

# How Deep-sea Jellyfish Impact Different Ecosystem Functions

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## **Abstract:**

Jellyfish have adapted to a variety of ecological niches across the ocean, contributing to essential ecosystem functions. This paper explores the critical role of jellyfish, particularly deep-sea gelatinous zooplankton (GZ), in marine ecosystems, focusing on their influence on the food web, carbon cycle, and nutrient cycle. With such a diverse range of species within GZ, they exhibit diverse feeding strategies, making them significant predators within the food web. They help regulate prey populations and transfer energy across trophic levels, comparable to larger marine species. Additionally, jellyfish play a vital role in the carbon cycle by transporting carbon to the ocean floor through their feeding, excretion, and decomposition, potentially alleviating the effects of ocean acidification. Jellyfish blooms, while temporary, significantly impact the benthic ecosystem by enhancing carbon and nitrogen transport. Jellyfish play a crucial role in the nutrient cycle by dispersing key elements like nitrogen and phosphorus, which drive primary production and uphold the balance of ecosystems. These findings highlight the importance of jellyfish in regulating deep-sea ecosystems and underscore the need for further research, especially as advancing technologies open new opportunities for exploring and understanding deep-sea habitats. Recognizing the ecological contributions of jellyfish is crucial for preserving marine biodiversity and ecosystem health in the face of environmental challenges.

**Key Words:** Benthic Organisms; Biochemical cycling; Deep-Sea ecosystem services; Food Web; Gelatinous Zooplankton; Trophic Levels

## Introduction:

Jellyfish are part of the phylum Cnidaria and belong to the class Scyphozoa, commonly referred to as true jellyfish (Katsuki 2013). However, the term "jellyfish" is often used more broadly to encompass various gelatinous zooplankton (GZ) within the marine environment (Doyle et al., 2013). For the purposes of this paper, the term will encompass all gelatinous zooplankton (GZ) species, which share a soft, translucent, gelatinous body structure.

Throughout the marine environment, jellyfish have adapted to inhabit diverse ecological niches, contributing to essential processes such as the food web, carbon cycle, and nutrient cycle (Pauly et al., 2009). Near the ocean surface, jellyfish aid in carbon transport by consuming phytoplankton and releasing it to the ocean floor through fecal pellets (Choy 2017). Their movement also enhances primary production and surface mixing (Doyle et al., 2013). Jellyfish in deep-sea environments remain some of the most unexplored inhabitants of the ocean, but advancements in technology are now facilitating deeper and more comprehensive exploration of these habitats (Gallo, 2015). Fossil evidence indicates that jellyfish have existed for over 500 million years, adapting to environmental changes such as climate shifts (Lucas et al., 2014). This resilience and adaptability allow jellyfish to thrive in deep-sea ecosystems, emphasizing the importance of studying their impact on these environments. For example, the species *Bathycorus bouilloni* was previously undetected in deep-sea environments, likely due to technological limitations in earlier exploration methods (Jamieson, 2021). Recent advancements in submersible technologies, however, have allowed researchers to uncover its presence and activity within the deep-sea water column (Raskoff, 2010). This discovery underscores how improved technology is expanding our understanding of deep-sea ecosystems and revealing previously unknown species that contribute to these

environments. The detection of *B. bouilloni* highlights the need to reassess the ecological roles of gelatinous zooplankton in deep-sea habitats. These organisms, including *B. bouilloni*, play critical roles in various zones, such as the bathyal and abyssal columns, influencing key ecosystem functions (Jamieson, 2021). Building on this example, this paper examines how deep-sea jellyfish, as a group, impact essential processes like the food web, carbon cycle, and nutrient cycle, shedding light on their broader ecological significance.

### **Food Web:**

The food web provides essential functions such as energy transfer, biodiversity support, population control, and nutrient cycling, all of which are fundamental to the health and sustainability of marine ecosystems (Sweetman 2016). These interactions influence both marine species and human activities. There are two primary methods for studying feeding interactions. The first involves analyzing gut contents, which can be challenging for deep-sea organisms as their contents are often destroyed during retrieval (Choy 2017). The second method involves in situ observations, which allow for direct study in their natural environment (Gould 2013). Jellyfish exhibit diverse feeding strategies based on their structures. They may feed on marine snow and phytoplankton through selective grazing, actively hunt other species, or passively trap prey using their tentacles (Nagata 2018). These varied methods make jellyfish significant contributors to the food web. Choy (2017), conducted in situ observations over 27 years within the deep depths of the California Current, recording 743 independent feeding events. The findings showed that jellyfish, particularly narcomedusae, consumed the greatest diversity of prey. The study highlights their role as key predators with ecological importance comparable to large fish and squid (Choy, 2017). Furthermore, jellyfish serve as prey for higher trophic level predators, facilitating energy

transfer across trophic levels (Dunlop 2017). By converting energy from their prey into biomass, they support energy flow in marine ecosystems. Some large-bodied organisms even feed semi-exclusively on gelatinous zooplankton (Choy, 2017). Jellyfish play a pivotal role in marine food webs by acting as both predators and prey, facilitating energy transfer across trophic levels. Their presence supports biodiversity by sustaining populations of smaller planktonic organisms they consume, while simultaneously providing nourishment for larger predators. This dual role makes them an essential focus of study for understanding the dynamics of ocean ecosystems and the balance within food webs.

### **Carbon Cycle:**

Carbon cycling is crucial for maintaining healthy marine ecosystems, as a build-up of carbon can result in ocean acidification, negative impacts on photosynthesis, and reduced oxygen levels, all of which affect biodiversity (DeVries 2022). Deep-sea gelatinous zooplankton (GZ) contribute significantly to this process, providing multiple ecosystem services. When GZ consume organic matter and subsequently die, their gelatinous bodies sink to the ocean floor, transporting carbon and delivering essential nutrients to benthic organisms (Sweetman et al., 2016). Increases in jellyfish populations have been associated with large-scale deposition phenomena, which periodically take place in various regions around the world (Billett, 2006). These large-scale decomposition events significantly impact ecosystems by increasing respiration rates and altering productivity. The short-lived blooms facilitate the transport of carbon and nitrogen to the seafloor through the carcasses of jellyfish (Sweetman, 2011). Such rapid changes in biochemical cycling caused by jellyfish blooms can have profound effects on benthic ecosystems, influencing oxygen levels and disrupting carbon cycling processes (Billett, 2006).

**Nutrient Cycle:**

Jellyfish play a crucial role in the nutrient cycle of deep-sea environments by influencing both the distribution and availability of nutrients such as Nitrogen, Phosphorus (Tinta 2021). Additionally, their vertical migrations in the water column facilitate the mixing of nutrients between different ocean layers, which can boost primary production and support the broader marine food web (Lucas et al., 2014). These gelatinous predators consume large quantities of zooplankton and other small organisms, effectively regulating their populations and ensuring a balance in the food web (Pitt 2009). As jellyfish excrete waste, they release essential nutrients like nitrogen and phosphorus into the water, which are readily available for primary producers like phytoplankton (Pitt 2009). By influencing both the water column and the seafloor, jellyfish help maintain nutrient flow, ensuring the continued health and productivity of marine ecosystems.

**Discussion:**

The findings presented in this paper highlight the diverse roles that jellyfish contribute to help maintain ecosystem functions. Including all gelatinous zooplankton in the definition of jellyfish allows us to better get a broader view and more information on how their contributions are key factors in different environments.

The data from in situ observations in the California Current demonstrate that jellyfish are not merely passive inhabitants of the ocean, rather, they are active participants in the food web, showing diverse feeding strategies that allow them to occupy critical ecological niches (Choy 2017). Their role as predators is vital, as they help regulate prey populations and transfer energy across trophic levels, comparable to larger fish and squid species.

Furthermore, the impacts of jellyfish on the carbon cycle are significant. Their ability to transport carbon enhances the various benthic communities (Sweetman et al., 2016). As they consume organic matter, such as zooplankton and phytoplankton, they contribute to the downward transport of carbon through their fecal pellets and decomposing bodies, effectively transporting these elements in deeper ocean layers (Sweetman et al., 2016). Additionally, Jellyfish help mitigate ocean acidification through their role in the carbon cycle. This process reduces the amount of carbon dioxide in surface waters, potentially alleviating the acidification of the upper ocean (Sweetman et al., 2016). Jellyfish blooms also contribute to these processes with the potential for large-scale changes in benthic ecosystems due to their rapid decomposition and alteration of nutrient dynamics (Billett, 2006).

In terms of the nutrient cycle, jellyfish play a key role in nutrient redistribution. Their waste products and decomposing bodies provide essential nutrients that enhance primary production in the deep sea, thus supporting the overall productivity of these environments (Pitt 2009). This nutrient recycling is crucial for maintaining the ecological health of deep-sea ecosystems, where nutrient availability can be limited.

### **Conclusion:**

In conclusion, jellyfish are a major input to the functioning of deep-sea ecosystems, influencing the food web, carbon cycle, and nutrient cycle in profound ways. Their diverse feeding strategies and significant role as both predators and prey highlight their ecological importance and the necessity of further research in understanding their roles within the marine ecosystem. Further exploring the deep-sea environments with advancing technologies will help provide a better understanding to the contributions of jellyfish and other gelatinous zooplankton will be essential for a comprehensive understanding of deep-sea ecosystems. The resilience and

adaptability of jellyfish, observed over their extensive evolutionary history, underscore their potential to respond to environmental changes, making them a critical focus for future studies aimed at preserving marine biodiversity and ecosystem health in the face of global change.

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