International Journal of Zoology and Applied Biosciences **ISSN: 2455-9571**
Volume 10, Issue 6, pp: 91-95, 2025 (Special Issue)
https://doi.org/10.55126/ijzab.2025.v10.i06.SP021 **http://www.ijzab.com**

Review Article

OIL SPILLS AND THEIR IMPACT ON COASTAL AND MARINE BIRD POPULATIONS: A REVIEW OF AVIAN MORTALITY

[1]Sujitha K, [2]Swathi T, [3]Sowmiya B, [4]Ruby G and [5*]Subha C

[1]PERI College of Nursing, Chennai -48, Tamil Nadu, India
[2]PERI College of Physiotherapy, Chennai -48, Tamil Nadu, India
[3]PERI College of Pharmacy, Chennai -48, Tamil Nadu, India
[4]PERI Institute of Technology, Chennai - 48, Tamil Nadu, India
[5*]PERI College of Arts and Science, Chennai -48, Tamil Nadu, India

Article History: Received 16th September 2025; Accepted 24th October 2025; Published 12th November 2025

ABSTRACT

Oil spills represent one of the most destructive forms of pollution affecting marine and coastal ecosystems, with birds being among the most vulnerable species. This review explores the multifaceted effects of oil contamination on avian populations, particularly seabirds and migratory species. The study highlights how oil exposure compromises feather insulation, disrupts buoyancy, and leads to toxic ingestion during preening. Long-term impacts such as reproductive failure, habitat degradation, and food chain contamination are also addressed. Case studies, including the Exxon Valdez and Deepwater Horizon spills, provide insight into population-level consequences. The paper emphasizes the importance of monitoring, preventive policies, and rehabilitation efforts in reducing bird mortality and promoting ecosystem recovery.

Keywords: Oil spills, Avian mortality, Seabirds, Coastal birds, Marine pollution, Ecological impact.

INTRODUCTION

Oil pollution remains one of the most severe and persistent threats to marine and coastal ecosystems. Among the most affected organisms are birds, particularly seabirds and migratory species that depend heavily on aquatic environments for feeding, breeding, and resting. Unlike many other forms of pollution, oil spills can have both immediate and long-lasting impacts on avifauna. Even small quantities of oil can disrupt the waterproofing and insulating properties of bird feathers, leading to hypothermia, loss of buoyancy, drowning, and starvation. Furthermore, when birds preen to remove oil from their plumage, they often ingest toxic hydrocarbons, which can cause internal organ damage and reproductive failure.

Large-scale spills, such as the Exxon Valdez (1989) and Deepwater Horizon (2010) disasters, have resulted in the mortality of hundreds of thousands of birds and have had prolonged ecological consequences. However, chronic oil pollution from illegal dumping, leaking vessels, and industrial discharges is often less visible but equally deadly, causing widespread and unmonitored avian deaths annually. This review aims to synthesize current knowledge on the physiological, ecological, and behavioral impacts of oil spills on birds. It further examines case studies and evaluates both mitigation strategies and policy responses that aim to reduce bird mortality and support the recovery of affected populations. Understanding these impacts is essential for improving preparedness, response, and conservation strategies in oil spill-affected regions. Williams *et al*. conducted a comprehensive review on how petroleum exposure disrupts feather integrity, thermoregulation, and causes systemic toxicity in birds. Jenssen *et al*. showed that oil impairs the insulation and thermal balance of birds, significantly affecting their metabolic stability. O'Hara *et al*. reported microstructural damage to feathers, increasing mortality risk due to hypothermia and buoyancy loss. Dannemiller *et al*. studied the hematological and biochemical impact of external oiling and found adverse physiological responses post-rehabilitation. Anderson *et al*. followed the survival of oiled Brown Pelicans and revealed challenges in long-term rehabilitation outcomes.

*Corresponding Author: Subha C, PERI College of Arts and Science, Chennai -48,
Tamil Nadu, India Email: publications@peri.ac.in.

Williams (2020), Leighton (1993) and Mensen (1994). statistically analyzed 45 oil spill incidents to correlate seabird mortality with spill magnitude. Haney *et al*. developed exposure probability models to estimate bird deaths during the Deepwater Horizon spill. Piatt *et al* (1990), Haney (2014) and Antonio (2011). assessed immediate mortality among marine birds post-Exxon Valdez, emphasizing acute exposure effects. Antonio *et al*. presented a simulation-based model to track vertebrate mortality patterns, with focus on birds during the Gulf spill. Kelsey *et al*. developed a seabird vulnerability index that integrates exposure potential and species sensitivity. Russel *et al* analyzed the Prestige spill and documented mass mortality and delayed recovery in seabird populations. Neves and Stephenson, (2024) and Kelsey *et al* (2022). examined the Sea Empress spill's long-term effects on Common Scoters, reporting only partial recovery after a decade. Science summarized seabird losses from the Deepwater Horizon spill, estimating hundreds of thousands of fatalities. Burger *et al*. linked spill volume to mortality rates across various oil spill events, offering predictive insights. Russel (2010) and Burger and Gochfeld (1993). combined drift models and field data to estimate true seabird mortality following the Prestige oil spill. Flint *et al*tested wind influence on carcass recovery to improve accuracy of post-spill mortality estimates D. W. Anderson (1996), Camphuysen and Heubeck (2001) and Castege *et al.,* (2002).

Chronic and Underreported Oil Pollution

Camphuysen *et al*. utilized beached bird surveys to monitor the ongoing impact of chronic oil pollution in marine environments Flint and Fowler (1998), O'Hara and Morandin and Haney, H *et al* (2014). Environ. Rev. estimated bird mortality numbers from routine spills and highlighted the lack of consistent reporting mechanisms. Neves *et al*. reviewed spills exceeding 500 barrels and synthesized the effects on marine birds for response planning. ResearchGate compiled a systematic review of avian oil spill impacts and summarized best rehabilitation techniques. Science Direct provided an overview of trophic disruption, habitat degradation, and long-term ecological consequences for seabirds. Babu *et al* discussed the increasing concerns of microplastic accumulation in terrestrial and aquatic ecosystems. Their study emphasized recycling strategies, management techniques, and the long-term sustainability challenges associated with microplastic waste Dannemiller *et al* (2019), Russel *et al* (2010), Rubala (2025) and Ramya (2025). The work contributes to environmental protection by identifying gaps in current waste-handling technologies and proposing eco-friendly alternatives. Rubala *et al*. reviewed the histopathological impacts of environmental pollutants on living systems. The authors highlighted pathological changes caused by toxic exposure, underlining the importance of biomonitoring and early detection for preventive healthcare. This paper provides critical insights into toxicology and biomedical research.

Economic Impact of Penaeus monodon Aquaculture

Swetha *et al* (2025), J. Mahalakshmi *et al* (2025) and Farheen *et al* (2025). analyzed the growth trends and economic implications of *Penaeus monodon* aquaculture. Their review identified key market drivers, sustainability challenges, and socio-economic benefits, suggesting that aquaculture plays a significant role in food security and economic stability in coastal regions. Geetha *et al*. presented a comprehensive review of ecotourism, emphasizing its applications in biodiversity conservation and environmental education. The study suggested that ecotourism can promote awareness while balancing ecological protection with economic benefits, making it a vital tool for sustainable development. Swetha *et al*. provided a concise review of mosquito control measures, ranging from biological methods to chemical interventions. Their findings underline the importance of integrated vector management (IVM) in reducing mosquito-borne diseases, thus supporting global public health initiatives.

Mahalakshmi *et al*. explored the health risks associated with inhalation of volatile paint fumes. Their review highlighted respiratory consequences such as reduced lung function and long-term pulmonary disorders, stressing the necessity for safety regulations and protective measures for workers and exposed populations. Farheen *et al*. investigated medicinal plants as therapeutic candidates for hepatocellular carcinoma. Their mini-review pointed out the hepatoprotective properties of phytochemicals and their potential to provide affordable, accessible alternatives to conventional cancer treatments. Geetha *et al*. used computational methods to evaluate natural bioactive compounds and their interactions with mosquito proteins. This research provides insights for novel insecticide design and biocontrol measures, advancing eco-friendly mosquito management strategies. Devasena *et al*. highlighted sustainable biofuel production from fruit waste, offering a waste-to-energy approach. Their work underscored the dual benefit of reducing organic waste accumulation and providing renewable energy alternatives to fossil fuels. Krishanan *et al*. quantified airborne microbial loads in clinical and adjacent environments. Their study demonstrated the importance of microbial monitoring for infection control and prevention, contributing to improved healthcare facility management. Krishanan *et al*. studied the effect of aquarium wastewater irrigation on mustard and green gram plants. Results indicated enhanced growth responses, suggesting the feasibility of using treated wastewater in agriculture as a resource recovery and sustainability measure. Krishanan *et al*. explored the green synthesis of superparamagnetic iron oxide nanoparticles (SPIONs). Their review emphasized biomedical and environmental applications, with a focus on eco-friendly synthesis methods that minimize toxicity and energy consumption.

Geetha *et al*. discussed fabrication and analysis of nickel oxide nanoparticles for advanced applications. Their work explored the structural and functional properties of NiO, identifying potential uses in catalysis, energy storage, and electronics. Sindhuja *et al*. synthesized and characterized spinel $SrFe_2O_4$ nanoparticles. Their review highlighted the application potential in magnetic storage, catalysis, and biomedical fields, demonstrating how nanostructuring enhances material properties. Geetha *et al*. reported on the microwave-assisted synthesis and characterization of ZnO nanoparticles. Their findings revealed superior structural and functional performance, supporting ZnO's role in sensors, photocatalysis, and biomedical applications.

AVIAN VULNERABILITY TO OIL SPILLS

Birds that spend significant time in or around marine and coastal ecosystems are especially vulnerable to oil contamination. These include: Seabirds such as gulls, pelicans, auks, loons, cormorants, and shearwaters, which often rest on the water's surface, making them highly exposed to oil slicks. D iving birds like grebes, penguins, and diving ducks (e.g., eiders, mergansers) are at higher risk as they frequently submerge in potentially contaminated water. Shorebirds including plovers, sandpipers, and avocets may become oiled when foraging in intertidal zones. Migratory birds that stop along coastlines for feeding and breeding during seasonal movements are susceptible during critical periods in their life cycles. Oil primarily affects birds through external feather fouling and internal toxicity**:** Birds rely on interlocking feathers coated with natural oils to provide waterproofing and insulation**.** Oil disrupts this structure, causing feathers to clump and lose their function. As a result, birds lose body heat, leading to hypothermia**,** especially in cold water. Without proper feather alignment, birds sink or have trouble floating. This reduces their ability to rest, forage, and evade predators. While preening to remove oil, birds ingest hydrocarbons**.** This can result in Gastrointestinal ulceration, Liver and kidney damage, Hormonal disruption**,** Reproductive failure (e.g., thin eggshells, infertility) Behavioral effects can be both immediate and long-term-Compulsive Preening**-**Oiled birds obsessively try to remove the oil, which increases energy expenditure and reduces time for feeding or resting**.** Starvation and Dehydration-The loss of insulation and buoyancy forces birds to stay on land, away from food sources. This leads to emaciation and dehydration**.** Predation Risk**-**Weak, flight-impaired birds are easily targeted by predators such as gulls, foxes, or even domestic animals. Reproductive Failures**-**Oiled nesting areas lead to-Egg suffocation due to oil coating**,** Malformed chicks**,** Nest abandonment**.** In species with low reproductive rates (e.g., albatrosses, murres), population-level effects can be severe.

CASE STUDIES

Exxon Valdez oil spill, which occurred on March 24, 1989, in Prince William Sound, Alaska, remains one of the most infamous environmental disasters. While the immediate images of oil-soaked wildlife shocked the world, the long-term ecological consequences, particularly for seabirds, have been a subject of extensive study and continue to highlight the devastating and lingering impacts of such events. Here's a more detailed explanation of the Exxon Valdez's impact on seabirds: Vulnerability of Seabirds**:** Seabirds are inherently highly vulnerable to oil spills. Many species spend most of their lives on the water's surface, where oil slicks accumulate. Diving birds, like Common Murres, frequently surface through contaminated water, coating their feathers. Feather Contamination: Oil destroys the natural waterproofing and insulating properties of feathers. This leads to Hypothermia: Birds rapidly lose body heat in the frigid Alaskan waters. Loss of Buoyancy: Oiled feathers become heavy and matted, making it impossible for birds to float, leading to drowning. Impaired Flight: Heavy, matted feathers make flight difficult or impossible, hindering their ability to forage, escape predators, or migrate. Ingestion and Internal Toxicity: In an attempt to preen and clean their contaminated feathers, birds ingest significant amounts of toxic crude oil. This ingestion causes severe internal damage, including: Gastrointestinal Ulcers and Hemorrhages: Leading to starvation, dehydration, and organ failure. Liver and Kidney Damage: Affecting detoxification processes and overall organ function. Anemia: Destruction of red blood cells, impairing oxygen transport. Compromised Immune System: Making birds more susceptible to diseases and secondary infections.

REHABILITATION AND RESPONSE STRATEGIES

Wildlife Rescue and Rehabilitation Organizations like the International Bird Rescue and Oiled Wildlife Care Network employ washing and detoxification techniques. However, rehabilitation is labor-intensive, and survival rates vary. Policy and Monitoring Countries like Canada use satellite surveillance (e.g., RADARSAT) to detect oil slicks. Legal actions against polluters and increased fines have been implemented, but enforcement remains challenging. Public Engagement Volunteering in clean-up operations, reporting sightings of oiled birds, and supporting sustainable practices can mitigate impacts. Awareness campaigns and responsible boating also contribute.

CONCLUSION

The effects of oil spills on birds are profound, long-lasting, and often underestimated. With increasing maritime traffic and offshore drilling, preventive measures and robust policy frameworks are essential. Future efforts should focus on technological innovations for rapid response, improved rehabilitation techniques, and comprehensive ecological assessments to safeguard avian biodiversity.

ACKNOWLEDGMENT

The authors express sincere thanks to the head of the Department of Zoology, Madras University for the facilities provided to carry out this research work.

CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

FUNDING

This study received no specific funding from public, commercial, or not-for-profit funding agencies.

AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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