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**ΘΑΛΑΣΣΙΑ ΑΠΟΡΡΙΜΜΑΤΑ: Ανθρωπογενή Στερεά  
Απόβλητα στη Μεσόγειο Θάλασσα και τις Ακτές της.  
Αφθονία, Σύσταση και Προσδιορισμός Πηγών**

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**MARINE LITTER: Man-made Solid Waste Pollution  
in the Mediterranean Sea and Coastline.  
Abundance, Composition and Source Identification**

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## ΠΕΡΙΛΗΨΗ

Θαλάσσια απορρίμματα ονομάζεται κάθε επίμονο, τεχνητό ή επεξεργασμένο στερεό υλικό που έχει απορριφθεί ή εγκαταλειφθεί στο θαλάσσιο και παράκτιο περιβάλλον. Τα θαλάσσια απορρίμματα απαρτίζονται από διάφορα υλικά (πλαστικά, συσκευασίες, αλουμίνιο, μέταλλα, δέρματα, κ.λπ) που χρησιμοποιούνται καθημερινά από τους ανθρώπους, τα οποία είτε απορρίπτονται απευθείας στη θάλασσα και τις ακτές είτε καταλήγουν εκεί εμμέσως (π.χ. μέσω των ποταμών, των αγωγών διάθεσης λυμάτων, της απόπλυσης εδαφών ή μεταφέρονται μέσω δράσης του ανέμου). Τα θαλάσσια απορρίμματα προέρχονται κατά 80% από χερσαίες πηγές και δραστηριότητες το 20% από θαλάσσιες. Η Μεσόγειος θάλασσα έχει ιδιαίτερο πρόβλημα με τα θαλάσσια απορρίμματα και τις επιπτώσεις τους στη βιοποικιλότητα και την ποιότητα των νερών της. Υπολογίζεται ότι 7 εκατομμύρια τόνοι απορριμμάτων καταλήγουν στις θάλασσες.

Τα θαλάσσια απορρίμματα στις θάλασσες και στις παράκτιες περιοχές, πέρα από τις αισθητική επιβάρυνση του περιβάλλοντος, έχουν σοβαρές περιβαλλοντικές, οικονομικές και κοινωνικές επιπτώσεις. Επίσης, τα απορρίμματα αυτά λόγω της τοξικότητας των υλικών τους και της διάλυσης στο νερό αποτελούν απειλή και για τη δημόσια υγεία. Από το σύνολο των μελετών που έχουν ασχοληθεί με το πρόβλημα των απορριμμάτων, πολύ λίγες είναι εκείνες που ερευνούν τις οικονομικές επιπτώσεις. Τα πολυμερισμένα υλικά (είδη πλαστικών και συσκευασίες) έχουν ιδιαίτερη σημασία για το θαλάσσιο περιβάλλον και ως απόβλητα γίνονται διεθνείς εκστρατείες για την περισυλλογή τους πριν καταλήξουν στο θαλάσσιο περιβάλλον ή και μετά με ειδικές περιβαλλοντικές δράσεις σε θαλάσσιες περιοχές και ακτές.

Οι τοξικές χημικές ουσίες που απαρτίζουν τα θαλάσσια απορρίμματα διαλύονται και εκχυλίζονται από το νερό, εισχωρούν στην τροφική αλυσίδα και

σε ιστούς θαλασσίων ειδών. Επίσης, πολλά θαλάσσια ζώα εγκλωβίζονται ή καταπίνουν κομμάτια των απορριμμάτων προκαλώντας θάνατο από ασφυξία ή δηλητηρίαση και τραυματισμούς.

Την τελευταία δεκαετία το σοβαρό πρόβλημα των θαλάσσιων απορριμμάτων έχει αναγνωρισθεί και με συντονισμένες εκστρατείες έχουν γίνει προσπάθειες για τη μείωσή τους και την περισυλλογή τους από τις ακτές. Στο άρθρο αυτό ανασκόπησης περιγράφονται, μέσω της διεθνούς βιβλιογραφίας, οι κυριότερες πηγές αποβλήτων στις θάλασσες, το είδος των αποβλήτων και η αφθονία τους. Επίσης αναλύονται οι περιβαλλοντικές επιπτώσεις και τα προβλήματα με τους θαλάσσιους ζωντανούς οργανισμούς. Στην περίπτωση των εκστρατειών και νομοθεσίας περιγράφονται οι υπάρχουσες δράσεις και τα διεθνή δεδομένα για τον περιορισμό των θαλάσσιων απορριμμάτων.

## **Abstract**

Marine litter (marine waste, garbage or debris), is every type of man-made solid waste which deliberately or accidentally pollute rivers, lakes, seas and coastlines. Marine litter is found in all the world's oceans and seas, even in remote areas. Marine solid waste can float on the sea surface or sink on the seafloor and some can be washed on sea coastlines (beach-litter). Marine litter can spread very easily to the coastline as a result of marine transport, tourism and uncontrolled discharge of municipal waste in illegal landfills. Marine litter has become a serious pollution problem in all regional seas, including the Mediterranean Sea and coastal waters and shores...

The increasing use of plastic materials in the last decades, replacing wood, metal and leather, and their low biodegradability, has influenced substantially the spread of marine litter. Waterborne plastic waste poses a serious threat to marine biota. Seabirds, fish, marine reptiles and mammals can be damaged or killed by plastic debris, as well as plastic nets and fishing items. Ocean dumping, accidental container spillages, municipal litter washed into storm drains and wind-blown solid waste (paper, plastic, etc) from urban areas and waste landfills contribute to the marine litter.

Marine litter became such an urgent pollution issue that from the 1980s the United Nations Joint Group of Experts on the Scientific Aspects of Marine Pollution initiated research on abundance, composition and sources. In 1991 their Report estimated that up to 80% of the pollution by litter was land-based. Marine debris consist of a wide variety of anthropogenic industrial items, such as plastic bags, balloons, buoys, rope, medical waste, glass and plastic bottles, cigarette lighters, beverage cans, styrofoam, lost fishing line and nets, wooden and metallic items. Cruise ship and fishing boats produce litter which is commonly found to have washed ashore or on the bottom of the seafloor.

The continuous growth in the amount of solid waste thrown away, and the slow rate of its degradation in water, are leading to a gradual increase in marine litter found at sea, on the sea floor and coastal shores. It is very difficult to estimate the amount and type of marine litter. Some preliminary studies estimate that over more than 7 million tonnes of marine litter reach all oceans and regional seas each year. Marine litter is an economic, environmental, human health and aesthetic problem posing a complex and multi-dimensional challenge to authorities and environmental groups.

The greatest sources of marine litter are land-based activities, including: wastes released from dumpsites near the coast or river banks; the littering of beaches; tourism and recreational use of the coasts; fishing industry activities; and ship-breaking yards.

Studies have shown that 80% of marine debris is plastic items. Plastic litter accumulate in the seas because of its slow biodegradability. The ecological Impact of marine litter is very important. Although there are no precise studies, it is estimated that around several hundred thousand birds and more than 100.000 marine mammals die each year from becoming entangled in plastic bags and nets, or ingesting marine litter (especially plastic and metal items).

We present a comprehensive report on marine litter in the oceans and regional seas. From international and national reports we present statistical data of the sources, abundance, distribution and recent measures to reduce its volume with emphasis on the protection of the environment and the marine ecosystems and marine biota. Also, we reviewed extensively research papers and reports concerning marine litter the Mediterranean Sea and efforts to mitigate its impact. Finally, we provide an extensive presentation of international laws, publications and organizational efforts to educate the public, to reduce marine litter with systematic cleanup campaigns for collection, recycling and waste management practises, including. reuse or for the production of energy.

## **1. Introduction: Marine Litter as a Global Pollution Challenge for Oceans and Regional Seas**

Marine litter is a serious global environmental problem for the oceans and regional seas. Marine litter (called also marine debris) is any persistent, manufactured or man-made solid material which is discarded, disposed or abandoned in the marine and coastal environment. Marine litter consists mainly of very slowly degradable waste items such as plastic, metal, glass, wood and leather. Marine litter can be found on the beaches and shores, on the water surface, in the water column or on the seafloor. It can be found near the source of its source, but also can be transported over a long distances with sea currents and winds.<sup>1,2</sup>

The environmental impact of marine litter is very serious and multidimensional. It can cause serious environmental problem with the possible transfer of toxic chemical substances to the marine habitats. Marine litter threatens marine biota through entanglement, suffocation (fish, seabirds and other marine animals) and ingestion. Also, marine litter poses a risk to human health. Another dimension of marine litter is economic, as a result of polluting recreational beaches, gulfs and coastlines which attract tourists and apart from an aesthetic problem can cause damage to the quality of swimming water and the sea habitats and their biodiversity.<sup>3</sup>

Marine litter can cause major threats to the health, productivity and biodiversity of the marine environment. A large proportion (estimated at 80%) of the pollution load in the oceans originates from land-

based activities, including municipal, industrial and agricultural wastes and run-off, as well as atmospheric deposition. These pollutants affect adversely the most productive areas of the marine environment, including estuaries and near shore coastal waters. The marine environment is also threatened by physical alterations of the coastal zone, including destruction of habitats of vital importance to maintain ecosystem health.<sup>3</sup>

Marine litter monitoring programmes and national surveys of sources of marine debris have been initiated from the 1980s in most developed countries in order to formulate policies for dealing with the problem. Marine litter has been proved a serious and challenging environmental problem.<sup>4</sup>

## **2. Plastic Debris an Increasing Threat to the Marine Environment**

Marine plastic debris increased substantially in the last decades because plastic replaced wood, metal, leather and glass items. on the marine environment and 80% of marine litter consists of plastic materials. A large number of marine species is known to be harmed and/or killed by plastic debris, which could jeopardize their survival. Marine animals are mostly affected through entanglement in and ingestion of plastic litter. Other less known threats include the use of plastic debris by “invader” species and the absorption of polychlorinated biphenyls from ingested plastics. Less conspicuous forms, such as plastic pellets and “scrubbers” are also hazardous.<sup>5-7</sup>



**Figure 1.** Plastic items has reached almost 80% of marine debris accumulating in coastal shores and seas.

In the last 50 years, the world production of synthetic polymers (plastic resins) increased 30-fold, while recovery of the waste plastic materials remained below 5%. In the U.S., between 1970 and 2003, plastics became

the fastest growing segment of the municipal waste stream and marine litter is now 60–80% plastic. Albatross, fulmars, shearwaters and petrels mistake floating plastics for food. It is estimated that, around 40% of all seabird species are known to ingest plastic as well as sea turtles ingest plastic bags and fishing lines. The number of fish, birds, and mammals that succumb each year to derelict fishing nets and lines cannot be reliably known; but estimates are in the millions. Ingestion of plastic micro-debris by marine filter feeders at the base of the food web is known to occur, but has not been quantified. Ingestion of degraded plastic pellets and fragments raises toxicity concerns, since plastics are known to adsorb hydrophobic pollutants.<sup>8,9</sup>

Plastic marine litter can be dangerous to marine ecosystems from the accumulation of plastic debris on the sea floor. The accumulation of such debris can inhibit gas exchange between the overlying waters and the pore waters of the sediments, and disrupt or smother inhabitants of the benthos. The extent of this problem and its effects have recently begun to be investigated.<sup>10,11</sup>

### **3. What are the Sources of Marine Litter and Measures to Reduce Marine Pollution**

Marine litter has become an international environmental problem affecting every ocean and regional seas. The greatest sources of marine litter are land-based activities, but also sea-based sources are contributing to a certain extent, depending on the area. Unregulated land-based sources contribute especially to solid wastes which is carried out to sea where they sink to the bottom of the seafloor or float on the surface and are carried further away by coastal eddies and ocean currents.<sup>12,13</sup>

The main land-based sources of marine litter, according to various research projects and surveys, are:

- a. Municipal landfills (waste dumps) located on the coast. Unregulated landfills are the most dangerous.
- b. Riverine transport of solid waste from landfills or other litter sources along rivers and other inland waterways (such as canals)
- c. Discharge of untreated municipal sewage (especially discharged in the sea), including storm water (produced also from occasional overflows),
- d. Waste from industrial facilities, solid waste from landfills and untreated waste water. Most developed countries have adequate legislation to reduce and recycle industrial waste.
- e. Tourism and other recreational activities near beaches and coast shores (camping, organized beaches, harbours for recreational crafts).

The main sea and ocean-based sources of marine litter are:

- a. Merchant shipping, ferries and cruise liners (litter from used items and passengers throwing litter (plastic, paper, boxes, bottles, aluminium cans, etc),
- b. Fishing vessels (discarding nets, fishing tackle),
- c. Military fleets and research vessels,
- d. Pleasure crafts (yacht, boats),

- e. Offshore oil and gas platforms (environmental risks, most notably oil spills from oil tankers, pipelines leaks and accidents on the platform, strict regulations, waste management).
- f. Fish farming (aquaculture, raising fish commercially in tanks or enclosures, usually for food and producing marine waste).

In the last decades all countries initiated projects and practical measures to reduce or to prevent marine litter as part of a larger issue of waste management.<sup>14-18</sup>

The first practical efforts to reduce marine litter started with **merchant ships, offshore platforms and pleasure crafts**: Waste management plans advanced with storage onboard and discharged ashore in an organized waste facility. This measure requires adequate space onboard for storage, and the provision of reception facilities in all commercial harbours and marinas. It also calls for harmonized regional and global regulations.

**Fishing vessels** is another source of marine litter and reduction of waste discharged in open seas must be prohibited by regulations. Also, facilities for marine litter collection and treatment must be organized in all harbours. In some countries fishing vessels must mark their fishing gear and particularly drift nets, so that to make possible to find them again if they are lost at sea.<sup>19</sup>

Open **landfills of household waste** in coastal communities and municipalities must be sufficiently protected from rainfall and overflows which can remove waste towards the sea shores. Waste management strategies and better facilities can eliminate this threat. Sewage treatment by municipal authorities must be a priority and performed in adequately equipped facilities to contain and recycle household and industrial waste.<sup>20,21</sup>

**Beaches and Camping sites** can be potential sources of marine litter. All beaches and camping grounds should be sufficiently equipped with waste bins, regular collections, recycling and properly disposed facilities (landfills).



**Figure 2.** Marine litter is a serious pollution problem for beaches and coastlines, especially in the Mediterranean Sea and surrounding countries

The greatest sources of marine litter are land-based activities, especially wastes released from dumpsites near the coast or river banks and the littering of beaches by beachgoers, tourists and by recreational use of the coasts.<sup>22-24f</sup>

Marine litter is a symptom of a throw-away consumer society and shows the disregard of the overuse of our natural resources. At the same time it is a sign that consumer society with all its excesses contributes to the production of waste which causes dangerous environmental pollution. Marine litter affects every country and every ocean, and shows us in highly visible terms the urgency of shifting towards a low carbon, resource efficient Green Economy. Green Chemistry and Green Engineering are two new trends in the manufacture of chemicals and new consumer products with regard to their environmental fate and life cycle comprising their reuse or recycling.

Environmentally active societies need to address marine debris collectively across national boundaries and with the private sector, which has a critical role to play both in reducing the type of waste that can end up in the world's oceans, and through research into new recyclable materials.

#### **4. International Conventions and Regional Action Programmes on Marine Litter**

With the end of the Second World War there was great interest on an international scale to establish cooperative action among countries on regulations and practices affecting shipping, maritime safety and control of marine pollution from ships.

In 1948 an international conference in Geneva adopted a convention formally establishing **IMO (International Maritime Organization)** (the original name was the Inter-Governmental Maritime Consultative Organization, or IMCO, but the name was changed in 1982 to IMO). The IMO Convention entered into force in 1958 and its purpose summarized by Article 1(a) "*to provide machinery for cooperation among Governments in the field of governmental regulation and practices relating to technical matters of all kinds affecting shipping engaged in international trade; to encourage and facilitate the general adoption of the highest practicable standards in matters concerning maritime safety, efficiency of navigation and prevention and control of marine pollution from ships*".

- There are two primary international conventions that address waste and pollution in general in the oceans by ships :

A) **International Convention for the Prevention of Pollution from Ships (MARPOL)** (1973), and

B) **Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter** (1972, and 1996, in short **London Convention**).an international convention designed to minimize pollution of the seas, including dumping, oil and exhaust pollution

The overarching framework for these international conventions is set in the **United Nations Convention on the Law of the Sea** (1982, into force in 1994, describes the rights and responsibilities of nations to conduct and control activities affecting the oceans).

The MARPOL Convention and the London Convention are regulations for the prevention of marine litter and other pollutants from ships and are



supported by IMO. The IMO can not act as enforcement agency, but receives and disseminates reports on alleged inadequacies of port reception facilities, provides technical assistance to developing countries and fosters regional agreements as a basis for co-operation on enforcement.<sup>25,26</sup>

The IMO is co-operating with UNEP, FAO, regional centres such as MERRAC, individual countries and shipping industry, to reduce and, eventually, eliminate ship-generated waste worldwide.. The IMO is affiliated with other bodies and environmental programmes to reduce marine litter, such as GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection), established 1967 by UN Agencies, GloBallast Partnerships (IMO, UNDP, GEF), and Global Marine Litter Information Gateway (UNEP.GPA, IMO).<sup>27</sup>

<p><b>MARPOL THE INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973, AS MODIFIED BY THE PROTOCOLS OF 1978 AND 1997 RELATING THERETO</b> <b>In short: the MARPOL Convention</b> ..... <b>The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (the London Convention)</b> (oldest global conventions to protect the marine environment from human activities and has been in force since 1975 • Its objective is to promote the effective control of ALL SOURCES of marine pollution and take all practicable steps to prevent pollution of the sea by dumping of wastes and other matter (Articles I and II) • 81 States are Party to the London Convention)</p>	<p><b>ANNEXES to MARPOL</b> Annex I: Regulations for the Prevention of Pollution by Oil (October 1983). Annex II: Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk (April 1987). Annex III: Regulations for he Prevention of Pollution by Harmful Substances Carried at Sea in Packaged Form Annex IV: Regulations for the Prevention of Pollution by Sewage from Ships (September 2003). Annex V: Regulations for the Control of Pollution by Garbage from Ships (December 1998). Annex VI: Regulations for he Prevention of Air Pollution from Ships (May 2005)</p>
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The United Nations (UN) in 1995, in response to these major problems of marine pollution and marine litter, initiated a co-operative programme with 108 governments and the European Commission. They declared their commitment to protect and preserve the marine environment from the adverse environmental impacts of land-based activities. The United Nations Environment Programme (UNEP) started the **UNEP Global Programme of Action for the Protection of the Marine Environment from Land-based Activities** (it was adopted by the Washington Declaration, 1995).

The UNEP was tasked to lead the co-ordination effort and to establish a **GPA** Co-ordination Office. The objective of the Global Marine Litter Information Gateway is a co-operative effort of the UNEP GPA Coordination Office and the UN International Maritime Organization (IMO), in order to provide a clearing-house for supply and exchange of information on the global, regional and local problem of marine litter. The UNEP.GPA goals are to protect estuaries and coastal areas and their habitats which are very important to maintain marine ecosystem health.<sup>28</sup>

## 5. European Laws for Controlling Water and Marine Pollution

The European Community countries are covered by international laws and Conventions, but from the 1970s initiated environmental programmes for controlling marine pollution.

In 1972 and 1974, conventions were held in Oslo and Paris respectively, and resulted in the passing of the **OSPAR Convention**, an international treaty controlling marine pollution in the north-east Atlantic Ocean around Europe.<sup>29</sup>

A similar convention was held in 1976 in Barcelona (Spain) for the formulation of the **Barcelona Convention**. The Barcelona Convention for the Protection of The Mediterranean Sea Against Pollution. It was signed in 16 February 1976 (in force 12 February 1978 and revised on 10 June 1995) as the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean).<sup>30</sup>

The **Water Framework Directive of 2000** is a European Union directive committing EU member states to make their inland and coastal waters less polluted from human activities. European Water Policy has undergone a thorough restructuring process, and a new Water Framework Directive adopted in 2000 will be the operational tool, setting the objectives for water protection for the future.<sup>31</sup>

The **OSPAR or Paris Convention** is the current legal instrument guiding international cooperation on the protection of the marine environment of the North-East Atlantic. Work under the Convention is managed by the OSPAR Commission, made up of representatives of the Governments of 15 Contracting Parties and the European Commission, representing the European Union. The EU has its own 1998 council decision Council Decision 98/249/EC of 7 October 1997 “on the conclusion of the Convention for the protection of the marine environment of the North-East Atlantic (Paris Convention)”. The OSPAR Convention was extended and up-dated in 1992 (adopted 1998) to cover with a new annex on biodiversity and ecosystems in the marine environment



*(The fifteen Governments of OSPAR are Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, The Netherlands, Norway, Portugal,*

Spain, Sweden, Switzerland and United Kingdom. Finland is not on the western coasts of Europe, but some of its rivers flow to the Barents Sea, and historically it was involved in the efforts to control the dumping of hazardous waste in the Atlantic and the North Sea. Luxembourg and Switzerland are Contracting Parties due to their location within the catchments of the River Rhine).



**Figure 3.** There are many International organizations dealing with the environmental problems of marine litter.

## 6. Organizations and Initiatives on Marine Litter

The **Ocean Conservancy** is another very important conservation organization for marine life in the oceans and reduction of marine litter. The OC. was founded as The Center for Environmental Education in 1972 and is a nonprofit advocacy group based in Washington, D.C., USA. The OC goals are to promote healthy and diverse ocean ecosystems, and to oppose practices that threaten oceanic and human life. Since 1986, the international action programme **International Coastal Cleanup** (ICC) has gathered six million

volunteers to remove more than 50 million kg of marine litter from 170,000 miles of beaches and inland areas.<sup>32</sup>

Over the past 25 years OC and its ICC programme has become the world's largest volunteer effort for ocean health. Nine million volunteers from 152 countries and locations have cleaned 80 million kg (a one day annual event) of marine litter from shores, lakes, streams, rivers and ocean

The ICC saw an increase in international representation in recent years. Volunteers not only clear trash and debris from beaches, lakes and rivers but record everything they find. Ocean Conservancy uses this data to highlight the problem of litter or garbage in our ocean, identify sources of the debris and recommend solutions.

According to the analysis of ICC data collected, 52% of marine litter in the Mediterranean. Marine litter from smoking-related activities accounts for 40 percent of total marine litter (higher than the global average) and constitutes a serious problem that has to be given priority in a Regional Strategy



In response to the global challenge from the marine litter, UNEP's Regional Seas Programme and the Coordinating Office for the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA), embarked on the "Global Initiative on Marine Litter" in 2003.

The UNEP's initiative provides a platform for managing the problem through establishing partnerships and cooperative arrangements and coordinating joint activities. Its main partners include the **Regional Seas Conventions and Action Plans (RSCAPs)**, government representatives, UN bodies, donor agencies, the private sector and NGOs at global, regional and national levels. The UNEP has published many reports on marine litter. The report 'Marine Litter: A Global Challenge' (UNEP publs, Nairobi, Kenya, 2000) was the first attempt ever to take a world-wide stock of marine litter levels across 12 different regions.<sup>33</sup>

**Seas at Risk** (for the protection and restoration of the marine environment) is established in Brussels (Belgium) by the European association of non-governmental environmental organisations. The organisation, despite its small number of staff, is working to protect and restore to health the marine environment of the European seas, including marine litter, and the wider North East Atlantic. (<http://www.seas-at-risk.org/>).

The **North East Atlantic Fisheries Commission (NEAFC)** is another competent organisation responsible for recommending measures to promote the rational exploitation of fish stocks in the North East Atlantic. The Commission is made up of delegations from five Contracting Parties to the

1982 Convention on Future Multilateral Cooperation in North East Atlantic Fisheries. Seas At Risk has been an Observer at NEAFC annual meetings since it opened its doors to NGOs in 2002 (<http://www.neafc.org>).

**Regional Advisory Councils for European fisheries** (RACs) were set up to provide greater regional stakeholder involvement in EU fisheries management. The main task of the RACs is to provide the European Commission with advice on fisheries management in their specific regions. Marine litter reduction by fishing boats in the seas is one of their task. The overall objective of the RACs is to work towards integrated and sustainable management of fisheries resources, based on the ecosystem approach and the precautionary principle.

The **Centre for Marine Conservation** is a leading ocean conservation organization committed to protecting ocean environments and conserving the global abundance and diversity of marine life. (Washington DC, <http://www.cmc.ocean.org>) The Center for Marine Conservation has been coordinating coastal cleanups since 1986. (The first nationwide cleanup took place in 1988, just four months before the MARPOL treaty took effect. Canada and Mexico joined in on the act in 1989.).

## **7. Conferences, Workshops, Publications on Marine Litter**

International Conferences on Marine Litter started in 1983 and the Fifth International Marine Debris Conference (5IMDC) was held in Honolulu, Hawaii, USA (March 2001). The 5<sup>th</sup> was organised by the National Oceanic and Atmospheric Administration (NOAA) of the United States of America and UNEP, recognising that marine debris is a trans-boundary issue which can only be managed through regional and global collaboration. Other similar conferences on marine litter took place in the last decade.<sup>34,35</sup> The 5IMDC brought together 440 participants representing some 38 countries. Conference participants, researchers, natural resource managers, policy-makers, industry representatives, and non-governmental organizations (NGOs) and endorsed 12 actions to reduce marine debris.<sup>36</sup>

All over the world there in the last decade many workshops and meeting resulted in action plans for marine litter cleanups with thousands of volunteers.<sup>37</sup>

The scientific literature on marine litter is also very extensive, especially from reports and data analysis of marine debris in the world's oceans and regional seas.<sup>38-41</sup>

A very important conference was in 2005 "*The Plastic Debris Rivers to Sea Conference*", September 7-9, 2005 Crowne Plaza Hotel Redondo Beach, California organised by the Algalita Marine Research Foundation (AMRF), California Coastal Commission, and the H. John Heinz III Center for Science, Economics and the Environment .

## **8. Organisations, Action Programmes and Initiatives for Marine Litter in the Mediterranean Area**

The problem of marine litter in the Mediterranean Basin is complicated since it is addressed principally by local authorities and national authorities at

a sub-regional levels and competent non-governmental organisations (NGOs). There is a need for systematic and coordinated programmes and actions on a Mediterranean scale. Surveying and cleaning seas, coastlines and beaches must be more organized and to provide information on the volume, types of litter and management plans.

Despite these inadequacies and central coordination the types of marine litter in the Mediterranean has been calculated (an approximation) through the various ICC campaigns (International Coastal Cleanup) of Mediterranean beaches in the period 2002-2006, which accounts for over 80% of total marine litter collected. The participating countries were in the range of 15 and 7 (2002-2006).<sup>42</sup>

The ICC campaign in the Mediterranean countries was performed mainly in shorelines and recreational beaches (60%). The number of volunteers decreased substantially (from 15 thousands in 2002 to 7,7 thousands in 2006) and the amount of litter collected decreased from 100 thousand kg (2002) to 33 thousand kg (2006). The only quantitative analysis of the type of marine litter was performed by counting the items collected (although the weight is very different, thus cigarette/cigarette filters to be the most abundant item in beaches). The top 12 litter items and their percentage were:

1. cigarette/cigarette filters (222,563 item counts) , 27% (of the total),
2. cigar tips 10%,
3. plastic bottles (2 L or less) 10%,
4. plastic bags , 8.5%;
5. aluminum beverage cans, 7.6%,
6. caps/lids, 7.3%,
7. beverages bottles (glass), 5.8%,
8. cups/plates/forks/knives/spoons, 3.8%,
9. tobacco packaging/wrappers, 2.8%,
10. food wrappers & containers, 2.5%,
11. straws/stirrers 2%,
12. pull tabs , 2%

The main findings of this survey are limited in its scope and analysis but is indicative of the marine litter which accumulates in beaches and coastal shores. 55% of these litter are mainly plastics, aluminium and glass .which are highly persistent in the environment and can travel long distances with sea currents and winds, impacting the remotest parts of the Mediterranean Sea. The remaining 45% litter originates from smokers (higher than other marine regions). The litter from cigarette filters and cigarette packaging is expected to be higher in the Mediterranean because of the high number of smokers in these countries.

The main findings of this survey can be summarised as follow. Floating marine litter in the Mediterranean sea were limited. Relatively heavy items such as steel drums, wooden pallets and crates observed on the sea surface were responsible for the greater quantity of marine litter Observations were carried out mainly in the eastern Mediterranean (Aegean Sea, Libyan Sea and Eastern Mediterranean Levantine Sea), in the Alboran Sea between Spain and Morocco and in the Adriatic Sea). The higher concentration of litter was observed along routes close to coastal areas. Plastic accounted for about 80% of litter collected, while textiles, paper, metal, wood were around 17%. The average quantity of marine litter was estimated to be 230.8 kg/km<sup>2</sup> ranging from 0.002 to 2,627 kg/m<sup>2</sup>.

The IMO in an effort to initiate a campaign for the protection of the Mediterranean Sea as an important marine ecosystem with special needs decided to give it special status. The Marine Environment Protection Committee (MEPC) of the IMO at its 57<sup>th</sup> Session (April 2008) decided that the status of 'Special Area' of MARPOL Annex V for the Mediterranean will take

effect on 1 May 2009. Consequently, for all ships (beginning 1 May 2009), disposal into the Mediterranean Sea is prohibited : of the following: a) all plastics (plastic ropes, fishing nets, bags and plastic garbage), b) paper products, rags, packing material, glass, metal, bottles, crockery, etc.

The marine litter floating and seafloor debris in the Mediterranean Sea, especially plastic, have a negative impact on the health of marine habitats and marine biota. A study of the loggerhead sea turtle, *Caretta caretta*, indicates a high frequency of occurrence of debris in their stomachs in the Mediterranean. The loggerhead, widely considered one of the emblematic animals of the Mediterranean, is classified as 'vulnerable' by the International Union for the Conservation of Nature.<sup>43-45</sup>

Marine litter secondary pollution through the leaching or extraction of toxic metals, organic chemicals degradation products. A study in the Laboratory of Environmental Chemistry (University of Athens) found that cigarette tips under natural conditions produce leachates containing heavy metals (Cd<Pb<Cu<Zn).<sup>46</sup>

Similar studies concerning adverse effects of marine litter on the marine species have been advanced in recent years. Studies focused on cigarette butts and other marine debris.<sup>47,48</sup>

Marine plastic waste and their toxic leached products (metals, PCBs, DDE, polychlorinated biphenyls) as well as ingestion problems by birds and fish have been the subject of research studies. The plastic resin pellets (0.1-0.5 cm) or small granules that are widely distributed in the oceans and can be ingested are worrying scientist as serious marine pollutants.<sup>49-53</sup>

The Center for Marine Conservation (Washington DC, USA) which has been coordinating coastal cleanups since 1986., found that 50% of the 1,5 million kg of marine waste collected annually in the USA is plastic. According to CMC the "dirty dozen"—twelve" found most frequently: 1) cigarette butts, 2) paper pieces, 3) plastic pieces, 4) styrofoam, 5) glass pieces, 6) plastic food bags, 7) plastic caps and lids, 8) metal beverage cans, 9) plastic straws, 10) glass beverage bottles, 11) plastic beverage bottles and 12) styrofoam cups.<sup>54</sup>



**Figure 4.** Plastic resin pellets or small granules (0.1-0.5 cm) resulting from the break down of plastic debris in the marine environment is highly distributed form of pollution in the world's seafloor oceans

The socio-economic impact of marine litter is an additional burden on countries fighting the scourge of waste and especially marine debris in their seas and shorelines. Marine litter in the Mediterranean and other areas is not only an acute environmental problem but has also social and economic impacts on a national and regional level. The fishing industry is affected by the death of thousands of fish and marine life is degraded. Fishing nets can damage boats, wrap around propellers and clog cooling water intakes. The cost of cleaning is an additional financial burden to local authorities. Tourism around the coastline and beaches of many countries is affected by the sight of litter in their shores.<sup>55-59</sup>

There are many studies and surveys of marine litter in the Mediterranean countries and its impact on marine biota, fisheries, beaches and tourism.<sup>60-66</sup>

Measurements of persistent litter on 13 beaches in the Mediterranean Sea (Spain, Sicily, Turkey, Cyprus and Israel, in 1988-1989) show that plastic items are the most abundant, followed by wood, metal and glass. The study found that the quantity of litter on a beach is inversely related to its geographical distance to a population center and directly related to the number of visitors frequenting the beach.<sup>67</sup>

## **9. Marine Litter in the Mediterranean Sea: The Case of Greece and Eastern Mediterranean**

Greece is a country with a very long coastline, estimated at 13,676 km. The Greek archipelago has also a vast number of islands and islets (6,000, of which 227 are inhabited (Cyclades, the North Aegean islands, Sporades, Crete, Euboea, Dodecanese, Ionian islands). In recent years the number of tourists arriving reached 17 million each year, contributing almost 20% of the annual nation's GDP (Gross Domestic Product). Inevitably the issues of marine litter, clean seas and beaches are very important for its economy and quality of seas. Various studies and surveys were conducted in the last decade concerning marine litter in Greek seas, gulfs and beaches.

A monitoring programme for litter in deep water was published in two recent papers by researchers in the University of Patras. This study was performed in collaboration with fishermen (trawl nets) and was conducted in 4 major gulfs along the western coast of Greece (Gulfs of Patras, Echinades, Corinth, and Lakonikos). More than 5 thousand items were collected in an area of 30 km<sup>2</sup> reaching depths of 300 m. The mean number of items in the first two gulfs was 240 and 89 items/km<sup>2</sup>. The mean weight densities in the 4 gulfs in the second publication was 47-7 kg/km<sup>2</sup>. The major sources of litter were from land-based activities and 56% were plastic items, 17% metal, 11% glass. Packaging of soft drinks 32%, general packaging 28% and food packaging 21%. This finding suggests that the source of land-based litter is transported into the gulf by rivers and seasonal streams.<sup>68,69</sup>

Another survey of floating litter in the sea was conducted in 2007-2008 in Thessaloniki (second biggest city in Greece in the north). The company "North Aegean Slops" (a Clean Up Greece member) performed the survey on behalf of the Ministry of Macedonia and Thrace. The collection of marine litter



was conducted using a special, technically equipped boat and an additional rubber boat. The mean number of items per cubic meter was around 400 items/m<sup>3</sup>.<sup>70</sup>

The port of Piraeus (Greece) was studied by HELMEPA. In the period 2006-2007 a daily collection of floating debris from the port area was performed by a specialized skimmer vessel and/or manually from auxiliary boats. The litter was calculated by volume, it fluctuated from 1.47 to 3.46 m<sup>3</sup>/day (average 1.9 m<sup>3</sup>/day) During the summer months when the passenger port is very busy the average volume of litter increased to 3 m<sup>3</sup>/day (~30%).<sup>71-73</sup>

Since 1991, the NGOs Hellenic Marine Environment Protection Association (**HELMEPA**), the Mediterranean Information Office for Environment, Culture and Sustainable Development (**MIO-ECSDE**) and **Cleanup Greece** coordinate the campaign of marine litter in the sea and beaches.. HELMEPA acts a coordinator for the collection by volunteers every third weekend of every September, aiming to measure the degree of environmental sensitivity of individuals and local communities.<sup>74</sup>



**Figure 5.** HELMEPA and MIO-ECSDE are two important Greek NGOs coordinating actions for the collection and analysis of marine litter.

A study of marine litter was conducted by Greek researchers in Eastern Mediterranean Sea. The abundance and composition of marine benthic debris was investigated in shallow coastal areas of Greece (eastern Mediterranean). The mean total density of marine debris in the areas surveyed was 15 items per 1000 m<sup>2</sup> and ranged from 0 to 251 items per 1000 m<sup>2</sup>. Plastic marine litter as expected was the dominant type of marine litter.<sup>75</sup>

The **MIO-ECSDE** (Greece) with other organizations of the European Union became a key partner in the FP7 project entitled MARLISCO (“Marine Litter in Europe Seas: Social Awareness and CO-Responsibility”) concerning marine litter (36 months duration) The main objective of the MARLISCO project is to increase the awareness of the consequences of societal behaviour in relation to waste production and management on marine ecological systems, and to promote environmental responsibility among the different groups of people.<sup>76</sup>

An interesting study of the adverse impact of marine litter on epibenthic megafauna was performed in the Biology Department of the University of Athens. The effect of marine litter on the abundance and community structure of sea’s soft-bottom epibenthic megafauna was investigated in three coves of the Saronikos Gulf. At each site, two surfaces were defined as the sea-bottom. One of the surfaces was uniformly littered with debris (16 items per 100 m<sup>2</sup>), while the other remained ‘clean’ (control). The surface covered with litter showed gradual deviation in the community structure and composition, compared to control.<sup>77</sup>

Greek researchers from the University of Crete conducted a sampling experiment of floating tar, litter and sea water for dissolved/dispersed petroleum hydrocarbons in the Cretan Sea. Analysis of these data has allowed a first assessment of the status of floating marine pollution in the region. Tar concentrations were in the range of 1-4280 µg/m<sup>2</sup> and for plastic 0-1160 µg/m<sup>2</sup>. Mean tar concentration at 318 µg/m<sup>2</sup> was more than two times higher than from previous studies.<sup>78</sup>

On the educational level, the impact of marine litter on the marine environment can be used as a pilot educational programme in order to increase the environmental awareness of children at a young age.<sup>79</sup>

An extensive review on marine litter and its impact on marine biota has been published recently. It includes very important and detailed data on marine litter, sources, distribution and adverse effects on marine species. There are detailed tables of effects and species with full literature searches. It is a 2008 review by Dr. Stelios Katsanevakis (chapter 2 of a book). Dr Katsanevakis is a biologist, at the Institute of Marine Biological Resources, Hellenic Centre for Marine Research, Athens, Greece.<sup>80</sup>



**Figure 6.** Marine litter is a challenging environmental problem of our society

## References

1. UNEP/GPA. Marine Litter facts. Global Marine Litter Information Gateway (<http://marine-litter.unep.org/facts/facts.htm>).
2. Jetic L, Sheavly S, Adler E (compilers), Meith N (Ed). UNEP. *Marine Litter: A Global Challenge*. UNEP publications, Nairobi, 2009.
3. The UNEP Global Programme of Action for the Protection of the Marine Environment from Land-based Activities and the Washington Declaration were adopted in 1995 and UNEP was tasked to lead the co-ordination effort and to establish a GPA Co-ordination Office. GPA-UNEP (<http://marine-litter.gpa.unep.org>).
4. Rees G, Pond K. Marine litter monitoring programmes-A review of methods with special reference to national surveys. *Mar Pollut Bull* 30(2):103-108, 1995.
5. Pruter AT. Sources, quantities and distribution of persistent plastics in the marine environment. Review. *Mar Pollut Bull* 18(6) Suppl 8:305-310, 1987,
6. Sheavly, S.B. and Register, K.M. Marine Debris and Plastics: Environmental Concerns, Sources, Impacts and Solutions. *J Polym Environ* 15: 301-305, 2007.
7. Derralk JGB. The pollution of the marine environment by plastic debris: a review. *Mar Pollut Bull* 44(9):842-852, 2002.

8. Moore CJ. Synthetic polymers in the marine environment: A rapidly increasing, long-term threat. *Environ Res* 108(2):131-139, 2008.
9. Barnes DKA, Galgani F, Thompson RC, Barlaz M. Accumulation and fragmentation of plastic debris in global environment. *Phil Trans Royal Soc B: Biol Sci* 364:1985-1998, 2009.
10. Barnes DKA. Invasions by marine life on plastic debris. *Nature* 416:808-809, 2002.
11. Corcoran PL, Mark C, Biesinger MC, Grifi M. Plastics and beaches: A degrading relationship. *Mar Pollut Bull* 58 (1): 80-85, 2009.
12. Shahidul Islam M, Tanaka M. Impacts of pollution on coastal and marine ecosystems including coastal and marine fisheries and approach for management: a review and synthesis. *Mar Pollut Bull* 48(7-8):624-649, 2004.
13. Kusui T, Noda M. International survey on the distribution of stranded and buried litter on beaches along the Sea of Japan. *Mar Pollut Bull* 47(1-6):175-179, 2003.
14. Frost A, Cullen M. Marine debris on northern New South Wales beaches (Australia): sources and the role of the beach usage. *Mar Pollut Bull* 34(5):348-352, 1997.
15. Noh H-J, Oh J-H, Kang C-G, Kang S-G. Marine litter in the Northwest Pacific Region-Its problems and counter measures to be taken by NOWPAP MERRAC. Oceans 2003 MTS/IEEE Conference.
16. KIMO (Kommunenenes Internasjonale Miljøorganisasjon, Local Authorities International Environmental Organisation). *Economic Impacts of Marine Litter*. Report, Sept 2010, Holum-Ameland, The Netherlands ([www.kmointernational.org/MarineLitter.aspx](http://www.kmointernational.org/MarineLitter.aspx)) .
17. Committee on the Effectiveness of International and National Measures to Prevent and Reduce Marine Debris and Its Impacts, National Research Council, Ocean Studies Board and Division on Earth and Life Sciences. *Tackling Marine Debris in the 21st Century*. : The National Academies Press, Washington DC, 2008.
18. IMO (International Maritime Organization). *Prevention of Pollution by Garbage from Ships*. London, 2002, Available from: ([http://www.imo.org/Environment/mainframe.asp?topic\\_id=297](http://www.imo.org/Environment/mainframe.asp?topic_id=297)) [accessed July 2010.]
19. Horsman, PV The amount of garbage pollution from Merchant Ships. *Mar Pollut Bull* 13(5):167-169, 1982.
20. OSPAR (Oslo-Paris Commission). Marine litter in the North-East Atlantic Region: Assessment and priorities for response. London, 2009.
21. MAP/UNEP (Mediterranean Action Plan/United Nations Environment Programme). *Bibliography on Marine Litter*, MAP Technical Report Series No. 50, UNEP publications, New York, 1991..
22. Oigman-Pszczol S, Creed JC. Quantification and classification of marine litter on beaches along Armacaodos Buzios, Rio de Janeiro, Brazil. *J Coastal Res* (on line journal) 23(2):421-428, 2007.
23. US Environmental Protection Agency: *Assessing and Monitoring Floatable Debris* .Report by the US EPA Oceans and Coastal Protection Division, Office of Wetlands, Oceans and Watersheds, Office of Water., EPA publications, Washington DC, 2002.

24. MAP/UNEP. *Marine Litter. An Analytical Overview*. UNEP, Basel Convention and Regional Seas, UNEP publ., Nairobi, Kenya, 2005. ([www.unep.org](http://www.unep.org)).
25. International Maritime Organization (IMO) ([www.imo.org](http://www.imo.org)).
26. MARPOL 73/78 is the International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" is short for marine pollution and 73/78 short for the years 1973 and 1978.) (<http://www.imo.org/About/Conventions/listofconventions/...>).
27. GESAMP (Group of Experts on the Scientific Aspects of Marine Pollution). *The State of the Marine Environment*. Blackwell Scientific Publications, London, 1991.
28. UNEP.GPA. Global Marine Litter Information Gateway: (<http://marine-litter.gpa.unep.org>).
29. OSPAR Convention ([www.ospar.org](http://www.ospar.org) )
30. Barcelona Convention (Barcelona, Spain, 1976, in force 1978, revised 1995) ([www.unep.ch/regionalseas/regions/med/t\\_barcel.htm](http://www.unep.ch/regionalseas/regions/med/t_barcel.htm))
31. Water Framework Directive 2000 ([http://ec.europa.eu/environment/water/water-framework/info/intro\\_en.htm](http://ec.europa.eu/environment/water/water-framework/info/intro_en.htm))
32. Ocean Conservancy and International Coastal Cleanup. ([www.oceanconservancy.org](http://www.oceanconservancy.org)) & ([www.oceanconservancy.org/our-work/marine-debris/international-coastal-cleanup-11.html](http://www.oceanconservancy.org/our-work/marine-debris/international-coastal-cleanup-11.html)).
33. UNEP. *Marine Litter: A Global Challenge*. UNEP publ., Nairobi, Kenya, 2009; and UNEP. *Marine Litter; An Analytical Overview*. UNEP publications, Nairobi, Kenya, 2005.
34. Andrady, A.L. 1990. Environmental degradation of plastics under land and marine exposure conditions. In *Proceedings of the Second International Conference on Marine Debris*, Shomura, R.S. and M.L. Godfrey (eds.). U.S. Department of Commerce, Washington, DC.
35. Proceedings from the 4th International Marine Debris Conference on Derelict Fishing Gear and the Marine Environment. Honolulu, Hawaii, August 6–11, 2000. ([http://www.hiwnms.nos.noaa.gov/special\\_offerings/sp\\_off\\_imdc/proceedings.html](http://www.hiwnms.nos.noaa.gov/special_offerings/sp_off_imdc/proceedings.html))
36. 5<sup>th</sup> International Conference on Marine Debris, Honolulu, Hawaii, March, 2011. (<http://www.5imdc.org/>); Northwest Pacific Action Plan (NOWPAP). Workshops on Marine Litter. 1<sup>st</sup> and 2<sup>nd</sup> Workshops (2005 and 2006).
37. Rogers DB (eds.) *Marine Debris: Sources, Impacts, Solutions*. Springer-Verlag, New York, 1997.
38. US Environmental Protection Agency (2002): Assessing and Monitoring Floatable Debris. Report by the US EPA Oceans and coastal Protection Division, Office of Wetlands, Oceans and Watersheds, Office of Water., Washington DC, 2002;
39. Cheshire A, Adler E . *UNEP Guidelines on Survey and Monitoring of Marine Litter*. Regional Seas Reports & Studies No. 186, IOC (Intergovernmental Oceanography Commission) Technical Series No.83. UNEP, Nairobi, 2006
40. Allsop M, Walters A, Santillo D, Johnston P (Greenpeace). *Plastic Debris in the World's Oceans*. Greenpeace publ., 2006.

41. Ocean Conservancy (Dr. Sheavly S). *National Marine Debris Monitoring Program. Final Program , Data Analysis & Summary*. OC publs, Washington DC, sept. 2007.
42. ICC (International Coastal Cleanup).A Rising Tide of Ocean Debris, 2009.([http://www.oceanconservancy.org/pdf/A\\_Rising\\_Tide\\_full\\_hires.pdf](http://www.oceanconservancy.org/pdf/A_Rising_Tide_full_hires.pdf))
43. Marine Litter in the Mediterranean. Status and Assessment. In: UNEP. *Marine Litter: :A Global Challenge*. UNEP publs, Nairobi, Kenya, 2009, pp. 93-106.
44. Galil BS. Shipwrecked-Shipping impacts on the biota of the Mediterranean. *Ecol Transport Manag Mobil Environ* 10:33-69, 2006.
45. Tomas, J, Guitart, R,. Mateo R,, Raga JA., : Marine debris ingestion in loggerhead sea turtles, *Caretta caretta*, from the Western Mediterranean, *Mar Pollut Bull*, 44: 211-216, 2002.
46. Gramentz, D. Involvement of loggerhead turtle with the plastic, metal, and hydrocarbon pollution in the central Mediterranean, *Mar Pollut Bull*. 19 (1) :. 11-13, 1988.
47. Chalkiadaki M., "The contribution of marine litter to marine environmental pollution with trace metals, MSc thesis, Laboratory of Environmental Chemistry, University of Athens, Athens, 2005 ; Chalkiadaki M, Scoullou M, Dasenakis M. Determination of trace metals extracted from marine litter under simulated nature conditions. 1<sup>st</sup> Scientific Conference of EFMS: Oceanographical Aspects for a Sustainable Mediterranean. Athens, Sept. 27-29, 2002, vp. 2002.
48. Barnes RL. Regulating the disposal cigarette butts as toxic hazardous waste. *Tobacco Control* 20:i45-i48. 2011.
49. Moerman JW, Potts GE. Analysis of metals leached from smoked cigarettes. *Tobacco Control* 20:i30-i35, 2011.
50. Azzarello MY, Van Vleet ES. Marine birds and plastic pollution. Review. . *Mar Ecol –Progress Series*. 37:285-303, 1987.
51. Goldberg ED, Bertine KK. Beyond the mussel watch- new direction for monitoring marine pollution. *Sci Total Environ* 247(2-3): 165-174, 2000.
52. Brander SM, Fontana RE, Mata TM, et al. The ecotoxicology of plastic marine debris. *American Biol Teacher* 73(8):474-478, 2011.
53. Joyner CC, Frew S. Plastic pollution in the marine pollution. *Ocean Develop & Intern Law* 22(1):33-69, 1991.
54. Mato Y, Isobe T, Takada H, et al. Plastic resin pellets as a transport medium for toxic chemicals in the marine environment. *Environ Sci Technol* 35(2):318-324, 2001.
55. Center for Marine Conservation (Washington DC) ([www.cmc-ocean.org/](http://www.cmc-ocean.org/)).
56. Santos IR, Friedrich A, Walmer-Kersanach M, Fillmann G. Influence of soci-economic characteristics of beach users on litter generation. *Ocean Coast Manag* 48(9-10): 742-752, 2005.
57. Nash AD. Impacts of marine debris on subsistence fishermen . An exploratory study. *Mar Pollut Bull* 24(3):150-156, 1992.
58. Hall K. Impacts of marine debris and oil. Economic and social costs to coastal communities. *CoastWeb* 2000 (<http://library.coastweb.info/810/>).
59. Tonge J, Moore SA. Importance-satisfaction analysis for marine-park hinterlands. A Western Australia case study. *Tourism Manag* 28(3):768-776, 2007.

60. Gregory MR. Environmental implications of plastic debris in marine settings-entanglement, ingestion, smothering, hanger-on, hitch-hiking and alien invasions. *Phil Trans Royal Soc B.* 364:2013-2025, 2009.
61. Galgani F., Souplet, A, Cadiou Y.. Accumulation of debris on the deep sea floor off the French. Mediterranean coast, *Mar Ecol, Progress Series* 143: 225-234,1996
62. Aliani S., Griffa, A, Molcard A. Floating debris in the Ligurian Sea, north-western Mediterranean, *Mar Pollut Bull.* 46,:1142-1149, 2003.
63. MAP/UNEP/MED POL. *Guidelines on Management of Coastal Litter for the Mediterranean Region*, MAP Technical Reports Series No. 148, UNEP/MAP, Athens, 2004.
64. Martinez-Ribes L, Basterretxea, G, Palmer M, Subirana TJ. *Origin and abundance of beach debris in the Balearic Islands*, *Scientia Marina* 71 (2) 2007. (doi:10.3989/scimar.2007.71n2305)
65. Golik, A, Gertner Y. Litter on the Israeli coastline. *Mar Environ Res.* 33(1): 1-15, 1992.
66. Clean Up Greece/HELMEPA/MIO-ECSDE,. *Public Awareness and Education for the Management of Marine Litter in the Mediterranean*, Athens, 2007.
67. Gabrielides GP, Golik A, Loizides L., M.G. Marino MG, Bingel F, Torregrossa MV. Man-made garbage pollution on the Mediterranean coastline. *Mar Pollut Bull* 23:437-441, 1991.
68. Stefatos A, Charalampakis M, Papatheodorou G, Ferentinos G. Marine debris on the seafloor of the Mediterranean Sea. Examples from two enclosed gulfs in western Greece. *Mar Pollut Bull* 38: 380-383, 1999.
69. Koutsodendris A, Papatheodorou G, Kougiourouki O, Georgiadis M. Benthic marine litter in four gulfs in Greece-Eastern Mediterranean: abundance, composition and source identification. *Estuarine Coast Shelf Sci* 77(3):501-512, 2008.
70. Ministry of Macedonia and Thrace,. *Floating litter in the Gulf of Thessalonica: Report July 2007 – January 2008*, Thessaloniki, 2008.
71. HELMEPA/MIO-ECSDE. *Public Awareness an Education for the Management of Marine Litter in the Mediterranean*. HELMEPA, Athens, 2007.
72. MAP/UNEP/MED POL. *Guidelines on Management of Coastal Litter for the Mediterranean Region*. MAP Technical Reports Series No. 148, UNEP/MAP publication, Athens, 2004.
73. MED POL (Mediterranean Action Plan). *Meeting MED POL Focal Points (Rhodes),25-27/5/2011. Assessment of the Status of Marine Litter in the Mediterranean*. UNEP/MAP, Athens, Greece, 2011.
74. HELMEPA. (Hellenc Marine environment Protection Association). *Annual Reports 2010*, Athens, Greece, 2011.
75. Katsanevakis, S, Katsarou A. Influences on the distribution of marine debris on the seafloor of shallow coastal areas in Greece (Eastern Mediterranean). *Water Air Soil Poll.*, 159: 325-337, 2004.
76. MIO-ECSDE (Mediterranean Information Office for Environment, Culture and Sustainable Development). ([www.mio-ecsde.org](http://www.mio-ecsde.org)).
77. Katsanevakis S, Varriopoulos G, Nicolaidou A, Thessalou-Legaki M. Effect of marine litter on the benthic megafauna of coastal soft bottom: a manipulative field experiment. *Mar Pollut Bull* 54(6):771-778, 2007.

78. Kornilios S, Drakopoulos PG, Dounas C. Pelagic tar, dissolved/dispersed petroleum hydrocarbons and plastic distribution in the Cretan Sea, Greece. *Mar Pollut Bull* 36(12): 989-993. 1998.
79. Venizelos L. 2004a. The impact of "small garbage" on the marine environment: A pilot programme of education and environmental awareness. Sustainable Mediterranean, Newsletter of the MIO-ECSDE, the EEB and the RAED 34: 20.
80. Katsanevakis S, Marine debris, A Growing problem: Sources, distribution, composition, and impacts. In: Hofer TN (Ed). *Marine Pollution: New Research*. Nova Science Publishers, Inc., New York, 2008, pp. 54-100.

## MARINE LITTER : ANNEX

### ADDITIONAL REFERENCES. MEDITERRANEAN SEA and MARINE LITTER

1. Aliani, S, Griffa A, Molcard A.: Floating debris in the Ligurian Sea, north-western Mediterranean, *Mar Pollut Bull* 46 :1142-1149, 2003.
2. Bingel, F., D. Avsar and M. Unsal,: A note on plastic materials in trawl catches in the north-eastern Mediterranean. *Meeresforschung (Reports on Marine Science)*, 31 :227-233, 1987..
3. Dixon, T. Garbage Statistics: Data on Sources, Amounts, Types and Distribution of marine litter in the Mediterranean Sea, pp. 23-33. In: *Proceedings of the Workshop on the Elimination of Garbage from the Mediterranean and its Adoption as an Effective Special Area to Annex V of MARPOL 73/78*, Athens, 29-30 June 1989.
4. Gabrielides, G.P., A. Golik, L. Loizides, M.G. Marino, F. Bingel, . Torregrossa MV. Man-made garbage pollution on the Mediterranean coastline, *Mar Pollut Bull* 23 : 437-441, 1991.
5. Galgani, F., S. Jaunet, A. Campillo, X. Guenegon and E. His,: Distribution and Abundance of Debris on the Continental Shelf of the North-Western Mediterranean Sea, *Mar Pollut Bull* 30: 713-717, 1995.
6. Galgani, F., J.P. Leaute, P. Moguedet, A. Souplet, Y. Verin, A. Carpentier, H. Goraguer, D. Latrouite, B. Andral, Y. Cadiou, J.C. Mahe, J.C. Poulard and P. Nerisson,: Litter on the Sea Floor Along European Coasts, *Mar Pollut Bull* 40 (6): 516-527, 2000.
7. Galil, B.S., Golik A, Turkey M.: Litter at the bottom of the sea: A Sea bed survey in the Eastern Mediterranean, *Mar Pollut Bull* 30: 22-24, 1995.
8. Golik, A. and Y. Gertner, Solid waste on the Israeli coast: composition, sources, and management. In: *Proceedings of the Second International conference on marine debris*. Honolulu, Hawaii, 1989. NOAA, pp.369-378, 1989.
9. Golik, A. and Y. Gertner, Litter on the Israeli coastline. *Mar Environ Res* 33 : 1-15, 1992
10. Gramentz D. Involvement of loggerhead turtle with the plastic, metal, and hydrocarbon pollution in the central Mediterranean, *Mar Pollut Bull* 19 : 11-13, 1988..



11. HELMEPA: Proceedings of the Workshop on the Elimination of Garbage from the Mediterranean and its Adoption as an Effective Special Area to Annex V of MARPOL 73/78, Athens, 29-30 June 1989..
12. HELMEPA, Final Report "Public Awareness Campaign to Limit Garbage Pollution of the Greek Seas and Beaches", "Mediterranean Strategy and Action Plan" for the Protection of the Environment (MEDSPA), 1990.
13. HELMEPA. Final Report "Integrated Demonstration Scheme for Solid Waste Management/Recycling and Investigation for Waste on Unspoiled, Non-Developed Beaches", 1997.
14. HELMEPA,: Paradise in the Depth of the Saronikos Bay, Video Tape (in Greek)., 2002.
15. HELMEPA-LIFE. Integrated demonstration scheme for solid waste management / recycling and investigation for waste on unspoiled, non-developed beaches. Final Report, Athens, 1997.
16. HELMEPA-MEDSPA, Public Awareness Campaign for the Abatement of Pollution by Litter of the Greek coasts and Seas. Final Report. Athens, 1991..
17. HELMEPA-MEDSPA, Uniform Environmental Initiative / Action Programme in the Mediterranean. Final Report. Athens, 1994..
18. Horrocks, C.: Shipping Efforts and Needs to Limit Ship Generated Pollution. Emphasis on Garbage, pp. 114-123. In: *Proceedings of the Workshop on the Elimination of Garbage from the Mediterranean and its Adoption as an Effective Special Area to Annex V of MARPOL 73/78*, Athens, 29-30 June 1989.
19. IOC, Report of the Sixth Session of the Committee for the Global Investigation of Pollution in the Marine Environment Programme, Paris, 25 September – 1 October 1986, UNESCO, Paris, 1986.
20. IOC. : Report of the Seventh Session of the Committee for the Global Investigation of Pollution in the Marine Environment Programme, Paris, 12 – 18 January 1991, UNESCO, Paris, 1991.
21. IOC/FAO/UNEP, Report of the IOC/FAO/UNEP review meeting on the persistent synthetic materials pilot survey, Haifa, Israel, 1989.
22. IOC/UNESCO. Review of Activities by Regional and International Organizations Relating to the Assessment of Marine and coastal Litter in the Mediterranean Sea, Athens, 2000..
23. MAP, : Report of the IOC/FAO/UNEP *Ad Hoc* Meeting on Persistent Synthetic Materials, Athens, 14-16 Oct. 1987 (document UNEP(OCA) MED WG.1/Inf.6), 1988.
24. MAP. Summary Background Paper by the Secretariat, Consultation Meeting on Marine and Coastal Wastes in the Mediterranean, Athens, 20-21 Dec. 1999 (document UNEP(OCA)MED WG. 164/2), 1999.
25. MAP.: Report of the Consultation Meeting on Marine and Coastal Wastes in the Mediterranean, Athens, 20-21 Dec. 1999 (document UNEP(OCA)/MED WG. 164/3), 2000.
26. MAP. General Questionnaire about Litter Management in Coastal Zones, 7p. MAP, 2001: Litter Management in Coastal Zones of the Mediterranean Basin. Analysis of the Questionnaire and Proposals for Guidelines (document UNEP(DEC)/MED WG. 183/Inf. 4), 2000.
27. MAP. Strategic Action Programme: Guidelines for Management of Coastal Litter for the Mediterranean Region (document UNEP(DEC)/MED WG 231/7), 2003.
28. McCoy, F.W...: Floating megalitter in the eastern Mediterranean, *Mar Pollut Bull* 19 (1):. 25-28, 1988.
29. Mitsasos, D.,: Initiatives for Public Awareness – Educational Campaign, pp. 159-170. In: *Proceedings of the Workshop on the Elimination of Garbage from*

- the Mediterranean and its Adoption as an Effective Special Area to Annex V of MARPOL 73/78*, Athens, 29-30 June 1989.
30. Morios R.J., 1980: Floating plastic debris in the Mediterranean. *Mar Pollut Bull* 11 (5): 125-128, 1980.
  31. Pinon, H. International Regulations Affecting the Mediterranean, pp. 82-88. In: *Proceedings of the Workshop on the Elimination of Garbage from the Mediterranean and its Adoption as an Effective Special Area to Annex V of MARPOL 73/78*, Athens, 29-30 June 1989.
  32. Role A, Chircop AE. Institutional, Law and Policy Responses in the Management of Garbage Pollution at the National Level, pp. 143-152. In: *Proceedings of the Workshop on the Elimination of Garbage from the Mediterranean and its Adoption as an Effective Special Area to Annex V of MARPOL 73/78*, Athens, 29-30 June 1989.
  33. Rudischhauser, K.: EC Policy to limit garbage pollution in the Mediterranean, pp. 172- 177. In: *Proceedings of the Workshop on the Elimination of Garbage from the Mediterranean and its Adoption as an Effective Special Area to Annex V of MARPOL 73/78*, Athens, 29-30 June 1989.
  34. Saydam Cl. Salihoglu M. Sakarya, Yilmaz A. Dissolved/dispersed petroleum hydrocarbons, suspended sediment, plastic, pelagic tar and other litter in the Northeastern Mediterranean. In: *CIESM/UNEP/IOC: Workshop on Pollution of the Mediterranean*. Lucerne, 1984, CIESM, pp.509-517.
  35. Shiber, J.G.: Plastic pellets on the coast of the Lebanon, *Mar Pollut Bull* 10 (1,): 28-30, 1979.
  36. Shiber, J.G., Plastic pellets on Spain's "Costa del Sol" beaches, *Mar Pollut Bull* 13 (12),: 409-412, 1982.
  37. Shiber, J.G., Plastic pellets and tar on Spain's Mediterranean beaches, *Mar Pollut Bull* 18,(2): 84-86, 1987.
  38. Skordilis, S.: Possible initiatives of municipalities to limit garbage pollution, In: *Proceedings of the Workshop on the Elimination of Garbage from the Mediterranean and its Adoption as an Effective Special Area to Annex V of MARPOL 73/78*, Athens, 29-30 June, pp. 1340141, 1989.
  39. Tomas JR. Guitart, R. Mateo R, Raga JA. Marine debris ingestion in loggerhead sea turtles, *Caretta caretta*, from the Western Mediterranean, *Mar Pollut Bull* 44: 211-216, 2002.
  40. .UNEP/IOC/FAO, Assessment of the state of pollution of the Mediterranean Sea by persistent synthetic materials, which can float, sink or remain in suspension. MAP Technical Reports Series No. 56. UNEP, Athens, 1991.

## **ANNEX 2.**

**(26/9/2011 NEWS)**

### **Green Chemistry Company Turns Ocean Trash into Plastic Bottles**

*SustainableBusiness.com News*

Often referred to as the **Great Pacific Garbage Patch**, the North Pacific Gyre could be twice the size of Texas and contains about 3.5 million tons of trash - it's called the world's largest landfill. Much of the trash is plastic that's broken down into suspended particulates, a testament to humanity's reliance on petroleum and our failure to dispose of products made from it properly. For years it was believed the trash was unredeemable.

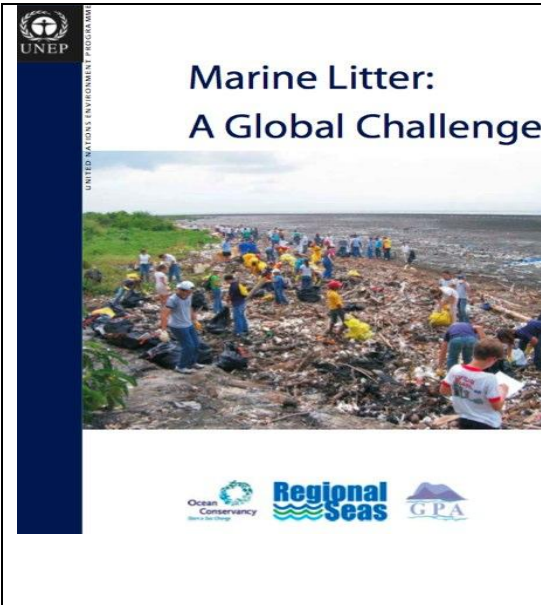
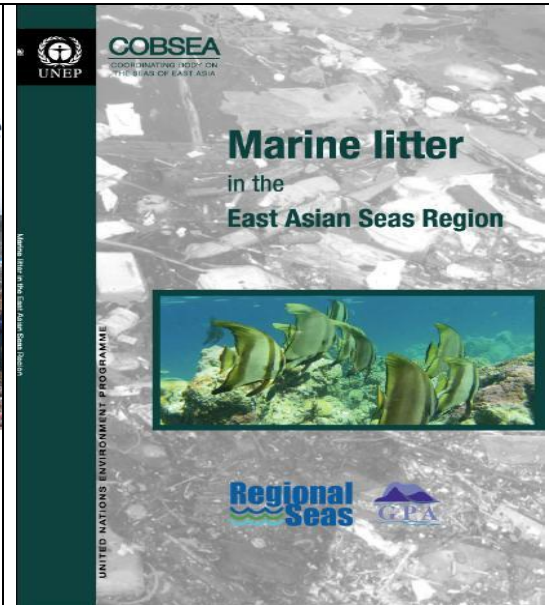
Not any longer. A California-based green household and personal products company called Method has figured out a way to use plastic from the Gyre in

the production of 100% post-consumer polyethylene bottles. 25% of the plastic used in the bottles is recovered from the Gyre.

Founded in 2000, Method made its first bottle entirely from post-consumer recycled plastic in 2006, and since then has manufactured tens of millions of plastic bottles a year that are completely free from virgin plastic.

Now, teaming with Envision Plastics, one of the largest recyclers in the US, Method has developed a recycling process to engineer a new plastic material it calls Ocean PCR that is the same quality as virgin HDPE plastic. Method is currently collecting enough usable ocean plastic to create a significant supply and turn it into bottles. The company plans to take the bottle to market early next year with a major, as yet unnamed, retailer.

Announcing the innovation, Adam Lowry, Method co-founder, said, "We've created a usable bottle from ocean plastic and upcycled it into something useful that can be recycled again and again. Our ultimate goal is to raise awareness that the real solution to plastic pollution lies in reusing and recycling the plastic that's already on the planet Method's founders just published a book, "The Method Method," which tells the story of their company.

 <p>UNEP. <i>Marine Litter: A Global Challenge</i>.          Jetic L, Sheavly S,          Adler E (prepared by) Meith N (Editor),          UNEP publications,          Nairobi, Kenya, 2008.</p>	 <p>UNEP: <i>Marine Litter in the East Asian Seas Region</i>, COBSEA, UNEP, 2007</p>
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