



## ENVIRONMENTAL RISK MANAGEMENT ACTION PLAN





## **PREFACE**

*This Environmental Risk Management Action Plan was developed within the framework of the EcoMarinas project (STHB.02.02-IP.01-0006/23) of the Interreg South Baltic Programme as one of its key outcomes aimed at supporting sustainable and environmentally responsible marina management.*

The EcoMarinas project serves as a guidepost to help you implement eco-friendly measures in your marina - for the good of all of us and for the good of the sea.

The EcoMarinas project is a joint initiative of eight partner organisations from Poland, Lithuania, Sweden, and Germany, implemented under the Interreg South Baltic Programme 2021–2027. In response to the growing impacts of climate change and the environmental pressure from recreational boating, the project focuses on raising ecological awareness and equipping marina operators with the knowledge and tools needed to minimise environmental harm. The project runs from July 2024 to June 2027 and is led by Gdańsk Sports Center.

*This Environmental Risk Management Action Plan offers information intended solely to assist the reader in the methodologies and/or techniques discussed. It is the reader's responsibility to carry out their own assessment and seek professional advice, if needed. Information contained herein is considered relevant at the time of publication, but may become invalid due to subsequent legislation, regulations, standards, methods, and/or more up-to-date information. The reader assumes full responsibility for compliance.*

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## 1. Introduction

Growing environmental pressures related to climate change, anthropogenic pollution, biodiversity loss, resource depletion, and other factors emphasise the need for proactive environmental management strategies at the organisational level, including those implemented by marina operators. Even small marinas, despite their limited individual footprint, can affect aquatic ecosystems through various pressures, including nutrient loading, pollution, habitat alteration, noise, light, and the spread of non-indigenous species (Nixon, 1995; Floerl et al., 2009; Byrnes, Dunn, 2020). According to ISO 14001:2015, key environmental pressures include:

- **Water quality degradation:** Discharges of untreated or improperly managed wastewater, fuel residues, antifouling chemicals, and stormwater runoff can lead to nutrient enrichment, oxygen depletion, and contamination by hydrocarbons and heavy metals (Floerl et al., 2009; Nixon, 1995).
- **Sediment contamination:** Accumulation of fine particulates, microplastics, and chemical residues in marina basins can alter benthic habitats and affect sediment-dwelling organisms (Andrady, 2017; Turner, 2010).
- **Habitat modification:** Marina construction, including breakwaters, pontoons, and dredging, may alter hydrodynamics, substrate composition, and natural coastal features, impacting seagrass beds, shellfish grounds, and other sensitive habitats (Prista et al., 2022).
- **Biological impacts:** Vessel hull fouling, equipment transfer and ballast water contribute to the introduction and spread of invasive species, which can disrupt native communities and ecosystem functioning (Davidson et al., 2016; Floerl et al., 2009). Recreational boating also produces noise and light disturbances that can affect behavioural patterns of fish, birds, and invertebrates (Davies et al., 2014; Slabbekoorn et al., 2010).
- **Waste generation:** Improper disposal of plastics, packaging and other solid waste contributes to macroplastic and microplastic pollution, with risks of ingestion and entanglement for wildlife (Galgani et al., 2015; Andrady, 2011).

Consequently, Environmental Action Plans are widely recognised as essential tools for managing the cumulative impacts of marina activities by integrating preventive measures, operational controls, monitoring programmes, and stakeholder engagement to address both routine and accidental pollution sources (Ytreberg et al., 2021). Proactive environmental risk management also improves regulatory compliance, social acceptance, and the long-term sustainability of marina operations.

Therefore, this Environmental Risk Management Action Plan (ERMAP) has been developed to provide a structured and science-based framework for identifying, assessing, and mitigating environmental risks associated with the operation of small marinas, including marina basin waters, onshore infrastructure, vessel-related activities, maintenance operations and management practices

that may affect the aquatic environment. The plan follows the principles of ISO 14001:2015 and applies a risk-based approach to environmental management, supporting both regulatory compliance and continuous environmental improvement. It addresses key environmental risk categories relevant to small marinas, such as wastewater management, water quality protection, invasive species prevention, plastic pollution, hazardous substances, energy-related pollution, fire risk, and management-related risks.

## 1.1 Policy and Legal Framework

Environmental management in marinas is governed by a combination of international conventions, regional agreements, and European Union legislation designed to protect marine and freshwater ecosystems. These include International and Regional Frameworks:

- **MARPOL Convention:** The International Convention for the Prevention of Pollution from Ships (MARPOL) establishes global standards for the prevention of pollution from ships, including sewage, garbage, oil, and hazardous substances. Several MARPOL annexes are relevant to recreational vessels and marina waste reception facilities (IMO, 2023).
- **HELCOM (Helsinki Convention):** The recommendations provide a comprehensive framework for reducing pollution from land-based sources, shipping, and recreational boating in the Baltic Sea region, recognising marinas as important points for implementing nutrient reduction, waste management, and invasive species prevention measures (HELCOM, 2019).

and **European Union Regulatory Framework:**

- **Water Framework Directive (2000/60/EC):** Requires Member States to achieve good ecological and chemical status of surface waters, making marina-related pollution control a key component of local water management.
- **Marine Strategy Framework Directive (2008/56/EC):** Establishes measures to achieve Good Environmental Status (GES) of marine waters, including descriptors for eutrophication, marine litter, non-indigenous species, and underwater noise.
- **Invasive Alien Species (IAS) Regulation (EU) No 1143/2014:** Addresses prevention and management of invasive species, with relevance to recreational boating pathways.

These instruments collectively require marina operators to adopt preventive, monitoring, and reporting measures proportionate to their environmental risks (European Commission, 2020).

## 1.2 Certification of Eco-Marinas and Sustainable Marina

Eco-marina and sustainable marina certification schemes provide voluntary frameworks that complement regulatory requirements by promoting best environmental practices. Programs such as Blue Flag for Marinas, Clean Marina, and other eco-marina initiatives establish criteria that cover wastewater management, waste reduction, energy efficiency, biodiversity protection, and environmental awareness.

Scientific evaluations show that participating in environmental certification programmes leads to improved environmental performance, increased stakeholder awareness, and greater consistency in environmental management practices compared to non-certified facilities (Prista et al., 2022), thereby enhancing the marina’s reputation. It also helps align with ISO 14001 principles and facilitates benchmarking and continuous improvement.

### 1.3 Environmental Aspects and Risk Identification for ERMAP

Environmental aspects to be included in the Action Plan were identified through a systematic review of marina-related activities and infrastructure that interact with the aquatic environment, considering both routine operations and non-routine or emergency situations. The assessment drew on multiple information sources, including data from marina operators throughout the EcoMarinas project, scientific literature, and relevant international and regional regulatory frameworks, as well as operational characteristics typical of small marinas, such as limited water flushing and high seasonal use.

The identified aspects encompass wastewater discharges, handling of hazardous liquids, vessel maintenance activities, plastic waste generation, pathways for invasive species, energy-related pollution, fire risk, and management-related factors (Dailianis et al., 2024). Environmental risks within this Action Plan were subsequently determined using a structured risk assessment framework aligned with ISO 14001 principles and marina-specific guidance (ISO, 2015; HELCOM, 2019). The framework integrates:

- **Systematic Identification of Environmental Aspects:**
  - Reviewing routine and non-routine activities (vessel maintenance, cleaning, fuel handling, waste management);
  - Mapping potential interactions with water, sediments, habitats, and species.
- **Literature and Regulator:**
  - Incorporating scientific evidence on marina impacts (Dailianis et al., 2024; Ytreberg et al., 2021);
  - Considering legal obligations under MARPOL, HELCOM, and EU Directives (WFD, MSFD, IAS Regulation).
- **Qualitative Risk Assessment:**

Environmental risks were categorised using a likelihood–severity matrix approach. Each identified aspect was evaluated based on **Likelihood (L)** – the probability of occurrence of a specific environmental event, and **Severity (S)** – the magnitude of potential environmental consequences.

Score	Likelihood (L) Level	Description
1	Rare	Highly unlikely; may occur only in exceptional circumstances

2	Unlikely	Could occur occasionally
3	Possible	May occur under normal operational conditions
4	Likely occurs regularly or repeatedly	Occurs regularly or repeatedly
5	Almost Certain	Expected to occur frequently
<b>Score</b>	<b>Severity (S) Level</b>	<b>Description</b>
1	Negligible	No measurable environmental impact; fully contained onsite
2	Minor	Localised and short-term impact; rapid natural recovery
3	Moderate	Measurable water or habitat disturbance requiring management action
4	Major	Significant contamination, habitat disturbance, or regulatory non-compliance
5	Severe	Long-term or irreversible ecosystem damage or a major pollution incident

- **Risk Significance Criteria:**

- The quantitative representation of the scale of risk was calculated using the following formula:

$$\text{Risk Rating} = \text{Likelihood (L)} \times \text{Severity (S)}$$

- High-risk activities are defined by the combination of high likelihood and high potential environmental impact, legal compliance requirements, and sensitivity of affected habitats or species;
- Medium- and low-risk activities are managed proportionally, but monitored to ensure compliance and continuous improvement (ISO, 2015; EPA, 2021) .

Risk Score	Risk Level	Required Management Action
1-6	Low	Manage through routine operational procedures and monitoring
6-12	Medium	Implement mitigation measures and periodic review
12-20	High	Immediate operational controls and management supervision required
20-25	Extreme	Urgent corrective action, operational restrictions, or emergency planning required

This approach ensures that environmental risks associated with marina activities are systematically identified, assessed, and managed in accordance with international standards and regulations, promoting sustainable and responsible operations.

## 2. Wastewater Management

### 2.1. Environmental Risk Management for Marina Wastewater Systems

Recreational vessels generate two main types of wastewaters: blackwater (sewage), which contains pathogens, organic matter, and nutrients, and greywater from sinks, showers and galleys, which contains detergents, surfactants and organic material (Sutherland et al., 2018; Žutić et al., 2022; Perić et al., 2024). In addition, marina sanitary facilities produce wastewater from restrooms and showers that may contribute further pathogens and nutrients if not properly managed (EPA, 2021). Maintenance and wash-down areas are another significant source, generating contaminated wastewater containing oils, hydrocarbons, metals and cleaning agents (Ytreberg et al., 2021). If untreated or poorly controlled, these wastewater streams can lead to serious environmental impacts, including eutrophication and oxygen depletion in enclosed marina basins (Nixon, 1995; Dailianis et al., 2024), contamination with faecal indicator bacteria that pose public health risks (Sutherland et al., 2018) and localised chemical pollution that can harm benthic organisms (Ytreberg et al., 2021).

### 2.2. Wastewater Risk Assessment and Control Points

This section presents an environmental risk assessment matrix for wastewater-related activities within the marina, to calculate the scale of a risk and to prioritize appropriate control measures that are presented in a matrix:

**Wastewater Risk Matrix**

Activity / Source	Potential Environmental Impact	Likelihood (1–5)	Severity (1–5)	Risk Level	Control Measures
<b>Vessel blackwater discharge</b>	Pathogen contamination, eutrophication	4	5	High	Pump-out facilities, holding tanks, discharge prohibition
<b>Greywater discharge from vessels</b>	Nutrient loading, organic pollution	3	4	Medium–High	Education, greywater management policies
<b>Marina sanitary facilities</b>	Fecal contamination	2	4	Medium	Sewer connection, regular inspections
<b>Maintenance wash-down runoff</b>	Chemical contamination	3	4	Medium–High	Containment areas, oil-water separators
<b>Pump-out system failure</b>	Accidental sewage release	2	5	Medium–High	Preventive maintenance, emergency response plan

### **2.3. Good Practice Measures for Wastewater Management in Marinas**

To ensure effective wastewater management and minimise environmental risks, the marina should implement a comprehensive system of operational controls, emergency preparedness, and performance monitoring.

Infrastructure controls should include the installation and regular maintenance of accessible pump-out stations with sufficient capacity, the mandatory use of certified holding tanks or marine sanitation devices (MSDs) on vessels, and the connection of marina sanitary facilities to municipal wastewater treatment systems or approved on-site treatment units (Ytreberg et al., 2021; Perić et al., 2024). These physical measures must be reinforced by administrative controls, including strict marina rules prohibiting the discharge of untreated blackwater and greywater, environmental awareness training for staff and boat users, and the provision of clear signage and written procedures for proper wastewater handling (IWEco, 2021).

The marina must also be prepared to respond to emergencies such as accidental sewage discharges, pump-out system failures, and sanitary system overflows through immediate actions, including stopping the discharge, isolating affected areas where possible, notifying environmental authorities, and documenting and investigating incidents (EPA, 2021). Following any incident, corrective measures must be implemented to prevent recurrence, supported by enhanced environmental monitoring. Ongoing monitoring and measurement of marina waters—such as dissolved oxygen, nutrient concentrations, biochemical oxygen demand (BOD), and faecal indicator bacteria—are essential for evaluating wastewater impacts and the effectiveness of control measures (Dailianis et al., 2024). Compliance with all relevant national and local wastewater regulations is mandatory; thus far, performance must be documented through pump-out usage logs, monitoring records and incident action reports (EPA, 2021; IWEco, 2021).

## **3. Hazardous Liquids Management**

### **3.1 Environmental Risk Management for Hazardous Liquids in Marinas**

This section of the ERMAP presents a structured approach to identifying, assessing, and controlling environmental risks associated with the use and storage of hazardous liquids in small marina settings. The plan covers all fuel-dispensing facilities and fuel storage areas, as well as the oils, lubricants, and hydraulic fluids used by vessels. It also includes chemicals, solvents, antifouling products, and paints used during boat maintenance, and applies to marina staff, contractors, and recreational boat users who handle or may be exposed to these substances.

Small marinas routinely handle a range of hazardous liquids, including diesel and gasoline for vessel propulsion and generators; engine, transmission, and hydraulic oils; chemical solvents and cleaning agents, such as degreasers and antifreeze; and antifouling paints and thinners used during

hull maintenance. Research has shown that marinas often become localised hotspots of petroleum hydrocarbons and metal-containing residues due to the routine handling, storage, and transfer of these materials (Ytreberg et al., 2021).

If not properly managed, hazardous liquids present significant environmental risks. Leaks and spills of fuels and oils can introduce toxic hydrocarbons into marina waters, where they may persist in sediments and harm aquatic organisms (Neff et al., 2000). Inadequate handling and transfer practices can also lead to chronic low-level contamination that accumulates over time, particularly in enclosed marina basins with limited water circulation (Dafforn et al., 2015). In addition, chemical solvents and antifouling paints may release volatile organic compounds (VOCs) and biocides, posing risks to both marine ecosystems and human health (Turner, 2010). Even small spills can have disproportionate impacts in marina settings due to high vessel density and restricted water exchange (Ytreberg et al., 2021).

### 3.2 Hazardous Liquids Risk Assessment and Control Points

This section presents an environmental risk assessment matrix for hazardous liquids used and stored within the marina. This approach supports proactive decision-making and ensures that hazardous liquid handling is carried out in a manner that minimises harm to the marina environment.

#### Hazardous Liquids Risk Matrix

Activity / Source	Potential Environmental Impact	Likelihood (1–5)	Severity (1–5)	Risk Level	Control Measures
Fuel transfer to vessels	Hydrocarbon spills, water contamination	4	5	High	Controlled fueling procedures, drip trays, trained staff
Fuel storage tanks	Chronic leakage to soil/water	2	5	Medium–High	Secondary containment, inspections
Oil and lubricant handling	Sediment contamination	3	4	Medium–High	Bunded storage, spill kits
Chemical and solvent use	Toxicity, VOC emissions	3	4	Medium–High	Proper labeling, limited quantities
Maintenance area runoff	Mixed chemical pollution	3	4	Medium–High	Designated work areas, containment

### 3.3 Good Practice Measures for Hazardous Liquids in Marinas

To minimise the environmental risks associated with hazardous liquids, the marina should implement a comprehensive system of operational controls, spill-prevention measures, emergency-response procedures, and performance monitoring. All hazardous liquids must be stored in clearly labelled, sealed containers that are compatible with the substances they contain, and must be placed within secondary containment systems, such as bunds or trays, capable of holding at least 110% of the largest container volume, in accordance with environmental best-practice guidance (EPA, 2021).



*Figure 1 Schematic of a secondary containment system for hazardous liquid storage. Image generated by DALL-E 3, based on the authors' description (March 2026).*

Incompatible substances, including fuels and oxidising agents, should be stored separately to prevent dangerous reactions. During transfer and handling, fuelling, and chemical use, procedures should be followed as written to reduce overfilling, splashing, and accidental releases. Automatic shut-off nozzles, drip trays and absorbent pads must be used during fuel transfer, and on-site quantities of chemicals and solvents should be limited to operational needs only. These technical controls must be supported by training and awareness programs that ensure marina staff are competent in safe handling, spill prevention and emergency response, while boat owners are provided with guidance on proper onboard storage and use of fuels and oils (IWEco, 2021). Spill prevention and preparedness should be central to effective environmental protection. Spill kits should be maintained at fuelling stations, storage areas and maintenance zones, and routine inspections of tanks, hoses and fittings must be carried out to identify early signs of leakage. In the event of a spill, staff have to be instructed to immediately stop the source where it is safe to do so, contain the spill using absorbent materials or booms, prevent its spread to open water or drains, notify marina management and relevant authorities, and ensure that contaminated materials are

collected and disposed of correctly. Rapid and well-coordinated response is essential, as early containment significantly reduces the scale and severity of environmental damage (Neff et al., 2000). To strengthen emergency readiness, the marina must maintain active communication with local fire services, environmental authorities, and specialist spill response contractors. Marina layout plans indicating fuel storage locations, hazardous material areas, and access points must be shared with these agencies, and, where feasible, periodic joint drills or communication exercises should be conducted to ensure a coordinated and effective emergency response (EPA, 2021).

Ongoing monitoring and compliance are essential for evaluating performance and ensuring legal obligations are met. Hazardous liquid storage areas must be inspected regularly for signs of leakage or deterioration, and all spill incidents, near misses, and corrective actions must be formally recorded. Where appropriate, marina sediments and waters should be monitored for hydrocarbons or chemical residues to detect longer-term contamination (Dafforn et al., 2015). The marina should comply with all relevant national and local regulations relating to fuel storage and transfer, hazardous substance management, and spill reporting and response.

Finally, marina management should review this plan annually to assess spill trends, evaluate the effectiveness of existing controls and identify opportunities to reduce hazardous liquid use and associated risks. Corrective and preventive actions must be implemented as part of a continual improvement process, ensuring that environmental performance is progressively enhanced and long-term impacts on the marina ecosystem are minimised.

## 4. Water Quality Protection

### 4.1 Environmental Risk Management for Water Quality Protection

The main goal of this ERMAP section is to identify key water quality indicators, assess pollution pathways, implement effective mitigation measures, and ensure regular monitoring and reporting to prevent environmental degradation and protect marine ecosystems. Accordingly, the plan could be applied to marina basin waters and coastal zones; recreational vessel operations; marina infrastructure and drainage systems; and all boat maintenance and wash-down activities.

Small marinas are typically semi-enclosed systems with limited water exchange, making them particularly sensitive to pollution and water-quality deterioration. For this reason, a set of key indicators is used to evaluate marina-related impacts. Nutrients, particularly nitrogen and phosphorus, are introduced through wastewater, organic matter, and runoff and are primary drivers of eutrophication and harmful algal blooms in marina environments (Nixon, 1995; Dailianis et al., 2024). Turbidity and suspended solids increase due to sediment resuspension from vessel propeller wash, shoreline erosion, and maintenance activities, thereby reducing light penetration and negatively affecting benthic habitats (Bilkovic et al., 2019). Petroleum hydrocarbons, originating from fuel handling, engine operation, and small chronic spills, are toxic to aquatic organisms and tend to accumulate in marina sediments (Neff et al., 2000).

Pollution reaches marina waters through several interconnected pathways. Surface runoff from impervious areas such as docks, parking zones and boatyards transports nutrients, hydrocarbons, metals, and suspended solids directly into the basin, and is widely recognised as a major non-point source of marina pollution (EPA, 2021). Vessel movement within confined marina basins further contributes to water quality degradation through the resuspension of contaminated sediments, the release of hydrocarbons from bilge water and engine exhaust and increased turbidity caused by frequent manoeuvring and mooring operations (Ytreberg et al., 2021). In addition, boat maintenance activities—including hull cleaning, sanding, and wash-down—can introduce solids, paint particles, biocides and detergents directly into the aquatic environment if not properly contained or treated (Turner, 2010; Ytreberg et al., 2021).

### 4.2 Water Quality Risk Assessment and Control Points

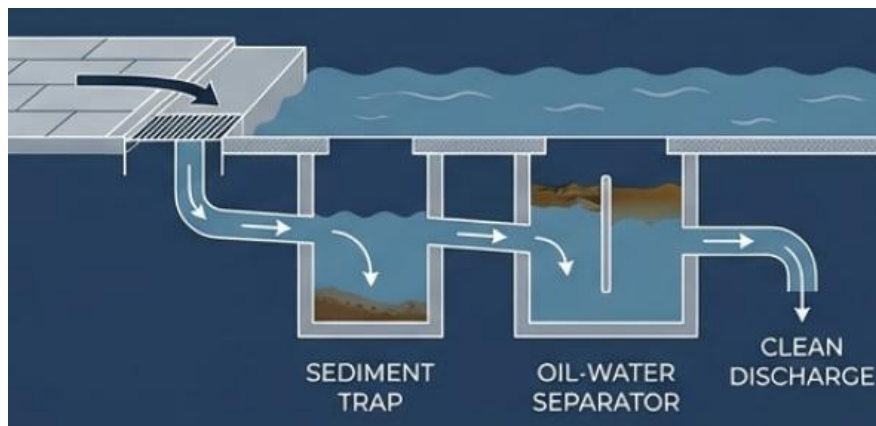
Water quality risks are assessed based on the likelihood of pollutant release and the severity of ecological impact. Thus far, water quality degradation in small marinas has been evaluated using a risk matrix. Enclosed marina basins exhibit higher vulnerability due to reduced flushing and prolonged pollutant residence times (Dailianis et al., 2024).

#### Water Quality Risk Matrix

Activity / Source	Potential Environmental Impact	Likelihood (1–5)	Severity (1–5)	Risk Level	Control Measures
<b>Surface runoff from docks and parking areas</b>	Nutrient and hydrocarbon loading	4	3	<b>High</b>	Sediment traps, oil-water separators, impermeable surfaces
<b>Vessel maneuvering and propeller wash</b>	Sediment resuspension, turbidity	3	3	<b>Medium</b>	Speed limits, basin design, operational controls
<b>Fuel handling and minor spills</b>	Hydrocarbon contamination	3	4	<b>High</b>	Spill kits, staff training, designated fueling areas
<b>In-water hull cleaning</b>	Release of paint particles and biocides	4	4	<b>High</b>	Cleaning restrictions, controlled maintenance areas
<b>Uncontrolled wash-down activities</b>	Increased turbidity and pollutant input	3	3	<b>Medium</b>	Contained wash-down zones, filtration systems

### 4.3 Good Practice Measures for Water Quality Control in Marinas

To protect marina and adjacent coastal waters, a combination of structural, operational and management measures should be implemented to minimize pollution and maintain high water quality standards. Structural and engineering controls should include the installation of sediment traps, oil-water separators, and filtration systems within drainage networks to intercept pollutants before discharge. Designated wash-down and maintenance areas should be equipped with containment and treatment systems to prevent direct release of contaminants into the marina.



*Figure 2 Schematic of a marina drainage treatment system with sediment trap and oil-water separator. Image generated by DALL-E 3, based on the authors' description (March 2026).*

Operational and best-practice measures complement these structural interventions. Eco-friendly maintenance practices should be promoted, such as the use of biodegradable detergents and non-toxic cleaning products, while in-water hull cleaning must be restricted in favour of controlled areas with runoff containment. Operational rules, including limitations on high-speed manoeuvring within marina basins, help reduce sediment resuspension and protect benthic habitats (Bilkovic et al., 2019).

A robust water quality monitoring program is essential to track environmental performance. Key indicators should include nutrient concentrations (total nitrogen and phosphorus), turbidity or total suspended solids, dissolved oxygen levels and hydrocarbon indicators. Scientific studies demonstrate that consistent monitoring is essential for detecting marina-related impacts and evaluating the effectiveness of mitigation measures (Dailianis et al., 2024). Monitoring data should be systematically recorded, and periodic water quality reports must be prepared for marina management and relevant regulatory authorities. These results are used to inform adaptive management decisions, guide operational improvements, and support continuous environmental performance enhancement.

Finally, management review and continuous improvement are integral components of the plan. Marina management shall review water quality performance annually, taking into account monitoring results, incidents and stakeholder feedback. Corrective and preventive actions should be implemented to reduce pollutant inputs, improve operational practices and strengthen the overall protection of marina and coastal waters.

## 5. Invasive Species Prevention

### 5.1 Environmental Risk Management for Invasive Species

Small marinas can serve as important nodes in coastal transport networks, facilitating the spread of non-indigenous species. Key pathways include hull fouling, where biofouling on recreational vessels transports invasive species between marinas and regions, particularly when cleaning and inspections are infrequent (Davidson et al., 2016; Floerl et al., 2009). Residual water in bilges, live wells and ballast compartments, especially on larger yachts, can carry larvae and microorganisms, even though most leisure vessels lack formal ballast tanks (Drake & Lodge, 2007). Furthermore, the movement of equipment such as anchors, ropes, fenders, diving gear and maintenance tools between different marine environments without proper cleaning can introduce invasive species (Clarke Murray et al., 2011).

In turn, this Environmental Risk Management Action Plan establishes an ISO 14001–aligned framework to prevent the introduction and spread of invasive aquatic species in small marinas serving leisure boats and yachts. It is designed to reduce ecological risks associated with recreational boating activities while ensuring compliance with national and regional biosecurity requirements. ERMAP could, therefore, be applied to visiting and resident recreational vessels, marina berths, pontoons, and submerged structures, as well as boat maintenance and cleaning activities and the transfer of equipment or materials between water bodies.

Local ecosystem vulnerability is influenced by the environmental similarity between source and recipient waters, the frequency and origin of visiting vessels, and the ecological sensitivity of habitats such as seagrass beds and shellfish areas. Semi-enclosed marina basins often provide favorable conditions for the establishment of invasive species due to sheltered waters and abundant artificial substrates (Floerl et al., 2009). Risks are assessed based on the likelihood of species introduction and the potential severity of ecological impacts, including competition with native species, habitat alteration, and long-term ecosystem degradation (Molnar et al., 2008).

### 5.2 Invasive Species Risk Assessment and Control Points

This section presents an environmental risk assessment matrix for effective biosecurity management. This approach enables marina management to focus resources on the highest-risk pathways, ensuring that preventive measures such as inspections, cleaning protocols, and user awareness programs are applied where they are most needed to protect local ecosystems.

#### Invasive Species Risk Matrix

Activity / Source	Potential Environmental Impact	Likelihood (L)	Severity (S)	Risk Level	Control Measures
Hull fouling on visiting vessels	Introduction of invasive species	4	4	High	Regular inspections, cleaning guidance, antifouling management

<b>Equipment transfer between water bodies</b>	Species spread between sites	4	4	<b>High</b>	Cleaning and drying protocols, user awareness
<b>Residual bilge or ballast water</b>	Transfer of larvae and microorganisms	3	3	<b>Medium</b>	Drain-and-dry procedures, signage
<b>Submerged marina structures</b>	Establishment of invasive colonies	3	3	<b>Medium</b>	Periodic inspection, maintenance planning

### 5.3 Good Practice Measures for Invasive Species Prevention

To minimise the risk of the introduction of invasive aquatic species, the marina should implement a combination of operational prevention measures, awareness initiatives and coordinated biosecurity management. Operational measures may include clean–drain–dry protocols for vessels and equipment entering the marina, routine hull inspections and maintenance, particularly for vessels arriving from other regions, and restrictions on in-water cleaning activities where biofouling material could be released. These practices reduce the likelihood of species transfer while supporting overall ecosystem protection.

Awareness and communication play a key role in effective prevention. Educational materials and signage should be provided to inform boat owners, visitors, and marina staff about the risks of invasive species and best-practice prevention strategies. Training programs and outreach campaigns are good practices to engage the marina community and encourage compliance with recommended protocols (Davidson et al., 2016).

Coordination with biosecurity authorities ensures alignment with national and regional regulations. The marina maintains active communication with environmental and biosecurity agencies, supports reporting procedures for suspected invasive species sightings and ensures that marina practices are consistent with national invasive species strategies and action plans.

Finally, monitoring, review and continuous improvement are integral to maintaining effective biosecurity. Periodic inspections must be conducted on submerged structures and high-risk vessels; incidents involving invasive species or near-misses should be reviewed during management evaluations. Prevention measures should be updated based on monitoring results, scientific advances and regulatory changes, supporting adaptive management and continual improvement in protecting local ecosystems.

## 6. Plastic Pollution Management

### 6.1 Environmental Risk Management for Plastic Pollution

This Environmental Risk Management Action Plan (ERMAP) establishes an ISO 14001–aligned framework for preventing and managing plastic pollution in small marinas serving leisure boats and yachts. The plan addresses both macroplastic and microplastic pollution sources, identifies associated environmental risks and outlines operational controls necessary to protect marine ecosystems. It applies to recreational vessels and their users, marina operational and maintenance activities, onshore visitor areas and waterfront zones, as well as marina basin waters, sediments, and close coastal areas.

Plastic pollution in small marinas arises from multiple sources. Recreational vessels contribute to pollution through the loss or improper disposal of packaging, disposable items, synthetic ropes, fishing gear, and protective covers during routine boating activities (Andrady, 2011). Marina operations generate plastic waste from maintenance materials, shrink wrap, containers and other consumables used during vessel servicing. Visitors and onshore activities also represent a significant source of plastic input, particularly single-use plastics associated with tourism and recreational use of marina facilities, with impacts amplified during peak seasons (Galgani et al., 2015).

Microplastic generation in marina environments occurs through several mechanisms. Mechanical cleaning of hulls and decks releases plastic particles from paints, coatings, and polymer-based materials. Abrasion and wear of synthetic ropes, fenders, and dock components further contribute to microfiber release through repeated mechanical stress and weathering (Andrady, 2017). Scientific studies indicate that small marinas serve as hotspots for microplastic accumulation due to limited water exchange and proximity to multiple plastic sources (Turner, 2010).

### 6.2 Plastic Pollution Risk Assessment and Control Points

Environmental risks associated with plastic pollution in small marinas are evaluated using a qualitative likelihood–severity risk matrix. This assessment supports prioritisation of preventive and corrective actions in line with ISO 14001 risk-based thinking.

**Plastic Pollution Risk Matrix:**

Source / Activity	Potential Environmental Impact	Likelihood (L)	Severity (S)	Risk Level	Control Measures
Improper waste disposal from vessels	Macroplastic release – ingestion and entanglement of fauna	4	3	<b>High</b>	Waste bins on pontoons, signage, user awareness

<b>Visitor-related littering</b>	Shoreline plastic accumulation – habitat degradation	4	4	<b>High</b>	Awareness signs, routine inspections
<b>Marina maintenance activities</b>	Debris entering marina waters	3	3	<b>Medium</b>	Waste segregation, staff procedures
<b>Boat cleaning and hull abrasion</b>	Sediment contamination	3	4	<b>High</b>	Controlled cleaning practices, product selection
<b>Wear of synthetic ropes and fenders</b>	Chronic microplastic input	2	3	<b>Medium</b>	Equipment management, replacement planning

### 6.3 Good Practice Measures for Plastic Waste Management and Pollution Prevention

To minimise plastic pollution in marina environments, a combination of improved waste management, user awareness, and active stakeholder engagement must be implemented. Waste management improvements include clearly labelled waste sorting and recycling stations that must be easily accessible to both boat users and visitors. Dedicated collection points may be provided for specific plastic items such as ropes, nets, and shrink wrap, and regular removal and maintenance of these facilities will ensure effective operation and reduce the risk of environmental leakage.

Awareness and behavioural measures support these structural improvements. Signage shall be installed throughout marina areas to educate users on plastic reduction and proper waste disposal practices. Marina staff and boat owners should be encouraged to minimise single-use plastics and securely manage on-board waste to prevent accidental loss into marina waters.

Waterfront clean-up and stakeholder involvement are critical components of pollution prevention. Routine protocols must be implemented for the cleanup of docks, waterfront areas, and the marina seabed, with active participation from boat owners, marina staff, local communities, and non-governmental organisations. Collected waste should be documented by type and quantity to help identify major pollution sources and guide ongoing improvement initiatives (Galgani et al., 2015). Finally, monitoring, review and continuous improvement ensure the effectiveness of these measures. Periodic inspections of marina waters, facilities and operational areas may be conducted to detect plastic pollution. Data from cleanup activities and pollution incidents must be reviewed during management evaluations, and prevention measures updated based on monitoring results, emerging scientific knowledge, and evolving best practices. This adaptive approach supports continual improvement in environmental performance and the protection of marina ecosystems.

## 7. Additional Environmental Risks

### 7.1 Environmental Risk Management for Additional Environmental Risks

This Environmental Risk Management Action Plan (ERMAP) addresses additional environmental risks in small marinas that extend beyond direct water pollution, including fire hazards, energy-related disturbances such as noise, light, and electromagnetic interference, and management-related factors that could compromise environmental protection measures. Aligned with ISO 14001, the plan supports a holistic Environmental Management System (EMS) covering marina infrastructure and utilities, fuel storage and electrical systems, operational management and staff activities, and coordination with emergency services and regulatory authorities.

Fires in marina environments can have significant secondary impacts, including the release of toxic gases, particulate matter and combustion by-products from fuels, plastics, and composite vessel materials, as well as contaminated runoff from firefighting water containing fuel residues and oils, which can cause acute toxicity to aquatic life (Babrauskas, 2016; Moody & Martin, 2017).

In addition to traditional water quality and pollution risks, small marinas can generate environmental disturbances related to:

- **Noise Pollution** - Noise generated by vessel engines, generators, maintenance equipment, and marina operations can disturb wildlife and reduce visitor experience. Chronic noise exposure has been shown to alter fish behavior and interfere with marine mammal communication (Slabbekoorn et al., 2010).
- **Light Pollution** - Artificial lighting in marinas contributes to light pollution, disrupting natural circadian rhythms and behavior of marine and coastal species, particularly fish, seabirds, and invertebrates (Davies et al., 2014).
- **Electromagnetic Disturbance** - Submerged power cables, shore power systems, and electrical infrastructure generate electromagnetic fields (EMFs) that may affect sensitive species, which use electroreception for navigation and foraging (Gill et al., 2012).

These factors can negatively affect marine and coastal ecosystems as well as the recreational experience of marina users.

Effective environmental management in small marinas depends not only on technical controls but also on robust organisational systems and practices. Policy and training deficiencies—such as unclear environmental policies, poorly defined responsibilities, or insufficient staff training—can undermine the effectiveness of environmental controls and increase the likelihood of pollution incidents (ISO, 2015). Operational coordination risks also pose significant challenges; a lack of consistent procedures within the marina or across multiple facilities can lead to variable environmental performance and potential non-compliance with regulations. Furthermore, alignment with recognised environmental standards and certification programs, including ISO 14001, Blue Flag, and Clean Marina initiatives, is critical. Failure to adopt and maintain these

standards can increase both reputational and environmental risks, while limiting opportunities for continuous improvement and stakeholder confidence.

Addressing these management-related risks through clear policies, coordinated operational procedures, staff training, and adherence to certification requirements is essential for ensuring the overall effectiveness of a marina’s Environmental Management System (EMS).

## 7.2 Additional Risk Assessment and Control Points

This section evaluates additional environmental risks in small marinas using a risk assessment matrix, which enables the prioritisation of management actions with the resulting risk level guiding the selection of appropriate control and mitigation measures. The matrix provides a structured approach to identify high-priority risks and ensures that resources are directed toward preventing significant environmental impacts while supporting continual improvement.

### Additional Environmental Risk Matrix

Activity / Source	Potential Environmental Impact	Likelihood (L)	Severity (S)	Risk Level	Control Measures
<b>Fire risk</b>	Air pollution, contaminated runoff due to fuel storage, electrical faults	3	4	<b>High</b>	Fire prevention systems, emergency plans
<b>Noise pollution</b>	Wildlife disturbance due to engines, generators, maintenance	3	3	<b>Medium</b>	Quiet-hour policies, equipment maintenance
<b>Light pollution</b>	Behavioral disruption of fauna	3	3	<b>Medium</b>	Shielded lighting, timers
<b>Electromagnetic disturbance</b>	Impacts on sensitive species due to shore power and cables	2	3	<b>Low – Medium</b>	Cable design and placement controls
<b>Management deficiencies</b>	Increased incident probability due to the lack of training or procedures	3	4	<b>Medium – High</b>	EMS training, audits, certification



### **7.3 Good Practice Measures for Additional Environmental Risks**

To effectively manage additional environmental risks, marinas should implement a continuous monitoring and review program. Incidents related to fire, noise, lighting, and management performance should be systematically recorded and analysed to identify trends and areas for improvement.

Given the proximity of fuel, vessels and water bodies, even small fires can cause disproportionately severe environmental damage. To mitigate these risks, marinas should implement proper fuel storage, regular electrical inspections and strict no-smoking policies; maintain fire detection and suppression systems suited to their infrastructure; develop coordinated emergency response plans with local fire brigades and environmental authorities; and conduct periodic staff training and fire drills to ensure rapid response and minimise environmental impacts. To prevent light pollution and electromagnetic disturbance, marina operators should implement quiet-hour policies and maintain low-noise equipment, use directional, shielded and low-intensity lighting with timers or motion sensors and apply best practices for cable installation and electrical infrastructure to minimise EMF exposure

Environmental performance should be evaluated regularly during management reviews and emergency plans, operational procedures, and staff training programs should be updated based on lessons learned, emerging best practices, and changes in regulatory requirements. This approach ensures that risks are proactively managed and that the marina's Environmental Management System remains adaptive and continuously improving.



## 8. Conclusions and Implementation Roadmap

### 8.1. Implementation Roadmap process

The analysis presented throughout this document confirms that, although small marinas individually represent relatively limited sources of pollution, their cumulative and localised impacts can be significant, particularly in semi-enclosed or environmentally sensitive waters. Without systematic risk management, these pressures may lead to long-term degradation of water quality, biodiversity loss and reduced ecosystem resilience.

Implementation of the measures outlined in this Action Plan will:

- Reduce the likelihood and severity of pollution incidents.
- Support compliance with international, regional and national environmental regulations.
- Improve consistency and effectiveness of marina operational practices.
- Enhance environmental awareness among marina users and staff.
- Strengthen the long-term sustainability and social acceptance of marina operations.

The Action Plan is designed to be scalable and adaptable, allowing marina operators to tailor measures to local environmental conditions, marina size, and available resources while remaining aligned with ISO 14001 principles and eco-marina certification schemes.

To support practical application, the Action Plan is structured into three progressive phases:

#### **Phase 1: Short-Term Actions (0–6 months)**

Priority actions focusing on immediate risk reduction and organisational readiness include:

- Formal adoption of the Environmental Risk Management Action Plan by marina management.
- Assignment of environmental roles and responsibilities.
- Staff training on key environmental risks, emergency procedures, and operational controls.
- Installation of basic infrastructure (e.g. spill kits, waste sorting bins, signage).
- Establishment of coordination protocols with local authorities and emergency services.

#### **Phase 2: Medium-Term Actions (6–24 months)**

Actions aimed at strengthening operational controls and monitoring include:

- Implementation of routine environmental monitoring programs (e.g. water quality, waste generation).
- Upgrading infrastructure where required (e.g. containment systems, drainage improvements).
- Standardisation of operational procedures across marina activities.
- Launch of marina user awareness and engagement initiatives.
- Internal audits to assess the effectiveness of implemented measures.

#### **Phase 3: Long-Term Actions (24 months and beyond)**

Long-term actions focus on consolidation, optimisation and strategic improvement:

- Integration of the Action Plan into a formal Environmental Management System (EMS).

- Alignment with ISO 14001 certification or eco-marina schemes (e.g. Blue Flag, Clean Marina).
- Continuous performance benchmarking and data-driven improvement.
- Periodic review of environmental objectives in response to regulatory or environmental changes.

## 8.2. Roles and Responsibilities

Effective implementation of the Action Plan requires clear allocation of roles and responsibilities among relevant stakeholders. Marina management holds overall accountability for implementation, including providing necessary resources and ensuring regulatory compliance. Where designated, an Environmental Coordinator is responsible for the day-to-day oversight of environmental monitoring, reporting and staff training activities. Marina staff are responsible for applying operational controls in daily activities and reporting environmental incidents or irregularities. Marina users and contractors are expected to comply with established environmental rules and follow best operational practices within the marina area. In addition, relevant authorities and emergency services provide support through regulatory oversight and coordinated response in the event of environmental emergencies.

## 8.3. Monitoring, Review, and Continuous Improvement

Progress in implementing the Action Plan shall be evaluated through periodic review of environmental monitoring data and incident records, as well as through internal audits and management reviews. The evaluation process will also include assessments of compliance with applicable regulatory requirements and voluntary environmental standards, as well as feedback from relevant stakeholders and authorities. The findings from these reviews will support the identification of corrective and preventive actions, ensuring that the Action Plan remains effective, relevant and responsive to evolving environmental challenges and scientific knowledge.

## 8.4. Final Remarks

This Environmental Risk Management Action Plan (ERMAP) provides a comprehensive, structured, and ISO 14001-aligned framework for identifying, assessing, and managing the key environmental risks associated with small marinas serving leisure boats and yachts. By addressing a broad range of environmental pressures, including wastewater and hazardous substances, water quality degradation, invasive species, plastic pollution, energy-related disturbances, fire risk and management-related challenges, the Action Plan responds to both regulatory requirements and scientific evidence on marina-related impacts on aquatic ecosystems.



The Environmental Risk Management Action Plan presented in this document provides a practical pathway for small marinas to transition from reactive environmental management toward a preventive, structured, and sustainable approach aligned with ISO 14001 principles. Through systematic implementation and continuous improvement, marina operators can play a meaningful role in protecting aquatic environments while supporting safe and responsible recreational boating. By systematically implementing this Action Plan, small marinas can protect local aquatic ecosystems, strengthen regulatory compliance and social acceptance and support the long-term sustainability of recreational boating.

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