EMBASSY OF COLOMBIA IN COSTA RICA

E.086 San Jose, March 14, 2016

Lic.
PABLO SAAVEDRA ALESSANDRI
Secretary
Inter-American Court of Human Rights
San José

REF. Advisory Opinion

Sir:

For the relevant effects, I have the pleasure to forward you Diplomatic Note S-DVAM-16-024746 of March 14, 2016, signed by Francisco Javier Echeverri Lara, Vice Minister for Multilateral Affairs of the Ministry of Foreign Affairs of Colombia, in which the Republic of Colombia requests an advisory opinion.

Accept, Sir, the assurances of my highest and most distinguished consideration.

[Signed]

JESUS IGNACIO GARCIA VALENCIA

Ambassador

Attached: the said request

JIGV/cemm

REPUBLIC OF COLOMBIA
MINISTRY OF FOREIGN AFFAIRS

S-DVAM-16-024746

Bogota, D.C., March 14, 2016

Sir:

Pursuant to Article 64(1) of the American Convention on Human Rights, the Republic of Colombia respectfully presents to the Inter-American Court of Human Rights a request for an advisory opinion concerning the interpretation and scope of Article 1(1) (Obligation to Respect Rights), 4(1) (Right to Life), and 5(1) (Right to Humane Treatment/Personal Integrity) of the American Convention. The complete text and annexes are attached to this communication.

I would be grateful if you would forward all notifications relating to this matter to Ricardo Abello Galvis. Mr. Abello Galvis will act as Agent of the Republic of Colombia for the purposes of this request for an advisory opinion. His contact information is as follows:

- E-mail: ricardoabello@gmail.com
- Telephone: (+57} 310 871 2079
- Address: Ministry of Foreign Affairs
  Carrera 5 No. 9-03, Office MR 301, Bogota D.C. (Colombia).

Accept, Sir, the assurances of my highest and most distinguished consideration.

· FRANCISCO JAVIER ECHEVERRI LARA
Vice Minister for Multilateral Affairs

Lic.
PABLO SAAVEDRA ALESSANDRI
Secretary
Inter-American Court of Human Rights
San Jose, Costa Rica

INTER-AMERICAN COURT OF HUMAN RIGHTS

REQUEST FOR AN ADVISORY OPINION

Presented by

THE REPUBLIC OF COLOMBIA

concerning the interpretation of Article 1(1), 4(1) and 5(1)
of the American Convention on Human Rights

San Jose, Costa Rica
March 2016

To the President of the Inter-American Court

Sir,

The Government of the Republic of Colombia (hereinafter “Colombia”), Member State of the Organization of American States and State Party to the American Convention on Human Rights – Pact of San José (hereinafter “the Pact of San José” or “the Pact”) refers to Article 64(1) of this Pact according to which:

> “The member states of the Organization may consult the Court regarding the interpretation of this Convention or of other treaties concerning the protection of human rights in the American states,”

and, pursuant to Article 2(2) of the Court’s Statute, requests the Court to provide an advisory opinion interpreting certain provisions of the Pact.

In accordance with the provisions of paragraphs 1 and 2 of Article 70 of the Court’s Rules of Procedure, which stipulate that:

> “1. Requests for an advisory opinion under Article 64(1) of the Convention shall state with precision the specific questions on which the opinion of the Court is being sought.
>
> 2.Requests for an advisory opinion submitted by a Member State or by the Commission shall, in addition, identify the provisions to be interpreted, the considerations giving rise to the request, and the names and addresses of the Agent or the Delegates,”

Colombia presents below the provisions to be interpreted (Chapter 1), the considerations giving rise to the request (Chapters 2 and 3), and the specific questions on which the opinion of the Court is being sought (Chapter 4).

SUMMARY

SECTION 3: INTERPRETATION OF ARTICLE 4(1) AND 5(1) OF THE AMERICAN CONVENTION ON HUMAN RIGHTS IN RELATION TO ARTICLE 1(1), IN LIGHT OF INTERNATIONAL ENVIRONMENTAL LAW

A. The articles to be interpreted in this request for an advisory opinion

B. Application of the principles and norms of international environmental law to the content of the State obligations under Articles 1(1), 4(1) and 5(1) of the American Convention on Human Rights

a) The obligation to make an environmental impact assessment

b) The obligation to cooperate with any States that may be affected

c) The importance of environmental impact assessments and the obligation of cooperation in the case of potential harm to the marine environment of the Wider Caribbean region

LIST OF ANNEXES

Annex I	Huggins A.E., S. Keel et al., *Biodiversity Conservation Assessment of the Insular Caribbean Using the Caribbean Decision Support System*, Technical Report, The Nature Conservancy, 2007
Annex II	J.B.R. Agard and A. Cropper, "Caribbean Sea Ecosystem Assessment (CARSEA), A contribution to the Millennium Ecosystem Assessment," prepared by the Caribbean Sea Ecosystem Assessment Team, Caribbean Marine Studies, Special Edition, 2007, p. XVI
Annex III	Burke and J. Maidens, *Arrecifes en Peligro en el Caribe,* World Resources Institute, 2005.
Annex IV	Dr. Karen Sumser-Lupson & Marcus Kinch, *Evaluation des risques de pollution maritime accidentelle dans la Manche, Typologie des pollutions maritimes*, University of Plymouth

CHAPTER 1. THE PROVISIONS TO BE INTERPRETED

1. This request refers specifically to the interpretation of articles:

- 1(1) (Obligation to Respect Rights),
- 4(1) (Right to Life),
- 5(1) (Right to Humane Treatment/Personal Integrity), and
- 4(1) and 5(1) of the Pact of San Jose, in relation to Article 1(1), in light of international environmental law.

2. The essential issue raised before the Court – and which will later be disaggregated into specific questions – is as follows: how should the Pact of San José be interpreted when there is a risk that the construction and operation of major new infrastructure projects will have a severe impact on the marine environment of the Wider Caribbean Region and, consequently, the human habitat that is essential for the full exercise and enjoyment of the rights of the inhabitants of the coasts and/or islands of a State Party to the Pact, in light of the environmental laws established in treaties and in customary international law applicable between the respective States?

3. Furthermore, how should the Pact of San José be interpreted in relation to other treaties concerning environmental matters that seek to protect specific areas, such as the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, in relation to the construction of major infrastructure projects in States Parties to these treaties and the respective international obligations as regards prevention, protection, and mitigation of damage and cooperation between the States that may be affected?

4. The specific questions posed to the Court will be developed in Chapter 4 of this document. However, they are summarized below:

> *I. Pursuant to Article 1(1 of the Pact of San José, should it be considered that a person, even if he is not in the territory of a State Party, is subject to the jurisdiction of that State in the specific case in which the following four conditions are met cumulatively?*
>
> *(i) That the person resides or is in an area delimited and protected by a treaty-based environmental protection system to which that State is a party;*
>
> *(ii) That the said treaty-based system establishes an area of functional jurisdiction, such as, for example, the one established in the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region;*
>
> *(iii) That in the said area of functional jurisdiction, the States parties have the obligation to prevent, reduce and control pollution by means of a series of general and/or specific obligations, and*
>
> *(iv) That, as a result of damage to the environment or of the risk of environmental*

damage in the area protected by the convention in question that can be attributed to a State party – to that convention and to the Pact of San José – the human rights of the person in question have been violated or are threatened.

II. Are the measures and the actions taken by one of the States parties the effects of which, by act and/or omission, may cause serious damage to the marine environment – which constitutes the way of life and an essential resource for the subsistence of the inhabitants of the coast and/or the islands of another State party – compatible with the obligations set out in Articles 4(1) and 5(1), read in relation to Article 1(1), of the Pact of San José? Or of any other permanent provision?

III. Should we interpret – and to what extent – the norms that establish the obligation to respect and ensure the rights and freedoms set out in Articles 4(1) and 5(1) of the Pact in the sense that they infer the obligation of the States Parties to the Pact to respect the norms of international environmental law that seek to prevent any environmental damage which could restrict or preclude the effective enjoyment of the rights to life and to personal integrity, and that one of the ways of complying with that obligation is by making environmental impact assessments in an area protected by international law, and by cooperation with the States that could be affected? If applicable, what general parameters should be taken into account when making environmental impact assessments in the Wider Caribbean Region, and what should be the minimum content of these assessments?

5. The Court's opinion will have great relevance for effective compliance with international human rights obligations by the agents and organs of the States of the Wider Caribbean Region, as well as for reinforcing global awareness, by clarifying the scope of the obligations under the Pact in relation to environmental protection and, in particular, the importance that should be accorded to environmental and social impact assessments, to projects that prevent and mitigate environmental damage, and to cooperation between the States that may be affected by harm to the environment in the context of the construction and operation of mega projects that, once commenced, may have an irreversible negative impact on the marine environment.

CHAPTER 2. THE FACTUAL CONSIDERATIONS GIVING RISE TO THIS REQUEST

6. The Court's case law considers that an advisory opinion must have a practical effect in inter-American law. Thus, it has indicated that:

> "[T]he advisory jurisdiction of the Court is "an alternative judicial method" (Restrictions to the Death Penalty (Arts. 4(2) and 4(4) American Convention on Human Rights), Advisory Opinion OC-3/83 of September 8, 1983. Series A No. 3, para. 43) for the protection of internationally recognized human rights, which shows that this jurisdiction should not, in principle, be used for purely academic speculation, without a foreseeable application to concrete situations justifying the need for an advisory opinion."[1]

Bearing this in mind, we will refer to actual situations that demonstrate the specific usefulness and importance of obtaining a response to this request.[2]

7. The situation that has led Colombia to present this request for an advisory opinion relates to the severe degradation of the human and marine environment of the Wider Caribbean Region that may result from the acts and/or omissions of States with coasts on the Caribbean Sea in the context of the construction of major new infrastructure projects.

8. In particular, this request for an advisory opinion responds to the development of major new infrastructure projects in the Wider Caribbean Region that, owing to their dimensions and permanence in time, could cause significant ham to the marine environment and, consequently, to the inhabitants of the coastal areas and islands located in this region, who depend on this environment for their subsistence and development. As an example, we will include some considerations on the possible risks of pollution entailed by the execution of these projects and the implications for the marine environment of the Wider Caribbean Region and, hence, for the quality of life, personal integrity and development of the inhabitants of the region with the sole purpose that the Court may issue its opinion with regard to the scope and application of certain provisions of the Pact of San José and of any other treaties that the Court finds it pertinent to analyze.

9. It is evident that this problem is of interest not only to the States of the Wider Caribbean Region whose coastal and insular population may be directly affected by the environmental damage suffered by this region, but also to the international community. This is because we are living at a time when major infrastructure projects are frequently being built and brought into operation in maritime zones with effects that may exceed State boundaries, and that may end up having negative repercussions on the quality of life and personal integrity of those who depend on the marine environment for their subsistence and development.

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1 ICourtHR, *Judicial Guarantees in States of Emergency (Arts. 27.2, 25 and 8 American Convention on Human Rights),* Advisory Opinion OC-9/87 of October 6, 1987. Series A No. 9. Para. 16.

2 ICourtHR, *Judicial Guarantees in States of Emergency (Arts. 27.2, 25 and 8 American Convention on Human Rights),* Advisory Opinion OC-9/87 of October 6, 1987. Series A No. 9. Para. 17.

10. The protection of the human rights of the inhabitants of the islands of the Wider Caribbean Region and, consequently, the prevention and mitigation of environmental damage in this area, is an issue of special interest for Colombia, insofar as part of its population inhabits the islands that form part of the Archipelago of San Andres, Providencia and Santa Catalina and, therefore, depends on the marine environment for its economic, social and cultural survival and development.

11. Owing to the ecological and oceanographic interconnectivity of the Wider Caribbean Region – a situation that is very well documented[3] - it is vitally important that marine environmental problems are dealt with taking into consideration their effects on relevant areas and on the ecosystem as a whole, with the cooperation of other States that could be affected.

12. The Wider Caribbean Region[4] and, specifically, the Caribbean Sea, is considered the heart of Atlantic biodiversity[5] and the source of resources that sustain the way of life of the coastal populations and contribute to the region's economic growth.

13. The marine environment of this region determines the living conditions and way of life of the inhabitants of its coasts and, in particular, its islands, who depend essentially on fishing and on tourist activities in the area – and these activities, in turn, depend on the living resources provided by the Caribbean Sea. In other words, the marine environment constitutes the natural habitant of these persons, a necessary condition for their development and their life projects, their ancestral resources, and the legacy for future generations. All of which would be severely threatened by damage to the marine environment (Section I).

14. The Wider Caribbean Region and, specifically, the Caribbean Sea, consists of three main ecosystems – the coral reefs, the mangroves, and the seagrass beds – which are home to an exceptional flora and fauna, essential for the sources of the livelihood of the coastal communities, such as fishing and tourism. Owing to its inherent characteristics, the Wider Caribbean Region is particularly sensitive to the environmental harm that could result from acts and/or omissions of States with coasts around the area limited to the north by Florida and the Bahamas, to the west and to the south by Central America, and to the east by the Antilles.

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3 UNEP, "Specially Protected Areas and Wildlife of the Wider Caribbean Region: a regional biodiversity protocol, July 2000.

4 As explained below and according to Article 2(1) of the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, adopted in Cartagena de Indias on March 24, 1983, the Wider Caribbean Region consists of:

> "The 'Convention area' means the marine environment of the Gulf of Mexico, the Caribbean Sea and the areas of the Atlantic Ocean adjacent thereto, south of 30 deg north latitude and within 200 nautical miles of the Atlantic coasts of the States referred to in article 25 of the Convention."

5 Annex I: Huggins A.E., S. Keel et al., *Biodiversity Conservation Assessment of the Insular Caribbean Using the Caribbean Decision Support System,* Technical Report, The Nature Conservancy, 2007. Available at: www.conserveonline.org/workspaces/Caribbean,conservation.

15. Today, the delicate balance of these places is threatened by numerous human activities that day-by-day contribute to their progressive degradation. In this context, specific threats of serious damage to the marine environment of the Caribbean Sea are also a serious threat to the way of life and personal integrity of all the inhabitants of the coasts and, especially, the islands in this Region (Section 2).

SECTION 1: THE RELEVANCE OF THE MARINE ENVIRONMENT FOR THE INHABITANTS OF THE COASTS AND ISLANDS OF THE WIDER CARIBBEAN REGION

16. The inhabitants of the coasts and, particularly, of the islands of the Wider Caribbean Region, such as the Colombian islands, depend fundamentally on their marine environment to live and develop as individuals and as a community. Indeed, the conditions of this environment define their possibilities of survival, their living conditions and way of life, and their ability to achieve sustainable development. The immediate surroundings of the inhabitants of the coasts and islands of the Wider Caribbean Region, their habitat, is also their ancestral resource, the legacy for the future generations, and the essential source of their economic, social and cultural development, which is based on fishing and tourism. In the specific case of the Colombian islands, the critical importance of the environment for their inhabitants has been recognized in the different policies and laws that have been adopted in order to provide them with adequate protection.[6]

17. The intrinsic link that exists between the inhabitants of the Wider Caribbean Region and the marine environment has been fully explained by experts in this field, who have emphasized not only the economic value of this environment, but also its cultural, spiritual and recreational value for the communities that depend on it:

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6 Colombia has adopted diverse policies and laws in order to improve protection of the maritime environment of the Caribbean coast. They include: Declaration of the Seaflower Biosphere Reserve, declared part of the World Network of Biosphere Reserves by the Man and the Biosphere Programme of the United Nations Educational Scientific, and Cultural Organization (UNESCO), November 10, 2000; Constitution of Colombia of July 20, 1991, Official Gazette No.116, Article 101; Law No. 19 of September 21, 1983, National Congress of Colombia, Official Gazette No. 36,354; Law No. 47 of February 19, 1993, National Congress of Colombia, Official Gazette No. 40,763.; Law No. 99 of December 22, 1993, National Congress of Colombia, Official Gazette No. 41,146; Law No. 136 of June 2, 1994, National Congress of Colombia, Official Gazette No. 41,377; Law No. 165 of November 9, 1994, National Congress of Colombia, Official Gazette No. 41,589; Law No. 915 of October 27, 2004, National Congress of Colombia, Official Gazette No. 45,714; Decree 1681 of August 4, 1978, President of the Republic; Decree 1875 of August 2, 1979, Ministry of Agriculture; Decision No. 1602 of December 21, 1995, Ministry of the Environment; Decision No. 1021 of December 22, 1995, Ministry of the Environment; Ministerial Decision No. 20 of January 9, 1996; Decision No. 1426 of December 20, 1996; Decision No. 151 of March 9, 1998, Corporation for the Sustainable Development of the Department-Archipelago of San Andres, Providencia and Santa Catalina (Coralina); Decision No. 1132 of January 3, 2005, Corporation for the Sustainable Development of the Department-Archipelago of San Andres, Providencia and Santa Catalina (Coralina); Decision No. 107 of January 27, 2005, Ministry of the Environment, Housing and Territorial Development, Official Gazette No. 45,809; Decision No. 409 of May 22, 2006, Corporation for the Sustainable Development of the Department-Archipelago of San Andres, Providencia and Santa Catalina (Coralina); Decision No. 004 of August 8, 2005, Departmental Fisheries and Aquaculture Board (Jundepesca).

"The peoples of the Caribbean are defined by the Sea whose shores they inhabit. In the rich diversity of cultures and nations making up the region, the one uniting factor is the marine ecosystem on which each ultimately depends.

If that ecosystem is under threat, so are the livelihoods of millions of people. The economic activity of the Caribbean is based to a very great extent on the bounty of the Sea and the natural beauty which attracts visitors from around the world which, in turn, require the healthy functioning of complex physical and biological processes. The coral reefs and the seagrass beds, the white-sand beaches and the fish shoals of the open ocean: these are natural capital assets whose loss or degradation has huge implications for the development of the region.

Apart from the economic importance of the ecosystem, it shapes the lives of all the inhabitants of the Caribbean in ways which defy statistical analysis. The Sea and its coasts form the stage on which the cultural, spiritual, and recreational life of the region is played out."[7]

18. The same report also indicates:

"The well-being of the 116 million people living within 100 km of the sea (Burke and Maidens 2004) is highly dependent on the services it provides as an ecosystem. Critical among these is the unique character of its coastlines and open waters, making it a desirable place to live and to visit: in the terminology of the Millennium Ecosystem Assessment (MA, www.maweb.org), this desirability translates into a range of cultural services based on the recreational and aesthetic value of the land and seascape. The economies of the Caribbean islands are especially dependent on these functions of the marine environment that support tourism. Another key ecosystem service linked to well-being in the region is the availability of fish and marine invertebrates, a provisioning service within the MA definitions. […]"[8]

"Coral reefs in the Caribbean Sea are prolific providers of ecosystem services, including food, protection from storms, recreational value and therefore tourism income, and medicinal products. [...]"[9]

"In the terminology of the MA the living marine resources of the Caribbean Sea constitute the most important 'provisioning' service of the ecosystem. Fisheries have always been a source of livelihoods and sustenance for the people of the region, contributing towards food security, poverty alleviation, employment, foreign-exchange earnings, and the development of rural and coastal communities, recreation, and tourism [...]."[10]

"Fisheries play a very important role in providing nutrition and food security within the Caribbean region. Fish is a vital source of animal protein and minerals in the diet of

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7 Annex II, J.B.R. Agard and A. Cropper, "Caribbean Sea Ecosystem Assessment (CARSEA), A contribution to the Millennium Ecosystem Assessment", prepared by the Caribbean Sea Ecosystem Assessment Team, Caribbean Marine Studies, Special Edition, 2007, p. XIV

8 *Ibid.* p. 1.

9 *Ibid.* p. 13.

10 *Ibid.* p. 21.

> Caribbean people, particularly the poor and vulnerable members of society."[11]

19. For its part, on different occasions, the General Assembly of the United Nations has acknowledged the dependence of the inhabitants of the coasts and islands of the Caribbean on their marine ecosystem and, consequently, the fundamental importance of the protection of this environment for all the States of the region. For example, in the preamble to Resolution A/Res/61/197: "Towards the sustainable development of the Caribbean Sea for present and future generations," adopted on December 20, 2006, the General Assembly indicated that:

> "Recognizing that the Caribbean Sea has a unique biodiversity and highly fragile ecosystem,
>
> Bearing in mind the heavy reliance of most of the Caribbean economies on their coastal areas, as well as on the marine environment in general, to achieve their sustainable development needs and goals,
>
> Acknowledging that the intensive use of the Caribbean Sea for maritime transport, as well as the considerable number and interlocking character of the maritime areas under national jurisdiction where Caribbean countries exercise their rights and duties under international law, present a challenge for the effective management of the resources,
>
> Noting the problem of marine pollution caused, inter alia, by land-based sources and the continuing threat of pollution from ship-generated waste and sewage, as well as from the accidental release of hazardous and noxious substances in the Caribbean Sea area,
>
> Cognizant of the importance of the Caribbean Sea to present and future generations and to the heritage and the continuing economic well-being and sustenance of people living in the area, and the urgent need for the countries of the region to take appropriate steps for its preservation and protection, with the support of the international community."

20. The dependence of the inhabitants of the Caribbean on the marine environment, as well as its fragility, have also been verified and recognized by all the States of the Region that are party to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena de Indias, March 24, 1983), the preamble of which states:

> "The Contracting Parties,
>
> Fully aware of the economic and social value of the marine environment, including coastal areas, of the wider Caribbean region,
>
> Conscious of their responsibility to protect the marine environment of the wider Caribbean region for the benefit and enjoyment of present and future generations,
>
> Recognizing the special hydrographic and ecological characteristics of the region and its vulnerability to pollution,
>
> Recognizing further the threat to the marine environment, its ecological equilibrium, resources and legitimate uses posed by pollution and by the absence of sufficient integration of an environmental dimension into the development process,

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11 *Ibid.* p. 22.

> Considering the protection of the ecosystems of the marine environment of the wider Caribbean region to be one of their principal objectives."

21. The living resources of the Caribbean are the main source of the services that this environment provides for the inhabitants of its coasts and, particularly, of its islands.

22. As already indicated, one of those services is fishing, which contributes to the well-being of the inhabitants of the region in different ways. First, fishing plays a very important role for the food security of the Caribbean Region, because fish is a vital source of animal protein and minerals in the diet of the inhabitants of this region, particularly, the poorest and most vulnerable sectors. Second, fishing makes a significant contribution to the trade balance of the Caribbean Region, as regards imports and exports. Lastly, and most importantly, fishing contributes to the well-being and quality of life of the inhabitants of the Wider Caribbean Region by generating hundreds of thousands of jobs – both directly (the fishermen), and by means of all the fishing-related activities (boatbuilding, netmaking, fish processing, etc.), on which the inhabitants depend for their subsistence.[12]

23. The importance of fishing for the well-being and quality of life of the inhabitants of the coasts and islands of the Wider Caribbean Region has been recognized by the Special Rapporteur on the right to food as follows:

> "3. Fisheries contribute to food security through two pathways: directly, by providing fish for people, especially low-income consumers, to eat, thereby improving both food availability and the adequacy of diets; and indirectly, by generating income from the fisheries sector. […]
>
> 4. […] Fish consumption, and dependency on fish, can be much higher in island and coastal countries, and in countries with large freshwater lakes and rivers. […]
>
> 6. The fisheries sector can contribute to the realization of the right to food by providing employment and income and sustaining local economies. Globally, 54.8 million people are engaged in capture fisheries and aquaculture and approximately three times as many are involved in upstream and downstream activities (e.g. fish processing, selling, netmaking and boatbuilding)."[13]

24. Furthermore, the Caribbean is universally considered to be a tourist destination, popular owing precisely to the appeal of its marine resources. It has even been considered that, worldwide, the insular Caribbean is the region most dependent on tourism.[14] Consequently, the tourism sector has become a fundamental source of the well-being, economic growth and development of the coastal communities of the Caribbean, through the generation of employment

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12 *Ibid.* pp. 22-23.

13 General Assembly, United Nations, "Provisional report of the Special Rapporteur on the right to food," A/67/268, 8 August 2012, pp. 4-5.

14 Annex II, p. 28.

and foreign exchange earnings, and the development of other industries, such as agriculture and construction.[15]

25. Finally, the marine environment has a direct effect on the quality of life of the inhabitants of the Caribbean islands, as well as on their ability to live in the place where they were born and have founded a family.

26. To the extent that the inhabitants of the coasts and islands of the Wider Caribbean Region depend fundamentally on the resources provided by the marine environment, any serious harm to this environment will undoubtedly affect the survival possibilities of these communities and their economic, social and cultural development.

27. As explained in the following section, the construction and operation of major new infrastructure projects in the Wider Caribbean Region may have serious consequences for the marine environment, negatively and irreversibly affecting life with dignity and the quality of life of the inhabitants of the islands located in this region, as well as their potential economic, social and cultural development, and their physical, mental and moral integrity.

SECTION 2: THE SERIOUS THREATS TO THE MARINE ENVIRONMENT IN THE WIDER CARIBBEAN REGION

28. Owing to the intense fragility of the ecosystem of the Wider Caribbean Region, most environmental damage could be severe and irreparable (A). At the present time, several activities implemented by the coastal States of this region could generate this type of damage. These activities may take different forms including, in particular: petroleum exploration and exploitation, maritime transportation of hydrocarbons, port construction and maintenance, and the construction, maintenance and expansion of shipping canals, among others (B).

A. The immense fragility of the Caribbean Sea ecosystem

29. The ecosystem of the Caribbean Sea depends on the quality of its waters, its corals, its mangroves, and its seagrass beds. Considered as a whole, these three coastal formations, together with the beaches, are the source of the services that the Caribbean marine environment provides to the inhabitants of its coasts and, particularly, of its islands: mainly, tourism and fishing.[16]

30. The vital importance of the coral reefs and their considerable value, both for the

15 *Ibid.*

16 *Ibid,* p. xv.

conservation of the ecosystem and for tourism and fishing, has already been noted by the scientific community and experts in this field:

> “Coral reefs in the Caribbean Sea are prolific providers of ecosystem services, including food, protection from storms, recreational value and therefore tourism income, and medicinal products. It is estimated that the potential yields for fisheries from coral reefs amount to 10 t / square kilometer / year, which could provide up to 6% of global fisheries if properly managed (Burke and Maidens 2004). Commercially valuable species fished on coral reefs include snappers (Lutjanidae), groupers (Serranidae), and jacks (Carangidae), while less valuable species include parrot fish (Sparidae) and surgeon fish (Acanthuridae). Important shellfisheries include those for conch (a large marine gastropod mollusc) and lobster.
>
> Harvesting of other reef resources includes live ornamental fish for the aquarium trade; collection of coral skeletons and shells of other creatures for jewellry and other ornaments; mining of reef rock, coral heads, and coral sand for construction, and bioprospecting for potential pharmaceuticals. Only a small fraction of the huge reef biodiversity has so far been tested for the presence of products useful for medicine and industry, but already many have been found and exploited commercially.
>
> Coral reefs are among the most beautiful and visually impressive habitats on earth, full of life and colour. The Caribbean tourism industry owes much to the opportunities they provide for diving and snorkelling. Reefs also contribute to the attraction of beach holidays through the calm water and blue-green colouring provided by their lagoons, the protection they offer against beach erosion, and the role of coral skeletons in forming the white sand of Caribbean beaches. Shoreline protection is a very important service provided by coral reefs, and an assessment of their value should include the replacement cost of beaches and of buildings and developments close to shore a service likely to become increasingly important according to models which predict both rising sea level and more destructive storm activity as a result of global warming.”[17]

31. Mangroves have also proved to be determinants for maintaining the balance of the marine environment, as well as to attract tourism:

> “Mangroves help to provide nutrients for a range of marine life, shield coastal communities from the full force of wind and waves, purify wastes from land-based sources that enter the coastal zone, and attract eco-tourists to their vibrant wildlife.”[18]

32. As for seagrass beds, it has been proved that they are vital for the conservation of marine life:

> “The beds formed by seagrass perform a number of important roles in the Caribbean Sea ecosystem, including the stabilization of sediments, reducing the energy of waves as they approach the shore, and the provision of a nursery habitat for organisms that as adults live in other systems.
>
> Seagrass communities serve as habitats for a wide range of organisms. They provide food for species such as parrot fish, surgeonfish, queen conch, sea urchins, and green turtles.

[17] *Ibid.* p. 13-14.

[18] *Ibid.* p. 15.

The seagrass leaves carry epiphytic algae and animals, which are grazed by invertebrates and fish. The seagrass blades enhance sedimentation and reduce erosion by slowing down waves and currents, while the roots and rhizomes bind and stabilize the sediment surface.

Seagrass beds are very important in the marine food chain as a result of the high rate at which they convert carbon dioxide dissolved in the water into organic matter, through the process of photosynthesis (high net productivity). This rate, approximately 1 kg of carbon for each square meter in the course of a year (1kgCm-2year-1) is significant because about half of this material is exported as detritus, which contributes food to offshore ecosystems.

Seagrass habitats act as a nursery for the young of many commercial species of fish, crustaceans, and molluscs, while reef-based carnivores venture off into nearby seagrass beds in search of food. The wide variety of epiphytes which live in the seagrasses become the food of many bottom-dwelling fish species which feed off detritus.

Organisms in seagrass beds with calcium-based external skeletons (for example, molluscs, echinoderms, crustaceans, calcareous algae, and some protozoa) also help to form beach sand."[19]

33. According to the report on the Caribbean Sea prepared in the context of the Millennium Ecosystem Assessment sponsored by the United Nations, each of these three habitats forms one large interdependent marine ecosystem with shared biodiversity. Consequently, degradation of one type of habitat can have far-reaching impacts on the services that another habitat provides to the inhabitants of the coasts and islands of the Caribbean. For example, damage to sea grass beds could affect income from fisheries and also speed up erosion of nearby beaches, which might reduce the appeal of a particular tourist resort and, therefore, damage local livelihoods.[20]

34. As is well known, each of these formations that compose the ecosystem of the Caribbean Sea already shows signs of significant damage as a result of human activity. As has been demonstrated, in most cases this damage is irreparable. For example, it has been shown that recovery of coral has been both rare and, when present, slow.[21] Today, a large percentage of the habitats – corals, mangroves and sea grass beds – that support fishing and tourism in the Caribbean have been lost, while another significant proportion is severely threatened.

35. To illustrate this point, a map appears below showing the location of the reefs where there is limited threat (in blue), those where there is a medium threat (in yellow), and those where there is a high or very high threat (in orange).[22]

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[19] *Ibid.* p. 13.

[20] *Ibid.* p. 17.

[21] *Ibid.* p. 15.

[22] Annex III, L. Burke and J. Maidens, *Arrecifes En Peligro en el Caribe,* World Resources Institute, 2005, p. 38.

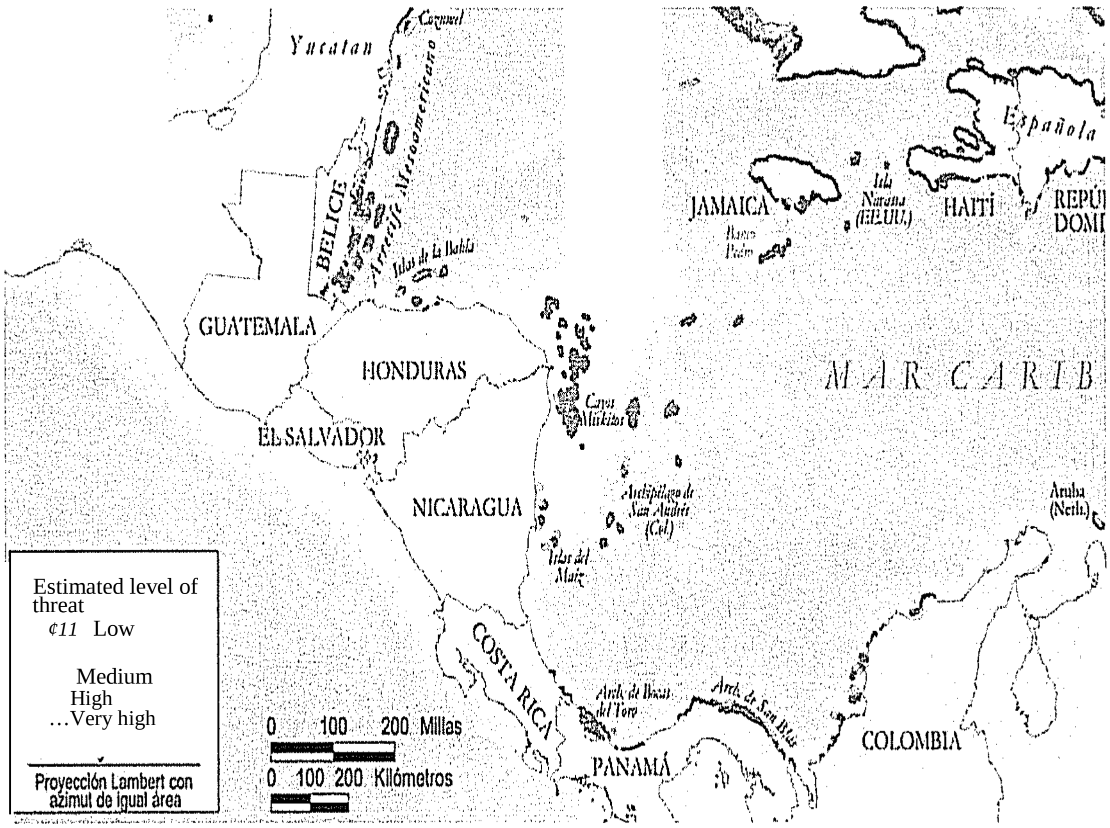

Illustration No. 1: Map of the Caribbean's threatened coral reefs

36. Aware of the economic and social importance of the marine environment, as well as its vulnerability to pollution, the States of the region, jointly, and certain international organizations, have taken various measures designed to protect it for the benefit and enjoyment of present and future generations. A significant example of these efforts was the adoption of the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region in 1983, aimed at implementing measures to prevent, reduce and control pollution in the Caribbean Sea, not only within each State party, but also through international cooperation.

37. An example of the above, is the obligation to "take all appropriate measures to protect and preserve rare and fragile ecosystems, as well as the habitat of depleted, threatened or endangered species," and "to establish protected areas."[23] In application of this provision, and at the request of Colombia, in 2000, UNESCO included the area where the Archipelago of San Andres and

[23] See Article 10 of the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, Cartagena de Indias, March 24, 1983: "*The Contracting Parties shall, individually or jointly, take all appropriate measures to protect and preserve rare or fragile ecosystems, as well as the habitat of depleted, threatened or endangered species, in the Convention area. To this end, the Contracting Parties shall endeavour to establish protected areas. […].*"

Providencia is located in the "Man and the Biosphere" (MaB) program, as the Seaflower Biosphere Reserve, owing to its special characteristics as an ecosystem. Subsequently, in 2005, the Colombian Government created a Protected Marine Area within the Biosphere Reserve under domestic law (Decision 107 of 2005 of the Ministry of the Environment, Housing and Territorial Development). Moreover, since 2012, this Protected Marine Area of the Seaflower Biosphere Reserve has been included under the Protocol concerning Specially Protected Areas and Wildlife (SPAW), which is extremely important to ensure its protection.[24] This is also in keeping with the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region.

B. Potential negative impacts in the Wider Caribbean region as a result of the construction and operation of major new permanent infrastructure projects

38. The construction, maintenance and operation of major infrastructure projects could have a severe impact on the environment and, therefore, on the populations that inhabit areas that could be affected either directly or indirectly as a result of such projects. This has been recognized by the Inter-American Commission on Human Rights as follows:

> "Mega infrastructure or development projects, such as highways, canals, dams, ports and similar, as well as concessions for the exploration for, or exploitation of, natural resources in ancestral territories may have particularly serious consequences for the indigenous peoples, because such projects jeopardize their territories and the respective ecosystems, and thus represent a mortal danger for their survival as peoples, especially when the ecological fragility of their territories coincides with their low population density."[25]

39. In addition, it should be considered that the potential negative impacts on the Caribbean marine environment of the new infrastructure projects could, obviously, have serious consequences for other coastal States of the Wider Caribbean Region as well as for the people who live on its coasts and islands. This is because the pollutants (i.e. the water, sediments, impurities, waste materials), are easily able to cross the borders between States.

40. As regards Colombia, the projects developed in the Caribbean and, therefore, the acts and/or omissions of the States in whose jurisdiction they are implemented, could affect not only the populations that inhabit the continental coast, but also the islands of Albuquerque, San Andres, Providencia, Santa Catalina, Serrana, Quitasueño and Roncador. The Seaflower Biosphere Reserve could also be affected.

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[24] See Articles 3 and 4 of the Protocol concerning Specially Protected Areas and Wildlife in the Wider Caribbean Region, Kingston, January 10, 1991.

[25] Inter-American Commission on Human Rights (IACHR), *Third report on the situation of human rights in Colombia*. Doc. OEA/Ser.L/V/11.102, Doc. 9 rev. 1, February 26, 1999, Chapter X, paras. 33-35.

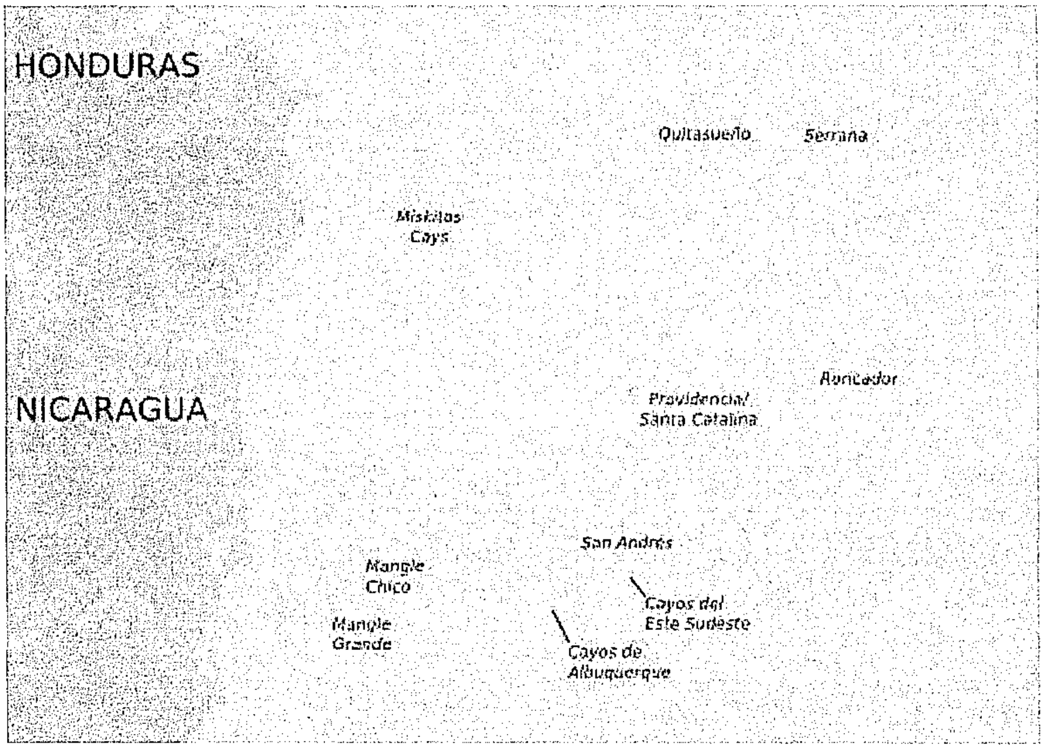

Illustration No. 2. Map of Colombia's islands in the Caribbean Sea

41. As shown by past experience, the development of major new infrastructure projects in the Wider Caribbean Region could have serious environmental impacts on the marine ecosystem as a result of activities related to their construction and maintenance, and owing to the maritime traffic that such projects may cause or increase.

42. For example, in the case of Malaysia v. Singapore, the International Tribunal for the Law of the Sea concluded that, as alleged by Malaysia, the land reclamation activities carried out by Singapore in the Straits of Johor could cause serious transboundary harm to the marine environment, including deterioration of water quality in sensitive areas and increase of sedimentation. Consequently, the Tribunal considered that, based on prudence and precaution, Malaysia and Singapore should establish a group of independent experts to prepare a report on the effects of those activities.[26]

43. Regarding the damage that could occur in this case, it is certain that the construction of any major new infrastructure project in the Wider Caribbean Region could significantly increase the amount of sediments in the marine environment, including the waters and coasts of other States present in the region, such as the Colombian coasts and islands.

[26] International Tribunal for the Law of the Sea, Case concerning land reclamation by Singapore in and around the Straits of Johor (Malaysia v. Singapore), Provisional Measures, Order of 8 October 2003.

44. The increased sedimentation in the Wider Caribbean Region and, specifically, in the Caribbean Sea, could cause a series of irreparable harms to the marine ecosystem, including: (i) suffocation of corals, mangrove stands and seagrass beds; (ii) reduced growth of natural vegetation; (iii) damage to fish and their habitat; (iv) greater risk of flooding on the coasts of surrounding States, and (v) increased deposition of other toxic substances.[27]

45. Furthermore, the maritime traffic caused or increased by the execution of major new infrastructure projects in the Caribbean would also increase the risk of polluting the marine environment on which the habitat of the inhabitants of the Colombian islands and the habitat of the people of other coastal States depend. There are numerous causes of the pollution to be expected from maritime traffic – either voluntary, such as illegal degasification, cleaning out of ballast tanks, dumping of waste, or the use of certain toxic anti-fouling paints; or involuntary, such as accidents owing to heavy seas. A brief description of the main causes of the pollution caused by maritime traffic appears below:

- Fuel pollution: is considered one of the most visible causes on shipping lanes. In this regard, the Royal Yachting Association has affirmed that one liter of fuel is sufficient to pollute more than one million liters of water.[28]

- Cleaning out ballast tanks at sea: is one of the main causes of the introduction of invasive species, which has serious effects on the biodiversity of the marine ecosystem, displacing local species and decreasing the fish population. A brief summary of the effects of the introduction of invasive species follows:

> "The introduction of invasive species and pathogens into an environment upsets the original ecology and the local economies. It results in a genetic loss and a change in the functioning of the ecosystem and the positions in the food chain, which have implications for marine life and livelihoods. The pathogens that are introduced may cause new diseases and even death in human beings. The situation after the introduction of invasive species arises from the change that occurs when water is cleaned out from the ballast tanks and hulls of the ships that transport them. Species such as burrowing or adhering sessiles (without peduncles) are some of the transported species most frequently identified (Claire, Clarke and Anderson, 1997). For example, the ballast water of ships was responsible for introducing dinoflagellate toxic algae. Indeed, these algae can survive for many years in the ballast and, when confronted with new environments, can poison shellfish which may then become lethally toxic in the context of human consumption (CSIRO, 2006)."[29]

- Pollution from waste:

> "Waste, known as inert and transitory pollutants, come from diverse sources. [...]. Despite

[27] The Caribbean Environment Programme, UNEP, "Sedimentation and Erosion." Available at: www.cep.unep.org/publications-and-resources/marine-and-coastal-issues-links/sedimentation-and-erosion.

[28] Annex IV, Dr. Karen Sumser-Lupson & Marcus Kinch, *Evaluation des risques de pollution maritime accidentelle dans Ia Manche, Typologie des pollutions maritimes,* University of Plymouth, p. 15.

[29] *Ibid.* p. 20.

international law, it is calculated that, since 1982, the world's shipping fleet (with the exception of the fishing fleet) is responsible for disposing in the sea of approximately 4.8 million metal objects, 450,000 plastic objects, and 300,000 glass containers. [...] Maritime activities are a major cause of pollution from waste. Vauk and Schrey (1987) mention that "large concentrations of marine debris are found around shipping lanes and fishing areas," and Pruter (1987) also asserts that waste from ships may also be present around oceanic current the convergence zones. Williams, (1993) states that, in such zones, 70% of the waste sinks to the ocean floor, 15% floats on the surface, and 15% is deposited on the coast (MCA, 2004)."[30]

- Pollution from anti-fouling paint: The purpose of several international conventions is to prohibit the paints that are the most harmful for the environment, although there is still a possibility that, if the flag State has not undertaken to respect such conventions, or if there is no real control of their application, the most harmful paints – which are also the most effective and, therefore, the most advantageous from an economic standpoint – may continue to be used despite their effects on the environment.

- Pollution caused by accidents: this type of pollution is fairly predictable with the increase of maritime traffic, because ships transport all kinds of merchandise, including crude oil and, above all, containers. In addition, it should be pointed out that it is possible to transport by sea around 600 chemical products in bulk, such as chemical raw materials (sulfuric acid, phosphoric acid, nitric acid, hydrochloric acid, sodium, ammonia), alcohol-based products and molasses, and chemical oil and coal tar products (benzene, xylene, naphthalene, phenol and styrene).

46. The pollution of the marine environment of the Wider Caribbean Region that could result from one of the causes described above, may have long-lasting, and often irreparable, effects on marine flora and fauna and, consequently, on the capacity (which is already fragile) of the ecosystem to provide income from tourism and fishing for the inhabitants of the coasts and islands of the region. Furthermore, it should be stressed that this type of harm to the marine environment not only continues over time, but tends to increase, affecting present and future generations.

47. Bearing this in mind, it is evident that the construction and operation of major new infrastructure projects in the Wider Caribbean Region could have a negative and irreparable impact on the right to a decent life and the quality of life of the inhabitants of the coasts and, particularly, the islands located in this region, as well as the possibilities for their economic, social and cultural development, and their physical, mental and moral integrity. These factual circumstances and, therefore, the need to implement appropriate and effective projects to prevent and to mitigate environmental damage during the execution of major new infrastructure projects in the Wider Caribbean Region – with the cooperation of the States that could be affected – constitute the factual context in which this request for an advisory opinion is made.

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30 *Ibid.* pp. 17-18.

48. However, in addition to this factual context – i.e. the development of new infrastructure projects in the Wider Caribbean Region that could affect the rights of the inhabitants of this region – the pertinent legal context of this request must also be specified.

CHAPTER 3. THE LEGAL CONSIDERATIONS GIVING RISE TO THIS REQUEST FOR AN ADVISORY OPINION

49. Nowadays it is widely recognized that the quality of the environment in which we human beings live and on which we depend constitutes a condition *sine qua non* for the effective enjoyment of the rights and freedoms recognized by international human rights law (Section 1). In addition, there is no doubt as regards the normative relationship between environmental law and human rights, considering that the object and purpose of the former is precisely to protect the natural surroundings in which we human beings live and develop, both individually and collectively (Section 2). In this context, the mutual need for both environmental law and human rights law has been recognized in order to ensure their full effectiveness.

SECTION 1: QUALITY OF THE ENVIRONMENT AND HUMAN RIGHTS

50. The environment is "the combination of elements whose complex interrelationships make up the settings, the surroundings and the conditions of life of the individual and of society, as they are and as they are felt."[31] Thus the physical life and a life with dignity of the individual, as well as his physical, mental and moral integrity depend on the habitat from which he derives his sustenance and in which he carries out his cultural, social and economic activities, and develops his life project.

51. The intrinsic relationship that exists between the environment, understood as habitat, and the effective enjoyment of human rights was expressly recognized in 1972 in the preamble to the Stockholm Declaration which established that the environment is essential for the well-being of man and for the full enjoyment of his fundamental rights, including the right to life itself.[32]

52. The International Court of Justice, in an advisory opinion on the *Legality of the threat or use of nuclear weapons,* stated that:

> "The Court recognizes that the environment is under daily threat and that the use of nuclear weapons could constitute a catastrophe for the environment. The Court also recognizes that the environment is not an abstraction but represents the living space, the

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[31] D. Bodansky, *The Art and Craft of International Environmental Law,* Harvard University Press, 2010, p. 10.

[32] Stockholm Declaration adopted by the United Nations Conference on the Human Environment: 1. Man is both creature and moulder of his environment, which gives him physical sustenance and affords him the opportunity for intellectual, moral, social and spiritual growth. […] Both aspects of man's environment, the natural and the man-made, are essential to his well-being and to the enjoyment of basic human rights, including the right to life itself." U.N. Doc. A/Conf.48/14/Rev. 1)

quality of life and the very health of human beings, including generations unborn."[33]

53. Subsequently, in the case concerning the *Gabčíkovo-Nagymaros Project,* the International Court of Justice emphasized the great importance of the environment, not only for the States, but also for all humanity, as follows:

> "The Court recalls that it has recently had occasion to stress [...] the great significance that it attaches to respect for the environment, not only for States but also for the whole of mankind."[34]

54. In addition, international organizations such as the Organization of American States and the United Nations, whose mandate includes the protection of human rights, have recognized the undeniable connectivity between the protection of the environment and the full exercise and enjoyment of human rights.

55. Similarly, the Inter-American Commission on Human Rights has frequently affirmed:

> "[...] even though neither the American Declaration of the Rights and Duties of Man nor the American Convention on Human right include express references to the protection of the environment, it is clear that several rights of a fundamental nature that are recognized in these instruments require, as a precondition for their due exercise, a minimum environmental quality, and are profoundly affected by the degradation of natural resource."[35]

56. Meanwhile the Inter-American Court of Human Rights has asserted that:

> "[I]n accordance with the case law of this Court and the European Court of Human Rights, there is an undeniable link between the protection of the environment and the enjoyment of other human rights. The ways in which environmental degradation and the adverse effects of climate change have impaired the effective enjoyment of human rights in the continent has been the subject of discussion by the General Assembly of both the Organization of American States and the United Nations. It should also be noted that a considerable number of States Parties to the American Convention have adopted constitutional provisions which expressly recognize the right to a healthy environment."[36]

57. Again citing the Stockholm Declaration adopted at the 1972 United Nations Conference on the Human Environment, the enjoyment of fundamental rights presupposes *per se* access to an environment "of quality" as established in Principle 1 of this Declaration:

> "Man has the fundamental right to freedom, equality and adequate conditions of life, in an

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[33] I.C.J., *Legality of the threat or use of nuclear weapons,* Advisory Opinion of July 8, 1996, para. 29.

[34] I.C.J., Case concerning *the Gabčíkovo-Nagymaros Project,* judgment of September 25, 1997, para. 53.

[35] IACHR, *Report on the situation of human rights in Ecuador.* Doc. OEA/Ser.L/V/II.96, Doc.10 rev.1, April 24, 1997; IACHR, *Indigenous and tribal peoples' rights over their ancestral lands and natural resources. Norms and jurisprudence of the inter-American human rights system.* OEA/Ser.L/V/II, Doc. 56/09 (December 30, 2009), para. 190 and, more recently, in: IACHR, *The Kuna Indigenous People of Madungandi and the Embera Indigenous People of Bayano and their members*, Report No. 125/12, Case 12,354, Merits, para. 233.

[36] ICourtHR, Case of *Kawas Fernández v. Honduras, merits, reparations and costs*. Judgment of April 3, 2009. Series C No. 196, para. 148.

environment of a quality that permits a life of dignity and well-being, [...]."[37]

58. Owing to the connectivity between the quality of the environment and the effective enjoyment of human rights, at the present time it is widely recognized that States have the obligation to protect against environmental harm that interferes with the enjoyment of those rights.[38]

59. In this regard, the case law of the Inter-American Court has stressed that the human rights recognized in the Pact of San José include an environmental dimension when the degradation of the environment affects the true enjoyment of those rights[39] - which supposes that the State has an obligation to protect the environment. This obligation has been recognized in relation to the indigenous and tribal peoples – who, among others, live in the coastal areas of the Caribbean Sea – because such peoples are particularly vulnerable to changes in their environment. Based on this State obligation to provide protection against harm to the environment, the Commission, for example, has recommended the States it is monitoring to adopt the necessary measures to protect the habitat of the communities affected by environmental damage, in order to ensure the exercise and enjoyment of their fundamental rights.[40]

60. In addition, it should be pointed out that the Commission has stressed that the development of the States must be sustainable and that this calls for an adequate protection of the environment.[41] In the words of the Commission:

> "The norms of the inter-American human rights system neither prevent nor discourage development; rather, they require that development take place under conditions that respect and ensure the human rights of the individuals affected. As set forth in the Declaration of Principles of the Summit of the Americas: "Social progress and economic prosperity can be sustained only if our people live in a healthy environment and our ecosystems and natural resources are managed carefully and responsibly."[42]

61. The relevance of environmental law in relation to the protection of the human habitat and,

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37 Stockholm Declaration on the Human Environment, in the *Report on the United Nations Conference on the Human Environment.* UN Doc. A/CONF.48/14/2 and Corr.1 (1972).

38 General Assembly of the United Nations, Human Rights Council, *Report of the Independent Expert on the issue of the human rights obligations related to the enjoyment of a safe, clean, healthy and sustainable environment,* John H. Knox, A/HRC/25/53, 30 December 2013, para. 44

39 ICourtHR, Case of the *Mayagna (Sumo) Awas Tigni Community v. Nicaragua* (2001); ICourtHR, Case of the *Yakye Axa Community of the Enxet-Lengua People v. Paraguay* (2005); ICourtHR, Case of the *Sawhoyamaxa Community v. Paraguay* (2006); ICourtHR, Case of *Claude Reyes et al. v. Chile* (2006); ICourtHR, Case of the *Saramaka People v. Suriname* (2007); ICourtHR, Case of the *Xakmok Kasek Indigenous Community. v. Paraguay* (2010); ICourtHR, Case of the *Kichwa Indigenous People of Sarayaku v. Ecuador* (2012); ICourtHR, Case of the *Afro-descendant Communities displaced from the Cacarica River Basin (Operation Genesis) v. Colombia* (2013).

40 See, for example, IACHR, *Third report on the situation of human rights in Paraguay,* OEA/Ser.L/V/11.110, Doc. 52, March 9, 2001

41 D. Shelton, "Derechos ambientales y obligaciones en el sistema interamericano de derechos humanos," *Anuario de Derechos Humanos,* 2010, p. 118.

42 IACHR, *Report on the situation of human rights in Ecuador.* Doc. OEA/Ser.L/V/11.96, Doc. 10 rev.1, April 24, 1997, para. 204.

therefore, its relationship to the protection of human rights will be analyzed in the following section.

SECTION 2: ENVIRONMENTAL LAW AND HUMAN RIGHTS

62 The source of environmental law is, on the one hand, domestic law and, on the other, international law. As regards international environmental law, this is composed not only of treaties such as the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, but also of customary norms, which we will refer to below.

63. The purpose of the norms of environmental law is to protect man's natural surroundings and the diverse elements that this is comprised of and on which, as previously mentioned, the effective enjoyment of human rights depends. In this context, the principles and rules of environmental law benefit not only the natural milieu as such, but also the quality of life of the individual and his life project.

64. This is fully demonstrated, for example, by the preamble to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, which indicates clearly that the States parties are: "Conscious of their responsibility to protect the marine environment of the wider Caribbean region for the benefit and enjoyment of present and future generations." This phrase merely proves that the obligation to protect the marine environment is essential to ensure the factual conditions on which depend the physical life, a life with dignity, and the personal integrity of present and future generations.

65. Furthermore, Principle 7 of the Stockholm Declaration establishes that:

> "States shall take all possible steps to prevent pollution of the seas by substances that are liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea."[43]

66. Owing to the relationship that exists between the protection of the environment and the quality of life of the individual, several of the obligations of States that are party to the body of norms of international environmental law are relevant to ensure compliance with State obligations in relation to human rights – considering, in particular, the current needs of society in this area.

67. In this regard, in the case concerning the *Gabčíkovo-Nagymaros Project*, Judge Weeramantry, former Vice Present of the International Court of Justice considered that:

> "The protection of the environment is likewise a vital part of contemporary human rights doctrine, for it is a *sine qua non* for numerous human rights such as the right to health and

[43] Stockholm Declaration on the Human Environment, in the *Report on the United Nations Conference on the Human Environment.* UN Doc. A/CONF.48/14/2 and Corr.1 (1972).

> the right to life itself. It is scarcely necessary to elaborate on this, as damage to the environment can impair and undermine all the human rights spoken of in the Universal Declaration and other human rights instruments
>
> While, therefore, all peoples have the right to initiate development projects and enjoy their benefits, there is likewise a duty to ensure that those projects do not significantly damage the environment."[44]

68. Although not every violation of environmental law results *per se* in a violation of a decent life and personal integrity, certain actions that are contrary to environmental law and whose specific consequences may have a serious impact on the habitat of human beings, may be considered as acts that prevent the enjoyment of the right to a decent life and to personal integrity, as well as of other human rights recognized in the Pact. Consequently, an action that is not fully adapted to the rules of environmental law may, owing to its nature, lead to a violation of human rights; specifically, if this action has an impact on the environment that is so significant that it limits or prevents the effective enjoyment of the human rights recognized in the Pact of San José.

69. In this context, the specificity of the norms of environmental law is important not only to provide content to the obligations of the States Parties under the Pact, but also, in general, to ensure a greater effectiveness to the protection of human rights, in accordance with the specific characteristics of our times, and thus reinforce the Inter-American system.

70. Furthermore, it should be underscored that international human rights law regularly refers to the principles and norms of international environmental law. For example, the European Court of Human Rights has frequently referred to the principles and standards of international environmental law.[45] The Inter-American Commission has also recognized the need to interpret human rights norms "with due attention to other pertinent norms of international law applicable to the Member States against which complaints of human violations have been duly lodged."[46] Similarly, in the *Coard* case, the Commission stated that "it would not be congruent with the general principles of law if the Commission founded and exercised its Charter-based mandated, without taking into account other international obligations of the Member States that could be relevant."[47]

71. Moreover, in its "Report on the situation of human rights in Ecuador," the Commission cited the following international agreements supported by Ecuador when referring to the crucial relationship between the survival of the human being and the environment: the Additional Protocol to the American Convention on Human Rights in the Area of Economic, Social and Cultural Rights, the International Covenant on Civil and Political Rights and the International

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44 I.C.J., case concerning *the Gabčíkovo-Nagymaros Project,* judgment of September 25, 1997, *Rev.* 1997, pp 91-92.

45 Council of Europe, *Manual on Human Rights and the Environment,* Council of Europe Publishing, ed. 2012, p. 149 and *ff.*

46 IACHR, Case of *Lorenzo Enrique Copello Castillo et al. v. Cuba,* merits, October 21, 2006, para. 50.

47 IACHR, Case of *Coard v. United States,* Report No. 109/99, Case No. 10,951, September 29, 1999, para. 40.

Covenant on Economic, Social and Cultural Rights, the Stockholm Declaration, the Amazon Cooperation Treaty, the Amazon Declaration, the World Charter for Nature, the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere, the Rio Declaration on the Environment and Development, and the Convention on Biological Diversity.[48]

72. The foregoing considerations on the legal context of this request for an advisory opinion underline the connectivity between environmental law and the human rights recognized in the Pact of San José, which is the essence of the questions asked below.

CHAPTER 4. THE SPECIFIC QUESTIONS ON WHICH THE OPINION OF THE COURT IS BEING SOUGHT

73. In view of the fact that certain activities may have serious consequences and cause severe damage to the marine environment on which the habitat of the inhabitants of the coasts and islands of the Wider Caribbean Region depends, as indicated in Chapter 2, the essential legal question posed to the Court is to know whether, and to what extent, the rights recognized in the Pact of San José can ensure the protection of those inhabitants in relation to this potential harm.

74. Neither the Court nor the Commission has examined or had to rule on questions such as these, which are extremely important for all the States of the Wider Caribbean Region and, particularly, for all the inhabitants of the coasts and islands of this region – who depend on the quality of their marine environment for the effective enjoyment of their human rights. At the present time, it is certain, or can be envisaged, that new infrastructure projects will be constructed in maritime zones, and these could potentially have a severe impact on the quality of life and the personal integrity of the inhabitants of the Caribbean, irrespective of whether or not they live in the territory of the State in whose jurisdiction such new projects are being executed.

75. In addition, to date neither the Court nor the Commission has had the occasion to rule on the scope of the obligation of the States Parties to the Pact to respect and ensure the human rights and freedoms of the inhabitants of the Wider Caribbean Region in those cases in which major infrastructure projects executed within their jurisdiction could cause severe damage to the marine environment of this region, which could harm the rights that are recognized in the Pact of San José (Section 1).

76. As mentioned previously, the Court's response to this request will be extremely relevant for effective compliance with international human rights obligations by the agents and organs of the States of the Wider Caribbean Region, as well as to reinforce global awareness, by clarifying the scope of the obligations under the Pact, particularly those contained in Articles 4(1) and 5(1), in relation to the protection of the environment and, consequently, to the development and

[48] IACHR, *Report on the situation of human rights in Ecuador,* OEA/Serv.L/V/II.96, Doc. 10 rev. 1, April 24, 1997.

implementation of studies and projects to prevent and mitigate damage (Section 2).

77. Third, to date the Court has not had the opportunity to rule on whether, or to what extent, it is desirable to interpret the Pact, specifically Articles 1(1), 4(1) and 5(1) in connection with the principles that arise from international environmental law such as the obligations to prevent environmental damage and to cooperate with third States affected by any damage, as recognized, for example, in Articles 12 and 13 of the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region. This request for an advisory opinion provides the Court with an opportunity to do this (Section 3).

SECTION 1: INTERPRETATION OF ARTICLE 1(1) OF THE AMERICAN CONVENTION ON HUMAN RIGHTS (OBLIGATION TO RESPECT RIGHTS)

A. The text of Article 1(1)

78. Article 1(1) stipulates that:

> "The States Parties to this Convention undertake to respect the rights and freedoms recognized herein and to ensure to all persons subject to their jurisdiction the free and full exercise of those rights and freedoms, without any discrimination for reasons of race, color, sex, language, religion, political or other opinion, national or social origin, economic status, birth, or any other social condition."

79. This provision establishes two obligations with regard to the rights and freedoms recognized in the Pact: an obligation "to respect" and another obligation "to ensure."[49] Bearing in mind the facts described in Chapter 2, this request for an advisory opinion seeks to clarify the scope of the two obligations contained in Article 1(1) of the Pact; that is, to respect and to ensure the human rights recognized in this instrument in the case of damage to the marine environment that could interfere with the full exercise and enjoyment of the rights and freedoms of the inhabitants of the coasts and islands of the Wider Caribbean Region. In particular, it seeks to determine whether these obligations benefit the inhabitants of the coasts, of one or several islands, or of an archipelago, when the execution of major infrastructure projects by a State Party to the Wider Caribbean Region Convention and to the Pact of San José could harm the rights of the inhabitants of these coasts, of this or these islands, or of the said archipelago.

B. Scope of the State obligations under the American Convention

80. The obligation to respect the rights and freedoms recognized in the Pact consists in complying with this provision (either by abstaining from acting or by providing a service), while the obligation to ensure entails "the obligation of the States Parties to organize the government apparatus and, in general, all the structures through which public power is exercised so that they

[49] ICourtHR, Case of Velasquez *Rodriguez v. Honduras. Merits.* Judgment of July 29, 1988. Series C No. 4, para. 164.

are able to legally ensure the free and full exercise of human rights."[50] As a result of this obligation, States must prevent, investigate and punish any violation of the rights recognized by the Pact and, also, endeavor to re-establish any right that has been violated, as well as to redress the harm caused by the human rights violation.[51]

81. The scope of the State obligations under the Pact depends on the scope accorded to the word "jurisdiction" in the text of Article 1(1) of the American Convention.

82. The concept of "jurisdiction" or "competence" (concepts that are synonymous in international law) denotes, principally, a "territorial" element, because it is, above all, in its territory that a State exercises its sovereignty, executes its competences and, essentially, implements its powers.

83. However, at times, a State may exercise is competence, or its jurisdiction, outside its territory. In such cases, it is evident that the persons who it is sought to protect by the exercise of this extraterritorial competence are considered subject to the "jurisdiction" of the State that exercises that competence, in keeping with the scope that international human right law grants to this concept. In other words, even if the persons who are under the jurisdiction of a State are, in principle, those persons who are within its territory (or in the ships carrying its flag, or in other situations of this type), it may happen, exceptionally, that persons who are outside the territory of a State are considered, from the point of view of the application of international human rights law, as if they were under the jurisdiction of this State, if the latter is exercising jurisdiction outside its territory.

84. This interpretation was recognized by the International Court of Justice in its Advisory Opinion on the *Legal consequences of the construction of a wall in the Occupied Palestinian Territory:*

> "[W]hile the jurisdiction of States is primarily territorial, it may sometimes be exercised outside the national territory."[52]

85. This accords with the position of different human rights protection bodies, as well as that of the Inter-American Commission on Human Rights, which has established that:

> "Even though jurisdiction usually refers to the authority over persons who are within the territory of a State, human right are inherent for all human beings and are not based on their citizenship or location."[53]

86. Thus, although the jurisdiction of a State is, in principle, territorial, it may, exceptionally,

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50 ICourtHR, Case of *Velasquez Rodriguez, v. Honduras,* merits, *op. cit.,* para. 166.

51 *Ibid.*

52 I.C.J., *Legal consequences of the construction of a wall in the Occupied Palestinian Territory,* Advisory Opinion of July 9, 2004, para. 109.

53 IACHR, *Case of Franklin Guillermo Aisalla Molina,* Report No. 112/10, October 21, 2010, para. 91

be exercised extraterritorially. One of such exceptional events is that in which the agents of a State exercise, outside its territory, authority and control over individuals located in another State. In this situation, to cite the words of the Inter-American Commission on Human Rights, the extraterritorial jurisdiction of a State may occur if the following is verified:

> "The exercise of authority over individuals by agents of a State even though does not occur in its territory."[54]

87. However, apart from this classic case which recognized the exercise of extraterritorial jurisdiction by States, a very particular phenomenon has arisen under international environmental law with regard to the protection of the different oceans and seas, which leads us to wonder whether, at the present time, there is another exception to the principle of the territoriality of "jurisdiction" pursuant to the Pact of San José.

88. In 1974, the United Nations Environment Programme (UNEP) launched the Regional Seas Programme and, currently, more than 140 States participate in its activities. Under this program, the protection of marine resources is implemented by a series of agreements and action plans adopted by the different States for the benefit of present and future generations. Each of these agreements is aimed at the protection of a specific marine area in which the territories and inhabitants of different States converge. In the Caribbean, the States of the Region have adopted the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region which seeks to include all the different aspects of the deterioration of the environment and to meet the special needs of the Region.

89. The signature of the said Convention and its widespread acceptance by the different States of the Region is, without doubt, one of the most important advances in legislation in favor of the protection of the marine environment of the Caribbean – natural habitat of all those who reside on its coasts and islands and on which their living conditions and life projects depend.

90. In order to protect the region's marine environment, the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean establishes a series of obligations applicable to a specific geographical space called "the Convention area." One of these obligations, perhaps the most important and the most general, consists in, "individually or jointly, tak[ing] all appropriate measures in conformity with international law and in accordance with this Convention and those of its protocols in force to which they are parties to prevent, reduce and control pollution of the Convention area and to ensure sound environmental management, using for this purpose the best practicable means at their disposal and in accordance with their capabilities."

91. According to this instrument, the States parties to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region have the obligation to

[54] *Ibid.* para. 99.

prevent, reduce and control maritime pollution not only within their borders, but throughout the so-called "Convention area." This area includes "the marine environment of the Gulf of Mexico, the Caribbean Sea and the areas of the Atlantic Ocean adjacent thereto, south of 30 deg north latitude and within 200 nautical miles of the Atlantic coasts of the States referred to in article 25 of the Convention."[55]

92. Pursuant to the general obligation of prevention, the Contracting Parties also have the obligation to assess, or to ensure the assessment of, the potential effects of their major development projects on the marine environment in order to prevent any substantial pollution, or significant and harmful changes, not only within their borders, but throughout "the Convention area."[56] Moreover, "when a Contracting Party becomes aware of cases in which the Convention area is in imminent danger of being polluted or has been polluted, it shall immediately notify other States likely to be affected by such pollution, as well as the competent international organizations. Furthermore, it shall inform, as soon as feasible, such other States and competent international organizations of measures it has taken to minimize or reduce pollution or the threat thereof."

93. When establishing a specific area of application, the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean created an area of functional jurisdiction located beyond the borders of the States parties and in which the latter are obliged to comply with certain obligations in order to protect the marine environment of the whole region. Evidently, the obligations contained in this Convention are not exclusive to one or a group of States parties, but rather apply to all of them. And this is so because the Wider Caribbean Region is considered a kind of "Environmental Condominium," the protection of which is the responsibility of each and every Contracting Party.

94. Considering the potential direct and indirect effects of an event that pollutes the marine environment on the living conditions and life projects of the inhabitants of the coasts and islands, it is clear that compliance or failure to comply with the provisions of the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean will have a direct impact on the possibility of these individuals to enjoy their rights fully.

95. In this context, and in order to promote the effective protection of human rights, it is essential to clarify the Pact's scope of application in relation to those persons who inhabit the coasts and islands of the Wider Caribbean Region in light of the obligations assumed by the States of the region when ratifying the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region in order to protect the marine environment.

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55 Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, Article 2(1).

56 *Ibid.* Article 12(2).

96. Based on the foregoing, the Republic of Colombia respectfully asks the Court to answer the following question:

> *Pursuant to Article 1(1) of the Pact of San José, should it be considered that a person, even if he is not in the territory of a State Party, is subject to the jurisdiction of the said State in the specific case in which, accumulatively, the following four conditions are met?*
>
> *(i) That the person resides or is in an area delimited and protected by a treaty-based environmental protection system to which the said State is a party;*
>
> *(ii) That the said treaty-based system establishes an area of functional jurisdiction, such as, for example, the one established in the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region;*
>
> *(iii) That in the said area of functional jurisdiction, the States parties have the obligation to prevent, reduce and control pollution by means of a series of general and/or specific obligations, and*
>
> *(iv) That, as a result of damage to the environment or of the risk of environmental damage in the area protected by the convention in question that can be attributed to a State party – to that convention and to the Pact of San José – the human rights of the person in question have been violated or are threatened.*

SECTION 2: INTERPRETATION OF ARTICLE 4(1) (RIGHT TO LIFE) AND 5(1) (RIGHT TO PERSONAL INTEGRITY) OF THE AMERICAN CONVENTION ON HUMAN RIGHTS

A. The text of Articles 4(1) and 5(1)

97. According to Article 4(1) of the Convention:

"Article 4. Right to Life

1. Every person has the right to have his life respected."

98. Article 5(1) establishes that:

"Article 5. Right to Humane Treatment

1. Every person has the right to have his physical, mental, and moral integrity respected."

B. The right to life and the relevance of the environment for the inhabitants of the coasts and islands of the Caribbean

99. The right to life includes not only the right of every human being not to be deprived arbitrarily of his life, but also the right to a dignified existence. For example, in the case of the

Yakye Axa Indigenous Community v. Paraguay, the Court reiterated its case law in this regard and indicated that:

> "In essence, this right includes not only the right of every human being not to be deprived arbitrarily of his life, but also the right that conditions are not created that prevent or obstruct access to a dignified existence."[57]

100. As a corollary of a dignified life or existence, the Court has emphasized that States have the obligation to ensure certain basic living conditions and to abstain from taking measures that could create conditions that would obstruct the access to a dignified existence by taking positive concrete measures to this end. In the words of the Court:

> "One of the obligations that the State must inescapably undertake as guarantor, to protect and ensure the right to life, is that of generating minimum living conditions that are compatible with the dignity of the human person and of not creating conditions that hinder or impede it. In this regard, the State has the duty to take positive, concrete measures geared toward fulfillment of the right to a decent life, especially in the case of persons who are vulnerable and at risk, whose care becomes a high priority."[58]

101. The relationship between the degradation of the environment and the violation of the right to a decent life, as indicated in Section 1, has long been recognized. For example, Principle 1 of the Stockholm Declaration of June 1972, adopted by the United Nations Conference on the Human Environment, established that:

> "Man has the fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being."[59]

102. The intrinsic relationship that exists between the environment and the right to life was also recalled by the Commission in the "Report on the situation of human rights in Ecuador" as follows:

> "The realization of the right to life, and to physical security and integrity is necessarily related to and in some ways dependent upon one's physical environment. Accordingly, where environmental contamination and degradation pose a persistent threat to human life and health, the foregoing rights are infringed."[60]

103. As a result of the relevance of the physical environment for the exercise of the right to life, the Commission clarified that States have the obligation to take any reasonable measure to prevent cases of "serious environmental pollution" that could threaten the life and health of the

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57 ICourtHR, Case of the *Yakye Axa Indigenous Community v. Paraguay*. Merits, reparations and costs. Judgment of June 17, 2005. Series C No. 125, para. 161; *Case of the Juvenile Re-education Institute v. Paraguay*. Judgment of September 2, 2004. Series C No. 112, para. 156; Case of the *Gomez Paquiyauri Brothers v. Peru.* Judgment of July 8, 2004. Series C No 110, para. 128; Case of *Myrna Mack Chang v. Guatemala*, Judgment of November 25, 2003. Series C No. 101, para. 152, and Case of the *"Street Children (Villagrán Morales et al.) v. Guatemala*. Judgment of November 19, 1999. Series C No. 63, para. 144.

58 ICourtHR, Case of the *Yakye Axa Indigenous Community v. Paraguay*. Merits, reparations and costs. Judgment of June 17, 2005. Series C No. 125, para. 162.

59 Stockholm Declaration, United Nations Conference on the Human Environment, June 5 to 16, 1972.

60 IACHR, Report of the situation of human rights in Ecuador, OEA/Ser.L/V/11.96, Doc. 10 rev. l, April 24, 1997, Chapter VIII, 2.

individual, or else, the measures required to respond when anyone has been harmed.[61]

104. In the case of the *Yakye Axa Indigenous Community v. Paraguay*, the Court considered that in order to analyze whether the State had violated the right to life (Article 4 of the Pact) it was necessary to establish:

> "whether the State had created conditions that exacerbated the difficulties of access to a decent life for the members of the Yakye Axa Community and whether, in that context, it had taken appropriate positive measures to fulfill that obligation, taking into account the especially vulnerable situation in which they were placed, given their different manner of life (different worldview systems than those of Western culture, including their close relationship with the land) and their life aspirations, both individual and collective, in light of the existing international *corpus juris* regarding the special protection required by the members of the indigenous communities, in view of the provisions set forth in Article 4 of the Convention, in combination with the general obligation to respect rights, embodied in Article 1(1) and with the obligation of progressive development set forth in Article 26 of that same Convention, and with Articles 10 (Right to Health); 11 (Right to a Healthy Environment); 12 (Right to Food); 13 (Right to Education) and 14 (Right to the Benefits of Culture) of the Additional Protocol to the American Convention in the Area of Economic, Social, and Cultural Rights, and the pertinent provisions of ILO Convention No. 169."[62]

105. The Court's considerations reveal that harm to the environment may also entail harm to the right to a decent life as, indeed, occurred in the facts that the Court was analyzing at that time.

106. In the present case, the magnitude and severity of the environmental damage that could occur in the Wider Caribbean Region represents an imminent threat for the natural habitat of the inhabitants of the coasts and islands of this region, living environment and essential source of their subsistence, decent life and development as individuals and as a community. In this regard, transboundary damage to the marine environment of the Caribbean could affect, irreparably, not only the resources obtained from this environment, but also the quality of life of the inhabitants of the coasts and islands located in this Region, their lifestyle and subsistence, the possibilities of their economic, social and cultural development, and their individual and collective life projects – as indicated in the factual considerations of this request.

107. Considering the possible consequences of severe damage to the marine environment on the quality of life and life projects of the inhabitants of the Caribbean and, particularly, of its islands, any new projects in this Region should be developed in conjunction with positive measures that prevent serious cases of pollution of the marine environment and that ensure the conditions for a decent life and the personal integrity of the inhabitant of the Caribbean islands who may be affected by such projects – regardless of whether they are in the territory of another State party to the Pact – with the support of those other States that may also be affected, in order to protect the living environment and the essential source of subsistence and development of the inhabitants of

61 *Ibid.*

62 ICourtHR, Case of the *Yakye Axa Indigenous Community v. Paraguay*. Merits, reparations and costs. Judgment of June 17, 2005. Series C No. 125, para. 163

the coasts and islands of this Region.

C. The right to personal integrity and the relevance of the environment for the inhabitants of the coasts and islands of the Caribbean

108. As is widely accepted, the right to physical integrity – understood as the right to physical, mental and moral integrity – is one of the basic pillars of a human being's dignity.[63] The relationship between personal integrity and human dignity has even been recognized by the Court starting with its first cases,[64] because a violation of personal integrity may also, in different ways, constitute a violation of dignity.[65]

109. The right to personal integrity, closely related to the right to life, seeks to protect the three basic dimensions of human life: the physical, mental and moral dimensions. As indicated by doctrine, physical integrity refers to the human body and to the health of the individual; mental integrity to the motor, emotional and intellectual capabilities, and moral integrity to the right of every individual to live his life according to his convictions.[66]

110. As a result of the relationship between life and personal integrity, it is also logical that the right to personal integrity also depends on the conditions of the environment for its full exercise and enjoyment.

111. Thus, for example, in Resolution 2398/68 (XXIII) "Problems of the human environment" – in which it was decided to convene the Stockholm conference – the General Assembly indicated its concern owing to "the continuing and accelerating impairment of the quality of the human environment [...] [and the consequent effects on the condition of man, his physical, mental and social well-being, his dignity and his enjoyment of basic human rights."

112. The serious effects of the degradation of the environment on the different dimensions of human life have also been recognized by the Commission in relation to the indigenous and tribal peoples, when asserting that the protection of natural resources and environmental integrity was "necessary to ensure certain basic rights [of the members of such communities], such as to life, dignity, personal integrity, health, property, privacy and information."[67]

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63 Claudio Nash, "Articulo 5. Derecho a la integridad personal" in *Convención Americana sobre Derechos Humanos, Comentario,* Editorial Temis, Bogotá, 2014, p. 133.

64 *Ibid.* pp. 134-135; ICourtHR, Case of *Castillo Paez v. Peru.* Merits. Judgment of November 3, 1997. Series C No. 34, para. 66.

65 See also, Claudio Nash, "Articulo 5. Derecho a la integridad personal" in *Convención Americana sobre Derechos Humanos, Comentario,* Editorial Temis, Bogotá, 2014, p 135.

66 Andean Commission of Jurists, *Protección de los derechos humanos.* Centro Editorial, Universidad del Rosario, Colombia 1999, p. 58

67 IACHR, *Indigenous and tribal peoples' rights over their ancestral lands and natural resources. Norms and jurisprudence of the inter-American human rights system.* OEA/Ser.L/V/II, Doc. 56/09 (December 30, 2009), para. 194.

113. This is not surprising, because it is evident that, in addition to affecting an individual's life, severe damage to the environment may affect his physical, mental and moral integrity, which, among other elements, is a condition *sine qua non* for a decent life.

114. In this case, as mentioned previously, serious damage to the environment in the Caribbean Sea may entail a violation not only of the right to a decent life, but also of the right to personal integrity of the inhabitants of its coasts and islands.

115. Based on the above, the Republic of Colombia respectfully asks the Court to answer the following question:

> *Are the measures and the actions of one of the States parties, by act and/or omission, the effects of which may cause serious damage to the marine environment – which constitutes the way of life and an essential resource for the subsistence of the inhabitants of the coast and/or the islands of another State party – compatible with the obligations set out in Articles 4(1) and 5(1), read in relation to Article 1(1), of the Pact of San José? Or of any other permanent provision?*

SECTION 3: INTERPRETATION OF ARTICLES 4(1) AND 5(1) OF THE AMERICAN CONVENTION ON HUMAN RIGHTS IN RELATION TO ARTICLE 1(1), IN LIGHT OF INTERNATIONAL ENVIRONMENTAL LAW

A. The articles to be interpreted in this request for an advisory opinion

116. Articles 1(1), 4(1) and 5(1) of the Pact. Since they were transcribed above, we do not consider it necessary to repeat them.

B. Application of the principles and norms of international environmental law to the content of the State obligations under Articles 1(1), 4(1) and 5(1) of the American Convention on Human Rights

117. At the present time, there is no doubt that the rights and guarantees recognized in the Pact of San José, specifically in Articles 4(1) and 5(1) require a minimum quality of the environment, as a precondition for their exercise.

118. As established by the Court, States "have the legal obligation, under Article 1(1) to exercise a reasonable prevention of human rights violations,"[68] which, in this case entails the obligation to protect the environment in a way that ensures the full exercise and enjoyment of the said rights.

[68] ICourtHR, Case of *Velasquez Rodriguez,* Judgment of July 29, 1988, para. 172.

119. The object and purpose of environmental law, as mentioned in Chapter 3, is precisely to protect the environment against harm that results in the degradation of the human habitat and, consequently, the degradation of an individual's living conditions. To this end, international environmental law contains a series of norms and tools to implement the principle of prevention with regard to the environment, such as environmental impact assessments, environmental quality standards, and maximum permissible limits.[69]

120. In this context, several State obligations that are included in the body of norms of environmental law are relevant for compliance with State obligations in the area of human rights and promote their effectiveness – considering that the exercise and enjoyment of those rights depends, above all, on the habitat and physical environment of the human being (see Chapter 3). In the case of the construction of major infrastructure projects in the Caribbean Sea that could have a significant impact on the marine environment of this Region and, consequently, on the exercise and enjoyment of the basic rights of the inhabitants of its coasts and islands, the norms of international environmental law – which see, precisely, to prevent and to mitigate damage to the human habitat – play a crucial role in order to ensure the human rights of those potentially affected.

121. Despite the foregoing, to date, the Court has not had the occasion to establish whether, and to what extent, State obligations under international environmental law can be considered human rights obligations in light of the Pact, particularly as part of the obligations recognized in Articles 4(1) and 5(1) of this instrument; a question posed in this request for an advisory opinion.

122. This question does not seek to determine the existence of a formal legal relationship between environmental law and human rights, in the sense that a formal violation of environmental law would automatically be considered a violation of human rights. The presentation of this request for an advisory opinion seeks to determine the substantive normative interaction between environmental law and human rights in order to establish whether, and to what extent, international human rights law should be interpreted in light of, or in connection with, certain obligations established by international environmental law.

123. Two obligations established by international environmental law are absolutely essential for the real, full and effective guarantee of the rights and freedoms established in the Pact of San José and, consequently, they should be considered obligations that arise from that instrument. These obligations are: (a) the obligation to make complete environmental impact assessments not only of a national, but also of a transboundary nature, prior to the startup of any project that could cause a severe negative impact on the environment – assessments that should necessarily include the determination of the necessary and sufficient measures to prevent and to mitigate any possible

69 Marcos A. Orellana, Derechos Humanos y Ambiente: Desafios para el Sistema Interamericano de Derechos Humanos, Center for International Environmental Law (CIEL) 2007. Available at: www.ciel.org/Publications/Morellana_DDHH_Nov07.pdf, p. 296

environmental damage, and (b) the obligation of the State in which the environmental damage could originate to inform third States that could be affected in order to ensure cooperation to prevent the damage or, at least, to attenuate its severity, as established by articles 12 and 13 of the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region.

a) The obligation to make an environmental impact assessment

124. One of the pillars of international environmental law is the principle according to which States have the obligation to ensure that the activities carried out in their territory do not harm the environment and, consequently, individuals from other States, as emphasized by the International Court of Justice in its 1996 Advisory Opinion.[70] This principle of "due diligence" had already been recognized by arbitration case law in the case of *Trail Smelter (Canada* v. *United States of America).*[71] Furthermore, the International Court of Justice underscored its content in its judgment in the case concerning *Pulp Mills on the River Uruguay (Argentina v. Uruguay),* as follows:

> "The principle of prevention, as a customary rule, has its origins in the due diligence that is required of a State in its territory. It is "every State's obligation not to allow knowingly its territory to be used for acts contrary to the rights of other States" *(Corfu Channel (United Kingdom* v. *Albania), Merits, Judgment, IC.J. Reports 1949,* p. 22). A State is thus obliged to use all the means at its disposal in order to avoid activities which take place in its territory, or in any area under its jurisdiction, causing significant damage to the environment of another State. This Court has established that this obligation "is now part of the *corpus* of international law relating to the environment" *(Legality of the Threat or Use of Nuclear Weapons, Advisory Opinion, IC.J. Reports 1996 (1),* p. 242, para. 29)."[72]

125. The obligation of prevention or *due diligence* recognized in general international law calls for the application of special measures aimed at preventing, or at least restricting, environmental damage. As the Arbitral Tribunal indicated in its decision of May 24, 2005, in the case of the *Iron Rhine*:

> "Today, both international and EC law require the integration of appropriate environmental measures in the design and implementation of economic development activities [...] where development may cause significant harm to the environment there is a duty to prevent, or at least mitigate, such harm. This duty, in the opinion of the Tribunal, has now become a principle of general international law."[73]

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70 I.C.J., *Legality of the threat or use of nuclear weapons,* Advisory Opinion of July 8, 1996, pp. 241-242, paras. 29-30.

71 In this regard see: *Trail Smelter* case (United States, Canada), 16 April 1938 and 11 March 1941. UN III pp. 1905-1982.

72 I.C.J., Case concerning *Pulp Mills on the River Uruguay (Argentina contra Uruguay),* judgment of April 10, 2010, pp. 55-56, para. 101

73 Award in the Arbitration regarding the *Iron Rhine ("Ijzeren Rijn")* between the Kingdom of Belgium and the Kingdom of the Netherlands, decision of 24 May 2005, UN Reports of International Arbitral Awards, Vol. XXVII, p. 35, para. 59

126. These measures include, above all, an obligation of each State to make a serious and complete assessment of the repercussions on the environment before executing any project that could harm the environment of third States.

127. In this regard, Principle 17 of the Rio Declaration on the Environment and Development adopted by the 1992 United Nations Conference on the Environment and Development, establishes that:

> "Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority."[74]

128. This principle is now considered part of general international law, as recognized by the International Court of Justice in the case of *Pulp Mills on the River Uruguay:*

> "It may now be considered a requirement under general international law to undertake an environmental impact assessment where there is a risk that the proposed industrial activity may have a significant adverse impact in a transboundary context."[75]

129. The International Court of Justice defined and confirmed the existence and the content of this obligation in its decision of December 16, 2015, in the joindered cases of *Certain activities carried out by Nicaragua in the border area (Costa Rica v. Nicaragua)* and *Construction of a road in Costa Rica along the San Juan River (Nicaragua v. Costa Rica).* Citing an extract from the case of *Pulp Mills on the River Uruguay* mentioned in the preceding paragraph, that Court added:

> "Although the Court's statement in the Pulp Mills case refers to industrial activities, the underlying principle applies generally to proposed activities which may have a significant adverse impact in a transboundary context. Thus, to fulfil its obligation to exercise due diligence in preventing significant transboundary environmental harm, a State must, before embarking on an activity having the potential adversely to affect the environment of another State, ascertain if there is a risk of significant transboundary harm, which would trigger the requirement to carry out an environmental impact assessment."[76]

The International Court of Justice also asserted that:

> "A State's obligation to exercise due diligence in preventing significant transboundary harm requires that State to ascertain whether there is a risk of significant transboundary harm prior to undertaking an activity having the potential adversely to affect the environment of another State. If that is the case, the State concerned must conduct an environmental impact assessment. The obligation in question rests on the State pursuing

[74] The Rio Declaration on the Environment and Development is available at: http://www.unep.org/documents.multilingual/default.asp?documentid=78&articleid=1163.

[75] I.C.J., Case concerning *Pulp Mills on the River Uruguay (Argentina contra Uruguay),* judgment of April 10, 2010, p. 73, para. 205

[76] I.C.J., Cases concerning *Certain activities carried out by Nicaragua in the border area (Costa Rica v. Nicaragua)* and *Construction of a road in Costa Rica along the San Juan River (Nicaragua v. Costa Rica),* judgment of December 16, 2015, p. 45, para. 104.

the activity."[77]

130. The obligation to make an environmental impact assessment – that examines potential national and transboundary harm – is established not only in customary law embodied in general international law, but also in the conventions to which the coastal States of the Wider Caribbean Region are party and that regulate everything relating to the protection of the environment.

131. As mentioned in the preceding chapters, an example of this is the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region to which coastal States of the Caribbean Sea and Colombia are parties. In this regard, the preamble states that the Contracting Parties are:

> "Conscious of their responsibility to protect the marine environment of the wider Caribbean region for the benefit and enjoyment of present and future generations."

132. The Convention establishes diverse obligations, including that of assessing the potential harmful effects of any project that could have an impact on the marine environment of the Caribbean and on present and future generations in order to take measures to prevent its pollution or other harmful changes (Art. 12(2)); the obligation to develop procedures to share information on this assessment (Art. 12(3)), and the obligation to take all appropriate measures to prevent, reduce and control marine pollution in the Wider Caribbean Region (Art. 4(1) and (3); Art. 7 and Art. 12(1)). The obligation to make prior assessments so "as to prevent or minimize harmful impacts on the Convention area" (Art. 12(l)), as regards potential impacts on the marine environment of the Caribbean is expressly established in Article 12(2) of this instrument as follows:

> "Each Contracting Party shall assess within its capabilities, or ensure the assessment of, the potential effects of such projects on the marine environment, particularly in coastal areas, so that appropriate measures may be taken to prevent any substantial pollution of, or significant and harmful changes to, the Convention area."

133. Additionally, article 14 of the Convention on Biological Diversity establishes the obligation of each State party to "introduce appropriate procedures requiring environmental impact assessment of its proposed projects that are likely to have significant adverse effects on biological diversity with a view to avoiding or minimizing such effects."

134. In keeping with the above, the obligation to make a prior and effective environmental impact assessment – that examines possible national and transboundary effects – arises from customary international law as well as from the applicable treaty-based law, specifically in the Wider Caribbean Region.

135. The importance of environmental impact assessments has also been recognized under international human rights law. Indeed, in its case law, the Inter-American Court of Human Rights

77 *Ibid*, p. 57, para. 153.

has affirmed, in certain cases concerning indigenous communities, that the obligation to make prior environmental impact assessments arises from the Pact of San José.

136. In the case of the *Saramaka People v. Suriname,*[78] in which the Court examined the issue of logging permits and mining concessions for the exploration and extraction of certain natural resources found on the Saramaka territory, the Court asserted that, as a result of the right to property established in the Pact, the State of Suriname was obliged to ensure:

> "that no concession was issued within the Saramaka territory at least until independent technically capable entities, under the State's supervision, had make a prior assessment of their environmental and social impact."[79]

137. This decision was subsequently ratified in the case of the *Kichwa Indigenous People of Sarayaku v. Ecuador.*[80]

138. According to the findings of the Inter-American Court of Human Rights, the environmental impact assessment must be made before granting the concession for any specific project. Similarly, the International Court of Justice has emphasized that such assessments must be made prior to implementation of a project and that, where necessary, the effects of the project on the environment should be subject to continuous monitoring. In the words of the Court:

> "The Court also considers that an environmental impact assessment must be conducted prior to the implementation of a project. Moreover, once operations have started and, where necessary, throughout the life of the project, continuous monitoring of its effects on the environment shall be undertaken."[81]

139. Also, in its decision of December 16, 2015, in the cases of Costa Rica v. Nicaragua and Nicaragua v. Costa Rica, the International Court of Justice stressed that:

> "A State must, **before embarking on an activity having the potential adversely to affect the environment of another State**, ascertain if there is a risk of significant transboundary harm, which would trigger the requirement to carry out an environmental impact assessment."[82]

Or, in other words, States must:

> "ascertain whether there is a risk of significant transboundary harm **prior to undertaking**

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78 ICourtHR, Case of the *Saramaka People v. Suriname.* Preliminary objections, merits, reparations and costs. Judgment of November 28, 2007. Series C No. 172.

79 *Ibid.* p. 29.

80 ICourtHR, Case of the *Kichwa Indigenous People of Sarayaku v. Ecuador.* Merits and reparations. Judgment of June 27, 2012. Series C No. 245, paras. 204 to 207

81 I.C.J., Case concerning *Pulp Mills on the River Uruguay (Argentina contra Uruguay),* judgment of April 10, 2010, para 205.

82 I.C.J., Cases concerning *Certain activities carried out by Nicaragua in the border area (Costa Rica v. Nicaragua)* and *Construction of a road in Costa Rica along the San Juan River (Nicaragua v. Costa Rica),* judgment of December 16, 2015, p. 45, para. 104 [bold added].

> **an activity having the potential adversely to affect the environment of another State.** If that is the case, the State concerned must conduct an environmental impact assessment."[83]

140. This interpretation regarding the moment at which the environmental impact assessment should be made is in keeping with the guidelines approved by the UNEP Governing Council in its decision 14/25 "Goals and Principles of Environmental Impact Assessment," according to which:

> "Principle 1
>
> States (including their competent authorities) should not undertake or authorize activities without prior consideration, at an early stage, of their environmental effects. Where the extent, nature or location of a proposed activity is such that it is likely to significantly affect the environment, a comprehensive environmental impact assessment (EIA) should be undertaken in accordance with the following principles."[84]

141. Similarly, at the fourth meeting of the Conference of the Parties to the Convention on Biological Diversity, it was asserted that: "[t]o be most effective, the environmental impact assessment should be carried out at the design stage of a project to identify where practical plans can be made to minimize any adverse effects."[85]

142. Secondly, as the Inter-American Court of Human Rights has indicated, environmental impact assessment must be made by "independent and technically capable entities, under the State's supervision,"[86] in order to ensure an objective, impartial and technically verifiable assessment[87] and also so that the State can verify that the assessment meets the requirements established in the applicable norms.

143. Regarding the specific content of an environmental impact assessment, in the case of the *Saramaka People*, the Inter-American Court Human Rights specified that such assessments "should be carried out in accordance with the relevant international standards and best practice."[88] This means that environmental impact assessments should include:

(i) Potential national and transboundary impacts of the respective project;

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83 *Ibid,* p. 57, para. 153 (bold added).

84 UNEP, Goals and Principles of Environmental Impact Assessment, Decision14/25, June 1, 1987

85 Conference of the Parties to the Convention on Biological Diversity, Fourth Meeting, Bratislava, 4 to 15 May 1998, "Impact assessment and minimizing adverse effects: implementation of Article 14," UNEP/CBD/COP/4/20, 11 March 1998, p.2.

86 ICourtHR, Case of the *Saramaka People v. Suriname.* Preliminary objections, merits, reparations and costs. Judgment of November 28, 2007. Series C No. 172, p. 29.

87 IACHR, *Indigenous and tribal peoples' rights over their ancestral lands and natural resources. Norms and jurisprudence of the inter-American human rights system.* OEA/Ser.L/V/II, Doc. 56/09 (December 30, 2009), para 252. Decision No. 004 of August 8, 2005, Colombian Departmental Fisheries and Aquaculture Board (Jundepesca).

88 ICourtHR, Case of the *Saramaka People v. Suriname.* Interpretation of the judgment on preliminary objections, merits, reparations and costs. Judgment of August 12, 2008. Series C No. 185, Para. 41.

(ii) Evaluation of possible alternative, when possible, and

(iii) Evaluation of potential measures of prevention and/or mitigation of environmental damage in the protected region.

144. In this regard, Principle 4 of the UNEP "Goals and Principles of Environmental Impact Assessment establishes that:

> "An EIA should include, at a minimum:
> […]
> (c) a description of practical alternatives, as appropriate;
>
> (d) an assessment of the likely or potential environmental impacts of the proposed activity and alternatives, including the direct, indirect, cumulative, short-term and long-term effects.
>
> (e) an identification and description of measures available to mitigate adverse environmental impacts of the proposed activity and alternatives, and an assessment of those measures [...]."[89]

145. During the Conference of the Parties to the Convention on Biological Diversity, it was established that "[t]he environmental impact assessment should, where adverse impacts are envisaged, identify alternative project designs (including rejection or the "no-action" alternative), as well as mitigation measures or environmental safeguards that can be incorporated into the project design to reduce the adverse impacts."[90]

146. In addition, the World Bank's Operational Manual OP 4.01 defines the purpose of environmental impact assessment as follows:

> "[Environmental impact assessment] examines project alternatives; identifies ways of improving project selection, siting, planning, design, and implementation by preventing, minimizing, mitigating, or compensating for adverse environmental impacts and enhancing positive impacts; and includes the process of mitigating and managing adverse environmental impacts throughout project implementation. The Bank favors preventive measures over mitigatory or compensatory measures, whenever feasible."[91]

147. The obligation to analyze and establish possible measures to prevent or mitigate environmental damage in impact assessments is also established in other international instruments, such as in the Voluntary Guidelines for the Conduct of Cultural, Environmental and Social Impact Assessment regarding Developments Proposed to Take Place on, or which are Likely to Impact on, Sacred Sites and on Lands and Waters Traditionally Occupied or Used by Indigenous and Local Communities.

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[89] UNEP, Goals and Principles of Environmental Impact Assessment, Decision 14/25, June 17, 1987. Principle 4.

[90] Conference of the Parties to the Convention on Biological Diversity, Fourth Meeting, Bratislava, 4 to 15 May 1998, "Impact assessment and minimizing adverse effects: implementation of Article 14," UNEP/CBD/COP/4/20, 11 March 1998, p.2.

[91] World Bank, Operational Manual, OP 4.01: Environmental Assessment, Revised April 2013.

> "Environmental impact assessment must evaluate "the likely environmental impacts of, and propos[e] appropriate mitigation measures for, a proposed development, taking into account interrelated socio-economic, cultural and human health impacts, both beneficial and adverse." [92]

b) The obligation to cooperation with States potentially affected

148. However, if significant transboundary impacts are identified, the State in whose jurisdiction the project is being executed must notify the States potentially affected regarding the activity to be implemented and forward it the relevant information from the environmental impact assessment, as established by international practice.[93] Once this information has been transmitted, it is extremely important that the different States that could be affected by the environmental damage cooperate with each other in order to propose appropriate and effective measures of prevention and mitigating measures.

149. In this regard, principle 19 of the above-mentioned Rio Declaration on the Environment and Development establishes:

> "States shall provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse transboundary environmental effect and shall consult with those States at an early stage and in good faith."[94]

150. Since then, general international law has incorporated the obligation of cooperation between States affected by the risk of harm to the marine environment. In this regard, in the *MOX Plant case* the International Tribunal for the Law of the Sea stated that:

> "The duty to cooperate is a fundamental principle in the prevention of pollution of the marine environment under Part XII of the Convention and general international law."[95]

151. In its decision of December 16, 2015, in the cases of Costa Rica v. Nicaragua and Nicaragua v. Costa Rica, the International Court of Justice decided that:

> "If the environmental impact assessment confirms that there is a risk of significant transboundary harm, the State planning to undertake the activity is required, in conformity with its due diligence obligation, to notify and consult in good faith with the

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[92] Conference of the Parties to the Convention on Biological Diversity, Seventh meeting (COP-7), Kuala Lumpur, 9-20 February 2004, Decision VII/16, Annex (Akwé: Kon Voluntary Guidelines), para. 6(d).

[93] UNEP, Goals and Principles of Environmental Impact Assessment, Decision 14/25, June 17, 1987. Principle 12; Conference of the Parties to the Convention on Biological Diversity, Fourth Meeting, Bratislava, 4 to 15 May 1998, "Impact assessment and minimizing adverse effects: implementation of Article 14," UNEP/CBD/COP/4/20, 11 March 1998, p.2.

[94] The Rio Declaration on the Environment and Development is available at: http://www.unep.org/documents.multilingual/default.asp?documentid=78&articleid=1163

[95] International Tribunal for the Law of the Sea, Case concerning the MOX Plant between the United Kingdom and Ireland (Ireland v. U.K,), Provisional measures, December 3, 2001, p. 245, paras. 204-207. Series C No. 172.

> potentially affected State, where that is necessary to determine the appropriate measures to prevent or mitigate that risk."[96]

152. This obligation of cooperation is also established in conventions to which the coastal States of the Wider Caribbean Region are party, such as the Convention on Biological Diversity (Article 5).

c) Importance of environmental impact assessments and the obligation of cooperation in the case of potential harm to the marine environment of the Wider Caribbean Region

153. Regarding the natural and social impacts of harm to the marine environment of the Caribbean, UNEP has ruled on the crucial importance of adopting preventive measures – as opposed to remedial measures– as follows:

> "The economies of a large number of the countries of the region are highly dependent upon the marine environment primarily through tourism and fishing. These major economic sectors are the first to be affected as a result of degraded ecosystems such as coral reefs, mangrove forests and seagrass beds. Remedial action, taken after harmful effects are evident in a fragile system, may involve very expensive clean-up operations or, at worst, the damage of essential life-supporting systems may be irreparable. Remedial measures for the environment will not necessarily revive a damaged tourist industry, particularly in the short term."[97]

154. Considering the irreparable nature of most damage to the marine environment of the Caribbean and, therefore, the serious harm that the quality of life of the inhabitants of its coasts and islands may suffer, it is crucially important that, in the case of the construction of major infrastructure projects in the Caribbean Sea, complete and reliable environmental impact assessments are carried out – that examine not only the national impacts, but also the transboundary impacts of the respective projects, as well as the measures required to prevent and to mitigate the harm to the marine environment. Furthermore, the obligation to cooperate with the States that may be affected by the execution of a specific project in the Wider Caribbean Region is relevant in order to ensure the suitability of the said measures of damage prevention and mitigation. This is in order to ensure the human rights of all those who could be affected by the construction and operation of such projects, irrespective of the State in which they are executed.

155. Based on the foregoing, the Republic of Colombia respectfully asks the Court to answer the following questions:

Should we interpret – and to what extent – the norms that establish the obligation

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[96] I.C.J., Cases concerning *Certain activities carried out by Nicaragua in the border area (Costa Rica v. Nicaragua)* and *Construction of a road in Costa Rica along the San Juan River (Nicaragua v. Costa Rica),* judgment of December 16, 2015, p. 45, para. 104.

[97] UNEP: Relevance and Application of the Principle of Precautionary Action to the Caribbean Environment Program. CEP Technical Report No. 21. UNEP Caribbean Environment Programme, Kingston, Jamaica, 1993. Available at: www.cep.unep.org/pubs/Techreports/tr21en/content.html.

to respect and ensure the rights and freedoms set out in Articles 4(1) and 5(1) of the Pact in the sense that they infer the obligation of the States Parties to the Pact to respect the norms of international environmental law that seek to prevent any environmental damage which could restrict or preclude the effective enjoyment of the rights to life and to personal integrity, and that one of the ways of complying with that obligation is by making environmental impact assessments in an area protected by international law, and by cooperation with the States that could be affected? If applicable, what general parameters should be taken into account when making environmental impact assessments in the Wider Caribbean Region, and what should be the minimum content of these assessments?

INTER-AMERICAN COURT OF HUMAN RIGHTS

REQUEST FOR AN ADVISORY OPINION

Presented by the

REPUBLIC OF COLOMBIA

Concerning the interpretation of

Articles 1(1), 4(1) and 5(1) of the American Convention on Human Rights

ANNEXES

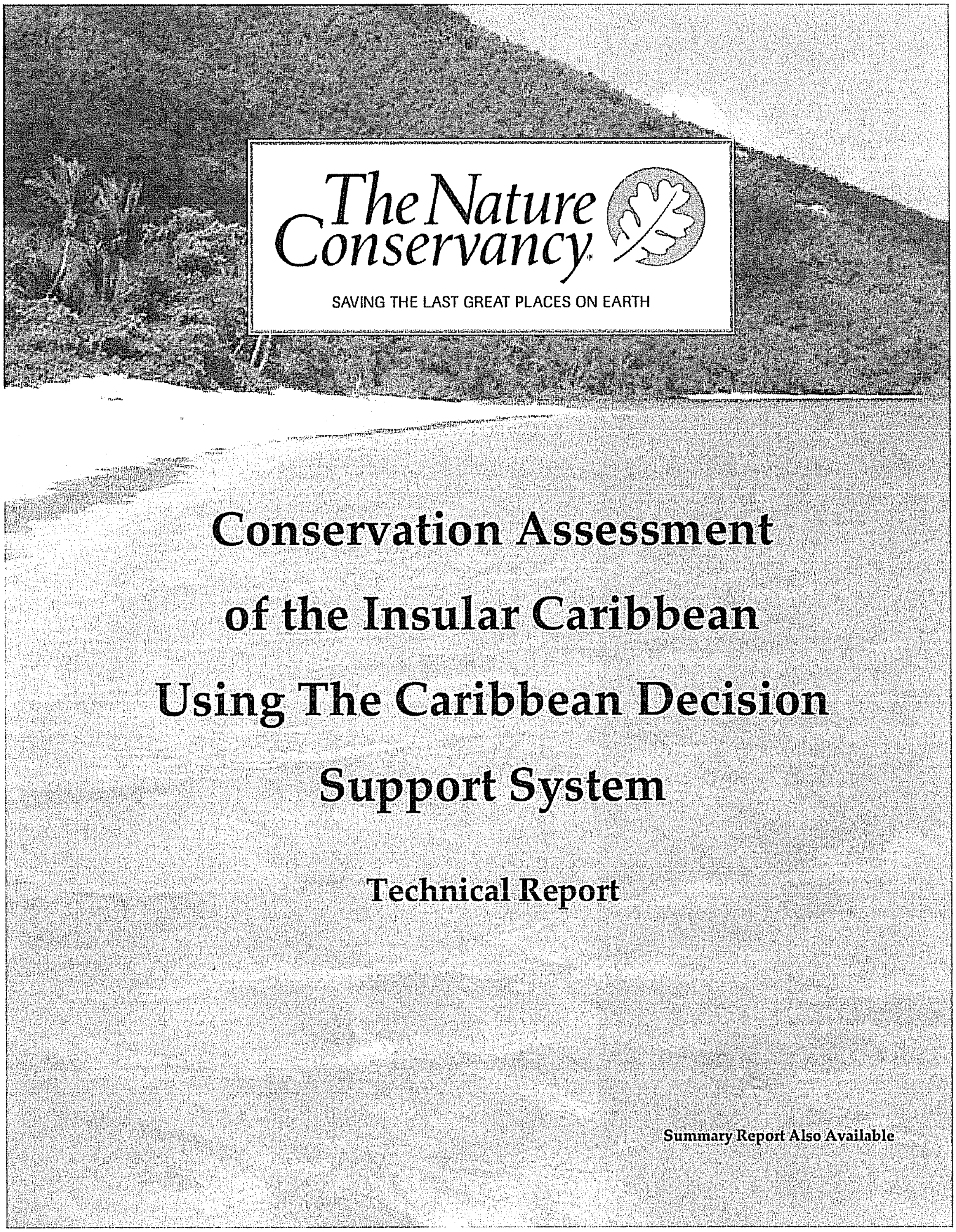
San José, Costa Rica
March 2016

LIST OF ANNEXES

Annex I

Huggins A.E., S. Keel et al., *Biodiversity Conservation Assessment of the Insular Caribbean Using the Caribbean Decision Support System*, Technical Report, The Nature Conservancy, 2007 *(extract: pages 1-2 and 9-17)*

The complete document is available at: www.conservationgateway.org/ConservationPlanning/SettingPriorities/EcoregionalReports/Documents/CDSS-technical-report-final.pdf



The Nature Conservancy

SAVING THE LAST GREAT PLACES ON EARTH

Conservation Assessment of the Insular Caribbean Using The Caribbean Decision Support System

Technical Report

Summary Report Also Available

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THE CARIBBEAN REGION

The Caribbean basin comprises over 20 nations and territories, each characterized by unique and wide ranging biodiversity and culture. It is one of the world's greatest centers of biodiversity and endemism, arising from the region's geography and climate: an archipelago of habitat-rich tropical and semi-tropical islands tenuously connected to surrounding continents. Plants and animals arrived from the neighboring continents and islands, and as their descendants spread into new environments they evolved as a result of new ecological opportunities. The region harbors a staggering 12,000 plant species, 1,518 vertebrate species and 3,000 shallow marine species. Of this diverse flora and fauna, many are endemics found nowhere else on Earth, some unique to individual islands, or to isolated places within specific islands.

Marine

The Caribbean forms the heart of Atlantic marine diversity. Roughly 8 to 35% of species within the major marine taxa are endemic to this area. The shallow marine environment contains 25 coral genera (62 species scleractinian coral), 4 mangroves, 7 seagrasses, 117 sponges, 633 mulluscs, 378 bivalves, 77 stomatopods, 148 echinoderms, over 1400 fishes, 76 sharks, 45 shrimp, 30 cetaceans, 1 sirenia, and 23 seabirds. Only one marine species has gone extinct, the Caribbean Monk Sea, which was last seen in the mid 1950's.

The Caribbean contains approximately 10,000 square kilometers of reef (Spalding, *et al.*, 2001; Andréfouët *et al.*, 2005); 22,000 square kilometers of mangrove (amended from Spalding *et al.*, 1997); and as much as 33,000 square kilometers of seagrass beds (Spalding *et al.*, 2003). Other unique and interesting carbonate structures found in the insular Caribbean include stromatolites, algal ridges, ooid shoals, and blue holes.

There is surprisingly little variation in marine species diversity within the Caribbean province in large part because of the high degree of connectivity. The strong and predictable Caribbean Current that meanders through the basin year round transporting larvae between islands and regions. As a result, marine habitats share many of the same marine species and show remarkably low degree of endemism (between marine ecoregions) in stark contrast to the regions highly endemic terrestrial island biodiversity. Large ranging and highly migratory species such as turtles, whales, sea birds and pelagic fishes, inhabit different portions of the Caribbean basin during different stages of life. Despite this high degree of mixing, there are significant differences in geology, climate, productivity, and island size all of which influence the relative abundance, extent, intactness, and vulnerability of marine biodiversity in the Caribbean. Three distinct ecosystems are identified as follows;

The Bahamian marine ecoregion encompasses the large shallow bank systems of the Bahamas and Turks and Caicos as well as several smaller banks at the southern terminus owned by the Dominican Republic. This region of the Caribbean is tectonically very stable creating massive build-up of carbonate sediments that make up the banks. The sediments are almost entirely composed of carbonate grains derived from the shells of living organism that thrive in the warm shallow waters. Islands and small islets number into the thousands and are all generally low-lying with very limited freshwater river outflows that occur as groundwater discharge. Tides are larger than in other parts of the Caribbean and have shaped complex coastal landforms of tidal creeks, mud flats, and ooid sand shoals. Habitat diversity (beta diversity) is similarly different than other parts of the Caribbean. Reefs tend to be narrow fringing barriers (bank margin reefs) and Holocene biogenic reef islands are virtually absent. Soft-bottom communities such as seagrass beds are generally sparser than other parts of the Caribbean while macroalgal biomass on deeper fore reefs is significantly higher. Coral reefs vary in form mainly with respect to exposure to wave energy and generally occur along all of the windward margins of the banks. A number of distinct carbonate structures unique to this part of the Caribbean include an extraordinary number of blue holes, modern stromatolites actively growing in tidal channels, and active ooid sand shoals.

Species diversity in the Bahamian ecoregion is different to other parts of the Caribbean such as along the coasts of south and central America. Absent are manatees, saltwater crocodiles, and many of the species associated with large fluvial estuaries. Acroporid corals (*Acropora palmate*) is particularly abundant on shallow fringing reef structures and *Montastraea annularis* is the major reef builder on the deeper fore reefs. Extensive hardbottom algal communities characterize large areas of the exposed southern banks whereas soft bottom communities occur in the island sheltered banks. Reef fish communities in much of the region contain largely intact predator assemblages, including large numbers of Nassau groupers (*Epinephelous striates*) with a very high number of intact spawning aggregation sites. A recent rapid ecological assessment of this area found that it harbors some of the largest populations of bonefish in the world.

Sea turtles (mainly greens and loggerheads) forage over much of this area during juvenile life stages with some of the highest densities ever observed. Seabirds occupy many of the uninhabited offshore cays particularly in areas of higher productivity such as Cay Sal Bank. The largest breeding ground for Atlantic humpback whales occur on the banks at the southern end of this ecoregion. Pressure on the marine resources continues to be comparatively light due to the fairly low population densities and opportunities in the growing tourism industries.

The Greater Antilles are the large, tectonically active and mountainous islands of Cuba, Jamaica, Hispaniola, and Puerto Rico. The sheer size and height of these island masses are enough to create localized daily adiabatic winds that can override the regional easterly trade winds and produce localized climate and rainfall. Watersheds are small to moderate in size producing substantial fluvial discharge and nutrients into the coastal zones. Tectonic activity in this area of the Caribbean remains high because of the underlying plate boundary and tectonic uplift continues today. Estuaries tend to occur as large tectonic shaped inlets (perpendicular to the coastline) that may be highly stratified and deep depending on the amount of fluvial discharge. Except for the north coasts of Cuba and Puerto Rico, tides are typically quite low (~25 cm) for much of the rest of the ecoregion. The marine habitat beta diversity in the Greater Antilles is higher than in the eastern Caribbean or Bahamian ecoregions because of the substantial gradients around the islands with respect to exposure and productivity. Fringing reefs are most common with larger barriers forming along the wider shelf areas south as found along the south coast of Cuba. There are several banks within this ecoregion including Pedro Bank and several off the south coast of Cuba but the water depths are greater than for banks in the Bahamian ecoregion.

Marine species diversity is high but larger megafauna have been severely impacted by human activity over the past several hundreds of years. Small populations of manatees and saltwater crocodiles still occur on all of the Antilles but are restricted to a very small portion of their original distribution. Similarly, sea turtle populations and nesting occurrences have also been dramatically reduced from what was observed several hundreds of years ago but still occurs on all of the islands in small numbers. Coral reef species include all of the known scleractinian corals that exist in the western tropical Atlantic. With a combined population of over 25 million on these islands, the density of people living on the Greater Antillean islands is some of the highest in the world. Severe overfishing has depleted reef fish stocks and altered the trophic structure of the entire coastal zone.

The Lesser Antilles or Eastern Caribbean is a half-moon shaped string of over 60 islands stretching 600 miles from the U.S. and British Virgin Islands to Grenada. This region of the Caribbean is a back-arc basin and characterized by small island sizes many of volcanic origins associated with the adjacent plate boundary. The Virgin islands (U.S. and British) found at the northern boundary of this ecoregion are geologically more similar to the Greater Antilles but have been grouped into the Eastern Caribbean because of their small island size and easterly exposure to the Atlantic swells. The small size of the islands minimized localized climate and rainfall effects and produces very few large freshwater rivers or estuaries.

Coastal salt ponds are quite common that are orientated parallel to the coastline but are often not hydraulically connected to the sea in part because of the lower tidal amplitudes (~25 cm) in this portion of the Caribbean. Much of the eastern Caribbean is influenced by the discharge of massive amounts of freshwater from several large South American rivers such as the Orinoco. This produces salinities well below oceanic conditions for several months each year. Coral reefs tend to occur as fringing forms around the islands and the northern more exposed portions of the eastern Caribbean also has unique coral algal ridges which form in response to high wave energy.

Marine species in the eastern Caribbean are similar to elsewhere in the Caribbean but is somewhat lower diversity than found along the larger islands or continental coasts. Species such as manatees and saltwater crocodiles are rare (although historically Manatees were found in Guadeloupe) as are species associated with larger estuaries. Sea turtle nesting for both Leatherback and Hawksbills is common on many of the islands and the area is important for Green turtle foraging. Seabirds are also very abundant in this area of the Caribbean possibly because of easy access to deeper water productive fishing grounds. Whales, including Humpback and Sperm, frequently use this area during the winter possibly because the easy access through numerous deep water channels that bisect the islands. This ecoregion spans more than 17 distinct political units, with a population of just 2.5 million inhabitants. The small island size and developing economies and their isolation make these islands more vulnerable to environmental degradation and more dependent on tourism than the other regions.

Terrestrial

The large geographic expanse of the Caribbean contains at least fourteen Holdridge Life Zones and a complex geology (Lugo *et al.*, 2000). The Greater Antilles (Cuba, Hispaniola, Jamaica, Puerto Rico and the Virgin Islands) are located on a partially elevated platform that supports a mature volcanic range. The Lesser Antilles (the islands from Anguilla to Grenada), are of more recent origin, consisting of an outer chain of islands composed of low coral and limestone and an inner chain of steep volcanic islands. The Bahamas bank assemblage (including Turks and Caicos), located southeast of the Florida peninsula, rises from a rock submarine plateau (Lugo *et al.*, 2000; Areces-Mallea *et al.*, 1999).

The Caribbean is one of the world's centers of terrestrial biodiversity and endemism. It harbors about 12,000 plant species and 1,518 vertebrate species (668 bird, 164 mammal, 497 reptile, and 189 amphibian species). Of this diverse flora and fauna, 7,000 vascular plant species and 779 vertebrate species (148 bird, 49 mammal, 418 reptile, and 164 amphibian species) are endemic to the Caribbean. This accounts for 2.3% of the world's 300,000 plant species, and 2.9 % of the world's 27,298 vertebrate species. Total land surface of the Caribbean islands is only 263,500 km^2 with only 11.3% of the original primary vegetation remaining, an aggregated area of only 29,840 km^2. Many species are endemic not only to the region, but to individual islands, or to isolated places within specific islands. Among the faunal groups, very high endemism is found in fish, amphibians, reptiles, and mammals (Myers, *et al.*, 2000; Davis *et al.*, 1997; Woods & Sergile, 2001; Global Amphibian Assessment, 2004; Raffaele *et al.*, 1998; Nowak, 1994; Nature Serve).

Caribbean species richness is supported by diverse habitats; there are 4 major habitat types, 16 WWF ecoregions, and 14 Holdridge life zones. The distribution and biodiversity characteristics of the major habitat types (Adams 1972; Areces-Mallea et al., 1999; Borhidi 1991; Correll and Correll, 1982; Howard 1973; Lugo et al., 2000; Neotropical Ecosystems Integrity Assessment 2001) are described below:

Tropical/ Subtropical Moist Broadleaf Forests are characterized by the large number of tree species occurring together with a closed canopy. Gregarious dominants are uncommon. The forest in general has smooth, wind-sculptured canopies without emergent trees. Understory vegetation, especially herbaceous plants, is often sparse. Cylindrical bole, pinnate leaf, large leaf blade, buttress, liana, and cauliflory are common. It occurs in a climate where water stress is absent with no regular annual dry season and an average of monthly rainfall of 100 mm or more, or where water stress is intermittent with short dry season of monthly rainfall of 60 mm or more or with particular soil conditions. This factor is coupled with high temperature (mean temperature 18^0C or more in the coldest month of the year) and a strong evapo-transpiration. The high net primary productivity of successional forests supports a large animal population, but not the same species as a mature forest. Dominant species groups include Leguminosae, Moraceae, Meliaceae, Palmae, and Lauraceae. Diagnostic species groups are Bromeliaceae and tree ferns. In the Caribbean, moist forests occur mainly in lowland areas influenced by north-easterly or north-westerly winds, and windward mountain slopes, e.g., northern part of eastern Cuba, northern Jamaica, eastern Hispañola, northern Puerto Rico, and small patches in the Lesser Antilles, Trinidad and Tobago.

Tropical / Subtropical Dry Broadleaf Forests are found in areas with high temperatures throughout the year, an annual precipitation of less than 1,600 mm with one or two long and pronounced dry seasons. The duration and intensity of drought govern the distribution of dry forests. Dry forests during the rainy season are often similar physiognomically to tropical humid forests but are generally smaller in stature and biomass, lower in biodiversity, and more seasonally pulsed in tree growth, reproductive cycles, and organic matter turnover than forests with higher and less seasonal rainfall. The structure and composition of dry forest vary greatly relative to climate, soil, and other environmental factors. Factors that are largely governed by latitudinal position such as timing, frequency, and duration of dry periods, are also important determinants of dry forest characteristics. Dry forests usually have a high level of endemism. Most woody plants and succulents are diecious or hermaphrodites but self incompatible. Their reproduction relies on pollinators, particularly bees. Dominant species groups include Capparidaceae, Cactaceae, Erythroxylaceae, Zygophyllaceae, Anacardiaceae, Asteraceae, Malvaceae, Lamiaceae, and Leguminosae. Common genera include *Acacia, Caesalpinia, Cassia, Mimosa, Tabebuia, Capparis, Byrsonima, Lysiloma, Ceiba, Aspidosperma, Erythroxylon*, *Brya, Pictetia, Plumeria*, and *Bursera*. Diagnostic species are *Melocactus spp., Cephalocereus royenii, Leptocerreus quadricostatus*, and *Thrinax morrisii*. In the Caribbean dry forests are found in The Bahamas, Caymen Islands, Cuba, Hispaniola, Jamaica, Leeward Islands, Puerto Rico, Trinidad and Tobago, and Windward Islands. The dry forest life zone tends to be favored for human habitation, largely because of relatively productive soils and reasonably comfortable climate. For this reason, few dry forests remain undisturbed.

Tropical / Subtropical Coniferous Forests belong to a fire-maintained, single-species dominant system. They occur on nutrient-poor acidic soils, either on quartz sands, slates and sandstones as subclimax communities, or as paraclimax communities on ferritic soils. In addition to fires, hurricanes and landslides are the major natural disturbance affecting the distribution, composition and structure of the pine forests. In the Caribbean pine forests are found in The Bahamas, Turks, Caicos, Cuba, and Hispaniola. In Cuba, coniferous forests occur in the eastern and western ends of the island. The lowland pine forests on the ferritic soils or slately sandstone are dominated by *Pinus caribaea* var. *caribaea*; while pine forests on deep, acidic ferritic soils are dominated by *P. cubensis*. They are rich in endemics. Low-altitude pine forests of Isla de La Juventud are dominated by *P. tropicalis*. Montane pine forests on acidic soils derived from sandstone and andesitic tuffs in south eastern Cuba are dominated by *P. maestrensis*. On the island of Hispaniola, montane pine forests are found in the Cordillera Central with *P. occidentalis*. Pine barrens or open pine woodlands on limestone with monospecific canopy of *P.caribaea var. bahamensis* occur in The Bahamas. The major threats to pine forests include irrational timber extraction and frequent man-made fires which change the age structure and density of the pine forests, and exotic species which displace native species in the understory modifying the fire regime, water and nutrient availability.

Shrublands and Xeric Scrub occur in areas of rain shadows created by mountains in areas of extreme temperatures. Xeric areas generally have low and highly seasonal precipitation, with great interannual variation. Xeric shrublands are open vegetation with small trees and shrubs, cacti are dominant or co-dominant in both shrub and canopy layers. Vegetation cover by annual plants varies due to large quantitative and seasonal rain fluctuations. During the dry season the landscape is barren. A large proportion of xeric vegetation consists of annual plants. Microphyllous shrubs, small succulent trees, plants in rosettes (such as agaves and terrestrial bromeliads) or perennial and semi-deciduous shrubs can also be present. Xeric vegetation has high levels of endemism at the species and genus level. Flowering and faunal reproduction processes are adapted to rainy seasons. Ants and rodents are fundamentally important species. Habitat diversity in the hot xeric system is spatially very heterogeneous and patchy. Dominant species include *Rittereocereus hystrix, Opuntia spp., Cylindropuntia histrix, Rhodocactus cubensis, Caesalpinia spp:, Capparis spp., Gaujacum officinale, Consolea macracantha, Dendrocereus nudiflorus, Pilosocereus brooksianus, Harrisia fernowii, Agave albescens,* and *Melocactus acunae.* Diagnostic species group are *Jacquinia, Gochnatia, Cordia, Guettarda, Lantana and Coccothrinax* palms. In the Caribbean xeric shrublands and cactus scrubs are found on the Leeward Islands, Windward Islands, and Cuba.

The biological diversity of Caribbean islands is very spatially compact. It was recently noted (Lugo *et al.*, 2000) that major environmental gradients and vegetation change occur over short distances of less than 100 km. Natural disturbances, such as earthquakes, volcanic eruptions and hurricanes, in combination with human interference such as mining/quarrying, air/water pollution, forest fires, agriculture development, urban sprawl, tourism, introduced animals, and invasive exotics have modified vegetation and the landscape of the Caribbean. Strategies must be developed to prioritize conservation actions to prevent the remaining endemic species habitats becoming severely fragmented.

Freshwater

The Caribbean's freshwater biodiversity is found in a variety of habitats including large lowland rivers, montane rivers and streams, lakes, wetlands and underground karst networks. In addition to being habitats for many important, unique and migratory animals and plants, these freshwater habitats provide clean water, food and many services to local communities. These services are especially important as the small islands of the insular Caribbean are completely surrounded by salt water, and rely greatly on limited, land-based freshwater from functional ecosystems.

Information on the distribution of many Caribbean freshwater species is scarce, distribution is not known for most freshwater taxa, even for fish that are otherwise well studied. 167 freshwater fish species have been identified (Neodat, 2007; Lee *et al.*, 1983; Reis *et al.*, 2003), although there have been a large number of introduced species from aquaculture and aquarium collections. Fifty of these species are endemic to the Caribbean, with the genera Limia and Gambusia being predominant.

Reptiles are represented by several species that are included in the IUCN Red List such as the American and Cuban Crocodiles (*Crocodylus acutus* and *C. rhombifer*) and the Hispaniolan Slider (*Trachemys decorata*). Amphibians are primarily terrestrial in the Caribbean represented by the Genus Eleutherodactylus but some truly aquatic species exist within the Genera *Bufo*, *Hyla* and *Osteopilus* (e.g. *Bufo fluviaticus, B. guentheri, Hyla heilprini, H. vasta* and *Osteopilus dominicensis*) with a tendency to be locally endemic.

Macroinvertebrates are important to Caribbean freshwater biodiversity due to their disproportionate influence on ecosystem functioning. *Macrobrachium* is a widespread genus indicated in the ecological literature as a keystone species in insular Caribbean freshwater environments (Pringle *et al.*, 1993; Ramírez & Pringle 1998; March *et al.*, 2001). At least six species of Macrobrachium shrimp (*M. acanthurus, M. carcinus, M. crenulatum, M. faustinum, M. heterochirus,* and *M. olfersii*) are known to occur in freshwater habitats on Caribbean islands (Holthuis, 1952; Chace & Hobbs, 1969; Hunte, 1976; Covich & McDowell, 1996; Bowles *et al.*, 2000). Widespread freshwater prawns found in the Caribbean belong to the genus *Atya* that has at least three known species (*A. innocuous, A. lanipes,* and *A. scabra*). Aquatic insects have representatives in the taxonomic groups Tricoptera, Ephemeroptera, Diptera and Odonata, with some being included in the IUCN Red List (*Ortholestes clara, O. trinitatis*, and *Phylolestes ethelae*).

The Bahamas Archipelago Ecoregion: The entire region was shaped by sea level changes during the Pleistocene Ice Age, encouraging karst and cave development. The numerous caves and sinkholes in the Bahamas can reach depths of 100 metres, representing the lowest sea level from Pleistocene times. Today, the groundwater on many islands consists of a freshwater lens floating on underlying sea water. Most of these islands contain much shallow water and swamps, some of them connected to freshwater streams. Southern islands lack well-developed groundwater resources, although localized freshwater lenses do occur. Caicos island has the only standing freshwater ponds, of which there are seven. Literature from the eighteenth century report a large lagoon that fragmented as consequence of increased aridity from land clearance (Keegan, 1993).

The inland blue holes found in the Bahamas are a unique type of cave ecosystem, with a layer of freshwater lying above a layer of salt water below. They were created during the ice ages, when sea levels were 400 feet lower and the Bahamas was a great exposed limestone platform. Stalactites and flowstone present within the caves were formed at these times when the caves were dry or above sea-level. Blue holes are particularly abundant in the north of Andros Island, with other concentrations of blue holes occuring on Grand Bahama, Eleuthera and Mayaguana islands. Fauna found in Blue Holes include Typhlatya shrimps, Cyprinodon variegats baconi, Lophogobius cyprinoids and Gambusia hubbi. Isopods of the genus Bahalana are endemic to the Bahamas with five species, originally described from Mount Misery Cave, Little Bay, Mayaguana Island, and later found in Duncan Pond Cave on Acklins Island.

The Cuba Archipelago Ecoregion: includes the island of Cuba, the Isla de la Juventud and 1,600 islets and cays. The island of Cuba is mostly flat land rolling plains with mountain systems, such as the Sierra del Escambray, the western Sierra de los Organos and the rugged easterly Sierra Maestra. Much of the southern coast is low and marshy with wetland ecosystems. Cuba has over 200 rivers as well as small streams that are dry in summer. The country's longest river is the Cauto. The highest point is the Pico Real del Turquino at 2,005 meters in the Sierra Maestra.

The Sierra del Escambray mountain range in south central Cuba is characterized by rivers, waterfalls and caves. Sierra de los Organoscontains many cave systems and underground rivers. Sierra del Rosario mountain range has high pluviometry and many waterfalls. Sierra Maestra is home to the headwaters of the area's most important rivers, including El Cauto, Cautillo, Contramaestre, Bayamo, Guisa and Guamá, forming part of the extensive Cauto basin. In the southern part of the Sierra, are the deltas of Mota and Macio. The Delta of the Cauto River is a biodiversity refuge and is a Ramsar site covering 61,700 hectares with extensive mangroves. It includes the Turquino Nacional Park and the Alejandro de Humboldt National Park. Wetlands can be found throughout Cuba. They harbour a wide diversity of species including ducks, herons, gallinules and rails, many of which are endemic to the island. The southern Zapata Peninsula and its surrounding areas contain extensive wetlands. The Cauto river flows into the Gulf of Guacanayabo in the east of the island. The 48,000 hectares of the Cauto delta with its complex of estuaries and lagoons has been proposed as a Ramsar site. Cienaga de Lanieron the Isle of Youth consists of approximately 88,000 hectares of wetlands. The area also includes other habitats including semi-deciduous forest, freshwater coastal lagoons, mangroves, swamp grasses and small rivers. Humedal Río Máximo-Cagüey is an extremely fragile marine-coastal ecosystem undergoing salinization. Located at the mouth of the rivers Máximo and Cagüey, with a number of keys in the shallow waters, this area is the largest nesting site for flamingos in the Caribbean and is also a refuge for other migratory birds from across the Americas. Large populations of American crocodile and Caribbean manatee, both vulnerable species, inhabit the Humedal Río Máximo-Cagüey.

The Jamaican Ecoregion: The island is made up of coastal lowlands, a limestone plateau, and several mountain ranges; the Blue Mountains, a group of volcanic hills, in the east, the Central Range in the north and the Port Royal Mountains that rise above the Liguanea Plain just north of Kingston. The highest point is Blue Mountain Peak, at an elevation of over 2,255 meters. The John Crow Mountains are the largest limestone range in the country. The mountains create a network of 160 rivers and waterfalls. The eastern face of the Blue Mountains receives more than 300 inches of rain each year, providing water for nearly half of Jamaica's population. The largest river on the island is the Black River. Other significant rivers include the Rio Cobre, the White River, the Rio Grande, and the Lethe.

The limestone substrate accounts for the great number of caves found in Jamaica. Karst habitat is found near the Cockpit Country which is a rugged area of inland Jamaica that has been proposed as a World Heritage Site. It includes the upper parts of three important watersheds of the Great River, Black River and Martha Brae, and is next to the Montego River and St. Ann watersheds, recharging aquifers in St Elizabeth, St. James and Trelawny. The porous nature of karst landscapes means that relatively little exploitable surface water runoff is present. Karst springs well-up from the limestone aquifer in the northern, lower elevation areas. Drainage is mostly vertical and feeds underground rivers more than 100m below ground level. These rivers may re-emerge more than 8 km from their source. Small rivers can emerge from blue holes and run short distances before disappearing underground, but generally the areas are dry or, in the case of low elevation regions, contain ponds only during the wet season. The limestone aquifer, however, has the capacity to contribute over 40% of the island's exploitable ground water. Negril Great morass is the second largest stand of freshwater wetlands in Jamaica. This forest covers an area of 6,000 hectares, and acts as a filter of freshwater from the Fish River Hills to the east, flowing into the Negril marine park in the West.

The Black River Lower Morass is a diverse set of habitats, where five rivers meet, including wetlands, mangroves, and marshland containing the largest crocodile population in Jamaica and birds such as egrets, herons, ducks and the blue-winged teal, and savannas with plants such as butterfly ginger, bull thatch, saw grass, water hyacinths and pancake lilies. Portland Bight is a body of water between the Hellshire Hills to the west of Kingston and Portland Ridge. The Portland Bight Protected Area is rich in wildlife with the dry limestone forests of Hellshire, Portland Ridge and Braziletto Mountain, and the largest almost continuous mangrove stands remaining in Jamaica. The wetlands support many waterfowl and crocodile, which, together with the extensive sea-grass beds in the waters of the Bight provide probably the largest nursery area for fish, crustaceans and molluscs on the island. This supports 4,000 of Jamaica's 16,000 fishers and their families.

The Hispaniola Island Ecoregion: Hispaniola, the second largest island in the Greater Antiles, is formed from continental rock and and has five major mountain ranges, the Cordillera Central, the Cordillera Septentrional, Cordillera Septentrional, Cordillera Oriental, and the Sierra de Neiba. Pico Duarte in the Cordillera Central is the highest peak in the Antilles at 3,087meters and Pic de la Selle in the southern range is the highest point in Haiti, at 2,680 meters.

The Dominican Republic has seven major drainage basins. Five of these rise in the Cordillera Central and a sixth, in the Sierra de Yamasá. The seventh flows into Lago Enriquillo from the Sierra de Neiba to the north and from the Sierra de Baoruco to the south. The Yaque del Norte is the most significant river in the country at 96 km long, with a basin area of 7,044 square kilometres. Its headwaters are near Pico Duarte at 2,580 meters and it flows into the Bahía de Monte Cristi on the northwest coast, where it forms a delta. The Yaque del Sur is the most important river on the southern coast. The headwaters are at an altitude of 2,707 meters in the southern slopes of the Cordillera Central. Three quarters of its 183 km length is through the mountains, and has a basin area of 4,972 square kilometers. The river forms a delta near its mouth in the Bahía de Neiba. The Artibonite river flows from the western Dominican Republic across central Haiti to the Caribbean Sea. The watershed of 9,530 square kilometres is critical to the sustained development of the

Western San Juan valley and border area within the Dominican Republic, and is the prime source of water for the Peligre Dam, whose irrigation, domestic water, and hydro-electric services are essential to the economic development and food security of Haiti.

The Lago Enriquillo lies in the western part of the Hoya de Enriquillo. Its drainage basin includes ten minor river systems and covers an area of over 3,000 square kilometers. The northern rivers of the system rise in the Sierra de Neiba and are perennial, while the southern rivers rise in the Sierra de Baoruco but only flow after heavy rainfall. Most of the wetlands are found in the north-central part of the island; Laguna Limón, Laguna Redonda and floodplains of the Río Yuna and Río Barracote and also in the southeast; Lago Enriquillo, Laguna Limón, Laguna Cabral, Laguna de Oviedo and Laguna Salada.

The Puerto Rico Island Ecoregion: The Freshwater System in Puerto Rico is composed of surface running water, ground water, wetlands, coastal lagoons, a few natural ponds and geothermal springs. There are also artificial reservoirs, channels for agricultural irrigation and cattle ponds. Most of the wetlands are in the lower watersheds and the one lake, Cartagena, suffers from high sedimentation rates. All headwaters are below 1,350 meters elevation. Despite low elevations, Puerto Rico has a highly diversified and complex aquatic ecological system. As usual for the Caribbean, stream flows in Puerto Rico vary widely because the rainfall pattern is influenced by windward / leeward orographic effects, as well as the impact of seasonal storms and hurricanes.

There are 17 major watersheds on the island with chemical composition of stream water reflecting the island's geology (Bogart *et al.*, 1964). These are divided into 33 watersheds and sub-watersheds. The largest by drainage area are: Grande de Loiza, La Plata, Grande de Arecibo, Grande de Añasco, Caliza de Arecibo, Guayanilla and Guajataca. The watersheds were grouped based on a potential historical connectivity, common geology, physiographic and climatic characteristics. In the Northeast there is a complex of small watersheds where the Loiza is the only relatively large river. Topography in the south is flat and the climate is drier than the rest of the island. Its watersheds are very small, with low flow rate and drainage density but are subject to flash flooding. Rivers in this part of the island include: Guamani, Seco, Salinas, Coamo, Jacaguas, Tallaboa, Guayanilla, and Yauco. There is also a large wetland system, which has been impacted by intensive agriculture and irrigation channels. Water temperature has no significant variation, ranging from 70°F to 90°F, in contrast to islands such as Hispaniola and Cuba and is a consequence of the island's low elevation. There is turbidity due to sedimentation because of steep topography, heavy rainfall and erodable soils. Turbidity has also been accentuated by human activities, such as urban development and agriculture. The west of the island has few relatively large watersheds with a high precipitation rate. Although climatic conditions are similar to the northeast, the drainage density is not and catchments surface is larger in the main rivers including Grande de Añasco, Guanajibo and Culebrinas. In the northwest, there is a karstic system with low drainage density and few large rivers. Many of the rivers run underground, hindering efforts to accurately map their distribution. They include the Guajataca, Camuy, Grande de Arecibo, Grande de Manatí, Cibuco, La Plata, and Bayamón.

Lesser Antilles Complex Ecoregion: The Lesser Antilles are a chain of islands from the Virgin Islands in the North to Grenada in the south. As small islands, many areas do not have representatives of freshwater biodiversity.

The Guadeloupe Archipelago consists of five islands including St Barthelemy and St Martin. The Soufriere Mountain is the highest point in the Lesser Antilles at 1,484meters and is located in the Parc National de la Guadeloupe on Basse-Terre. There are two main rivers, the Bras-David and Corossol. *Dominica* is mostly covered by rainforest and has many waterfalls, springs and rivers including the Layou, L'Or, Macoucherie, White river and Indian river. Cabrits National Park contains tropical forest and the largest wetland of the island. Morne Trois Pitons contains several crater lakes and waterfalls. The highest point is Morne Diablotin at 1,438m. *Martinique* is mountainous with three principal volcanoes; Mount

Pelée which is an active volcano of 1,397metres, Lacroix Peak at 1188 meters and Mount Vauclin at 501 meters. The relief of the island has led to a complex drainage pattern, characterized by short watercourses, with some mangroves and estuaries. In the south, the Salée and the Pilote rivers flow from Mount Vauclin. In the center, the rivers flow outwards from the Carbet Mountains, including the Lorrain, Galion, Capot, and Lézarde rivers. In the north, the Grande River, the Céron, the Roxelane, the Pères, and the Sèche irregular torrents. *St Lucia* is the most mountainous Caribbean island, with the highest peak being Mount Gimie, at 950 meters. Rivers include the Rosseau, Cul de Sac and Troumasse. *St. Vincent* is a rugged volcanic island. La Soufriere is the highest peak at 1178 meters, and dominates the northern third of the island. Very little of the island is flat, the Central and Southern sections of the island fall sharply from the 300 to 600 meter mountains to the sea. *Grenada* is a rolling, mountainous and volcano island with several small rivers and waterfalls, rainforests including Mount St. Catherine at 835 meters, a wetland system and the volcanic lakes of Levera Pond and Antoine Lake.

The diverse marine, terrestrial and freshwater habitats and species of the region are closely linked to the local human communities. Human well being relies upon diverse ecosystem services, such as buffering coastal communities from the effects of storms, freshwater, growing and harvesting food, providing a basis for recreational and tourism industries in addition to providing habitat for commercial species.

VULNERABILITY AND THREATS

Heightening human pressures in the region are thought to be putting the biodiversity of the region under unprecedented stress. Activities include cruise ship tourism, terrestrial and marine tourism and their associated infrastructures, hydropower dams and reservoirs, canalization, freshwater withdrawals, road building, agriculture, over-fishing, introduction of alien species, sand and bedrock mining, discharge of untreated sewage and industrial waters, intensive agrochemicals use, aquaculture, overharvesting, population growth, urban sprawl and resource extraction. These activities can lead to changes in ecological systems such as habitat fragmentation, degradation and loss, invasive species, hyrdrological regime change, degraded water quality, pollutant release, sedimentation, ecosystem service degradation and the resulting effects on local human communities. The cumulative impacts of all these influences on biodiversity are largely unknown.

The complex mix of political and social factors exacerbates these problems and results in the Caribbean being one of the world's most threatened places. The strategies necessary to balance sustaining the livelihoods of people and the growth of economies with the need to reduce threats and protect remaining biodiversity are complex and interrelated. Deciding how and where to act in the face of multiple, imminent threats is an increasing challenge. It is hoped the data on many of these threats in addition to conservation targets and tools contained within the Caribbean decision support system (Appendix H) will greatly facilitate actions to meet these challenges.

Annex II

J.B.R. Agard and A. Cropper, "Caribbean Sea Ecosystem Assessment (CARSEA), A contribution to the Millennium Ecosystem Assessment", prepared by the Caribbean Sea Ecosystem Assessment Team, Caribbean Marine Studies, Special Edition, 2007
(extract: pages xiv-xix, 1-17 and 21-31)

The complete document is available at: www.cbd.int/doc

Executive Summary

Introduction — the Argument in Brief

The peoples of the Caribbean are defined by the Sea whose shores they inhabit. In the rich diversity of cultures and nations making up the region, the one uniting factor is the marine ecosystem on which each ultimately depends.

If that ecosystem is under threat, so are the livelihoods of millions of people. The economic activity of the Caribbean is based to a very great extent on the bounty of the Sea and the natural beauty which attracts visitors from around the world which, in turn, require the healthy functioning of complex physical and biological processes. The coral reefs and the seagrass beds, the white-sand beaches and the fish shoals of the open ocean: these are natural capital assets whose loss or degradation has huge implications for the development of the region.

Apart from the economic importance of the ecosystem, it shapes the lives of all the inhabitants of the Caribbean in ways which defy statistical analysis. The Sea and its coasts form the stage on which the cultural, spiritual, and recreational life of the region is played out.

It may be united by its sea, but the Caribbean region is divided by its history. Five hundred years of settlement by Europeans, Africans, Asians, and people from other parts of the Americas has bequeathed to the region a patchwork of independent states and numerous colonies administered by governments in a different hemisphere. This presents unique challenges to the establishment of the co-operative policies needed to manage this ecosystem for the common good, and to achieve the most secure long-term future for the Caribbean peoples.

The situation is made even more complex by the influence on the Caribbean Sea ecosystem of decisions in parts of the world with no direct territorial link to the region: from the use of the waters for fishing by Asian fleets and by international shipping, including the transport of nuclear waste en route to the Panama Canal and oil shipments from the Middle East to refineries in the Gulf of Mexico; to the pollution and sediments carried by rivers from deep inside the South American continent; and even the energy choices of societies throughout the world which have major implications for the Caribbean Sea through the pace of global warming.

All of these factors combine to create an urgent need for a new overview of the state of the Caribbean Sea; an analysis of the forces driving change and the implications for the well-being of the Caribbean peoples; and a review of the options available to policy-makers in the region and beyond. This Caribbean Sea Ecosystem Assessment (CARSEA) attempts to fulfil that need.

In common with the practice of the Millennium Ecosystem Assessment (MA) of which it is a part, CARSEA first sets out a detailed picture of the condition and trends of the ecosystem; it then develops a number of scenarios aiming to simulate the likely outcome of different plausible future paths for the region; and finally it reviews the responses available to decision-makers.

The main points of the assessment will be summarized in the following pages. More detailed analysis and references to the sources on which it is based are available in the body of the document.

Three key messages can be highlighted at the outset. First, some of the vital services which human communities derive from the Caribbean Sea ecosystem are being placed in jeopardy, often by the very activities and industries whose long-term future depends on the continuing provision of those services.

Second, a reduction in the stresses being placed on the natural functions of the Caribbean Sea will require new ways of working together amongst the disparate political authorities making up the region.

Finally, the combination of dependence on the integrity of its marine ecosystem and vulnerability to global forces beyond its control puts the Caribbean in a special position which merits recognition and concrete action by the international community.

The Sea and its People

The semi-enclosed Caribbean Large Marine Ecosystem (CLME) is a distinct ecological region, bounded to the North by the Bahamas and the Florida Keys, to the East by the Windward Islands, to the South by the South American continent, and to the West by the isthmus of Central America. Covering an area of more than 2.5 million square kilometres, it is the second largest sea in the world. For the purposes of this assessment, the Caribbean is taken as these waters, the islands within the Sea and bordering it, and the river basins of continental territories draining into the Sea.

The Caribbean, home to more than 116 million people,[1] is divided among 22 independent states, of which 9 are continental countries of South and Central America, and the remainder islands and archipelagos. In addition, four colonial authorities—the United States (U.S.), the United Kingdom (U.K.), France, and the Netherlands—still exercise political control over 17 island territories in the region.

The complex political structure, produced by the historic struggles for control of the resources of the Caribbean, and reflecting a wide cultural diversity arising from that history, has left the region with a series of overlapping regional authorities exercising varying degrees of policy co-ordination over parts of the Sea. This creates a significant problem in the exercise of a holistic approach to the management of the Caribbean Sea ecosystem.

What unites the people inhabiting this region is a common dependence on two particular products of the marine ecosystem, known in the terminology of the MA as ecosystem services. Because of the dominant role of fishing and tourism in the Caribbean economy, this assessment concentrates mainly on the implications for these two services of current trends and future options.

Why Fishing and Tourism?

A few facts and figures help to justify the choice of these two services.

New data provided for this assessment confirm that relative to its size, the island population of the Caribbean is more dependent on income from tourism than that of any other part of the world. In 2004, more than 2.4 million people were employed either directly or indirectly in travel and tourism, accounting for 15.5% of total employment, a proportion nearly twice as high as the global average. The sector contributed U.S. $28.4 billion to the Gross Domestic Product (GDP), 13% of the total, and U.S. $19 billion or 16% of exported services and merchandise. Over one-fifth (21.7%) of all capital investment was linked to tourism, well over twice the global average.

Twenty-five million tourists choose to holiday in the Caribbean each year, in large part in pursuit of a dream of sensuous relaxation shaped by its natural features—palm-fringed beaches, blue-green lagoons with crystal-clear water, opportunities to see multi-coloured fish swimming amongst coral reefs. Dependence on tourism, therefore, also implies dependence on the capacity of nature to continue providing the conditions which make the Caribbean such a popular destination. In cases such as the diving industry, this connection is so close that degradation of ecosystem quality can be measured directly in lost income.

Fishing is also a significant provider of jobs and income in the Caribbean. It is estimated that more than 200,000 people in the region are directly employed, either full-time or part-time, as fishers. In addition, some 100,000 work in processing and marketing of fish, with additional job opportunities in net-making, boat-building, and other supporting industries. Assuming each person employed has five dependents, more than 1.5 million people in the Caribbean rely for their livelihood on commercial fishing. The activity also brings in approximately U.S. $1.2 billion annually in export earnings, with the U.S. the principal destination.

However, the true importance of fishing is not fully reflected in these figures. In a region where most of the population has access to the Sea, fish provide a vital resource for poor communities in ways which do not always appear on the national accounts. It is estimated, for example, that fish products account for on average 7% of the protein consumed by people in the Caribbean region. Anything which damages the productivity of the marine food chain is therefore a significant threat both to the health and to the wealth of these societies.

State of the Ecosystem — Signs of Trouble

Damaged infrastructure

The functioning of the Caribbean Sea ecosystem and the delivery of its services are heavily reliant on the condition of four interdependent coastal formations: beaches, coral reefs, mangroves, and seagrass beds. The white-sand beaches beloved of tourists are formed partly from the fragments of coral skeleton; the coral reefs themselves are both a rich source of food and a magnet for visitors; seagrass beds act as nurseries for many species of fish and shellfish; and mangroves help to provide nutrients for a range of marine life, shield coastal communities from the full force of wind and waves, purify wastes from land-based sources that enter the coastal zone, and attract eco-tourists to their vibrant wildlife.

Each of these formations is showing signs of significant damage as a result of human activities, with serious implications for the future capacity of the ecosystem to provide income from tourism and fishing. The best documented example is for corals: recent studies suggest that some 80% of living coral in the reefs of the Caribbean

[1] Defined as those living within 100 km of the Caribbean coast.

has been lost in the past 20 years. This unprecedented rate of degradation has seen some reefs change from 50% cover with live coral organisms, to just 10%. It has been estimated that the continued decline of coral reefs could cost the region between U.S. $350 million and U.S. $870 million per year by 2050.

A number of factors, each interacting with the other, are causing the degradation of coral reefs. They include increased sedimentation from rivers discharging into the Caribbean; excess nutrients due to pollution from farmland runoff and sewage, including from cruise ships; overfishing; diseases affecting creatures such as sea fans and sea urchins critical to the ecological balance of the reef; physical damage through dynamiting and dredging; and "bleaching" of corals, in which rising sea temperatures upset the symbiotic balance between coral polyps and the algae on which they feed.

The decline of coral reefs has reduced their ability to act as a protective barrier, and this may be one reason for increased levels of beach erosion. It has recently been estimated that 70% of Caribbean beaches are eroding at rates of between 0.25 and 9 metres per year. The cost of artificially replacing this sand, in a process known as beach nourishment, can run into millions of dollars.

Seagrass beds and mangrove forests have each seen widespread declines through direct removal to make way for various types of coastal development: seagrass is often cleared to "improve" bathing beaches, while mangroves have made way for commercial and housing construction, and for shrimp-farming ponds.

Fish stocks under pressure

In common with ocean regions across the world, the Caribbean has seen dramatic change over the past 30 years in the efficiency and intensity with which fish stocks have been targeted. Greatly increased demand, combined with the use of new types of catching gear, have helped to exert unprecedented pressure on this key resource of the ecosystem.

A number of factors set the Caribbean apart and present particular problems in protecting fish stocks for future generations. One is the sheer variety of fish and invertebrates involved in commercial fishing. It has been estimated that 680 species of bony fish, including 49 types of shark, are targeted in the region. This makes it extremely difficult to monitor the state of particular stocks, and to manage them sustainably. For example, of the 197 fish stocks falling under the jurisdiction of the Caribbean Fisheries Management Council (CFMC), the status of 175 (88%) was unknown or undefined.

Another problem arises from the lack of a unified political authority with responsibility for the resources of the Caribbean. Fish are no respecters of national boundaries, and the failure to regulate adequately those stocks shared by different states has led to damaging disputes between Caribbean countries in competition for shared resources. In addition, existing arrangements enable fishing fleets from throughout the world to engage in a "free for all," placing added pressure on the marine life of the Sea. It is the tragedy of the commons.

Lack of reliable data makes it difficult to give a complete picture of the condition of this particular service of the Caribbean Sea ecosystem. Some trends, however, give cause for concern. All the major commercially important species and groups of species in the region are reported to be fully developed or over-exploited. In the case of one valuable stock, the conch, the pressure has been serious enough to put it on the list of threatened species held by the Convention on International Trade in Endangered Species (CITES).

New analysis of historical trends carried out for this assessment suggests that fish landings in the Caribbean rose to unprecedented levels during the 1990s, reaching a peak of nearly 500,000 tonnes in 1998, but subsequently went into sharp decline.

The reasons for variations in the size of catches are complex, involving both human and environmental factors, but some indicators do point to the impacts of overfishing. A recent study of fishing data for four of the Windward Islands, for example, found that while overall catches increased in the period from 1980 to 1999, the increase in the effort used to catch those fish was very much greater. The ratio of fish caught for each "unit of effort" is estimated to have declined by up to 70% over these two decades, an indication that fish are becoming more difficult to find.

There are also signs that Caribbean fish stocks are suffering from the phenomenon known as "fishing down the food web," in which longer-lived, predatory fish become more scarce, and stocks become dominated by shorter-lived, plankton-eating species. This reduction in the average trophic level, as it is termed, may not affect catches in the short term, but signals long-term trouble for the ecosystem.

Drivers of Change

It is a central part of the assessment of any ecosystem to identify the key factors leading to changes which can affect the services provided by the natural systems of a region or locality. Known as drivers, these can either be direct (such as pollution) or indirect (such as population increase leading to pollution); they can be local drivers (such as habitat destruction) or external ones (such as global climate change).

By analysing these drivers, it becomes possible to understand better the full consequences of particular policies or activities on the well-being of our societies, and to suggest the type and scale of changes which may be required to reduce the stress on ecosystems.

It is important to note that ecosystem change is often the result of two or more of these factors working together—for example, a healthy coral reef may be able to withstand the introduction of a disease organism, but that same disease could have a devastating impact on another reef already weakened by the effects of nutrient pollution or overfishing.

The main drivers affecting the Caribbean Sea are set out in Table 3.1. Here are some of the key examples in each category:

Local, direct

Changes in coastal land and sea use in the Caribbean have been the single greatest cause of ecosystem damage. Flat land along the coastline and reclaimed from the Sea has been used for industry and commerce, and in a wide range of tourism developments such as hotels, apartments, and golf courses. The consequence has been severe depletion of habitats such as seagrass beds and mangroves, damage to coral reefs, and the destabilization of beaches.

Sewage pollution from land sources and from cruise ships has been the most pervasive form of contamination of the coastal environment. Apart from affecting bathing beaches and thereby the tourism potential for particular areas, the elevated nutrient levels from such pollution can overstimulate the growth of algae, causing fish kills and coral damage.

Overfishing through the increasingly widespread use of certain types of gear is putting unprecedented strain on the fish stocks of the Caribbean.

Local, indirect

Urbanization of coastal communities has been the major factor underlying the direct pressures on the Caribbean Sea ecosystem.

High tourism dependency has led to a massive amount of capital investment in coastal infrastructure, which has, in turn, damaged the capacity of the ecosystem to provide services to the region.

Lack of co-ordinated governance in the region has led to a competitive rather than co-operative approach to issues such as fish stocks and tourism management, to the detriment of the ecosystem.

External, direct

Global climate change can potentially have a profound impact on the Caribbean Sea ecosystem. Increased intensity and frequency of tropical storms have devastated the tourism industry of some islands, and the overall scale of destruction has been exacerbated due to the increased population along the coasts. Rising sea temperatures, meanwhile, have increased the incidence of coral "bleaching."

River discharge from the Magdalena, Orinoco, and Amazon basins can cause significant damage to the marine environment of the Caribbean, through an excess of sediments or contamination resulting from deforestation or pollution in distant regions.

Alien species introductions are thought to have caused ecological damage when marine creatures were carried in the ballast tanks of ships, and even dust particles from the Sahara Desert are implicated in spreading disease organisms to Caribbean reef species.

External, indirect

International shipping rules under the United Nations Convention on the Law of the Sea (UNCLOS) grant foreign vessels the right of "innocent passage" through Caribbean waters, exposing the ecosystem to extra pressures of pollution, overfishing, and even the risk of radioactive contamination from shipments of nuclear material.

The combined impact of these drivers is that the poorest economies and communities of the Caribbean are prone to suffer the consequences of changes to the marine ecosystem, while enjoying few of the benefits that accrue from exploitation of its resources. For example: the least-developed countries and territories are especially vulnerable to the damage caused by more destructive storms; small-scale fishing communities are unable to compete fairly with better-equipped fleets for scarce stocks; local people are sometimes prevented from enjoying coastal resources as space is taken up by "enclave tourism" and other uses benefiting more prosperous sections of society; and lack of co-ordinated governance prevents more of the profits from tourism from being returned to local economies.

Scenarios

As part of the development of this assessment, four scenarios illustrating possible futures for the Caribbean region up to 2050 were drawn up and analysed. These are not intended as predictions of what will happen, but rather as tools to assess the consequences of certain plausible alternative pathways. Using our knowledge about the drivers of ecosystem change, scenarios can help to map out potential prospects for services such as tourism and fishing, depending on the values and priorities exercised by people inside and outside the Caribbean region in the coming decades.

The "storylines" and outcomes of the scenarios are shown in Chapter 5 of this report.

A challenging general message emerges from these scenarios. They suggest that in the short and medium term, there may be little difference in terms of tangible costs and benefits to the population, between approaches which favour greater environmental care and regional co-operation, and those which prioritize unrestricted development and the dominance of international market forces in the Caribbean.

The outcomes only begin to diverge towards the middle part of this century, when continued neglect of ecosystems could start to create such degraded environments that the Caribbean would lose its appeal for many tourists, and fish stocks might start to collapse. It is at this point that alternative scenarios start to reap benefits, for example, where a more controlled approach to "niche" tourism (in the scenario *Quality over Quantity*) has produced a sustainable, higher-value industry less susceptible to sudden shocks or surprises.

The challenge for policy-makers is that to avoid serious negative consequences for the future, decisions, whose benefits may only be realized well beyond the normal time-cycles of politics, will need to be taken now.

In other words, the changes required to secure a better long-term future for the Caribbean will require courage and vision. The good news is that these changes will incur no significant costs, and even in the short term will enhance the quality of life of many in the region.

The Policy Response — Options for Change

In 2006, the United Nations General Assembly passed the final of a series of resolutions recognizing the importance, uniqueness, and vulnerability of the Caribbean Sea, and stressing the need to take an integrated approach to its management. The interest of the Association of Caribbean States (ACS) is to achieve an additional resolution which would declare the Sea a "special zone" in the context of sustainable development.

It is not part of the remit of this assessment to take a position on whether such a resolution is justified or necessary, although the information contained within CARSEA should help to inform the debate on this issue. It is important that the campaign over many years to achieve this status for the Caribbean should be seen as a means to an end, not an end in itself. This assessment has found very little evidence of action to implement the integrated management of the sea mentioned in the existing resolutions.

There has been no shortage of programmes and ad hoc initiatives aimed at addressing particular problems afflicting the marine environment of the Caribbean (for a summary of these programmes, see Annex 3b). Some have had impressive results and can serve as models for future action.

However, these initiatives have been set up and operated by different governments, inter-governmental groups, and nongovernmental organizations, with little or no co-ordination between them. They are also frequently directed at a specific sector or activity, and lack an overview of the ways in which programmes may conflict with one another, or produce better results with greater collaboration. As this assessment has shown, the interconnected nature of the ecosystem services of the Caribbean Sea, and of the threats they face, require a much broader outlook.

Among the priorities for improvement of policy must be a better system of managing fisheries in the region, recognizing the value of the Sea as a complete ecosystem rather than a series of interlocking national territories; and capturing more of the value of tourism in the region, to be reinvested in measures to protect the natural beauty and diverse cultures without which there would be no tourists.

To address the shortcomings of current management of the Caribbean Sea ecosystem, strong arguments have emerged during the CARSEA process for a new technical commission or council, with responsibility for the entire region (i.e., the Wider Caribbean) to be set up. Its precise title, status, and remit are matters for open debate, but some of its essential functions would be:

- To monitor and assess the condition of the Caribbean Sea as an ecosystem, and to use that information to inform policy in the region.
- To assess the effectiveness of existing programmes at all levels, and to offer advice as to how they may be improved and better co-ordinated.

- To initiate studies on specific policy options available to decision-makers in the region, for example, economic policy instruments to enhance the protection of ecosystem functions.
- To act as a catalyst to achieve better co-ordination between the disparate institutions whose decisions affect the Caribbean Sea, and to promote greater co-operation with states outside the region, whose activities have an impact on its ecosystem.
- To provide continuing analysis of the impacts of policies and programmes, so that the correct lessons can be fed back into better design of future measures.

To avoid adding to the complexity of the existing governance of the Caribbean, it is not suggested that this body should be a new institution, but rather that it should reside within one or other of the existing inter-governmental groups. It is to be note that the ACS has responded to this idea by setting up a Follow-up Commission for its Caribbean Sea Initiative.

Its nature requires that it be advisory rather than executive, and for the commission to address the problems facing the Caribbean Sea and its peoples, decision-makers must be prepared to value and act on its advice — or, if they ignore it, to be accountable to the citizens whom they represent.

Better information and more co-ordinated institutions are an essential first step to a brighter future for the region. Ultimately, however, it will be up to those in positions of responsibility in the Caribbean and beyond to use that information and those institutions to ensure that the natural wealth of this unique Sea is passed on to future generations.

Caribbean Sea Ecosystem Assessment (CARSEA)

A contribution to the Millennium Ecosystem Assessment
prepared by the Caribbean Sea Ecosystem Assessment Team

1.0 INTRODUCTION

1.1 Rationale

The Caribbean Large Marine Ecosystem (CLME) is the second largest sea in the world, covering an area of approximately 2,515,900 km^2 (NOAA 2003), and comprising some of the territorial waters and coastal areas of 39 bordering countries and territories.[2] The well-being of the 116 million people living within 100 km of the sea (Burke and Maidens 2004) is highly dependent on the services it provides as an ecosystem. Critical among these is the unique character of its coastlines and open waters, making it a desirable place to live and to visit: in the terminology of the Millennium Ecosystem Assessment (MA, www.maweb.org), this desirability translates into a range of cultural services based on the recreational and aesthetic value of the land and seascape. The economies of the Caribbean islands are especially dependent on these functions of the marine environment that support tourism. Another key ecosystem service linked to well-being in the region is the availability of fish and marine invertebrates, a provisioning service within the MA definitions.

The Caribbean Sea has also been critically assessed and ranked by expert consensus as having the highest priority for conservation of any marine eco-region in the whole of Latin America and the Caribbean (Sullivan Sealey and Bustamante 1999). The two ecologically distinct small island groups of the region, the Bahamian and the Lesser Antilles, each have very high percentages of endemic species,[3] many of which are endangered. Also the Caribbean islands as a whole have been classified as a biodiversity hot spot, meriting global priority for conservation purposes (Myers et al. 2000).[4] Although this classification reflects the diversity and vulnerability of land-based flora and fauna, the many interactions between marine life and island habitats make it highly relevant to the global importance of the Caribbean Sea ecosystem.

However, the management of the Caribbean Sea is characterized by uncoordinated efforts without any holistic integrated management plan. This fragmentation involves not only the 22 independent countries in the region, including 9 from mainland South and Central America, but also 17 territories administered by colonial authorities from North America and Europe—the United States of America (U.S.A.), France, the United Kingdom (U.K.), and the Netherlands (see Box 1.1). The Caribbean Sea is also used and impacted by many states and their economic interests which lie outside the geographical boundaries of the Sea (for example, Japan, Korea, France, U.K., and the U.S.A.).

At present, there appears to be a mismatch between the managerial capabilities of authorities in the region, and the scale of important problems related to overfishing, pollution, and unsustainable tourism. Management is organized primarily at the level of individual countries or political blocs, while what is required is to deal with marine environmental problems at the scale of the entire ecosystem. This disjuncture suggests the need for broader, more inclusive, and better co-ordinated managerial arrangements.

The Caribbean Sea Ecosystem Assessment (CARSEA) attempts to deal with the multiplicity of issues associated

[2]A precise definition of what is meant by the Caribbean is set out in Section 1.2.
[3]Species which occur no where else in the world.

[4]The Caribbean Islands meet the criteria of a hot spot because they have less than 30% remaining of primary vegetation (the Caribbean figure is 11.3%) and contain, as endemics, at least 0.5%, i.e., 1,500 of the world's known vascular plant species (the Caribbean figure is 2.3%). The number of endemic vertebrate species, 779, accounts for 2.9% of the world's total. Myers et al. ranked the Caribbean as the fifth 'hottest' hot spot according to various criteria, after Madagascar, Phillippines, Sundaland, and Brazil's Atlantic Forest.

Box 1.1: Countries and Territories Bordering the Caribbean Sea

Anguilla (U.K.)	*Montserrat (U.K.)*
Antigua and Barbuda	*Martinique (France)*[5]
Aruba (Netherlands)	Panama*
Bahamas	*Puerto Rico (U.S.A.)*
Barbados	Mexico*
Belize*	*Netherland Antilles (Neth.): Curaçao, Bonaire, St. Maarten, St. Eustatius, Saba*
British Virgin Islands (U.K.)	
Cayman Islands (U.K.)	
Colombia*	Nicaragua*
Costa Rica*	*St. Barthélemy (France)*†
Cuba	St. Kitts/Nevis
Dominica	St. Lucia
Dominican Republic	*St. Martin (France)*
Grenada	St. Vincent and the Grenadines
Guadeloupe (France)	Trinidad and Tobago
Guatemala*	*Turks and Caicos (U.K.)*
Haiti	*U.S. Virgin Islands (U.S.A.)*
Honduras*	Venezuela*
Jamaica	

NOTE: Overseas/dependent territories are shown in italics, with their metropolitan countries in parentheses.
*Continental states bordering the Caribbean Sea.
† Recognized as a territory of France on February 22, 2007.

with effective protection and management of a Sea shared among so many individual states, political systems, economies, languages, and cultures.

1.2 Definition of the Caribbean Sea

The geographic focus of the assessment is the area known as the CLME and the countries and territories bordering this marine expanse (Fig 1.1), an area which will subsequently be referred to as the Wider Caribbean. However, it should be noted that a larger region, known as the Greater Caribbean, has been recognized in international agreements including the 1994 Convention, which set up the Association of Caribbean States (ACS). The scientific rationale behind the 'Greater Caribbean' definition is that the oceanography of the southern Caribbean is strongly influenced by the outflow of two of the world's largest river systems (the Amazon and the Orinoco), and that the Caribbean in turn has a great influence on the "downstream" Gulf of Mexico—so the Gulf and the Guianan region of the Atlantic Ocean are included.

From a geographical and political perspective, several overlapping groupings of countries in the region present a confusing framework for the governance of the Caribbean Sea:

- The Caribbean Community (CARICOM) grouping of Antigua and Barbuda, Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St. Kitts/Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago;
- The Organization of Eastern Caribbean States (OECS) grouping of six eastern Caribbean Islands: Antigua and Barbuda, Dominica, Grenada, St. Kitts/Nevis, St. Lucia, and St. Vincent;
- The ACS grouping (also called the Greater Caribbean or Caribbean Basin), including all the island and mainland states in the CARSEA definition, plus El Salvador, Guyana, Suriname, and French Guiana.

1.3 Framework for the Caribbean Sea Ecosystem Assessment

The Caribbean Sea Ecosystem Assessment is an approved project of the Millennium Ecosystem Assessment. In addition to the global assessment carried out between 2001 and 2005, the MA supported a number of sub-global studies applying the same conceptual framework to ecosystems and human communities at various lower scales, ranging from small localities to major world regions. This is one of those sub-global assessments.

The four-year international work programme of the MA, launched by the then UN Secretary-General Kofi Annan in 2001, was designed to meet the needs of decision-makers for scientific information on the links between ecosystem services and human well-being. It was a response to the recognition that people depend on ecosystems not only for providing basic needs (*provisioning services*) such as food, fresh water, and timber, but also for essential *regulating services* such as purification of air, filtration of water pollutants, and protection from extreme events such as storms and tidal surges. *Supporting services*, including soil formation, pollination, and nutrient cycling, provide indirect benefits to people by creating the conditions

[5]Martinique is a department of France.

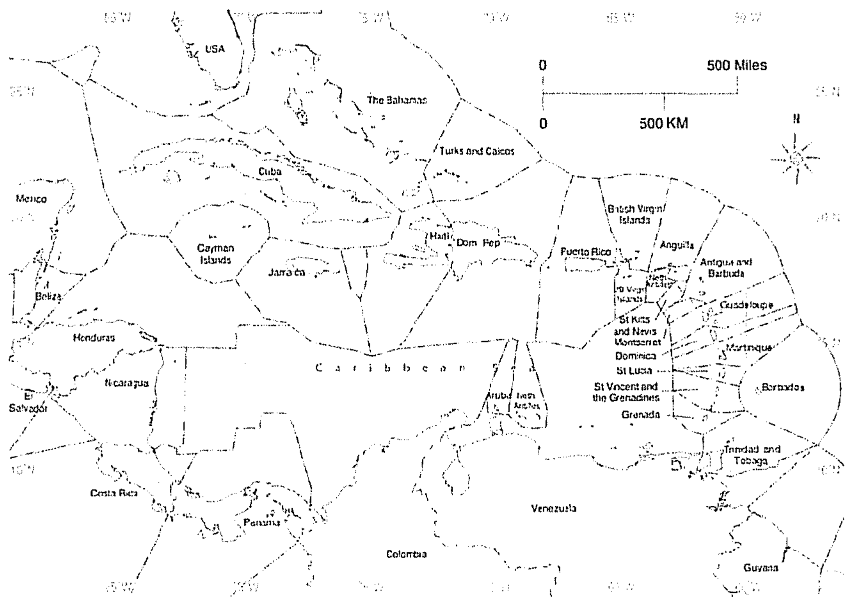


FIG. 1.1. The Caribbean Large Marine Ecosystem (yellow line) with hypothetical Exclusive Economic Zone (broken line) boundaries.[8]
SOURCE: The Nature Conservancy (TNC; pers. commun. 2005).

necessary for other services to function. In addition, ecosystems provide less tangible *cultural services* such as recreational, aesthetic, and spiritual values, which are nevertheless highly valued by human societies, and which can generate very significant financial returns, as in the case of tourism (Fig. 1.2).

According to the MA conceptual framework (MA 2003), human well-being includes the *basic material for a good life*, such as secure and adequate livelihoods, enough food, adequate shelter, clothing, and access to goods; *health*, including feeling well and having a healthy physical environment, such as clean air and access to clean water; *good social relations*, including social cohesion, mutual respect, and the ability to help others and provide for children; *security*, including secure access to natural and other resources, personal safety, and security from natural and human-made disasters; and *freedom of choice and action*, including the opportunity to achieve what an individual values doing and being.

Humans are thus highly dependent on the flow of ecosystem services (Fig. 1.3). However, the links have become less obvious to some urban dwellers who are buffered against environmental change by factors such as culture and technology, and therefore associate water with treatment plants, food with supermarkets, air with air conditioners, and recreation with television. The central focus of the MA is an examination of the effects of ecosystem changes on people in future decades, and the types of responses that may be adopted at local, national, regional, and global scales to improve ecosystem management, and so enhance human well-being.

The Caribbean Sea Ecosystem Assessment draws heavily upon the MA conceptual framework and methodology. The technical work of the assessment was conducted by three working groups[7]—on Condition and Trends, Scenarios, and Responses—and at three scales (described later).

[8]It should be emphasized that the lines on this map are indicative only, as some boundaries are disputed.

[7]Experts were selected during an initial workshop conducted by the MA on Scenarios for the Caribbean Region in April 2002, and further experts from the region added through invitations. Disciplines represented were environment and development, agriculture, engineering, law, economics, marine sciences, geo-informatics, politics, ecology, epidemiology, international relations, media/literature, information management and communication, and meteorology.

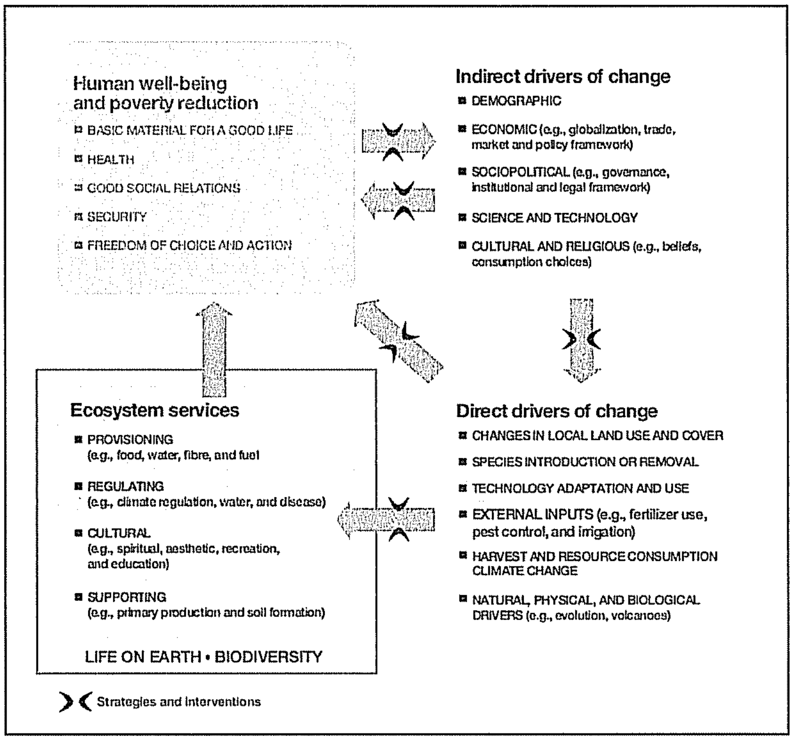


FIG. 1.2. Millennium Ecosystem Assessment conceptual framework diagram.
SOURCE: MA (2005a).

The main ecosystem services being examined in CARSEA are:[8]

- Provisioning: The fisheries production service
- Cultural: Tourism amenity value of the ecosystem, a product of aesthetic and recreational services
- Supporting: The biodiversity service through coral reefs and other coastal habitats.

The components of human well-being prioritized in this study are:

- *Material minimum for a good life*: livelihoods (jobs and income related to tourism and fisheries), food (fish protein as % total protein)
- *Security*: tropical cyclone property damage
- *Health*: the recreational benefits to local populations and tourists, provided by well-functioning coastal ecosystems.

The three scales for assessment are:

- Scale 1: Small island states of the Caribbean
- Scale 2: Coastal zones and Exclusive Economic Zones (EEZs) of countries surrounding the Caribbean Sea
- Scale 3: The Caribbean Sea marine environment.

[8]Important ecosystem services not covered in detail in the assessment are:
- Provisioning: The provision of desalinated/fresh water; oil and gas (it is arguable that this is a provisioning service of ecosystems, albeit from the distant past); ornamental resources; fibre; fuel-wood from mangroves; construction material; pharmaceuticals.
- Regulating services: Climate regulation; water purification; and waste treatment.
- Supporting services: The Sea as a medium of transport.

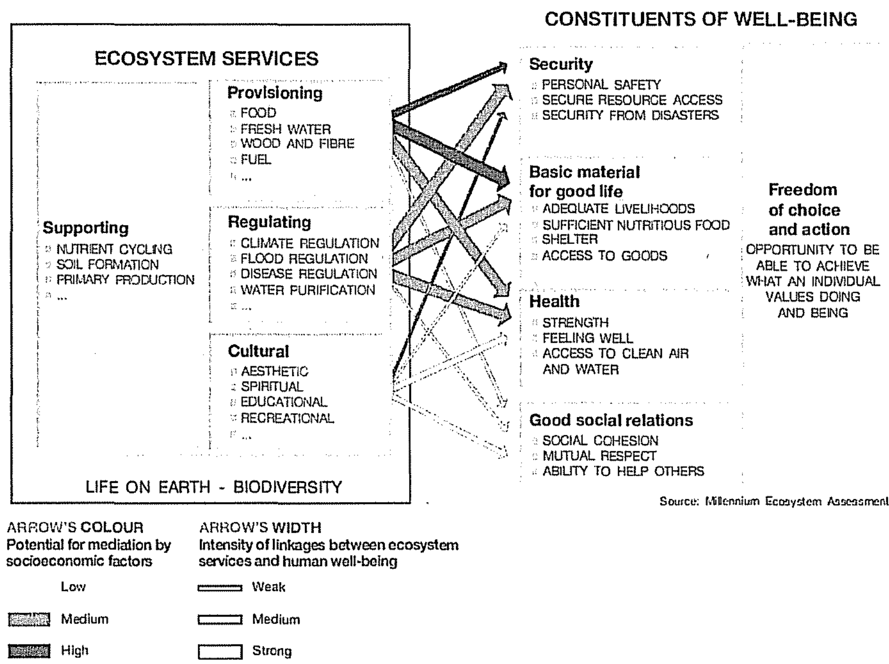


FIG. 1.3. Links between ecosystem services and human well-being.
SOURCE: MA (2005a).

The quality of assessment at these different scales varied greatly according to the availability of data. Little data were available on the Caribbean Sea as a whole—most information refers to individual countries and their EEZs, with little coverage of international waters. Another problem is that most of the continental Caribbean Sea countries also have coasts bordering on either the Pacific or the Atlantic, so that only some undetermined portion of an individual country's statistics will be associated with the Caribbean Sea. The most complete data were available for the islands of the Caribbean, because of their isolated or discrete nature. This inevitably influenced the assessment, with the result that it may generally seem to give more prominence to the insular Caribbean.

The project also analyses and presents response options according to three scales of intervention:

1. For Individual states
2. Collectively as Caribbean States
3. For non-Caribbean states involved.

This assessment builds on several recent studies of the Caribbean environment which have thoroughly documented threats from multiple sources, such as pollution from international marine shipping (including nuclear waste trans-shipment); waste from yachts and cruise liners; and large foreign commercial fishing vessels from nations not indigenous to the subregion (UNEP 2004a, 2004b, 2006).

2.0 THE CARIBBEAN SEA — PHYSICAL FORM AND DEFINING PROCESSES

2.1 Coastal Form and the Littoral

The form of the coastline around the Caribbean Sea is extremely varied, and determined by local geological history. Coasts adjacent to mountain ranges may have steep cliffs and deeply indented bays. Coasts in areas adjacent to major stable plates, in contrast, may be generally flat and consist of recent sediments. Where there is plate collision or subduction, coastal form may also be variable, partly from volcanic activity and partly from the elevation of deposits of marine origin, including paleoreefs, ancient reefs, beach rock, and sandstones. The littoral (area close to the shoreline) is typically the most densely populated region of all Caribbean countries and has been much perturbed by human settlement.

2.2 The Shallow Sub-littoral

The characteristics of the shallow sub-littoral (the area below the low-tide mark) again vary with geological history. Adjacent to continental landmasses and larger islands there is generally a wide shallow sub-littoral or shelf. This may be seen in various places, such as off northern South America, off Nicaragua and Honduras, parts of Cuba, and the Bahamas. Many small countries of the Lesser Antilles, however, have narrow island shelves and are surrounded by deep water.

2.3 Bathymetry

The form of the Caribbean basin floor is highly folded, with many ridges and troughs. The most prominent ridge is that between Nicaragua and the Greater Antilles, along which the island of Jamaica emerges. On either side of this prominent feature are deep troughs that extend down to depths of about 5,000 metres. There are several smaller ridges and rises, notably the Cayman Ridge south of Cuba, the Beata Ridge south of Hispaniola, and the Aves Ridge running north from Venezuela. These ridges effectively separate the deep-water masses of the Caribbean Sea into three prominent basins.

There are two notable deep troughs in the Caribbean Sea, the Cayman Trough south of Cuba and the Puerto Rico Trench north of Puerto Rico and Hispaniola. A final prominent feature of the bathymetry (the shape of the ocean floor) of the Caribbean Sea is the Great Bahama Bank, with its extensive shallows and low-lying islands. There are also many other less prominent ridges and basins that convey a picture of highly irregular contours to the floor of the Sea, and a separation of the deep-water masses. The overall picture projected is of a Sea largely enclosed by the landmasses of South and Central America and the Greater Antilles, with comparatively narrow passages between the Lesser and Greater Antilles, connecting it with the Atlantic Ocean. Therefore the Caribbean Sea is a semi-enclosed sea which, according to Article 122 of the 1982 United Nations Convention on the Law of the Sea (UNCLOS), is defined as 'a gulf, basin or sea surrounded by two or more States and connected to another sea or the ocean by a narrow outlet or consisting entirely or primarily of the territorial seas and exclusive economic zones of two or more coastal States.'

2.4 Plate Tectonics, Seismic Activity, and Volcanism

The distinctive shape of the Caribbean Sea and the arc of islands surrounding it relate closely to the tectonics of the region—the position of the dynamic plates of the Earth's crust and the boundaries between them. Figure 2.1 shows that all of the islands, with the exception of the Bahamas, lie close to the boundary of a formation known as the Caribbean Plate. It is moving eastward with respect to the adjacent North American and South American plates at a rate of approximately 20 mm/yr (Miller et al. 2005).

Seismic activity caused by the movement between the plates is generated along these boundaries. Along the Northern margin, including areas close to Jamaica and the Virgin Islands, moderate earthquakes of shallow depth are generated. Near the plate boundaries there is also activity caused by movement within the plates themselves: for example, in the Northern Caribbean earthquakes are caused by internal deformation in a slab of the North American Plate. Concentrations of these earthquakes occur at depths of up to 300 km (Fig. 2.2).

Seismic events in the Eastern Caribbean are principally associated with a subduction zone[9] at the junction of the Caribbean and the North American plates. The North American Plate dips from East to West beneath the Caribbean Plate along a north-south line just east of the main island arc. Earthquakes are also concentrated in the Leeward Islands due to movement within the Caribbean Plate and in the region north-west of Trinidad, where the plate boundary changes direction.

The pattern of earthquakes along the boundaries of the Caribbean Plate (Fig. 2.1) illustrates that except for the Bahamas, Cuba, and the Yucatan Peninsula of Mexico, the countries surrounding the Caribbean Sea are prone to significant earthquake hazards (Fig. 2.2). This is perhaps one of the three distinctive and defining features of the Caribbean region.

2.5 Climate and Circulation

Given its latitude, the Caribbean Sea and the adjacent littoral coastal landmasses have a wet tropical climate with

[9]A subduction zone is a region where two tectonic plates converge, with one sliding underneath the other towards the molten rock of the Earth's mantle. It is typically associated with volcanic activity and earthquakes.

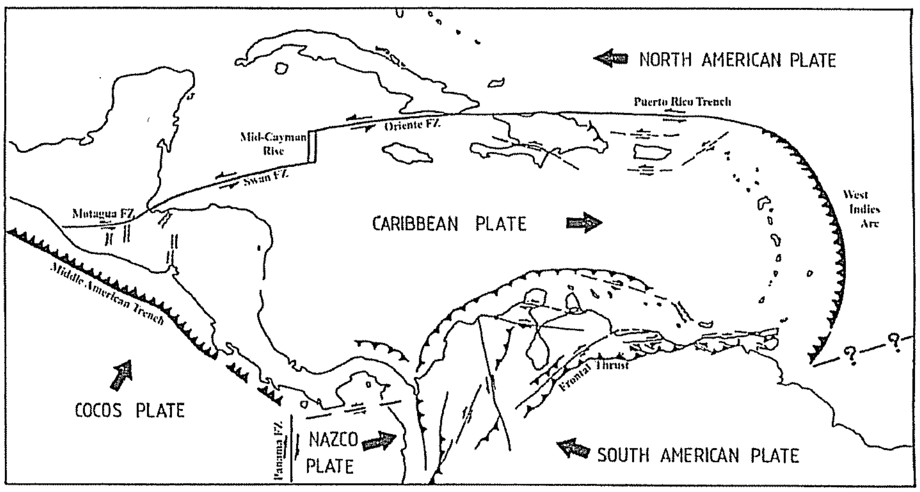


FIG. 2.1. Tectonic setting of the Caribbean.
SOURCE: Molnar and Sykes 1969.

distinctive wet and dry seasons, moderate temperature ranges, and persistent trade winds. The wet season is associated with the seasonal northward migration of the Inter-tropical Convergence Zone (ITCZ) and a continuous series of tropical waves that move westward, some developing into depressions, tropical storms, and hurricanes. While local climate may be varied by other factors such as topography or deforestation, the region as a whole experiences a distinctive hurricane season from June to November. The Caribbean region is also influenced periodically by the wider El Niño/Southern Oscillation (ENSO), a multi-year cycle involving variations in surface temperatures and salinity, due to the changes in rainfall patterns on the South American continent. Some of the hurricane activity is generated far out to the east in the Atlantic Ocean, but may also originate in the Caribbean Sea. This phenomenon is perhaps the second distinctive and defining feature of the Caribbean Sea.

The third defining feature of the Caribbean Sea is its general surface circulation pattern (Fig 2.3). The pattern is that of waters of the South Equatorial Current that flows from a major upwelling of the southern area of Africa flowing across the Atlantic and along north-eastern South America into the Caribbean Sea, through the island arc of the Lesser Antilles. In the Caribbean Sea, this stream of water is known as the Antillean Current that flows in a generally westward direction, exiting the Sea via the Yucatan Channel. There is also some inflow of northerly waters into the Caribbean Sea through the inter-island passages in the Greater Antilles, and persistent gyres (circular or spiral movements of water) in the Colombian and Yucatan basins. Water quality, particularly salinity and turbidity of the incoming stream, is much influenced seasonally by discharge from the Amazon and Orinoco rivers and those of the Guianas. The Sea is also affected by continental river discharge directly into it.

2.6 River Plume Dynamics

The ecology of the Caribbean is greatly affected by the massive quantities of fresh water and sediments entering the Sea from three great South American river systems: the Amazon, Orinoco, and Magdalena. Although a large part of the outflow of the Amazon is taken eastward across the Atlantic, a significant quantity flows northward around the coast of the continent into the Eastern Caribbean and, together with the waters of the Orinoco, this creates plumes of buoyant fresh water across wide stretches of the ecosystem (Müller Karger et al. 1988, 1989). In the Western Caribbean, the plume of the Magdalena River extends north and eastward under the influence of a current known as the Colombian gyre (Box 2.1).

The influx of sediments and nutrients originating from human activities in the Magdalena drainage basin has a

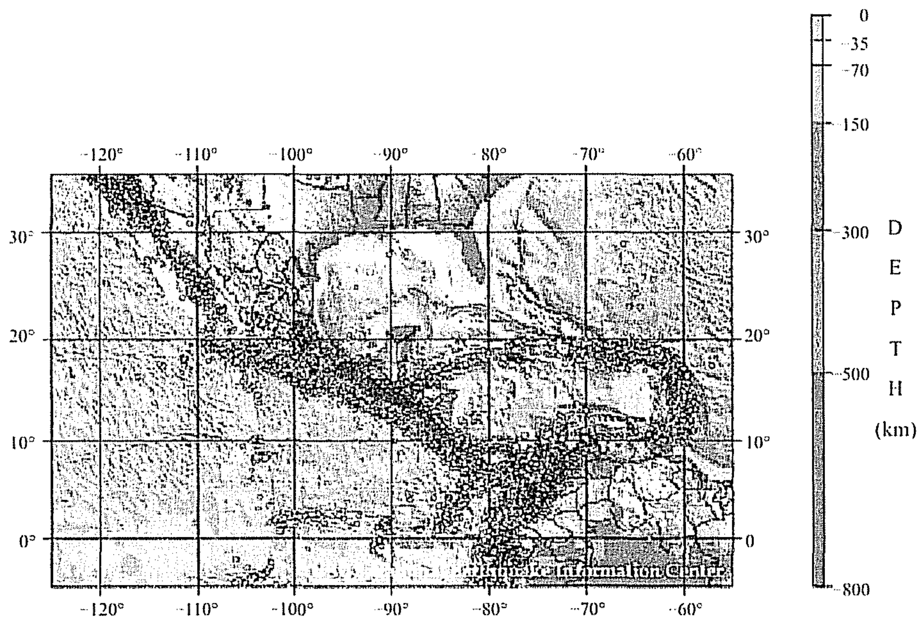


FIG. 2.2. Seismicity of Central America: 1990–2000.
SOURCE: United States Geological Survey 2007.

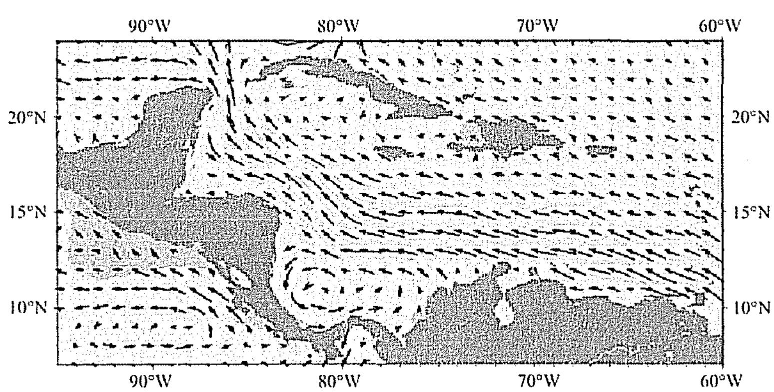


FIG. 2.3. Caribbean Sea circulation.
SOURCE: Gyory et al. 2006.

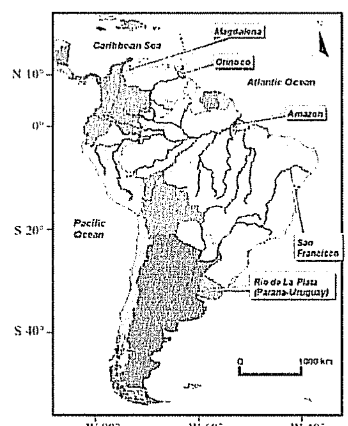
major influence on the dynamics of plankton and, hence, on the fisheries of the Caribbean. These river plumes extend to very shallow depths in the southern Caribbean (less than 10 m) but, under the influence of wind and current, slowly mix into the underlying saltier water. They can achieve depths of between 40 m and 60 m in the north-east Caribbean. Eddies crossing the sea further complicate the transport of fresh water, resulting in a complex mosaic of different levels of salinity on the surface.[10] Recent studies have shown that the impact of these river plumes can be very great, even hundreds of kilometres from the deltas where they originate. Dissolved organic matter from the Orinoco, for example, has been found to stimulate the growth of plankton far out into the Caribbean, through a process known as photomineralization which releases nutrients into the marine environment (Corredor et al. 2003).

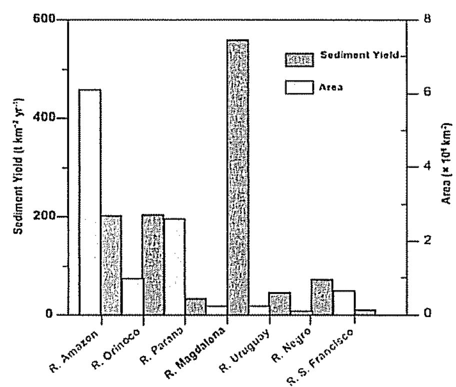
BOX 2.1: The Magdalena River and its Impacts on Coastal Ecosystems[11]

The Magdalena River is one of the most important rivers in the world in terms of its impact on the wider environment. For example:

- It discharges more sediment for each square kilometre of its catchment area than any of the other large rivers along the Caribbean and Atlantic coasts of South America (the rate is 560 t km^{-2}year^{-1}).
- The total amount of sediment transported into the Caribbean by the Magdalena is of the same magnitude as the three larger rivers of the continent, the Amazon, Orinoco, and Paraná (Plata), which all drain into the Atlantic.
- It has a large drainage basin (257,438 km) covering 24% of the territory of Colombia.

The Magdalena River extends for 1,612 km and drains the Western and Central Cordilleras of the Andes. The basin is characterized by high tectonic activity, landslides, steeply sloping tributary basins (71% of the catchment area corresponds to elevations above 1,000 m), and moderate precipitation, with an average rainfall of 2,500 mm per year.





SOURCE: Restrepo and Kjerfve 2000b, 2002, 2004.

During the past 50 years, the Magdalena River has come under increasing environmental stress accompanying economic development in Colombia between the 1970s and 1990s, with major implications for the Caribbean coastal areas into which the river drains. Ongoing trends include (1) escalating population densities along the basin and at the river mouth. Eighty per cent of the Colombian population, including the cities of Bogotá, Medellín, Cali, and Barranquilla are located in the Magdalena watershed. This gives rise to a density of 120 inhabitants/km^2 for the basin as a whole, compared to just 0.24 inhabitants/km^2 in the Amazon basin; (2) accelerating upland erosion rates due to increasing deforestation, mining, and poor agricultural practices; and (3) increasing levels of water pollution, also linked to increased population, deforestation, and poor farming practices. The overall result has been a distortion of the natural dynamics of the river system, in turn leading to the loss of critical habitat, biodiversity, and altered patterns of the transport of sediments and other material.

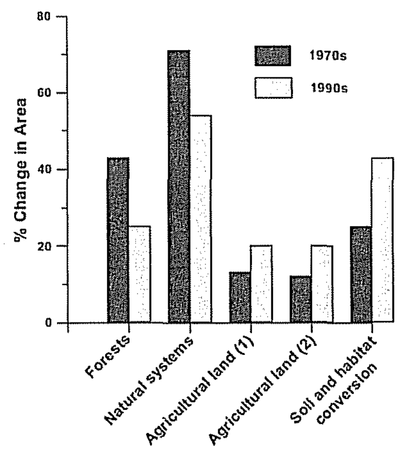
[10]Dramatic satellite-derived imagery of these interactions can be viewed on the website of the US Naval Research Laboratory at http://www7320.nrlssc.navy.mil/IASNFS_WWW/

[11]The information in this box is largely sourced from Restrepo and Kjerfve 2000a, 2000b, 2002, 2004; Restrepo and Syvitski 2006; Restrepo et al. 2005.

BOX 2.1: *(Continued)*

Land Use Change in The Magdalena River Basin

During the past 30 years, the Magdalena basin has been under increasing environmental stress. Recent land use analysis for the 1970–1990 year period indicates that forest cover was reduced from 71% to 54% within the river's watersheds. The only remaining rainforest area is located in the lower Magdalena valley, and most of the land on the lower and middle slopes is under cultivation. In addition, this period witnessed an increase in the proportion of soils and habitats converted to agricultural use, from 25% to 40% of the basin area.

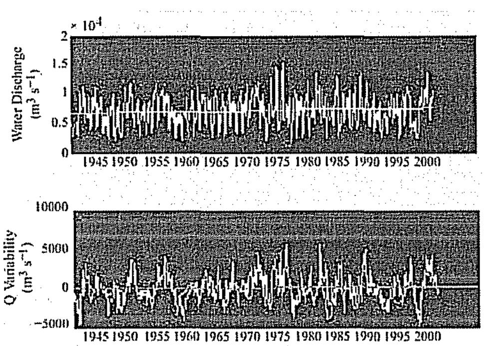


SOURCE: Restrepo and Syvitski 2006.

Water Discharge into the Caribbean Sea

The Magdalena River discharges 228 km^3 of water annually, or on average 7,200 m^3 per second, into the western Caribbean, based on 70 years of daily data between 1942 and 2002.

Analysis has shown that 69% of the variation of the Magdalena streamflow is explained by the multi-annual cycle of the Southern Oscillation (the El Niño effect), with high discharge occurring during La Niña phase and low discharge during El Niño phase.

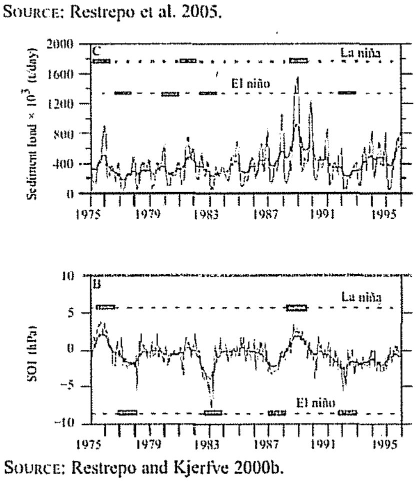


SOURCE: Restrepo et al. 2005.

Sediment Load into the Caribbean Sea

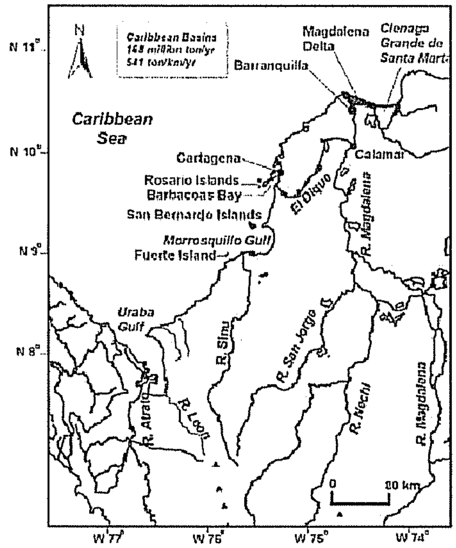
The mean sediment load for the Magdalena is 144 million tonnes per year, corresponding to a sediment yield of 560 t $km^{-2} yr^{-1}$ for the 257,438 km^2 basin. This corresponds to 86% of the total sediment load of all Colombian rivers draining into the Caribbean. The main tributary, the Cauca River, contributes 31% of the Magdalena total.

The sediment load also shows an inter-annual oscillation well correlated with the El Niño/Southern Oscillation (ENSO) cycle which explains 54% of the variation. The La Niña high flow in 1988–89 caused a marked increase in sediment load from the Magdalena, with one prominent peak of 1.6 m tonnes per day. Other flood events are clear but less pronounced, e.g., in 1975–76, 1981–82, and 1995. Low sediment loads occurred during El Niño events in 1977–78, 1982–83, and 1991–92. The mean daily sediment loads during El Niño and La Niña years are 256 tonnes per day and 511 tonnes per day, respectively.



SOURCE: Restrepo and Kjerfve 2000b.

BOX 2.1: (*Continued*)



Nutrient fluxes of phosphate (PO_4^{-3}) and nitrate (NO^3) in non-pristine fluvial systems of the Caribbean basins of Colombia. Nutrient values are based on averages calculated from monthly samples covering three-year period 1998–2000

River	Water discharge ($km^3\ yr^{-1}$)	Total nitrate	Total phosphate PO_4^{-3} ($\times 10^3$ t yr^{-1})
Caribbean			
Magdalena	228	186	47
Dique	9.4	12	3.0
Sinu	11.8	1.5	0.07
Leon (Uraba Gulf)	2.1	2.5	0.7
Turbo (Uraba Gulf)	12	0.1	0.003
Atrato (Uraba Gulf)	81	58	2.4

SOURCE: Restrepo and Kjerfve 2004.

Sediment Load and its Impact on Coastal Ecosystems

Sediment load from the Magdalena River has had a strong impact on coastal ecosystems. Since 1954, the government of Colombia has dredged the El Dique Canal, a 114-km man-made channel from the Magdalena River at Calamar to Cartagena Bay. Because of increased sedimentation in the bay during the 1970s, new canals were constructed from El Dique to Barbacoas Bay, and since then, the suspended sediment load in Barbacoas has reached and impacted the El Rosario Islands, a 68-km^2 coral-reef ecosystem in the Caribbean Sea. Sediment load is responsible for most of the observed reef mortality, with dead coral-reef cover reaching 58 per cent. Also, the suspended sediment load from the Sinú River is probably responsible for impacts on the largest coral reef on the Colombian Caribbean coast, a system covering 135 km^2 between the San Bernardo and Fuerte Islands, north and south from the Morrosquillo Gulf. Live coral cover had, in some areas, decreased 25% between 1995 and 2000.

Human-induced Nutrient Fluxes and their Impact on Coastal Systems

Since the 1950s, the use of nitrogen (N) and phosphorous (P) in agricultural fertilizers, and in a range of products such as detergents, has resulted in a rapid increase in the flow of these elements through rivers, now exceeding pristine levels by a factor of 10 in some world rivers. This can drastically alter the ecology of aquatic systems, overstimulating the growth of algae and leading to oxygen depletion, toxic blooms, fish kills, and coral-reef degradation.

In Colombia, non-pristine fluvial systems like those draining the Caribbean basins have much more phosphate (PO_4^{-3}) and nitrate (NO^3) loads when compared to pristine rivers (e.g., Pacific rivers). The Magdalena and Atrato rivers are the Colombian systems which contribute by far the highest P and N fluxes to the Caribbean Sea, with total phosphate and nitrate flows up to 186,000 t and 47,000 t per year, respectively. Many causes are responsible for these high nutrient loads, including massive sewage discharges in cities and towns, mainly in the Magdalena basin, and also the use of chemical fertilizers on banana plantations in the lower course of the Atrato River.

Urban, agricultural, mining, and industrial waste inputs from the Magdalena basin have aggravated the condition of the Ciénaga Grande lagoon and coastal ecosystems. Biodiversity has been reported to be considerably lower in the area affected by mangrove mortality, as well as in the coastal zone. A decline in fisheries catches by a factor of eight, from 63,700 t in 1978 to 7,850 t in 1998, is another indication of the environmental degradation caused by reduced water quality.

BOX 2.1: (*Concluded*)

Water Diversion and Mortality of Mangrove Ecosystems

Water diversion due to the construction of a highway in the Magdalena delta/lagoon complex, the Ciénaga Grande de Santa Marta, has resulted in hypersalinization of mangrove soils, and the consequent die-off of almost 270 km^2 of mangrove forests during the past 39 years. Between 1956 and 1995, 66% of the original mangrove forest died. Recent estimates indicate that for the whole Magdalena lagoon/delta complex and associated coastal zones, the mangrove area has been reduced from 62,000 ha in 1991 to 52,478 ha in 1996, a loss of almost 2,000 ha per year. In addition, fresh-water input from the Magdalena River to the lagoon was also diverted for irrigation purposes, and interrupted by dikes built along the delta distributaries to prevent flooding of farm lands. The changes in the hydrological regime have also caused water quality changes in the lagoons and canals, resulting in low dissolved oxygen concentration, fish kills, and eutrophication.

2.7 Major Coastal and Marine Habitats

2.7.1 Beaches

Beaches are deposits of sand between the high- and low-tide marks, transported to shore and moulded by waves. The sand can be calcareous (derived from the broken skeletons of corals, calcareous algae, molluscs, and echinoderms) or siliceous (derived from eroded rocks). Beaches are dynamic, the sand being constantly subjected to deposition (accretion) or loss (erosion). Storms, offshore reefs, sand shoals, currents, and onshore dunes play important roles in controlling deposition and erosion on a beach. The stability of a beach, whether eroding or accreting, depends on a balance, over time, between the supply of sand and the rate at which it is transported away.

Beach and dune sands serve as one of the world's major sources of construction aggregate. Noncalcareous sand is also used to produce minerals and ores for various industries, including electronics. However, beaches in the Caribbean are best known for their importance to tourism: the quality of the beach is cited by most tourists as the main feature of a successful holiday (Uyarra et al. 2005). They also provide areas of recreation and enjoyment for local people throughout the region and, therefore, have great cultural value in addition to their economic importance in attracting overseas visitors.

Beaches are important habitats for sea turtles, which nest in the zone above the high-tide mark. This can create a conflict between the use of a beach for recreation and its contribution to the biodiversity of the Wider Caribbean Sea ecosystem, but it can also provide income, community employment, and educational opportunities through well-managed eco-tourism.

A number of threats linked to human activity are causing beach erosion and polluting coastal waters, compromising the ability of Caribbean beaches to continue providing ecosystem services. Unregulated sand mining, for example, causes loss of sand and prevents the natural replenishment of other beaches as material is carried around the coast by tides and currents.

Another key threat is being brought about largely by the tourism industry itself, despite its reliance on beaches to attract visitors. Many poorly planned developments are simply too close to the edge of the sea. They frequently lack adequate waste-disposal facilities, which leads to contamination with sewage and other effluents, causing a health hazard and badly diminishing the aesthetic value of beaches. Failure to set buildings back 50 m or more from the shore also exposes them to storms and damages dunes which are part of the dynamic system stabilizing beaches. In addition, construction on beaches may alter patterns of water currents which, in turn, could increase erosion.

It has recently been estimated that 70% of beaches on the islands of the Caribbean are eroding at rates of between 0.25 m and 9 m per year (Cambers 1997). It is possible that the decline in Caribbean coral reefs (a source of much of the calcareous sand) has reduced both protection from wave action and the supply of sand, thereby increasing erosion. The cost of artificial replacement of sand, a process known as beach nourishment, can run into millions of U.S. dollars (U.S. $).

2.7.2 Seagrass Beds

Seagrasses are flowering plants that flourish in shallow, sheltered, marine environments, such as lagoons near mangroves or coral reefs, or just offshore from beaches. The Caribbean region has six species of seagrass, the most common of which is turtle grass (*Thalassia testudinum*).

The beds formed by seagrass perform a number of important roles in the Caribbean Sea ecosystem, including the stabilization of sediments, reducing the energy of waves as they approach the shore, and the provision of a nursery habitat for organisms that as adults live in other systems.

Seagrass communities serve as habitats for a wide range of organisms. They provide food for species such as parrot fish, surgeonfish, queen conch, sea urchins, and green turtles. The seagrass leaves carry epiphytic algae[12] and animals, which are grazed by invertebrates and fish. The seagrass blades enhance sedimentation and reduce erosion by slowing down waves and currents, while the roots and rhizomes[13] bind and stabilize the sediment surface.

Seagrass beds are very important in the marine food chain as a result of the high rate at which they convert carbon dioxide dissolved in the water into organic matter, through the process of photosynthesis (high net productivity). This rate, approximately 1 kg of carbon for each square metre in the course of a year ($1\ kg\ C\ m^{-2} year^{-1}$) is significant because about half of this material is exported as detritus, which contributes food to offshore ecosystems.

Seagrass habitats act as a nursery for the young of many commercial species of fish, crustaceans, and molluscs, while reef-based carnivores venture off into nearby seagrass beds in search of food. The wide variety of epiphytes which live in the seagrasses become the food of many bottom-dwelling fish species which feed off detritus.

Organisms in seagrass beds with calcium-based external skeletons (for example, molluscs, echinoderms, crustaceans, calcareous algae, and some protozoa) also help to form beach sand.

Threats to seagrass beds in the Caribbean include their removal from shallow water to "improve" bathing beaches; dredging to allow access to shipping or to lay cables, pipes, and other submarine structures; burying by sediment from nearby dredging and filling activities; and pollution from nutrients such as nitrogen which causes excessive growth of epiphytes. Nutrient pollution can also overstimulate the growth of the seagrass itself, leading to difficult decisions on whether to clear beds which expand into previously unsettled sandy areas.

In summary, seagrass colonies are undervalued for the contribution they make to key services of the Caribbean Sea ecosystem, including fisheries (directly) and tourism (indirectly) through the production of sand, protection from wave action, and nurturing of wildlife important for eco-tourism).

[12]An epiphyte is an organism which grows naturally on another but does not use it for nourishment.
[13]A rhizome is a plant stem which grows beneath the soil or sediment surface.

2.7.3 Coral Reefs

Coral reefs are among the most productive tropical marine ecosystems and have the highest biodiversity (MA 2005b). Corals are sessile (immobile) organisms whose bodies are in the form of a small polyp, usually less than 1 cm in diameter. Reef-building corals are colonial, occurring as sheets of many thousands of polyps over a calcium-carbonate skeleton. Corals are found in all of the oceans, but it is only in the tropics that they form reefs. This is done with the help of symbiotic single-celled algae contained in their tissues. The algae use sunlight to carry out photosynthesis and provide organic nourishment for the corals, and also help to deposit the skeleton. The accumulated skeletons of many generations of corals, cemented together with other carbonate sediments, form the reef.

The living corals, and the spurs and canyons within the reef, give the three-dimensional structure which provides habitats for so many species. The typical structure of a Caribbean fringing reef includes a lagoon tens to hundreds of metres wide, a shallow platform or reef flat, a defined reef crest, and a more or less steeply sloping fore-reef on which spurs may develop.

Seven per cent of the world's coral reefs are located in the Wider Caribbean (Burke and Maidens 2004). They include the Meso-American reef, the largest coral system in the Northern Hemisphere, stretching nearly a thousand kilometres from the northern tip of the Yucatan peninsula in Mexico, along the coasts of Belize and Guatemala, to the north-east shoreline of Honduras.

Coral reefs in the Caribbean Sea are prolific providers of ecosystem services, including food, protection from storms, recreational value and therefore tourism income, and medicinal products. It is estimated that the potential yields for fisheries from coral reefs amount to $10\ t\ km^{-2} year^{-1}$, which could provide up to 6% of global fisheries if properly managed (Burke and Maidens 2004). Commercially valuable species fished on coral reefs include snappers (Lutjanidae), groupers (Serranidae), and jacks (Carangidae), while less valuable species include parrot fish (Sparidae) and surgeon fish (Acanthuridae). Important shellfisheries include those for conch (a large marine gastropod mollusc) and lobster.

Harvesting of other reef resources includes live ornamental fish for the aquarium trade; collection of coral skeletons and shells of other creatures for jewellery and other ornaments; mining of reef rock, coral heads, and coral sand for construction; and bioprospecting for potential pharmaceuticals. Only a small fraction of the huge reef biodiversity has so far been tested for the presence of products useful for medicine and industry, but already many have been found and exploited commercially.

Coral reefs are among the most beautiful and visually impressive habitats on earth, full of life and colour. The Caribbean tourism industry owes much to the opportunities they provide for diving and snorkelling. Reefs also contribute to the attraction of beach holidays through the calm water and blue-green colouring provided by their lagoons, the protection they offer against beach erosion, and the role of coral skeletons in forming the white sand of Caribbean beaches.

Shoreline protection is a very important service provided by coral reefs, and an assessment of their value should include the replacement cost of beaches and of buildings and developments close to shore—a service likely to become increasingly important according to models which predict both rising sea level and more destructive storm activity as a result of global warming.

Taken together, the annual value of services provided by Caribbean coral reefs has been estimated at between U.S. $3.1 billion and U.S. $4.6 billion, with degradation by 2015 potentially costing between U.S. $350 million and U.S. $870 million per year (see Table 2.1; Burke and Maidens 2004).

Caribbean coral reefs are already greatly degraded. They have lost some 80% of living coral over the last 20 years, an unprecedented rate of degradation, declining in some instances from more than 50% live cover to less than 10% (see Fig. 2.4; Gardener et al. 2003). The degradation has, in most cases, been due to a mixture of impacts, all of

TABLE 2.1 — Estimated value of ecosystem services from Caribbean coral reefs, and potential losses from their degradation.

Good/service	Estimated annual value in 2000 U.S. $	Estimated future annual losses due to coral-reef degradation
Fisheries	312 million	Fisheries productivity could decline an estimated 30–45% by 2015 with associated loss of annual net benefits valued at U.S. $11–140 million (in constant-dollar terms, standardized to 2000).
Tourism and recreation	2.1 billion	Growth of Caribbean dive tourism will continue, but the growth achieved by 2015 could be lowered by 2–5% as a result of coral-reef degradation, with the region-wide loss of annual net benefits valued at an estimated U.S. $100–300 million (in constant-dollar terms, standardized to 2000).
Shoreline protection	0.7–2.2 billion	Over 15,000 km of shoreline could experience a 10–20% reduction in shoreline protection by 2050 as a result of coral-reef degradation. The estimated value of lost annual net benefits is estimated at U.S. $140–420 million (in constant-dollar terms, standardized to 2000).
TOTAL	3.1–4.6 billion	U.S. $350–870 million

SOURCE: Burke and Maidens 2004.

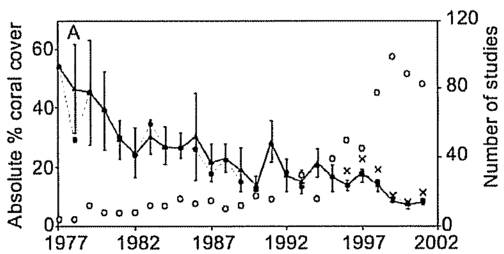


FIG. 2.4. Absolute per cent coral cover from 1977 to 2001 across the Caribbean Basin.[14]
SOURCE: Gardener et al. 2003.

which are still present. These include hurricane damage; disease; bleaching;[15] pollution, including sediment runoff from coastal developments and agriculture; overfishing; and direct damage from boat anchors, fish traps, grounded ships, dredging, collection, and dynamite.

All of these impacts probably have some human component. Global warming may have led to more frequent occurrence of severe hurricanes which results in mechanical damage to reefs and is also largely responsible for coral bleaching. The spread of coral diseases has probably been enabled by shipping and possibly through increased transport of disease organisms over long distance via dust through desertification.[16] Overfishing, especially of alga-grazing fish such as parrot fish, has allowed algae to overgrow corals. Jamaica, for example, has been cited as having some of the most overfished coral communities in the world.[17] Pollution, principally elevated nutrient levels from sewage and agricultural fertilizers, has further stimulated the growth of these algae. In fact, most Caribbean reefs have experienced a shift in ecological dominance from corals to algae. Recovery has been both rare and, when present, slow.

2.7.4 Mangroves

A mangrove is a tree or shrub adapted to colonize tropical, sheltered, coastal environments between the high-water and low-water marks. Mangroves reach their greatest development in estuaries, where they may form extensive forests. The term mangrove is also used to describe the complex community of animals, plants, and micro-organisms adapted to life in a saline and muddy environment. Tree-dwelling animals, including nesting and roosting seabirds, occupy the upper level of the mangrove plants, while marine animals occupy the bases. Sessile marine organisms such as barnacles, oysters, and sponges are dependent upon the hard surfaces provided by the mangrove roots, while mobile animals such as crabs, gastropod molluscs, shrimps, and fish occupy the mud around the stilt roots and the water in the tidal creeks. In the Caribbean region, only 4 common mangrove species are present, far fewer than in the Indo-Pacific region where some 44 species occur.

Mangroves are found along sheltered coastlines of almost all countries and territories surrounding the Caribbean Sea, and they fulfil important socioeconomic and environmental functions. These include the provision of a large variety of wood and non-wood forest products; coastal protection against the effects of wind, waves, and water currents; conservation of biological diversity—including a number of endangered mammals, reptiles, amphibians, and birds; protection of coral reefs, seagrass beds, and shipping lanes against siltation; and provision of habitat, spawning grounds, and nutrients for a variety of fish and shellfish, including many commercial species. Mangroves can provide income as eco-tourist attractions for viewing birds, manatees, crocodiles, and other fauna and flora.

High population pressure in coastal areas has, however, led to the conversion of many mangrove areas to other uses, including infrastructure, aquaculture, rice, and salt production. Numerous case studies describe mangrove losses over time, but information on the status and trends of mangrove area extent at the global level is scarce.

A comprehensive database on mangrove extent has been assembled by the UN Food and Agriculture Organisation (FAO 2002, 2003a). This contains a compilation of mangrove area estimates by country along with revised estimates for 1980, 1990, and 2000 for each country (Table 2.2). The results of the trend analyses indicate that the mangrove area around the Caribbean Sea has in general decreased by about 1% per year since 1980. Table 2.2 also shows that the region of Central America and the Caribbean has lost about 413,000 ha of mangroves since 1980, but that the rate of loss seems to have slowed from about 1.4% per annum between1980 and 1990 to 1.1% from 1990 to 2000. The highest rates of deforestation in the 1980s were found in Barbados, Jamaica, Dominica, and Honduras, while the same countries plus Dominican Republic, El Salvador, Haiti, and Honduras had the greatest rate in the 1990s.

[14]The trend line represents the decline in percentage live coral cover based on weighted means of several studies, the exact number of which are shown by open circles. The error bars indicate 95% confidence intervals.
[15]Coral bleaching is a phenomenon in which elevated sea temperatures cause stress to the symbiotic algae, which then leave the tissues of the coral polyp. Since the algae provide pigment to the corals, the reef loses its colour and rapidly declines in biodiversity. Caribbean corals typically bleach when the water temperature exceeds 30°C.
[16]See Section 3.3.
[17]See Section 3.2.

TABLE 2.2 — Estimates for mangrove area in the Caribbean, 1980, 1990, 2000

	Mangrove area estimates								
	Extent								
	Most recent, reliable, mangrove area estimate		Mangrove area 1980	Mangrove area 1990	Annual change 1980–1990		Mangrove area 2000	Annual change 1990–2000	
Country/ Area	ha	Ref. Year	ha	ha	ha	%	ha	ha	%
Anguilla	90	1991	90	90	n.s.	n.s.	90	n.s.	n.s.
Antigua and Barbuda	1,175	1991	1,570	1,200	−37	−2.7	900	−30	−2.8
Aruba	420	1986	420	420	n.s.	n.s.	420	n.s.	n.s.
Bahamas	141,957	1991	170,000	145,000	−2,500	−1.6	140,000	−500	−0.4
Barbados	14	1991	30	16	−1	−6.1	10	−1	−4.6
Belize	65,767	1995	75,000	68,800	−620	−0.9	62,700	−610	−0.9
Bermuda	16	1992	17	16	n.s.	−0.6	15	n.s.	−0.6
British Virgin Islands	587	2001	660	630	−3	−0.5	590	−4	−0.7
Cayman Islands	7,268	1991	7,300	7,300	n.s.	n.s.	7,200	−10	−0.1
Costa Rica	41,330	1992	41,000	41,000	n.s.	n.s.	41,000	n.s.	n.s.
Cuba	529,700	1992	530,500	529,800	−70	n.s.	529,000	−80	n.s.
Dominica	10	1991	40	13	−3	−10.6	9	n.s.	−3.6
Dominican Republic	21,215	1998	33,800	26,300	−750	−2.5	18,700	−760	−3.4
El Salvador	26,800	1994	47,200	35,600	−1,160	−2.8	24,000	−1,160	−3.9
Grenada	255	1992	295	262	−3	−1.2	230	−3.2	−1.3
Guadeloupe	2,325	1997	3,900	2,500	−140	−4.3	2,300	−20	−0.8
Guatemala	17,727	1998	19,800	17,800	−200	−1.1	15,800	−200	−1.2
Haiti	15,000	1990	17,800	15,000	−280	−1.7	10,000	−500	−4.0
Honduras	54,300	1995	156,400	103,300	−5,310	−4.1	50,000	−5,330	−7.0
Jamaica	9,731	1997	23,000	10,800	−1,220	−7.3	9,300	−150	−1.5
Martinique	1,840	1998	1,900	1,900	n.s.	n.s.	1,800	−10	−0.5
Montserrat	5	1991	5	5	n.s.	n.s.	5	n.s.	n.s.
Netherlands Antilles	1,138	1980	1,140	1,140	n.s.	n.s.	1,140	−0.8	−0.1
Nicaragua	282,000	1992	336,000	280,000	−5,600	−1.8	214,300	−6,570	−2.6
Panama	158,100	2000	230,000	166,000	−6,400	−3.2	158,000	−800	−0.5
Puerto Rico	6,410	2001	6,500	6,400	−10	−0.2	6,400	n.s.	n.s.
St. Kitts and Nevis	79	1991	84	80	n.s.	−0.5	75	−0.5	−0.6
St. Lucia	200	2002	200	200	n.s.	n.s.	200	n.s.	n.s.

TABLE 2.2 — (*Concluded*)

	Mangrove area estimates									
	Extent									
	Most recent, reliable, mangrove area estimate		Mangrove area 1980	Mangrove area 1990	Annual change 1980–1990		Mangrove area 2000	Annual change 1990–2000		
Country/ Area	ha	Ref. Year	ha	ha	ha	%	ha	ha	%
St. Vincent and Grenadines	51	1991	60	52	-1	-1.4	45	-0.7	-1.4
Trinidad and Tobago	7,150	1991	9,000	7,200	-180	-2.2	6,600	-60	-0.9
Turks and Caicos Islands	23,600	1991	23,600	23,600	n.s.	n.s.	23,600	n.s.	n.s.
United States Virgin Islands	978	1991	978	978	n.s.	n.s.	978	n.s.	n.s.
Central America and the Caribbean	1,417,238	1994	1,738,289	1,493,402	-244,887	-1.4	1,325,407	-167,995	-1.1
Colombia	379,954	1996	440,000	396,600	-4,340	-1.0	354,500	-4,210	-1.1
Venezuela	250,000	1986	260,000	240,000	-2,000	-0.8	230,000	-1,000	-0.4
South America	629,954	1992	700,000	636,600	-63,400	-0.9	584,500	-52,100	-0.8

NOTES TO THE TABLE: According to FAO, the 1980, 1990, and 2000 figures have been determined as follows:
1. When sufficient quantitative information permitted a reliable trend analysis, 1980, 1990, and 2000 figures were based on the results of a regression analysis (Central America: Antigua and Barbuda, Belize, British Virgin Islands, Cuba, Dominican Republic, El Salvador, Grenada, Guadeloupe, Guatemala, Honduras, Martinique, Panama, Puerto Rico; South America: Colombia, Venezuela).
2. Where recent information was unavailable the extrapolation to year 2000 was based on the overall forest change rate 1990–2000 as reported in the Global Forest Resources Assessment (FRA) 2000 (FAO 2001; Central America: Cayman Islands, Montserrat, Netherlands Antilles, U.S. Virgin Islands), or on expert estimation (Central America and Caribbean: Anguilla, Aruba, Bahamas, Barbados, Costa Rica, Dominica, Haiti, St. Lucia, Turks and Caicos islands).
3. Where insufficient information was available, the area estimations for 1980 and 1990 were based on the overall forest change rates as reported in the Global FRA 2000 (FAO 2001; Central America and Caribbean: Nicaragua, St. Kitts and Nevis, St. Vincent and the Grenadines, Trinidad and Tobago), and in the FRA 1990 (FAO 1995;Caribbean: Bahamas).

SOURCE: Adapted from FAO 2002, 2003a.

2.7.5 Interdependence of Caribbean Habitats

It is important to note that, besides the large diversity of species that are resident in mangrove and seagrass communities, there is a continuous flow of biomass between these habitats and coral reefs in all directions. It is therefore necessary to consider all three habitats as one large interdependent marine ecosystem with shared biodiversity.

In addition, mangroves and seagrass communities are permanent recipients of planktonic larvae from the open sea (Eggleston 1995) and, in return, nurture crustaceans whose larvae provide food for ocean-going fish and mammals.

This interdependent nature of the marine ecosystem is a vital consideration in the management of the Caribbean Sea, as degradation of one type of habitat can have far-reaching impacts on the services provided to human communities by another. For example, the clearing of seagrass beds for cosmetic reasons could affect income from fisheries and, in the long run, speed up erosion of nearby beaches, which might reduce the appeal of a particular tourist resort and therefore damage local livelihoods.

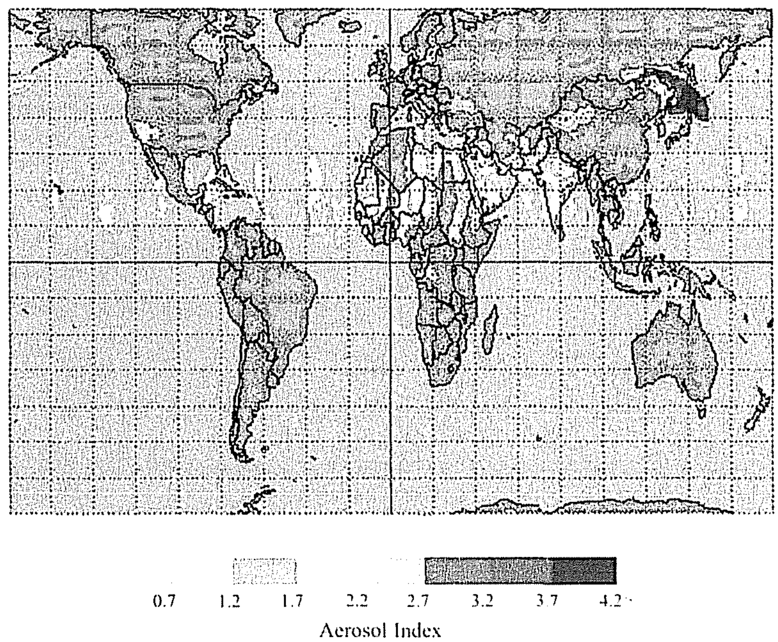


FIG. 3.1. Transatlantic flux of Saharan dust as recorded by TOMS satellite.
SOURCE: http://toms.gsfc.nasa.gov/aerosols/today_aero_v8.html

causing capability of microbes present on the reef, or that shift the structure of the microbe or sea-bed communities of the reef, thereby affecting the ecology.

There is mounting evidence to suggest that some of the declines occurring on Caribbean coral reefs today may be linked to African dust. The 1983 die-off of the long-spined sea urchin (Section 3.2) and the beginning of the Plague II outbreak in 1997 followed within months of peak dust events in the region. The strongest evidence thus far is that *Aspergillus sydowii*, a known fungal disease affecting sea fans, has been identified in its active pathogenic form, in air samples collected during Saharan dust events in the U.S. Virgin Islands, but not from clear atmospheric conditions (Garrison et al. 2003). *Aspergillus sydowii* is associated with soils, does not reproduce in seawater, has a wide geographical distribution, and occurs on reefs far from terrestrial sources of soil. Saharan dust is eroded soil and must thus be seen as a possible source of the disease.

Although dust has been making this journey for thousands of years, recent changes in climate since the mid-1960s, particularly decreased rainfall and desertification in northern Africa, have resulted in increased amounts of dust crossing the Atlantic.

4.0 ASSESSMENT OF MAIN CARIBBEAN SEA SERVICES: LINKS TO HUMAN WELL-BEING AND CONDITION AND TRENDS

4.1 Fisheries[19]

4.1.1 Importance of Fisheries

In the terminology of the MA the living marine resources of the Caribbean Sea constitute the most important 'provisioning' service of the ecosystem. Fisheries have always been a source of livelihoods and sustenance for the people of the region, contributing towards food security, poverty alleviation, employment, foreign-exchange earnings, and the development of rural and coastal communities, recreation, and tourism.

The fisheries of the Caribbean Sea are, with few exceptions, multi-species, small-scale fisheries conducted by low-capital, labour-intensive operators. The main

[19]A detailed description of the fisheries of the Caribbean and issues relating to their management is available in Annex 1

exceptions are the industrial shrimp and tuna fisheries on the northern coast of South America and on the continental shelf adjacent to the Central American countries. The fishing sector is dominated by small, artisanal boats constructed of fibreglass and wood. These may be powered by outboard engines, oars, or sails, or a combination of all three. There are approximately 25,000 artisanal boats, 5,000 medium-sized boats, and 1,500 industrial vessels in the region.[20] Hook and lines, gillnets, and traps are the main types of gear used. In addition, trawls are common in the shrimp fisheries of South and Central America. Diving using compressed air is common in the lobster and conch fisheries. The main fisheries targeted in the region are based on the following resources: coral reefs and reef-associated fish; deep-water snappers and groupers; large pelagic fish;[21] small coastal pelagic fish; flyingfish; groundfish; shrimp; lobster and conch.

The fish resources of the Wider Caribbean region are extremely diverse. It has been estimated that there are some 680 species of bony fish and about 49 species of sharks targeted by fisheries in the region (Cervigón 1993). The invertebrates including shrimp, lobsters, and molluscs (conch, octopus, and squid) must be added to these figures to determine the total number of species that are of interest to fisheries.

This diversity presents a major challenge to the effective management of fish stocks in the Caribbean. There is little information on the status of most of the commercially important resources, and even less on the hundreds of species of lesser importance to the region's fisheries. For example, of the 197 stocks falling under the jurisdiction of the Caribbean Fisheries Management Council (CFMC), covering the U.S. Virgin Islands and Puerto Rico, the status of 175 (88%) was unknown or undefined.

Since the 1980s, aquaculture has been making an increasingly significant contribution to the economies of the region. The main species farmed are tilapia and penaeid shrimp (Haughton and Jacobs 1998).

4.1.1.1 Per Capita Consumption of Fish

Fisheries play a very important role in providing nutrition and food security within the Caribbean region. Fish is a vital source of animal protein and minerals in the diet of Caribbean people, particularly the poor and vulnerable members of society. Per capita consumption of fish in the region is approximately 15 kg per year. It is more variable in Central and South America, where the average is approximately 10 kg, and highest in the island states where the average per capita consumption is 19 kg, well above the world-wide average (FAO Database).[22] Consumption in several of the Small Island Developing States (SIDS) is higher than local production and has to be satisfied by high levels of imports. The high diversity of species of different shapes and sizes, the variation in taste and texture, and broad range in the commercial value of fish mean that fish is generally available at affordable prices to both rich and poor throughout the year.

4.1.1.2 Imports and Exports

Fisheries make a significant positive contribution to the balance of trade of the Caribbean region, even though the quantity of imports by weight considerably exceeds that of exports. According to statistics from the UN FAO, approximately 360,000 tonnes of fish and fishery products, worth some U.S. $410 million, were imported in 2000, while exports amounted to around 200,000 tonnes, worth U.S. $1.2 billion.

This apparent anomaly is due to the fact that exports are dominated by high-value products such as shrimp, spiny lobster, tuna, snappers and groupers, and queen conch, which command premium prices on the international market. The U.S.A. is the major destination of most exports from the Caribbean, which have been growing steadily in value.

Imports are very high in the island states, where they account for most fish supplied for human consumption. Haiti, for example, imports 70% of its fish, Jamaica 78%, and Martinique 80 per cent. The composition of imports in the small island states is dominated by dried, salted, and smoked fish. Fresh, chilled, and frozen products are also imported, mainly by the countries with a tourism industry.

4.1.1.3 Employment

Perhaps one of the most important roles of fisheries is the employment which the sector provides for hundreds of thousands of people, in a region where high levels of unemployment and under-employment continue to be a major concern. In a 1998 survey of 17 Caribbean countries, approximately 65% of respondents reported that they were either "concerned" or "very concerned" about losing their job in the next 12 months (Constance 1998).

[20] Fishery Information, Data, and Statistics Unit (FIDI), FAO 1998.

[21] Pelagic fish are those species spending most of their lives in the upper-water column, i.e., relatively close to the surface, as opposed to those finding sustenance close to the seabed (demersal).

[22] http://www.fao.org/docrep/T8365E/t8365e04.htm#1.3%20annual%20consumption%20of%20fish%20and%20shellfish

The fisheries sector in the CARSEA region provides stable full-time and part-time direct employment (as fishers) for more than 200,000 people, and jobs for an estimated additional 100,000 in processing and marketing. Indirect employment is also provided by boat-building, net-making, and other support industries. People engaged in fishing often have low levels of formal education, limited access to capital, and limited occupational and geographic mobility. It is estimated that each person employed in the fisheries sector has five dependents, suggesting that well in excess of 1.5 million people in the Caribbean rely on fisheries for their livelihood.

4.1.1.4 Recreational Fisheries and Non-consumptive Uses

Within the Caribbean region, fisheries are important not only as a source of food and employment for commercial and subsistence fishers, but also for a growing number of people involved in recreational fishing, defined as fishing conducted for the purpose of pleasure and relaxation rather than for commercial gain or subsistence by the fisherman. Popular sport-fishing magazines, such as *Marlin*, *Salt Water Sportsman*, and *Sport Fishing*, consistently rate the Caribbean as a prime destination for international anglers targeting billfish, such as marlins and sailfish, and for several other species of game fish. Dozens of international, regional, and national fishing tournaments are held each year throughout the region.

Despite its popularity, there is a lack of data and information on the recreational fishing industry of the Caribbean. Research is needed to understand better the scope and economic importance of the activity, as well as its impact on marine resources and management requirements. Statistics from the U.S. suggest the pastime generates very significant revenues and employment: the National Marine Fisheries Service estimated in 1996 that direct expenditure from sport fishing amounted to more than U.S. $7 billion per year, providing more than one million U.S. jobs. In most Caribbean countries, sport fishing is promoted by tourism interests and is neither monitored nor regulated by the national fisheries administrations.

There is therefore a strong link between the management of Caribbean fisheries and the value and impacts of tourism in the region, which are discussed in more detail later in this report. This link is also evident in the economic value of the diving industry, which depends on abundant and varied populations of coral-reef species of fish and other marine life.

4.1.2 Driving Forces Impacting Caribbean Sea Fisheries

The Caribbean Sea Ecosystem Assessment has identified the following drivers affecting the fisheries of the Caribbean:

4.1.2.1 Direct Drivers

- Environmental degradation and pollution of the world's seas and oceans, for example, the dumping of toxic waste at sea, and the destruction of mangroves and other critical coastal habitats which are spawning and nursery grounds.
- Irresponsible fishing practices, for example, the use of some types of trawls, dynamite, certain high-technology fishing techniques, and the capture of non-target species by nonselective gear.
- Global warming and sea-level rise are emerging as important factors affecting fisheries globally and in the Caribbean, although the precise relationships and impacts are still to be fully defined and quantified.

4.1.2.2 Indirect Drivers

- Inadequate policy framework and institutional capacity to manage fisheries in many countries as well as at the regional level for the management of shared stocks.
- Inadequate legal and regulatory framework, and capacity for enforcement.
- Lack of knowledge of the fish stocks; the fisheries; the social and economic conditions of the fishers; and the environmental and ecological processes which control abundance and distribution of the resources.
- Growing demand for fish and fishery products, resulting from population growth, increasing purchasing power, and improved awareness of the nutritional value of fish, has resulted in excessive pressure on the resource.
- Excessive investment in fishing capacity leading to overcapitalization, compounded by the open-access nature of most fisheries—there are just too many fishers, boats, and fishing gear.
- Growing desire for improvement in the standard of living coupled with high levels of unemployment and poverty in many developing states force large numbers of persons to enter and remain in fisheries.

4.1.3 Condition and Trends in Fisheries Resources

4.1.3.1 Overview

Within the Caribbean Sea, many species of fish are under stress from over-exploitation and/or habitat degradation, and are therefore not making an optimum contribution to socioeconomic development of the region. All the major commercially important species and species groups targeted by specific fisheries are reported to be either fully developed or over-exploited. These include conch, which has been placed on the Convention on International Trade in Endangered Species (CITES) list of threatened species (www.cites.org); lobsters and shrimp; groundfish; shallow shelf reef fish; deep-slope fish and some of the large oceanic pelagic species which are managed by the International Commission for Conservation of Atlantic Tunas (ICCAT; CFMC and CFRAMP 2000). It is likely that the status of Caribbean fisheries is similar to that of fisheries globally: the FAO observed in 1993 that over 70% of world fish stocks were either over-exploited, fully exploited, or were in a state of rebuilding after being overfished.

4.1.3.2 Trends in Finfish and Invertebrate Landings in the Caribbean Region (1950–2004)

Accurate data on trends for fish catches specific to the Caribbean Sea have been difficult to obtain because regional FAO statistics are generally combined with parts of the Atlantic Ocean. Recently, however, new analysis of these data has helped to build up a coherent picture of the state of fisheries in the CARSEA region.

Annual landings of finfish and invertebrates are provided in Figure 4.1. They are based on data from the Sea Around Us Project (SAUP) of the University of British Columbia (UBC) Fisheries Center (http://www.seaaroundus.org). The figures were reconstructed or reallocated from the larger Western Central Atlantic Region in the Fisheries database of the FAO (FAO FISHSTAT), to include only catches from the CLME, the focus of the CARSEA Project. Individual country data were re-examined jointly by UBC and national sources such as fisheries departments and research institutions in some countries including Venezuela, Cuba, Belize, St. Lucia, St. Vincent and the Grenadines, Barbados, and Trinidad and Tobago (Zeller et al. 2003).

According to this analysis, fish catches in the Caribbean generally increased from 84,411 tonnes in 1950 to 482,848 tonnes in 1998, before declining to 401,561 tonnes by 2004 (Fig. 4.1). The data suggest that the increased use of more efficient fishing gear including purse seines,[23] relative to other gear such as bottom trawls, may have contributed to the larger catches. The bulk of the catch is dominated by the artisanal sardine fishery (mainly "round sardinella") based in Venezuela. In terms of landed value, sardines, catfish, shrimp, and lobster are the leading products, worth about U.S. $600 million in 2004.

4.1.3.3 Trends in Landings of Inshore and Offshore Fisheries (1980–1999): Case Study — Windward Islands

Data on the quantity of fish landed in any particular year provide only limited information about the status of stocks in a given sea area. Trends in landings of individual countries or islands reflect differences in the level of development of the fishing industry, initiatives to manage stocks through rules on the gear used and/or species targeted, and the overall effort applied to catching fish in a specific area. These factors can lead to marked differences between the pattern of fish landings observed in particular areas and across the Caribbean Sea as a whole.

A more informative measure of the condition of the fishery ecosystem service can be obtained by comparing the size of the catch with the effort exerted by fishing fleets or Catch Per Unit of Effort (CPUE). A recent calculation of catch-and-effort trends in four of the Windward Islands provides a useful case study for this assessment (Mohammed 2003).

The data for the study were reconstructed from published material, "grey literature,"[24] historical documents, and recently computerized databases of the fisheries departments of the respective countries: Grenada, St. Lucia, St. Vincent and the Grenadines, and Barbados. This produced improved information on the catches of particular species, compared with current data in the FAO database for the respective island nations. Fishing effort was represented as the product of the number of boats, the average engine horsepower, and the average number of fishing days per year. The percentage change in these parameters between 1980 (Table 4.1) and 1999 was used to quantify the impacts of fishing on the available resources, for both offshore and coastal waters (Table 4.2).

Although the results are preliminary, some stark changes are evident during this 20-year period. Reconstructed catches declined by 12% in the inshore fisheries of Grenada

[23] A purse seine is a net which can be closed at the bottom using a line to draw together metal rings, forming the shape of a bag and trapping the fish.

[24] Grey Literature refers to publications issued by government, academia, business, and industry, in both print and electronic formats, but not controlled by commercial publishing interests and where publishing is not the primary business activity of the organization.

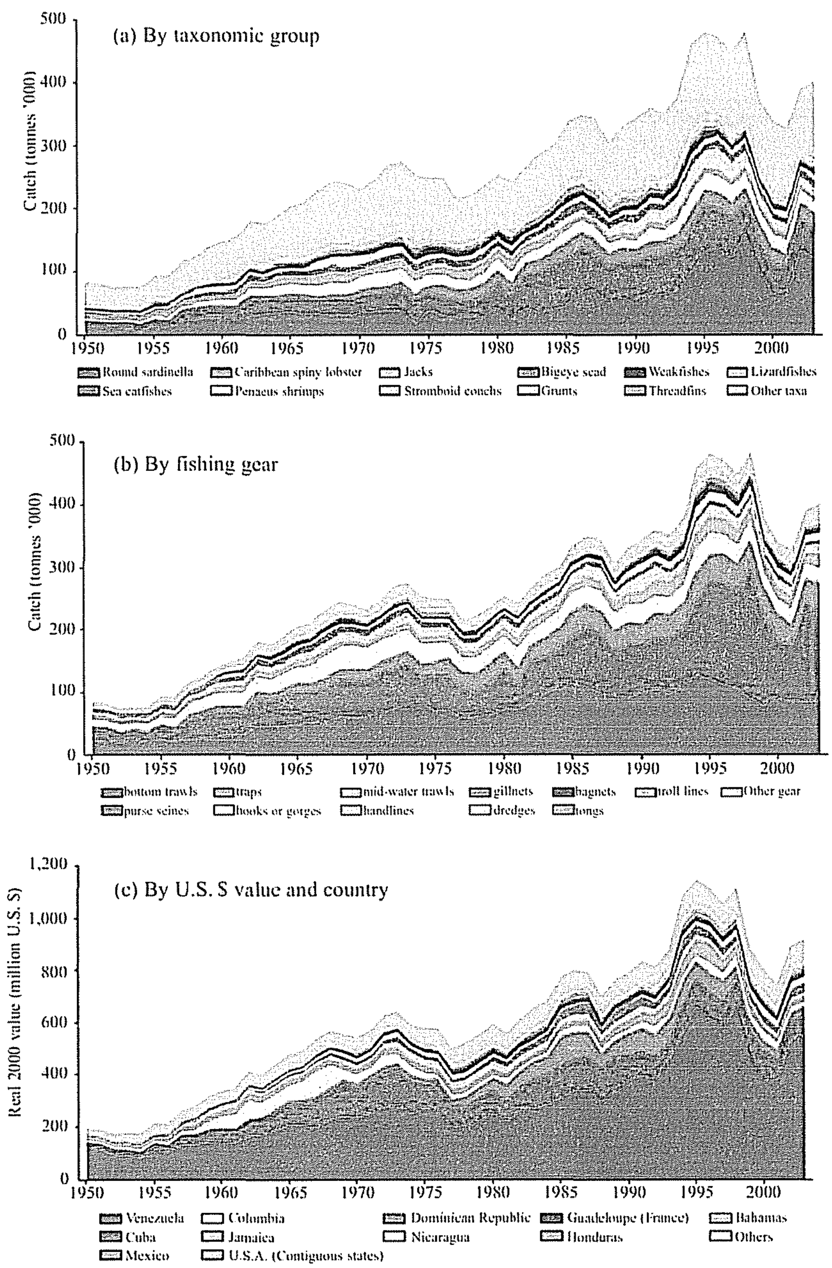


FIG. 4.1. Fish landings in the Caribbean Sea.
SOURCE: University of British Columbia (UBC) Fisheries Centre. Sea Around Us Project 2006.

TABLE 4.1 — Reconstructed catch, effort, and catch per unit effort of four countries in the south-eastern Caribbean, 1980

Fishery statistic	Grenada & Grenadines	St. Lucia	St. Vincent & Grenadines	Barbados
Inshore				
Catch (tonnes)	660	275	397	558
Effort (10^3 Hp-days)	302	527	1357	1018
CPUE (tonnes per 10^3 Hp-days)	2.08	0.38	0.27	0.51
Offshore				
Catch (tonnes)	745	549	204	3211
Effort (10^3 Hp-days)	815	1254	6445	2255
CPUE (tonnes per 10^3 Hp-days)	0.84	0.47	0.29	1.34

TABLE 4.2 — Percentage change in catch, effort, catch per unit area, and catch per unit effort of four countries in the south-eastern Caribbean, 1980–1999

Fishery statistic	Grenada & Grenadines	St. Lucia	St. Vincent & Grenadines	Barbados
Inshore				
Catch (tonnes)	−12	+36	+64	+16
Effort (10^3 Hp-days)	+42	+133	+4	+134
CPUE (tonnes per 10^3 Hp-days)	−38	−24	+58	−71
Offshore				
Catch (tonnes)	+129	+143	-29	+36
Effort (10^3 Hp-days)	+598	+513	+170	+339
CPUE (tonnes per 10^3 Hp-days)	−67	−65	−52	−69

and its associated islands. This was despite a 42% increase in fishing effort. While inshore catches in the fisheries of St. Lucia and Barbados increased by 36% and 16%, respectively, the corresponding CPUE declined by 24% and 71 per cent. Of the four island states examined, only St. Vincent and the Grenadines experienced an increase in CPUE for inshore waters (58%). This increase might be explained by two factors: changes in the areas favoured by fishing boats, such as would occur with the targeting of previously unexploited stocks in deeper waters; and improved data collection systems in the Grenadines, where most catches are taken from the shelf and slope areas. However, these reasons remain to be verified.

Many governments in the Eastern Caribbean, faced with the over-exploited state of inshore fisheries and the increasing need for food security, have promoted development of the offshore fishery, targeting large pelagic species such as tuna, through the provision of loans and other incentives. The data assembled for this study suggest that the increases in offshore catches between 1980 and 1999 (36% to 143%) were far outweighed by the corresponding increases in fishing effort to produce such catches (339% to 598%). The CPUE declined substantially in the offshore fisheries of each of the four countries (by a range of between 52% and 69%).

The data in this study suggest, therefore, that fish catches by the fleets of the Windward Islands failed to keep pace with a dramatic expansion of fishing effort in the last two decades of the 20th century, especially in offshore waters. This is consistent with international studies suggesting that oceanic pelagic stocks are either fully exploited or over-exploited.

A declining CPUE also affects the economic viability of a fishery—since a smaller quantity of fish is produced from the same investment of fuel, labour, etc. However, government financial incentives and increases in export prices may act to preserve or increase the economic gains from the fishery, despite obvious declines in stock abundance evident from declining catch per unit of effort. The economic impacts of increasing offshore activity have not been investigated.

Offshore resources are shared regionally, in the case of large coastal pelagic fish, or with other fishing nations including developed countries, in the case of large oceanic pelagics. Although each country is charged with the responsibility for management of the resources within its EEZ, this study highlights the need for regional and international collaboration and governance to preserve the long-term viability of shared Caribbean fish stocks and the human livelihoods associated with them.

4.1.3.4 Fishing Down the Food Web: Evidence of Declining Trophic Levels in the Caribbean

Another indicator of unsustainable fishing patterns has been an observed change in the structure of the marine food web, as reflected in the composition of fish catches over time. A landmark 1998 study by the fisheries scientist Daniel Pauly and colleagues demonstrated a gradual transition in global landings from long-lived, fish-eating species higher up the food chain (higher-trophic level), towards short-lived, plankton-eating fish and invertebrates lower down the food chain (lower-trophic level; Pauly et al. 1998). The phenomenon, known as "fishing down the food web," tends to lead first to increasing catches, then to an ecosystem transition associated with stagnating or declining catches. The SAUP has recently carried out the same analysis for the CLME, and the results indicate a decline in mean trophic level of fish in the catch (shown in Fig. 4.2a), from about 3.64 in 1950 to about 3.4 by 2004.

Changes are also evident at the local level. Analysis of data from the four Windward Island states mentioned in the previous section suggests a general shift of catch composition towards the bottom of the food web between 1980 and 2001 (Fig. 4.3; Mohammed et al. 2002). This decline in mean trophic level was most pronounced for the fisheries of Grenada and Barbados (0.17 and 0.22 per decade, respectively), and greater than the global average of 0.1 per decade estimated by Pauly et al. (1998).

Fishing at lower trophic levels may, however, be a deliberate fishing strategy to harvest the increase in biological production associated with "fishing down the food web." As a result, a decline in mean trophic level alone is insufficient to confirm the negative impacts of fishing on the ecosystem. Pauly et al. (2000) introduced the Fishing-In-Balance Index (FIB) to identify cases where the expected increase in biomass at lower trophic levels no longer holds true. The FIB declines if the observed catches are not consistent with expectations at the associated trophic level (Pauly et al. 2000).

Such an analysis indicates that the FIB index has steadily increased for the Caribbean Sea since the late 1950s (Fig. 4.2b), which may be the result of the expansion of fishing effort to deeper and more remote waters. Mixed trends for the FIB are evident in the four Windward Island states (Fig 4.3).

Taking these data together, the inescapable conclusion is that the phenomenon of fishing down the food web by selective removal of top predators is well advanced in the Caribbean Sea and has already had a significant impact on the inshore fisheries of some countries, including Grenada and Barbados. This strengthens the case for managing the industry in an integrated manner to safeguard the entire ecosystem, including the establishment of new marine protected areas.

4.2 Tourism and Recreation

4.2.1 Locational Advantage

The natural setting of the Caribbean, a product of the marine, island, and coastal ecosystems of the region, constitutes an asset of immense value due to the positive associations it invokes around the world. People from a wide range of nationalities and social backgrounds are prepared to travel thousands of miles, and commit a significant portion of their income, to spend just a few days on vacation there.

The attraction of the insular Caribbean is linked to a romantic perception of islands as "warm and sensuous" destinations, offering "stressed out visitors the much needed opportunity to relax, escape, recharge their batteries, and generally appreciate a way of life that has been lost in the too-busy commercial environment of the globalizing, post-industrial Western world" (Royle 2001; Harrison 2001).

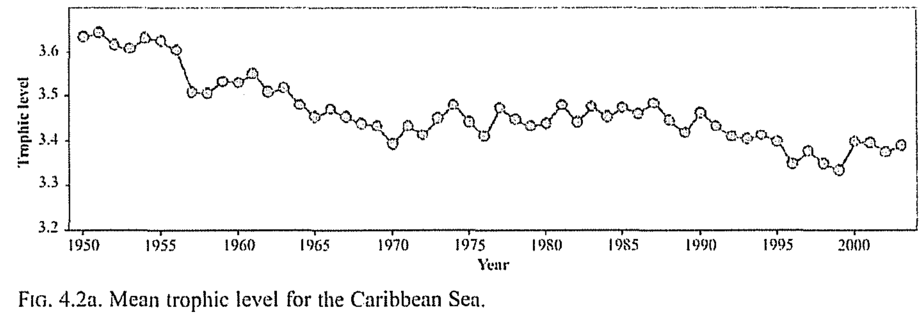


FIG. 4.2a. Mean trophic level for the Caribbean Sea.

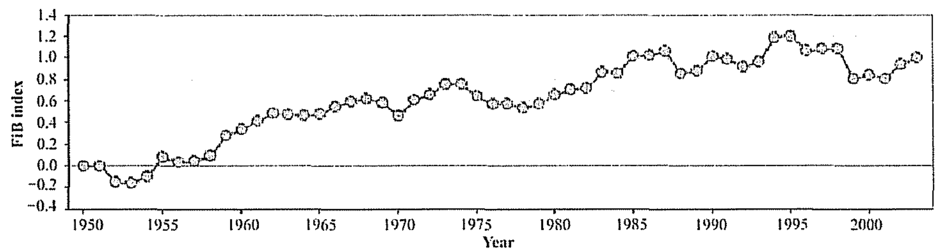


FIG. 4.2b. FIB index for the Caribbean Sea.
SOURCE: UBC Fisheries Centre. Sea Around Us Project 2006.
(http://www.seaaroundus.org/TrophicLevel/LMETrophicIndex.aspx?LME=12&FAO=0&country=Caribbean%20Sea)

Caribbean tourism conjures up images of sun-drenched, palm-fringed, white sandy beaches that epitomize the ideal symbol of paradise, rest, and relaxation.

4.2.2 Links between Tourism and Human Well-being

Recreation and tourism-related jobs and income are linked to the amenity value or cultural service provided by the Caribbean Sea ecosystem. As the fastest-growing economic activity in the region and, indeed, in many individual countries, the tourism sector contributes much by way of employment, foreign-exchange earnings, and, in some countries, important economic linkages with other sectors such as agriculture and construction. Tourism also has the potential to be the main engine of sustainable economic growth and development in many Caribbean islands.

To quantify the economic contribution made by tourism, new data and forecasts have been provided to CARSEA by Oxford Economic Forecasting (OEF). As shown in Tables 4.3 and 4.4, this analysis confirms the conclusion of the World Travel and Tourism Council (WTTC) in 2004 that relative to its size, the insular Caribbean is the most tourism-driven region in the world. In terms of jobs and export income, the contribution of tourism is nearly double that of the global average, and it accounts for more than a fifth of all capital investment in the region.

According to data from the Caribbean Tourism Organisation (CTO 2002) almost 25 million tourists travelled to destinations in the CARSEA region during the year 2000. The most popular destinations were Puerto Rico (3.3 million), Dominican Republic (3.0 million), Cancun (2.3 million), Cuba (1.8 million), Bahamas (1.6 million), and Jamaica (1.3 million). The total number of cruise-ship passenger arrivals in the Caribbean Sea was 14.6 million, with the most frequent ports of call being in the Bahamas (2.5 million), U.S. Virgin Islands (1.8 million), Cozumel (1.5 million), Puerto Rico (1.3 million), and Cayman Islands (1.0 million).

The number of rooms providing tourist accommodation in the CARSEA region (including Cancun, Cozumel, Venezuela, and Belize) increased from 122,000 in 1990 to almost 283,000 in 2000—an increase of more than 132% over the 10-year period. In 2000, the Dominican Republic

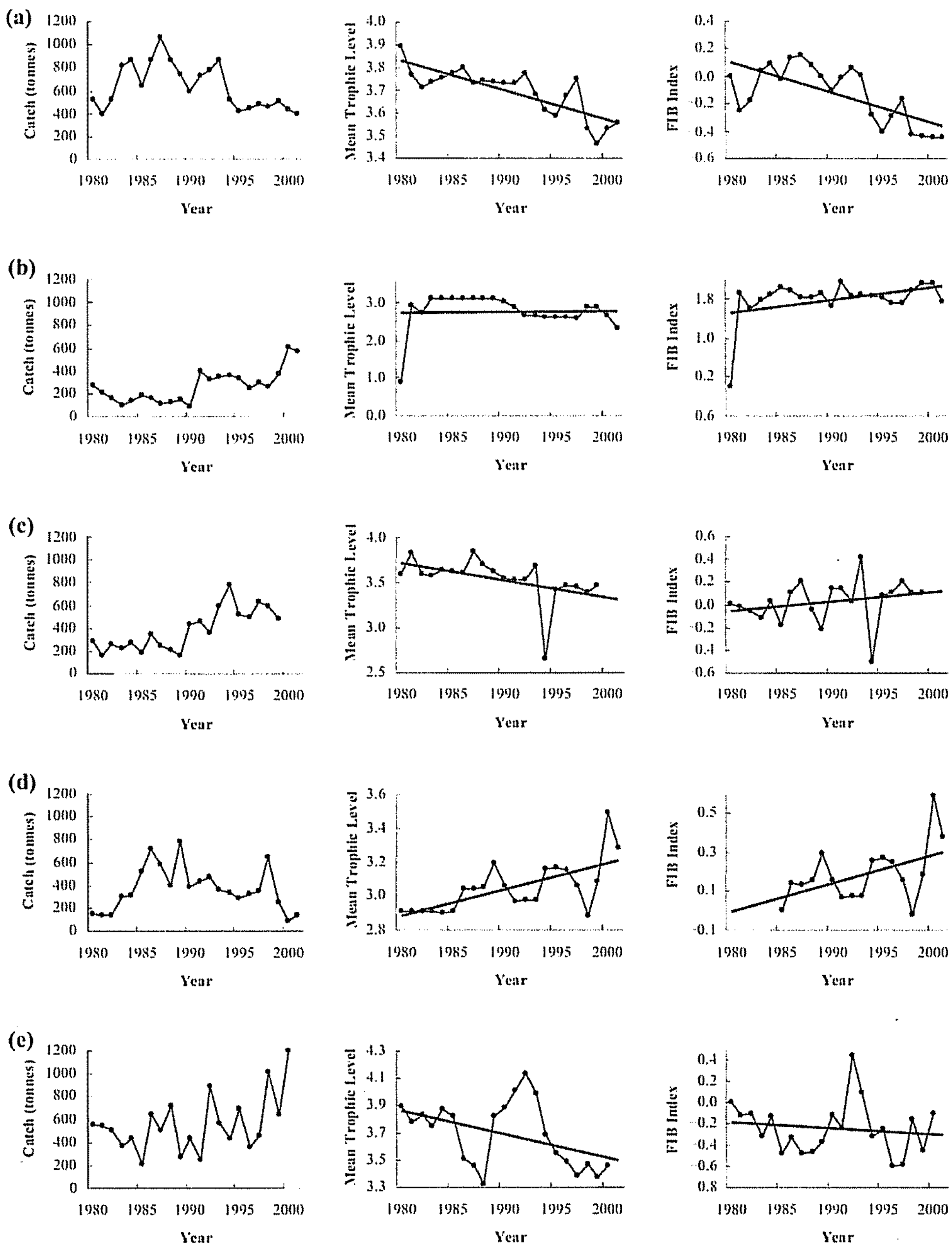


Fig. 4.3. Trends in annual catches and associated mean trophic level, and mean FIB index for islands of the south-eastern Caribbean: (*a*) Grenada; (*b*) St. Lucia; (*c*) St. Vincent; (*d*) Grenada and St Vincent Grenadines combined; and (*e*) Barbados.

TABLE 4.3 — Contribution of tourism to the economy of the insular Caribbean, relative to the global average, 2004 forecast

Tourism-related activities	Number/U.S. $ value for insular Caribbean	Percentage (%) of total, insular Caribbean	Global average, %
Jobs (direct and indirect)	2,416,500	15.5	8
Contribution to GDP	$28.4 billion	13	10
Exported services and merchandise	$19.0 billion	16.1	9
Capital investment	$7.4 billion	21.7	9

SOURCE: CARSEA/OEF.

TABLE 4.4 — Selected travel and tourism country rankings[1] forecasts for the Caribbean within the World Countries List 2004 and 2014

	2004	2014
Caribbean[2]	Relative size	Relative size
Personal & travel tourism	8	10
Government expenditures	1	1
Capital investment	1	1
Visitor exports	3	3
Economy GDP	1	1
Economy employment	1	1

[1]Total 13 regions (161 countries). Best is number 1, worst is number 13.
[2]Includes 23 insular Caribbean countries/territories. Adapted from World Tourism and Travel Council http://www.wttc.org/ (sub-menu: TSA Accounts, World Reports, Caribbean) accessed Aug. 17, 2004.

recorded the largest number of rooms (51,916), followed by Venezuela (33,149), Cancun/Mexico (25,434), and Jamaica (23,640).

The 2000 CTO data show the overwhelming statistical importance of U.S. visitors (50% of the total) and Europeans (25%). Some 6.5% of visitors are from Canada, 7% from the Caribbean, and 12% are classified as "Other." The dominance of U.S. tourists is consistent with the fact that tourist numbers are highest in destinations closest to the United States of America.

Cruise-ship arrivals represent the fastest-growing segment of the industry and will soon rival the hotel sector in bed/berth capacity (McElroy 2004). In their shore visits, cruise passengers provide a major source of direct income for small entrepreneurs such as taxi drivers and handicraft vendors, as well as the informal sector. This contribution to the development of entrepreneurial activity can be as important as that of the stay-over sector, whose link to the local economy is often limited by the enclave nature of the accommodation.

4.2.3 Driving Forces Impacting Caribbean Tourism

4.2.3.1 Climate Variability and Change

In its Third and Fourth Assessment Reports, the Inter-Governmental Panel on Climate Change (IPCC) cautioned that because many small islands are so heavily dependent on the tourism sector for their economic survival, adverse impacts on the industry, from climate change or other causes, would be of great concern to these countries (IPCC 2001; Mimura et al. 2007).

Since the tourism infrastructure of the Caribbean region is mostly located on the coast, an increase in the frequency and intensity of hurricanes represents a major threat to this essential service of the Caribbean Sea ecosystem. This is demonstrated by calculations of the losses to tourism income caused by recent storms.

In 1995, hurricanes Luis and Marilyn caused severe damage to hotel and other tourism properties in Antigua and Barbuda, leading to a 17% decrease in the number of tourist arrivals and adversely affecting employment and foreign exchange.[25] Similar experiences occurred in 1998 and 1999 with the passage of hurricanes Jose, Georges, and Lenny.[26] The cost associated with damage from Hurricane Gilbert in 1988 was in the region of J $25 million.[27] Hurricanes Georges and Mitch in 1998 affected Jamaica's tourism sector.[28] Hurricane Lenny in 1999 caused approximately U.S. $250,000 damage to tourism infrastructure in Dominica, mainly along the western coast.[29] Tourism arrivals in St. Kitts by air and sea were negatively affected by the passage of hurricanes Luis and Marilyn (1995), Georges (1998), and Jose (1999).[30]

The precise relationship between human-induced climate change and the frequency and intensity of tropical cyclones remains a matter for scientific debate. Figure 4.4 shows, however, that the Caribbean has recently been experiencing a phase of more frequent storms relative to the past 100 years. Current research also suggests that the coming decades are likely to witness an increase in the destructive power of hurricanes, associated with higher sea-surface temperatures.

Emmanuel (2005) defined an index for the potential destructiveness of hurricanes based on total release of power over the lifetime of the cyclone. This index is a better indication of tropical cyclone threat than storm frequency or intensity alone. Using this index, he found there had been a marked increase in both the frequency and severity of tropical cyclones since the mid-1970s, with a near doubling of power dissipation over the period of record. This trend is due to both longer storm lifetimes and greater storm intensities. The research also found a close correlation between net hurricane power and sea-surface temperature and suggested that future warming may lead to an upward trend in tropical cyclone destructive potential, and a substantial increase in hurricane-related losses in the 21st century.

[25] Government of Antigua and Barbuda. 2001. Antigua and Barbuda's Initial Communication on Climate Change. pp. 35. Available from http://unfcc.int/national_reports/non-annex_i_natcom/items/2979.php

[26] Government of Antigua and Barbuda. 2001. Antigua and Barbuda's Initial Communication on Climate Change. pp. 36-37. Available from http://unfcc.int/national_reports/non-annex_i_natcom/items/2979.php

[27] Government of Jamaica. 2000. Jamaica's Initial Communication on Climate Change. p. 72. Available from http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php

[28] Government of Jamaica. 2000. Jamaica's Initial Communication on Climate Change. p. 12. Available from http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php

[29] Commonwealth of Dominica. 2001. Commonwealth of Dominica's Initial Communication on Climate Change. p. 51. Available from http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php

[30] Government of St. Kitts – Nevis. 2001. St. Kitts – Nevis Initial Communication on Climate Change. p. 38. Available from http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php

4.2.4 Consequences of Trends in Tourism for the Caribbean Sea

As well as being highly dependent on the services provided by the Caribbean Sea ecosystem, the tourism industry has an important influence on its condition. Most tourism facilities in the Caribbean, for example, are located within 800 metres of the high-water mark and can disturb sensitive ecological processes provided by habitats such as reefs and mangroves (see Section 2; Crompton 1999).

The true impact of tourism on the environment can only be addressed if one takes into account its use of resources such as fresh water, land and energy, as well as the wastes and pollution generated by the tourism industry. Tourism is a major consumer of water, with many resorts showing water consumption 5 or 10 times higher than other residential areas (UNEP 1999; SEDU 2002). Of equal importance is the widespread transformation of coastal environments by the filling-in of wetlands as well as beach and coral-reef loss, for hotel and marina construction.

The growth of the cruise-ship sector presents challenges for the sustainability of Caribbean tourism for two principal reasons. The first relates to the concentration of the industry in the hands of a few companies based outside the region. Three operators, CARNIVAL, Norwegian Cruise Lines (NCL), and Royal Caribbean International accounted for nearly 90% of cruise capacity in 2004 (Wood 2004).

Secondly, from the environmental perspective, one of the major implications of this growth is the potential for increased pollution of the Caribbean Sea from effluent such as sewage and lubricants. It has been estimated that cruise ships contribute around 77% of all marine pollution worldwide. On a single voyage, a large cruise ship produces on average 210,000 gallons of sewage, 1,000,000 gallons of waste water, 125 gallons of toxic chemicals and hazardous waste, 8 tonnes of garbage, and 25,000 gallons of oil bilge water.

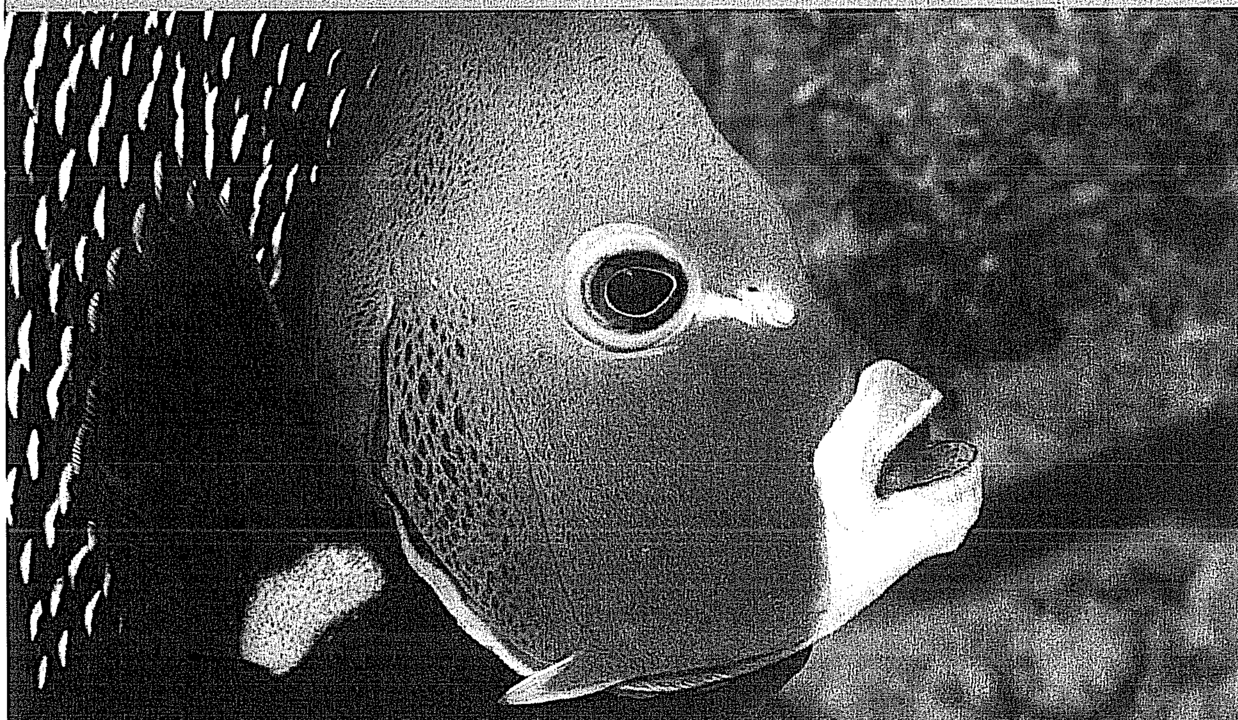
While relatively little data exist on cruise-ship pollution in the Caribbean Sea, particular cases of environmental damage have been recorded. They include the destruction of 300 acres of coral reef by cruise-ship anchors around George Town, Cayman Islands, and severe damage to 80% of a reef in a marine park off Cancun, Mexico, when a cruise ship ran aground.

Caribbean national and regional authorities have only limited capacity to prevent such damage to the ecosystem, as the "flag of convenience" regime enshrined in UNCLOS and other international agreements effectively insulates cruise ships from territorially based state and regional regulation.

Annex III

Burke and J. Maidens, *Arrecifes en Peligro en el Caribe,*
World Resources Institute, 2005
(extract: pages 1, 24-40)

The complete document is available at: www.wri.org/sites/default/files/pdf/arrecifesen_peligro.pdf



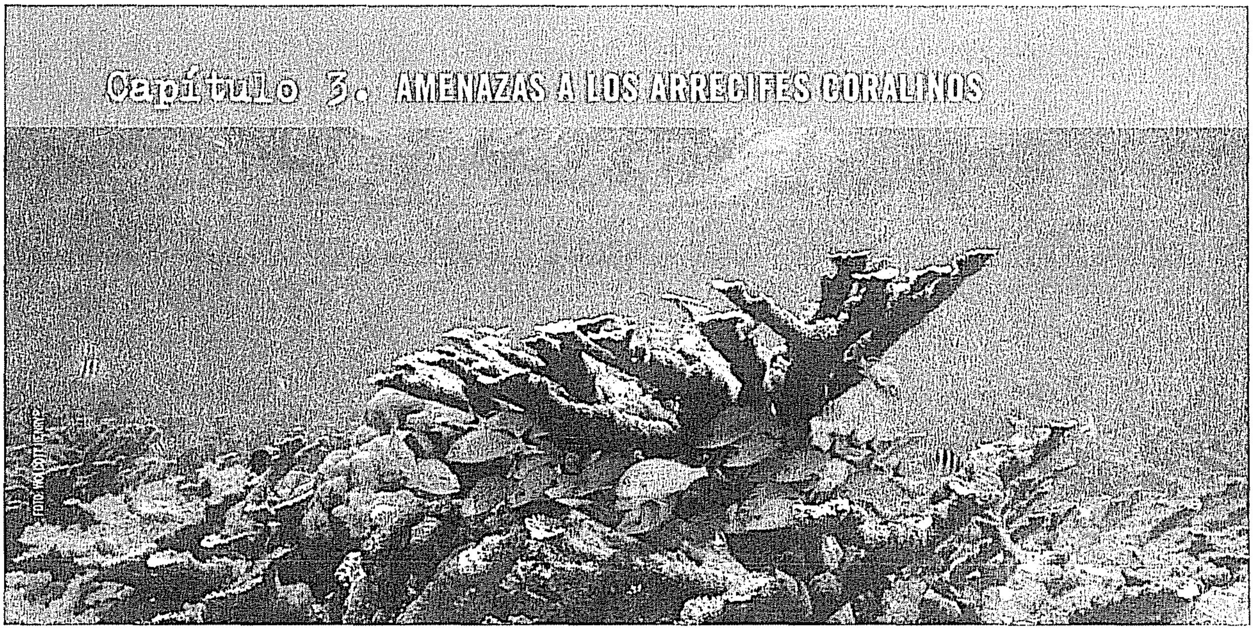
Arrecifes en Peligro

en el Caribe

LAURETTA BURKE

JONATHAN MAIDENS

Capítulo 3. AMENAZAS A LOS ARRECIFES CORALINOS



El crecimiento de la densidad de población y el desarrollo costero asociado al mismo, así como el incremento de las actividades pesqueras, agrícolas e industriales son las causas más importantes de las presiones sobre los arrecifes del Caribe. Las fuentes en sí no han cambiado en las últimas décadas, pero su intensidad si ha aumentado dramáticamente.[8] Por milenios, las comunidades arrecifales se adaptaron a muchas presiones naturales, tales como los huracanes, cuyos daños vienen seguidos por procesos de recuperación, pero ahora, se ha sumado una gran variedad de presiones humanas directas e indirectas. Actuando solas o en conjunto, estas presiones pueden conducir al estrés agudo o crónico de los ecosistemas, lo que resulta en la descomposición y pérdida de las comunidades de corales o en cambios más sutiles en la estructura de los ecosistemas, tales como el crecimiento excesivo de algas sobre los arrecifes. Los cambios de los arrecifes pueden ser graduales o rápidos, pero al final estos cambios hacen que el valor de sus bienes y servicios decaiga, por ejemplo, al disminuir los hábitats arrecifales que sostienen las pesquerías, o la protección costera que estos ofrecen.

La capacidad de los arrecifes de soportar presiones y recuperarse del daño de los disturbios varía considerablemente. Esto puede estar determinado en parte por factores ecológicos, como la propia composición por especies y conectividad con otros arrecifes. Por otra parte, el entorno físico (distancia de la tierra, profundidad, y velocidad del flujo del agua en el área) también influye sobre su vulnerabilidad. Caracterizar las presiones que actúan sobre cualquier arrecife es complicado ya que hay múltiples fuentes de estrés operando sobre varias escalas de espacio y tiempo.[9]

Este capítulo examina las cuatro amenazas regionales incluidas en el modelo de Arrecifes en Peligro del Caribe: desarrollo costero, sedimentación y contaminación desde fuentes terrestres, amenazas de origen marino, y sobrepesca. Además, se analizan los problemas del cambio climático (incluido el blanqueamiento de corales) y las enfermedades de corales. Se sugieren remedios aplicables a toda la región del Caribe para cada una de estas amenazas. El capítulo concluye con la integración de estos cuatro tipos de amenazas en el índice general de amenaza de Arrecifes en Peligro, el cual intenta representar la amenaza acumulativa de los arrecifes coralinos a partir de estas cuatro categorías clave. En el Capítulo 4 se vinculan estas proyecciones de amenazas a nivel de la región con cambios ambientales observados en los arrecifes y las respuestas de manejo en nueve subregiones del Caribe.

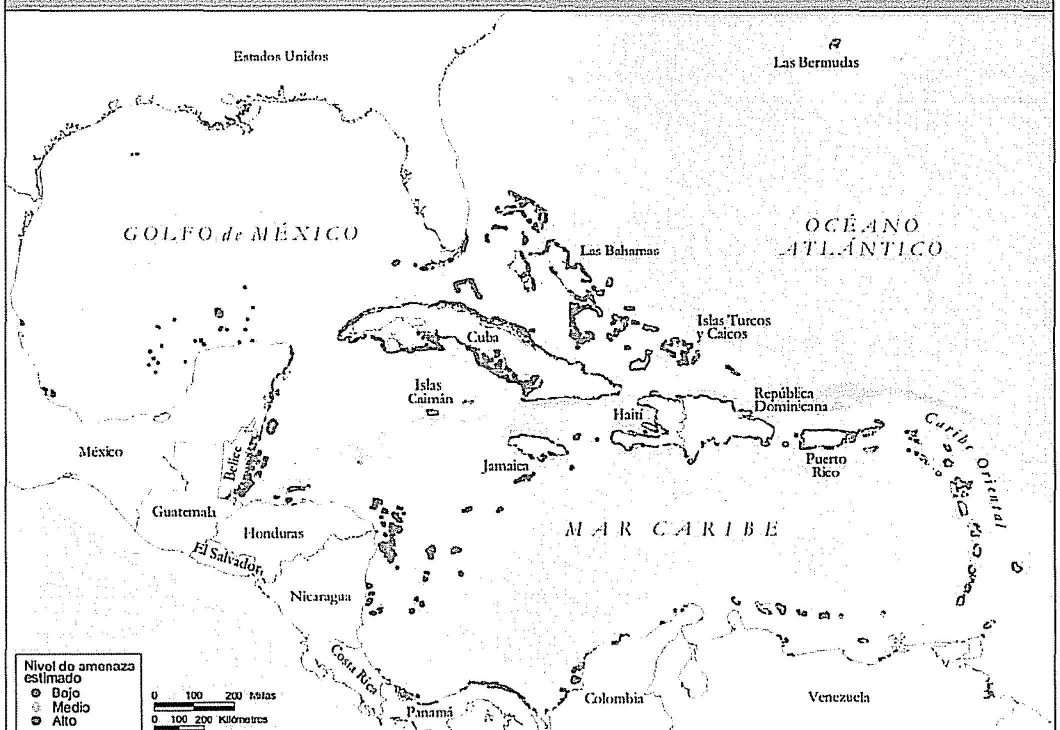
DESARROLLO COSTERO

El número estimado de personas que viven dentro de 10 km de la costa en el Caribe creció de 36 millones en 1990, a 41 millones en el 2000.[10] Cerca de 36% de los arrecifes caribeños están ubicados dentro de 2 km de distancia de tierras habitadas y por eso son altamente susceptibles a las presiones que se derivan de la actividad humana.[11] El desarrollo extensivo ha generado la construcción de viviendas, carreteras, puertos y otros para sostener la población residencial y turística.

El desarrollo mal manejado somete a los arrecifes coralinos a estrés por daño directo del dragado, los rellenos de tierra, y la minería de arena y cal para la construcción, así como por presiones menos directas, como son el escurrimiento desde sitios de construcción y la eliminación de hábitats costeros. La pérdida de manglares y pastos marinos, filtradores de sedimentos y nutrientes que vienen de tierra, se han extendido por el Caribe[12] y contribuye a la presión. El aumento de sedimentos en las aguas costeras reduce la cantidad de luz que llega a los corales y dificulta la capacidad de sus algas simbióticas (*zooxantelas*) para fotosintetizar.[13]

Además, la extensa descarga de aguas residuales no tratadas es una fuente muy importante de nutrientes que ingresan en las aguas costeras. Los arrecifes coralinos florecen en aguas casi desprovistas de nutrientes, y un incremento de la concentración de éstos promueve el crecimiento de las algas a expensas de los corales.[14] Aunque la información es incompleta, los datos sugieren que menos de 20% de las aguas residuales generadas dentro de la región del Caribe son tratadas de forma apropiada.[15] La descarga de aguas servidas es un problema en los países en desarrollo, pero también lo es en los Cayos de la Florida, donde la filtración de fosas sépticas, y las descargas al océano de aguas residuales con tratamiento secundario a través de emisarios submarinos contribuyen a la acumulación de nutrientes.[16]

MAPA 2: ARRECIFES AMENAZADOS POR EL DESARROLLO COSTERO



Las amenazas del desarrollo costero a los arrecifes fueron estimadas tomando como base la distancia desde ciudades, puertos, aeropuertos y centros de buceo, así como la densidad de población, crecimiento poblacional, y crecimiento del turismo en el área. Para los arrecifes dentro de áreas marinas protegidas, se incluyó la efectividad del manejo como un factor que mitiga el estrés. (*Ver el Recuadro 3 en el Capítulo 4 y la Tabla A5 en el Apéndice A.*)

Fuente: WRI, *Arrecifes en Peligro en el Caribe*, 2004 (*ver Apéndice B*).

Otra fuente de disminución de la calidad del agua es el escurrimiento de aceite de motor y otros residuales desde las carreteras. La contaminación industrial de las refinerías de petróleo, fábricas de azúcar, destilerías, cerveceras, procesadoras de alimentos, y las industrias papelera y químicas, causan también inquietud.[17]

En años recientes, la región caribeña ha estado sufriendo un crecimiento masivo del turismo, un sector de notable importancia para la economía regional. Un desarrollo del turismo bien planificado puede tener un mínimo impacto, e incluso un efecto neto positivo sobre los arrecifes coralinos, pero éste es raramente el caso. El turismo no planificado o pobremente regulado puede aniquilar los arrecifes. Las actividades turísticas pueden producir tanto daños físicos directos (tales como los ocasionados por buceadores y anclas) como impactos indirectos por el desarrollo y operación de centros turísticos (contaminación por aguas residuales no tratadas). El desarrollo de infraestructura turística (construcción de puertos, aeropuertos y hoteles) también se hace sentir sobre los arrecifes coralinos. Muchos de estos disturbios son similares a los causados por el desarrollo costero de forma general, pero el turismo es diferente porque se mueve frecuentemente hacia nuevas áreas no desarrolladas, apartadas de los desarrollos urbanos existentes.

Resultados de la modelación. El indicador del modelo que refleja la amenaza de desarrollo costero —incorpora la presión estimada de la descarga de aguas residuales, el escurrimiento urbano, la construcción y el desarrollo del turismo— mostró que cerca de un tercio de los arrecifes de la región está amenazado (ligeramente más de 15% se calificó como de amenaza media, y la misma cantidad como de amenaza alta). La presión del desarrollo costero fue identificada como importante a lo largo de las costas de la mayoría de las Antillas Mayores, el Caribe oriental, las Islas de la Bahía en Honduras, y a lo largo de parte de los Cayos de la Florida, Yucatán y el Caribe Sur. Las áreas identificadas como de amenaza más baja del desarrollo costero fueron las Bahamas, las Islas Turcos y Caicos, y Cuba (*ver Mapa 2*).

Remedios. Los impactos del desarrollo costero sobre los arrecifes coralinos pueden ser minimizados de diferentes formas. Un mejor planeamiento puede asegurar la protección de importantes hábitats al prevenir el dragado o construcción cerca de hábitats sensibles y valiosos (tales como humedales, manglares y pastos marinos). La existencia de normas para las actividades de construcción e ingeniería también puede ayudar a reducir la amenaza. Las inversiones en construcción y mantenimiento de sistemas de tratamiento de aguas residuales en poblados y áreas turísticas


FOTO: JON MADEIIS

Donde ocurre y cómo se maneja el desarrollo costero, influye grandemente en el grado de impacto a los arrecifes coralinos.

pueden reducir la descarga de esas aguas al mar. La aplicación de medidas legales innovadoras que aseguren la responsabilidad y el pago por la disposición y tratamiento de residuales, y la exigencia de intervenciones "sin pérdidas netas" en ecosistemas sensibles, pueden ayudar a modificar el diseño de edificaciones y promover el desarrollo de infraestructura compatible con la protección ambiental.

El turismo toma muchas formas (turismo de masas, pequeños hoteles, instalaciones "ecológicas") y puede aportar una gran variedad de beneficios a la población local.[18] La propiedad de una instalación turística, las fuentes de alimentos y bebidas (locales o importadas), y las reglamentaciones de impuestos, inciden en el grado en que una comunidad local se beneficia del turismo. Además, el diseño y desarrollo del centro turístico, las fuentes y uso de la energía, y el grado del tratamiento de las aguas residuales, todos influyen sobre el impacto ambiental de dicho centro. Determinar la capacidad de carga del área y del propio arrecife, como parte del proceso de planeamiento del desarrollo, puede ayudar a asegurar que el desarrollo turístico reporte el máximo beneficio a las comunidades locales a la vez que se minimizan los impactos nocivos al ambiente. Los esquemas de certificación, acreditación y premios basados en logros reales (y no en promesas de que lo lograrán) de buenas prácticas ambientales por hoteles y operadores de buceo y turismo, brindan incentivos para un desarrollo compatible con el ambiente. La educación de los turistas, especialmente enseñar a los buceadores de tanque y equipo ligero a no dañar los arrecifes, es esencial para reducir los impactos. Los turistas pueden contribuir financieramente a los esfuerzos de recuperación y manejo a través del pago de entrada a los parques o mediante donaciones.

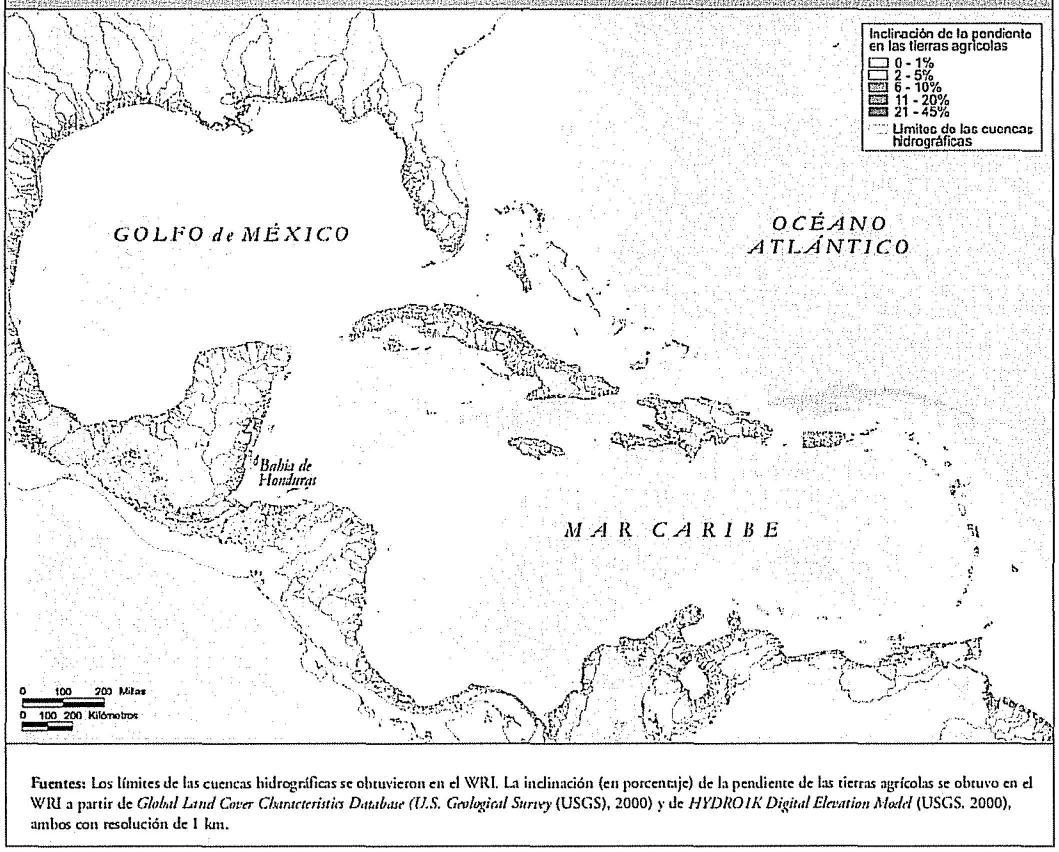
SEDIMENTACIÓN Y CONTAMINACIÓN DESDE FUENTES TERRESTRES

La agricultura, aunque importante para el desarrollo económico y la seguridad alimentaria, es una fuente de incremento de escurrimiento de sedimentos, nutrientes y plaguicidas. La conversión de tierras a la agricultura incrementa la erosión del suelo y el aporte de sedimentos a las aguas costeras. En áreas donde la agricultura coincide con pendientes abruptas y fuerte precipitación, la erosión del suelo puede ser extrema. Este análisis clasificó cerca de un cuarto de las áreas que drenan al Caribe como territorio de uso agrícola.[19] El Mapa 3 muestra las tierras agrícolas por categorías de pendiente. Varias cuencas hidrográficas fueron identificadas como áreas de riesgo de erosión particularmente alto: en México (las que descargan al Golfo de México), en Guatemala y Honduras (las que desaguan a la Bahía de Honduras), y en Colombia, el este de Jamaica, Haití y Puerto Rico (las que drenan al Mar Caribe).

El aumento de la liberación de sedimentos a las aguas costeras causa un notable estrés a los ecosistemas costeros: entorpece el paso de la luz necesaria para la fotosíntesis, pone en peligro la supervivencia de los corales juveniles debido a la pérdida de substrato adecuado y, en casos extremos, conduce a la asfixia completa de los corales. El daño a los arrecifes coralinos por sedimentación se ha documentado en las costas de Panamá, Costa Rica y Nicaragua, entre otras localidades.[20]

El escurrimiento de fertilizantes y de estiércol de ganado desde campos agrícolas es una fuente importante de nutrientes (especialmente nitrógeno y fósforo) que ingresan a las aguas costeras. Algunos de los cultivos más importantes de la región —caña de azúcar, cítricos, bananos, granos y café— requieren grandes aportes de fertilizantes y plaguicidas.[21] Por ejemplo, la tasa promedio de aplicación de fertilizantes para plantaciones de banano es 479 kg/ha por

MAPA 3: TIERRAS AGRÍCOLAS POR CATEGORÍA DE PENDIENTE



Fuentes: Los límites de las cuencas hidrográficas se obtuvieron en el WRI. La inclinación (en porcentaje) de la pendiente de las tierras agrícolas se obtuvo en el WRI a partir de *Global Land Cover Characteristics Database (U.S. Geological Survey* (USGS), 2000) y de *HYDRO1K Digital Elevation Model* (USGS, 2000), ambos con resolución de 1 km.

temporada de cultivo.[22] La descarga de nutrientes en las aguas costeras es una causa muy importante de eutrofización, especialmente en áreas de poco flujo, y puede provocar florecimientos de algas, cambios en la estructura de las comunidades acuáticas y disminución de la diversidad biológica. La presencia de algas sobre el substrato puede inhibir la colonización por larvas reclutas, iniciando así una disminución de la cobertura de coral vivo y un aumento del recubrimiento algal o de otras cubiertas vegetales. En casos extremos, los elevados niveles de nutrientes producen "zonas muertas" debido al agotamiento masivo del oxígeno en las aguas ricas en nutrientes. Tales zonas aparecen regularmente frente al Delta del río Mississippi, y se han registrado eventos menores a lo largo de buena parte de la costa de la Florida.[23] Donde estos eventos coinciden con arrecifes coralinos, los resultados pueden ser devastadores. Un evento aislado en Venezuela en 1996 condujo a la muerte de casi todos los organismos en varios kilómetros cuadrados.[24]

La acumulación de plaguicidas tóxicos en organismos costeros es otro aspecto de la amenaza del escurrimiento agrícola. Los impactos negativos incluyen el daño a los pastos marinos por herbicidas, y cambios en la estructura de las comunidades arrecifales, tales como pérdida de cobertura de coral vivo e incremento de algas y esponjas.[25] Los efectos ambientales del escurrimiento de plaguicidas dependen del compuesto químico empleado, la cantidad aplicada, la forma en que está dispuesto el campo agrícola (incluyendo la cubierta vegetal, pendiente y drenaje) y la presencia de zonas de amortiguamiento a lo largo de ríos y arroyos.

Resultados de la modelación. El análisis de más de 3.000 cuencas hidrográficas de toda la región[26] identificó aguas costeras con muchas probabilidades de experimentar aportes crecientes de sedimentos y contaminantes relacionados con actividades del uso del territorio. Aproximadamente 9.000 km^2 de arrecifes coralinos (cerca de un tercio del total regional) fueron identificados como amenazados (cerca de 15% con nivel medio de amenaza, y 20% con nivel alto). Se identificaron áreas con una gran proporción de arrecifes amenazados en Jamaica, La Española, Puerto Rico, Panamá, Costa Rica y Colombia. Algunos arrecifes en el oriente de Cuba fueron identificados como amenazados, al igual que los arrecifes cercanos a la costa en Belice, Venezuela, y los de las islas montañosas del Caribe oriental (*ver Mapa 4*).

Remedios. El planeamiento y manejo agrícola sostenibles fomentan prácticas de conservación del suelo y el agua que protegen los arrecifes coralinos por medio del control de la erosión de los campos de cultivo y el escurrimiento superficial del agua. La creación de terrazas ayuda a evitar el escurrimiento excesivo de la labranza sobre pendientes abruptas. Las prácticas óptimas en la roturación, aplicación de fertilizantes, y cosecha reducirán aún más la pérdida tanto del suelo como de nutrientes, mientras que la reforestación cerca de ríos y arroyos ayuda a reducir la erosión. Los fertilizantes y plaguicidas pueden ser empleados de maneras que minimicen su escape y transporte a las áreas costeras.

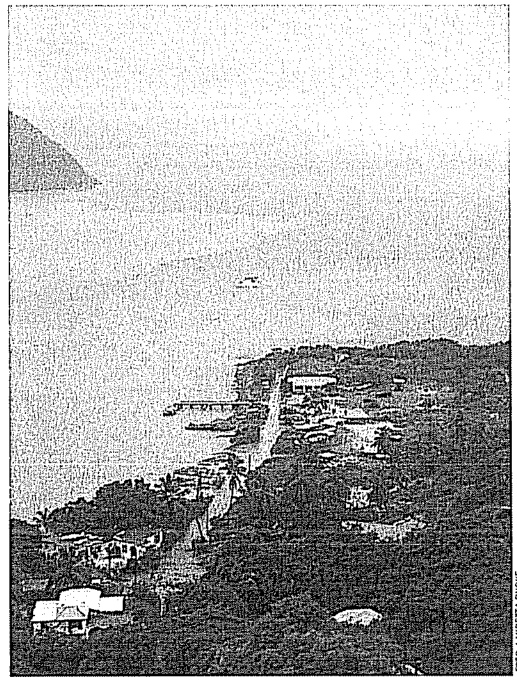
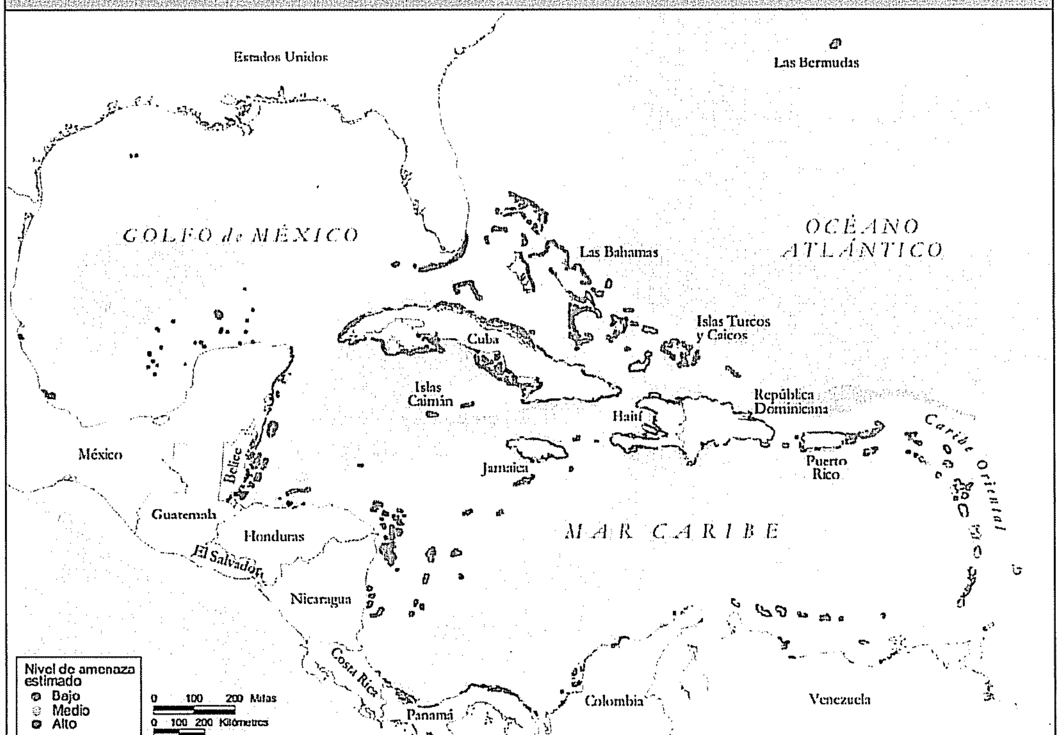


FOTO: LAURETTA BURKE

La construcción de caminos y viviendas en terrenos de gran pendiente, puede provocar una enorme erosión en eventos de intensa lluvia.

En áreas sensibles donde hay recursos costeros particularmente importantes, el establecimiento de regulaciones más fuertes sobre prácticas agrícolas puede ayudar a proteger los arrecifes y los medios de vida de las poblaciones costeras. En otras áreas, añadir impuestos por contaminación al costo de los compuestos agroquímicos en los puntos de venta puede reducir su uso desmesurado. La conservación de los humedales costeros, manglares y pastos marinos cerca de desembocaduras de ríos mitigaría impactos dañinos al filtrar sedimentos y nutrientes del agua antes de que lleguen a los arrecifes coralinos.

MAPA 4. ARRECIFES AMENAZADOS POR SEDIMENTACIÓN Y CONTAMINACIÓN DESDE FUENTES TERRESTRES



Las amenazas sobre los arrecifes de la sedimentación y contaminación desde fuentes terrestres fueron modeladas para más de 3.000 cuencas que descargan en el Caribe. El modelo incorpora estimados de tasa relativa de erosión a través del paisaje (basada en la pendiente, tipo de uso del territorio, precipitación durante el mes más lluvioso, y tipo de suelo) resumidos por cuenca hidrográfica, para estimar el aporte total de sedimentos en las desembocaduras de los ríos. La dispersión de la pluma de sedimentos fue estimada como una función de la distancia a las desembocaduras de los ríos y calibrada con impactos observados de sedimentación en los arrecifes coralinos.

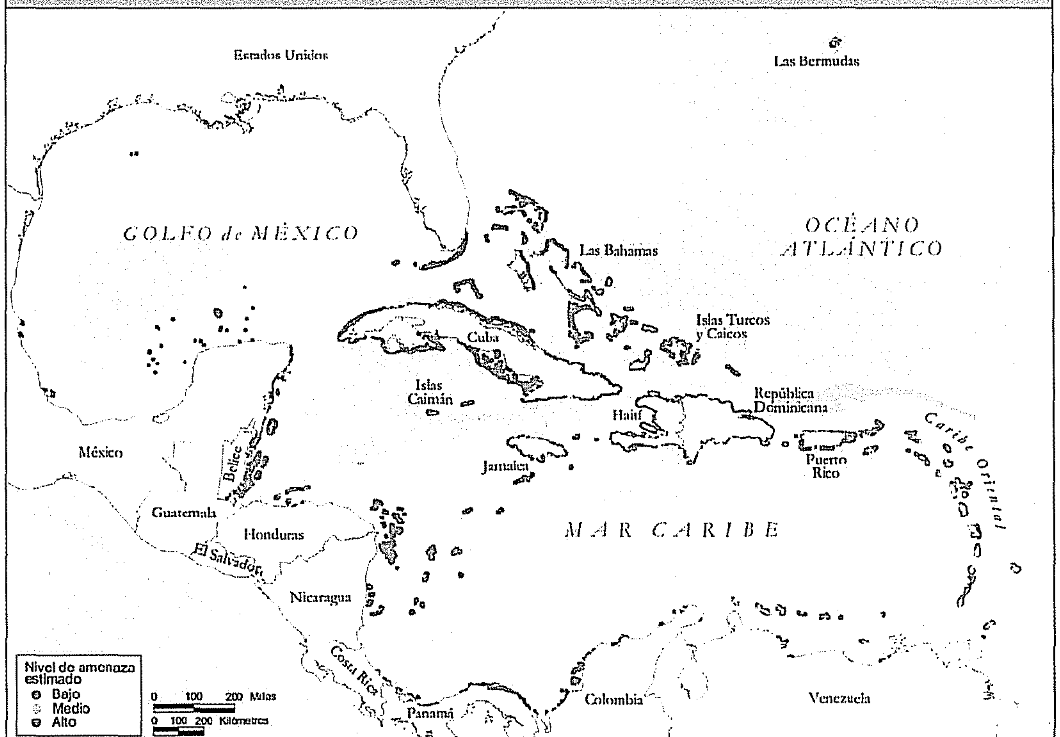
Fuente: WRI, *Arrecifes en Peligro en el Caribe*, 2004 (*ver Apéndice B*).

FUENTES DE AMENAZAS DE ORIGEN MARINO

En la región del Caribe hay gran preocupación por las fuentes de contaminación que se producen en el mar. Las actividades que dan lugar a ese tipo de contaminación incluyen las descargas de petróleo y de aguas residuales, de lastre y de sentina, y el vertimiento de basura y otros desechos humanos desde embarcaciones. Hay daños directos por varamientos y anclajes, particularmente en áreas de gran visitación. Las anclas pueden devastar los arrecifes coralinos. El ancla de un gran buque de crucero y su cadena pueden pesar 4.5 tm. Incluso en un mar tranquilo, el anclaje imprudente puede dañar hasta 200 m² de fondo marino.[27]

La mayoría de las embarcaciones pequeñas, incluyendo las de pesca, las privadas de recreo, y las de buceo permanecen en aguas costeras, pero muchas otras, incluyendo las de transporte comercial y de petróleo, y los cruceros, se entrecruzan en el Caribe en una trama intrincada. El Caribe también es un área productora de petróleo, y la mayor parte de éste se transporta dentro de la región. Las áreas más vulnerables a los accidentes de derrame son las adyacentes a puertos o canales reservados para el tráfico de buques cisterna. Sin embargo, las fugas accidentales de petróleo son una fuente relativamente pequeña de contaminación, comparadas con la cantidad de petróleo que ingresa al ambiente

MAPA 5. ARRECIFES AMENAZADOS POR ACTIVIDADES EN EL MAR



Las amenazas por fuentes de origen marino fueron evaluadas tomando como base la distancia a los puertos (estratificados por tamaño), intensidad de la visitación de buques de crucero, y la distancia a infraestructuras, e instalaciones de procesamiento y oleoductos de petróleo y gas.

Fuente: WRI, *Arrecifes en Peligro en el Caribe*, 2004 (*ver Apéndice B*).

por el vertimiento de agua de sentina y de lavado de los tanques de buques, y por el mantenimiento de rutina de las plataformas petroleras y oleoductos.[28] El petróleo daña los tejidos reproductores de los corales y las zooxantelas, inhibe el reclutamiento de juveniles, y reduce la resiliencia de los arrecifes a otros factores de estrés.[29] La descarga de agua de sentina o de lastre desde buques, libera una mezcla nociva de petróleo, nutrientes, especies marinas exóticas, y otros contaminantes. Las mareas y las corrientes disipan en tiempo y espacio gran parte de esta contaminación, pero ésta a menudo persiste en áreas confinadas, y en aguas tranquilas con menor circulación e intercambio.

Los buques de crucero también son una fuente importante de contaminación en el Caribe. Un buque de crucero típico genera un promedio de 8 tm (2.228 galones) de agua aceitosa de sentina[30] y 1 tm de basura[31] cada día. El volumen del turismo de crucero casi se ha cuadruplicado en los últimos 20 años[32] y la industria cuenta en el Caribe con cerca de 58% de los pasajeros de crucero del mundo.[33] De acuerdo con estimados recientes de la organización The Ocean Conservancy, 25 millones de días-cama de pasajeros sobre buques de crucero en el Caribe generaron un estimado de 90.000 tm de residuales en el 2000.[34]

Los desperdicios generados por embarcaciones son una fuente muy importante de residuales sólidos en las áreas costeras.[35] En la campaña 2003 "A limpiar la costa" de The Ocean Conservancy, participaron más de 55.000 personas en el Caribe. Esta operación retiró más de 1.200 tm de basura a lo largo de 2.100 km de costa.[36]

En zonas de intensa visitación existe una gran preocupación por la descarga de aguas residuales provenientes, tanto de buques de crucero como por el creciente número de yates. Los grandes barcos tienen tanques retenedores de aguas residuales y el Anexo IV de MARPOL prohíbe descargar esas aguas no tratadas a menos de 7 km de la tierra más cercana.[37] Los barcos de cabotaje y las embarcaciones de recreo, carecen muy probablemente de tanques retenedores. Debido a la falta de instalaciones de recepción de residuales en los puertos de la mayoría de los países del Caribe, estas embarcaciones pequeñas tienen más probabilidades de descargar sus aguas residuales en marinas y aguas cercanas a la costa que los barcos grandes.[38] En el caso de las embarcaciones de recreo, estas descargas pueden tener lugar muy cerca de los arrecifes coralinos.

Resultados de la modelación. Muchas de las pequeñas islas de la región fueron calificadas de amenaza alta por fuentes de contaminación de buques y de otras actividades marítimas. Se estimó que la amenaza es alta en Santa Lucía, Montserrat, Saint Kitts y Nevis, Antillas Holandesas (incluyendo Aruba), Islas Vírgenes y Bermudas. Además, en Puerto Rico, República Dominicana, Jamaica y Panamá se identificaron varios arrecifes amenazados (*ver Mapa* 5). En general, el análisis mostró que cerca de un 15% de los arrecifes de la región están amenazados por fuentes de contaminación originadas en el mar (cerca de 10% con amenaza media, y alrededor de 5%, con amenaza alta).

Remedios. El desarrollo de un marco regulatorio puede inducir el establecimiento en los puertos de instalaciones de recepción y manejo de residuales de las embarcaciones. Esto es esencial para los buques de crucero, los cuales contribuyen con un estimado de 77% de los residuales de todos los tipos de embarcaciones, comparado con un 20% de los provenientes de cargueros.[39] El desarrollo de una legislación para incorporar los convenios internacionales sobre la prevención de la contaminación desde embarcaciones (MARPOL, London Dumping, OPRC, CLC, y FUND, ver *Notas* para los nombres completos de estos acuerdos)[40] ayudará en gran medida a reducir esta amenaza. La contaminación desde pequeñas embarcaciones como los yates, también puede ser atendida a través de regulaciones y normas, mientras que la educación ambiental de los propietarios de embarcaciones ayuda a cumplir con lo establecido. Mas aún, la suspensión del uso de anclas en todos los arrecifes coralinos y pastos marinos es crucial, con una alta prioridad en las áreas donde el tráfico marítimo actual es elevado. El uso de boyas de amarre o zonas de anclaje debe ser promovido como una alternativa.

SOBREPESCA

En la región del Caribe, la pesca ha sido siempre un pilar fundamental de las comunidades costeras, particularmente en los estados insulares. Las pesquerías en arrecifes coralinos —predominantemente artesanal, de pequeña escala y de subsistencia— son una fuente barata de proteína y proveen empleo donde existen pocas alternativas. En áreas turísticas, muchos peces son vendidos directamente a los restaurantes locales. Para países como Belice y las Bahamas, el mercado de exportación de especies arrecifales como los pargos, meros, la langosta espinosa y el caracol (también conocido como cobo, botuto o lambí) genera millones de dólares para la economía nacional, cumpliendo la demanda de países que se encuentran lejos de estas fuentes tropicales.[41]

El acceso abierto a las pesquerías de arrecifes, usualmente con pocas regulaciones, hace a los peces arrecifales particularmente susceptibles a la sobreexplotación. Debido a que la mayoría de los arrecifes están cerca de la costa y geográficamente confinados, la distribución de los peces es altamente predecible en tiempo y espacio.[42] Las trampas portátiles de peces (nasas), el arte de pesca más ampliamente usado en el Caribe, son baratas y efectivas.[43] Lamentablemente, dichas trampas pueden ser también destructivas y despilfarradoras: destructivas cuando los pescadores las dejan caer directamente sobre el arrecife, rompiendo los corales, y despilfarradoras cuando se pierden en el agua y continúan capturando peces durante varios meses o años, fenómeno conocido como pesca fantasma. El ciclo de vida de los peces de arrecife también los hace vulnerables a la presión pesquera. Los pescadores eliminan selectivamente los organismos más grandes debido a su mayor valor, y un signo típico de sobrepesca es la disminución del tamaño promedio de los peces a los cuales está dirigida la operación de pesca. Como los individuos más grandes tienen el mayor rendimiento reproductivo, eliminarlos de la población reduce su capacidad natural de reposición.[44]

Otra forma particularmente nociva de sobrepesca en el Caribe es pescar en las agregaciones de desove. En varias de las especies mayores de meros y pargos, individuos provenientes de áreas que abarcan cientos de kilómetros cuadrados, se congregan una o dos veces al año en localidades conocidas para desovar en grandes cantidades. Cuando los pescadores conocen la ubicación de tales agregaciones de desove, pueden extraer la población desovadora en el término de unas pocas noches.

En sistemas arrecifales fuertemente pescados, los peces grandes y valiosos —tales como los meros y pargos— se hacen tan escasos que los pescadores empiezan a pescar especies de menor valor[45] (lo que se conoce como "pescar cuesta abajo en la trama alimentaria"). Por ejemplo, en

Bermudas los peces herbívoros (como los loros, cirujanos, y balístidos) se incrementaron desde menos de 1% de la captura, en los años 60s, a 31% en los 1990s. Este cambio condujo a la prohibición de las trampas de peces en 1990, lo que aún sigue en vigor.[46]

La sobrepesca no sólo afecta el tamaño de las poblaciones pesqueras, sino que puede conducir a cambios muy importantes, directos e indirectos, en la estructura de las comunidades, tanto la de peces como la del arrecife en su conjunto.[47] En la competición entre corales y algas por el espacio, los peces herbívoros ayudan a controlar las algas, de ahí que favorezcan el crecimiento y reclutamiento de corales.[48] Cuando los herbívoros son extraídos, las algas pueden florecer y la cobertura de corales se reduce. Este efecto es evidente en la secuencia de eventos que condujo a la dramática degradación de los arrecifes de Jamaica (*ver Recuadro 2*). La sobrepesca puede llevar a pérdidas de biodiversidad en un corto plazo y la desaparición de las especies que desempeñan un papel importante en los ecosistemas, pero también puede disminuir la resiliencia de los arrecifes a otras amenazas.

Resultados de la modelación. El índice de Arrecifes en Peligro para la amenaza de sobrepesca permitió identificar áreas densamente pobladas y áreas donde las plataformas costeras son estrechas (tales como las del Caribe oriental) como sometidas a una amenaza alta, al suponer la existencia de gran cantidad de pescadores en un área relativamente pequeña de pesca (*ver Mapa 6*). El análisis estimó que la presión de pesca es menor en las Bahamas, donde la población humana es pequeña. En el Caribe occidental y Cuba, donde muchos arrecifes están lejos del territorio principal, el análisis también consideró la amenaza como baja.

Debe notarse que este indicador no recoge la presión de pesca de localidades más remotas, ni de la pesca ilegal (*ver Capítulo 2 - "Limitaciones del análisis" y Tabla 1*). En la región en su conjunto, el estudio identificó cerca de 60% de los arrecifes como amenazados por sobrepesca (con cerca de 30% bajo amenaza media, y 30% como alta). Las prácticas destructivas de pesca (por ejemplo, el uso de dinamita o cianuro) no fueron evaluadas en el Caribe, ya que su uso es raro en la región. Hay que destacar el impacto destructivo de la pesca con trampas y la pérdida de redes de pesca que se enredan en los arrecifes. Las afectaciones de estos tipos de pesca deben seguir de manera general el patrón de presión de pesca de las trampas.

Remedios. El manejo efectivo de los recursos costeros es crucial, especialmente a lo largo de costas densamente pobladas. Una pesca menos intensa permitirá la recuperación de los recursos pesqueros hasta un nivel en que la captura se equilibra con la reposición natural de la población.[49] Los incentivos financieros y de otro tipo pueden fomentar las prácticas de pesca sostenibles, mientras que las multas y penalizaciones pueden desalentar la pesca ilegal y otras infracciones de las prácticas sostenibles. La aplicación de un sistema de otorgamiento de licencias a pescadores ayuda a limitar el acceso a pesquerías que actualmente son vulnerables a la sobrepesca. También pueden establecerse sistemas legales para restringir la captura de especies sobrepescadas, tales como la prohibición de toda extracción de caracol,

RECUADRO 2. LOS ARRECIFES DE JAMAICA: ¿DE VUELTA DESDE EL FILO DEL ABISMO?

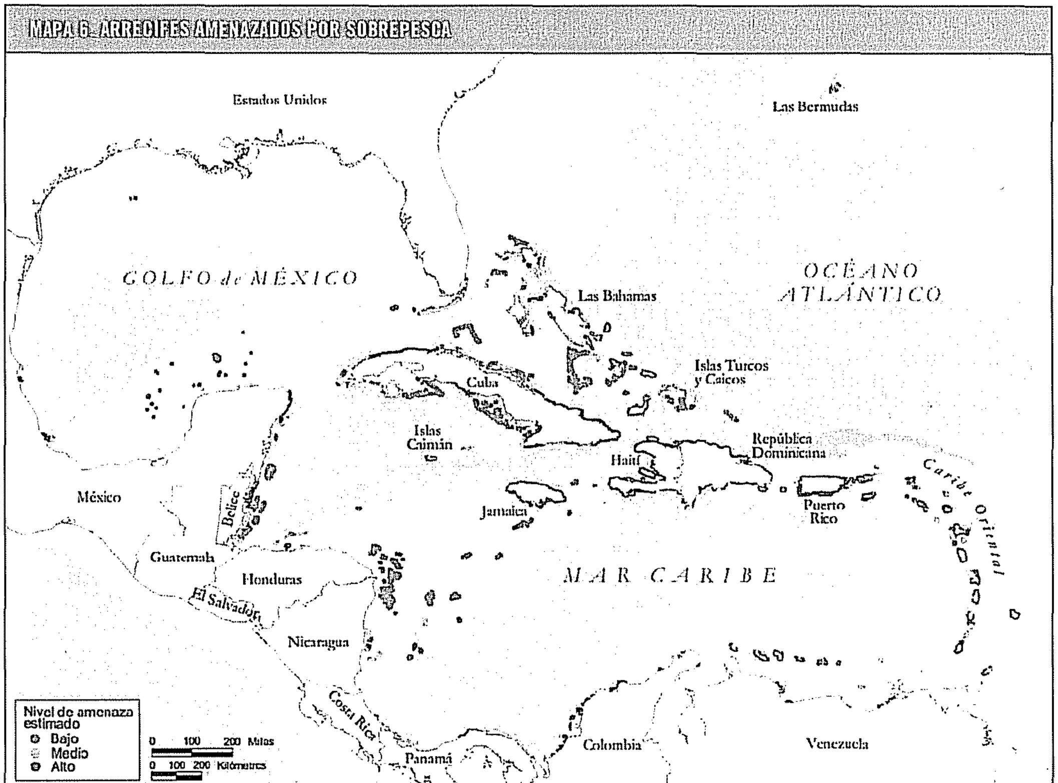
La sobrepesca en aguas de Jamaica puede ser recapitulada desde hace 100 años, con la captura no sólo de grandes depredadores sino también de la mayoría de los peces herbívoros que se alimentan de algas. Esto redujo la resiliencia del ecosistema arrecifal, y lo hizo muy dependiente de una sola especie para mantener controlados los niveles de algas, el erizo negro de espinas largas. Los arrecifes se destrozaron durante el Huracán Allen en 1980, pero empezaron a recuperarse lentamente, con el pastoreo de los erizos desempeñando un importante papel en el control de las algas y el establecimiento de nuevos corales. Posteriormente, en 1983, todos los erizos fueron aniquilados por una enfermedad. Con la pesca en pleno desenfreno, no quedaron herbívoros importantes. Los corales recién establecidos podrían haber sobrevivido, pero los niveles de algas empezaron a aumentar. En 1988 el Huracán Gilbert golpeó la isla, una vez más devastando los corales. Entonces las algas florecieron, quizás ayudadas por los altos niveles de contaminación con nutrientes en el agua, con el beneficio de la falta de herbívoros. Ocurrió un "cambio de estado" en que los arrecifes coralinos fueron reemplazados en buena parte por ecosistemas algales. Entre 1977 y 1993, la cobertura de coral vivo decreció de 52% a 3%, y el recubrimiento de algas carnosas aumentó de 4% a 92%. Las razones de este cambio son complejas y múltiples: sobrepesca, enfermedades, y dos huracanes, quizás exacerbadas por contaminación por nutrientes.[a] Sin embargo, los resultados de un estudio reciente brinda algunos signos de esperanza: el regreso de los erizos negros, la disminución del recubrimiento algal y el incremento de la cobertura de coral vivo en algunas localidades.[b] El incremento de los esfuerzos de manejo costero unido a la resiliencia del sistema parece estar contribuyendo a esta modesta recuperación.

Notas:

a. T.P. Hughes et al. (2003).

b. J. Mendes, J.D. Woodley, y C. Henry, "Changes in Reef Community Structure on Lime Cay, Jamaica, 1989–1999: The Story Before Protection." Publicación presentada en la Conferencia Internacional sobre Aspectos Científicos de la Evaluación, Monitoreo y Restauración de Arrecifes, Fort Lauderdale, Florida, 14–16 de abril de 1999; L. Cho y J. Woodley, "Recovery of Reefs at Discovery Bay, Jamaica and the Role of *Diadema antillarum*." Publicación presentada en el 9º Simposio Internacional de Arrecifes Coralinos, Bali, Indonesia, 23–27 octubre del 2000.

MAPA 6. ARRECIFES AMENAZADOS POR SOBREPESCA



Las amenazas a los arrecifes coralinos por sobrepesca fueron evaluadas tomando como base la densidad poblacional costera ajustada al área de la plataforma (hasta 30 m de profundidad) dentro de 30 km de distancia del arrecife. La efectividad del manejo de las áreas marinas protegidas fue incluida como un factor que mitiga las amenazas a los arrecifes dentro de sus fronteras. El análisis se calibró usando las observaciones de estudios de abundancia de peces arrecifales. (*Ver el Recuadro 3 en el Capítulo 4, y la Tabla A5 en el Apéndice A.*)

Fuente: WRI, *Arrecifes en Peligro en el Caribe*, 2004 (*ver Apéndice B*).

instituidas en varios países caribeños. Otros controles limitan el número de animales capturados, la talla de los individuos que pueden pescarse (para asegurar que alcancen la edad de reproducción), el arte de pesca utilizado (por ejemplo, varios países requieren ahora el uso de paneles biodegradables en las trampas de peces para evitar la "pesca fantasma" por trampas perdidas). Las vedas estacionales pueden ser usadas para proteger a las especies cuando desovan. Una de las herramientas más importantes, con cada vez mayor reconocimiento y aplicación en todo el Caribe, es el cierre total de áreas a la pesca. Tales "zonas de exclusión de pesca" (o zonas de no extracción) ofrecen un refugio para los peces, al permitir el incremento de las poblaciones de desovadores y la derrama de adultos hacia las aguas circundantes. Estas zonas han mostrado que se incrementa grandemente la captura general de amplias áreas con ecosistemas arrecifales.[50]

CAMBIO CLIMÁTICO

La rápida acumulación de gases de invernadero (GIs) en la atmósfera durante el siglo pasado ya ha alterado el clima mundial. Las concentraciones de GI han crecido en más de un tercio desde la época preindustrial y, si no ocurre alguna intervención política importante, su magnitud puede duplicarse a finales del siglo XXI.[51] La temperatura promedio de la Tierra ha subido de 0.6°C a 0.8°C en los últimos 100 años, y el promedio mundial del nivel del mar ha aumentado unos 18 cm.[52] No se ha determinado aún en toda su magnitud los impactos de estos cambios, pero se sabe que pueden alterar los patrones de circulación de las corrientes superficiales y los procesos de afloramiento del océano, la ubicación e intensidad de eventos climáticos extremos, y los procesos químicos del océano (asociados con los elevados niveles de dióxido de carbono disuelto).[53] Las secciones siguientes describen algunos de los impactos actuales y pronosticados del cambio climático sobre los arrecifes coralinos en el Caribe.

Blanqueamiento de corales

La evidencia más directa del impacto del calentamiento del clima sobre la biodiversidad marina del Caribe ha sido el ampliamente extendido "blanqueamiento" de los corales constructores de arrecifes. Actualmente, la falta de evidencia científica concluyente impide la incorporación del cambio climático o blanqueamiento de corales al modelo de Arrecifes en Peligro. Sin embargo, estos fenómenos deben ser reconocidos como amenazas importantes a los arrecifes coralinos en el Caribe.

El blanqueamiento se refiere a la pérdida del color natural del coral (a menudo tonos de verde y pardo) causada por la expulsión de algas simbióticas (*zooxantelas*), dejando al coral con una apariencia que varía de muy pálida a blanca brillante. El blanqueamiento puede ser la respuesta a diversos factores de estrés, incluyendo cambios de salinidad, luz excesiva, y la presencia de toxinas e infecciones microbianas, pero el incremento de la temperatura superficial del mar (TSM) es la causa más común del blanqueamiento en áreas extensas.[54] El blanqueamiento de corales en el Caribe se dispara usualmente al incrementarse la TSM en al menos 1.0°C sobre los máximos normales de verano, durante al menos 2 a 3 días.[55]

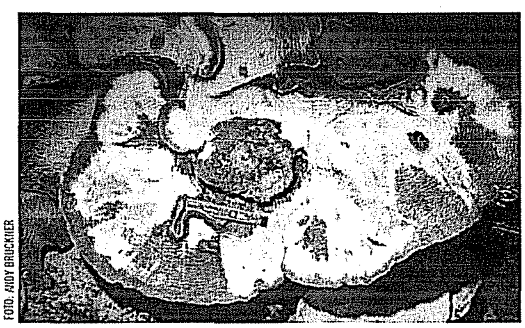
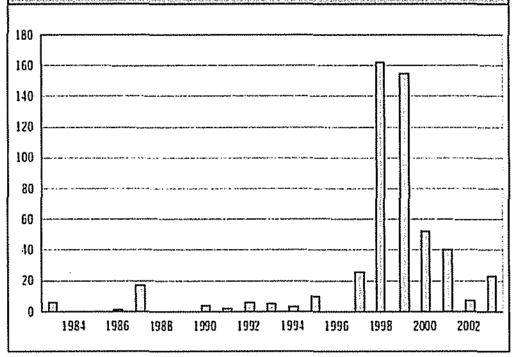


FOTO: ANDY BRUCKNER

En respuesta al estrés, los corales expelan sus algas simbióticas (zooxantelas), dándole un aspecto descolorido. Los corales blanqueados pueden recuperarse y recobrar su color, pero en casos muy severos, mueren.

FIGURA 1: NÚMERO DE OBSERVACIONES DE BLANQUEAMIENTO POR AÑO



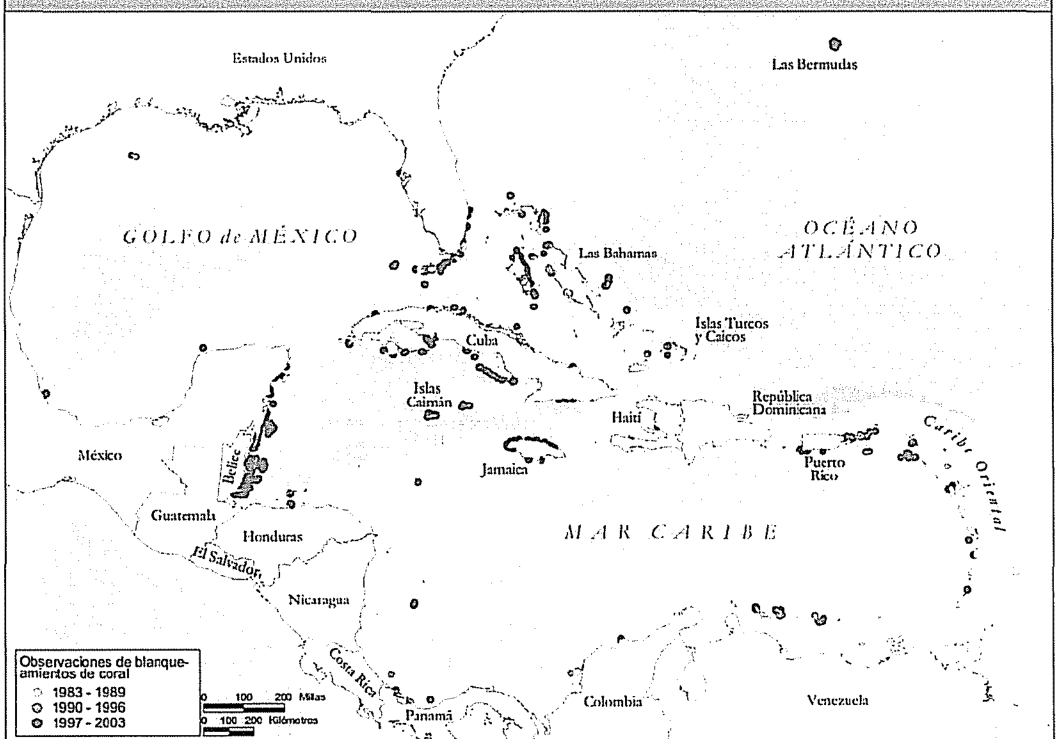
En eventos leves, el blanqueamiento es transitorio, y los corales recuperan su color (las algas zooxantelas) en unos meses, con poca mortalidad aparente. En casos más severos, muchos de los corales mueren. Prospecciones posteriores al blanqueamiento han mostrado que algunos corales tienen mayores tasas de mortalidad que otros.[56] Los eventos repetidos de blanqueamiento en el Caribe durante la década pasada han causado un extenso daño a los corales constructores de arrecifes, y contribuido a la degradación general de la condición de los arrecifes.[57]

Antes de 1983 no se había registrado formalmente ningún incidente de blanqueamiento masivo de corales en el Caribe.[58] Sin embargo, desde principios de los 1980s, se han reportado más de 500 observaciones (*ver Mapa 7 y Figura 1*).[59] Una de las incidencias más tempranas ocurrió durante el evento "El Niño Oscilación del Sur" (ENOS) de 1982–83, seguido de otro muy importante en 1987, durante otro ENOS.[60] Durante los 1990s se han reportado más incidentes de blanqueamiento en varias localidades. En 1998 coincidió el mayor máximo promedio de TSM registrado en el Caribe con un gran ENOS[61] y extensas áreas de esta región experimentaron blanqueamiento en este período, con casos severos en las Bahamas y el Caribe occidental.[62]

Predicción de futuras amenazas de blanqueamiento

Las condiciones en las que los arrecifes han vivido en el Caribe por milenios están cambiando rápidamente. Los modelos del clima mundial predicen que para el 2070, la temperatura atmosférica en el Caribe subirá entre 2°C y 4°C, con grandes cambios en el Caribe septentrional y alrededor de los bordes continentales.[63] Debido a que los niveles actuales de TSM están cerca del umbral superior de temperatura para la supervivencia de los corales, se pronostica

MAPA 7. OBSERVACIONES DE BLANQUEAMIENTO DE CORALES



Las observaciones de blanqueamiento de corales se extienden por todo el Caribe. De los más de 500 reportes en décadas recientes, 24 se hicieron en los 1980s, más de 350 en los 1990s, y más de 100 desde el 2000. El incremento de incidentes reportados refleja no sólo el aumento de la temperatura de la superficie del mar, sino también una mayor conciencia y comunicación de los eventos de blanqueamiento de corales.

Fuente: *Reefbase "Coral Bleaching Dataset"* tomado de http://reefbase.org el 10 de agosto del 2004.

que, para el año 2020, el blanqueamiento se convertirá en un evento anual en el Caribe.[64] La supervivencia a largo plazo de los corales de aguas poco profundas podría depender de su capacidad de adaptación a temperaturas cambiantes; las investigaciones sugieren que algunos corales se recubren de algas más tolerantes al calor después del blanqueamiento, lo que les permitiría ser más resistentes a futuros eventos de estrés térmico.[65] También, la circulación del océano podría permitir a las especies de corales migrar hacia las áreas que se calientan con mayor tolerancia a la temperatura.[66]

Durante los eventos de mayor relevancia hasta la fecha, se han observado áreas localizadas con menos incidencia de blanqueamiento, particularmente en aguas más profundas, así como de mayor circulación. Los científicos no pueden predecir actualmente patrones específicos de tolerancia de los ecosistemas o variaciones en los cambios de temperatura a través de la región. La realización de monitoreos de amplia cobertura geográfica y el intercambio amplio de información sobre patrones de blanqueamiento y recuperación, son esenciales para mejorar nuestra comprensión de esta importante y extendida amenaza a los arrecifes coralinos del Caribe.

Huracanes y tormentas tropicales

La mayor parte del Caribe yace dentro de la ruta de los huracanes. Durante los meses de verano se desarrollan tormentas tropicales de elevada intensidad sobre áreas de aguas marinas cálidas que pueden barrer toda la región, con consecuencias devastadoras en la tierra y el mar. La mayor de estas tormentas puede generar olas de más de 16 m de altura, batiendo las aguas someras y destrozando muchos arrecifes costeros hasta reducirlos a escombros. Las copiosas lluvias asociadas con las tormentas, a menudo resultan en un incremento de la sedimentación alrededor de los arrecifes cercanos a la costa o a desembocaduras de ríos. Estos son eventos naturales de los cuales los arrecifes pueden recobrarse, aunque la recuperación de los más severamente dañados puede tomar una o dos décadas después de las tormentas más feroces.

De 1995 al 2000, la región del Caribe experimentó el mayor nivel de actividad de huracanes que se conoce de los registros confiables. Sin embargo, esto ocurrió después de un período de actividad de tormentas por debajo del nivel promedio.[67] Los modelos climáticos no pueden todavía proyectar con exactitud cómo cambiará la frecuencia e intensidad de los huracanes.[68] Si el perfeccionamiento de los modelos indica una mayor probabilidad de incremento de la intensidad de las tormentas, esto debe causar preocupación, particularmente si se añade una escalada de las presiones de la contaminación desde el mar y la tierra, y de las enfermedades de corales sobre los arrecifes coralinos.

Elevación del nivel del mar

Se predice que durante el próximo siglo, el nivel medio mundial del mar subirá de 3 a 10 cm por década.[69] El Panel Intergubernamental sobre el Cambio Climático (PICC) ha concluido que dichas tasas de elevación del nivel del mar podrían no constituir una amenaza muy importante para los arrecifes coralinos.[70] Los ecosistemas de arrecife saludables tienen el potencial de responder al incremento del nivel del mar a través de la acreción; o sea, del crecimiento vertical del arrecife con la deposición de sus esqueletos de calcio.[71] Sin embargo, la situación es menos clara para los arrecifes ya degradados o bajo el estrés de otras amenazas, así como para los pastos marinos y manglares asociados en zonas costeras bajas.[72]

Reducción del potencial de calcificación

Los crecientes niveles de dióxido de carbono atmosférico (CO_2) están empezando a alterar la química del océano poco profundo.[73] Una mayor concentración de CO_2 disuelto aumentaría la acidez del agua superficial, afectando a la vez la solubilidad de otros compuestos. Unos de estos compuestos, conocido como aragonito, es usado por los corales en la construcción de los arrecifes. Actualmente, los niveles de aragonito están cayendo, y es cada vez más evidente la reducción de la capacidad de los corales para construir arrecifes con la deposición de sus esqueletos calcáreos. Esto sugiere una reducción del ritmo o una inversión del proceso de construcción de los arrecifes y la pérdida de los mismos en el futuro.[74]

Panorama de los arrecifes en un clima cambiante

La mayoría de los científicos concuerdan en que la capacidad de los corales para adaptarse a las cambiantes condiciones ambientales del Planeta depende de la severidad de otros factores humanos de estrés, tales como la sobrepesca, el desarrollo costero y la contaminación desde fuentes terrestres. Las áreas de arrecifes no sometidas a otras amenazas tienen mayor probabilidad de ser más resilientes que las que están fuertemente estresadas. Los esfuerzos de manejo pueden dirigirse hacia la reducción de factores de estrés localizados. Una herramienta clave de manejo será la creación de áreas marinas protegidas (AMPs). Las áreas ideales para establecer nuevas AMPs deben tener arrecifes donde los corales puedan ser resistentes al blanqueamiento (debido a su profundidad, mayor circulación del agua, o sombreo) o tener un buen potencial para la recuperación (corriente abajo de las fuentes de larvas). Esfuerzos internacionales constituidos en acuerdos tales como el Convenio sobre Diversidad Biológica y el Convenio Marco sobre el Cambio Climático pueden impulsar respuestas políticas y financieras a los problemas.[75] Al mismo tiempo, es esencial frenar las emisiones excesivas de CO_2 para reducir la amenaza a largo plazo.

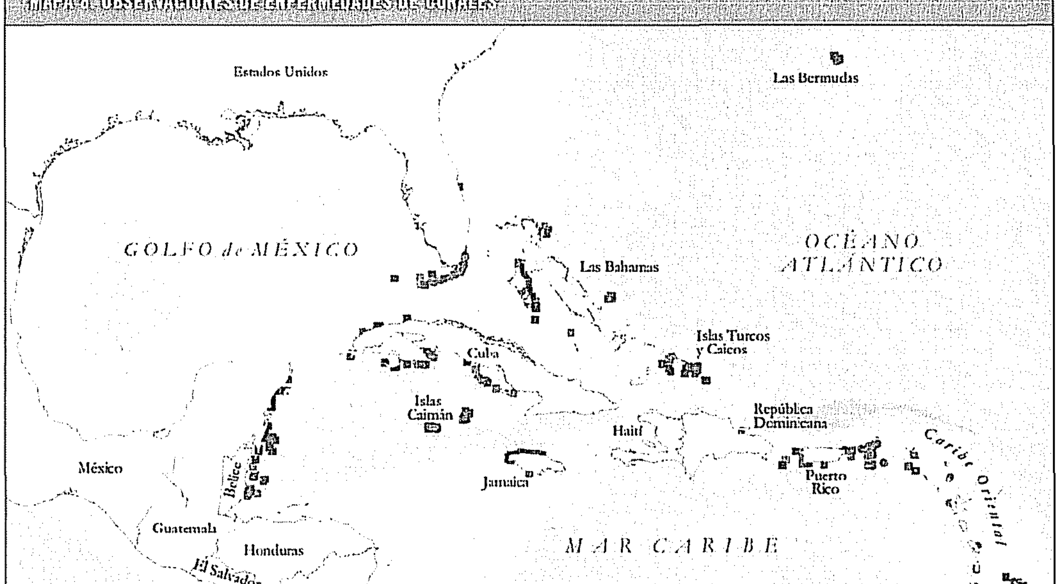
ENFERMEDADES

Quizás los cambios más profundos y extendidos en los arrecifes coralinos del Caribe en los últimos 30 años han sido causados por enfermedades de corales y otros organismos. En décadas recientes, ha aparecido un despliegue sin precedentes de nuevas enfermedades que afectan severamente los arrecifes coralinos. La mayoría de las observaciones de enfermedades de corales reportadas en todo el mundo han venido de la región del Caribe.[76] Entre los fenómenos reportados se destacan la mortandad masiva del erizo negro de espinas largas *Diadema antillarum* en todo la región Caribe;[77] grandes pérdidas de corales importantes constructores de arrecifes (cuerno de ciervo y cuerno de alce) debido a la enfermedad banda blanca;[78] la amplia diseminación de aspergilosis, una enfermedad causada por hongos que ataca a algunas especies de gorgonias (abanicos de mar);[79] y numerosos brotes de plaga blanca en corales.[80]

La Base de Datos Mundial de Enfermedades de Corales[81] incluye, sólo en el Caribe, 23 enfermedades y síndromes con nombres diferentes que afectan los corales. Tres de estas enfermedades —banda negra, banda blanca y plaga blanca— constituyen dos tercios de los reportes en la base de datos y afectan al menos 38 especies de corales a través del Caribe (*ver Mapa 8*). El impacto de las enfermedades de corales varía de acuerdo a diversos factores: una enfermedad puede causar diferentes niveles de mortalidad en diferentes años en la misma localidad.

No se conocen bien las razones de esta repentina aparición y rápida diseminación de enfermedades por todo el Caribe. Las enfermedades han sido observadas en toda la región, aún en arrecifes que se encuentran en lugares remotos, lejos de las fuentes humanas de estrés.[82] No se sabe casi nada sobre los agentes causales; de hecho, sólo se han identificado patógenos para 3 de las 23 enfermedades observadas en la región.[83] Los vínculos con otras fuentes de estrés (por ejemplo, sedimentación o contaminación) no son bien conocidos, y tampoco está claro el papel que despeñan las actividades humanas en la aparición de estas enfermedades en la región. Al menos un patógeno está relacionado con la desertificación en África y el arrastre del polvo por el viento a través del Atlántico,[84] mientras que el patógeno responsable de la muerte masiva del erizo negro de espinas largas podría haber sido transportado a la región por la vía del Canal de Panamá en el agua de lastre de embarcaciones.[85] Se requiere mayor investigación y monitoreos ambientales integrales para entender mejor y ayudar a predecir esta importante amenaza a los arrecifes coralinos, tan extendida en la región.

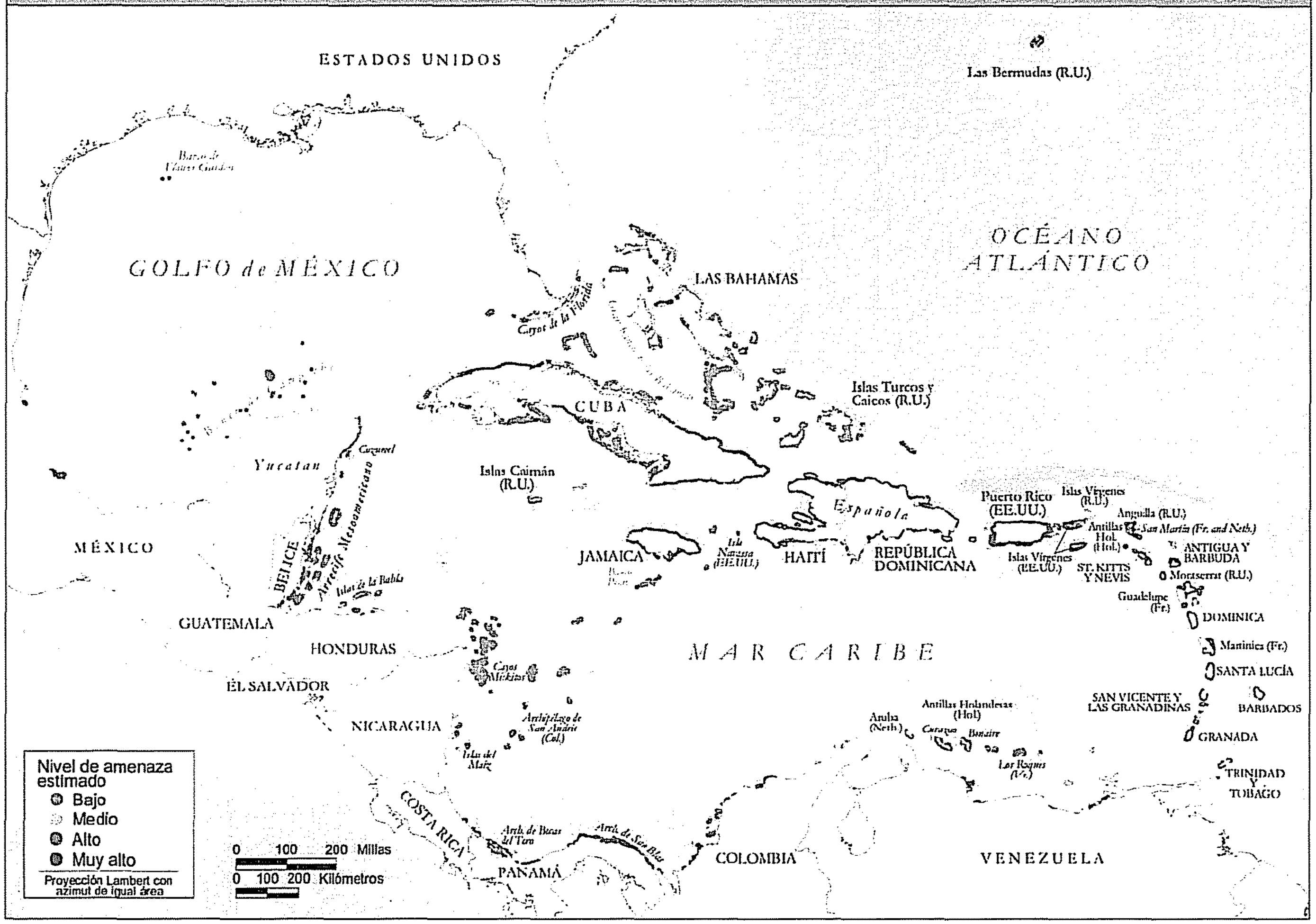
MAPA 8. OBSERVACIONES DE ENFERMEDADES DE CORALES



La mayoría de las observaciones de enfermedades de corales reportadas en el mundo han sido en el Caribe. Las tres enfermedades más registradas son la banda negra, banda blanca y plaga blanca. El reporte de incidencias de estas enfermedades está limitado por la distribución de las actividades de monitoreo en la región.

Fuente: Global Coral Disease Database, United Nations Environment Programme - World Conservation Monitoring Centre, 2001.

MAPA 9: AMENAZA INTEGRADA - EL ÍNDICE DE AMENAZA DE ARRECIFES EN PELIGRO



Fuente: WRI, *Arrecifes en Peligro en el Caribe*, 2004 (*ver Apéndice B*).

TABLA 2. ARRECIFES AMENAZADOS POR ACTIVIDADES HUMANAS

País o territorio	Área de arrecifes (km²)	Área de arrecifes como % del total de la región	Indice de amenaza de Arrecifes en Peligro[a] (%)				Amenazas individuales[b]: Desarrollo costero (%)			Sedimento y contaminación desde fuentes terrestres (%)			Fuentes de amenaza de origen marino (%)			Presión pesquera (%)		
			Bajo	Medio	Alto	Muy alto	Bajo	Medio	Alto	Bajo	Medio	Alto	Bajo	Medio	Alto	Bajo	Medio	Alto
Anguila	70	< 1	0	11	89	0	33	33	34	99	1	0	100	0	0	0	11	89
Antigua y Barbuda	180	< 1	0	39	51	11	29	55	16	71	29	0	71	18	11	0	39	61
Antillas Holandesas Norte[c]	40	< 1	48	21	31	0	59	41	0	76	24	0	65	9	26	72	27	1
Antillas Holandesas Sur[d]	210	< 1	37	15	39	9	57	27	15	100	0	0	55	19	26	64	4	32
Aruba	25	< 1	0	0	85	15	0	28	72	100	0	0	26	48	26	0	0	100
Bahamas	3.580	14	75	24	2	0	95	5	0	100	0	0	99	1	0	78	21	1
Barbados	90	< 1	0	0	86	14	0	20	80	40	60	0	85	15	0	0	6	94
Belice	1.420	5	37	29	32	2	89	11	0	51	20	29	92	8	0	63	30	7
Bermudas	210	< 1	0	20	61	19	51	20	29	100	0	0	38	34	28	0	25	75
Colombia	2.060	8	56	24	19	1	86	7	7	76	16	8	97	3	0	61	25	14
Costa Rica	30	< 1	0	0	77	23	14	62	24	0	0	100	77	0	23	0	77	23
Cuba	3.290	13	32	32	33	3	78	14	7	71	20	8	92	7	1	32	35	33
Dominica	70	< 1	0	0	63	37	4	49	47	0	25	75	86	10	4	0	0	100
Estados Unidos	840	3	38	48	14	0	57	31	11	100	0	0	97	3	0	42	56	3
Granada	160	< 1	0	20	41	40	15	22	63	43	27	30	76	14	9	0	37	63
Guadalupe[e]	400	2	0	15	66	18	15	33	52	55	31	13	73	23	4	1	28	71
Guatemala	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Haiti	1.260	5	0	0	45	55	8	33	59	1	8	91	92	7	0	0	0	100
Honduras	1.120	4	66	13	21	0	75	11	14	90	7	3	94	5	1	70	24	5
Islas Caimán	130	< 1	17	57	26	0	35	43	22	100	0	0	99	0	0	17	63	20
Islas Turcos y Caicos	1.190	5	50	46	4	0	87	9	4	100	0	0	98	2	0	51	49	0
Islas Virgenes Británicas	380	1	3	62	25	10	54	29	18	83	17	0	76	16	7	4	77	19
Islas Virgenes Norteamericanas	590	2	0	9	73	18	42	39	18	66	34	0	57	22	22	0	13	87
Jamaica	1.010	4	32	2	34	32	45	24	32	39	19	42	69	24	7	32	2	67
Martinica	260	1	0	0	65	35	9	43	48	2	79	19	62	31	8	0	0	100
México	1.220	5	50	20	20	10	70	15	15	86	2	12	83	10	7	51	29	20
Montserrat	25	< 1	0	0	71	29	8	81	11	0	30	70	24	47	29	0	100	0
Nicaragua	870	3	86	11	2	0	96	2	2	99	1	0	99	1	0	86	14	0
Panamá	1.600	6	0	16	75	10	80	12	8	0	18	82	64	28	8	0	98	2
Puerto Rico	1.610	6	7	8	59	25	46	30	24	37	32	31	72	20	8	9	8	84
República Dominicana	1.350	5	18	8	63	10	41	22	37	55	24	21	90	6	4	21	11	68
Saint Kitts y Nevis	160	< 1	0	0	77	23	5	67	28	0	81	19	74	15	11	0	3	97
San Vicente y las Granadinas	140	< 1	0	38	48	14	36	29	35	84	0	16	71	19	10	0	59	41
Santa Lucia	90	< 1	0	0	39	61	1	32	67	0	51	49	60	29	11	0	2	98
Trinidad y Tobago	40	< 1	0	0	99	1	1	46	52	13	87	0	99	1	0	0	31	69
Venezuela	230	< 1	57	16	11	16	68	16	16	73	0	27	86	8	6	64	14	22
Total regional	**25.960**	**100**	**36**	**21**	**33**	**10**	**67**	**17**	**16**	**66**	**15**	**20**	**87**	**10**	**4**	**39**	**29**	**32**

FUENTE:

WRI, *Arrecifes en Peligro en el Caribe*, 2004.

NOTAS:

a. El Indice de amenaza de Arrecife en Peligro refleja la amenaza acumulada de cuatro amenazas indivuales en una localidad. En áreas donde tres o cuatro de las amenazas fueron consideradas como altas, el índice se establece como muy alto.

b. En el análisis, las amenazas individuales son clasificadas como alta, media y baja. Las amenazas suman 100%.

c. Antillas Holandesas Norte incluye las islas de St. Maarten, St. Eustatius, y Saba.

d. Antillas Holandesas Sur incluye Bonaire y Curazao.

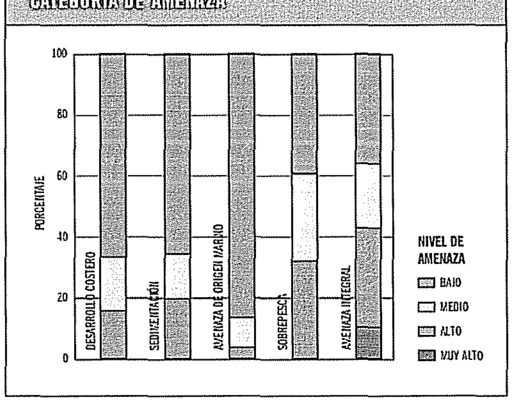
e. Guadalupe incluye las islas francesas de St. Martín y St. Barthelemy.

INTEGRACIÓN DE AMENAZAS: EL ÍNDICE DE AMENAZA DE ARRECIFES EN PELIGRO

Alrededor del mundo, pero quizás especialmente en el Caribe, los arrecifes coralinos están amenazados por una multitud de fuentes. Bastante a menudo, el arrecife es suficientemente fuerte para sobrevivir un nivel bajo de amenaza de una sola fuente. Sin embargo, en muchos casos, los arrecifes están sujetos a múltiples fuentes de estrés, y la combinación de impactos de múltiples fuentes, aunque sea de bajo nivel, puede conducir a una degradación abrupta de estos ecosistemas. Uno de los mejores ejemplos de impactos combinados puede verse en los arrecifes de Jamaica. (*Ver Recuadro 2.*)

De las cuatro amenazas modeladas en este estudio, la amenaza directa más omnipresente es la sobrepesca, que amenaza más de 60% de estos ecosistemas en la región. Las presiones asociadas con el desarrollo costero, y la sedimentación y contaminación desde fuentes terrestres amenazan cada una a cerca de un tercio de los arrecifes coralinos de la región. Cerca de 15% de los arrecifes del Caribe están amenazados por fuentes de contaminación de origen marino. (*Ver Figura 2 para un resumen de estas amenazas.*)

FIGURA 2. ARRECIFES EN PELIGRO EN EL CARIBE POR CATEGORÍA DE AMENAZA



Al integrar las cuatro amenazas en un índice general de amenaza de Arrecifes en Peligro, cerca de dos tercios de los arrecifes de la región aparecen como amenazados por actividades humanas (cerca de 20% con amenaza media, un tercio con alta, y 10% con muy alta).[86] (*Ver Mapa 9.*) Las áreas con alto nivel de amenaza comprenden el Caribe oriental, la mayor parte del Caribe sur, las Antillas Mayores, los Cayos de la Florida, Yucatán y las porciones cercanas a la costa del Sistema Arrecifal Mesoamericano y del Caribe suroccidental. En áreas identificadas como amenazadas, la degradación de los corales —que incluye la reducción de la cobertura de coral vivo, el aumento del recubrimiento por algas, o la disminución de la diversidad de especies— ya podría haber ocurrido o se considera que ocurra muy probablemente dentro de los próximos 5 a 10 años.

Además de estas amenazas crónicas, para las que pudimos desarrollar indicadores, los arrecifes coralinos están también afectados por amenazas actuales menos predecibles de enfermedades y blanqueamiento de corales. A medida que se calienta el océano, puede esperarse un aumento de la incidencia del blanqueamiento de corales acompañada de eventos de mortandad. Asimismo, la tendencia de la década pasada indica que las enfermedades de corales podrían persistir, o incluso proliferar, a menudo después de eventos de blanqueamiento de corales, en respuesta a nuevos patógenos, o posiblemente en áreas estresadas por mucha contaminación o sedimentación. En conjunto, las enfermedades y el blanqueamiento de corales son amenazas importantes a escala regional que deben ser tomadas en cuenta cuando se consideran los resultados de Arrecifes en Peligro. Por todo esto, recursos costeros altamente valiosos de la región están en serio peligro.

Ningún arrecife coralino tiene inmunidad garantizada contra las amenazas del blanqueamiento, las enfermedades, o el despojo de la pesca excesiva, pero algunos arrecifes tienen menor riesgo de las amenazas provenientes de tierra y de la presión de la pesca costera. En varias partes del Caribe, el análisis identificó extensas áreas de arrecifes poco amenazadas por las actividades humanas evaluadas. Éstas incluyen las Bahamas, las Islas Turcos y Caicos, los archipiélagos de Colombia y Nicaragua, y algunos arrecifes de Cuba, Belice y México. Dichas áreas pueden haber sufrido enfermedades y blanqueamiento de corales, y algunas también han sufrido la captura de peces de alto valor, pero en general parecen estar en un estado relativamente saludable y podrían ser importantes refugios para el resto de la región. La Tabla 2 presenta un resumen estadístico por país para cada amenaza examinada.

La amenaza acumulativa a los arrecifes por estas cuatro categorías demuestra que para manejar el desarrollo en la zona costera y todos los problemas complejos asociados con ésta, es fundamental un enfoque holístico e intersectorial. En el Capítulo 6 analizamos estas necesidades de manejo y los principios del Manejo Integrado de la Zona Costera. En el Capítulo 4, se examinan con más detalle las amenazas en nueve subregiones del Caribe.

Annex IV

Dr. K. Sumser-Lupson & M. Kinch, *«Evaluation des risques de pollution maritime accidentelle dans Ia Manche* », *in* La Gestion des pollutions maritimes dans l'Espace Manche, University of Plymouth

The document is available at: www.vigipol.com/emdi.php

RETOUR SOMMAIRE | INTRO

ÉVALUATION DES RISQUES DE POLLUTION MARITIME ACCIDENTELLE DANS LA MANCHE

PARTIE 1.1

TYPOLOGIE DES POLLUTIONS MARITIMES

University of Plymouth - Marine Institute, Dr. Karen Sumser-Lupson & Marcus Kinch

PARTIE 1 EVALUATION DES RISQUES DE POLLUTION MARITIME ACCIDENTELLE DANS LA MANCHE

1.1. TYPOLOGIE DES POLLUTIONS MARITIMES

1.1.1. Introduction – Définition d'un polluant

Les écosystèmes marins sont extrêmement fragiles. Ils sont complexes et exigent un milieu structuré pour survivre. Des mesures scientifiques attestent que ces systèmes sont perturbés par les activités anthropiques sur terre et en mer. Leurs impacts à court terme sont maintenant évidents, mais l'impact global à long terme ne peut être mesuré en raison de la complexité des écosystèmes marins. En conséquence, il est essentiel que la pollution maritime soit considérée comme un problème global et soit abordée dans son intégralité, prenant en compte le fait qu'elle ne connaît pas de frontière. Afin de commencer une évaluation qui permettrait de diminuer les risques subis par l'environnement marin, il est essentiel d'identifier quels peuvent être ces risques. Dans ce but, les informations suivantes présenteront une vue d'ensemble des principaux risques marins « connus » qui sont associés à l'activité maritime.

La définition du terme « pollution », fournie par le United Nations Group of Experts on the Scientific Aspects of Marine Protection (GESAMP), a été incorporée, quelques fois avec de légères modifications, dans le texte des conventions internationales. Elle est aussi la base d'une définition plus étendue sur « la pollution par hydrocarbures » dans la Section 138A de l'article 1995.1.23. du Merchant Shipping Act. La définition opérationnelle utilisée ici, qui apparaît dans la United Nations Convention on the Law of the Sea (UNCLOS), est la suivante :

> « L'introduction par l'Homme, directement ou indirectement, de substances ou d'énergies dans le milieu marin, estuaires compris, et qui a pour conséquence ou est susceptible d'engendrer des effets nuisibles tels qu'ils porteraient atteinte aux ressources vivantes et à la vie marine, mettraient la santé humaine en danger, gêneraient les activités marines, telles que la pêche et autres utilisations légitimes de la mer ».

Un polluant peut être classé comme naturel (d'origine complètement biogéochimique) ou comme artificiel (xenobiotique). La plupart des critères Persistants, Bioaccumulables et Toxiques (PBT) s'appliquent aux xenobiotiques, les rendant considérablement plus dangereux pour l'environnement. Les polluants peuvent être regroupés en fonction du principal écosystème qu'ils affectent. Un polluant a souvent des conséquences sur plus d'un écosystème. Souvent, lors de débats sur l'environnement, des mots tels que « éléments contaminants » peuvent se heurter à des contresens. C'est pourquoi il est important qu'un « langage commun » soit établi dès le départ. La pollution et l'évaluation des risques dépendent des hypothèses d'un grand nombre d'utilisateurs.

Ces hypothèses contiennent souvent des éléments identifiables qui peuvent être expliqués. Par exemple, dans un accident de « pollution » il y aura toujours des déchets – c'est un des principes fondamentaux de la seconde loi de la nature, déchets et pollution ne sont jamais au niveau zéro, donc il est nécessaire de sans cesse trouver de meilleures façons de contrôler et diminuer les problèmes des déchets.

Risques encourus

De nombreuses conséquences biologiques préjudiciables, liées à la pollution maritime, se produisent par la réduction d'oxygène dissous dans l'eau. L'importance de ces conséquences dépend de l'équilibre entre les taux de réduction d'oxygène par les bactéries (mesurés en laboratoire comme la Demande Biologique d'Oxygène (DBO)) et de réapprovisionnement en oxygène. De nombreux types de polluants, eaux sales et usées comprises, ont des niveaux de DBO extrêmement élevés. J.M Garcia (2005) précise que « dans le milieu marin, les niveaux d'oxygène semblent contrôler et réapprovisionner la quantité des différentes espèces, alors que les polluants contrôlent leur qualité ».

1.1.2. Sources de pollution

La pollution maritime se produit lorsque le milieu est exposé à des effets nuisibles, dus à l'introduction d'une quantité de matériaux « étrangers » dans l'écosystème. Par conséquent, le type, l'origine, la localisation et la quantité de polluants doivent être identifiés afin de diminuer les effets de la pollution maritime. Les sources de polluants en milieu marin peuvent être regroupées en utilisant comme identifiant les données décrites ci-après.

1.1.2.1. Pollution localisée

Les sources de pollution localisées (définies comme localisables de façon précise, identifiables et en grande partie contrôlées) représentent seulement une fraction des sources de pollutions diffuses et sont principalement attribuées à des origines telluriques. Elles sont identifiables à partir d'un point précis : par exemple l'emplacement des usines industrielles ou les installations de traitement des déchets.

1.1.2.2. Pollution diffuse

La pollution diffuse (définies comme difficilement localisables, et le plus souvent non contrôlées) est plus difficiles à identifier et à contrôler car, souvent, ce type de pollution est issu d'une multitude de sources précises qui, lorsqu'elles sont évaluées d'un point de vue individuel, apparaissent souvent mineures. Comme sources de pollution diffuses, on peut citer, par exemple, l'écoulement à la surface des champs d'une grande quantité d'eau, l'infiltration de substances nutritives dans la terre puis dans les nappes phréatiques, ou le ruissellement des eaux de surfaces dans les zones urbaines. Les sources diffuses sont individuellement mineures, mais significatives collectivement. Quelques fois, elles sont aussi uniformément dispersées, mais rassemblées dans un secteur. Elles sont étroitement liées aux activités à terre : par exemple, l'utilisation d'engrais sur les terres cultivées, les plantations forestières, la quantité de bétail dans les pâturages, la gestion et le transport des hydrocarbures, les produits chimiques ainsi que les matières premières et produits bruts. L'activité maritime opérationnelle est l'une des principales causes de la pollution diffuse au large, activités marchandes et non-marchandes comprises. Les activités maritimes, qu'elles soient petites ou grandes, émettent toutes une pollution diffuse. Elles comprennent des « sources distantes » – des pollutions qui pénètrent dans le milieu marin par les retombées atmosphériques, créées par les gaz d'échappement des moteurs et autres résidus pétrochimiques, des déchets inertes, des toilettes chimiques, des produits anti-fouling et autres débris quotidiens. La pollution diffuse des zones urbaines vers les zones rurales est une problématique du côté britannique de la Manche et a été identifiée comme le prochain défi par l'Agence pour l'Environnement dans son rapport « Working for a Better Marine Environment Strategy » pour 2005-2011.

1.1.3. Typologie des risques de pollution maritime pour l'écosystème marin

Des outils de gestion ont été développés afin d'aider les instances de décision, les responsables côtiers et terrestres ainsi que les personnes en lien avec les sources de pollution ponctuelles ou diffuses. Ces outils, qui incluent la collecte et la compilation des données, ont pour but d'aider les responsables à identifier les polluants connus, comprendre leurs effets, et fournir une échelle-temps probable pour leur dispersion. Ces démarches ont stimulé le développement des conventions (sur terre et en mer) qui permettent l'application de règles strictes : par exemple, la Convention sur la protection du milieu marin de l'Atlantique Nord-Est de 1992 (remplaçant la Convention d'Oslo de 1972 sur les déchets rejetés en mer et la Convention sur la pollution de la mer du Nord de 1974). Le tableau 1 présente une liste des produits chimiques dangereux. Lorsqu'une pollution survient, les préjudices biologiques dépendent du type de polluant en question et du lieu de contamination.

Substances Prioritaires pour les Sources de Pollution diffuses (OSPAR)		
Brominated flame retardants	Polyaromatic hydrocarbures	Chlorinated paraffines
PCBs and PCB substituts	Metaux (Cd, Hg, Cu, Zn, Pb, As, Cr, Ni)	Traitements chimiques du bois
Nonyl phenol ethoxylates	Triazine herbicides	Musc Synthétiques (musk xylenes)
Composé Organotin		

Tableau 1 Liste des substances considérées comme prioritaires par la Convention Marine Atlantique Nord *(Source : OSPAR, mise à jour 2005)*

En ce qui concerne la **pollution provenant du transport maritime** dans « la zone de contrôle de pollution du Royaume-Uni » et dans les eaux nationales, les statistiques réalisées sur les pollutions d'une année à l'autre sont coordonnées par l'Advisory Committee on Protection of the Sea (ACOPS). En 2004, par exemple, les polluants observés en mer étaient composés de 95% de pétrole et autres produits raffinés à base de pétrole (dont 40% de pétrole brut), 0,7% de produits chimiques, 0,5% d'huiles animales ou végétales, 0,4% de déchets et 3% de substances diverses. Mazout, diesel, carburant et gazole ont été les substances polluantes les plus fréquemment identifiées (ACOPS DTI, 2004).

Risques encourus

La pollution due au transport maritime dépend d'un certain nombre de facteurs, notamment le type de polluant dont il s'agit et sa persistance dans une zone déterminée. La Royal Yachting Association précise, par exemple, qu'il suffit d'un litre de carburant pour contaminer plus d'un million de litres d'eau, des pertes même minimes pouvant donc avoir de graves conséquences sur le milieu marin. L'ampleur des conséquences dépend de la persistance et de la diffusion des polluants dans l'eau. Cela permet de classifier les polluants en groupes : éphémères, modérément persistants, très persistants et quasiment permanents.

1.1.3.1. Pollution en provenance des ports de pêche, de ports de plaisance, des ports de commerces, et des installations pétrolières et gazières maritimes

On constate une augmentation des éléments contaminants dans les ports et marinas, sièges d'intenses activités maritimes. D'une manière générale, les similarités entre les types de polluants comparables peuvent être extrapolées vers toute autre zone puisque c'est la taille et la fréquence du port et de la marina qui seront le plus probablement les facteurs déterminants. Par exemple, le trafic portuaire déterminera le potentiel et la catégorie du polluant, en terme de nombre et de taille des navires, aussi bien que selon les types de cargos qui rentrent dans les ports. Au Royaume-Uni, l'autorité portuaire doit effectuer une « évaluation du potentiel de pollution », qui devrait identifier les polluants éventuels et fournir des évaluations sur les échelles probables de déversement, ainsi que des indicateurs de fréquence détaillés.

La pollution provenant des installations pétrolières et gazières en pleine mer contribue aussi à la fréquence et à la gravité de dispersion des polluants dans le milieu marin. La contamination provenant des installations en pleine mer comprend des fuites de pétrole, d'eau salée concentrée et de métaux lourds, notamment du mercure et de l'arsenic (GESAMP, 2000). D'après l'ACOPS, le pétrole et autres produits raffinés représentent les polluants les plus fréquemment enregistrés (95% des accidents), faisant des installations gazières et pétrolières des prétendants évidents comme sources de pollution (2004).

1.1.3.2. Hydrocarbures (huiles minérales, dont le pétrole brut)

L'introduction d'hydrocarbures dans les milieux marins et côtiers a de nombreuses conséquences. Les plus visibles sont celles liées aux déversements importants d'hydrocarbures. Toutefois, les effets plus subtils de la pollution pétrolière, effectuée de façon continue, sont moins visibles mais tout aussi importants car ils sont responsables d'une perturbation très étendue des écosystèmes. Pour cette raison, ils sont classés comme « *polluants modérément persistants* » car dans la plupart des cas, la grande majorité d'entre eux se sera dispersée dans les deux ans. Toutefois, dans de nombreux cas, des résidus nocifs persistent (le taux de toxicité des hydrocarbures dépend de leur solubilité dans l'eau de mer). Des analyses scientifiques indiquent que la propagation géographique de la pollution par hydrocarbures va dans le sens de l'augmentation de la population mondiale, et là où les opérations pétrolières ont augmenté : fret, nettoyage de cuves, raffineries et explorations en pleine mer ont causé de nombreuses fuites et déversements accidentels. Les routes de navigation et les ports sont des zones spécifiques où les navires rejettent des éléments à base de pétrole dans les eaux environnantes. Les POP (Polluants Organiques Persistants) sous la forme de HAP (Hydrocarbures Polycycliques et Aromatiques) se concentrent dans les sédiments. Une classification a été spécialement établie pour répondre aux déversements d'hydrocarbures : très léger, léger, moyen et lourd. Ceux-ci sont classés ci-dessous par catégories :

Hydrocarbures (Breuel, 1981)				
Type d'hydrocarbures	**Description**	**Hydrocarbures représentatifs**	**Diagnostique des propriétés**	**Propriétés physiques/chimiques**
A **Très Léger**	Hydrocarbures Légers et volatiles	Fuel distillé et la plupart des hydrocarbures Légers bruts.	Très fluide, en général transparent- peut être opaque, odeur soutenue, se répand rapidement, peut être rincé à partir de l'installation	Peut être inflammable, niveau élevé d'évaporation des composants volatiles, présumé hautement toxique pour le milieu marin lorsqu'il est frais, à tendance à former des émulsions instables, peut pénétrer les substrats
B **Léger**	Hydrocarbures non-gluants	Hydrocarbures à base de paraffine raffinée et pétrole brut moyen à lourd	Viscosité modérée à forte, cireux/huileux au toucher, peut être rincé des surfaces par jets d'eau à basse pression.	Généralement possible de l'enlever des surfaces, pénétration des substrats variable, toxicité variable
C **Moyen**	Hydrocarbures lourds et gluants	Hydrocarbures Fuel résiduels, Hydrocarbures bruts mélangés et asphalte Moyen et lourd	Typiquement brun opaque ou noir, gluant, visqueux et ne peut être rincé à partir de l'installation	Viscosité élevée, difficile à enlever des surface, à tendance à former des émulsions stables, gravité spécifique élevée et potentiellement capable de couler après exposition au temps, pénétration faible dans les substrats, toxicité faible (effets biologiques principalement dus à l'étouffement).
D **Lourd**	Hydrocarbures non-fluides (à température ambiante).	Hydrocarbures résiduels et lourds (tous les types).	Morceaux goudronneux ou cireux	Ne s'étale pas, ne peut être récupéré des surfaces aquatiques par les équipements de nettoyage conventionnels, ne peut être pompé sans un réchauffement, initialement relativement non-toxique, peut fondre et couler lorsque exposé au soleil

Tableau 2 Type d'hydrocarbures - Description et propriétés
(Source : The National Oceanic and Atmospheric Administration (2006) from Breuel (1981))

Risques Encourus

Les milieux estuariens sont réputés pour agir comme des éviers pour les POP, où les sédiments, chargés en polluants, servent de sources secondaires de contamination. Les HAP sont désormais largement distribués dans le monde en raison du degré des processus pétrogéniques qui sont effectués. Dans certains secteurs, les POP atteignent des niveaux dangereux, s'accumulant à travers les chaînes alimentaires et affectant de nombreuses espèces, l'homme y compris. Les hydrocarbures sont réputés pour être la cause la plus connue de pollution de l'eau (Environmental Agency, 2006) pouvant parfois être grave. Ceci s'avère particulièrement vrai lorsque la nappe atteint le rivage comme cela est le cas lors d'accidents de pétroliers. Les nappes d'hydrocarbures sur les rivages rocheux peuvent se disperser, puisque l'action des vagues augmente le mélange et la dispersion. Sur les rivages sableux et vaseux, ce n'est pas aussi simple et il peut y avoir une pénétration profonde dans le limon, la vase et le gravier. En outre, lorsqu'une opération de nettoyage par dispersants chimiques est engagée, le produit chimique doit généralement être utilisé en petite quantité puisque les dispersants eux-mêmes peuvent devenir un polluant ; ainsi, pour les modalités de réduction il est vital que les responsables comprennent bien les propriétés physiques et chimiques des substances basées sur le pétrole.

1.1.3.3. Déchets (polluants transitoires inertes)

Les déchets, connus sous le nom de **polluants inertes et transitoires,** proviennent de sources variées. La majorité d'entre eux provient des activités à terre et/ou des personnes qui visitent ou travaillent sur les plages. Cependant, il faut également souligner qu'une proportion significative est produite par l'activité maritime. Les objets en plastique représentent le type de déchets principal et posent des problèmes majeurs puisqu'ils sont emportés sur de longues distances par les courants océaniques. La Marine Conservation Society (MCS) estimait en 2004 que la quantité de déchets domestiques et de déchets provenant des cuisines de navires se situait entre 0,5 et 4 kg par personne et par jour, tandis que 5 à 7 millions de tonnes de résidus de pétrole et 1 million de tonne de déchets solides sont générés annuellement par des bâtiments visitant les ports de l'Union Européenne. Malgré la législation internationale, on estime que depuis 1982 la flotte mondiale de navires (à l'exception des navires de pêche) est responsable d'avoir rejeté en mer, approximativement, 4,8 millions d'objets en métal, 450 000 objets en plastique et 300 000 récipients en verre. Au Royaume-Uni, l'ACOPS (Advisory Committee on Protection of the Sea) détaille les accidents de pollution enregistrés concernant les rejets de déchets attribués aux navires. Ceux-ci comprennent les déchets de cuisine et autres types de déchets. De nombreuses Organisations Non-Gouvernementales (ONG) détaillent et détiennent des statistiques sur les pollutions par déchet dans le secteur de La Manche (tel que ACOPS, Vigipol et Marine Conservation Society). Un recensement des déchets sur les plages, effectué en 2004 par la Marine Conservation Society (MCS), a montré qu'environ 2 500 déchets étaient présents pour chaque kilomètre de plage, ce qui montre que la quantité actuelle de déchets dans le milieu marin doit être particulièrement élevée. Ci-dessous, une analyse des types de déchets trouvés dans les secteurs maritimes de la mer du Nord :

TYPE DE DEBRIS	DESCRIPTION	PERSISTANCE
Plastiques	Fragments, bâches, sacs et récipients	Indéfiniment
Polystyrène	Verres, emballages et balises	Plus de 30 ans
Caoutchouc	Gants, bottes et pneus	Plus de 50 ans
Bois	Bois Construction, palettes, fragments	Plus de 10 ans
Métaux	Cannettes, barils d'essence, aérosols et débris	Plus de 100 ans
Relatifs aux déchets sanitaires	Tampons, préservatifs, fèces	Environ 30 ans
Papier et tissu	Vêtements, matériaux et chaussures	Environ 40 ans
Verre	Bouteilles, ampoules	Environ 4000 ans
Poterie/Céramique	Morceaux jetés	Plus de 500 ans
Munitions	Fusées éclairantes	Plus de 100 ans

Tableau 3 Débris en mer par type et par description
(Source : M. Kinch, Marine Institute, University of Plymouth)

Risques encourus

Les activités maritimes sont une cause majeure de pollution par les déchets. Vauk et Schrey (1987) mentionnent que « de grandes concentrations de débris marins sont trouvées aux alentours des voies de navigation et des zones de pêche », et Pruter (1987) précise également que des débris de navires peuvent aussi être présents autour des zones de convergence des courants océaniques. Williams, (1993) déclare que dans ces zones, 70% des débris coulent vers le fond, 15% flottent en surface et 15% sont rejetés sur les côtes (MCA, 2004).

1.1.3.4. Agents Anti-fouling

Nombre de produits anti-fouling ont des effets durablement néfastes sur le milieu marin. L'anti-fouling est spécialement conçu pour que les organismes marins, tels que les bernaches, algues et mollusques, n'adhèrent pas aux parois des coques de bateaux et autres structures marines. Traditionnellement, les voiliers et autres bateaux utilisaient de la chaux comme système anti-fouling, et par la suite, des composés chimiques (arsenic/mercure) et des pesticides (biocides) ont été utilisés. Dans les années 1960, l'industrie a pu développer des produits chimiques pour la peinture en utilisant des composés métalliques, comprenant le composé organotine/tributyline, plus connu sous le nom TBT. L'Organisation Maritime Internationale (OMI) précise que dans les années 1970, la plupart des navires avaient leurs coques peintes avec de la TBT. Conformément aux règlements de l'Union européenne, l'utilisation de TBT est maintenant interdite et l'OMI attend la ratification de la convention internationale sur les systèmes antisalissures (convention AFS).

Risques Encourus

La plupart des peintures anti-fouling peuvent entraîner des perturbations endocriniennes sérieuses qui interfèrent avec les systèmes hormonaux. Les systèmes endocriniens contrôlent les aspects fondamentaux de tous les organismes biologiques vivants, notamment le développement du cerveau, les caractéristiques sexuelles et les activités cellulaires. L'usage des produits à base de biocide et de TBT ont été généralement interdit, et remplacés par des peintures « respectueuse de l'environnement », mais celles-ci sont également toxiques pour les organismes non-visés.

I.1.3.5. Substances Dangereuses

Ce sont les produits chimiques qui constituent l'essentiel des substances dangereuses que l'on peut trouver dans le milieu marin. Historiquement, les problèmes de pollution associés au transport de produits chimiques xénobiotiques ont été relativement peu nombreux, mais cela ne signifie pas qu'ils sont sans danger. Au contraire, si un déversement accidentel venait à se produire, les incidences au niveau de la pollution pourraient être catastrophiques.

Risques encourus

De nombreuses substances dangereuses sont des polluants très persistants. L'OMI énumère nombre de ces substances contrôlées et met ainsi en lumière l'importance et la complexité des produits utilisés par les industries chimiques. Douze Polluants Organiques Persistants (POP) spécifiques sont compris dans cette liste, répertoriés par les Nations Unies et mentionnés dans la Convention de Stockholm du 17 mai 2004 qui interdit et cherche à éliminer les « douze salopards ». Ces 12 POP sont également appelés *« poisons sans passeports »* parce qu'ils « se déplacent par air et par courants marins sans se décomposer » (Greenpeace, 2006). Ces POP, répertoriés dans le tableau ci-après, sont si persistants que l'on peut les trouver dans le monde entier, voyageant sur de grandes distances à travers les courants océaniques et de manière plus concentrée aux pôles Nord et Sud. Ces POP endommagent le système nerveux des organismes biologiques, et provoquent des maladies du système immunitaire, des désordres au niveau du développement, ainsi que des cancers.

Les douze Polluants Organiques Persistants (POP) Spécifiques - « Les douze salopards »					
Aldrin	Dieldrin	Chlordane	Toxaphene	Polychlorinated Biphenyls (Pcbs)	Endrin
Heptachlor	Hexachlorbenzene	Polychlorinated Biphenyls	Dichloro Diphenyl Trichloroethane (Ddt)	Dibenzofurans (Pcdf)	Mirex

Tableau 4 Les douze polluants organiques (POP) spécifiques - Les douze salopards
(Source: Stockholm Convention on the Persistent Organic Pollutants; site internet IPEN)

1.1.3.6. Substances Nutritives – A terre & en mer

Les principales sources de substances nutritives contenues dans l'eau de mer sont l'azote inorganique (N) et le Phosphore (P) qui sont accumulés dans les eaux sales et usées. Ces substances sont issues de vidanges effectuées en mer ou de rejets traités déversés dans les cours d'eau. D'autres sources incluent les eaux s'écoulant des terrains agricoles traités et les déchets provenant des industries alimentaires.

Risques encourus

En concentrations élevées, ces résidus inorganiques peuvent devenir des polluants en réduisant fortement la quantité d'oxygène dissout disponible. Les principales formes de N dans l'eau de mer sont les Nitrate (NO_3^-), Nitrite (NO_2^-) et Ammoniaque (NH_4^+). Pour **P**, il s'agit de l'orthophosphate (HPO_4^{2-}). Le dépôt de nitrogène oxydes entraîne une acidification des écosystèmes, et « l'enrichissement excessif des substances nutritives peut transformer les secteurs marins en friche » (GESAMP 2000). Par exemple, l'eutrophisation (enrichissement en substances nutritives) encourage la croissance du phytoplancton et favorise la croissance des espèces toxiques, la décomposition de la biomasse de plancton en quantité excessive augmente la consommation d'oxygène dissous et provoque la diminution périodique ou permanente de l'oxygène amenant à une mortalité en masse des poissons et autres organismes. « L'éclosion des algues impliquant des espèces productives de toxine est la cause fréquente de problèmes de santé humaine très sérieux, surtout lorsque les toxines sont ingérées par le biais de fruits de mer contaminés » (GESAMP 2000).

1.1.3.7. Espèces invasives

L'introduction dans un milieu d'espèces invasives et de pathogènes perturbe l'écologie d'origine et les économies locales. Il en résulte une perte génétique et un changement dans le fonctionnement de l'écosystème et l'emplacement dans la chaîne alimentaire, ce qui a des implications sur la vie marine et les moyens d'existence économiques. Les pathogènes qui sont introduits peuvent provoquer de nouvelles maladies et la mort chez l'homme. Le relevé relatif au suivi de l'introduction des espèces invasives provient du changement au moment du déballastage d'eau des navires et des coques de navires qui les transportent. Des espèces telles que les sessiles (sans pédoncules), térébrant ou accrochant, font partie des espèces transportées les plus identifiées (Claire, Clarke et Anderson, 1997). Par exemple, l'eau de ballast des navires a été responsable de l'introduction des algues toxiques dinoflagellés. Ces algues peuvent en effet survivre pendant de nombreuses années dans les ballasts et peuvent, lorsqu'elles sont en présence de nouveaux milieux, empoisonner les fruits de mer qui peuvent s'avérer toxiques voir mortels, dans le cadre d'une consommation humaine (CSIRO, 2006).

Risques encourus

L'eau de ballast peut contenir une grande variété d'organismes provenant de plusieurs groupes taxonomiques différents, qui peuvent être presque microscopiques à l'état de larves. Ceux qui supportent le transport ont souvent la résilience nécessaire pour envahir de nouveaux territoires et altérer l'écosystème envahi. Dans les eaux britanniques, plus de 50 espèces différentes ont été étudiées et reconnues comme ayant été introduit par des facteurs autres que naturels. Plus de la moitié du nombre total des espèces décrites est considérée comme ayant été introduite par les navires. Les espèces marines non natives des eaux britanniques, proviennent principalement de latitudes similaires, en particulier de la côte Est des USA (surtout la faune) et du Pacifique Ouest (surtout la flore) et les espèces provenant d'Australie et de Nouvelle-Zélande ont été remarquées du fait qu'elles reflètent les principales voies de navigation.

Malheureusement, une espèce introduite a de forte chance de devenir visible à court-terme, notamment après qu'elle soit devenue économiquement « coûteuse ». Les dispositions relatives à l'invasion biologique, à l'évaluation des risques et à leur gestion ont rapidement évoluées, poussées par des initiatives globales des organisations relatives à la navigation, groupes gouvernementaux et autres parties concernées. Il y a eu très tôt des suggestions de réductions de dispositions pratiques comme le déchargement d'eau de ballast loin des secteurs portuaires sensibles, l'échange d'eau de ballast au milieu de l'océan, ou l'incorporation de systèmes filtrant et mécanismes ultra violet dans la construction de nouveaux bâtiments.

1.1.4. Les techniques de nettoyage des côtes

Les tableaux suivants fournissent une vue générale des différents types de techniques de nettoyage de côtes (du point de vue des autorités locales britanniques). Il est important de prendre en considération les nombreux facteurs qui peuvent affecter le choix des méthodes utilisées et les priorités fixées. L'estimation du degré de nettoyage nécessaire est compris dans les actions (par exemple, il est plus efficace, dans certains cas, d'autoriser que la nappe soit dispersée naturellement plutôt que d'utiliser un produit spécifique). Des facteurs techniques dans le processus de prise de décision sont également pris en compte, tel que définir la part de nettoyage qui sera effectuée naturellement, les effets de la technique sur l'environnement ainsi que le taux de recouvrement consécutif.

Tableau 5 Récapitulatif des méthodes de nettoyage des côtes

Technique de Nettoyage	Description	Première utilisation de la technique	Conditions d'accès	Conséquences physiques	Conséquences biologiques
Techniques de Pompage et d'Ecumage					
Puisard et pompe/ Ecumoire	Les hydrocarbures sont récupérés dans un puisard au fur et à mesure qu'ils se propagent sur la plage, et ils sont enlevés avec une pompe ou une écumoire	Utilisée sur sable ferme et plages envasées avec de grandes accumulations d'hydrocarbures	Accès routier ou à la plage pour entreposer et prélever l'hydrocarbure récupéré	Demande de creuser un puisard de 1m de profondeur, toutes les traces d'hydrocarbures ne seront pas enlevées	Enlève les organismes à l'endroit du puisard, conséquences éventuelles de l'hydrocarbure laissé sur les côtes, le recouvrement dépend de la persistance de l'hydrocarbure restant
Camions Aspirants	Le camion est reculé jusqu'à la nappe d'hydrocarbure ou la zone de récupération, hydrocarbure récupéré via le tuyau aspirant	Utilisée pour récupérer l'hydrocarbure accumulé sur les côtes, et où l'équipement pour écumer n'est pas disponible	Accès routier au site	N'enlèvera pas toutes les traces d'hydrocarbure	Enlèvera peut-être certains organismes, conséquences éventuelles de l'hydrocarbure restant sur la côte, recouvrement dépend de la persistance de l'hydrocarbure restant
Techniques de Nettoyage à grande eau					
Nettoyage à haute pression	Jet d'eau à haute pression enlève l'hydrocarbure du substrat, hydrocarbure dirigé vers la zone de récupération	Utilisée pour enlever les couches d'hydrocarbure Des pierres, rochers et structures artificielles	Accès simple pour la pompe portable et l'équipement pour écumer	Peut perturber la surface de substrat; peut transporter hydrocarbure dans les sédiments sous la surface	Enlève les organismes du substrat; hydrocarbure restant peut affecter les organismes en contrebas de l'opération de nettoyage
Nettoyage à moyenne pression	Jet d'eau à faible pression chasse hydrocarbure du substrat, hydrocarbure dirigé vers la zone de récupération	Utilisée pour chasser les hydrocarbures non-gluants des plages vaseuses, galets, pierres, structures artificielles et végétation.	Accès simple pour la pompe portable et l'équipement pour écumer	Peu de perturbations à la surface du substrat; peut transporter l'hydrocarbure dans les sédiments sous la surface	Laisse la plupart des organismes vivant en place; hydrocarbure restant peut affecter les organismes en contrebas de la zone de nettoyage
Eau tiède Lavage / Nettoyage à sec	Eau chauffée ou vapeur utilisée pour enlever hydrocarbure du substrat, hydrocarbure dirigé vers la zone de récupération	Utilisée pour enlever les couches d hydrocarbure des pierres, rochers et structures artificielles	Accès simple pour la pompe portable et demande une alimentation en eau fraîche	Ajoute de la chaleur à la surface	Enlève certains organismes du substrat; conséquence fatale aux organismes par la chaleur; hydrocarbure restant peut affecter les organismes en contre bas de l'opération de nettoyage à grande eau.

Tableau 6 Récapitulatif des méthodes de nettoyage des côtes

Technique de Nettoyage	Description	Première utilisation de la technique	Conditions d'accès	Conséquences physiques	Conséquences biologiques
Techniques d'enlèvement des Sédiments					
Niveleuse	Niveleuse forme des fenêtres d'hydrocarbures et les sédiments contaminés pour ramassage par racloir	Utilisée sur des plages de sable ou de graviers où les hydrocarbures ne pénètreront pas plus de 3 cm	Accès pour équipement lourd, bonne condition de circulation sur la plage	Enlève seulement les 3 premiers cm de la plage	Enlève les organismes en faible profondeur; leur re-colonisation a de grande chance de suivre le recouvrement rapide et naturel du substrat
Racloir	Prélève directement les matériaux contaminés de la plage	Utilisée sur des plages de sable et graviers où les hydrocarbures ne pénètrent qu'à moins de 3 cm de profondeur, aussi utilisée pour récupérer des boules de goudron et traces isolées d'hydrocarbures	Accès pour équipement lourd ; bonne condition de circulation sur la plage	Enlève entre 3 et 10 cm de plage, faible réduction de la stabilité de la plage mais risque d'érosion et retrait de la plage	Enlève les organismes en faible profondeur, la rétablissement du substrat peut être lente, re-colonisation a de grande chance de suivre le recouvrement rapide et naturel du substrat
Niveleuse / chargeuse	Niveleuse rassemble les matériaux contaminés pour ramassage par chargeuse	Utilisée sur des plages de sable et de graviers où les hydrocarbures ne pénètrent qu'à moins de 3 cm de profondeur	Accès pour équipement lourd ; bonne condition de circulation sur la plage	Enlève seulement les 3 premiers cm de la plage	Enlève les organismes en faible profondeur; leur re-colonisation a de grande chance de suivre le recouvrement rapide et naturel du substrat
Chargeuse par devant	La chargeuse ramasse les matériaux directement sur la plage	Utilisée sur des plages de vase, sable et graviers où la pénétration des hydrocarbures est modérée et la contamination est de légère à modérée, des chargeuses sur pneus plutôt que tractées car plus rapides et minimise les effets sur la surface de la plage, les chargeuses sont la méthode préférée pour le ramassage de galets pollués	Accès pour équipement lourd, condition correcte à bonne pour la circulation des chouleurs sur la plage	Enlève 10 à 25 cm de plage, la réduction de la stabilité de la plage peut engendrer de l'érosion et le retrait de la plage	Enlève les organismes en faible profondeur, le recouvrement du substrat peut être lente

Bulldozer	bulldozer pousse les sédiments contaminés en tas pour ramassage par chargeuse	Utilisée sur des plages à gros, graviers et galets où les hydrocarbures pénètrent en profondeur, la contamination par hydrocarbures importante et la circulation sur la plage mauvaise	Accès pour équipement lourd, condition correcte à bonne pour la circulation des chargeuses sur la plage	enlève 15 à 50 cm de plage, perte de la stabilité de la plage peut engendrer une érosion importante et le retrait de la plage	Enlève tous les organismes, recouvrement du substrat et re-population par la faune seront extrêmement lents

Tableau 7 Récapitulatif des méthodes de nettoyage des côtes

Technique de Nettoyage	Descripti on	Première Utilisation de la Technique	Conditions d'accès	Conséquences Physiques	Conséquence s Biologiques
Techniques d'Enlèvement des Sédiments					
	Travaille du haut du remblai ou de la plage pour enlever les sédiments contaminés et les charger dans les camions	Utilisée pour enlever les sédiments contaminés sur des remblais pentus	Accès pour Equipement lourd et substrat stable en haut du remblai	Enlève de 25 à 50 cm de plage, perte de stabilité à ce niveau peut entraîner une érosion grave et le retrait de la plage	Enlève tous les organismes, recouvrement du substrat et re-population de la faune seront extrêmement lentes
Excavatrice	Fonctionne du haut de la zone contaminée pour enlever les sédiments contaminés	Utilisée sur du sable, des graviers et plages de galets fortement contaminés, où il sera difficile d'utiliser des équipements tractés.	Accès pour équipement lourd; équipement doit accéder à la zone contaminée	Enlève de 25 à 50 cm de plage, perte de stabilité à ce niveau peut entraîner une érosion grave et le retrait de la plage	Enlève tous les organismes, recouvrement du substrat et re-population de la faune sera extrêmement lente
Techniques de Biodégradation					
Recouvrement naturel	Les hydrocarbures laissés sur place pour qu'ils se dégradent naturellement	Utilisée sur des plages actives où l'action des vagues enlèvera la plus grande partie des hydrocarbures en un temps limité, aussi utilisée lorsqu'un nettoyage intensif aurait des conséquences inacceptables	aucune	N'enlèvera peut-être pas toutes les traces d'hydrocarbures, ceux-ci pourraient contaminer des endroits propres au départ, une longue période sera peut-être nécessaire pour un recouvrement substantiel	Les conséquences de la contamination par hydrocarbures sont plus étendues en raison du caractère plus lent de l'enlèvement, recouvrement biologique ajournée de la même façon
Biodégradation	Recouvrement naturel encouragé	Les plages qui sont légèrement touches par les	Equipements et matériaux peuvent être portés et	N'enlèvera peut-être pas toutes les traces d'hydrocarbures,	Les conséquences de la contamination par hydrocarbures

	avec l'ajout de substances nutritives et/ou bactéries	hydrocarbures, comme une dernière étape après d'autres efforts de nettoyage, aussi utilisée lorsqu'un nettoyage intensif aurait des conséquences inacceptables	utilisés manuellement	ceux-ci pourraient contaminer des endroits propres au départ, une longue période sera peut-être nécessaire pour recouvrement substantiel	sont plus étendues en raison du caractère plus lent de l'enlèvement, recouvrement biologique ajournée de la même façon

De plus amples informations sur les capacités à répondre à une pollution par hydrocarbures en France et au Royaume-Uni peuvent être trouvées dans le document EMSA « Inventory of EU Member States Oil Pollution Response Capacity »[1]. D'autre part, le document du Cedre contient des informations sur la capacité à répondre de la France[2].

1.1.5. Conclusion

Cette section a identifié les types de polluants et leurs sources potentielles dans le milieu marin. Il ne fait aucun doute que les zones côtières sont également menacées par les pollutions provenant de la terre, et que ces sources de pollution nécessiteront à l'avenir une attention particulière. Toutefois, peu de recherches ont été effectuées en ce qui concerne les réactions chimiques dans les milieux marins, et il ne serait pas irraisonnable de suggérer que les produits chimiques présumés inertes, qui pénètrent dans le milieu marin par le biais de l'activité humaine en mer, pourrait en fait se révéler extrêmement toxiques, s'ils venaient à se mêler à la pollution issue des activités terrestres déjà présente dans le milieu marin. Les sujets relatifs à la pollution sont vitaux lors de discussions transnationales, car ils sont liés et s'influencent entre eux. Une connexion directe existe entre la santé des océans et la santé humaine. Ce qui fait des pollutions maritimes un sujet majeur dans les débats internationaux, notamment ceux au sein du GESAMP et avec d'autres législateurs gouvernementaux. A l'appui de leurs découvertes, il y a un besoin d'attention globale plus volontaire afin de réussir à s'attaquer à une menace qui n'a pas de frontières, pour les nommer « POP, métaux, toxines algal, pathogènes et pollution pharmaceutique » (GESAMP, 2000). Toute augmentation des activités maritimes dans la Manche provoquera en parallèle une augmentation des pollutions qui sont trouvées dans les milieux marins de la Manche, et pour les régions qui ont une interface avec une zone maritime. D'autre part, l'étendue géographique de la zone maritime de la Manche annulera toute conséquence environnementale causée par la pollution. Contrairement à d'autres zones maritimes, la Manche est contenu entre les deux masses terrestres franco-britanniques. Cette configuration géographique peut à la fois amplifier les conséquences d'une pollution de grande ampleur et permettre une coopération intense entre les autorités françaises et britanniques. Pour cette raison, les facteurs de réduction devraient s'intensifier parallèlement à toute augmentation de l'activité maritime.

[1] http://www.emsa.europa.eu/Docs/other/inventory.pdf
[2] http://www.cedre.fr/fr/technique/ter/R_04_36_C.pdf/

ÉVALUATION DES RISQUES DE POLLUTION MARITIME ACCIDENTELLE DANS LA MANCHE

PARTIE 1.2 TYPOLOGIE DES CÔTES MENACÉES

University of Plymouth - Marine Institute, Dr. Karen Sumser - Lupson & Marcus Kinch

1.2. TYPOLOGIE DES COTES MENACEES

1.2.1. Introduction

Cette section identifie les secteurs côtiers sensibles de la Manche qui ont été répertoriés pour leur importance écologique, sociale ou culturelle, et qui sont préservés par la législation internationale, européenne et/ou nationale. L'identification de ces sites a été basée entre autres sur leur degré de sensibilité aux activités maritimes. La zone maritime de la Manche demandera des considérations spéciales à long terme si l'on souhaite qu'une destruction grave soit évitée à l'avenir. La zone maritime de la Manche est un secteur dont la gestion est complexe, avec un niveau d'activités maritimes très élevé, en comparaison avec d'autres zones maritimes. Ces facteurs influeront sur les opérations de secours en cas de survenue d'un désastre majeur.

1.2.2. Zone maritime particulièrement sensible

D'après l'OMI, une Zone maritime particulièrement sensible, susceptible d'être endommagée par les activités liées à la navigation internationale, demande une protection spéciale en raison de son importance écologique, scientifique ou socio-économique. Cette notion permet d'identifier les secteurs sensibles sur les cartes de navigation internationale, ceci afin que les marins naviguent avec plus de prudence autour de ces régions particulièrement sensibles. Les secteurs maritimes inclus dans la proposition PSSA en 2006 comprenaient les dispositions concernant les routes maritimes de l'OMI, quatorze démarcations de voies de navigation, deux voies profondes, sept secteurs à éviter et quatre systèmes obligatoires de signalement des navires. Il est vital que les zones sensibles qui côtoient l'espace maritime de la Manche soit connues si les responsables de la mise en œuvre de plans de secours veulent pouvoir gérer un accident de manière optimale. Cette étude établit un examen comparatif de part et d'autre de la Manche et un travail cartographique qui fournira des informations fondamentales pour améliorer la prise de conscience relative à la sécurité maritime.

1.2.3. Zone d'étude des régions côtières de la Manche

Séparant la côte Sud du Royaume-Uni de la côte Nord de la France, la Manche couvre une superficie de 75 000 km². Au Royaume-Uni, la limite terrestre s'étend de Douvres (à l'Est) et continue vers Lands End en Cornouaille et vers les îles Scilly, avant de finir dans la mer Celtique au Sud-Ouest. En France, la limite terrestre s'étend à partir du Cap Gris Nez dans le Pas-De-Calais, vers la Pointe de Corsen située à l'Ouest du Finistère.

A proximité de la côte normande, les Iles Anglo-Normandes regroupent l'île de Jersey et ses îlots ainsi que les îles de Guernesey (comprenant les îles de Guernesey, Sark, Alderney, Brecqhou, Herm, Jethou et Lihou). Guernesey et Jersey sont sous la dépendance de la couronne britannique, mais aucune ne fait partie du Royaume-Uni. Les Iles Anglo-Normandes ne sont pas représentées au Parlement britannique et chaque île a sa propre législature. La Manche se rétrécit en allant de l'Est vers l'Ouest, en passant de 34 km de distance à son point minimum, à 180 km à son point maximum. Sa profondeur moyenne augmente en allant vers l'Ouest, d'environ 50 m à 100 m, avec une descente jusqu'à 1000 m dans la partie la plus éloignée. Son fond possède deux formations caractéristiques, composé tout d'abord de sable et de graviers avec des rochers affleurants, sur ses côtés Ouest, et se mêlant à des dépôts plus denses de sable, de galets et de cailloux en allant vers l'Est[4].

1.2.3.1. Royaume-Uni

La côte anglaise, qui couvre les Îles de Scilly et les comtés de Cornwall, Devon, Dorset, Hampshire, l'Ile de Wight, Kent et Sussex, devient de plus en plus anthropisée en allant vers l'Est. La plupart de ces zones sont situées sur de vastes plaines littorales inondables, les rendant sensibles à l'influence de la mer et aux pollutions accidentelles. Les secteurs vulnérables comprennent, notamment, Hastings, Brighton & Worthing, Portsmouth, Southampton, Bournemouth et Poole. Les sites industriels de grande ampleur sont nombreux dans cette région, que ce soit, par exemple, la grande raffinerie de pétrole à proximité de Southampton ou les grandes usines de papier dans le Kent.

Il y a également deux centrales nucléaires à Dungeness dans le Kent. Portsmouth comprend à la fois la base navale la plus importante de l'Europe de l'Ouest et une gare maritime pour ferry. Le plus grand champ pétrolifère du Royaume-Uni, près de Kimmeridge, se situe à quelque distance de la Manche parmi les collines de Purbeck dans le Dorset. Les côtes de la Manche sont équipées de brise-lames et autres défenses contre la mer, utilisées pour minimiser l'érosion des plages et réduire les risques liés aux inondations, mais ces équipements ont modifié une grande partie du profil littoral. Ceci a été particulièrement important dans des secteurs à basse altitude dans le comté du Hampshire, où une des particularités de cette région est la concentration de vallées estuariennes inondées, appelées rias. D'importantes activités de dragage sont également effectuées le long de la côte Est pour l'exploitation de sable et de graviers pour la construction.

La côte Sud-Ouest présente également de grandes conurbations résidentielles à Torbay, Plymouth et Falmouth. Plymouth a les plus grands chantiers navals du Royaume-Uni où les navires de la Marine Royale sont entretenus et où les sous-marins conventionnels et nucléaires sont révisés et approvisionnés en carburant. Dans l'estuaire du Tamar il y a une grande station de carburant approvisionnant des navires de l'OTAN. Newlyn, situé plus à l'ouest, est le plus grand port de pêche britannique.

Des propositions récentes sur l'emplacement d'éoliennes le long de cette côte représentent un nouvel impact de développement qui pourrait avoir à l'avenir des implications pour la sécurité

[4] Un lien utile pour en savoir plus sur le type de littoral et les vulnérabilités de la côte française : http://www.ifen.fr/publications/DossiersInternet/marees_noires/france.htm.
En ce qui concerne les vulnérabilités de la côte britannique (carte de recherche des secteurs côtiers du patrimoine national et le type de littoral) : http://www.countryside.gov.uk/LAR/Landscape/DL/heritage_coasts/index.asp.
http://www.english-nature.org.uk/livingwiththesea/project_details/good_practice_guide/habitatcrr/ENRestore/Sites/UK/England/Index.htm fournit également des informations sur le type de littoral au Royaume-Uni. Ces informations pourraient être utiles aux décideurs lors de la gestion d'une crise puisqu'elles fournissent les caractéristiques géomorphologiques et naturelles des côtes de la Manche.

maritime dans la région. Le littoral Ouest rassemblent les caractéristiques environnementales les plus riches du Royaume-Uni, en rassemblant les habitats les plus rares et les plus menacés de la nation. Plus de cinq millions de personnes vivent dans cette région et plus de 15 millions de personnes viennent la visiter chaque année. « L'Agriculture, le tourisme et la pêche représentent les principales sources d'emplois dans le secteur » (Defra, 2005).

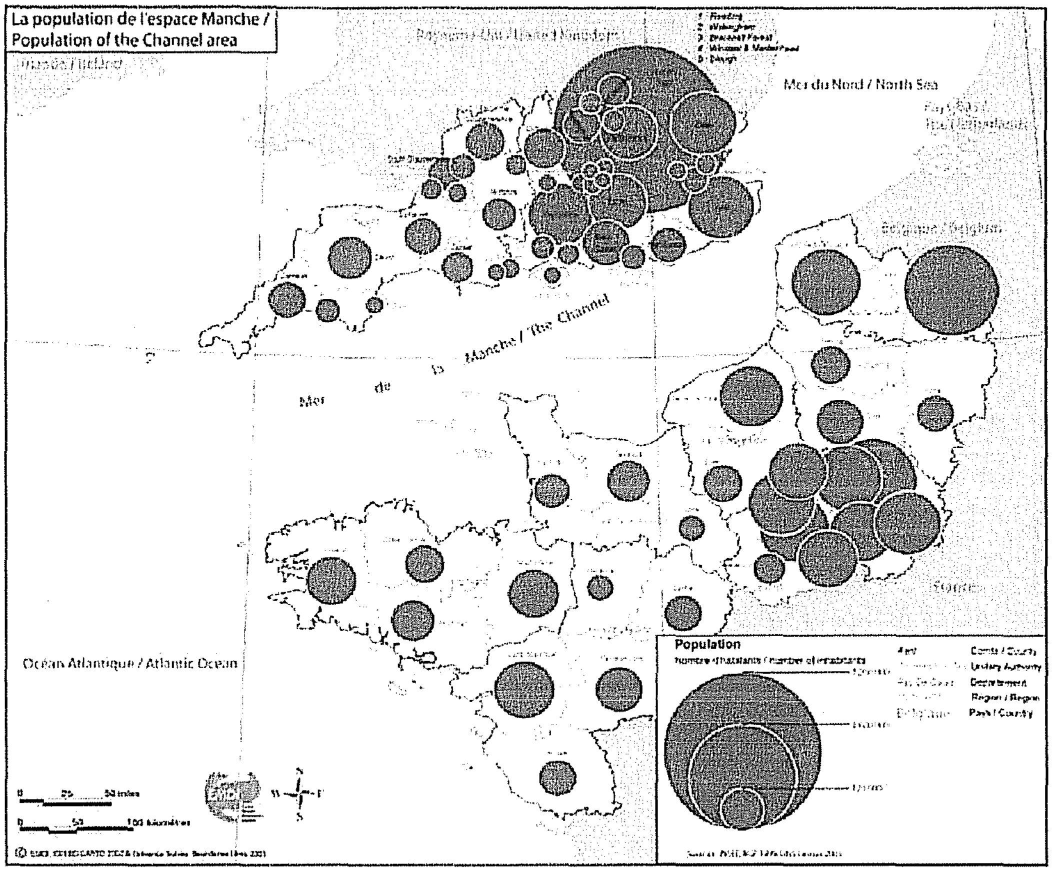
1.2.3.2. France

Le littoral français compte pour seulement 4% du territoire métropolitain. Cependant, plus de 5,8 millions de personnes y résident (Corine, 2000). La pression anthropique a augmenté, et l'agrandissement des parcs industriels et portuaires, ainsi que la création de zones de loisirs, peuvent être observées dans de nombreux endroits. En France, un inventaire des ressources côtières a été effectué en utilisant une importante base de données géographiques européennes appelée « Corine Land Cover (CLC) inventory ». Ces données ont été regroupées en cinq secteurs : zones urbaines, champs arables, forêts ouvertes et environnements naturels, marécages et autres surfaces d'eau. L'analyse CLC établit un rapport sur tout le territoire côtier dans les limites de certaines communes (secteurs classés). Le taux d'occupation du terrain est variable et les terres arables prédominent sur les secteurs côtiers du Nord de la France. L'analyse montre également une augmentation régulière des zones résidentielles (+ 8 500 ha), portuaires, industrielles et nœuds de communication (+ 3 700 ha) sur les quinze dernières années, et une forte réduction des terres arables (- 7 700 ha) et des environnements naturels (- 6 600 ha) sur cette même période.

L'étude a conclu que la majorité des changements relatifs aux aménagements dans les dernières années se sont effectués le long de la côte bretonne et du Nord Pas de Calais, avec une augmentation de la population (Corine, 2000). Une étude similaire (Ifen, 1998) met en lumière le changement de tendance d'utilisation de la terre dans les régions côtières de la Bretagne, du Nord-Pas-De-Calais et de la Picardie, que ce soit au travers de l'aménagement de vastes complexes de loisirs, de ports de plaisance et d'installations industrielles énergétiques.

1.2.4. Population de l'Espace Manche

La première comparaison des zones littorales sensibles portera sur la densité de population : le degré d'urbanisation par régions et la densité des zones urbaines (du côté britannique et français).



Carte 2 Densité de population basée sur les derniers recensements effectués en France et au Royaume-Uni
(Source : Atlas Transmanche[5], carte et informations mises à jour le 03/06/2004).

[5] http://infodoc.unicaen.fr/transmanche

Population 2001					
Départements	Nombre d'habitants	Comtés	Nombre d'habitants	Autorités autonomes	Nombre d'habitants
Finistère	852418	Cornwall et Iles Scilly	501267	Plymouth	240720
Côtes d'Armor	542373	Devon	704493	Torbay	129706
Ile-et-Vilaine	867533	Dorset	390980	Poole	138299
Manche	481471	Hampshire	1240103	Bournemouth	163444
Calvados	648385	West Sussex	753614	Portsmouth	186701
Seine-Maritime	1239138	East Sussex	492324	Ile de Wight	132731
Somme	555551	Kent	1329718	Brighton et Hove	247820
Pas-de-Calais	1441568			Medway	249502
Nord	2555020			Southampton	217445

Tableau 8 Population des comtés et départements côtiers bordant la Manche
(Source : Atlas transmanche)

La population des comtés et départements côtiers de la Manche est de 22 773 324 d'habitants. Ce chiffre ne comprend pas les deux zones métropolitaines nationales de Londres et Paris. Au total, la population des différents comtés et départements côtiers représente presque 46 % des 49 591 594 habitants de toute la zone transmanche. Au niveau national, les comtés côtiers concernés représentent 14,5 % de la population anglaise ou 12,1 % du Royaume, soit un total de 7 118 867 d'habitants répartis sur 7 comtés et 8 autorités unitaires en bordure de la Manche.

1.2.5. Zones maritimes protégées dans la Manche

Il y a de nombreux secteurs le long des régions de la Manche qui bénéficient de mesures de protection. Celles-ci sont promulguées par une appellation statutaire appliquée à une caractéristique donnée, et représentée soit par un groupement de types d'habitats - tels que de vastes marais salants ou vasières – soit par un rassemblement d'espèces qui vivent dans un secteur particulier - tels que les oiseaux en période hivernale - ou des caractéristiques touristiques et/ou géographiques particulières - tel que les sites du patrimoine mondial de l'UNESCO.

Bien que le classement d'une grande partie du littoral soit maintenant bien avancé de part et d'autre de la Manche, il importe que chacun des pays membres de l'Union Européenne applique des mesures de conservation, non seulement dans les eaux territoriales, mais également dans les eaux marines au large. Notons que les efforts déployés afin de protéger le milieu marin ne sont toujours pas aussi avancés qu'au niveau terrestre. Cette situation peut s'expliquer par la logistique qu'une telle mission implique, notamment, d'un point de vue cartographique, du coût de l'opération, mais également compte tenu de l'absence de coordination entre le niveau national et celui de l'union Européenne. Ceci est un fait historique qui a amené de nombreux secteurs côtiers à connaître un développement inapproprié ou insuffisamment protégé. Des estimations récentes ont suggéré que plus de 50% de toute la biodiversité du Royaume-Uni est présente dans les mers (EN, 2000). Toutefois, la sélection spécifique de réserves naturelles marines (Marine Nature Reserves - MNR) au Royaume-Uni en est toujours à ses premiers balbutiements.

Dans un avenir proche, de nombreux autres secteurs marins feront probablement l'objet d'une grande attention. Ceux-ci comprendront invariablement des habitats représentatifs (galets et sable) allant du Kent au Hampshire dans l'Est du Royaume-Uni jusqu'aux fonds de maërl (éléments carbonatés de style corallien dont la préservation est importante au niveau international) dans le Dorset et les régions côtières de Cornwall, ainsi que d'autres caractéristiques le long des bordures Ouest de la Manche. Les Iles Scilly possèdent également des écosystèmes bien spécifiques (bancs de sable et écueils) mais elles sont préservées grâce à la loi sur les Zones Spéciales de Conservation (Special Areas of Conservation – SAC). En France, il existe également de grandes zones de maërl, d'importance internationale, situées notamment au large de la Bretagne. Celles-ci représentent la majorité de toutes celles présentes en France et ont été identifiées comme étant les plus importants en Europe (Grall J. & Hall-Spencer JM., 2003). Bien que ces secteurs de maërl (britanniques et français) ne bénéficient pas de protection statutaire, ils doivent cependant être pris en compte dans ce rapport comme étant une zone sensible à la pollution.

1.2.6. Typologie des protections réglementaires applicables à la zone d'étude

Comme les ressources naturelles environnementales interagissent à l'échelle mondiale, elles ne peuvent être contenues dans des limites nationales particulières, les oiseaux migrateurs et les poissons sont de bons exemples de ce fait. La destruction d'un de leur habitat a donc des effets importants sur leur fécondité. Ce fut le cas le 12 décembre 1999, lorsque le pétrolier *Erika* se brisa en deux, à 30 miles nautiques des côtes bretonnes, déversant 10 à 15 000 tonnes d'hydrocarbures dans la mer. Son impact écologique fut catastrophique et les données locales françaises, relatives aux populations d'oiseaux rares, ont estimé que dans le Golfe de Gascogne, entre 80 000 et 150 000 oiseaux marins ont été tués suite à ce naufrage. Le « guillemot commun » (*Uria aalge*) représentait plus de 80% des oiseaux touchés et la majorité des individus provenaient de colonies situées entre l'Ouest de l'Écosse et la Mer Celtique (Cadiou B. et al., 2004). La couverture médiatique de l'évènement a aussi touché huit Zones de Protection Spéciales (ZPS) classées par la Directive Oiseaux (FOE 2000); alors que le montant des indemnités s'élevait à *175 550 000 euros* (J. Roberts et al., 2005).

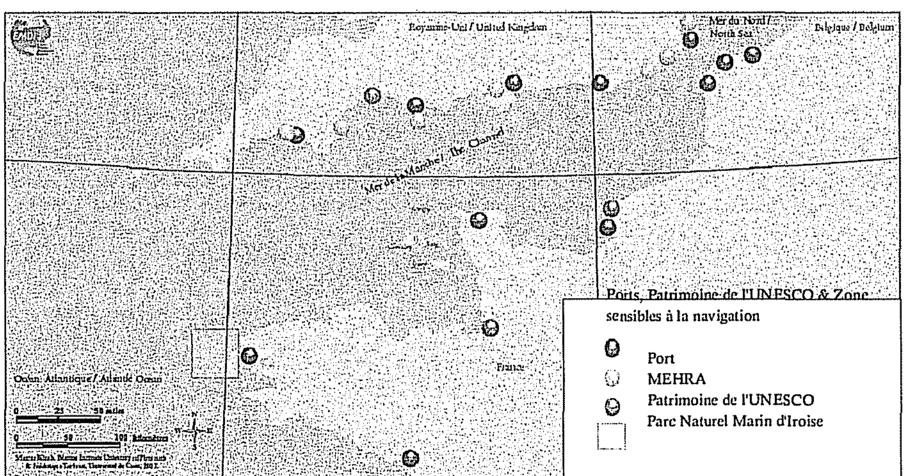
Bien que chaque Etat membre possède ses propres lois de préservation pour les secteurs menacés, des appellations plus larges au niveau international et européen sont en place pour diminuer de manière significative les ambiguïtés liées aux différents champs d'application des lois des divers pays. Cela fournit un cadre commun qui protège et souligne les riches atouts naturels et facilite la résolution de problèmes et l'échange d'informations dans les domaines des ressources transnationales.

❖ **Natura 2000 : La convention de Bern (Etats-membres de l'UE) intègre :** ❖ **SPA** - Special Protection Areas (UK) ❖ **ZPS** - Zone de Protection Spéciale (France) ❖ **SAC** - Special Areas of Conservation (UK) ❖ **ZSC** – Zone Spéciale de Conservation (France)
❖ **RAMSAR** – Zone RAMSAR
❖ **SSSi** - Sites of Special Scientific Interest (UK) / Sites spéciaux d'intérêt scientifiques
❖ **ZNIEFF** – Zone Naturelle d'Intérêt Ecologique Faunistique et Floristique (France)
❖ **SSI** - Sites of Special Interest (Jersey)
❖ **MPZ** – Marine Protection Zones (Jersey) / Zone de Protection Marine
❖ **NNR** - National Nature Reserves / Réserves Naturelles nationales
❖ **MEHRA** - Marine Environmental High Risk Areas (UK)
❖ **UNESCO** - Zone UNESCO

Tableau 9 Définitions des Appellations Applicables *(Source : EMDI, 2007)*

1.2.7. Identification des sites sensibles aux pollutions maritimes

Les sites identifiés peuvent être classés par ordre de sensibilité en cas de pollution maritime, selon l'importance de leur place au niveau international (Appellations de l'UNESCO & RAMSAR), européen (SPA/SAC & ZPS/ZSC – NATURA 2000) ou national (SSi/SSSi & ZNIEFF/MEHRA). Par conséquent, selon son niveau d'appellation, plus un site spécifique aura une position élevée dans le classement, plus il subira probablement des impacts négatifs importants causés par les activités maritimes dans ce secteur. La carte suivante permet de situer les principaux ports, et les caractéristiques du Patrimoine Mondial de l'Unesco dans le cadre de l'étude, aux côtés des appellations de MEHRA, le long de la côte britannique et du Parc Marin d'Iroise.

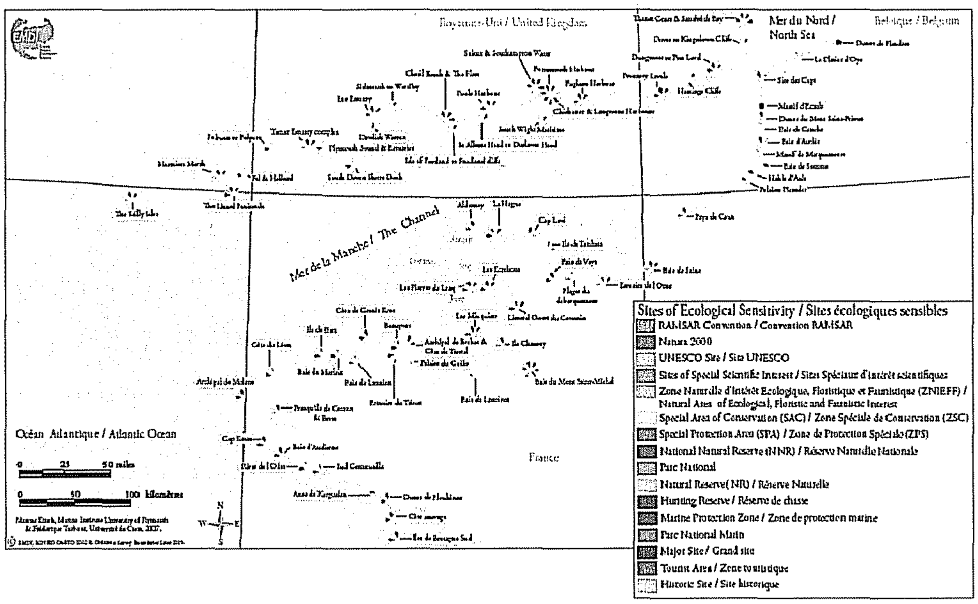


Carte 3 Ports, appellations culturelles et secteurs sensibles pour la navigation
(Source : M.Kinch; Marine Institute; University of Plymouth & F. Loew; University of Caen)

1.2.8. Conclusions

Cette partie a examiné les zones littorales de la Manche et a signalé plus spécifiquement celles qui sont particulièrement sensibles. A travers les représentations visuelles (cartes), il est évident que les zones littorales de la Manche sont extrêmement sensibles. Il y a par exemple de réelles implications sociales, économiques et environnementales en cas de pollution accidentelle. La côte entière, de chaque côté de la Manche, a un certain degré d'urbanisation avec les plus fortes densités situées à proximité des grandes villes et des ports. Une population sera probablement affectée si une pollution venait à toucher la côte. Il y a également de fortes chances que ce soit en fonction de la densité de la population, ainsi que d'autres facteurs sociaux et économiques que des décisions stratégiques soient prises concernant la pollution et la gestion de la crise.

Il y a de réelles implications écologiques qui ont des incidences sur la gestion d'une pollution maritime accidentelle. Les sites marins situés le long des côtes de la Manche, sensibles écologiquement, ont une grande valeur environnementale et fournissent aux populations côtières une ressource sociale et un revenu économique (opportunités touristiques). Il est clair qu'une gestion soutenue de ces sites écologiquement sensibles sera primordiale dans la procédure de prise de décision en cas de pollution. Cependant, la Manche requiert une gestion particulière du fait qu'elle associe des sites à grande valeur écologique à des sites qui ont une grande valeur sociale. La proximité des zones côtières de chaque côté de la Manche contrecarrerait encore plus la gestion dans une situation de pollution maritime ; la rapidité de mise en place d'un plan de secours sera donc un facteur déterminant si la gestion des ressources marines se veut d'être durable sur le long terme.



Carte 4 Sites Sensibles Ecologiquement
(M.Kinch; Marine Institute; University of Plymouth & F. Loew; University of Caen)

RETOUR SOMMAIRE | INTRO

PARTIE 1.3 ÉVALUATION DU TRAFIC MARITIME DANS LA MANCHE

Vigipol, Sophie Bahé

1.3. ÉVALUATION DU TRAFIC MARITIME DANS LA MANCHE

La Manche constitue un espace maritime unique au monde en raison de particularités géographiques, d'une densité de trafic exceptionnelle notamment en matière de transport de produits dangereux, de la multiplicité des activités qui se partagent l'espace maritime, de la dimension rapidement internationale de toute opération et de littoraux fortement anthropisés. Pour toutes ces raisons, la Manche est devenue, depuis les années 1970, un espace maritime très réglementé.

1.3.1. La circulation maritime dans la Manche

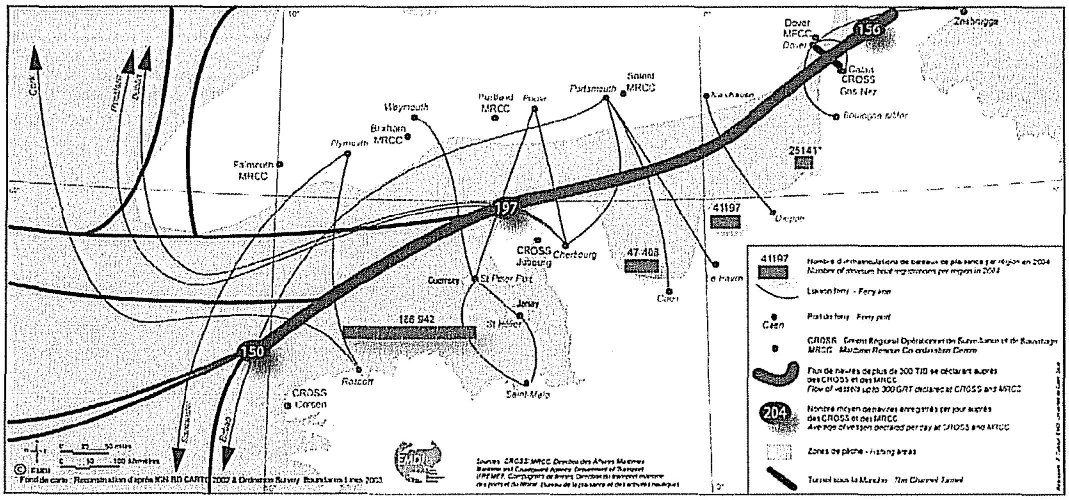
1.3.1.1. Particularités géographiques

La Manche, mer bordière de l'océan Atlantique s'ouvrant au Nord-Est sur la mer du Nord, constitue une zone maritime resserrée. Sa largeur oscille entre 180 Km dans la partie occidentale et 34 Km dans le détroit du Pas de Calais. Sa profondeur ne dépasse pas 120 mètres et se réduit d'Ouest en Est pour n'être, au maximum, que de 65 mètres dans le détroit du Pas de Calais, avec certaines zones n'excédant pas 30 mètres de profondeur. Une telle configuration géographique induit des courants marins parmi les plus violents du monde, courants combinés à de forts marnages (jusqu'à 15 mètres dans la baie du Mont Saint Michel). En outre, les conditions météorologiques y sont particulièrement difficiles d'octobre à avril. L'ensemble de ces particularités géographiques sont autant de facteurs qui influent sur les conditions de navigation dans la Manche.

1.3.1.2. Densité du trafic

La Manche est une zone d'activités maritimes historiquement dense, *le plus puissant carrefour maritime du monde* (A. Vigarié, 1979). Elle représente, en effet, un lieu de transit obligatoire pour les navires circulant entre l'océan Atlantique et le *Northern Range*, première façade portuaire du monde qui s'étend de l'Elbe à la Seine, de Hambourg au Havre et Rouen, et dessert toute l'Europe du Nord-Ouest, combinant bassins industriels et bassins de consommation importants.

La densité du trafic maritime y est sans équivalent au monde, avec près de 20% du trafic mondial. A une circulation de marchandises longitudinale très dense s'ajoutent de très nombreux mouvements transversaux entre les côtes britanniques et françaises, notamment le transport de 70 000 passagers par jour entre le Royaume-Uni et la France. Ainsi, 700 à 800 bateaux (hors pêche et plaisance) passent par jour dans le détroit du Pas de Calais (Cf. Carte 5). Le tableau 10 ci-après recense le nombre de navires, par catégories, passant annuellement dans le Dispositif de Séparation du Trafic (DST) des Casquets. Notons que seuls les navires d'une capacité égale ou supérieure à 300 tonneaux de jauge brute (TJB), obligés de déclarer leur passage dans les DST, sont pris en compte.



Carte 5 La densité du trafic maritime en Manche en 2006
(Sources : Frédérique Turbout, Université de Caen)

TYPES DE NAVIRES*	NOMBRE DE NAVIRES
Pétroliers	2 844
Gaziers	2 593
Chimiquiers	7 680
Cargo	28 944
Vraquiers	9 444
Porte-conteneurs	14 291
Navires à passagers	3 811
Bateaux de pêche	396
Navires de balisage, sauvetage, police	64
Navires scientifiques	157
Remorqueurs	424
Autres	327
Total	**70 975**

* Ne sont pris en compte que les navires supérieurs à 300 TJB

Tableau 10 Nombre de navires traversant le DST des Casquets en 2006 par catégories de navires
(Sources : Affaires maritimes, base de données Trafic 2000)

Parmi l'ensemble des marchandises transportées, on recense, en 2006, plus de 313 millions de tonnes de produits dangereux. L'International Maritime Dangerous Goods (IMDG) Code, adopté en 1965 par l'Organisation Maritime Internationale (OMI) et largement amendé depuis pour tenir compte des évolutions de l'industrie, établit une typologie des produits dangereux en neuf classes. Le tableau 11 détaille les quantités de produits dangereux transportées en 2006 dans le DST des Casquets par des navires supérieurs à 300 TJB en fonction de cette classification. Notons que plus de 80% des produits dangereux transitant dans la Manche sont des hydrocarbures.

CLASSES IMO	TYPES DE PRODUITS	QUANTITES *(en tonne)*
1	Explosifs	411 537,00
2	Gaz	17 705 595,01
3	Liquides inflammables	260 064 828,22
4	Solides inflammables	7 963 018,59
5	Oxydants et peroxydes organiques	4 159 927,43
6	Matériaux toxiques et substances infectieuses	4 771 379,89
7	Matériaux radioactifs	118 888,75
8	Matériaux corrosifs	8 485 463,88
9	Divers	9 676 840,64
Total		**313 357 479,41**

Tableau 11 Transport maritime de produits dangereux dans la Manche en 2006
(Sources : Affaires maritimes, base de données Trafic 2000)

1.3.1.3. Multiplicité des activités en mer

Le trafic de marchandises et de passagers côtoie des activités maritimes de natures diverses, multipliant ainsi les conflits d'usage. La pêche joue, notamment, un grand rôle dans la Manche, à la fois par l'existence de zones de pêche, de nombreux ports de part et d'autre et par le nombre de bateaux de pêche immatriculés (1 000 sur la façade maritime française). Boulogne est d'ailleurs le premier port de pêche européen. Les techniques de pêche employées conjuguent des arts traînants et des arts dormants, ce qui favorise les conflits entre pêcheurs français, belges et hollandais. La Manche est aussi très appréciée des plaisanciers. En 2004, 300 688 bateaux de plaisance étaient immatriculés dans les régions maritimes de l'espace Manche côté français. En outre, de nombreux câbles sous-marins pavent également l'ensemble de la zone mais il est difficile de les recenser avec précision. Ces câbles nécessitent un entretien régulier d'où des risques de collision supplémentaires. A cela s'ajoute une activité d'extraction de granulats marins, ce qui favorise les conflits avec les pêcheurs. Enfin, des projets d'implantation d'éoliennes en mer sont actuellement à l'étude et pourraient encore accroître l'encombrement de l'espace maritime.

1.3.1.4. Dimension rapidement internationale de toute opération

En raison de la configuration géographique très resserrée et de la nature des activités maritimes, les conséquences d'un événement en mer prennent rapidement un caractère international dans la Manche. Par conséquent, les relations entre autorités françaises, britanniques et belges sont beaucoup plus étroites que ne le sont habituellement les échanges internationaux sur d'autres façades maritimes. En Manche, les autorités ont, en effet, l'habitude d'échanger nombre d'informations et sont régulièrement amenées à conduire des opérations en commun. En janvier 2007, les opérations d'assistance et de remorquage du porte-conteneurs *MSC Napoli* illustrent bien cette intense coopération franco-britannique. En effet, le navire a signalé son avarie dans les eaux territoriales françaises à l'entrée Ouest de la Manche, les autorités britanniques ont procédé à l'évacuation de l'équipage avant que le navire ne soit pris en remorque par des remorqueurs français et finalement conduit par ceux-ci en baie de Lyme après décision conjointe des autorités françaises et britanniques d'accueillir le navire côté britannique.

1.3.1.5. Des littoraux fragiles et fortement anthropisés

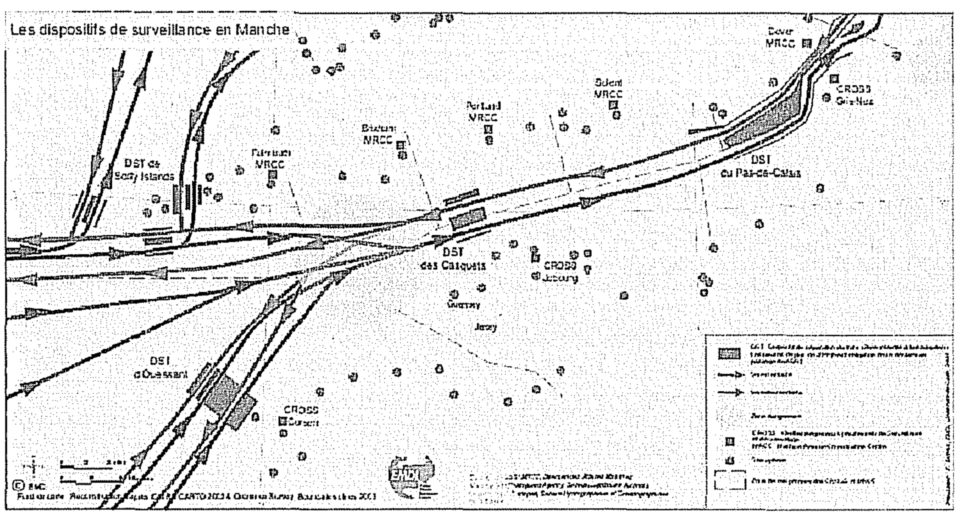
Enfin, il convient de prendre en compte la très forte anthropisation des littoraux de part et d'autre de la Manche. Densément urbanisés, ces littoraux sont aussi pourvus d'activités nombreuses et variées. Outre la pêche mentionnée ci-dessus, de nombreuses industries se répartissent tout le long du littoral, notamment des sites Seveso aux abords des grands ports comme Le Havre. On trouve aussi plusieurs centrales nucléaires côté français (Gravelines, Flamanville, La Hague, etc.). La prise en compte de l'interface maritime de ces activités à risque pour les populations ne doit donc pas être négligée en cas d'accidents en mer (risque d'explosion en chaîne, altération des prises ou des rejets d'eau en mer, etc.). Par ailleurs, les rivages de la Manche constituent un espace touristique de plus en plus attractif où les sites naturels remarquables et sensibles sont nombreux. L'économie de l'ensemble des régions riveraines de la Manche est donc largement tributaire de la mer. Par conséquent, tout incident susceptible de perturber le trafic maritime ou d'occasionner des dommages (une pollution par exemple) pourra avoir des conséquences préjudiciables pour l'ensemble de l'économie de ces régions.

1.3.2 La sécurité du trafic maritime dans la Manche

La densité du trafic maritime dans la Manche a nécessité la mise en place de règles de navigation spécifiques. Dès les années 1960, l'analyse des statistiques d'accidents montrait que les collisions entre navires devenaient une cause préoccupante d'accidents, notamment dans les eaux encombrées (OMI, 1998). Plusieurs rapports préconisèrent alors d'instaurer des règles d'organisation du trafic dans certaines zones au niveau mondial. En juin 1967, le premier Dispositif de Séparation du Trafic (DST) fut mis en place dans le détroit du Pas de Calais. Le nombre de collisions entre navires suivant des routes opposées chuta alors de façon significative. Cependant, ce dispositif n'était initialement que facultatif. Il fallut attendre 1971 et les collisions successives du *Texaco Caribbean* avec le *Paracas*, le *Brandenburg* et le *Niki*, à l'origine de la mort de 51 membres d'équipage pour que l'OMI rendit obligatoire le respect des dispositifs de séparation du trafic, en particulier au travers du Règlement pour prévenir les abordages en mer (COLREG).

Selon l'OMI, « l'organisation du trafic maritime a pour but d'améliorer la sécurité de la navigation dans les zones de convergence, dans les zones à forte densité de trafic et dans les zones où la liberté de mouvement des navires est entravée par l'insuffisance de l'espace maritime, par l'existence d'obstructions à la navigation, par une profondeur limitée ou par des conditions météorologiques défavorables » (OMI, 1973). La Manche combine l'ensemble de ces facteurs. Par conséquent, deux autres DST y furent mis en place ultérieurement : le DST des Casquets et le DST d'Ouessant (Cf. Carte 6). L'objectif est de séparer les navires qui se déplacent dans des directions opposées afin de réduire les risques d'abordage frontal, simplifier la configuration du trafic dans les zones de convergences, assurer la sécurité du trafic dans les zones d'exploration ou d'exploitation intensive qui sont situées au large des côtes et réduire les risques d'échouement en fournissant des directives spéciales aux navires à fort tirant d'eau, dans les zones où la profondeur de l'eau est incertaine ou critique.

Cette organisation du trafic spécifique en Manche repose sur une gestion concertée entre les autorités maritimes françaises et britanniques. Le trafic est ainsi canalisé au travers d'une voie montante et d'une voie descendante, délimitée par une zone de séparation. Cependant, certains croisements demeurent inévitables, en particulier entre la côte Nord de la Bretagne et la côte Sud du Devon et de la Cornouaille. Les autorités ont mis en place un réseau de surveillance fondé, côté français, sur les CROSS (Centre Régionaux Opérationnels de Surveillance et de Sauvetage) et, côté britannique, sur les MRCC (Maritime Rescue Co-ordination Centre). Ce dispositif est complété par une chaîne sémaphorique particulièrement dense (Cf. Carte 6) qui permet aux autorités de suivre précisément les mouvements des navires et de porter assistance en cas de besoin. En 1994, la règle 8-1 du chapitre V de la convention SOLAS (Safety Of Life At Sea) imposa les systèmes de comptes-rendus de navires au passage des DST afin de contribuer à « garantir la sauvegarde de la vie humaine en mer, la sécurité et l'efficacité de la navigation et la protection du milieu marin » (OMI, 1994). En conséquence, depuis 1999, les navires supérieurs à 300 TJB ont obligation de se déclarer au passage d'un DST.



Carte 6 Organisation du trafic maritime dans la Manche
(Sources : Frédérique Turbout, Université de Caen)

PARTIE 1.4 RECENSEMENT DES POLLUTIONS MARITIMES ACCIDENTELLES SURVENUES DANS LA MANCHE ET SES ABORDS DEPUIS 1960

Vigipol, Sophie Bahé

1.4. Recensement des pollutions maritimes accidentelles survenues dans la Manche et ses abords depuis les annees 1960

1.4.1. Méthodologie

1.4.1.1. Objectifs

La Manche est une des routes maritimes les plus fréquentées du globe. Toutes sortes de marchandises (pétrole, produits chimiques, conteneurs, etc.) y transitent, notamment pour approvisionner les grands ports de la Mer du Nord. Il s'agit, par conséquent, d'une zone où le risque de pollution maritime est élevé, comme le montre la longue liste des pollutions survenues depuis les années 1960. Le but de ce recensement est de montrer l'importance du risque de pollution maritime accidentelle dans la Manche et ses abords. Il s'agit de déterminer quelles ont été les zones les plus accidentogènes sur la période 1960 - janvier 2007 et quels sont les principales causes des accidents maritimes induisant une pollution du milieu. Seules les pollutions accidentelles seront, par conséquent, recensées. Les rejets illicites des navires ne seront volontairement pas ici mentionnés.

Trois types de pollutions ont été retenus : pollutions par hydrocarbures, pollutions chimiques et autres pollutions. Seuls les déversements d'hydrocarbures supérieurs à 50 tonnes ont été pris en compte. En deçà de ce seuil, il est difficile d'obtenir des informations homogènes sur l'ensemble de la zone et de la période. En ce qui concerne les pollutions chimiques, aucun seuil n'a été fixé dans la mesure où la dangerosité du polluant est indépendante de la quantité déversée. En effet, certains produits chimiques sont très dangereux en très faible quantité tandis que d'autres restent relativement inoffensifs même en grande quantité. Toutes les pertes en mer connues et localisables de produits chimiques ont donc été répertoriées, même pour les quantités les plus faibles. La catégorie « *Autres pollutions* » regroupe, quant à elle, des pollutions plus atypiques. Il s'agit, par exemple, de la perte en mer de conteneurs, de billes de bois, de détonateurs ou d'huile végétale. Le manque d'exhaustivité et de fiabilité des données disponibles sur les pertes de conteneurs en mer nous a contraint à ne prendre en compte dans cette catégorie que les événements les plus significatifs et détaillés.

1.4.1.2. Recueil des données

A ce jour, il n'existe pas réellement de cartographie analytique des pollutions maritimes ni dans la Manche ni en Europe ni dans le monde depuis les cartes réalisées par A.R. Bertrand en 1979 au niveau mondial, européen et français. La carte interactive de localisation des pollutions maritimes (chimiques et hydrocarbures), présentée sur le site Internet du Cedre (www.cedre.fr), est la plus complète. Les principaux critères retenus sont la quantité déversée, la médiatisation de la pollution et le fait que le Cedre soit sollicité pour cette pollution, mais il n'y a pas de seuil strictement défini. Il fut donc nécessaire de recouper les informations du Cedre avec d'autres sources, telles la base de données de la Lloyd's Maritime Intelligence Unit qui recense les accidents maritimes depuis 1976, des ouvrages spécialisés (Hooke, 1997 et NOAA, 1992) et toute autre information ponctuelle sur chacune des pollutions (rapports officiels d'enquête sur les accidents maritimes, informations recueillies auprès des autorités françaises et britanniques, sites Internet des armateurs, coupures de presse, etc.) ; aucun recensement ne couvrant, à ce jour, l'ensemble de la zone sur la totalité de la période (1960 - janvier 2007). Notons que deux bases de données font référence en matière de pollutions par hydrocarbures, celle de l'ITOPF (The International Tanker Owners Pollution Federation Ltd) qui recense tous les déversements en mer d'hydrocarbures supérieurs à 7 tonnes depuis 1974, et celle de Dagmar Schmidt Etkin, qui comprend tous les déversements d'hydrocarbures en mer supérieurs à 10 000 gallons (34 tonnes) depuis 1960. Mais nous n'avons pas pu y avoir accès.

1.4.2. Cartographie et analyse

1.4.2.1. Présentation de la base de données « Pollutions maritimes accidentelles dans la Manche 1960-2007 »

Pour chaque pollution, dans la mesure du possible, les données suivantes ont été recueillies : nom du navire, coordonnées de l'accident (en latitude et en longitude), date, type de navire, âge du navire, pavillon, nature de la cargaison, quantités transportées, cause de l'accident, quantités déversées, type de polluant, littoral touché ainsi que des détails sur les conditions de l'accident et les conséquences de la pollution.

L'ensemble de ces données a été intégré sous MapInfo®. Notons que cette base de données a été réalisée en français. Le tableau 12 décrit la répartition des pollutions dans le temps et par type de polluant.

	Pollutions par hydrocarbures *(supérieures à 50 tonnes)*	Pollutions chimiques	Autres pollutions	Total
1960 - 1969	8	-	-	8
1970 - 1979	19	-	-	19
1980 - 1989	8	4	-	12
1990 - 1999	8	5	5	18
2000 - 2007	4	5	6	15
Total	47	14	11	72

Tableau 12 Répartition des pollutions survenues dans la Manche par type et par décennie
(Source : Sophie Bahé, Vigipol)

Concernant les pollutions chimiques, il convient de noter que toutes les pollutions recensées n'ont pas pu être intégrées dans la base de données, et par conséquent, indiquées sur la carte en raison du peu d'informations disponible quant à leur localisation. C'est le cas notamment de pollutions mentionnées dans une analyse réalisée en 1999 par le groupe de travail OTSOPA de l'Accord de Bonn *(Cf. Tableau 13).* Dans un rapport soumis par le Royaume-Uni à l'OMI (Organisation Maritime Internationale) en septembre 2002, on trouve également mention du *Katerina S'* dont 21 fûts d'acide hydrochlorique passèrent par-dessus bord dans la Manche le 19 février 1996, certains s'échouant sur les côtes françaises. Plus récemment, l'exemple du *Safmarine Léman*, porte-conteneurs de 140 mètres de long, battant pavillon suisse, est particulièrement intéressant. Ce navire a prévenu les autorités maritimes de Brest, le 8 décembre 2006, qu'il avait perdu en mer, lors d'une tempête, 13 fûts de 200 litres de produits chimiques (7 fûts contenant de l'isopropanol et 6 du toluène) entre la Pointe du Cotentin et le Sud de la Bretagne. *NB : Au vu de l'étendue de la zone potentielle de perte, il est impossible de représenter cette pollution sur la carte.* En dépit de missions de reconnaissance sur zone, les autorités ne sont pas parvenues à localiser les fûts à la dérive qui présentaient un risque en cas d'arrivée à la côte. Aucune statistique n'est accessible à ce jour sur les pertes réelles de cargaison en mer, notamment celles de conteneurs ou fûts toxiques. Rappelons, cependant, que les navires qui déclarent leurs pertes en mer aux autorités maritimes sont rares. Il convient donc de garder en mémoire que les pollutions chimiques en mer sont sous-évaluées ; et cartographiquement sous-représentées dans cette étude.

Par ailleurs, certains accidents impliquant des produits chimiques n'occasionnent pas une pollution du milieu. Nous avons néanmoins pris en compte ceux qui ont suscité un risque humain potentiel élevé. Par exemple, l'*Ascania*, en 1999 ne généra aucune pollution de la mer mais l'incendie qui se déclara à bord du navire, laissa craindre l'apparition d'un nuage toxique. Par mesure de précaution, l'équipage fut évacué ainsi que 200 habitants alentour. En revanche, nous n'avons pas retenu le *ROSA M*, dans la mesure où il n'y eut ni pollution ni évacuation de population. Cependant, cet exemple a largement contribué à alimenter la réflexion des autorités sur le risque chimique. Le 30 novembre 1997, une avarie contraint ce porte-conteneur à être remorqué vers le port de Cherbourg. À l'approche du port, le navire est volontairement échoué afin de pomper une partie de sa cargaison, corriger sa gite et permettre son entrée dans la rade. Le manifeste de chargement indique la présence dans les conteneurs d'environ 70 tonnes de substances dangereuses, notamment des gaz et liquides inflammables, des substances corrosives et oxydantes. Une évaluation du risque chimique à bord du navire est nécessaire. Celle-ci nécessite alors la concertation de nombreux acteurs (autorités maritimes et portuaires, représentants de l'armateur, unités opérationnelles et experts).

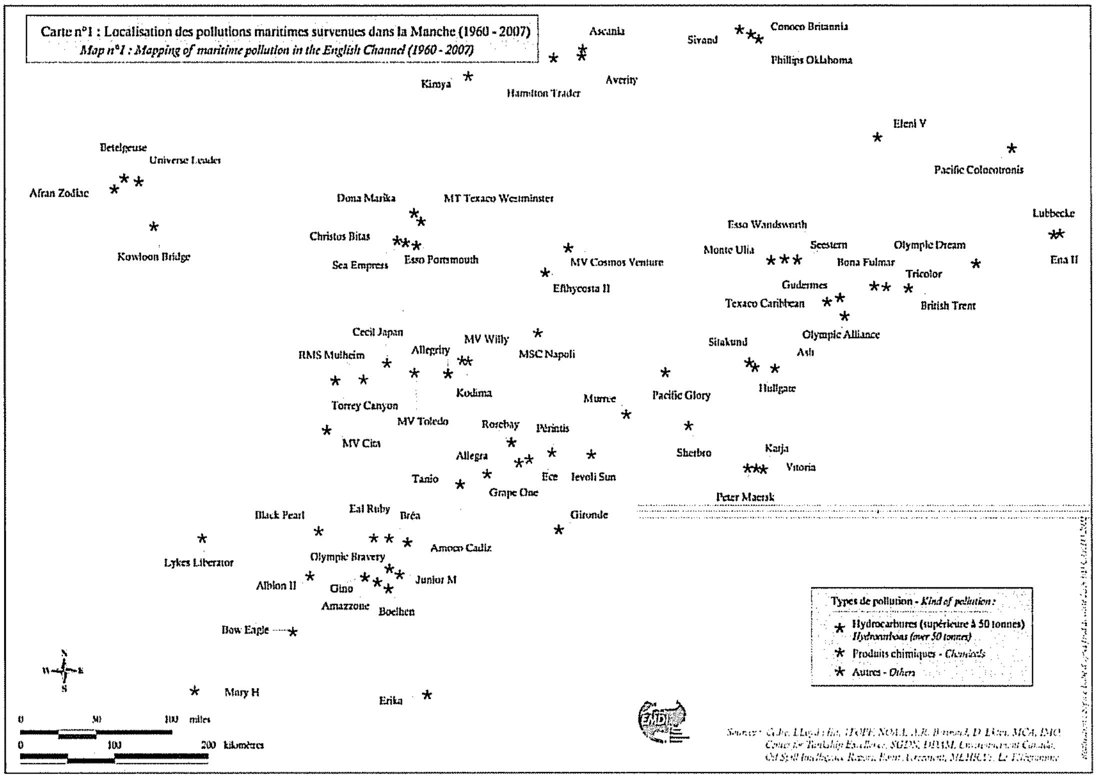
NOM DU NAVIRE	ANNEE	PRODUITS CHIMIQUES	PAYS	ZONE MARINE
Produits transportés en colis				
SINBAD	1979	Chlore	Hollande	Mer-du-Nord
ARIEL	1992	White spirit	Hollande	Mer-du-Nord
APUS	1998	Solides inflammables *(allumes feux)*	Hollande	Mer-du-Nord
BAN-ANN	1998	Sulphur-phosphine	Hollande	Mer-du-Nord
EVER DECENT	1999	Matières dangereuses	Grande Bretagne	Mer-du-Nord
Produits en vrac qui se dissolvent				
ANNA BROERE	1988	Acrylonitrile (DE) Dodecylbenzène (F)	Hollande	Mer-du-Nord
Produits en vrac qui coulent				
NORAFRAKT	1992	Sulfure de plomb (S)	Hollande	Mer-du-Nord

Tableau 13 Extrait du récapitulatif des accidents chimiques en mer ***(Source : Accords de Bonn)***

La catégorie « *Autres pollutions* » regroupe des pollutions autres que par hydrocarbures ou chimiques. A titre d'exemple, l'*Allegra* et le *Kimya* perdirent en mer des huiles végétales, de l'huile de palmiste pour le premier, de l'huile de tournesol pour le second. Le souvenir de la perte de cargaison du *Mary H* est encore bien présent dans les esprits. En 1993, des détonateurs pyrotechniques s'échouèrent sur les plages françaises, des Côtes d'Armor aux Pyrénées Atlantiques, pendant plus d'un mois et demi, interdisant ainsi l'accès à de nombreuses plages. Nous avons, également, classé dans cette catégorie le *Tricolor*, ce navire transportant des voitures qui coula dans le détroit du Pas de Calais en décembre 2002 suite à une collision. Certes, il y eut pollution par hydrocarbures lors de la collision initiale et des collisions ultérieurés avec d'autres navires venant s'encastrer dans l'épave mais chacune de faible ampleur. En revanche, l'obstacle à la navigation que représenta l'épave, affleurant au ras de l'eau à marée basse, entre décembre 2002 et septembre 2004, dans une des zones maritimes les plus étroites et les plus fréquentées du monde est beaucoup plus porteur d'enseignements. Cela démontre le fort pouvoir accidentogène d'une épave à cet endroit précis et les moyens matériels colossaux nécessaires pour signaler une épave aux autres navires et la relever.

1.4.2.2. La localisation des pollutions maritimes survenues dans la Manche (1960-2006)

La carte 7 localise les pollutions maritimes survenues dans et aux abords de la Manche entre 1960 et janvier 2007. La densité de pollutions est élevée sur l'ensemble de la Manche. Certaines zones concentrent, cependant, plus de pollutions que d'autres. C'est notamment le cas des DST (Dispositif de Séparation du Trafic) d'Ouessant, des Casquets et du Pas de Calais. Cette constatation n'est pas surprenante dans la mesure où les DST ont été établis à l'initiative de l'OMI à la fin des années 1960 afin de réduire les risques d'abordage dans une région où le trafic maritime est dense dans les deux sens, et dans les zones où se croisent des flux importants de navires. Les abords de plusieurs grands ports (Le Havre, Milord Haven et Bantry) et certains estuaires (l'Humber et la Tamise notamment) comptent également une densité de pollutions plus forte. Plus spécifiquement, les pollutions chimiques sont principalement localisées aux abords du rail des Casquets et au large de la Pointe de la Bretagne tandis que les autres pollutions se concentrent presque intégralement à l'entrée Ouest de la Manche entre le Sud de la Cornouaille et le Nord de la Bretagne.



Carte 7 Localisation des pollutions maritimes survenues dans la manche (1960-2007)

La figure 1 indique comment les pollutions se répartissent au fil des mois sur la totalité de la période considérée (1960 – janvier 2007). Des pollutions par hydrocarbures se sont produites tout au long de l'année. Cependant, six mois (janvier, mars, avril, septembre, octobre et novembre) concentrent les 2/3 des pollutions. De même, les pollutions chimiques, à deux exceptions près (l'*Ena II* et le *Bow Eagle*) ainsi que les autres pollutions se sont produites entre octobre et mars. Ceci montre que les conditions météorologiques plus difficiles en automne et en hiver favorisent la survenue d'accidents maritimes.

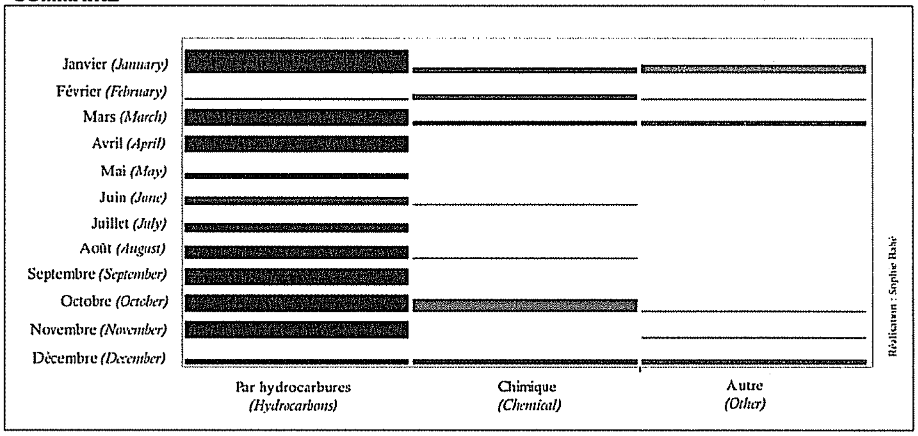


Figure 1 Corrélation entre le mois de survenue de l'accident et le type de pollution

La carte 8 détaille spécifiquement les pollutions par hydrocarbures en fonction de leur ampleur. Si l'on considère une ligne médiane dans la Manche allant de la Pointe du Cotentin à l'Ouest de l'île de Wight, on constate que, si en nombre d'événements les deux côtés sont à peu près équivalents, la partie occidentale de la Manche a connu des pollutions de plus grande ampleur que la partie orientale (les deux pollutions supérieures à 100 000 tonnes, le *Torrey Canyon* et l'*Amoco Cadiz* ainsi que quatre des cinq pollutions comprises entre 10 000 et 100 000 tonnes). La figure 2 présente, quant à elle, la répartition des pollutions par hydrocarbures au fil des mois. Si les pollutions inférieures à 10 000 tonnes se produisent tout au long de l'année, les pollutions supérieures à 10 000 tonnes surviennent uniquement entre novembre et avril. Ceci laisse à penser que les mauvaises conditions météorologiques en automne et en hiver sont, par conséquent, un facteur déterminant pour les pollutions de très grande ampleur alors qu'elles jouent un rôle moindre pour les pollutions inférieures à 10 000 tonnes.

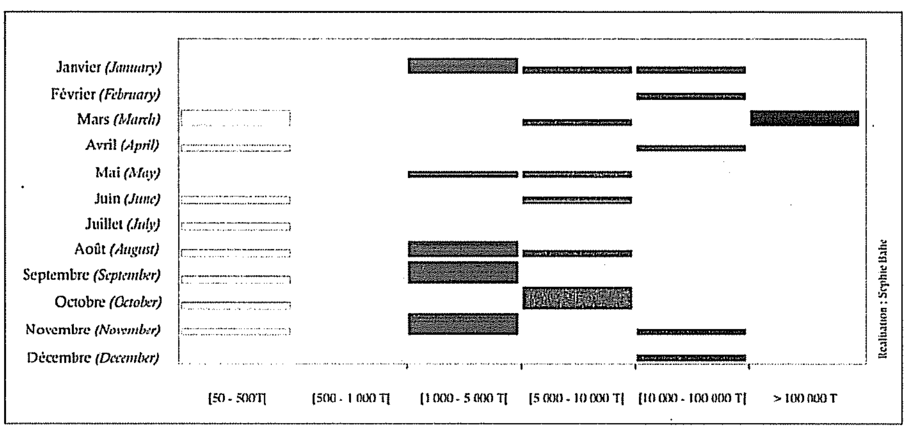
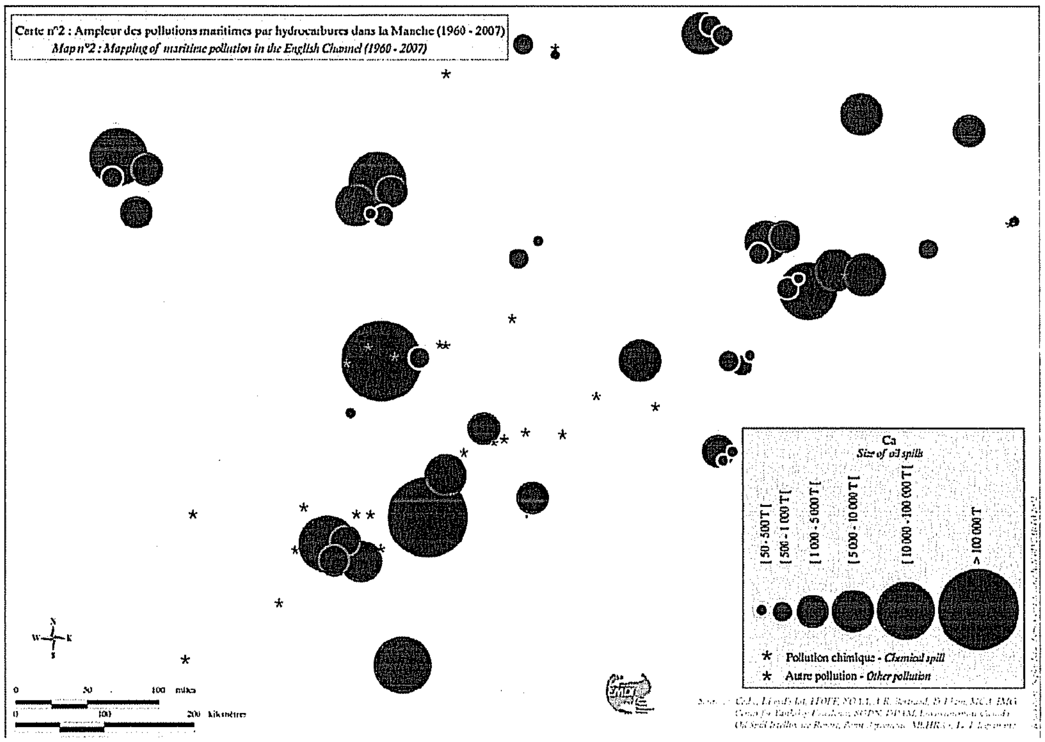


Figure 2 Corrélation entre le mois de survenue de l'accident et l'ampleur des pollutions par hydrocarbures

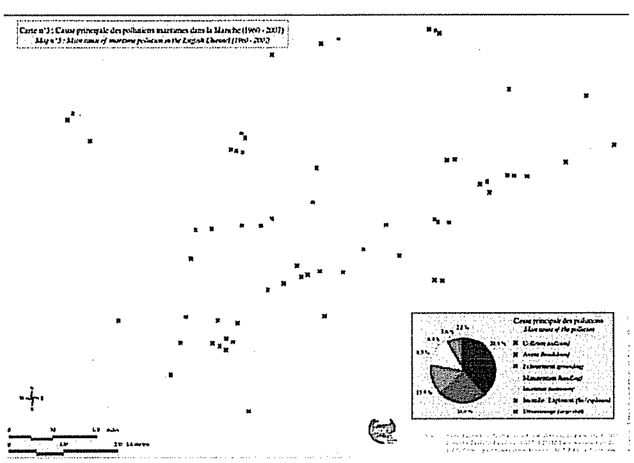


Carte 8 Ampleur des pollutions maritimes par hydrocarbures dans la Manche (1960-2007)

1.4.2.3. Les principales causes des pollutions maritimes dans la Manche

La carte 9 illustre la cause principale des pollutions. Seule la cause principale de chaque accident a été prise en compte. Il convient, cependant, de rappeler qu'un accident maritime résulte souvent de la combinaison de plusieurs facteurs ; le mauvais temps et/ou une avarie peuvent, par exemple, provoquer un échouement. Par conséquent, il n'est pas toujours aisé de déterminer la cause principale, surtout quand nous ne disposons que d'informations succinctes sur les circonstances de l'accident. Nous avons donc retenu pour cause principale le facteur qui déclenche la pollution accidentelle. La collision est la cause principale de plus d'un tiers *(38,9 %)* des accidents maritimes dans la Manche. Là encore, le DST du Pas de Calais se distingue clairement puisque la totalité des pollutions survenues dans cette zone fut causée par une collision. Les abords des ports sont également des zones où les collisions sont fréquentes. Les pollutions survenues au large des côtes bretonnes, et notamment au large du Finistère et au large de la côte Nord, furent très largement causées par des avaries. Notons que, dans la zone entre le Golfe de Gascogne et la Manche, les conditions de mer sont particulièrement difficiles. Les pollutions maritimes causées par des erreurs de manutention apparaissent comme peu nombreuses, dans la plupart des cas dans un port lors des manœuvres de chargement et de déchargement. Ceci ne reflète, cependant, pas l'ampleur du facteur humain dans les pollutions. En effet, les échouements et les collisions peuvent résulter d'une erreur humaine (manque de vigilance de l'officier de quart par exemple). De même, les désarrimages sont sous-évalués. Rappelons, en effet, que nous n'avons pas recensé l'ensemble des pertes de conteneurs en raison du manque d'exhaustivité et de fiabilité des données, mais nombre de conteneurs et de fûts, dangereux ou non, sont régulièrement perdus en mer. Enfin, les échouements sont la cause de 15,9 % des pollutions. L'échouement peut résulter d'une erreur humaine ou d'une avarie. D'une manière générale, le facteur humain joue un rôle plus important dans la survenue des accidents maritimes que ne le laissent supposer les statistiques issues de notre base de données, mais, dans la plupart des cas, il est n'est pas aisé à mettre en lumière. A ce sujet, rappelons que le code ISM (International Safety Management) fut mis en place en 1998 par l'OMI pour remédier à la fréquence des erreurs humaines dans les causes d'accidents maritimes à la fin des années 1980 et au début des années 1990 (Huijer, 2005).

Les figures 3 et 4 permettent de corréler la cause principale des accidents avec la période de l'année à laquelle ils surviennent, et donc avec les conditions météorologiques. Les pétroliers subissent des accidents occasionnant des pollutions tout au long de l'année. En revanche, les cargos, chimiquiers et vraquiers, à de rares exceptions près, ainsi que les porte-conteneurs ne causent de pollution qu'entre octobre et mars. En outre, d'après la répartition de la cause principale des accidents au fil des mois *(Cf. Figure 4)*, la quasi-totalité des échouements, avaries et désarrimages surviennent entre octobre et mars. Ceci laisse à penser que de mauvaises conditions météorologiques causent ou, tout du moins, accentuent les difficultés rencontrées par les navires et qu'un incident, qui pourrait rester mineur par temps calme, a de plus grandes chances d'être considérablement aggravé par temps difficile, entraînant ainsi une pollution. Par ailleurs, il ne semble pas y avoir de corrélation directe entre la période de l'année et les collisions, les explosions/incendies et les erreurs de manutention.



Carte 9 Cause principale des pollutions maritimes dans la Manche (1960-2007)

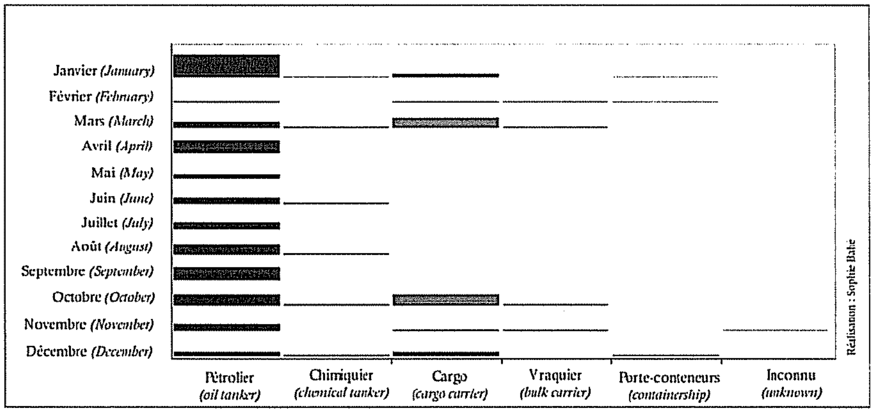


Figure 3 Corrélation entre le mois de survenue de l'accident et le type de navire

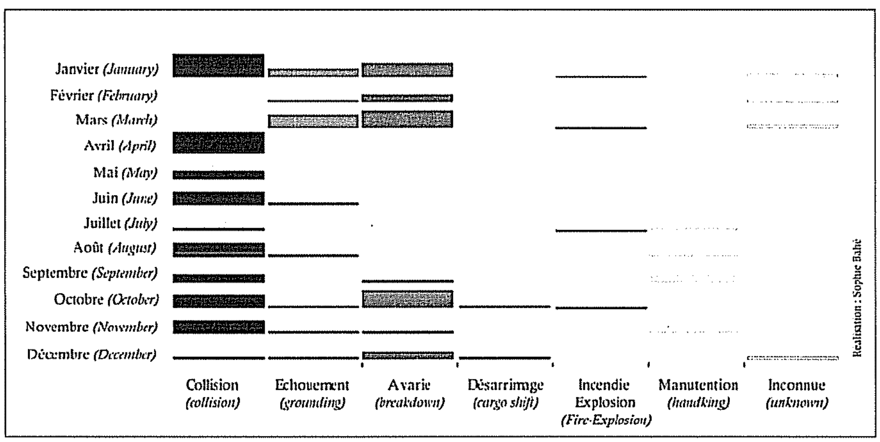
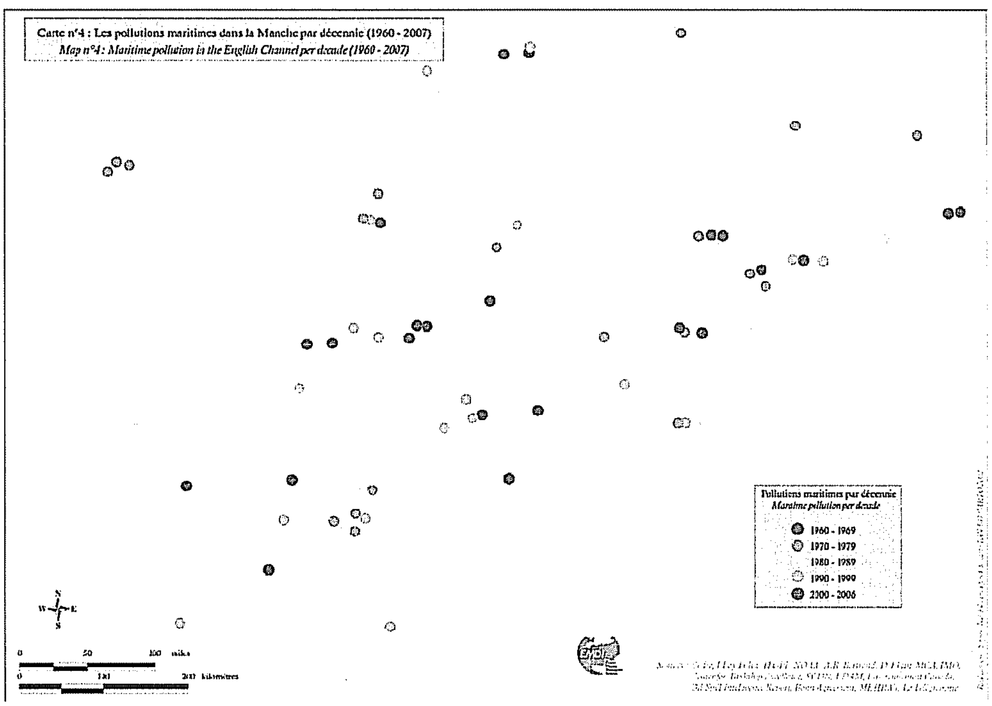


Figure 4 Corrélation entre le mois de survenue de l'accident et sa cause

1.4.2.4. Quelles évolutions ?

D'après la carte 10, la Manche comprend des zones plus ou moins accidentogènes en fonction des périodes. Ainsi, la majorité des pollutions qui ont affecté les côtes de la pointe de la Bretagne sont survenues dans les années 1970 et 1980. De même, les ports ont subi la plupart de leurs pollutions entre les années 1960 et 1980. Les années 1990 et 2000 leur sont vraisemblablement plus favorables, à l'exception des ports de Manchester et de Hambourg. Depuis les années 1990, les pollutions se situent majoritairement à l'entrée occidentale de la Manche (au Sud et à l'Ouest de la Bretagne dans le Golfe de Gascogne ainsi que sur les côtes de

Cornouaille), aux abords Ouest du DST des Casquets et aux abords du DST du Pas de Calais. La mise en place du DST d'Ouessant et l'ensemble des mesures de prévention prises par les autorités françaises et britanniques, notamment la mise en place de remorqueurs, peuvent expliquer la réduction du nombre de pollutions causées par des avaries. Les procédures d'accueil des navires en difficulté *(aussi appelées « zones refuges »)*, généralisées en France et au Royaume-Uni depuis la directive européenne 2002-59, devraient sans doute réduire encore ce facteur. A contrario, l'augmentation des accidents dans les DST des Casquets et du Pas de Calais tient à la densification du trafic. La composition des équipages, le nombre d'hommes à bord et leur formation influent aussi certainement sur l'accroissement du nombre de collisions.



Carte 10 les pollutions maritimes dans la Manche par décennie (1960-2007)

Les statistiques réalisées par l'ITOPF sur la période 1974-2005 démontrent que le nombre de pollutions par hydrocarbures tend à diminuer depuis la fin des années 1970, ce que corrobore la figure 12 ; et ce, en dépit d'une augmentation constante des quantités de pétrole transportées par voie maritime au niveau mondial, estimée à 46 % entre 1988 et 2001 (Etkin, 2001). En revanche, la fréquence des pollutions chimiques, apparues dans les années 1980, ne cesse d'augmenter. De même, les pollutions que nous avons qualifiées d'atypiques ne sont apparues que dans les années 1990. Il conviendrait d'ajouter dans cette catégorie l'ensemble des pertes de cargaisons (conteneurs, fûts, billes de bois, etc.) qui sont de grands obstacles à la navigation et qui peuvent se révéler dangereux en fonction de leur nature. Autrement dit, les pollutions maritimes ne diminuent pas en nombre mais changent de nature. Si les *nouvelles* pollutions (chimiques, obstacles à la navigation) sont moins visibles et spectaculaires que les pollutions par hydrocarbures, elles n'en sont pas moins dangereuses. Les conséquences de pollutions chimiques sur l'environnement sont potentiellement aussi graves, voire plus encore, que celles causées par des hydrocarbures. En outre, les risques humains sont multipliés, à la fois pour l'équipage et les populations littorales. En effet, les hommes d'équipage pâtissent des risques chimiques et du risque accru de collision avec les obstacles à la navigation. Et la survenue d'une pollution chimique en eaux littorales menace les populations riveraines dans la mesure où les produits chimiques sont souvent moins visibles que les hydrocarbures, donc plus difficilement repérables pour les promeneurs qui peuvent les inhaler ou les manipuler et le risque de dégagement d'un nuage toxique peut nécessiter l'évacuation des populations.