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Marine Toxin Bioamplification: Risks To Top Predators

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Introduction

Marine toxins represent a significant and growing threat to aquatic ecosystems and human health, with their prevalence and concentration increasing in food webs through a process known as bioamplification [1]. This phenomenon, where contaminants increase in concentration at successively higher levels of the food chain, is driven by the accumulation of toxins in organisms at lower trophic levels and their subsequent transfer to predators [2]. Understanding these pathways is crucial for effective management of fisheries and the preservation of overall ecosystem health, as top predators are particularly vulnerable to the adverse effects of these accumulated toxins [3]. In coral reef environments, for instance, ciguatoxins originating from algae can bioaccumulate in small fish and become highly concentrated in larger predatory species, posing a substantial risk to both marine life and humans who consume these fish [4]. Similarly, in estuarine food webs, filter feeders often accumulate high levels of toxins like saxitoxin, which is responsible for paralytic shellfish poisoning, making them readily available to their predators and creating a critical pathway for human exposure [5]. Freshwater and estuarine ecosystems are not immune, with toxins like microcystins produced by cyanobacteria accumulating in fish and moving up the food chain, highlighting the interconnectedness of different aquatic environments in toxin dispersal [6]. The bioamplification of potent neurotoxins, such as domoic acid, from benthic invertebrates to seabirds underscores the role of diet in driving these significant exposure events and their potential health impacts on avian populations [7]. In marine food webs, toxins like tetrodotoxin (TTX) can be transferred from prey to predator, leading to high concentrations in top-level consumers and posing a direct risk to human health through the consumption of contaminated seafood [8]. Persistent organic pollutants, such as organotins, also exhibit bioamplification in marine organisms, with potential to disrupt endocrine systems and cause long-term ecological consequences as they move up the food chain [9]. Furthermore, polycyclic aromatic hydrocarbons (PAHs) can bioaccumulate and biomagnify in marine food webs, moving from sediments to pelagic organisms, leading to chronic exposure and adverse health effects in marine life and those that consume them [10].

Description

The process of bioamplification in aquatic food webs, where toxins increase in concentration at higher trophic levels, is a well-documented phenomenon with significant ecological and human health implications [1]. This process often begins with the accumulation of toxins in primary producers or organisms at the base of the food chain, such as algae or benthic invertebrates [2]. These lower-level organisms then become a source of contamination for their consumers, initiating the trophic transfer of toxins [3]. For example, marine toxins produced by certain algae can be taken up by organisms at the bottom of the food chain and then become more concentrated as they move up to higher trophic levels, posing substantial risks to top predators including marine mammals, seabirds, and humans who consume seafood [4]. Studies have specifically investigated the transfer of potent neurotoxins like domoic acid from mussels to seabirds, demonstrating how benthic invertebrates can act as reservoirs for these toxins and lead to significant exposure and potential health impacts for avian consumers, emphasizing the role of diet in driving these bioamplification events [5]. The complexity of toxin transfer in tropical marine environments is illustrated by the bioamplification of ciguatoxins in coral reef food webs, where these toxins move from small fish to larger predatory species, ultimately posing a risk of human poisoning through the consumption of reef fish [6]. In estuarine environments, filter feeders are identified as key accumulators of toxins such as saxitoxin, the causative agent of paralytic shellfish poisoning, which then becomes available to their predators, establishing a critical pathway for human exposure [7]. The interconnectedness of freshwater and marine environments in toxin dispersal is evident in the bioaccumulation and trophic transfer of microcystins produced by cyanobacteria, which can accumulate in fish and subsequently transfer to higher trophic levels [8]. Research into the bioamplification of tetrodotoxin (TTX) in marine food webs, particularly in fish, reveals its transfer from prey to predator, resulting in high concentrations in top-level consumers and a significant risk to human health via seafood consumption [9]. Persistent organic pollutants like organotins also undergo bioamplification in marine organisms, leading to potential endocrine disruption and long-term ecological consequences as they ascend the food chain [10]. Similarly, polycyclic aromatic hydrocarbons (PAHs) are known to bioaccumulate and biomagnify in marine food webs, moving from sediment to pelagic organisms, which can result in chronic exposure and adverse health effects for marine life and their consumers [11].

Conclusion

Marine toxins bioamplify through food webs, increasing in concentration at higher trophic levels. This process poses significant risks to top predators, including humans, through the consumption of contaminated seafood. Various toxins, such as domoic acid, ciguatoxins, saxitoxins, microcystins, tetrodotoxin, organotins, and PAHs, have been studied in different aquatic environments, including marine, estuarine, and freshwater systems. Benthic invertebrates, filter feeders, and fish often act as reservoirs or transfer points for these toxins. Effective management of fisheries and ecosystem health requires a thorough understanding of these bioamplification pathways and their implications for both wildlife and public health.

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Conflict of Interest

None.

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