Summary

The ocean, covering approximately 71% of the Earth's surface, is one of the vastest yet least understood ecosystems. The thesis emphasizes that the deep-sea areas, which account for more than half of the ocean's depth, remain significantly unexplored. In fact, by 2010, only about 5% of the deep ocean had been studied through remote instruments, and less than 0.01% of the deep seabed had been examined. Despite this limited knowledge, it is known that the deep ocean houses the highest levels of biodiversity on Earth, with species adapted to extreme conditions like high pressure, low temperatures, and the absence of light.

This thesis focuses on the isolation and distribution patterns of oceanic pelagic species, specifically Ostracoda. This group of small crustaceans, often found in marine plankton, plays an integral role in ocean ecosystems, influencing marine food webs and energy flow. The thesis stands out for its multidisciplinary approach, combining elements from marine biology, oceanography, and data science. The focus on Ostracoda, a relatively lesser-known but ecologically significant group of pelagic organisms, provides a fresh perspective on how pelagic species adapt to and are influenced by their environment. The research demonstrates that understanding species distribution in the ocean is a complex task that requires a deep integration of biological, environmental, and technological methods and addresses the complex environmental factors that affect the distribution of Ostracoda and utilizes advanced database and data analysis technologies to explore these patterns in the North Atlantic Ocean

Pelagic Ostracoda, a model group of zooplankton, are highlighted as one of important components of this formation and thus the oceanic food web. Zooplankton serve as prey for larger organisms, thus playing a pivotal role in the energy transfer within marine ecosystems. The introduction also stresses the significance of physical factors, such as temperature, salinity, and water stratification, in shaping the oceanic environment. Understanding how these factors influence the distribution of pelagic species like Ostracoda is vital for marine ecological studies.

The thesis sets out to expand the understanding of the environmental factors that influence the distribution of Ostracoda in the North Atlantic Ocean. Modern technologies, such as autonomous vehicles and advanced satellite systems, have led to an increase in the availability of oceanographic data. However, biological data, especially from deep-sea environments, remain limited and fragmented. This research seeks to address these gaps by combining biological data with environmental datasets to investigate the distribution patterns of pelagic species, using Ostracoda as a model organism.

The thesis outlines several specific objectives:
1. Selection of a coherent and consistent database for deep-sea zooplankton.
2. Harmonization of biological data with hydrographic data from sources like the British Oceanographic Data Centre.
3. Development of tools to analyze marine ecosystems and study the relationship between Ostracoda distribution and environmental conditions.
4. Aggregation of hydrographic data with biological datasets from oceanic expeditions such as Discovery and CMarZ (Census of Marine Zooplankton).
5. Identification of natural barriers, such as temperature gradients and ocean currents, that influence the distribution of Ostracoda.

6. Classification of these environmental barriers in terms of their significance for specific species or habitats.
7. Analysis of trends in the distribution of dominant Ostracoda species across the North Atlantic.

By achieving these objectives, the thesis aims to contribute to the broader field of marine ecology and oceanography, providing a framework for studying other pelagic species in different marine environments.

The research focuses on the eastern Atlantic Ocean, a region characterized by its diverse ecological niches, suitable for the study of pelagic Ostracoda. The physical characteristics of this region, such as bathymetry, water column stratification, and ocean currents, create various environmental conditions that influence species distribution. For instance, the presence of the thermocline (a layer of water where temperature rapidly decreases with depth) and other vertical stratifications in the water column are crucial in determining the habitats available to different species.

The thesis highlights that the northern Atlantic, influenced by boreal conditions, and the southern Atlantic, with subtropical conditions, represent distinct regions for Ostracoda distribution. This division provides a natural experiment for studying the effect of different environmental barriers on species isolation and distribution.

The data used in this study originates from multiple sources, including unpublished data from the CMarZ expeditions, as well as hydrographic models and other oceanographic datasets. One of the key challenges addressed in the thesis is the integration of large and heterogeneous datasets. Ostracoda data, which includes information about species presence, abundance, and distribution, is combined with environmental data such as temperature, salinity, and water circulation models.

One of the key innovations of the thesis is the development of custom tools for analyzing and processing large, diverse datasets. In oceanography, collecting data from deep-sea environments is labor-intensive and often expensive, which results in smaller datasets compared to physical data collected from automated sensors. Biological data, especially from groups like zooplankton, are often gathered manually and analyzed in laboratories, adding to the complexity of their integration with environmental data.

To handle the complex data, the author developed custom software tools, including a data warehouse based on OLAP (Online Analytical Processing) technology. This system allows for the efficient processing and aggregation of large datasets, enabling the author to conduct detailed analyses of Ostracoda distribution patterns. Tools supporting the usage of the statistical methods such as PRIMER were also used to compare the faunal composition in different regions of the study area.

The results of the analysis show a clear division between northern and southern regions of the eastern Atlantic in terms of Ostracoda species composition. The northern region is dominated by boreal species like *Obtusoecia obtusata* and *Boroecia borealis*, while the southern region is home to subtropical species like *Microchoecia curta* and *Proceroecia procera*. These findings demonstrate that environmental factors, particularly temperature gradients and ocean currents, play a crucial role in determining the distribution of these pelagic species.

Additionally, the thesis examines how the environmental barriers that isolate certain species in specific regions are not solely geographical but also shaped by oceanographic conditions. For example, ocean currents can act as barriers or conduits for species dispersal, while temperature gradients may limit the range of certain species by affecting their metabolic processes.

The thesis makes several significant contributions to the field of oceanography and marine ecology. First, it provides a comprehensive analysis of the distribution patterns of pelagic Ostracoda in the North Atlantic, emphasizing the importance of environmental barriers in shaping species distribution. Second, it demonstrates the utility of integrating biological and environmental data, supported by advanced data processing tools and statistical analysis, in studying marine ecosystems.

To address these works it was necessary to design and develop an **OLAP (Online Analytical Processing) data warehouse**, which plays a crucial role in harmonizing biological and environmental datasets. This system allows for rapid data aggregation and enables advanced statistical analysis of the relationships between environmental conditions and Ostracoda distribution. By utilizing OLAP technology, the researcher created a flexible and scalable solution for analyzing Big Data in the context of marine ecosystems.

The research also highlights the challenges of working with large and diverse datasets in oceanography. By developing new tools and methods for handling these data, the author provides a framework that can be applied to other species and regions, thus advancing the study of pelagic ecosystems.

The central finding of the thesis is that **environmental barriers**, such as temperature gradients, ocean currents, and stratification of water masses, significantly influence the distribution of Ostracoda in the North Atlantic. These barriers often create distinct faunal regions, separating species that are adapted to different environmental conditions. The study identifies two primary regions in the eastern Atlantic: a northern region dominated by boreal species and a southern region dominated by subtropical species.

Boreal species such as *Obtusoecia obtusata* and *Boroecia borealis* are more prevalent in the northern part of the study area, where cooler water temperatures and different circulation patterns prevail. In contrast, **subtropical species** like *Microchoecia curta* and *Proceroecia procera* dominate the southern regions, which are characterized by warmer temperatures and distinct hydrographic conditions.

In conclusion, the thesis underscores the importance of interdisciplinary approaches in marine research. By combining oceanographic, ecological, and computational methods, the study offers valuable insights into the dynamics of pelagic species and their habitats, contributing to the broader understanding of how environmental factors influence biodiversity in the world's oceans. This work not only enhances our knowledge of Ostracoda but also serves as a model for future studies on marine ecosystems and species distribution.