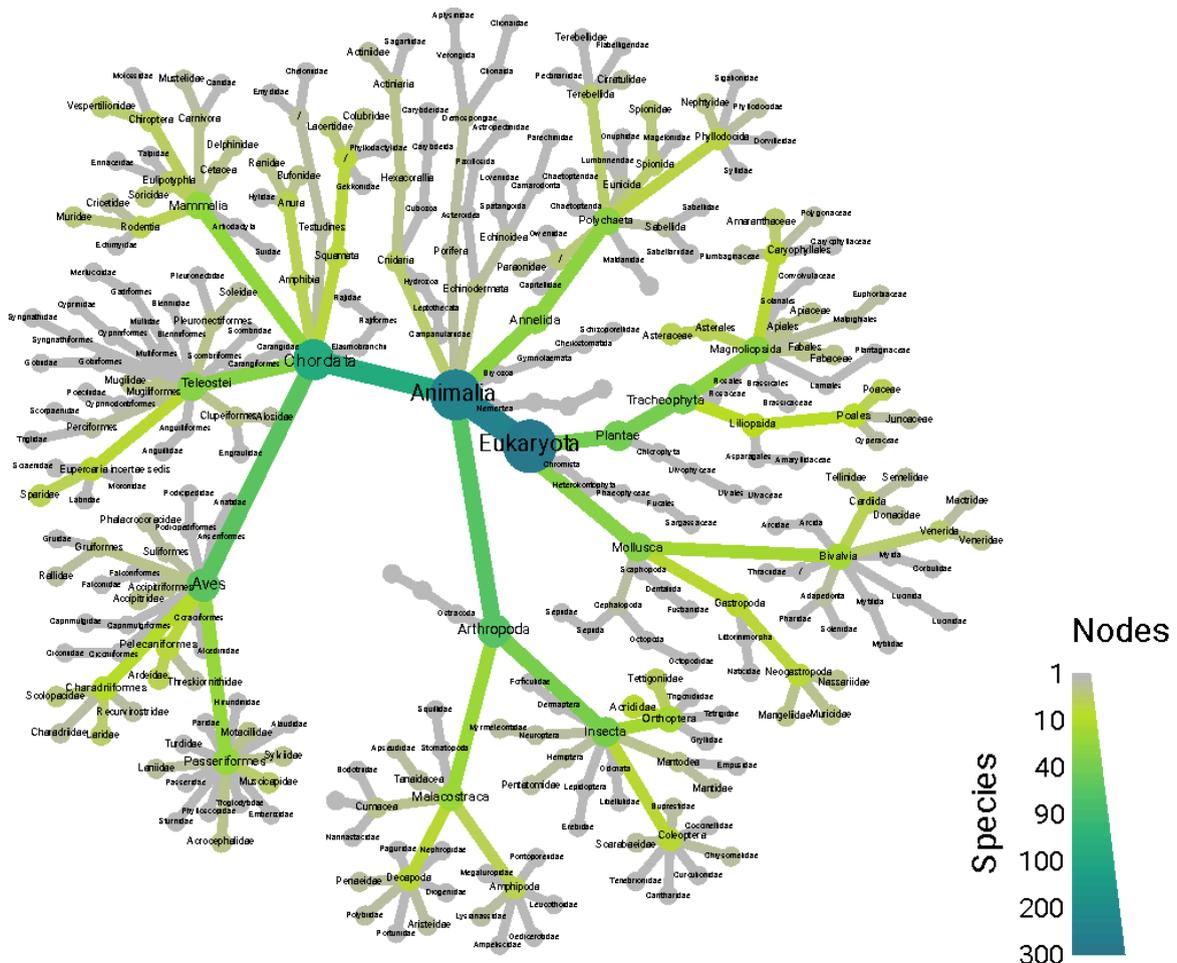
The occurrences recorded in the Coast of San Benedetto del Tronto - Natural Reserve Sentina Pilot Area are categorized into three distinct biological kingdoms, as outlined in the taxonomic scheme presented in Table 6. This classification underscores the diverse range of organisms that inhabit the Pilot Area.



**Table 6.** Kingdoms scheme for the Aquatina di Frigole and Ionian Sea mariculture Pilot Area.

Kingdom	Number of occurrences
Animalia	271
Plantae	44
Chromista	1

A taxonomic heat tree was generated to visually represent the species that belong to the kingdoms Animalia, Plantae, and Chromista within the Coast of San Benedetto del Tronto - Natural Reserve Sentina Pilot Area, as shown in Figure 36. This graphical representation provides an insightful overview of the distribution of species across these three major biological kingdoms. The heat tree allows for a detailed comparison of the relative abundance and diversity of species within each kingdom, highlighting areas of ecological significance.

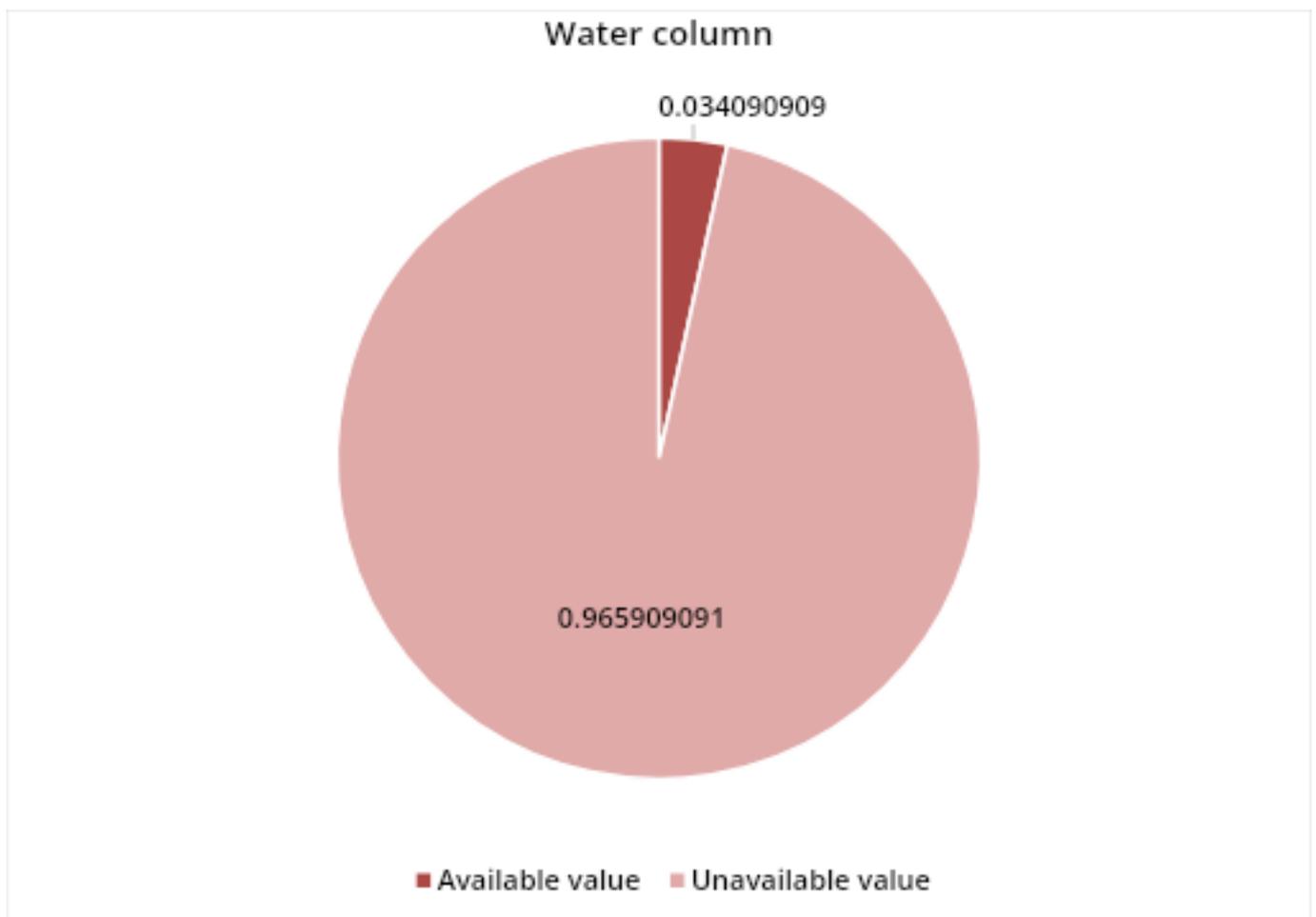


**Figure 36.** Heat tree representation of Coast of San Benedetto del Tronto - Natural Reserve Sentina species that belong to the Animalia, Plantae and Chromista kingdoms. The graph shows the



classification until the family rank. Colour and size of the nodes are directly proportional to the number of species present in that taxon.

Regarding abiotic data, a total of 3 observations from the water column were recorded over the span of 1 year, as illustrated in Figure 37. These observations provide valuable insights into the physical and chemical characteristics of the water, such as temperature, salinity, and nutrient levels, which are crucial for understanding the environmental conditions that influence the local ecosystem.



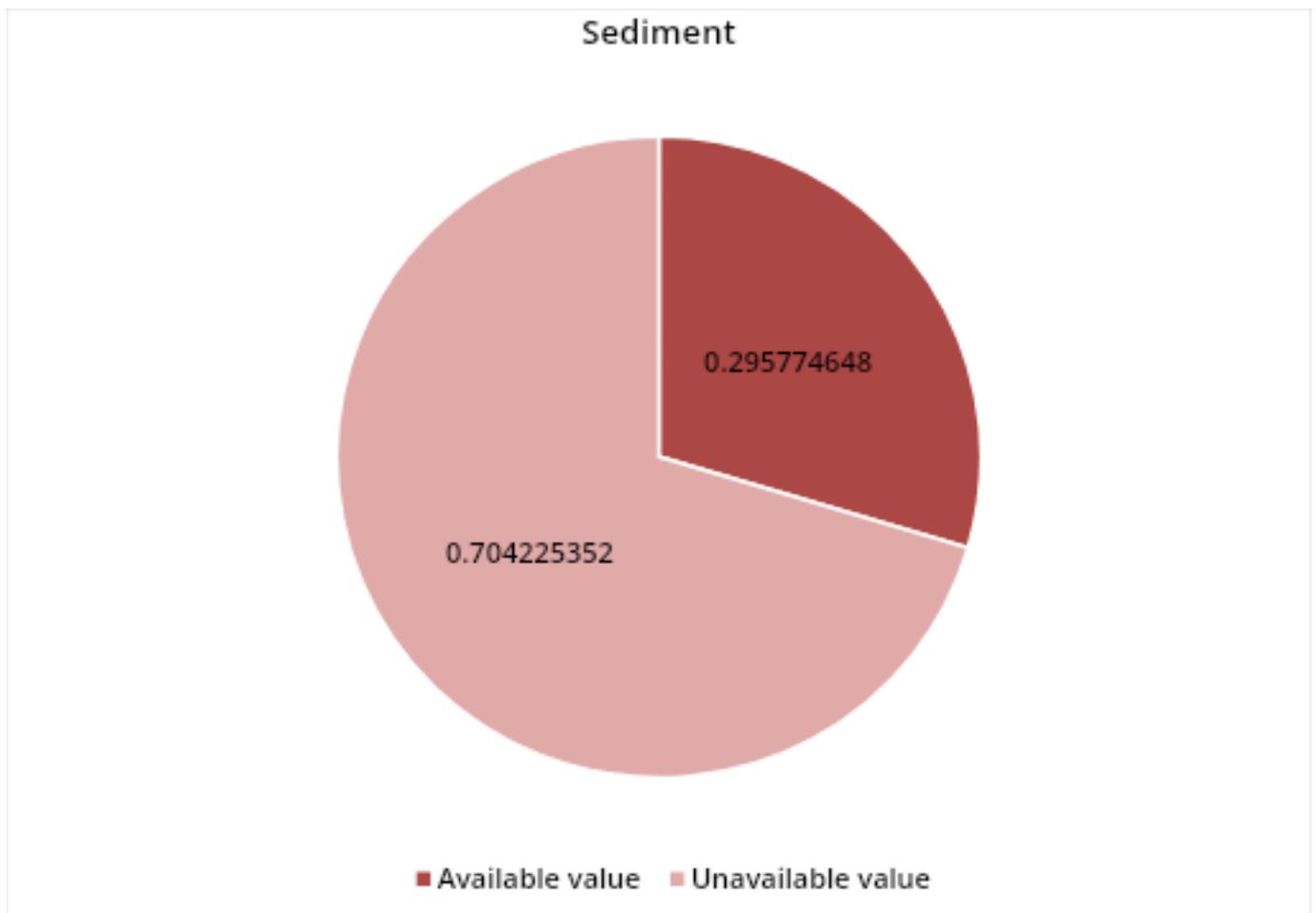
**Figure 37.** Percentage of available values from the abiotic dataset for the water column.

Additionally, 3 observations from the sediments were recorded across a period of 2 years, as shown in Figure 38. Sediment analysis is vital for assessing the substrate quality and monitoring



pollutants or changes in sediment composition that may affect the benthic organisms and overall ecosystem health.

The availability of such data is essential for developing a comprehensive understanding of the abiotic factors that shape the reserve's ecological dynamics and inform conservation measures aimed at maintaining the balance between biotic and abiotic components of the ecosystem.



**Figure 38.** Percentage of available values from the abiotic dataset for the sediments.



4.6. VENICE LAGOON

The Venice Lagoon Pilot Area (Figure 39) encompasses the Lagoon of Venice, located in the northern part of the Adriatic Sea, and is recognized as the largest transitional environment within the Mediterranean Sea. This vast and ecologically significant lagoon serves as a critical interface between the terrestrial and marine ecosystems, where freshwater from rivers meets the salty waters of the Adriatic, creating a unique and dynamic habitat.

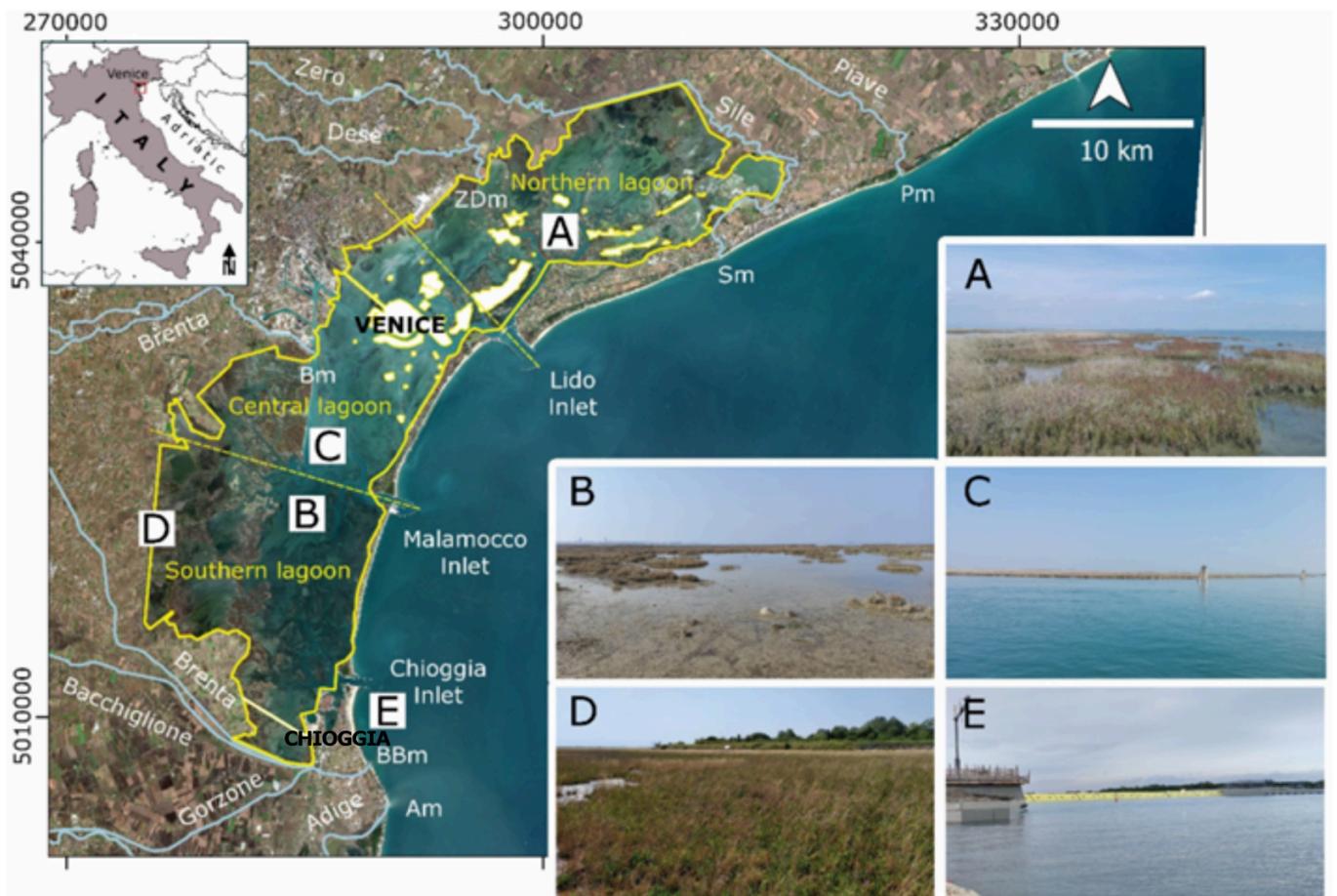


Figure 39. Venice Lagoon.

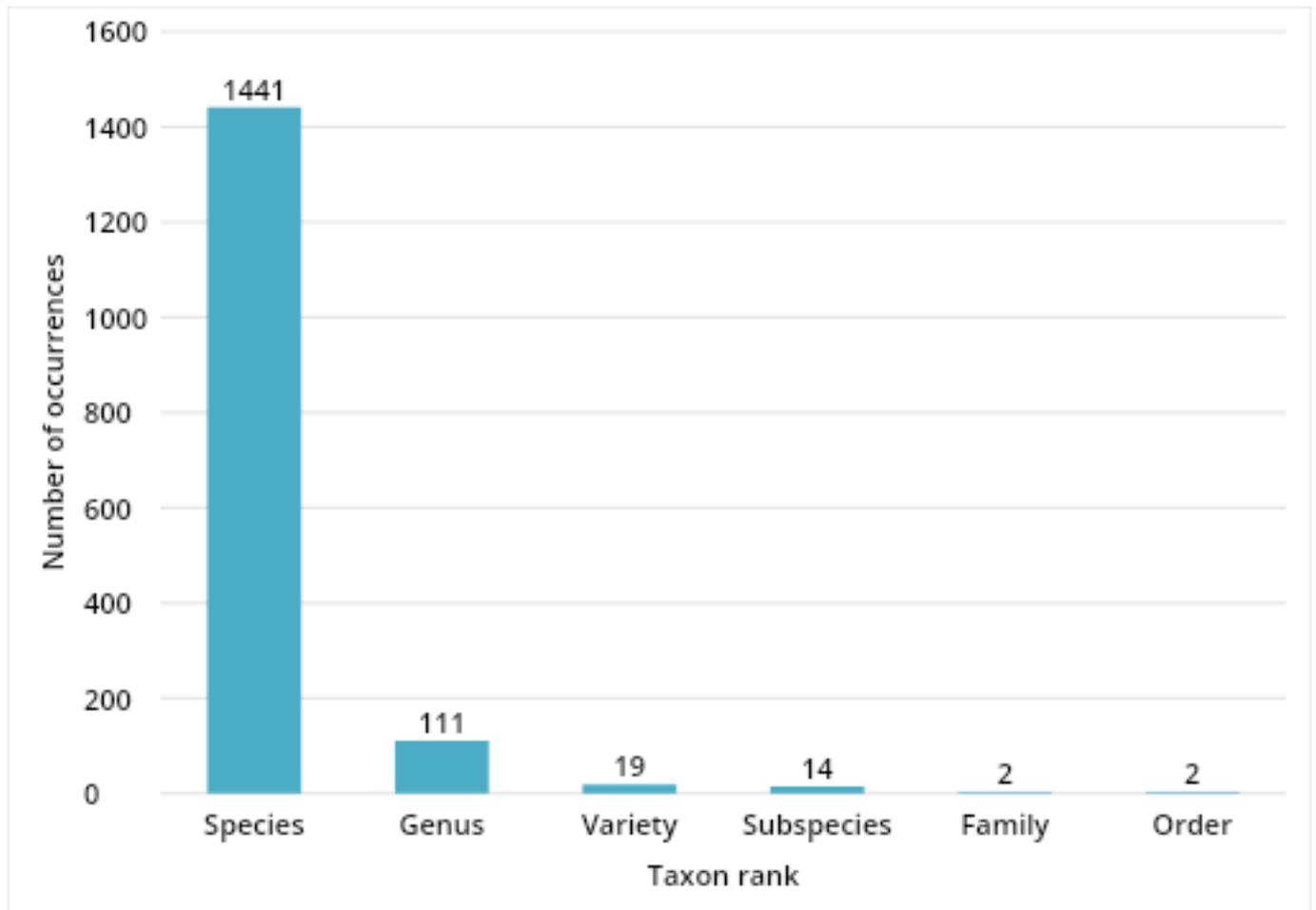
In the Venice Lagoon Pilot Area, a total of 1,589 occurrences were recorded, as shown in Figure 40. Among these, 1,441 occurrences are annotated up to the species level, reflecting the detailed taxonomic identification of the majority of the recorded organisms. Additionally, 111 occurrences are identified up to the genus level, providing a broader but still informative classification. A further 19 occurrences are recorded up to the variety level, 14 up to the subspecies level, and 2 up to the family level, which offers an even higher level of taxonomic grouping. Lastly, 2 occurrences are classified up to the order level, indicating that these are more distantly related organisms within



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their broader taxonomic categories. This comprehensive set of annotations demonstrates the richness and complexity of the biodiversity within the Venice Lagoon, offering a detailed overview of the species and taxa that populate this vital transitional environment.



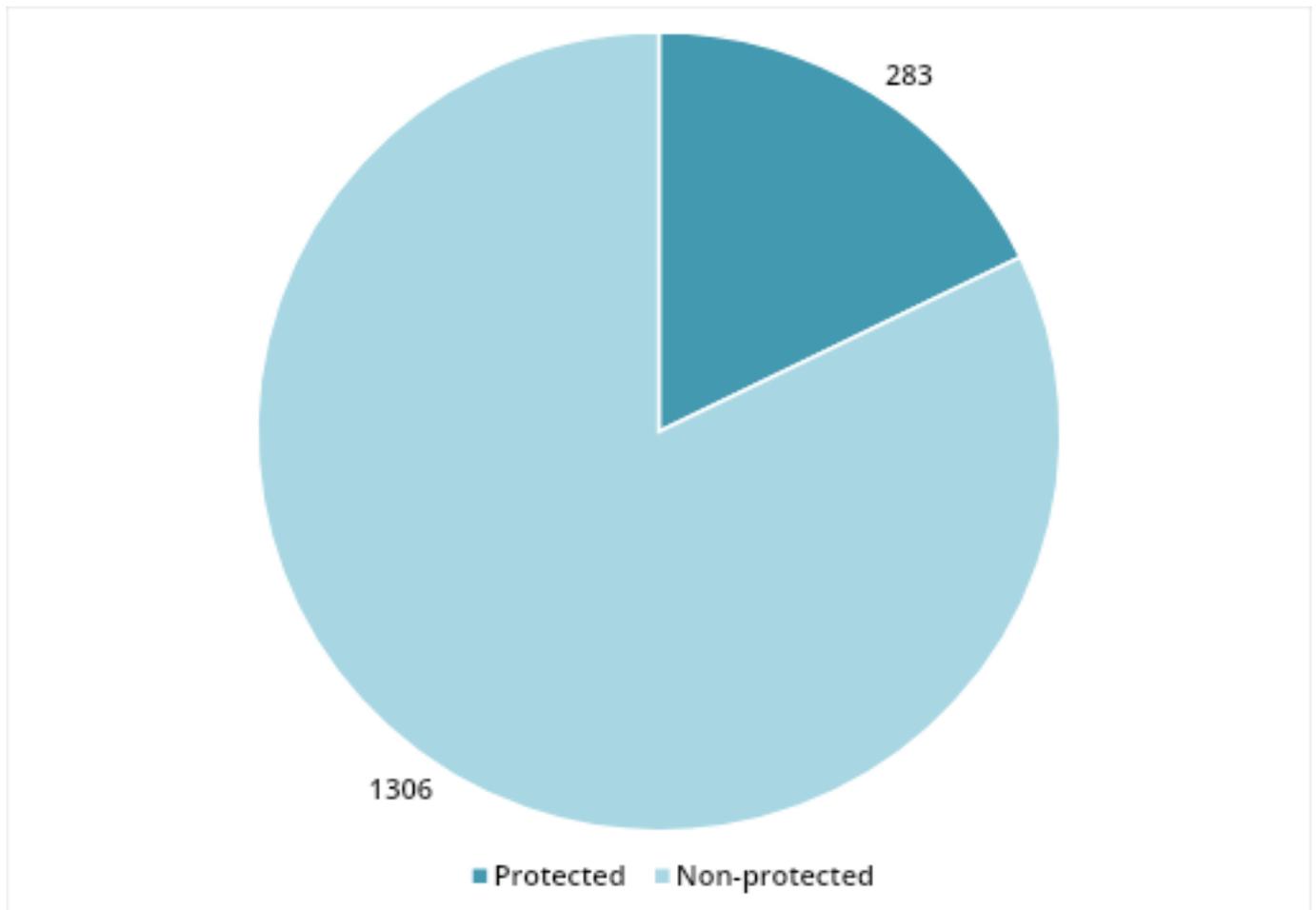
**Figure 40.** Number of occurrences per taxon rank for the Venice Lagoon Pilot Area.

In the Venice Lagoon Pilot Area, a total of 283 occurrences are represented by protected species, as shown in Figure 41. These occurrences include a wide array of organisms across various taxonomic groups. The species that are protected by legislation or conservation agreements are diverse, encompassing birds, fish, molluscs, plants, and marine invertebrates.

Examples of protected bird species include *Acanthis flammea*, *Accipiter gentilis*, *Anas acuta*, *Ardea purpurea*, and *Ciconia ciconia*. Among the fish species, the *Anguilla anguilla* (European eel) is notable for its critically endangered status, and marine plants such as *Cymodocea nodosa* and *Zostera marina* are also included in the list of protected species, reflecting their importance for maintaining the ecological integrity of the lagoon environment.



The variety of protected species highlights the ecological significance of the Venice Lagoon, as it serves as a crucial habitat for numerous species that require conservation efforts.



**Figure 41.** Number of occurrences according to the protection level for the Venice Lagoon Pilot Area.

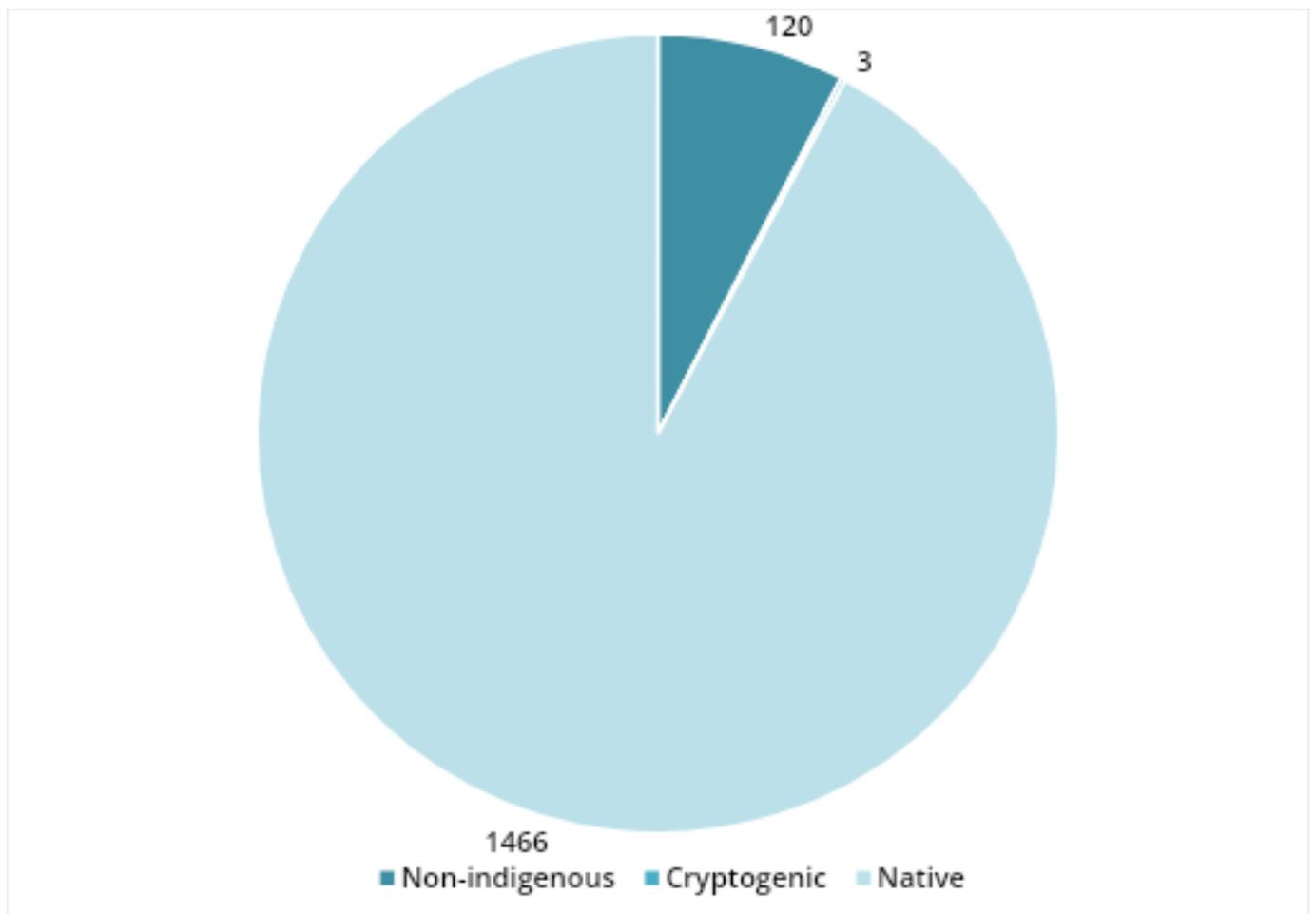
At the same time, in the Venice Lagoon Pilot Area, 120 occurrences are attributed to non-indigenous species, and 3 occurrences are linked to cryptogenic species, as shown in Figure 42.

The list of non-indigenous species recorded in the Venice Lagoon is extensive and includes a variety of organisms across different taxonomic groups. Examples include marine algae like *Desmarestia viridis* and *Grateloupia turuturu*, which are known to form dense mats that can smother native seagrasses and alter the composition of local marine communities. *Undaria pinnatifida*, a species of kelp, is another notable non-indigenous species that has spread in many coastal areas, potentially displacing native marine plants.



In the invertebrate realm, species such as *Botrylloides leachii*, *Styela clava*, and *Didemnum vexillum* are present, which can rapidly colonize hard substrates and pose a threat to native filter-feeding organisms by fouling structures and disturbing ecosystem dynamics. Similarly, *Callinectes sapidus* (the blue crab), native to the western Atlantic, is a predator that can negatively affect local benthic communities and commercial fisheries.

Other notable non-indigenous species in the Venice Lagoon include various mollusks such as *Ruditapes philippinarum*, *Anadara inaequalis*, and *Rapana venosa*, which have been introduced through the ballast water of ships or as byproducts of aquaculture activities. *Sargassum muticum*, a brown alga, is another non-indigenous species that has been observed in the lagoon, affecting local habitats by forming dense floating mats that can change water circulation and nutrient dynamics.



**Figure 42.** Number of occurrences according to the establishment means for the Venice Lagoon Pilot Area.



The occurrences in the Venice Lagoon Pilot Area are classified into five distinct kingdoms, as outlined in the scheme presented in Table 7.

These kingdoms represent broad categories of life forms, each containing species with diverse ecological roles and biological characteristics. The classification of species into these kingdoms helps to organize and better understand the biodiversity present in the region.

**Table 7.** Kingdoms scheme for the Venice Lagoon Pilot Area.

Kingdom	Number of occurrences
Animalia	974
Plantae	316
Chromista	273
Protozoa	2
Chlorophyta	1

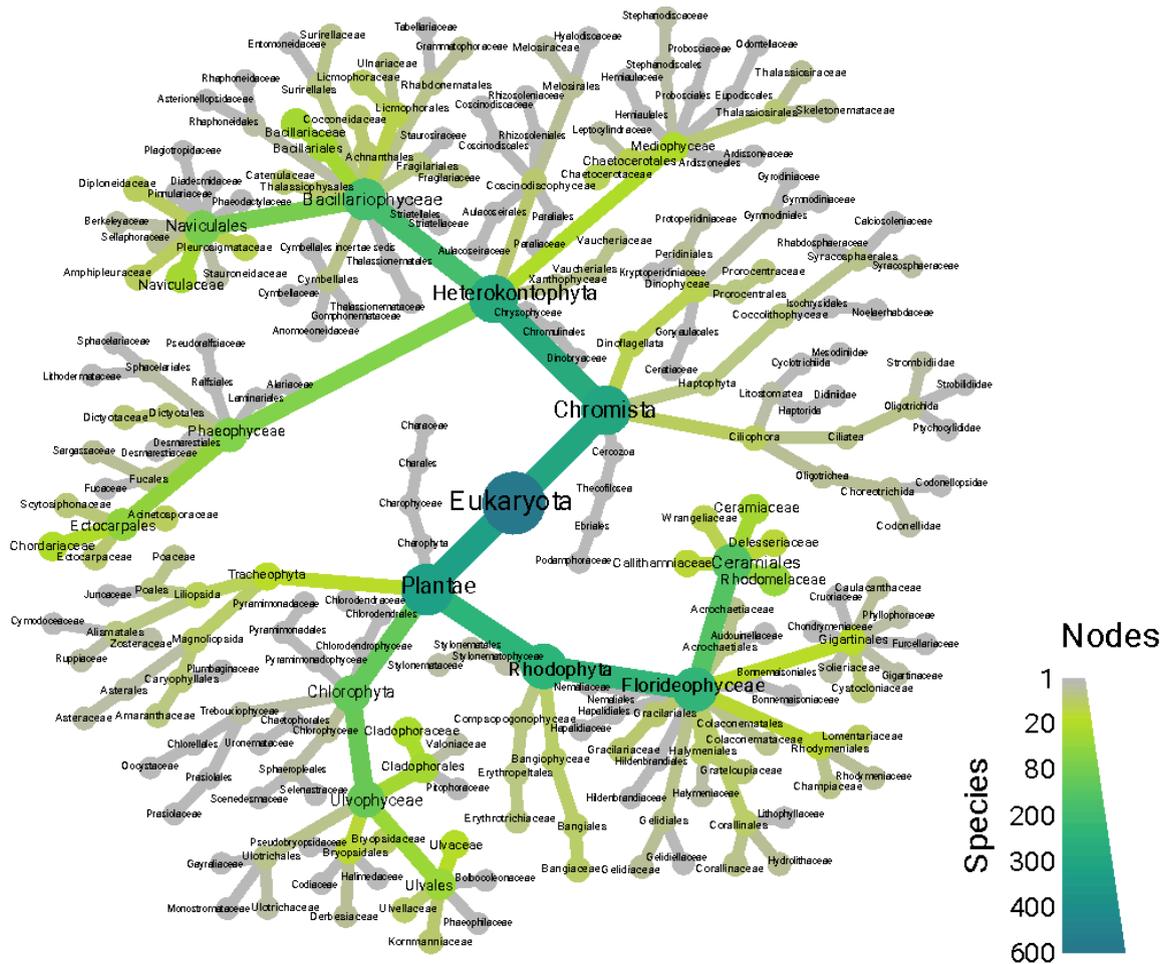
For each kingdom, taxonomic heat trees were generated to graphically represent the species that belong to the different kingdoms.

These heat trees visually display the distribution of species across various taxonomic levels, providing a clear overview of the biodiversity within each kingdom.

The figures (Figure 43, Figure 44, Figure 45, and Figure 46) show the hierarchical organization of species within the Animalia, Plantae, Chromista, and Protista kingdoms, illustrating the richness and complexity of life forms in the Venice Lagoon Pilot Area.

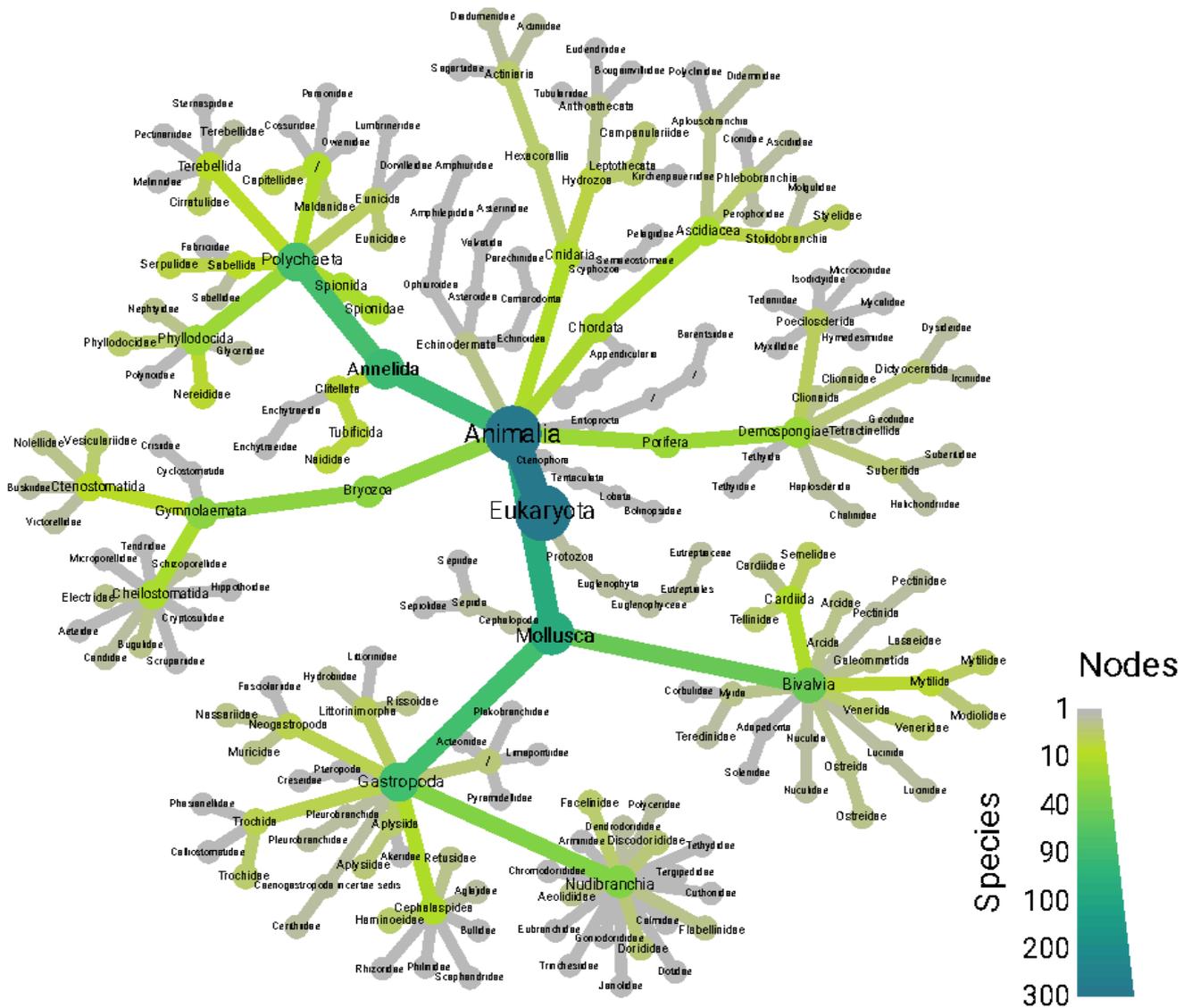
These visual representations serve as a valuable tool for understanding the diversity of organisms in this transitional environment and offer insights into the relative abundance of species within each taxonomic group.





**Figure 43.** Heat tree representation of Venice Lagoon species that belong to the Plantae and Chromista kingdoms. The graph shows the classification until the family rank. Colour and size of the nodes are directly proportional to the number of species present in that taxon.

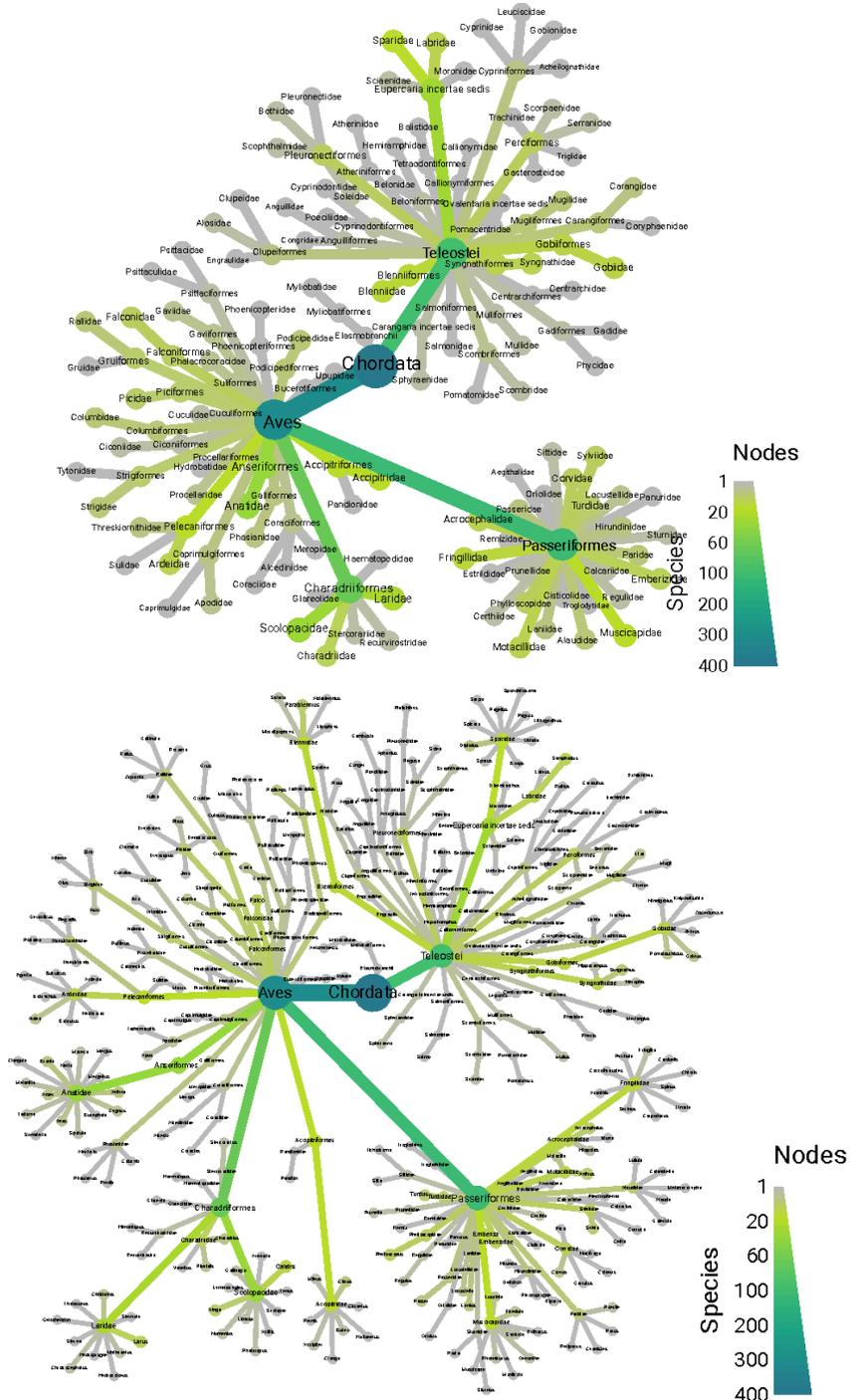




**Figure 44.** Heat tree representation of Venice Lagoon species that belong to the Animalia and Protozoa kingdoms. The graph shows the classification until the family rank. Color and size of the nodes are directly proportional to the number of species present in that taxon.





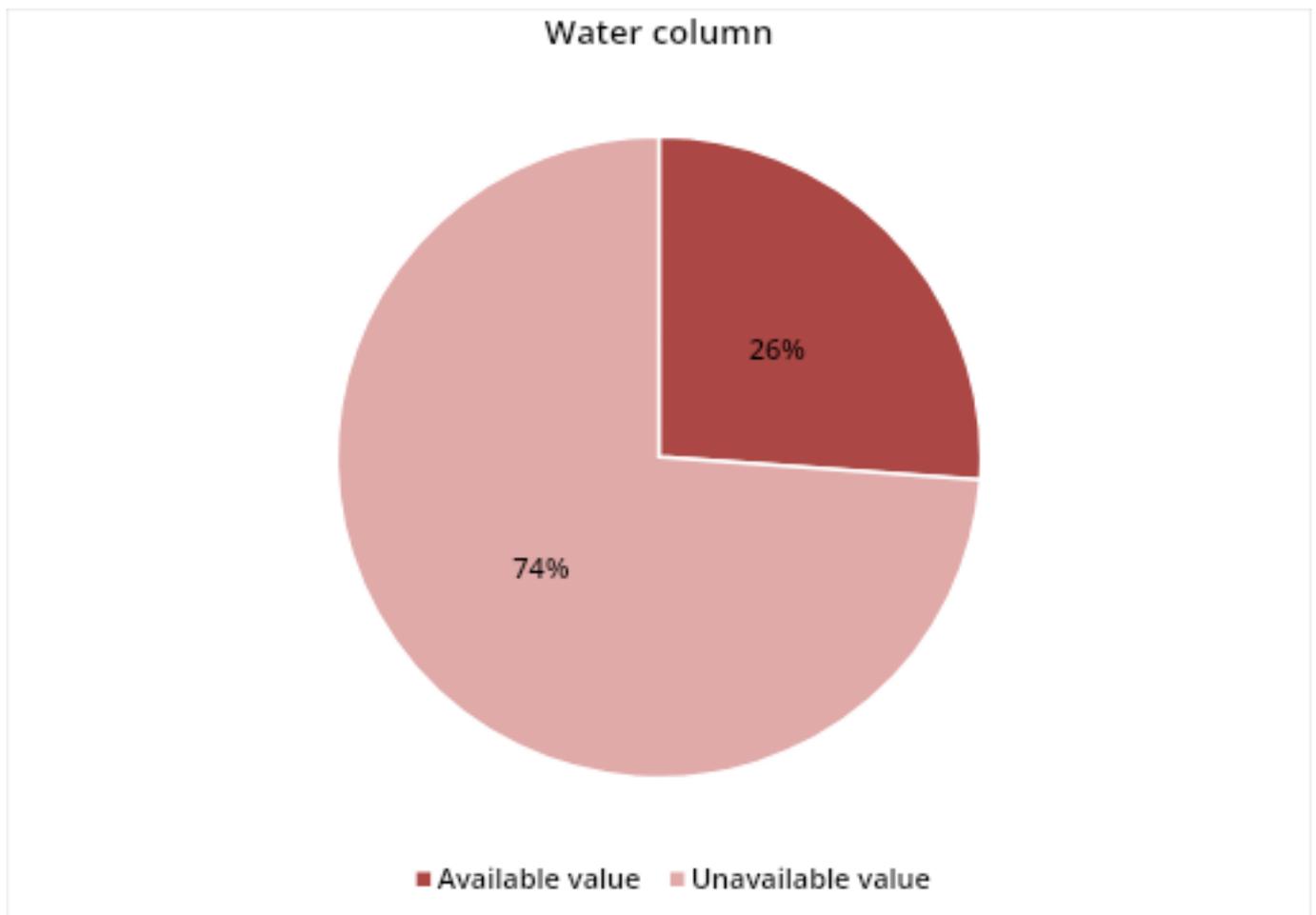


**Figure 46.** Heat tree representation of Venice Lagoon species that belong to the phylum Chordata. The graph shows the classification until the family (above) and genus (below) rank. Colour and size of the nodes are directly proportional to the number of species present in that taxon.



Concerning the abiotic data, a substantial set of 51 observations has been recorded over a span of 8 years from the water column, as depicted in Figure 47. These observations encompass various physical and chemical parameters, which are fundamental in understanding the water quality and overall environmental conditions of the Venice Lagoon Pilot Area. The data gathered from the water column provides insights into factors such as temperature, salinity, dissolved oxygen levels, and nutrient concentrations, all of which play a critical role in shaping the aquatic ecosystem.

By analysing these parameters over multiple years, it is possible to detect long-term trends, seasonal variations, and any potential disturbances or changes in the lagoon's ecosystem. This information is crucial for monitoring the health of the water body and can serve as a baseline for future studies and conservation efforts.



**Figure 47.** Percentage of available values from the abiotic dataset for the water column.

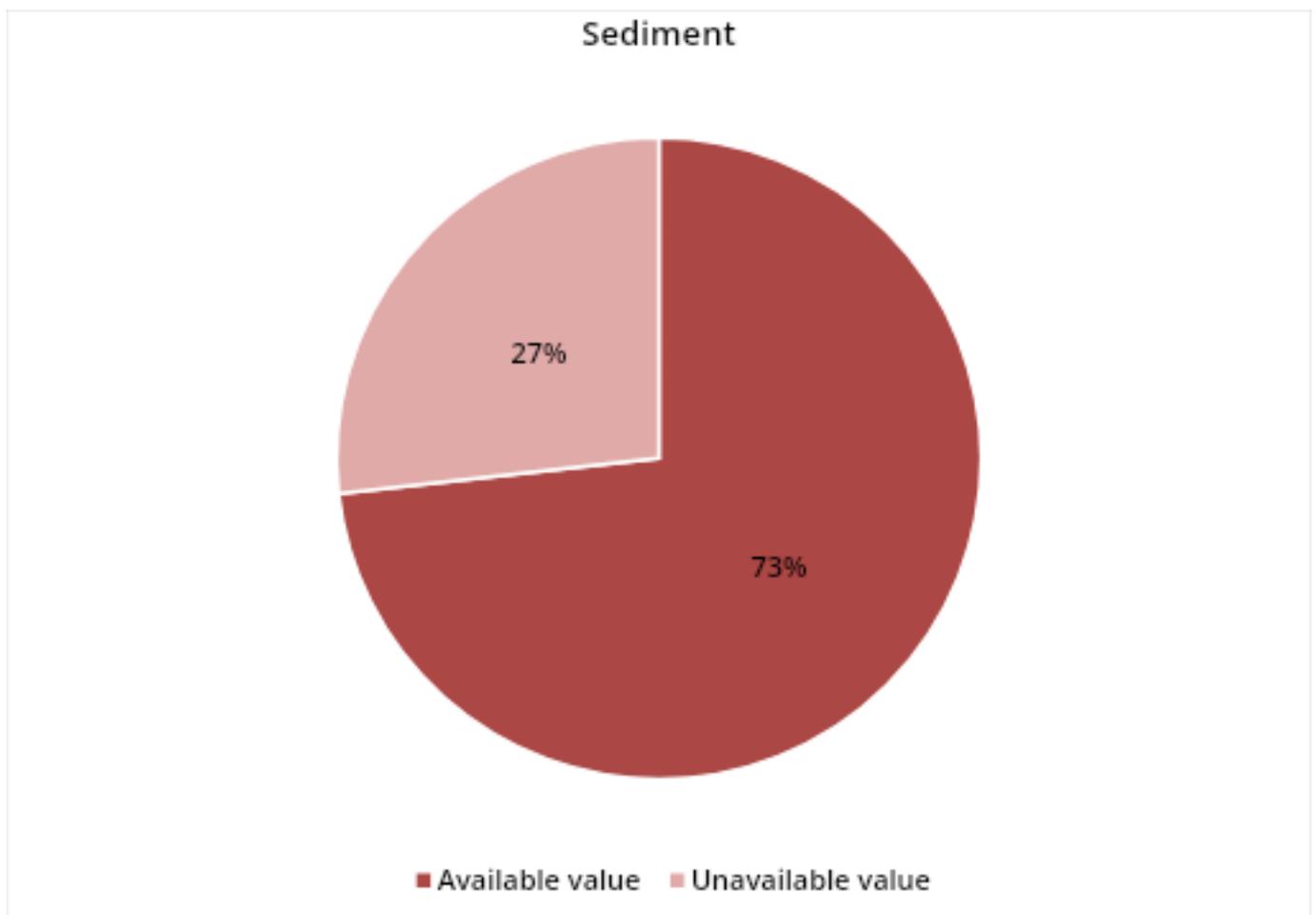


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Additionally, 12 observations have been made over a period of 2 years, focusing on the sediments within the Venice Lagoon (Figure 48). Sediment data is invaluable for understanding the substrate composition and its role in sustaining benthic organisms.

The quality of the sediment, including parameters such as organic matter content, grain size distribution, and contaminant levels, can greatly influence the biological community that resides in the lagoon. Sediment observations provide essential information for assessing habitat conditions for species that depend on the substrate for feeding, breeding, or sheltering.



**Figure 48.** Percentage of available values from the abiotic dataset for the sediments.



## 5. RESULTS FROM BLUE DIVERSITY DATABASE

The **BlueDiversity** Deliverable 1.1.1 “BlueDiversity Database” represents a concerted effort to document, analyse, and preserve the biodiversity and ecological integrity of coastal and marine environments along the Adriatic Sea. The database focuses on distinct Pilot Areas spanning Italy and Croatia. This database is a crucial resource, containing data that spans both the biological diversity of the region and the abiotic environmental conditions that influence these ecosystems. It aims not only to document current conditions but also to create a “living database” that can evolve and grow as new data becomes available. Through this ongoing effort, the database will serve as a long-term monitoring tool that supports informed decision-making for sustainable ecosystem management and conservation.

### 5.1. BIODIVERSITY DATASET

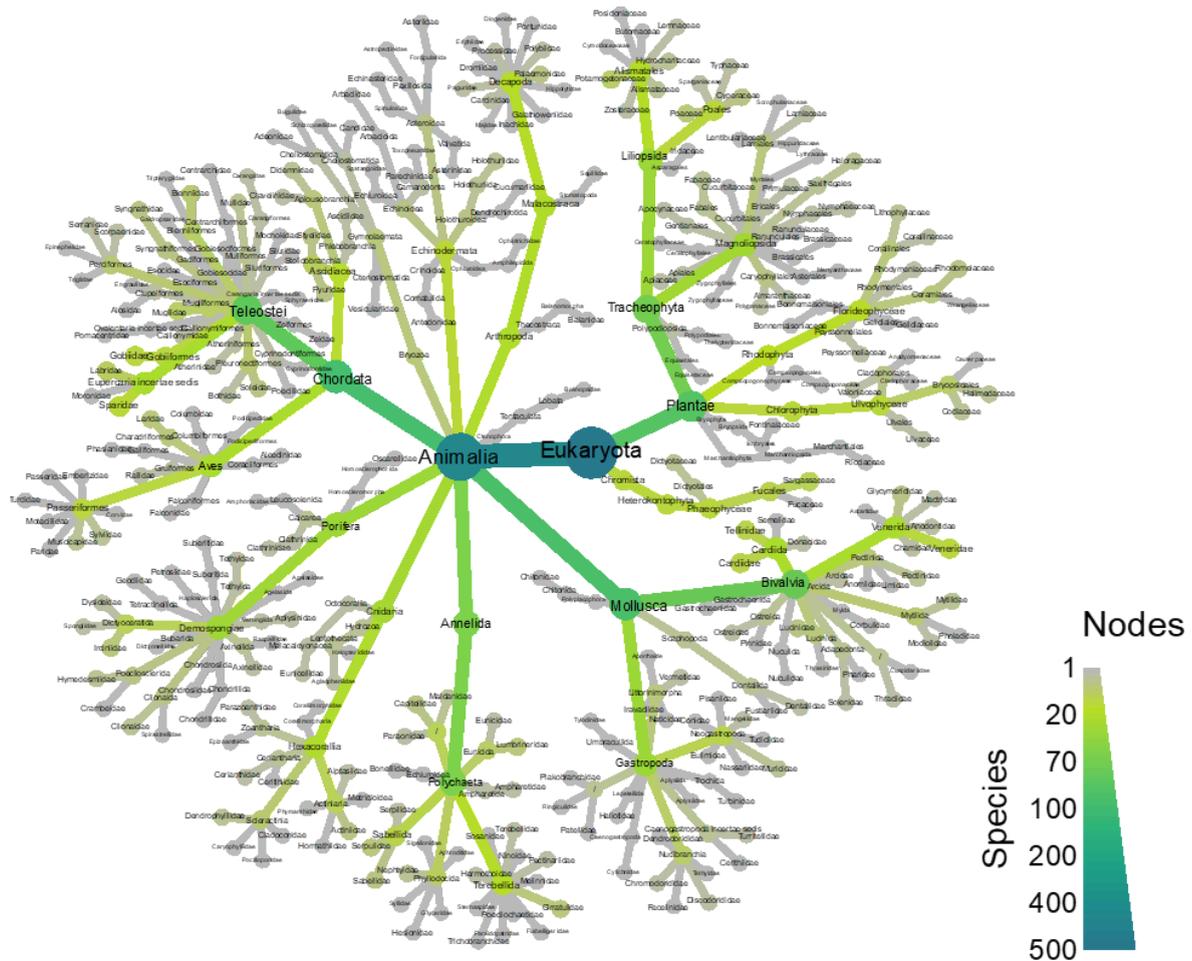
At the heart of the **BlueDiversity** Database is its biodiversity dataset, which provides an in-depth record of the species that inhabit the Adriatic’s coastal and marine environments. This dataset contains a total of 3,623 occurrence observations, representing a diverse array of species from across the five kingdoms of life—including Bacteria, Archaea, Protista, Fungi, Plantae, and Animalia (Figure 49, Figure 50, Figure 51).

The observations include species records derived from a variety of sources, such as field sampling, scientific literature, and grey literature, ensuring that the dataset reflects a broad range of ecological knowledge.

The total number of species documented in the database is **2,170 unique species**, spanning a wide variety of taxa. This number represents a significant portion of the biodiversity found in the selected Pilot Areas, providing a valuable snapshot of the ecological richness of the Adriatic region.

The species included in this dataset represent a diverse range of organisms, from microscopic plankton to larger, more conspicuous marine species. This diversity is essential for understanding ecosystem processes, as species interactions are fundamental to the structure and function of coastal and marine ecosystems.

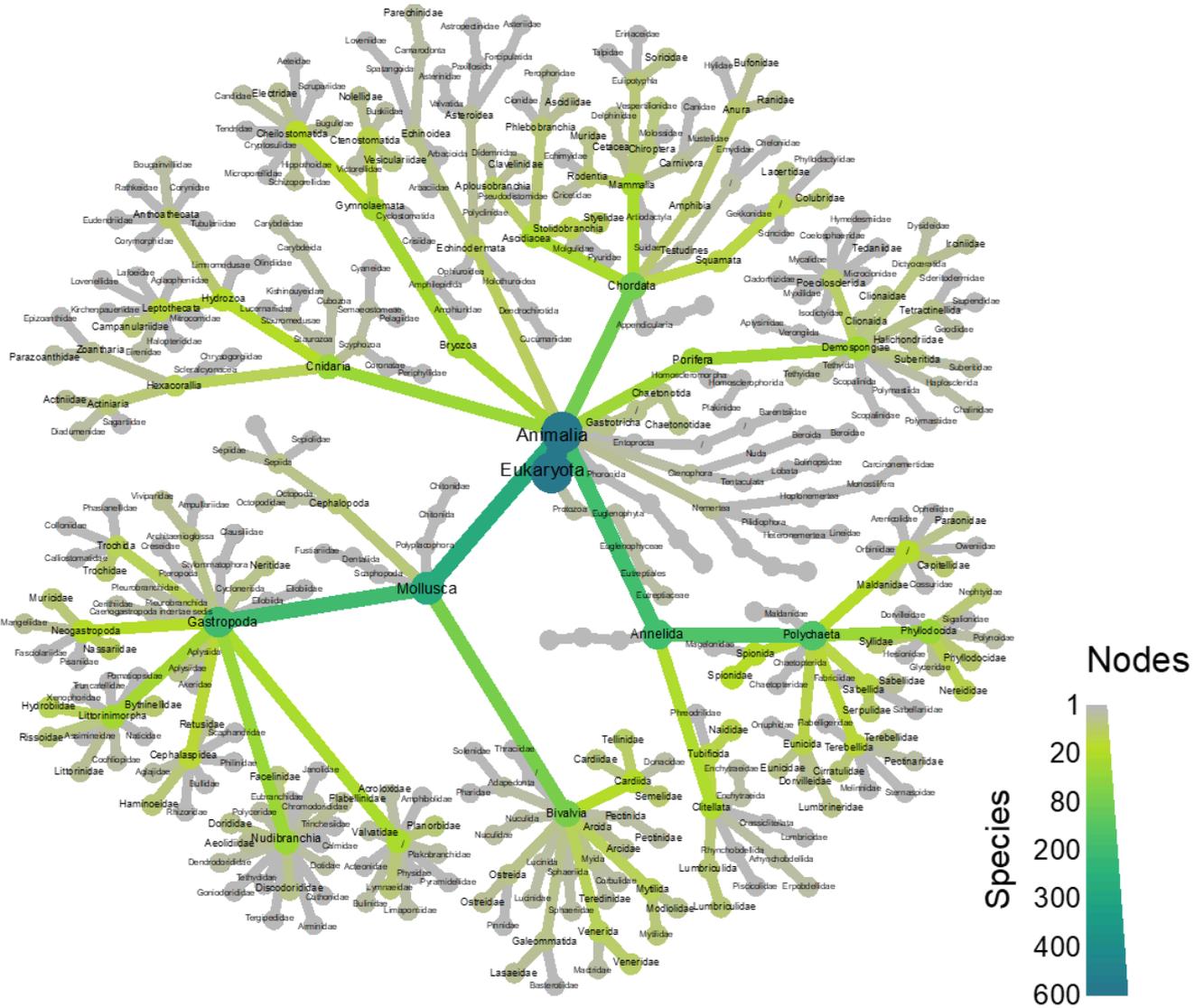




**Figure 49.** Heat tree representation of the Eastern Adriatic (Croatia – PP2, PP4, PP5) species. The graph shows the classification until the family rank. Colour and size of the nodes are directly proportional to the number of species present in that taxon.





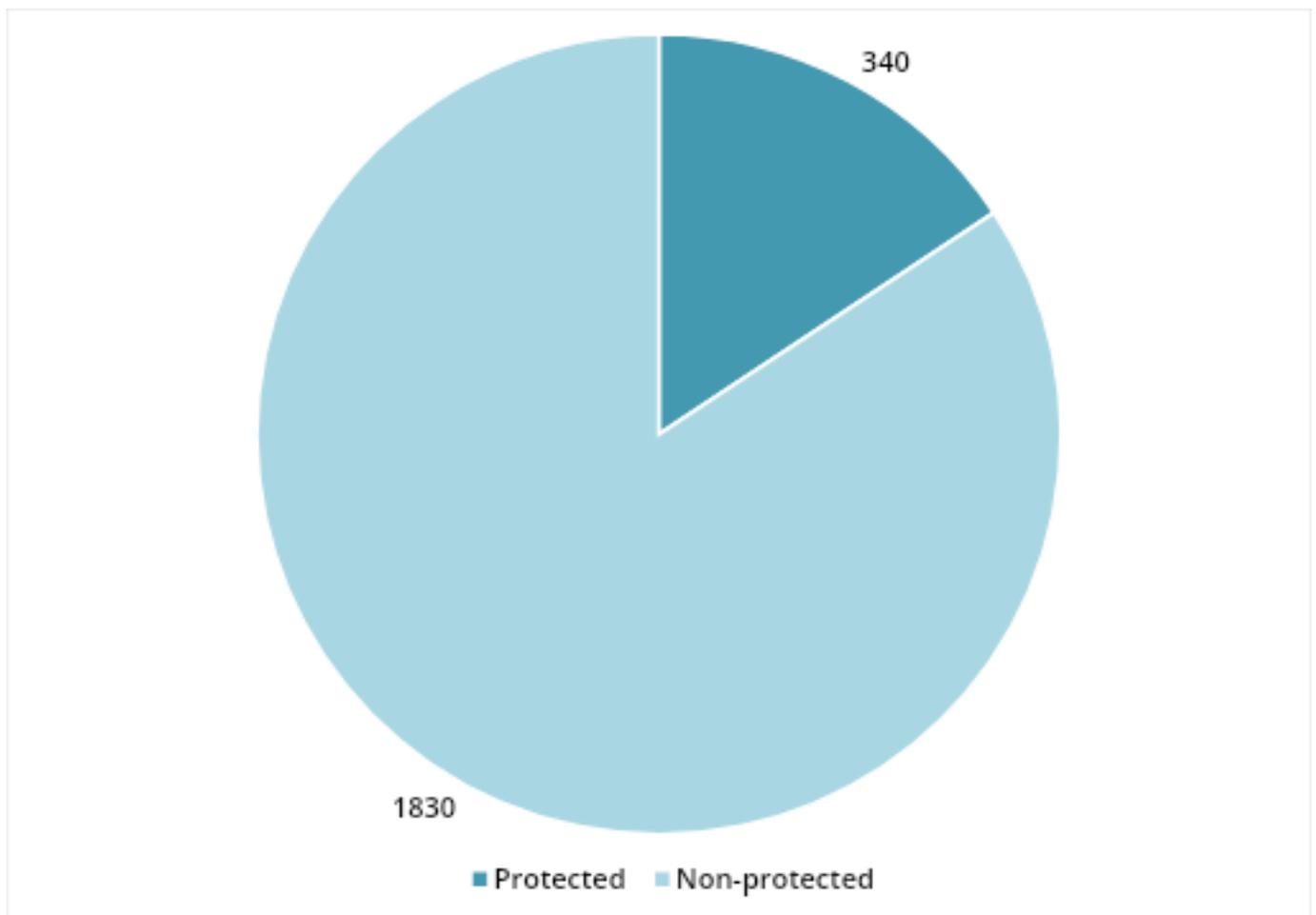


**Figure 51.** Heat tree representation of the Western Adriatic (Italy – LP1, PP6, PP7) species belonging to the Animalia and Protozoa kingdoms. The graph shows the classification until the family rank. Colour and size of the nodes are directly proportional to the number of species present in that taxon.



The biodiversity dataset also includes important information on species conservation status, with particular focus on those species that are protected by international, national, or regional legislation. The dataset identifies a total of 340 protected species (Figure 52), which are considered to be of special conservation concern.

These species are vital components of the Adriatic ecosystems, and their preservation is critical for maintaining ecological balance. Protected species often have specific habitat requirements and are vulnerable to threats such as habitat degradation, pollution, and climate change. By identifying and monitoring these species, the BlueDiversity project can prioritize conservation actions and develop targeted strategies to ensure their long-term survival.



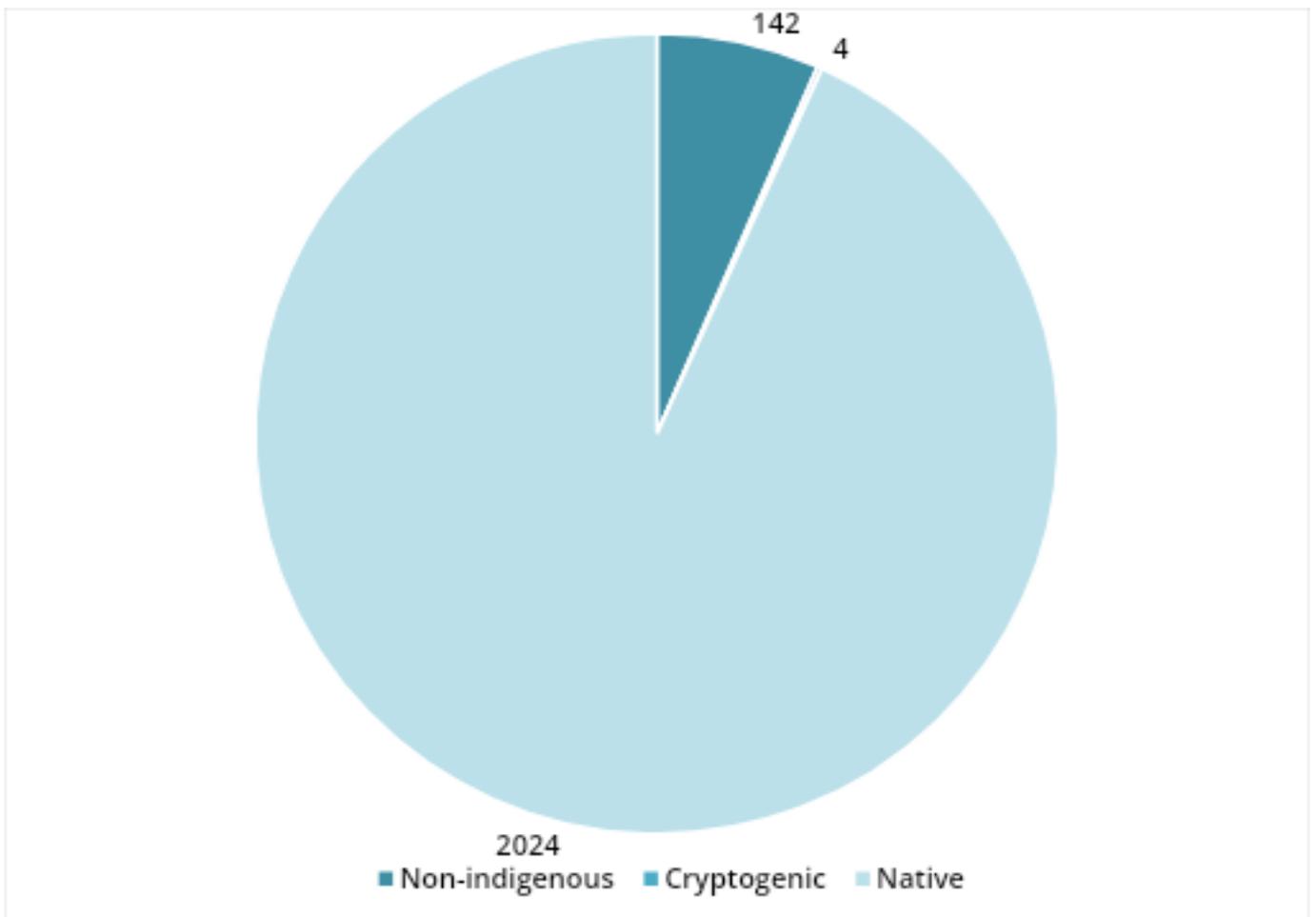
**Figure 52.** Number of occurrences according to the protection level for the BlueDiversity database.

Another important aspect of the biodiversity dataset is its documentation of non-indigenous species (NIS), which can be invasive and disruptive to native ecosystems. The database includes 142



non-indigenous species (Figure 53), providing essential information on the spread and impact of alien species within the Adriatic.

Non-indigenous species can outcompete native species, introduce new diseases, and alter the physical environment, leading to a shift in ecosystem structure. The documentation of these species allows the **BlueDiversity** project to track their movements and assess their impacts, contributing to ongoing efforts to manage biological invasions and mitigate their negative effects on biodiversity.



**Figure 53.** Number of occurrences according to the establishment means for the BlueDiversity database.



## 5.2. ABIOTIC DATASET

In addition to the rich biodiversity data, the **BlueDiversity** database also includes critical abiotic environmental data, which helps to contextualize the biological information and enhances the understanding of the factors that shape marine ecosystems. Abiotic data are vital for understanding the physical and chemical conditions of the environment that influence the distribution and abundance of species. The dataset is divided into two key components: abiotic data for the water column and abiotic data for the sediments, each of which provides insights into different aspects of the ecosystem.

The abiotic data for the water column includes a total of 264 observations that cover a variety of environmental parameters such as water temperature, salinity, pH, nutrient levels, and dissolved oxygen. These parameters are critical for the health of marine ecosystems, as they influence species metabolism, reproduction, and distribution. For example, temperature and salinity levels can directly affect species' thermal tolerance and osmoregulatory processes, while nutrient levels can influence primary productivity and the overall health of food webs. By documenting these parameters, the **BlueDiversity** database provides essential information for understanding the environmental factors that support or constrain biodiversity in the Adriatic.

In addition to the water column data, the **BlueDiversity** Database also includes 79 observations related to sedimentary abiotic parameters. Sediments play a key role in marine ecosystems, providing habitat for benthic organisms and influencing nutrient cycling. The abiotic characteristics of sediments, such as grain size and organic content, can significantly affect the composition and diversity of benthic communities. For example, fine-grained sediments may support a different set of organisms than coarse-grained sediments, and pollutants such as heavy metals can reduce species diversity and disrupt ecosystem processes. By tracking these parameters, the **BlueDiversity** database contributes to a better understanding of how sediment dynamics affect ecosystem health and biodiversity in coastal and marine environments.



### 5.3. DATA ACCESS AND INTEGRATION

A key feature of the **BlueDiversity** database is its dynamic, "living" nature, which allows for continuous updates and additions of new data as they become available. This characteristic is fundamental to the project's long-term objectives, as ecosystems are constantly changing due to a variety of natural and anthropogenic factors. The ability to integrate new data into the database ensures that it remains a relevant and up-to-date resource for stakeholders, researchers, and decision-makers involved in marine conservation and ecosystem management.

This evolving aspect of the database also makes it an essential tool for adaptive management. As new observations are collected, whether through field sampling, remote sensing, environmental DNA (eDNA) or other research efforts, the database is updated to reflect these findings, allowing for real-time tracking of changes in biodiversity and abiotic conditions. This flexibility is essential for monitoring trends over time, assessing the effectiveness of conservation measures, and identifying emerging threats to ecosystem health. By continuously improving the dataset, the **BlueDiversity** project can respond to changing environmental conditions and ensure that its actions are based on the most current and comprehensive information available.

The **BlueDiversity** database is not only a tool for scientific research but also a resource for public access and stakeholder engagement. While the database is available through a permission-based access system, allowing users to request data for specific purposes, its integration into the project's broader goals of promoting transparency and knowledge-sharing is fundamental. The open-access nature of the database allows stakeholders, including policymakers, environmental organizations, and the general public, to interact with and benefit from the data collected by the project.

To facilitate ease of use and ensure consistency, the **BlueDiversity** database adheres to established international standards, such as the Darwin Core for biodiversity data and the EU Water Framework Directive for abiotic data. This ensures that the data are interoperable with other datasets and can be easily shared with other initiatives working on similar environmental challenges. Standardised taxonomic references from reputable sources such as Algaebase, GBIF, and WORMS are used to ensure the accuracy and reliability of species identifications, promoting the widespread use and adoption of the database in the broader scientific community.



## CONCLUSION

The Deliverable 1.1.1 – “**BlueDiversity** Database” is a foundational element of the **BlueDiversity** project, serving as a comprehensive and evolving tool for understanding and managing the biodiversity and ecological health of the Adriatic coastal and marine environments. By incorporating a broad spectrum of data on biodiversity occurrences and abiotic environmental conditions, the database offers a holistic view of the ecosystems in the selected **BlueDiversity** Pilot Areas, supporting efforts to monitor, conserve, and sustainably manage these vital natural resources.

The database’s dynamic nature ensures that it remains a relevant resource for both short-term and long-term monitoring, while its integration of biodiversity and abiotic data enhances our understanding of the complex interactions between organisms and their environment. As the database continues to grow and evolve, it will serve as a critical tool for adaptive management, supporting the implementation of evidence-based conservation strategies and helping to safeguard the Adriatic Sea unique and valuable ecosystems for future generations.

