

Towards a Gulf Ecological Union: Pathways for Recovery and Resilience

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ABSTRACT

The Iran–USA conflict in the Persian Gulf has generated unprecedented ecological and socioeconomic disruptions across Iraq, Iran, Kuwait, Bahrain, Qatar, the United Arab Emirates, Oman, and Saudi Arabia. This study examines the environmental consequences of tanker strikes, refinery explosions, and port attacks, highlighting their impacts on coral reefs, mangroves, seagrass meadows, wetlands, and migratory corridors. Case studies from Basra, Kharg Island, the Strait of Hormuz, Fujairah, and the Gulf of Oman illustrate how oil spills, chemical leaks, and acoustic disturbances have impaired biodiversity, fisheries, aquaculture, desalination, and eco-tourism.

The analysis reveals systematic violations of international conventions (UNCLOS, CBD, Ramsar, CMS, AWEA, MARPOL), regional agreements (Kuwait Regional Convention), and national environmental laws, underscoring the legal dimension of ecological degradation. A comparative framework of location-specific impacts and solutions demonstrates that recovery is possible through coral transplantation, mangrove regeneration, seagrass restoration, biodiversity health monitoring, and pollution control.

The paper advocates for the establishment of a Gulf-wide ecological union under the auspices of UNEP and UNESCWA to coordinate restoration, resilience planning, and conflict-sensitive environmental governance. By harmonizing legal frameworks, strengthening rapid response capacity, and promoting community-based ecotourism, Persian Gulf states can transform ecological recovery into a cornerstone of regional peace, stability, and sustainable development.

The research paper relied on publicly available sources to conduct its analysis and formulate recommendations. The views expressed in this publication are those of the authors and do not necessarily reflect the affiliated research institution.

Keywords: Persian Gulf conflict; Ecological resilience; environmental law violations; Regional ecological governance: Gulf ecological union

INTRODUCTION

The Persian/Arabian Gulf (hereafter referred to as the Gulf) is a subtropical, epicontinental sea located between 23°50' N and 29°52' N. The Gulf extends approximately 989 km in length, with an average width of 50 km, covering an area of about 251,000 km². Its shallow nature is evident in its mean depth of 20 m, with a maximum depth of 90 m.

Eight countries border the Gulf: Iran, Iraq, Kuwait, Saudi Arabia, Bahrain, Qatar, the United Arab Emirates, and Oman. While referred to as the “Persian Gulf” in international contexts, Arab nations often use the term “Arabian Gulf” (Idrisi Nasseer, 2024). The Gulf’s shallow waters, high-latitude position, and surrounding deserts and plateaus create one of the most extreme environments endured by reef-building corals globally (De Roy, 2009).

The Gulf's coastal and marine ecosystems comprise ecologically significant habitats such as coral reefs, seagrass beds, mangroves, and mudflats. These habitats support diverse marine and avian life, including dugongs, dolphins, whales, sea turtles, sharks, and migratory birds. Several of these areas have been designated as protected zones, biosphere reserves, and sanctuaries, reflecting their ecological and cultural importance. They also serve as major centers for tourism due to their biodiversity and scenic value.

However, ongoing geopolitical conflict—particularly the USA–Israel–Iran war—has severely impacted these sensitive ecosystems. Oil spills, military strikes, and coastal infrastructure damage have degraded habitats, reduced species richness, and disrupted ecological services. This paper examines the status of natural resources and ecological habitats across Gulf countries, highlighting the compounded threats of war, climate stress, and unsustainable exploitation on coastal and marine ecology.

METHODOLOGY

This research adopted a qualitative and integrative approach, relying primarily on open-source information to examine the ecological consequences of the Iran–USA conflict in the Persian Gulf. Data were collected from publicly available sources including peer-reviewed journal articles, international organization reports, NGO publications, satellite imagery, and verified news outlets. These materials provided insights into ecological damage, biodiversity loss, and legal violations across Gulf countries. In addition, international conventions such as UNCLOS, CBD, Ramsar, CMS, AEWA, and MARPOL, as well as regional agreements and national environmental laws, were systematically reviewed to identify breaches and governance gaps.

The analysis was conducted through an interdisciplinary framework that integrated perspectives from international politics, ecological sciences, and environmental law. Political data on military strikes, tanker incidents, and geopolitical tensions were contextualized alongside ecological evidence of coral reef mortality, mangrove degradation, seagrass contamination, and species decline. Legal frameworks were then cross-referenced with observed ecological impacts to highlight violations of binding obligations. Case studies from Basra, Kharg Island, the Strait of Hormuz, Fujairah, and the Gulf of Oman were selected to illustrate location-specific ecological disruptions and their socioeconomic consequences.

Interpretation of the data followed a triangulation method, whereby multiple sources were cross-verified to ensure accuracy and reduce bias. Thematic coding was applied to categorize findings under ecological impacts, legal violations, and socioeconomic consequences such as fisheries collapse, desalination risks, and tourism decline. The study acknowledges certain limitations. As the research relied exclusively on open-source information, some ecological damage may be under-reported due to restricted access in conflict zones. Quantitative field data were limited, but the qualitative synthesis provided a robust framework for identifying trends and policy implications. Despite these constraints, the methodology enabled a comprehensive interdisciplinary analysis that connects geopolitical conflict with ecological degradation, legal violations, and pathways for recovery.

Biodiversity and Ecologically Important Areas in the Persian Gulf

Reefs in the Persian Gulf are concentrated around offshore islands where water conditions are more stable than near the mainland. In the United Arab Emirates, fringing reefs occur around Abu Dhabi and Sir Abu Nu'air. Iran hosts well-developed reefs around Kish, Qeshm, Larak, and Khark islands. It hosts some of the northernmost coral reefs on the western boundary of the Indo-Pacific, notably around Kharku Island, Iran. Saudi Arabia's high-diversity reefs are found near Jana and Karan islands, while Kuwait supports the northernmost reefs of the Gulf around Kubbar and Qaru islands (Sheppard et al., 2010). Branching corals such as *Acropora arabensis* and massive *Porites* species dominate reef communities. *Acropora arabensis* is endemic to the Gulf, but populations of *Acropora* have declined significantly, with table corals functionally extinct in many nearshore areas due to thermal stress and anthropogenic pressures (Riegl & Purkis, 2012). Seagrass meadows provide critical feeding grounds for dugongs and sea turtles, supporting one of the largest dugong populations. Mangrove forests, dominated by *Avicennia marina*, occur along the coasts of Iran, UAE, and Qatar. These habitats serve as nurseries for fish, crustaceans, and migratory birds. Despite ongoing

restoration projects, dredging and coastal reclamation continue to threaten their survival (Spalding et al., 2010).

The Gulf sustains over 700 fish species, including groupers, snappers, parrotfish, and commercially important shrimp. Invertebrates such as pearl oysters, crabs, and sea urchins are also abundant, historically linked to the region's pearl-diving industry. Overfishing and habitat degradation pose major risks to these populations (Idrisi Nasseer, 2024). More than 30 shark species inhabit the Gulf. Common species include blacktip reef sharks and Arabian carpetsharks, while larger predators such as bull sharks, tiger sharks, and hammerheads are found in deeper waters. Critically endangered sawfish are rare but still present. Sharks play a vital ecological role in maintaining reef and seagrass ecosystem balance (Moore, 2012).

The Gulf is a feeding ground for cetaceans of all sizes. Dugongs depend on seagrass beds, while whales and dolphins thrive in the nutrient-rich waters. Recorded whale species include Bryde's whale (*Balaenoptera edeni*), Arabian humpback whale (*Megaptera indica*), and false killer whale (*Pseudorca crassidens*). Dolphins such as the Indo-Pacific bottlenose (*Tursiops aduncus*), pantropical spotted (*Stenella attenuata*), and Indo-Pacific humpback dolphin are common. The Asiatic black finless porpoise (*Neophocaena phocaenoides*) has also been documented (Asuka Koda, 2026).

Over 70 species of migratory birds use the Gulf as a corridor between Eurasia and Africa. These include pelicans, cranes, flamingos, and warblers. Wetlands and mudflats serve as critical resting and feeding grounds, but many habitats are degraded due to urban expansion and industrial development (Idrisi Nasseer, 2024). The Gulf provides nesting grounds for endangered green turtles (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*), particularly along the coasts of Oman and the UAE. Nesting habitats are increasingly threatened by coastal development, oil pollution, and fisheries bycatch (Pilcher et al., 2014).

Impacts of the War on the Ecology and Biodiversity in the Persian Gulf

Military strikes on energy infrastructure have triggered oil spills, while naval blockades and tanker risks in the Strait of Hormuz threaten remaining habitats. Reports suggest that over two-thirds of Gulf coral reefs are already lost (UNEP, 2020). Crude oil compounds impair cardiac, respiratory, and immune function in marine animals, increasing susceptibility to infections. Neurotoxic effects disrupt navigation and sensory processing, critical for migratory species such as dolphins and turtles (Al-Majed et al., 2012).

Recurrent heat waves and climate change have already caused severe thermal stress in Gulf coral reefs, with some areas experiencing up to 97% mortality (Riegl & Purkis, 2012). Coastal development, including dredging and land reclamation, has further reduced reef resilience. The ongoing conflict compounds these pressures: oil slicks from damaged vessels and military strikes directly smother corals, while noise and blast impacts disrupt reef-associated species. The loss of reefs destabilizes fisheries and coastal livelihoods across Iran, Oman, and the wider Gulf (Sheppard et al., 2010).

At least 16 attacks on ships have occurred since the war began, leaving nearly 2,000 vessels trapped with 21 billion liters of oil onboard. The Iranian vessel Shahid Bagheri continues to leak oil near the Khuran Strait, threatening wetlands and coral ecosystems. Greenpeace has warned that the spill poses a major risk to nearby Ramsar-listed wetlands (Greenpeace, 2026). Kharg Island is a coral-based island and Iran's primary oil export hub, handling 90% of exports. Its coral foundation is overshadowed by oil infrastructure and military threats. In the Strait of Hormuz which is the home to the most diverse coral populations in the Gulf, nourished by currents from the Gulf of Oman. Dolphins, whale sharks, and critically endangered Arabian humpback whales (*Megaptera indica*) are at risk from oil spills and vessel traffic (Asuka Koda, 2026). Similarly, the UAE offshore islands, including Sir Bani Yas and other islands, serve as nesting sites for green and hawksbill turtles. Oil spills in UAE waters have been directly linked to turtle mortality (Pilcher et al., 2014). Mangroves (*Avicennia marina*) line the southern Gulf, particularly in Abu Dhabi, Ras Al Khaimah, and Umm Al Quwain. While resilient to moderate oil exposure, mangroves die if pneumatophores are smothered (Spalding et al., 2010). Seagrass meadows west of Abu Dhabi and south of Qatar host the world's second-largest dugong population. These meadows form the largest continuous seagrass beds globally, but oil contamination would pose a catastrophic threat (Preen, 2004).

Musandam (Oman), once a hotspot for scuba diving and dolphin-watching, has seen tourism collapse due to ecological damage and conflict. The war has disrupted the Blue Economy, undermining the provisioning services such as fisheries, aquaculture, salt production, and maritime transport. Regulating services such as coastal protection, carbon sequestration, and biodiversity support. The cultural services such as tourism, heritage, education, and scientific research (UNESCWA, 2021). Ecological conflict areas in the Persian Gulf have been shown in Map 1.



Map – 1 Persian Gulf ecological conflict areas

Khuran Strait, Persian Gulf

The Khuran Strait, located between Qeshm Island and the Iranian mainland, is a dynamic coastal system characterized by short-crested waves, strong tidal currents, and significant sediment transport (Hajibaba, Soltanpour, Taheri, & Haghshenas, 2025). These hydrodynamic processes influence nutrient cycling, mangrove distribution, and the transport of pollutants, making the strait ecologically sensitive. As of April 2026, the damaged Iranian drone carrier Shahid Bagheri continues to leak heavy fuel oil into the Khuran Strait. The vessel has remained grounded in shallow waters since being struck by U.S. warplanes in early March, approximately five kilometers off Qeshm Island (coordinates 27.034194, 56.075750). Satellite imagery from late April confirmed that the oil slick had expanded to more than 20 kilometers in length, with prevailing currents driving contamination westward toward the Hara wetlands despite tidal variations (Greenpeace, 2026).

The spill is occurring within a Ramsar-designated protected area. The Hara Biosphere Reserve, the largest mangrove forest in the Persian Gulf, is a critical sanctuary for migratory birds, diverse fish species, and endangered turtles. The mangrove forests (*Avicennia marina*) grow 3–8 meters tall, partially submerging at high tide, and provide breeding grounds for fish, reptiles, and arthropods. The Haraye Khamir protected area, covering more than 2,400 hectares, was established in 1972 to safeguard these ecosystems. It is recognized as a UNESCO Biosphere Reserve and supports sustainable tourism, local livelihoods, and biodiversity conservation (Spalding et al., 2010; Iranian Department of Environment, 2025).

The Khuran Strait supports migratory bird populations, including herons, pelicans, and flamingos, as well as endangered green turtles (*Chelonia mydas*), sea snakes, and dugongs. Oil contamination threatens these species by impairing feeding, nesting, and breeding habitats. The ecological scale of contamination raises the risk of becoming the most significant disaster in the region since the 1991 Gulf War (Sheppard et al., 2010).

Although a temporary ceasefire has been reported, active bombardment has prevented cleanup operations. Ongoing maritime tensions, combined with GPS/AIS signal interference, continue to obstruct coordination among international environmental response groups. The inability to mobilize rapid response mechanisms has amplified ecological damage, leaving the Khuran Strait vulnerable to long-term biodiversity loss (UNEP, 2020).

Strait of Hormuz – Iran/Oman Corridor

On April 5, 2026, Iranian drones and explosive-laden boats targeted commercial tankers transiting the Strait of Hormuz, the world's most critical oil shipping chokepoint. Several vessels reported hull breaches and crude oil leakage, while naval interception efforts released missile debris into the water column (Greenpeace, 2026).

The Strait of Hormuz is ecologically significant, hosting coral reefs, seagrass beds, and migratory corridors for dolphins and whales (Sheppard et al., 2010). Oil spills in this semi-enclosed passage smother coral polyps, reduce light penetration, and impair photosynthesis. Hydrocarbon exposure disrupts fish spawning and turtle feeding grounds, while acoustic disturbances from naval sonar threaten cetacean communication and navigation (Riegl & Purkis, 2012).

Socioeconomically, the Strait supports global energy trade and artisanal fisheries along the Iranian and Omani coasts. Oil contamination jeopardizes livelihoods, while shipping disruptions raise global energy security concerns (UNESCWA, 2021).

Kharg Island – Iran

On March 18, 2026, missile strikes targeted Kharg Island, Iran's largest oil export terminal. Fires at storage facilities released crude oil into surrounding waters, forming slicks that drifted toward coral and seagrass habitats (Greenpeace, 2026).

Kharg Island's marine environment includes coral reefs, seagrass beds, and mudflats that support fish nurseries and migratory birds. Oil slicks smother benthic organisms, impair turtle nesting, and reduce prey availability for avifauna. Hydrocarbon residues persist in sediments, complicating long-term recovery (Al-Majed et al., 2012).

The island is central to Iran's petroleum exports, and ecological damage undermines fisheries and coastal livelihoods. The incident highlights the vulnerability of energy hubs to geopolitical conflict and the cascading impacts on marine ecosystems (UNEP, 2020).

Hormuz & Qeshm Islands – Iran

On March 25, 2026, Iranian military facilities on Hormuz and Qeshm Islands were struck by retaliatory drone attacks. Explosions damaged port infrastructure and released petroleum products into adjacent mangrove and coral habitats (Greenpeace, 2026).

These islands host Ramsar-listed wetlands and mangrove forests (*Avicennia marina*), which provide critical feeding grounds for migratory birds and nursery habitats for fish. Oil contamination threatens pneumatophores, reducing mangrove resilience. Coral reefs and seagrass beds face compounded stress from hydrocarbon exposure and sedimentation (Sheppard et al., 2010).

Ecologically, the islands are biodiversity hotspots, while socioeconomically, they support fisheries and eco-tourism. Damage to habitats undermines both ecological integrity and community livelihoods (UNESCWA, 2021).

Iraq's Southern Ports—Basra/Umm Qasr

On March 11, 2026, two fuel tankers—the Safesea Vishnu (US-owned, Marshall Islands-flagged) and the Zefyros (Malta-flagged)—were attacked by explosive-laden boats near Iraq's southern Port of Basra/Umm

Qasr. The incident occurred within Iraq's territorial waters, close to the Basrah Oil Terminal (ABOT), a critical hub for petroleum exports in the Northern Arabian Gulf (Greenpeace, 2026).

The coastal and marine areas surrounding Basra and ABOT are ecologically vital yet highly sensitive. They feature seagrass beds, mudflats, and recently documented coral reef patches (Sheppard et al., 2010). These habitats serve as nursery grounds for fish and shrimp, support phytoplankton communities, and act as migratory corridors for birds and marine megafauna. Despite their ecological importance, the region faces intense pressures from shipping, oil transport, and industrial pollution (Al-Majed et al., 2012). The explosions triggered fires that breached cargo holds, releasing naphtha and crude oil into the Gulf. Burning oil spread across the water surface, forming hydrocarbon films. Naphtha, being lighter than water and highly volatile, caused acute toxicity to fish, plankton, and benthic organisms before evaporating. Hydrocarbon exposure impairs respiration and reproduction in marine life, while oil slicks smother seagrass and coral habitats (UNEP, 2020).

Explosive impacts also released metal debris and ship fragments into the water column, adding to contamination. The high-intensity fires likely resulted in localized fish kills and destruction of marine invertebrates. Smoke plumes carried particulate matter, heavy metals, and unburned hydrocarbons, which later settled into the water, compounding toxicity (Riegl & Purkis, 2012).

The Basra coastline supports artisanal fisheries and aquaculture, which are now threatened by contamination. Oil slicks jeopardize livelihoods dependent on shrimp and finfish harvests. Migratory birds using mudflats as feeding grounds face reduced prey availability. The incident also highlights the vulnerability of Iraq's coastal ecosystems to geopolitical conflict, with potential long-term impacts on biodiversity, fisheries, and maritime trade (UNESCWA, 2021).

Gulf of Oman – Oman and Fujairah (UAE)

On March 7, 2026, the Islamic Revolutionary Guards Corps (IRGC) attacked the Malta-flagged oil and chemical tanker *Prima* with a drone in the Gulf of Oman near the Strait of Hormuz, close to Omani waters. This incident was part of a series of confrontations in which Iran targeted vessels transiting this strategic chokepoint. Multiple tanker attacks in the Gulf of Oman resulted in stranded vessels leaking fuel into the marine environment, creating oil slicks that threatened Oman's beaches and coastal ecosystems (Greenpeace, 2026).

Subsequently, on April 2, 2026, tanker explosions near Fujairah Port released additional crude oil into the Gulf of Oman. Fires at oil storage tanks produced smoke plumes containing heavy metals and hydrocarbons, which later settled into coastal waters. These pollutants compounded the ecological stress already caused by repeated tanker strikes in the region (Greenpeace, 2026).

The Gulf of Oman connects the Arabian Sea to the Strait of Hormuz and serves as a biodiversity hotspot. Its coastal ecosystems include mangrove forests, wetlands, coral reefs, and seagrass beds. These habitats support diverse marine life, including fish stocks, sea turtles, dugongs, and cetaceans, while also functioning as migratory corridors for seabirds and pelagic species moving between the Arabian Sea and the Persian Gulf (Sheppard et al., 2010).

Oil spills from tanker incidents release hydrocarbons that smother coral reefs, reduce oxygen exchange in seagrass beds, and impair mangrove pneumatophores. Hydrocarbon exposure causes acute toxicity in fish and plankton, while heavier fractions persist in sediments, affecting benthic organisms. Toxic pollution from damaged petrochemical cargoes adds further stress, introducing heavy metals and chemical residues into the water column (Al-Majed et al., 2012).

Sensitive marine species—including green turtles (*Chelonia mydas*), hawksbill turtles (*Eretmochelys imbricata*), whale sharks (*Rhincodon typus*), and Indo-Pacific bottlenose dolphins (*Tursiops aduncus*)—are at risk from oil contamination and increased vessel traffic. Coral reefs in Muscat and Musandam, already stressed by warming waters, face compounded damage from oil slicks. Mangrove forests along Oman's coast,

dominated by *Avicennia marina*, are vulnerable to oil smothering, which can kill pneumatophores and reduce nursery habitat for fish and crustaceans (Spalding et al., 2010). Tourism in Oman, particularly scuba diving and dolphin-watching in Musandam, has collapsed due to conflict and ecological damage. Fisheries and aquaculture face reduced productivity from contamination of nursery grounds. Fujairah's role as a major oil storage and export hub outside the Strait of Hormuz further underscores the geopolitical importance of this corridor. Ecological damage undermines fisheries, desalination, and tourism, highlighting the intersection of geopolitical conflict, biodiversity loss, and global maritime trade disruption (UNESCWA, 2021).

Bahrain

The Iran–USA conflict has transformed Bahrain's coastal zone into a dual front of military risk and ecological crisis. Strikes on energy infrastructure have caused oil spills, toxic contamination, and habitat degradation, while the region's unique biodiversity—seagrass beds, mangroves, coral reefs, and pearl beds—faces mounting pressure. The overlap of geopolitical instability and environmental fragility underscores the urgent need for integrated marine governance and resilience planning (Sheppard et al., 2010). Bahrain hosts the US Navy's Fifth Fleet headquarters in Juffair, making it a focal point in the Iran–USA confrontation. Multiple missile and drone strikes have targeted military and energy infrastructure. On March 2, 2026, an Iranian missile was intercepted near Mina Salman Port, igniting the American oil tanker MT Stena Imperative. Strikes have also hit residential areas in Manama, including a March 10 incident that killed a civilian. A malfunctioning Patriot missile during interception efforts further damaged a residential neighborhood. In response, Bahrain imposed a maritime curfew from 18:00 to 04:00, restricting civilian, fishing, and leisure vessels (Greenpeace, 2026).

Attacks on energy facilities, including the BAPCO refinery complex, triggered oil spills and forced operational shutdowns. Fires at refineries released soot and sulphur compounds, producing “black rain” and toxic runoff into coastal waters. These pollutants severely impacted seagrass beds, coral reefs, and marine fauna already stressed by extreme Gulf conditions. Desalination plants face contamination risks, threatening freshwater security (Al-Majed et al., 2012). The Arabian Gulf ecosystem around Manama is highly productive yet vulnerable. Key habitats include the seagrass beds (*Halodule uninervis* and *Halophila* sp.) vital for endangered species and fish nurseries; mangroves (*Avicennia marina* at Ras Sanad, Tubli Bay), Bahrain's last natural stands, crucial for biodiversity and coastal protection; mudflats and coral reefs, supporting finfish, shellfish, and pearl oyster (*Pinctada radiata*) populations; the Hawar Islands and surrounding waters, hosting dugongs, green turtles, dolphins, and migratory shorebirds; and Tubli Bay, a critical feeding and roosting ground for wintering birds. The marine beds to the north and east are renowned for producing high-quality pearls, historically central to Bahrain's cultural and economic identity (Riegl & Purkis, 2012).

The ecological damage has undermined Bahrain's Blue Economy by disrupting provisioning services (fisheries, aquaculture, and pearl production), regulating services (coastal protection, carbon sequestration, and biodiversity support), and cultural services (tourism, heritage, and scientific research). The collapse of artisanal fisheries and threats to desalination plants highlight the intersection of ecological vulnerability and human security (UNESCWA, 2021).

Kuwait

The Iran–USA conflict has imposed severe geopolitical and ecological stress on Kuwait's coastal zone. Drone and missile strike have damaged critical infrastructure, induced oil spills, and disrupted shipping. The resulting pollution threatens mangroves, seagrass beds, coral reefs, fisheries, and protected species, while contamination from desalination plants endangers national water security. Persistent crude residues in sediments highlight the long-term ecological burden facing Kuwait's marine environment (Sheppard et al., 2010).

On February 28, 2026, Iran retaliated with drone and missile attacks targeting US bases, oil infrastructure, and commercial shipping. Kuwait reported multiple explosive incidents in its coastal waters and critical infrastructure. A tanker anchored 30 nautical miles southeast of Mubarak Al-Kabeer Port suffered a port-side explosion, causing a significant oil spill. Iranian drones and unmanned surface vehicles loaded with explosives targeted commercial ships, including the Kuwaiti crude tanker Al Salami in late March. Strikes damaged

desalination plants, power generation units, and oil facilities in Kuwait City and the Shuwaikh sector, prompting shipping companies to suspend services to Kuwaiti ports (Greenpeace, 2026). Tanker attacks in 2026 resulted in oil spills near Kuwaiti waters, including the incident southeast of Mubarak Al-Kabeer port that released toxic crude. Another tanker explosion in April 2026 caused leakage and raised fears of ecological catastrophe. Heavy crude spills threaten sensitive coastal ecosystems and are expected to persist in sediments for decades, complicating recovery. Fires and explosions released contaminants such as benzene, adding to marine and human health risks (Al-Majed et al., 2012).

Kuwait hosts the northernmost coral reefs in the Gulf, particularly around Kubbar and Qaru islands. These reefs, dominated by *Acropora* and *Porites* species, are vital nursery habitats for fish and shrimp. Seagrass meadows and mangrove stands provide critical feeding grounds for dugongs, dolphins, and sea turtles. Mudflats along the coast support migratory birds, including flamingos and herons. Oil contamination threatens these habitats by smothering benthic organisms, impairing turtle nesting, and reducing fish recruitment (Riegl & Purkis, 2012). Protected species—including green turtles (*Chelonia mydas*), hawksbill turtles (*Eretmochelys imbricata*), dolphins, and dugongs (*Dugong dugon*)—face heightened risks of ingestion or entrapment in oil slicks. Past incidents in the Gulf have shown high mortality rates among marine birds such as flamingos, underscoring the vulnerability of avifauna. Local fisheries face direct threats from habitat degradation, with declines in shrimp and finfish populations expected (UNEP, 2020).

Strikes near desalination plants, including the April 2026 attack on a Kuwaiti water treatment facility, jeopardize the source of nearly all potable water in Kuwait. Contaminants entering seawater complicate processing, threatening both human health and coastal ecosystems. This highlights the intersection of ecological vulnerability and national security (UNESCWA, 2021). Kuwait's economy is heavily dependent on oil exports and maritime trade. The ecological damage has disrupted fisheries, aquaculture, and shipping, undermining livelihoods and food security. Tourism linked to coral reefs and offshore islands has collapsed. The war has therefore undermined Kuwait's Blue Economy, affecting provisioning, regulating, and cultural ecosystem services (UNESCWA, 2021).

Qatar

The Iran–USA conflict has introduced acute geopolitical and ecological stress into Qatar's coastal and marine environment. Drone and missile strikes on energy and shipping infrastructure have caused oil spills, toxic contamination, and habitat degradation. Sensitive ecosystems—seagrass beds, mangroves, coral reefs, and mudflats—face mounting pressure, while desalination plants risk contamination that endangers national water security. The convergence of geopolitical instability and environmental fragility underscores the urgent need for resilience planning and integrated marine governance in Qatar (Sheppard et al., 2010). The confrontation has extended into Qatari waters, where the presence of US military facilities and energy infrastructure has made the country a strategic target. Retaliatory Iranian drone and missile strikes have threatened shipping lanes, offshore oil and gas platforms, and port facilities. Explosive incidents have been reported near Ras Laffan Industrial City and Hamad Port, raising concerns about the vulnerability of Qatar's liquefied natural gas (LNG) export terminals. Disruptions to maritime traffic have prompted precautionary restrictions on civilian and commercial vessels in Qatari waters (Greenpeace, 2026).

Attacks on tankers and offshore facilities have resulted in localized oil spills and hydrocarbon leakage into the Gulf. Fires at industrial sites released soot and sulfur compounds, contributing to atmospheric fallout and toxic deposition into coastal waters. These pollutants increase the risk of “black rain” and chemical contamination, placing immense stress on fragile marine ecosystems (Al-Majed et al., 2012).

Qatar's coastal zone supports diverse habitats, including seagrass meadows, mangrove stands, mudflats, and coral reefs. Oil contamination threatens nursery grounds for fish and shrimp, while protected species such as dugongs, turtles, and dolphins face risks of ingestion or entrapment in slicks. Migratory and resident seabirds are vulnerable to hydrocarbon exposure, with past Gulf incidents showing high mortality rates among flamingos and other avifauna. Coral reefs and seagrass beds, already stressed by high salinity and temperature extremes, face compounded degradation from oil spills and toxic runoff (Riegl & Purkis, 2012). Strikes near desalination plants and industrial water facilities pose a direct threat to Qatar's potable water supply, which

relies almost entirely on seawater processing. Hydrocarbon and chemical contamination complicates desalination, raising risks for human health and coastal biodiversity. This highlights the intersection of ecological vulnerability and national security (UNEP, 2020).

Qatar's Blue Economy—anchored in LNG exports, fisheries, and coastal tourism—has been disrupted by conflict. Oil spills and toxic contamination undermine provisioning services (fisheries and aquaculture), regulating services (coastal protection and carbon sequestration), and cultural services (tourism, heritage, and scientific research). The collapse of artisanal fisheries and threats to desalination plants emphasize the need for integrated resilience planning (UNESCWA, 2021).

Dubai

The UAE's coastal areas—particularly Dubai, Sharjah, and Fujairah—have become focal points of maritime attacks linked to the Iran–USA confrontation. On March 31, 2026, a Kuwaiti crude oil tanker was attacked in Dubai Port anchorage, sparking a fire attributed to Iranian forces. UK Maritime Trade Operations (UKMTO) reported multiple vessels struck by projectiles near the UAE coast, including a container ship 50 nautical miles northwest of Dubai on March 11. The UAE Ministry of Defence intercepted hundreds of Iranian missiles and drones, with debris falling into the sea and onto populated areas in Dubai and Abu Dhabi. Fires and damage were reported near Jebel Ali Port, Dubai International Airport, and oil storage tanks at Fujairah Port, producing extensive smoke plumes (Greenpeace, 2026).

Tanker attacks in the Gulf of Oman and Strait of Hormuz, including incidents near Mina Saqr, have released crude oil into waters drifting toward Dubai's coast. Oil spills suffocate coral reefs by blocking sunlight and inhibiting photosynthesis, while explosions and debris threaten mangroves, salt marshes, and intertidal systems. Strikes on port facilities and depots in Jebel Ali and Abu Dhabi have released petroleum products into sensitive coastal zones. Modern munitions, including sea mines and missiles, contribute heavy metals, dioxins, and toxic chemicals to the marine environment (Al-Majed et al., 2012).

Dubai's coastal ecosystems include mangroves, coral reefs, seagrass beds, and tidal mudflats, all of which provide essential services such as carbon sequestration, shoreline protection, and nursery habitats. The mangroves (*Avicennia marina*) are vital blue-carbon sinks. Large-scale projects such as Dubai Mangroves are capable of sequestering millions of tonnes of CO₂ annually, while protecting coastlines from erosion and supporting fisheries. The coral reefs, which are naturally limited by thermosaline stress, have resilient species distributed around this area. The Dubai Reef Project aims to deploy 20,000 reef modules across 600 km², enhancing fish biomass and biodiversity (Riegl & Purkis, 2012). The seagrass meadows are the extensive shallow-water beds that provide feeding grounds for green turtles (*Chelonia mydas*) and dugongs (*Dugong dugon*) while stabilizing sediments and filtering pollutants. The protected area Ras Al Khor Wildlife Sanctuary (Ramsar site) safeguards mangroves, mudflats, and salt flats, hosting over 450 migratory bird species, including flamingos. Jebel Ali Marine Protected Area preserves sea turtle habitats, particularly for endangered hawksbill turtles, and supports diverse coral ecosystems (Sheppard et al., 2010). Oil contamination and military debris threaten endangered turtles, dugongs, dolphins, and seabirds. Coral reefs face suffocation from hydrocarbon films, while mangroves and salt marshes are damaged by toxic fallout. Attacks on desalination infrastructure near Fujairah risk petroleum contamination of intake pipes, jeopardizing potable water supplies and coastal biodiversity (UNEP, 2020).

Dubai's Blue Economy—anchored in shipping, tourism, and coastal development—faces disruption from ecological degradation. Oil spills and toxic contamination undermine provisioning services (fisheries and aquaculture), regulating services (carbon sequestration and shoreline protection), and cultural services (tourism, heritage, and scientific research). The collapse of coral reef tourism and threats to desalination plants highlight the intersection of ecological vulnerability and human security (UNESCWA, 2021).

Abu Dhabi

Abu Dhabi's coastal and marine environment faces compounded risks from the Iran–USA conflict. Fires, oil spills, and toxic debris threaten mangroves, seagrass beds, mudflats, and coral ecosystems, while acoustic

disturbances endanger marine fauna. Seabirds, turtles, dolphins, and whale sharks are at heightened risk, and desalination plants face contamination that jeopardizes national water security. The possibility of nuclear contamination underscores the severity of ecological vulnerability in the Gulf (Sheppard et al., 2010). In April 2026, debris from intercepted missiles caused multiple fires in Ruwais Industrial City on Abu Dhabi's northwest coast. Strikes targeting Khalifa Port and other facilities damaged vessels, releasing fuel and pollutants into surrounding waters. Debris from missile interceptions also fell near Jebel Ali Port and Dubai International Airport, while drone strikes damaged oil storage tanks at Fujairah, producing extensive smoke plumes. Fires and explosions released toxic particles, heavy metals, and hydrocarbons into the atmosphere and sea (Greenpeace, 2026).

Oil slicks reaching intertidal systems such as mangroves and mudflats embed in sediments, creating medium-term ecological impacts. Seagrass beds, vital nurseries for fish and turtles, risk hydrocarbon accumulation that can be re-released when sediments are disturbed. Coral ecosystems, already stressed by high salinity and temperature extremes, face compounded degradation from oil contamination and debris fallout (Riegl & Purkis, 2012). Underwater explosions from sea mines and mid-frequency military sonar cause acoustic disturbances, rupturing internal organs in fish and damaging cetacean auditory systems. Oil spills destroy feather waterproofing in seabirds, leading to hypothermia and drowning, while toxic smoke plumes and noise disrupt migratory bird patterns. Surface feeders such as whale sharks (*Rhincodon typus*) are highly vulnerable to floating oil slicks (Al-Majed et al., 2012). Desalination plants cannot process oil-contaminated water; petroleum products damage reverse osmosis membranes, threatening potable water supplies. Potential damage to the Barakah Nuclear Power Plant raises risks of radioactive isotopes such as tritium and cesium entering the Gulf basin, where removal would be extremely difficult due to the semi-enclosed nature of the water body (UNEP, 2020).

Abu Dhabi's Blue Economy—anchored in shipping, fisheries, and tourism—faces disruption from ecological degradation. Oil spills and toxic contamination undermine provisioning services (fisheries and aquaculture), regulating services (coastal protection and carbon sequestration), and cultural services (tourism, heritage, and scientific research). The collapse of coral reef tourism and threats to desalination plants highlight the intersection of ecological vulnerability and human security (UNESCWA, 2021).

Saudi Arabia – Eastern Province (Jubail, Dammam, Ras Tanura)

On April 8, 2026, Iranian drones targeted oil refineries and petrochemical complexes in Saudi Arabia's Eastern Province. Explosions at Ras Tanura released petroleum products into the Arabian Gulf, while fires at Jubail produced toxic smoke plumes (Greenpeace, 2026).

The Eastern Province hosts mangrove forests, seagrass meadows, and turtle nesting beaches. Oil contamination threatens mangrove pneumatophores, reduces seagrass productivity, and disrupts turtle nesting. Hydrocarbon residues persist in sediments, complicating recovery. Migratory birds feeding along mudflats face reduced prey availability (Sheppard et al., 2010).

Socioeconomically, the region is central to Saudi Arabia's oil exports and fisheries. Ecological damage undermines livelihoods, desalination, and tourism while highlighting the vulnerability of coastal ecosystems to geopolitical conflict (UNESCWA, 2021). The location, event, impacts, and ecological/biological problems have been given in Table 1.

Location / Country	Event (2026)	Immediate Impacts	Ecological / Biological Problems
Khuran Strait, Iran	Drone carrier Shahid Bagheri leaking oil	20 km oil slick, contamination of Ramsar site	Mangrove mortality (<i>Avicennia marina</i>), turtle nesting disruption, bird habitat loss
Kharg Island, Iran	Missile strikes on oil export terminal	Crude oil spills, fires at storage facilities	Coral reef smothering, seagrass contamination, migratory bird habitat loss

Location / Country	Event (2026)	Immediate Impacts	Ecological / Biological Problems
Hormuz & Qeshm Islands, Iran	Drone and missile strikes on military/port facilities	Petroleum leakage, debris fallout	Mangrove pneumatophore damage, coral reef stress, migratory bird decline
Strait of Hormuz (Iran–Oman corridor)	Drone and explosive boat attacks on tankers	Hull breaches, crude oil leakage, missile debris	Coral reef suffocation, dolphin/whale acoustic disturbance, turtle feeding disruption
Basra / Umm Qasr, Iraq	Explosive attacks on tankers (Safesea Vishnu, Zefyros)	Naphtha & crude oil spills, fires	Acute toxicity to fish/plankton, benthic mortality, migratory bird decline
Kuwait	Drone & missile strikes on tankers (Al Salmi) and port	Heavy crude spills, desalination plant damage	Coral reef smothering (Kubbar/Qaru), dugong & turtle risk, flamingo mortality
Bahrain	Missile strikes near Mina Salman, refinery fires	Oil spills, “black rain”, toxic runoff	Seagrass & mangrove degradation, pearl oyster decline, desalination contamination
Qatar	Strikes near Ras Laffan LNG & Hamad Port	Hydrocarbon leakage, soot deposition	Seagrass nursery loss, dugong/turtle ingestion risk, avifauna mortality
Dubai, UAE	Tanker attack at Dubai anchorage, debris near Jebel Ali	Oil spills, heavy metal contamination	Coral reef suffocation, mangrove damage, turtle nesting disruption
Abu Dhabi, UAE	Fires at Ruwais, strikes at Khalifa Port	Hydrocarbon & heavy metal fallout, sonar disturbance	Seagrass hydrocarbon accumulation, cetacean auditory damage, whale shark vulnerability
Fujairah, UAE (Gulf of Oman)	Tanker explosions near port, fires at oil storage tanks	Crude oil spills, smoke plumes with heavy metals	Coral reef smothering, turtle feeding disruption, benthic contamination
Gulf of Oman (Oman coast)	Drone strike on tanker Prima near Strait of Hormuz	Oil slicks drifting to beaches, petrochemical leakage	Coral reef smothering, mangrove pneumatophore damage, dolphin & turtle mortality
Saudi Arabia – Eastern Province (Jubail, Dammam, Ras Tanura)	Drone strikes on refineries and petrochemical complexes	Petroleum spills, toxic smoke plumes	Mangrove pneumatophore damage, seagrass decline, turtle nesting disruption, bird prey loss

Table -1 Summary Table: Location, Event, Impacts, Ecological/Biological Problems

Recommendations for Ecological Recovery and Resilience

To address the compounded ecological and socioeconomic impacts of the Iran–USA conflict across the Gulf, a comprehensive program of restoration and resilience planning is required. Coral reef transplantation should be expanded through the establishment of nurseries and transplantation projects, following models such as the Dubai Reef Project, to restore degraded reef systems and enhance biodiversity. Location-specific initiatives must be prioritized, including coral regeneration at Kubbar and Qaru Islands in Kuwait, Musandam and Muscat in Oman, and reef patches near Kharg Island and the Strait of Hormuz.

Mangrove regeneration must be scaled up, particularly with the planting of *Avicennia marina* in RAMSAR-designated sites and degraded coastlines. Priority areas include the Hara Biosphere Reserve in Iran, Tubli Bay in Bahrain, Ras Al Khor in Dubai, and Jubail in Saudi Arabia. These efforts will strengthen blue-carbon storage, improve shoreline protection, and support fisheries. Similarly, seagrass restoration should be prioritized through transplantation and sediment stabilization initiatives, providing critical nursery habitats for dugongs, turtles, and fish species. Restoration programs are especially urgent in Qatar's Ras Laffan, Abu Dhabi's seagrass meadows, and Bahrain's pearl oyster beds.

Biodiversity health monitoring should be strengthened through regional programs that provide systematic health check-ups for large marine mammals such as dugongs, dolphins, and whale sharks. These programs should include veterinary interventions carried out by marine biologists, ensuring early detection of stress, disease, or injury and supporting long-term population resilience. Bird habitat regeneration must also be prioritized through the restoration of mudflats and wetlands, such as Tubli Bay in Bahrain and Ras Al Khor in Dubai, to support migratory bird populations. Where natural habitats have been lost, artificial roosting structures should be introduced to provide alternative resting and feeding grounds. Turtle nesting protection should be reinforced by conserving nesting beaches through regular patrols, hatchery programs, and the implementation of oil spill response protocols, ensuring the survival of vulnerable turtle populations across Oman, Kuwait, and Saudi Arabia.

Water quality and pollution control are essential for ecological and human security. Gulf-wide oil spill response capacity should be developed through joint rapid response units equipped with skimmers, dispersants, and bioremediation techniques. Desalination safeguards must be introduced, including pre-treatment systems to filter hydrocarbons before seawater enters desalination plants, thereby ensuring potable water security in Kuwait, Bahrain, and Saudi Arabia. Improving coastal water clarity will also support the recovery of tourism activities such as diving in Musandam, bird-watching in Bahrain, and dolphin-watching in Oman, while simultaneously enhancing ecosystem health.

Finally, the regeneration of the Blue Economy and community resilience must be prioritized. Fisheries, aquaculture, and pearl industries should be revitalized through habitat restoration and pollution control measures, particularly in Bahrain, Qatar, and Saudi Arabia. Tourism recovery programs should be promoted by linking eco-tourism to restored mangroves, coral reefs, and bird sanctuaries, thereby ensuring sustainable community livelihoods. Integrated marine governance should be established through a Gulf-wide ecological monitoring and governance framework under UNEP and UNESCWA, designed to coordinate restoration efforts, resilience planning, and conflict-sensitive environmental management. The location-wise solutions that directly respond to the ecological/biological problems have been listed in Table 2.

Location Country	Key Ecological Problems	Recommended Actions
Khuran Strait, Iran	Mangrove mortality, turtle nesting disruption, bird habitat loss	• Large-scale mangrove regeneration (<i>Avicennia marina</i>) • Turtle nesting patrols and hatcheries • Bird habitat restoration in Hara wetlands • Oil spill bioremediation and sediment clean-up
Kharg Island, Iran	Coral reef smothering, seagrass contamination, migratory bird habitat loss	• Coral transplantation near reef patches • Seagrass bed remediation • Migratory bird wetland regeneration • Long-term sediment monitoring
Hormuz & Qeshm Islands, Iran	Mangrove pneumatophore damage, coral reef stress, migratory bird decline	• Mangrove replanting and pneumatophore protection • Coral reef restoration projects • Bird sanctuary regeneration • Pollution control near port facilities
Strait of Hormuz (Iran– Oman corridor)	Coral reef suffocation, dolphin/whale acoustic disturbance, turtle feeding disruption	• Coral reef transplantation • Acoustic monitoring and sonar restrictions • Turtle feeding ground protection • Joint spill response units

Location Country	Key Ecological Problems	Recommended Actions
Basra / Umm Qasr, Iraq	Acute toxicity to fish/plankton, benthic mortality, migratory bird decline	• Emergency spill response with dispersants/skimers • Fish stock restocking programs • Wetland regeneration for migratory birds • Sediment health monitoring
Kuwait	Coral reef smothering, dugong & turtle risk, flamingo mortality	• Coral transplantation at Kubbar/Qaru islands • Dugong and turtle health monitoring • Flamingo mudflat regeneration • Desalination safeguard systems
Bahrain	Seagrass & mangrove degradation, pearl oyster decline, desalination contamination	• Seagrass transplantation (Halodule, Halophila) • Mangrove restoration at Ras Sanad/Tubli Bay • Pearl bed regeneration • Water quality improvement near refinery sites
Qatar	Seagrass nursery loss, dugong/turtle ingestion risk, avifauna mortality	• Seagrass meadow restoration near Ras Laffan • Dugong/turtle rescue programs • Birding area regeneration • LNG spill prevention systems
Dubai, UAE	Coral reef suffocation, mangrove damage, turtle nesting disruption	• Expansion of Dubai Reef Project • Mangrove regeneration at Ras Al Khor Sanctuary • Hawksbill turtle nesting site protection • Heavy metal cleanup from port debris
Abu Dhabi, UAE	Seagrass hydrocarbon accumulation, cetacean auditory damage, whale shark vulnerability	• Seagrass sediment remediation • Acoustic monitoring and sonar restrictions • Whale shark health checkups/tagging • Nuclear safety monitoring at Barakah plant
Fujairah, UAE (Gulf of Oman)	Coral reef smothering, turtle feeding disruption, benthic contamination	• Coral reef regeneration near Musandam • Turtle feeding ground monitoring • Heavy metal sediment clean-up • Tourism recovery through eco-diving
Gulf of Oman (Oman coast)	Coral reef smothering, mangrove pneumatophore damage, dolphin & turtle mortality	• Coral reef transplantation in Muscat/Musandam • Mangrove pneumatophore protection • Dolphin/turtle rehabilitation centers • Fisheries and aquaculture regeneration
Saudi Arabia – Eastern Province	Mangrove pneumatophore damage, seagrass decline, turtle nesting disruption, bird prey loss	• Mangrove replanting along Jubail/Dammam coasts • Seagrass restoration near Ras Tanura • Turtle nesting beach patrols • Bird habitat regeneration in mudflats

Table – 2 Location-wise solutions that directly respond to the ecological/biological problems

Legal Violations of Environmental and Ecological Standards

The Iran–USA conflict across the Gulf has not only triggered widespread ecological damage but has also resulted in systematic violations of binding legal provisions, standards, and guidelines at local, national, and international levels. These breaches underscore the failure to uphold obligations designed to protect marine ecosystems, biodiversity, wetlands, and migratory species.

At the international level, the United Nations Convention on the Law of the Sea (UNCLOS, 1982) has been repeatedly violated through pollution of semi-enclosed seas such as the Persian Gulf and Gulf of Oman, where tanker strikes and oil spills have compromised marine biodiversity and navigation safety. The Convention on Biological Diversity (CBD, 1992) has been flouted by the destruction of coral reefs, mangroves, seagrass beds, and critical habitats for species such as dugongs, turtles, and whale sharks. The Ramsar Convention on Wetlands (1971) has been breached in sites including the Hara Biosphere Reserve in Iran, Tubli Bay in Bahrain, and Ras Al Khor in Dubai, where oil contamination and habitat loss undermine wetland integrity.

Similarly, the Convention on Migratory Species (CMS, Bonn, 1979) and the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA, 1995) have been violated by the destruction of migratory corridors and feeding grounds for birds, dolphins, and turtles.

The International Maritime Organization (IMO) conventions have also been disregarded. The MARPOL Convention (1973/78), particularly Annex I on oil pollution and Annex II on noxious liquid substances, has been breached by repeated tanker explosions and petrochemical spills in Iraq, Kuwait, Oman, and Fujairah. Ballast water discharges from damaged vessels further contravene the Ballast Water Management Convention (2004), compounding ecological stress.

At the regional level, the Kuwait Regional Convention (1978) and its subsequent protocols on marine pollution (1989) have been undermined by cross-border oil spills and the lack of coordinated Gulf-wide emergency response mechanisms.

At the national level, multiple domestic environmental laws have been violated. Iran's Environmental Protection and Enhancement Act (1974) has been breached by oil leaks in Kharg Island and mangrove destruction in Qeshm. Iraq's marine pollution control provisions have failed to prevent contamination at Basra and Umm Qasr. Kuwait's Environmental Protection Law (2014) has been flouted by tanker strikes that compromised desalination plants and coral reefs. Bahrain's National Biodiversity Strategy has been undermined by refinery fires and toxic "black rain." Qatar's Environmental Protection Law (2002) has been breached by LNG facility spills affecting seagrass nurseries. The UAE's Federal Law No. 24 (1999) on Environmental Protection has been violated by tanker attacks in Dubai, Abu Dhabi, and Fujairah. Oman's Law on Conservation of the Environment and Prevention of Pollution (1982) has been breached by oil slicks in Musandam and the Gulf of Oman. Saudi Arabia's Environmental Law (2021) has been violated by refinery strikes in Jubail and Ras Tanura, which damaged mangroves, seagrass, and turtle nesting beaches.

Collectively, these violations demonstrate that the ecological crisis in the Gulf is not only an environmental catastrophe but also a profound breach of international, regional, and national legal frameworks. The failure to uphold these obligations highlights the urgent need for accountability, enforcement, and the strengthening of conflict-sensitive environmental governance mechanisms. Location-wise, legal violations have been listed in Table 3.

Location / Country	Ecological / Biological Problems	Legal Provisions & Standards Violated
Khuran Strait, Iran	Mangrove mortality, turtle nesting disruption, bird habitat loss	• UNCLOS (1982) – marine pollution in semi-enclosed seas • Ramsar Convention (1971) – Hara Biosphere wetlands • CBD (1992) – habitat destruction • Iran Environmental Protection Act (1974)
Kharg Island, Iran	Coral reef smothering, seagrass contamination, migratory bird habitat loss	• MARPOL (1973/78) – oil spill violations • CBD (1992) – reef and seagrass damage • CMS (1979) – migratory bird corridors • Iran national oil spill regulations
Hormuz & Qeshm Islands, Iran	Mangrove pneumatophore damage, coral reef stress, migratory bird decline	• Ramsar Convention – mangrove wetlands • AEWA (1995) – migratory water birds • UNCLOS – pollution control failures • Iran Environmental Law
Strait of Hormuz (Iran–Oman corridor)	Coral reef suffocation, dolphin/whale acoustic disturbance, turtle feeding disruption	• UNCLOS – pollution & navigation safety • CMS – cetacean/turtle protection • MARPOL Annex I & II – oil/chemical spills • IMO Ballast Water Convention (2004)
Basra / Umm Qasr, Iraq	Acute toxicity to fish/plankton, benthic mortality, migratory bird decline	• UNCLOS – pollution prevention • CBD – biodiversity loss • Iraq Marine Pollution Control Law • CMS – migratory bird protection

Location Country	Ecological / Biological Problems	Legal Provisions & Standards Violated
Kuwait	Coral reef smothering, dugong & turtle risk, flamingo mortality	• CBD – reef & dugong habitats • CMS – turtle & bird corridors • Kuwait Environmental Protection Law (2014) • MARPOL – tanker spill violations
Bahrain	Seagrass & mangrove degradation, pearl oyster decline, desalination contamination	• Ramsar Convention – Tubli Bay wetlands • CBD – pearl oyster beds • AEWA – migratory bird habitats • Bahrain National Biodiversity Strategy
Qatar	Seagrass nursery loss, dugong/turtle ingestion risk, avifauna mortality	• CBD – seagrass & dugong habitats • CMS – turtle & bird corridors • Qatar Environmental Protection Law (2002) • MARPOL – LNG spill violations
Dubai, UAE	Coral reef suffocation, mangrove damage, and turtle nesting disruption	• CBD – reef & mangrove habitats • Ramsar Convention – Ras Al Khor Sanctuary • CMS – turtle nesting protection • UAE Federal Law No. 24 (1999)
Abu Dhabi, UAE	Seagrass hydrocarbon accumulation, cetacean auditory damage, whale shark vulnerability	• CBD – seagrass & whale shark habitats • CMS – cetacean protection • UNCLOS – sonar disturbance • UAE Environmental Law
Fujairah, UAE (Gulf of Oman)	Coral reef smothering, turtle feeding disruption, benthic contamination	• MARPOL – tanker spill violations • CBD – reef & turtle habitats • CMS – migratory species corridors • UAE Federal Law No. 24 (1999)
Gulf of Oman (Oman coast)	Coral reef smothering, mangrove pneumatophore damage, dolphin & turtle mortality	• UNCLOS – pollution prevention • Ramsar Convention – mangrove wetlands • CMS – dolphin & turtle protection • Oman Law on Conservation (1982)
Saudi Arabia – Eastern Province	Mangrove pneumatophore damage, seagrass decline, turtle nesting disruption, bird prey loss	• CBD – mangrove & seagrass habitats • CMS – turtle & bird corridors • AEWA – migratory waterbirds • Saudi Environmental Law (2021)

Table -3 Location-wise legal violations

Pathways for Recovery and Regional Ecological Union

The ecological losses inflicted by the Iran–USA conflict across the Persian Gulf are severe, but they are not irrecoverable. Future recovery depends on a coordinated program of restoration, governance reform, and regional solidarity. Coral reefs, mangroves, seagrass meadows, and wetlands can regenerate if supported by science-based interventions, long-term monitoring, and pollution control. Fisheries, aquaculture, and pearl industries can be revitalized through habitat restoration, stock replenishment, and sustainable management practices. Tourism, once dependent on the Gulf’s biodiversity and coastal beauty, can rebound through eco-tourism initiatives linked to restored habitats and community-based conservation.

To ensure that these efforts are effective, Persian Gulf countries must move beyond fragmented national responses and establish a regional ecological union. Such a union would function as a cooperative platform for ecological governance, modeled on existing frameworks like the Kuwait Regional Convention (ROPME) but expanded to include conflict-sensitive environmental management. Under this union, Gulf states could:

- Create a Gulf-wide ecological monitoring system to track coral reef health, mangrove regeneration, seagrass productivity, and migratory species populations.
- Establish joint rapid response units for oil spills, chemical leaks, and maritime accidents, equipped with skimmers, dispersants, and bioremediation technologies.

- Develop shared biodiversity health programs, including veterinary interventions for dugongs, dolphins, and whale sharks, and coordinated patrols for turtle nesting beaches.
- Harmonize legal frameworks by aligning national environmental laws with international conventions (UNCLOS, CBD, Ramsar, CMS, AEWA), ensuring accountability and enforcement.
- Promote community resilience through cross-border eco-tourism, fisheries cooperation, and livelihood diversification, reducing vulnerability to future shocks.
- Institutionalize conflict-sensitive environmental governance, ensuring that ecological protection is insulated from geopolitical tensions and treated as a shared security priority.

By forming such a union, Gulf countries would not only recover ecological losses but also build a collective resilience framework that safeguards natural resources for future generations. This approach transforms ecological restoration into a cornerstone of regional peace, stability, and sustainable development.

A draft ToR for institutional mechanisms and organizational arrangements for the pathways for recovery and regional ecological union are indicated below:

Purpose

To establish a coordinated institutional framework that enables Gulf countries to jointly pursue ecological recovery, resilience, and long-term sustainability through a Regional Ecological Union.

Objectives

Institutional Integration: Develop cooperative structures that harmonize national policies with regional ecological priorities.

- **Organizational Coordination:** Create mechanisms for joint planning, monitoring, and implementation of ecological recovery programs.
- **Capacity Building:** Strengthen scientific, technical, and administrative capacities across member states.
- **Policy Alignment:** Facilitate convergence of environmental laws, standards, and enforcement mechanisms.

Resilience Pathways: Promote adaptive strategies for climate change, biodiversity loss, and marine ecosystem degradation.

Scope of Work

Governance Framework: Draft charters, bylaws, and protocols for the Regional Ecological Union.

Institutional Mechanisms:

Establish a Regional Council on Ecological Recovery (ministerial level).

Create technical working groups (marine ecosystems, pollution control, climate adaptation).

Set up a Regional Secretariat for coordination and knowledge management.

Organizational Arrangements:

- Define roles of national focal points.
- Develop joint monitoring and reporting systems.
- Establish funding and resource-sharing mechanisms.
- **Stakeholder Engagement:** Involve civil society, academia, and the private sector in consultative processes.
- **Knowledge Exchange:** Facilitate regional data platforms, joint research, and training programs.

Deliverables

- Draft institutional framework and organizational blueprint.
- Roadmap for phased implementation of the Regional Ecological Union.
- Policy recommendations for harmonization of ecological governance.
- Capacity-building plan and resource mobilization strategy.

Expected Outcomes

- Strengthened regional cooperation for ecological recovery.
- Enhanced resilience of Gulf ecosystems and communities.
- Institutionalized pathways for sustainable development and environmental security.

CONCLUSION

The Iran–USA conflict in the Persian Gulf has revealed the profound vulnerability of coastal and marine ecosystems to geopolitical instability. Across Iraq, Iran, Kuwait, Bahrain, Qatar, the United Arab Emirates, Oman, and Saudi Arabia, the war has triggered oil spills, chemical leaks, habitat destruction, and biodiversity loss. Coral reefs, mangroves, seagrass meadows, wetlands, and migratory corridors have all suffered damage, undermining fisheries, aquaculture, desalination, and ecotourism. These ecological crises are not isolated environmental events but systemic breaches of international conventions, regional agreements, and national laws designed to safeguard biodiversity and human security.

The evidence presented demonstrates that ecological degradation in the Gulf is both a scientific reality and a legal violation, with failures to uphold UNCLOS, CBD, Ramsar, CMS, AEWa, MARPOL, and national environmental laws. This dual dimension underscores the urgent need for accountability, enforcement, and conflict-sensitive governance.

Yet, the Gulf's ecological losses are recoverable. Restoration of coral reefs, mangroves, seagrass beds, and wetlands, combined with biodiversity health monitoring and pollution control, can rebuild resilience. Revitalization of fisheries, aquaculture, and pearl industries, alongside ecotourism linked to restored habitats, can regenerate the Blue Economy and community livelihoods. A Gulf-wide ecological union, built on shared monitoring, joint spill response, harmonized legal frameworks, and community-based conservation, offers a pathway to collective resilience.

Ultimately, ecological recovery in the Persian Gulf must be treated not as a secondary concern but as a cornerstone of regional peace and stability. Protecting natural resources is inseparable from protecting human security, economic prosperity, and cultural heritage. By uniting under a common ecological governance framework, Gulf states can transform the scars of conflict into an opportunity for cooperation, ensuring that the region's biodiversity and natural wealth are preserved for future generations.

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