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ACTION PLAN FOR THE RECOVERY OF THE MEDITERRANEAN MONK SEAL IN THE EASTERN ATLANTIC

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ACTION PLAN FOR THE RECOVERY OF THE MEDITERRANEAN MONK SEAL IN THE EASTERN ATLANTIC



CONVENTION ON THE CONSERVATION OF MIGRATORY SPECIES
OF WILD ANIMALS (BONN CONVENTION)



ACTION PLAN
FOR THE RECOVERY OF THE
MEDITERRANEAN MONK SEAL
(Monachus monachus)
IN THE EASTERN ATLANTIC

Prepared by the
WORKING GROUP OF THE MEDITERRANEAN MONK SEAL IN THE EASTERN
ATLANTIC

For the
CONVENTION ON THE CONSERVATION OF MIGRATORY SPECIES OF WILD ANIMALS
(BONN CONVENTION)

2005

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SUMMARY

The Mediterranean monk seal (*Monachus monachus* Hermann, 1779) is one of the most threatened mammals in the world. According to the IUCN, there may be less than 500 seals remaining in the Mediterranean and along the Eastern Atlantic coastline. It has disappeared from most of its distribution range, except for a few isolated groups. The low numbers and negative trends are a cause for concern, even based on the most optimistic estimates. There are two breeding colonies of Mediterranean monk seal in the Eastern Atlantic: one on the *Desertas* Islands (Madeira) and the other on the *Cabo Blanco* Peninsula (Morocco-Mauritania). Since the colonies are probably isolated demographically and genetically (with less than 200 seals each concentrated along a few kilometres of coastline), experts regard its status in the Atlantic as very critical. The alarming decline of seals at *Cabo Blanco* in 1997 increased international concern, to the point that the most important nature conservation bodies urge prompt and effective action.

The monk seal populations in the Mediterranean area have been the focus of attention since 1986 (UNEP/MAP 1987). Efforts have centred on implementing the Monk Seal Management Plan (an international strategy), within the framework of the Action Plan for the Mediterranean (Barcelona Convention 1976).

Important initiatives and projects have been developed in the Atlantic that are cause for a renewed optimism with regards to monk seal conservation. These include the setting up of the *Desertas Islands* Nature Reserve in Madeira and the Fisheries Protected Area in the Moroccan waters of *Cabo Blanco* peninsula. However, there is still a need for a coordinated international strategy and a regional action plan for the monk seal in the Atlantic area.

This document contains an Action Plan based on strong international collaboration to recover the Atlantic populations of monk seal and guarantee its continuity as a self-sustaining part of the ecosystem. The Plan reflects international concern about the critical status of the Mediterranean monk seal and the responsibility of Morocco, Spain, Mauritania and Portugal (the four countries in its distribution range in the Atlantic, in the framework of the Bonn Convention), to promote and undertake concerted and effective actions to reverse its decline and recover the species.

The threats that have been identified to date and which are reflected in the document range from massive die-offs due to red tides, diseases and sub-optimal pupping sites to interactions with fisheries and habitat disturbance. The Plan seeks to encourage the states involved to implement a series of measures to maintain or re-establish favourable conservation status, the seal's natural habitat and the seal populations in the region. The main action is the creation of a Network of Special Areas of Conservation for the Monk Seal (SACMS).

MEMBERS OF THE ATLANTIC MONK SEAL WORKING GROUP

Spain:

Luis Mariano González (Coordinator), *Dirección General para la Biodiversidad, Ministerio de Medio Ambiente Madrid.*

Julio Mas, *Centro Oceanográfico de Murcia Instituto Español de Oceanografía, San Pedro del Pinatar Murcia.*

Rogelio Herrera, *Viceconsejería de Medio Ambiente del Gobierno de Canarias La Laguna Tenerife.*

Fernando Aparicio, Pablo Fernández de Larrinoa, Hamdi M'Bareck and Michel Cedenilla (assistants), *Fundación CBD-Habitat.*

Morocco:

Amina Moumni, *Institut National de Recherche Halieutique (INRH) Casablanca.*

M'Hamed Idrissi, *Institut National de Recherche Halieutique (INRH), Director INRH- Laâyoune.*

Abdellah El Mastour, *Service de la Protection de la Nature Ministère de l'Agriculture, du Développement Rural et des Pêches Maritimes Rabat.*

Marraha Mustapha, *Haut Commissariat Eaux et Forêt et la lutte contre la desertification, Rabat.*

Mauritania:

Director, *Parc National du Banc d'Arguin, Nouakchott.*

Kallahi O. Mohamed Fall, *Institut Mauritanienne de Recherches Océanographiques et des Pêches Nouadhibou (IMROP).*

Azza Mint Jiddou, *Institut Mauritanienne de Recherches Océanographiques et des Pêches (IMROP), Nouadhibou.*

Antonio Araujo, *International Foundation of National Park Banc d'Arguin (FIBA), Nouatchokk.*

Portugal:

Henrique Costa-Neves, *Câmara Municipal do Funchal, Funchal Madeira.*

Rosa Pires, *Parque Natural da Madeira, Funchal, Madeira*

Marina Sequeira, *Instituto da Conservação da Natureza (ICN), Lisboa.*

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LIST OF ABBREVIATIONS

CMS: Convention on the Conservation of Migratory Species of Wild Animals or Bonn Convention

CBSG: Conservation Breeding Specialist Group IUCN

GEF: Global Environment Facility

IUCN: International Union for Nature Conservation

MoU: Memorandum of Understanding

PHVA: Population and Habitat Viability Analysis

SACMS: network of Special Areas of Conservation for the Monk Seal

SC/CMS: Scientific Committee of Bonn Convention

UNEP: United Nations for Environment Program

WGAMS: Working Group of Atlantic Monk Seal

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INTRODUCTION

The United Nations Convention on the Law of the Sea (which came into effect in 1994), is recognised by the United Nations Conference for the Environment and Development (1992) as the international basis on which to pursue the protection and sustainable development of the marine and coastal environment, as well as its resources. Often referred to as the “Constitution for the Oceans”, the convention establishes the overarching international legal framework for the exploitation and protection of the oceans and establishes equilibrium between the rights and duties of coastal states and states involved in the rational exploitation of the oceans and their resources. The Convention obliges all contracting party states to conserve living resources and to protect the marine environment.

The conventions and agreements are completed by several protocols containing provisions relating to specific measures that the contracting parties are obliged to put into practice. Certain conventions are provided with “action plans”, which are reviewed regularly, and with trusteeship funds established by the contracting parties to finance their action plans. The international agreements recognise that the task of protecting and effectively managing the oceans must be closely linked with developing national territories and that, within this context, coastal areas should be considered an integral part of a system that national management efforts must protect. They reflect the generally accepted idea that sound economic development must respect the environment, and help define the way to proceed.

It has been acknowledged that developing countries are hesitant to fulfil their obligations without a considerable amount of financial help. Their participation depends on the concession of extra financial resources to allow them to meet the obligations laid down in the conventions. The Global Environment Facility (GEF) has been set up by the World Bank and by countries that would like the conventions to be implemented effectively.

In the above context, and as part of the United Nations Environmental Programme, the Convention on the Conservation of Migratory Species of Wild Animals, or Bonn Convention (CMS), seeks to improve the conservation status of migratory species via actions at a national level and through international co-operation agreements. The Mediterranean monk seal is included in Appendix I (Endangered Species) of the CMS, which implies that Member states are committed and obliged to:

- conserve its habitat to counteract factors impeding movement and migrations,
- survey other threat factors,
- ban seal hunting and capture, and
- prevent disturbance to the species.

Such provisions must also be applied, in accordance with the UNEP, on boats from the member countries when operating outside the limits of national jurisdiction.

The Mediterranean monk seal is also included in Appendix II of CMS, meaning that its conservation requires International Co-operation Agreements. The minimum requirements of such agreements are:

- provisions for monk seal research,
- regular status evaluations,
- information exchange between states,
- co-ordinated management plans, and
- habitat conservation and regulation of factors that cause direct harm to species or impede their movements or migrations.

There are 16 member countries in the distribution range of the monk seal: Italy, France, Spain, Portugal, Greece, Egypt, Israel, Tunisia, Morocco, Monaco, Senegal, Mauritania, the Ukraine, Slovenia, Rumania and Bulgaria. The CMS Secretariat has been supporting conservation activities related to the Mediterranean monk seal for many years.

At the 8th Scientific Council of the CMS (SC/CMS, Wageningen, The Netherlands, 3-5 June 1998), a proposal by the Spanish delegation to draft an action plan for the Atlantic populations of Mediterranean monk seal was approved. The Plan referred to the geographic range and main countries in the region (Portugal, Morocco, Spain and Mauritania), and the development of a strategic and technical document of a consultative nature to serve as guideline for managers in the area. The Plan aimed to promote more international co-ordination to unify efforts and criteria for monk seal conservation including public and private institutions and the main institutions responsible for monk seal conservation in the region.

Task co-ordination efforts to elaborate the Plan were assigned to the Spanish authorities (Spain's Environment Ministry) and a technical Working Group for the Atlantic Monk Seal (WGAMS), was set up. The WGAMS included representatives from the relevant authorities in the four main countries. An advisor (Fundación CBD-Hábitat) was given the task of drafting and producing the Plan's technical document.

The first meeting of WGAMS was held in Las Palmas de Gran Canaria (Spain) on 10 and 11 April 2000 and a first draft of the Plan was agreed upon. It was also agreed to consult and discuss the document with the scientific community and people interested in the conservation of the species. In this regard, the coordinator requested the assistance of the IUCN Survival Species Commission and in 2001 a Workshop on Population and Habitat Viability Analysis (PHVA) was held in Valsain (Segovia, Spain), under the guidance of the Conservation Breeding Specialist Group (CBSG) of the IUCN. The workshop was chaired by the late Ulysses Seal and attended by the CMS Secretary, 17 representatives from the authorities of the four countries, and 62 international experts from different areas. The Workshop was organised into seven groups related to the chapters of the draft Plan. Each group had discussions and suggested modifications. In 2002 a document with the results of the PHVA was published and widely distributed (González *et al.*, 2002a).

Another WGAMS meeting was held from 12-15 October 2004 in Dakhla (Morocco) to review the Plan and incorporate recommendations from the PHVA workshop. Apart WGAMS members, the meeting was also attended by the Vice-president of the CMS and local and regional civil and military authorities, as well as representatives from various NGOs and Moroccan agencies (Ministry of Water and Forests, National Office of Fisheries, etc.). The WGAMS produced a revised document and a complementary document entitled the "Dakhla Declaration", which calls for international assistance in funding and support to create a marine protected area for monk seal conservation and a management plan for a future national park in the Dakhla area.

Following this process, and after technical approval by the WGAMS, the states involved aim to use the Plan as technical support for a Memorandum of Understanding (MoU), under the Bonn Convention framework, similar to those already drawn up for other species.

The Plan provides a new focus for monk seal conservation by specifying the commitment of the countries in the species' distribution range, as signatories to the Bonn Convention. It is the first time that monk seal conservation actions in the Atlantic region have been approached in a spirit of co-operation and international co-ordination. The above, together with the first signs of monk seal recovery in the *Desertas* islands and *Cabo Blanco* peninsula, will make it possible to take

on the task of achieving the Plan's aims, with some hope of success. However, success will depend on the degree of co-ordination and sufficient financial resources.

The action plan is a guideline that lays down the procedure to implement co-ordinated actions. It provides a means to combine programs from different states, local and private organisations into effective, efficient, concentrated efforts, which should lead to the recovery of the depleted population of the species. The immediate goal is to stop the decline and, in medium term, promote recovery.

The planning effort has been defined by biological species priorities, task priorities, foreseen benefits and inter-agency co-ordination needs. The Plan is based on biological considerations and does not attempt to resolve or intervene in other political or social aspects. The management for recovery of the monk seal population is based on biological principles and ecological understanding. It is exclusively consultive and technical, and sets out, in an orderly way, the actions required and recommended measures, the way to proceed and explanations to achieve the final goal. Furthermore, it attempts to serve as a reference document for any action related to the Mediterranean monk seal and its habitat that the authorities of the range countries or other bodies may seek to undertake. The actions recommended in Part II will require a considerable amount of funding, time and effort.

The Plan seeks to be proactive and dynamic over time. Therefore, it may be subject to modifications or changes as new information is gained, or as events affecting monk seal status and problems are identified. It will be regularly reviewed by the WGAMS so that recommended improvements and changes are incorporated.

PART I

1. NATURAL HISTORY

A. SPECIES DESCRIPTION

Monk seals belong to the Family *Phocidae*, Subfamily *Monachinae*. The genus *Monachus* contains three species, the Mediterranean Monk seal (*Monachus monachus* Hermann, 1779), the Hawaiian monk seal (*Monachus schauinslandi* Matschie, 1905) and the Caribbean monk seal (*Monachus tropicalis* Gray, 1850), extinct since 1951 (Kenyon 1981).

The Mediterranean monk seal is amongst the largest phocid seal species and shows dimorphism, males being slightly larger than females. Measurements from specimens at the *Cabo Blanco* colony (1993-2004) were 252 cm head-body for males (210-270; n=39) and 237 cm for females (210-262; n=50; Samaranch & González 2000). Previous studies have found that the standard length of a female with ovulation signs is 185 cm (Marchessaux 1989) and the standard length of four female pregnant was measured to be 223,226,229 and 234 cm (Samaranch & Gonzalez 2000). Three individuals from *Cabo Blanco* colony weighted 220 kg (male 240 std.length) (Maigret *et al.* 1976), 335 kg (male) and 300 (not sexed) (Marchessaux 1989) and the maximum weight of an adult individual, not sexed and from the Adriatic, was 360 kg (Gamulin-Brida *et al.* 1965). The average length of new-born pups are 108 cm (n=38), with a weight range of 14-22 kg (Marchessaux 1989, Samaranch & González 2000). Age and length have been correlated as a function of a growth curve (Marchessaux 1989).

The Mediterranean monk seal has a fusiform body shape, dark in colour dorsally and lighter ventrally. The fore and hind-flippers are inserted more laterally than in the otarids. The head is rounded with a protruding muzzle. Mystacial vibrissae are light yellow to brown, oval in cross section and smooth. Their fore flipper is short and haired, with a small claw on each of five digits. Nails are present on both flippers and are reduced compared with other pinnipeds. The first digit of the fore-flipper is about 25 mm long and the others decrease slightly in size towards the fifth digit. Hind-flippers are oriented posteriorly and cannot be rotated forward. Claws and hair with thin webbing connect the digits. The tail is short and wide. There are four nipples (2 + 2 = 4), in contrast with most pinnipeds which have only two. The skull is broad in proportion to its length and the backward extension of the zygomatic process of the maxilla is much greater than in the subfamily *Phocinae*. The dental formula is: I 2/2, C 1/1, PC 5/5 (King 1956).

Monachus has the shortest hair of all pinnipeds, only 5 mm in adults and secondary pelage is absent (Ling 1970). Unlike other mammals, all the members of the *Monachini* tribe have an unusual moult wherein the hairs are shed along with large sheets of cornified epidermis through which the club hairs penetrate. Preliminary data indicates that females from the *Cabo Blanco* colony moult throughout the year, with a peak in March. Males moult from April to October, with a peak in June (Badosa 1998).

Adults exhibit marked sexual dimorphism in adults pelage colour. The following six morphological age-classes, all identifiable in the field, have been described (Badosa et al 1998; Samaranch & González 2000): 1) *Newborn/Pup*, approximately 0-70 days old. Pelage woolly. Nape, throat and back black uniform. Belly black interrupted by a yellowish white patch; squarest in shape in females and quadrate in males. First moult of this pelage begins nearly 45 days after birth and lasts an average of 25 days; 2) *Youngster*. 70 days-9 months old. Nape, throat, belly and back light-grey. Aspect rounded; 3) *Juvenile*. 7-23 months old. Nape, throat, back and belly dark-grey. Aspect thinner than youngster; 4) *Subadult*. 18-? months old, class duration is unknown at present.

Nape, throat, back and belly medium-grey or dark-grey. Back interrupted with scars; 5) *Adult female*. Similar to subadult class, but the back has more scars and the form of patch in the dorsal region, named dorsal sash; 6) *Adult male*. Pelage black, except white throat and belly with a white patch similar to male pups. Back with scars, but no dorsal sash. This pelage appears at approximately four years old. A more detailed description is provided in Marchessaux (1989) and Samaranch & González (2000).

Subadults and adults have marks and scars in pelage due to the absence of hair pigmentation, caused by physical interaction and injuries inflicted by individuals. Dorsal marks appeared to be more common in females than in males, which suggest that they are caused by males during mating, as observed in Hawaiian monk seals.

B. LIFE HISTORY

Distribution and movements

Monk seals are the only tropical Pinnipeds along with the California seal lion (*Zalophus californianus wollebacki*) and the Guadalupe fur seal (*Arctocephalus towsonii*). Moreover, the Mediterranean monk seal occupies the lowest latitudes recorded among phocids (King 1983, Riedman 1990).

The earliest known remains of a monk seal are 15 million years old, the oldest recorded pinniped fossils (Ray 1976, Reppening 1981). The genus *Monachus* is considered to represent the most primitive living seals due to the presence of anatomical features (structure of the skull, skeleton and vein system) that predate the earliest fossil monachines (e.g. *Monotherium*), found in the Atlantic basin along the eastern seaboard of North America, some 14-16 million years ago (Ray 1976). The structure of the bony parts of the ear indicates that *Monachus* is the least specialised genus of living *Monachinae* seals (southern phocids). Thus, it has been suggested that the group of monk seals are living fossils (Reppening & Ray 1977).

The distribution range of monk seals is separated into three areas, the Mediterranean basin-eastern Atlantic region, the Caribbean and the Pacific (Hawaiian island). Three theories have been proposed for explain this range and the centre of origin of the *Monachini* (see review in Lavigne 1998). The first situates the centre of origin in the Atlantic basin and proposes that *Monachus* radiated from the Caribbean region and crossed the Atlantic to the west, following the warm Gulf Stream ten million years ago. The second theory situates the centre of origin in Europe where *Monachus* progenitors eventually gave rise to a number of species, including the Mediterranean monk seal. That lineage later crossed the Atlantic to Brazil, following the equatorial currents in the southern North Atlantic along the West coast of northern Africa. The third and more recent theory suggests that the centre of origin was the North Pacific. Evidence suggests that all pinnipeds are monophyletic, raising the possibility that the *monachine* lineage first arose in the Pacific basin.

Historically, the range of the Mediterranean monk seal extended throughout the coast of the Mediterranean and Black Sea, including the eastern Atlantic along the African coast from the strait of Gibraltar to Mauritania, and in the oceanic islands of Macaronesia (Madeira, Azores, Canaries and Cabo Verde archipelagos). Some individuals have also been sighted in Atlantic France, Gambia and Senegal (see review in Marchessaux 1989).

Until the 14th century, the monk seal in the Atlantic was distributed along all the oceanic islands and the coast of the adjacent African continent (Monod 1948). Until the middle of the 20th century, individuals could often be seen in the north islands of Lanzarote and on the island of Lobos de Fuerteventura (Hernández 1986, López-Jurado *et al.* 1995). Up until the 1980s it was observed in the Punta de Sao Lourenço in Madeira, where it used to breed (Melo Machado 1979) and on the coast between *Cabo Barbas* and *Cabo Corbeiro* up to *Guerguerat*, where it was also thought to breed (Marchessaux, 1989; CBD-Habitat 2004).

At present, the species is found regularly in only two areas, the coast of the *Cabo Blanco* peninsula (Morocco-Mauritania) (Figure 1), with a breeding colony on the western side of the peninsula (Figure 2), and the Madeira archipelago, with another breeding population on *Desertas* Island (Figure 3). There have also been occasional records of monk seals on the Canary Islands (Hernandez 1986, Lopez-Jurado *et al.* 1995) and on the front coast of Morocco (Bayed & Beaubrun 1987, Bayed 1999), in the Bay of Levrier and in the Banc d'Arguin National Park (Mauritania) (Marchessaux 1989, Cedenilla & de Larrinoa 2004a, A.Araujo com.pers). Stray animals have been sighted off Senegal and Gambia (Marchessaux 1989, Murphy 1998). In the Cape Verde Islands, the southern limit of their known range, skeletal remains of at least four seals, including an adult and a very young animal, were found in 1990 on the island of Sal (Kinzelback & Boessneck 1992) and there was a recent sighting in 1996 (Hazevoet 1999).

The monk seal populations of the Mediterranean and Atlantic are separated by such as great distances that the interchange of individuals seems improbably. Monk seals are not known to migrate, but appear to disperse widely. There are a significant number of sightings outside and far away from breeding populations (see review in Marchessaux 1989). Sporadic sightings of juveniles far away from breeding colonies suggest that juveniles disperse over long distances. Satellite tracking of two juveniles released after rehabilitation in *Cabo Blanco* and monitored during 55 and 47 days (Figure 4 & 5), indicates that juveniles can travel long distances (in this case mainly offshore of the National Park of Banc d'Arguin), and return to the release area after one month approximately (Lopez-Jurado *et al.* 1998, Mozetich *et al.* 2002, CBD-Habitat 2004).

Cabo Blanco-Guerguerat

The monk seal colony of *Cabo Blanco* is located in the peninsula of the same name on the southern coast of the Sahara desert (21°02'N, 17°03'W). The *Cabo Blanco* coast has a succession of very high cliffs, occasionally interrupted by sandy beaches of eolic origin, which extend from the southern tip of the *Cabo Blanco* peninsula to 170 km north (*Cabo Barbas*). The peninsula borders with the *Guerguerat* territory to the north and extends south to the *Cabo Blanco* lighthouse. According to González *et al.* (1997), monk seals live in four sectors of this coast (Figure 2): *Castillete de la Mesa* or *Tarf el Guerguerat cliffs*, 2.6 km of high cliffs situated in the cape of the same name; *Costa de las Focas*, 15 km of cliffs south of *Tarf el Guerguerat cliffs*, to the area known as the *La Agüera* beaches that include the *Duna Blanca* beach, c.1 km long; *Los Arcos* cliffs 4 km of coast with many large and deep caves and *Las Cuevecillas* or *Cueva de los Lobos*, 3.2 km of cliffs containing several caves. In this area there are references to at least eight caves that have been used by the seals: *La Agüera* beaches that extend almost continuously for about 21 km from the *Las Cuevecillas* cliffs to the small town of *La Agüera* and, from there, a further 8 km to the cliffs of the lighthouse on *Cabo Blanco Point*, at the southern end of the peninsula, where a series of cliffs extend from the *Punta de la Opera* to a beach situated on the other side of the tip of the Cape.

The marine environment is characterised by a wide continental platform (average width of c. 93 km or 50 nautical miles in the *Cabo Blanco* area). The northeast to southwest flow of the Canary Current moves cold waters along the northwestern African coast and, combined with the trade winds, brings nutrient rich water to the surface, resulting in high levels of biological productivity from continuous and powerful oceanic upwelling (Milstedaedt 1983, Wolff *et al.* 1993). Upwelling intensity varies with location and season, due to the variation in trade winds throughout the year. Upwelling ranges from 12°N to 33°N but can be subdivided into three main areas. North of 25°N upwelling primarily occurs in the summer, south of 20°N it occurs during the winter and spring, and between 20°N and 25°N, it occurs throughout the year (Bas *et al.* 1985, Tilot 1993). The region is classified as a Class I ecosystem, highly productive (>300 gC/m²-yr), based on global primary productivity estimates (Bas *et al.* 1985a, Bas 1993). The rich fishing grounds located there are a consequence of the upwelling zone. As a result, the increase in primary generates rich fishing grounds (Nehring & Holzlohner 1982). For a more detailed analysis of upwelling off the northwest African coast, see Bas *et al.* (1985), Wolff *et al.* (1993). For an account of the fisheries along the coast see Baddy and Guénette (2001) and INRH & IMROP, CECAF/FAO reports.

There is an uneven distribution of monk seals along the *Cabo Blanco* coastline. Adult males are mainly located in sections with high cliffs where they appear to be solitary and defend an aquatic 'territory' close to the cliff base (Marchessaux & Muller 1987, Marchessaux 1989, González *et al.* 1997). The breeding colony with reproductive females and young is found in only two caves at *Las Cuevecillas*. This breeding colony is considered the largest aggregation of the species and is the only one that maintains the original colony structure. This distribution of monk seals suggests dissimilar spatial use by different components of the population and, possibly, a complex social organisation that merits further investigation. The fact that some adult males have been identified in *Cabo Blanco*, *Las Cuevecillas* and *Tarf el Guerguerat* (Soriguer 1976, Marchessaux 1989, UB 1995-99), indicates a certain amount of mobility.

North of the *Cabo Blanco* peninsula, there is a coast of cliffs and beaches that extend 180 km between *Tarf el Guerguerat* to *Cabo Barbas* (in the *Aguerguer* region). That area is almost unexplored but may contain favourable habitat. The only information about monk seal along this coast is a sighting of a group of five seals entering a cave in *Tarf el Guerguerat* in 1975 (Soriguer, 1976), a few individuals seen in *Cabo Barbas* and *Cabo Corbeiro* cliffs in 1984 (Marchessaux & Muller 1987) and two aerial surveys in 1987 (Marchessaux & Aouab 1988). Nevertheless, a sea survey in 1990 (El Amrani *et al.*, 1991) failed to detect seals there. Recent reports based on questioning local fishermen suggest the presence of seals in that area (CBD-Habitat 2004).

Madeira

Monk seals in the Madeira archipelago are mainly found on the *Desertas* Islands, a group of three uninhabited volcanic islands (*Deserta Grande*, *Bugio* and *Ilhéu Chão*) lying c. 20 km south-east of Madeira island, between 32° 24' and 32° 25' N and 16° 35' W (Figure 3). The northernmost and smallest of the islands is *Ilheu Chao*, 1.6 km long and rising to a plateau 100 m above sea level. The central and larger island is *Deserta Grande*, which is 11.7 km long and rising 480 m above sea level. The southernmost island of *Bugio* is 7.5 km long, rising 348 m above sea level. Both *Bugio* and *Deserta Grande* have very rugged terrain. Most of the 37 km of coastline has steep inaccessible cliffs. The continuous erosion by the sea has

carved out many caves from the basalt structure, particularly where it alternates with compressed pyroclastic material. The islands are affected by the prevailing Canary cold current, a branch of the descending Gulf Stream. The *Desertas* are managed by the state and are uninhabited, with the exception of the observation station at *Doca* on the western side of *Deserta Grande* (see details in Neves & Pires 1999).

Historical accounts of exploration on Madeira mention seals at *Câmara de Lobos* near Funchal, suggesting that the species was not elsewhere around the island or that it was infrequent along other coasts (Neves & Pires 1999). The monk seal population on Madeira was virtually eradicated by the beginning of the 20th century, although in 1978 there remained a small colony of 4 adults and 2 pups around *Ponta de São Lourenço* (Figure 6), a wild and remote stretch of coast on the easternmost tip of the island, dominated by steep cliffs (Melo Machado 1979), which disappeared (Neves 1991). Recent records suggest that it was still possible to observe animals there occasionally and sporadically, as well as other areas of Madeira Island (Figure 7), where sightings have become more frequent since 1998 (Pires 2001).

Habitat use

Monks seal habitat includes marine and terrestrial areas that are used mainly to haul-out, for breeding and for feeding.

Studies on thermoregulation of seals at *Cabo Blanco* indicates that internal temperature ranges between 35.9° and 37.5°C, but individuals can tolerate solar thermal changes and high prevailing temperatures (36.3°C) without becoming hyperthermic (Marchessaux 1989). It has been observed that body posture on land varies with ambient temperature. The white ventral spot is more often exposed (78 %) at high temperatures (+20°C), when the animal is under direct sunlight, but is less apparent (27 %) at more moderate temperatures (- 20°C). Thermoregulatory factors probably play an important role in site selection (Marchessaux 1989). It has been suggested that the dark coloration of the pups, which disperses light energy, could be an adaptive in tropical areas with intensive solar radiation (King 1956, Marchessaux 1989).

Resting and pupping habitat

The most common resting and pupping habitat described in the pre-commercial era (XIV-XV Century) in the Atlantic seems to have been open beaches on islands and sand banks, where large aggregations of seals have been reported (Monod, 1948). Seals disappeared from these habitats due to human persecution, but survived in caves or beaches protected by cliffs (Gonzalez, unpublished data).

Cabo Blanco

Along the western coast of the *Cabo Blanco* Peninsula, monk seals prefer coastal waters with sheltered beaches and caves along inaccessible rocky cliffs. They haul-out in beaches inside these caves and also in open beaches protected by cliffs in the eastern coast of the peninsula (*Bay de l'Étolie* and *Cabo Blanco* point). The largest concentration of animals is in caves on the west coast of the peninsula, where up to one hundred individuals have

been observed hauling out at the same time (Gonzalez *et al.* 1997). Adult males also haul-out in open beaches (Marchessaux 1989, ULPGC 1995-97, CBD-Habitat 2004) at the tip of the *Cabo Blanco* peninsula, and north of the breeding caves known as *Los Arcos*. There is a significant negative correlation between the numbers of adults that haul-out in caves and low tides (Marchessaux 1989). Adult males also use the beaches inside the caves at *Tarf el Guerguerat* (CBD-Habitat 2004).

Females give birth on narrow sandy beaches inside the caves and prefer those that remain dry at high tide and are protected from waves (Marchessaux 1989; Francour *et al.* 1990; González *et al.* 1997). Surveys performed from 1993 to 2004 only detected two caves (caves 1 and 3), where births takes place regularly (Gonzalez *et al.* 1997; Gazo *et al.* 2000a, CBD-Habitat 2004). Incomplete surveys in Guerguerat (north of the caves) indicate that caves of those characteristics are very scarce in the region (Francour *et al.* 1990, CBD-Habitat 2004). The level of sand on the beaches inside the caves changes according to the maritime climate. In autumn-winter there are storms and ocean swells which decrease the amount of sand on the beaches. In the case of Cave 3, the sand almost disappears, making it uninhabitable, especially in high tides. On the contrary, during spring-summer, the climate is calmer and the level of sand inside the caves increases, remaining dry even at high tide. These variations will be significantly correlated with annual pup survival (Gazo *et al.* 2000a).

Two topographic features of the caves have been associated with pup survival: the type of entrance and the surface of sandy beach inside the cave (Gazo *et al.* 2000a, CBD-Habitat 2004). The sand and the slope of the beach are physical barriers that protect pups from the waves. There is a significant negative correlation between the level of sand in cave-3 and pup mortality (Gazo *et al.* 2000a; CBD-Habitat 2004).

Madeira

In *Desertas*, monk seals also frequent sea caves that can be used as alternative, temporary pupping or resting sites. Suitable seal shelters usually have one or multiple entrances (under or above water) leading to a dry surface or beach with various substrates: sand, pebbles, stones or rock (Pires & Neves, 2000). Seals mainly use caves at low tide (Neves & Pires 1999).

For pupping, females prefer caves with a beach above water during high tide and a long entrance corridor. This finding agrees with knowledge about pupping sites throughout the species range, where a protected beach during the weaning period is essential for the survival of newborn pups (Dendrinis *et al.*, 1999). Other important features for a pupping site are the steepness of the beach (wave breaker), and long entrance corridors to prevent waves from surging into the cave and sweeping away newborn pups (Karamanlidis *et al.* 2004). However, as the tide in *Desertas* can be up to 2.6 m (Neves 1994), only steep beaches will remain above water at high tide. Since steepness can change rapidly due to the mechanical influence of wave action, few caves are considered good for pupping (Karamanlidis *et al.* 2004). On this basis, 16 caves, 12 in *Desertas* and four in *Punta do São Lourenço*, are potentially suitable (Figure 8 & 9). This figure is low and represents only 17% of the cave habitat available to the species in the Madeira archipelago (Karamanlidis *et al.* 2004).

Recently, the elimination of human disturbances has allowed immature-size females to reoccupy previously abandoned open beaches to breed (Pires & Neves 2000), which could increase the quantity of available pupping habitat (Pires and Costa Neves 2000).

Pupping in recent years takes place in only three caves (*Tabaqueiro*, *Bufador* and *Lanço do Rico*) and one beach (*Tabaqueiro*), all south of *Deserta Grande*, the most important being *Tabaqueiro* (Neves 1994; Pires, 1997; Pires, 2003).

Feeding habitat

Cabo Blanco

Sea observations of monk seals have been performed from the shore to the edge of the continental shelf limited by the isobaths of 200m (Marchessaux 1989). Satellite telemetry of two individuals has shown that, during juvenile dispersal, they use offshore banks of the National Park of Bank d'Arguin probably as feeding areas (Figures 4 & 5) (ULPGC 1995-99, CBD-Habitat 2004).

Studies using time depth recorder placed on three individuals (two adult males and one lactating female) from the *Cabo Blanco* colony (Gazo 1996, UB 1995-99), showed that the feeding areas are situated between 40 and 60 meters. The lactating females dove to average depths of 38 m, with a maximum of 78. In an individual of Greek waters it has been recorded a maximum depth of 180 m. (MOM 2005).

The data from TDRs provided to three recently moulted pups (youngster) (Gazo et al 1995), showed that pups prefer shallow waters close (less than about 10 km) to the breeding caves and, as weaning occurs, depth of dives increases and deeper waters (up to 40m), in more distant areas, are reached. The maximum depth recorded in the 10 km distance from the breeding caves was 45 m isobath.

In *Desertas*, visual observations suggest that the feeding period is related to the flooding of resting and breeding caves at high tide. Seals do not feed in very deep water, preferring to look for prey between a depth of two and 25 meters (Pires & Neves 1998).

Diet

The information about feeding energetic and the diet of monk seals in the area is poor and scarce. Daily food intake is an estimated 5-10% of total body weight (Marchessaux 1989). There is information about the diet of *Cabo Blanco* monk seals from 1975-2004, based on 15 stomach contents, 13 faeces samples and 22 visual observations of direct captures (Soriguer 1979, Marchessaux, 1989, CBD-Habitat 2004). According to the stomach analyses (Table I), at least 77 prey were identified from at least 15 species, consisting of 58.4 % cephalopods, 32.5 % fish and 9.1 % crustaceans, where the most important was *Octopus vulgaris* (representing 50.6%). Most of the preys were benthonic species, which agrees with the known diving strategies (see below). Crustaceans (*Palinuridae*) were often found in stomachs (n=3) in two years from 1975 to 1976 and in 70% of the faeces (n=5) and in one stomach from 1984-86 (n=3); but they do not appear in the stomachs (n=9) in recent years (1993-2004). This suggests that crustaceans are less important in the diet in recent years. However, the degree of digestion and detectability of fish otoliths, cephalopod beaks and hard remains of crustaceans could bias the results (Tollit *et al.* 1997).

The predatory behaviour of a few males was observed in *Cabo Blanco*. There were 22 cases of predation on *Dicentrarchus punctatus*, 8 on Sparidae, 3 on *Sparus sp* and 1 on *Sparus aurata*. (Marchessaux 1989).

In Madeira, less information is available. Monk seals have been spotted at the surface eating *Bodianus scrofa*, *Sparisoma cretense*, *Sarpa salpa* and *Liza aurata*, and in several occasions *Sepia officinalis*. Subadult seals have also been recorded feeding on limpets (*Patella sp.*) and crabs (*Pachygrapsus sp.*) (Neves 1998). One individual accidentally caught on a long line at Madeira had 50 horse mackerel (*Trachurus sp*) in its stomach, one *Sparidae* and an unidentified ray (Sergeant *et al.* 1978).

Feeding strategy

Monk seals are considered opportunistic feeders, exploiting the resources that are most abundant at a specific time (Sergeant *et al.* 1978, King, 1983). Cephalopods, and lobsters are relatively easy to catch once detected since they cannot sustaining prolonged high-speed swimming when pursued (Klages 1996).

Seals often bring large fish (i.e. *Dicentrarchus sp.*) and *Octopus* to the surface, where they are shaken (Marchessaux 1989, CBD-Habitat 2004). According to a study on prey catching behaviour (n=179) of male adults in *Cabo Blanco* and tides, 76% of the hunting takes place at high tide and only 12% at low tide (Marchessaux 1989). The same study also found that there is strong individual variation in the prey selection (cephalopods and crustaceans; Marchessaux 1989).

Three individuals (two adult males and one lactating female) provides with time depth recorder (TDR) from the *Cabo Blanco* colony (Gazo 1996, UB 1995-99), showed that the seals spent the majority of their time in the sea, 81 % in the case of a adult male and 72.2% in the case of a lactating female. The individuals sampled left the resting caves to move towards the feedings areas, navigating under the surface and even sometimes swimming close to the sea floor. These movements last between two to four days. Once in the feeding area, the seals dive repeatedly to average depths of between 40 and 60 meters. One of the males dove to a maximum depth of 29.5 m (average 25.5) and the average duration of each dive was 3.5 minutes. The lactating females dove to average depths of 38 m, with a maximum of 78, and an average duration of 6 min.

Information about adult feeding strategies is scarce and based on time depth recordings in 1996 of three individuals (two adult males and one lactating female) from *Cabo Blanco* (Gazo 1996, UB 1995-99). Most of the dives were similar to those associated with benthonic feeding, which agrees with the habits of most of the prey found in stomach contents (Table I). However, it appears that males carry out more dives associated with pelagic feeding than females. When animals dive to maximum depths they remain underwater for a longer time, which indicates that they may be feeding more at these depths. Most dives are performed between 6h00 in the morning and 18h00 in the afternoon, which suggests a diurnal feeding schedule. Feeding dives are not related with vertical migrations of fish or crustaceans and are independent of the tide schedule (Gazo 1996, UB 1995-99).

Three recently moulted pups (youngster) provide with TDRs (Gazo *et al* 1995), learn to dive in shallow waters close to the breeding caves and, as weaning occurs, depth of dives

increases and deeper waters, in more distant areas, are reached; an contrary to adults, most diving activity took place during night hours.

Reproduction

Information about reproduction is scarce and mainly based on individuals from the *Cabo Blanco* colony.

Cabo Blanco

Adult males of this colony defend aquatic territories at the entrance to the breeding caves and surrounding areas (Gonzalez *et al.* 1997). These aquatic territories are maintained throughout the year and, in some cases, for several years (Marchessaux 1989, UB 1995-99). Mating and copulatory behaviour is underwater (Neves & Pires 1999, ULPGC 1995-99). According to genetic studies (Pastor *et al.* 2004), males probably mate with multiple females, suggesting a polygyny. Although the gestation period is unknown, it appears to be 9-10 month based on foetus and newborn growth (Marchessaux 1989). Females give birth to a single pup, which may occur at any time throughout the year (implying that mating does as well), although it is more frequent at the end of summer and beginning of autumn (Marchessaux 1989, Gazo *et al.* 1999, CBD-Habitat 2004). The monk seal is the only phocid with a pupping season that extends throughout the year (Riedman 1990). The average birth interval in 8 females was about approximately 375 days. In contrast with most other phocids, reproductive events are neither seasonal nor synchronous (Pastro & Aguilar 2003).

Prior to parturition, females look for isolated areas inside the caves, far from other seals. They dig a hole in the sand, probably with fore-flippers and muzzle, and defend the site from approaching seals, showing aggressive behaviour during parturition (Layna *et al.*, 1999). New-borns spend most of the time on beaches inside the caves. Older pups are highly mobile and have been observed making trips of up to 2.2 km in open waters without the mother. The suckling period can extend for over 100 days and, in some cases, up to 150 days. Nursing almost doubles the maximum lactation periods observed in other phocids (Riedman 1990), and appears to end gradually. This long nursing period is exceptional. Females alternate nursing with feeding trips to open waters during which they leave pups unattended (Gazo 1996). Fostering and milk stealing occurs frequently (ULPGC 1995-99, UB 1995-99, CBD-Habitat 2004). Milk composition is currently unknown. Mothering behaviour appears to be intermediate between the Otariidae and Phocidae, possibly more similar to the former. The monk seal preserves the ancestral mothering system and lactation pattern from which the rest of the Phocid evolved.

Annual productivity in 1993-1996 periods was 44-58 pups (González *et al.* 1997; Gazo *et al.* 1999). In June-July 1997, a mass-mortality episode caused the death of two thirds of the colony, producing a severe change in age-classes (Forcada *et al.* 1999): It reduced the size of adult females by over 50% (Harwood *et al.* 1998) and affected reproductive parameters (González *et al.* 2002b). Annual productivity in 1998-2004 varied between 23-29 pups (Gonzalez *et al.* 2002b; CBD-Habitat 2004). Annual birth rates (the ratio between annual productivity and the estimated number of adult females) in 1994, 1995 and 1996, was 0.37, 0.3 and 0.43 respectively (Gazo *et al.* 1999). The average number of reproductive females that reproduced each year before the 1997 mass-mortality, was

estimated at 51.9% (SE=12.4%) and the percentage of adult females that successfully reproduced from year to year ranged from about 30% to 70% (Forcada *et al.* 2002).

In *Desertas* and *Cabo Blanco* subadult seals have been observed with pups (Neves & Pires 1999, Samaranch & González 2000). Females can reach sexual maturity at 2.5 years old (Gazo *et al.* 2000b), the lowest age recorded for any phocid species (Riedman 1990).

Desertas

Mating at *Desertas* can occur throughout the year, but peaks during the weaning period (Pires 1997). Births mainly occur in October-November, but there has also been an annual birth in spring since 1999. Four reproductive females were identified (three active). From 1989 to 2002, gross production was 25 pups, with an increase from one to three annual births. Only three cases of mortality were detected, all involving pups. Apparently, the weaning period occurs 4-5 months after birth (Pires 2003).

Mortality rates and life expectancy

Age-specific mortality, estimated from recapture histories from 1993-1998 in *Cabo Blanco* (Forcada *et al.* 2002), is 59.0% (SD=10.5) for age-class 0-1 year, 20.8 % (SD=5.7) for 1-2 years, 10.0 % (SD=0.9) for 2-3 years, 10.0 (SD=6.1) for females and 3.4% (SD=0.3) for males 3-4 years and 4 years older.

Another more recent calculation of age-class mortality rates in *Cabo Blanco*, based on marked individuals from known age classes (Mozetich *et al.* 2002), found 0.48 (n=102) for pre-weaning pups (0-3 months), 0.23 (n=37) for post-weaning juveniles (3 months to 1 yr), and 0.20 (n=25) for juvenile/subadults (1-2.5 yrs). The mortality rate (including disappearance of the colony) seems to be higher in rehabilitated pups released to the wild than for same age class in the wild. Only 32% of pups born in this colony reach sexual maturity (Mozetich *et al.* 2002).

There is no information about life expectancy in Atlantic individuals. An individual aged by the canine layer technique was estimated to be around 24 years old (Marchessaux 1989). In Greece, another individual aged with the same technique was found to be 44 years old (Reijnders, P *et al.* 1997)

The causes of pup mortality include drowning and starvation after separation from the mother (Gazo *et al.* 2000a, CBD-Habitat 2004). Other causes include disease, predation or crushing by larger animals, which probably occurs but has not been reported. Neonate pup survival rate is 0.62 (Gazo *et al.* 2000a), similar to other pinnipeds breeding in caves (Anderson *et al.* 1979), but lower than those breeding in open beaches (Riedman 1990). Another source of natural mortality may be killer whales (El Amrani *et al.* 1991) which are frequent in these waters (Maigret 1980), but their possible impact is unknown.

C. POPULATION STATUS AND TRENDS

Cabo Blanco

At least until the 15th century, the Mediterranean monk seal abundant enough to justify hunting expeditions for seal oil and pelts. Accounts by explorers report as many as 5000 animals in Dhakla bay (Monod 1948). While historical population sizes are difficult to estimate, the fact that monk seals were exploited for oil and pelts suggests that it was relatively abundant. Overexploitation led to their decline and extermination from most of their range (Johnson 2004). In recent centuries, the number of seals continued to decrease because of commercial fishing in the Saharian fishing grounds in the middle of the XX century, which led to persecution and habitat disturbance. In the last century, larger distribution areas imply that the population was probably larger than at present (Gonzalez in prep.).

It is difficult to accurately estimate the size of the *Cabo Blanco* colony. As most pinnipeds, the partition time between land and sea is highly heterogeneous and variable (capture) compared to other terrestrial or aquatic mammals (Forcada 2000).

Population estimates have almost exclusively centred on the breeding caves at *Las Cuevecillas* using simple enumeration (see review in Marchessaux 1989) and a capture-recapture model (Forcada *et al.* 1999). The first estimates, based on counts on-land or near-water beaches, indicate a decrease from 300 individuals in the 1950s to 80 seals in the 1960s and 60 in the 1970s (Marchessaux 1989). The first reliable and detailed counts of seals in the area were carried out by land from 1984-1988 (Marchessaux 1989, Francour *et al.* 1990) and by sea in 1990 (El Amrami *et al.* 1991). The population trend in *Las Cuevecillas* breeding caves was also assessed from 1993-94 using the *guindola index* (see González and cols. 1997), based on methodology used for the Hawaiian monk seal (Wade & Angliss 1997, NMFS 2003). The index is obtained by adding the maximum number of individuals of each age class older than pups, recorded in the haul-out counts from breeding caves 1 and 3. The number of seals present at a given time in a given area (the two breeding caves in this case), is considered an unknown fraction of the total number of individuals that may use that area. So the index can only be considered a minimum estimate of the seals present. However, it can be compared to previous counts in the region using comparable methodology. The index was developed assuming that the maximum number of seals was detected at low tide, so counts were made in the two caves the same day in low tide.

The population estimate using the capture-recapture model with photo-identification data (assuming a closed-population, with its associated error), was established from 1994-1998 (Forcada *et al.* 1999). The age-class composition of the colony included 256 individuals (52 juveniles, 173 medium-sized and large grey seals, and 31 adult males). The proportions of seals did not change between 1994-1996. However, after the mass-mortality between June-July 1997, the proportion of juveniles and medium sized seals increased significantly, from 10% to 29% and 29% to 35% respectively. The proportion of adult females and males decreased from 44% to 26% and from 18% to 10%. The size of the colony, assuming a closed population with no migration (Forcada *et al.* 1999), was estimated to be 317 seals (95% CI, 236-449), with a coefficient of variation of 0.06, appearing to have stabilized in this period. The 1997 mass mortality reduced the population size to 109 individuals (95% CI: 86-145; Table 2). Changes in abundance were estimated by a least-square regression of point capture-recapture estimates against time. The slope was -0.0073, but not significant (Figure 9).

Although the confidence limits are broader than desired for a rare species, they indicate that the number of seals in *Cabo Blanco* before 1997 was around 300 individuals (older than pups

and youngsters). The number of individuals potentially contributing to reproduction fell to about 77 or less (Forcada *et al.* 1999). From 2000-2004, according to the *Guindola index*, the number of animals on land (caves) at standardized dates and times (CBD-Habitat 2004), appeared to show a slight recovery (Figure 10).

According to Forcada *et al.* (1999), the number of individuals in the colony was probably stable from 1993 to 1997. However, it is unclear whether the technique is precise enough to detect short term changes. Simulated capture-recapture experiments in the same population have been performed to investigate the relationship between population estimates and abundance and detect possible decreases (Forcada 2000). Those studies show that capture-recapture surveys produce reliable data, but they do not identify moderate or low population decrease.

A preliminary population analysis model was carried out using the *Cabo Blanco* colony to investigate the effect of mass mortality on the probability of extinction (Derry *et al.* 1997). The observed mortality did not drastically increase the probability of the extinction, unless the population fell below 20 individuals.

A very complete viability analysis was performed in 2001 (Forcada *et al.* 2002), within the framework of a special meeting supported by UICN Specialist Group. It included both populations: Madeira and *Cabo Blanco* (see Appendix I). In the absence of a catastrophic mortality event and inbreeding effects, the rate of population growth (r) was -0.034 in the baseline model. Thus, the simulated population is expected to decrease in size at a rate of about 3.5% per year. The impact of a catastrophe, similar to 1997, decreases the baseline growth rate from -0.034 to -0.056, and the risk of extinction increases from 1-2% to nearly 20% over a simulation timeframe of 50 years. A catastrophic event can clearly have a major impact on monk seal population dynamics and persistence.

The model also shows that overall female breeding characteristics are more important in terms of population dynamics than for males. Population growth rate is more sensitive to comparatively small changes in adult female mortality. Only minor increases in adult female mortality are required for positive population growth.

Regarding the effect of pup mortality at *Cabo Blanco* on general population dynamics, a small increase in adult female mortality must be compensated by a relatively larger decrease in pup mortality to maintain a stationary population trajectory. Assuming a basic adult female mortality rate of 10.0%, the threshold pup mortality rate would be 43.5%.

Madeira

The first Portuguese explorers that landed on Madeira in 1420 found an abundant population of monk seals (Melo Machado 1979). That discovery ushered in an intense period of persecution for oil and pelts (Melo Machado 1979, Neves & Pires 1999, Johnson & Lavigne 2003, Johnson 2004). By the mid-20th century, monk seals only remained in remote, inaccessible and uninhabited parts of Madeira, such as *Desertas* Islands, largely due to fishing pressures and human disturbance. In the 1970s, the estimated population size was around 50 animals (Sergeant *et al.* 1978), but it decreased rapidly to 6-8 animals in the 1980s (Pires & Neves 2001). The decline was eventually reversed following the implementation of a recovery programme in 1988, with the establishment of the *Desertas* Islands Nature Reserve in 1990 (Neves 1991). Since then, monk seal numbers have increased (Figure 11) to an estimated 28 individuals in 2004 (Pires & Neves com.pers). Moreover, in recent years, sightings around Madeira have become more frequent. In 2001, two reports enabled the identification of a known breeding female from the *Desertas* Islands. This was the first

confirmation that the range of seals inhabiting the *Desertas* Islands includes the main island of Madeira. Increased sightings around Madeira are likely are probably partly due to the growing seal population on *Desertas* Islands, which has increased the population's dispersal area (Pires2001).

According to the population analysis model for *Desertas* (Freitas, 1996) with a 20% juvenile mortality and 6% adult mortality (and no migration), the risk of extinction would be 0.12. The average time to the first extinction would be approximately 33 years. The risk of extinction increases to 0.51 if juvenile mortality is doubled or 0.76 if adult mortality is doubled. The model shows that the exchange of individuals with the *Cabo Blanco* colony would affect the risk of extinction (Freitas, 1996).

Although there are no reliable estimates of the total number of monk seals in the two Atlantic breeding colonies (*Desertas* and *Cabo Blanco*), observations and preliminary photoidentification studies indicate that there are probably no more than 200 animals, around 26-28 in Madeira (Costa-Neves unpubl.) and around 150 in *Cabo Blanco-Guerguerat* (CBD-Habitat 2004). Taking into account that the number of monk seals worldwide is estimated to be less than 400 individuals (Reijnders *et al.* 1997; Gonzalez 2003), the Atlantic population constitutes about half of the world population. Although the accuracy of such estimates is uncertain, estimates suggests that the Atlantic population about 3% of its original size (Pastor *et al.* 2004).

D. NATURAL FACTORS INFLUENCING THE POPULATION

Sub-optimal pupping sites

Inadequate beaches as pupping sites

Inadequate pupping habitat has been identified as one of the factors that could prevent the recovery of the monk seal population in the *Cabo Blanco* region (Marchessaux, 1989). Historically monk seals used beaches and sandbanks on islands and continents for haul-out and probably for pupping, since there are records of large aggregations of seals on these sites (Monod 1948). They are well protected from rough seas and predators, and were far away from human settlements or inaccessible. Nowadays, monk seals frequent sea caves, probably due to relentless persecution by humans (Sergeant *et al.* 1978, Marchessaux 1989; Pires & Neves 2000). It has been suggested that the surviving monk seals have modified important aspects of their biology and behavioural patterns (such as breeding in caves) in response to human persecution (Sergeant *et al.* 1978, Marchessaux 1989). Only two other pinnipeds use this type of habitat on land, the Guadalupe sea lion *Arctocephalus townsendii* and some populations of Grey seals *Halichoerus grypus* in the UK (Sergeant *et al.* 1978, Reijnders *et al.* 1997). In both those cases it has been considered sub-optimal habitat, due to the lower reproductive success (Riedmann 1990).

Pup mortality at the *Cabo Blanco* colony varied seasonally and appeared to increase in autumn-winter because of storms, large ocean swells, and high tides. Mother-pup pair separation (and resulting pup starvation) and physical injury caused by the impact of waves against rock walls of the cave and cliffs were the causes of most deaths (Gazo *et al.* 2000a, CBD-Habitat 2004). The beach surface area inside the caves also appeared to be important, tending to reduce pup mortality. Beaches inside the caves almost disappear

during very high tides or high swells. Waves can fatally injure pups by knocking them against the rock walls of the cave (Gazo *et al.* 2000a, Mozetich *et al.* 2002). The survival rate of pups in *Cabo Blanco* is similar to other pinnipeds breeding in caves, but lower than those breeding on open beaches (Riedmann 1990). It has been suggested that this habitat is sub-optimal for the monk seal due to the low pup survival rate (Sergeant *et al.* 1978, Francour *et al.* 1998, Marchessaux 1989).

In *Desertas*, although less pups die, the potential pupping habitat is low and represents only 17% of the cave habitat available to the species (Karamanlidis *et al.* 2004).

In this context, a conservation strategy for the recovery of this monk seal colony must consider a reoccupation of optimal habitats (i.e., open beaches), that will increase pup survival and help to protect them from storms- (González *et al.* 20002b).

Breeding cave collapse

The *Cabo Blanco* cliffs are composed of rocks that are easily eroded by wave action (calcareous stone), and there is a considerable risk of caves collapsing (Marchessaux 1989). Among the 8 caves used by seals since the mid-20th century, five have already totally or partially collapsed, making three uninhabitable (González *et al.* 1997). The incidence of frequent rockslides in caves represents a risk for the animals, particularly since; at least for part of the year, most adult females are located in a single cave (Cave 1). The concentration of the reproductive fraction of the colony makes it highly vulnerable. Surveys along the coastline of the *Cabo Blanco* Peninsula to *El Guerguerat* (Francour *et al.* 1990, CBD-Habitat 2004) have found very few caves that are similar to those being used by seals at the moment.

Toxic phytoplankton

Poison by algal toxins has been reported in several marine mammals, including Hawaiian monk seals (Gilmartin 1983), and cetaceans off Senegal during the 1970s (Maigret 1979).

From mid-May to mid-July 1997, 117 monk seal carcasses were found and examined on the beaches of the *Cabo Blanco* peninsula (Robinson & Hernández 1998). Necropsies showed that seals died by drowning after paralysis, and immunological tests showed no evidence of infection at the time of the die-off (Harwood *et al.* 1998). The mass-mortality episode killed over two thirds of the colony in one month (Forcada *et al.* 1999). It was first attributed to intoxication by the consumption of prey items contaminated with paralytic shellfish poison saxitoxins (PSPs), from a bloom of toxic algae (Franco *et al.* 1998, Hernández *et al.* 1998). However, PSP analyses of the same samples were negative (Osterhaus *et al.* 1998). Posterior studies using High Performance Liquid Chromatography (HPLC) on tissues from seals that died during the outbreak and on related fauna, found peaks with retention times that coincided with some Saxitoxin derivatives. Further analyses identified the toxins by Mass Spectrometry (MS), supporting the hypothesis for biotoxins (Reyero *et al.* 1999).

Oceanographic conditions at *Cabo Blanco* can favour the development of toxic algae blooms (Smayda in Harwood *et al.* 1998, González-Ramos *et al.* 1998). One of the species detected in the 1997 episode, *Gymnodinium catenatum*, is particularly well adapted to the area. Between 1971-1996, it was present in several important outbreaks of algae toxins along the Atlantic coast of Morocco (Tagmoute-Talha *et al.* 1996, Taleb *et al.* 1998; Joutei 1998,). It has been suggested that the *G. catenatum* on Moroccan shores may have been transported by maritime traffic from Galicia and

Portugal or that the species is native and that cysts germinate under favourable climatic conditions (Joutei 1998). It is difficult to predict when they may appear, but they have a direct effect on the monk seal. This is undoubtedly one of the most worrying threats to the conservation of the *Cabo Blanco* colony.

Parasites and diseases

One ectoparasite, *Lepidophtririus piriformis* (Anoploura), eight cestodes and three nematodes have been described for *Monachus monachus*, but only *Anisakis pegreffii* is host-specific (King 1956).

Viral and bacteria infections have been implicated in several mass-mortality episodes of pinnipeds. The Morbillivirus group is the most cited (see Harwood & Hall 1990). The incidence of disease at *Cabo Blanco* has not been properly studied, but a new virus (MSMV-WA) was isolated from three individuals that died during the 1997 mass-mortality (Osterhaus *et al.* 1997, Bildt *et al.* 1999). The MSMV-WA virus comes from monk seals in Greece from the canine and phocine distemper virus (CDV and PDV) and is closely related to the dolphin morbillivirus (DMV). Serum antibodies to canine distemper virus (CDV) were also detected in 4 of 17 blood samples collected during the mass-mortality event (Osterhaus *et al.* 1997, Jiddou *et al.* 1997, Osterhaus *et al.* 1998). Interspecies transmission of morbillivirus from cetaceans to monk seals is also possible (Bildt *et al.* 1999). Research on the role of the morbillivirus in the die-off was inconclusive. Since it was only found in three individuals, it was probably not the cause of the die-off (Harwood *et al.*, 1997). In this context, it has been suggested that the threat of acute infectious diseases by generalist pathogens (i.e. Morbillivirus), is lower than chronic infections with mild morbidity, due to the smaller group of the species' population that avoid the persistence of these agents (Swinton 1997).

We cannot rule out the idea that the MSMV-WA was involved in the mass-mortality or that it played an opportunistic role. Both morbillivirus and other possible infectious agents pose a risk to colonies that is difficult to predict and to evaluate.

Genetic depression

Genetic studies using mitochondrial DNA have found limited gene flow between the Mediterranean and Atlantic monk seal populations in recent centuries (Stanley 1995, Stanley & Harwood 1996). The distances are so great (approximately 2000 Km) that genetic flow is highly unlikely. The same studies indicate the presence of two genotypes, one in the Atlantic and western Mediterranean population and another in the eastern Mediterranean. Both populations have low levels of divergence and are likely to be genetically compatible. The *Cabo Blanco* population appears to have the clearest differences in genetic structure.

According to recent studies using molecular DNA (Pastor *et al.* 2004), individuals from *Cabo Blanco* have one of the lowest genetic variabilities among pinnipeds. Despite these findings, and the small population size, the amount of variability in terms of polymorphic loci and allelic diversity is still higher than Hawaiian monk seals or northern elephant seals, which have both gone through well documented reductions in size (Pastor *et al.* 2004). The data suggest that the *Cabo Blanco* population has lost approximately 53% of its heterozygosity due to a severe bottleneck in the past (Pastor *et al.* 2004). The fact that the study used many micro-satellites with markers from other pinniped species ($A=2.33; 0.33$ in Pastor *et al.* 2004), raises doubts about whether the results reflect low genetic variability or whether they are an artefact of the methodology used. However, that study may be

biased since it used microsatellite primers from other pinnipeds and did not obtain any loci with more than three alleles. The recent development of species specific microsatellites for Mediterranean monk seals will probably help to gain more accurate information about the current genetic status (I. Doadrio, in litt.).

A simulation study by Forcada *et al.* (2002) estimated that the decline in population due to the mass-mortality in 1997 could have caused a 12% loss in genetic variability (Derry *et al.*, 1997). The model shows that the effects of inbreeding are quite low and would only be expected to appear in the long term. It is also suggested that the low genetic variability in *Cabo Blanco* monk seals could play a role in the severity of mass mortality as well as stillborn pups and other perinatal mortality, with no apparent external causes (Pastor *et al.* 2004).

Uncertainty regarding the impact of environmental factors and human pressure

Since monk seals are in the upper levels of marine ecosystems, they are good indicators of environmental health. Its staple diet is crustaceans, cephalopods and fish. Monk seal distribution and numbers are clearly related to the abundance and geographic distribution of these prey species. In the Atlantic, stocks of those prey change in number and distribution in response to fluctuations in environmental factors and over fishing.

Large-scale changes in global energy use and climate conditions may be altering conditions and processes in the region's oceans and ecosystems in the following way:

- Modification of the flow of large-scale environmental systems (atmospheric, oceanographic, etc.), which will alter the distribution and composition of marine ecosystems, with very important ecological and economic consequences. For example, the distribution and numbers of shoals of fish may be profoundly altered by disturbances such as the "El Niño" phenomenon and its consequences in the Atlantic.
- The retreat of the polar ice caps and depletion of the ozone layer in the stratosphere may alter the spectrum and intensity of incident light, and thus the periodicity and abundance of primary production. Ecosystems are potentially vulnerable to these changes although the effects of ultraviolet radiation on aquatic organisms may have been overestimated.
- One of the potential consequences of climate change is the increase in the number and intensity of natural catastrophes, the consequences of which could be disastrous for marine systems, particularly for littoral and coastal systems.
- Furthermore, it is possible that changes in sea level, wave action and patterns of coastal erosion will eliminate a certain number of monk seal habitats.

Although little information is available about these factors, long-term effects cannot be ruled out (see details in Royal Commission on Environmental Pollution 2004).

2. KNOWN AND POTENTIAL HUMAN IMPACTS

The decline of the monk seal is the result of adverse interactions with humans, mostly through direct exploitation in the past, and deliberate killing, incidental entanglement in fishing gears, destruction or alteration of coastal habitat, overexploitation of fisheries, pollution and probably toxic algae blooms and viral infections.

Commercial harvest and human persecution

The Mediterranean monk seal was consumed by human coast-dwellers along the Atlantic Saharan coast in the Neolithic age (Marchessaux 1989). In the Middle Ages was captured on the oceanic islands by the European explorers and colonizers (Johnson 2004). The harvest of seals, mainly in the 14th and 15th centuries, lead to the disappearance of beach-based colonies. Later, and until the 20th, it was persecuted, but in that case because of the damage it supposedly caused to fishing interests. Deliberate or incidental killing of seals by fishermen, who perceive the species as a competitor, represents a significant source of adult seal mortality. In the Canary Islands, a sociological study to assess attitudes of fishermen and other collectives towards monk seals (ULPGC 1995-99) found that fishermen in the Sahara bank often have negative interactions with monk seals and are openly hostile towards the species. Some fishermen regard seals as competitors and, therefore, detrimental to their interests due to the amounts of fish they catch and the damage they cause to fishing tackle.

In Cabo Blanco, two monk seal corpses found in 1993 (CBD-Habitat 2004) and 1998 (UB 1995-1999) had holes which appeared to have been caused by a harpoon. In 2004, a rehabilitated monk seal was found dead with clear signs of having been killed (Cedenilla & Fernández de Larrinoa 2004b).

In Madeira, deliberate killings of monk seal have been reported during the 20th century (Mello Machado 1979, Reiner & Dos Santos 1984), the last one being in 1985 (Freitas 1986).

Fisheries interaction

Interaction with fisheries is one of the most pressing threats to marine mammals (Beddington *et al.* 1985). They can be divided into *operational* threats, when marine mammals interact with fishing gear to the detriment of animals (entanglement), fishing gear, or both and *ecological* threats, when the interaction between animals and fisheries is via trophic pathways (Gales *et al.* 2003). Both types of interaction require different conservation approaches (Northridge & Hofman 1999).

Entanglement and mortality in fishing gear.

Among marine mammals, pinnipeds are the most prone to incidental entanglement or capture in fishing gear because of their inquisitive nature and size (Fowler 1987). Trawl gear and gill/drift nets cause the most problems (Woodley & Lavigne 1991). Entanglement often kills the seals or, if there is no direct damage, may restrict movements which prevents escape from predators or leads to starvation.

In the past 20 years, durable and resilient plastic materials have replaced natural fibres used in fisheries. Polypropylene and nylon nets have replaced antiquated and once prevalent tarred cotton and linen webbing. Various plastic lines are now used instead of manila or other natural fibres (Pruter 1987). Pinnipeds may be particularly susceptible to entanglement (Fowler 1998). Hawaiian monk seal entanglement in marine debris is one of the main sources of mortality (Henderson 1990, 2001). Due to the general concern about the impact of this pollution, Annex V of the MARPOL Convention prohibits ocean dumping of plastics.

Hawaiian monk seal pups and immatures are more susceptible to entanglement in nets, while older seals are mostly entangled in the line (Henderson 2001). The probability that a seal will survive an entanglement in fishing gear depends of the type of gear and their behaviour and characteristics. In this context, it has been suggested that small marine mammals (i.e. monk seals), rarely survive once in contact with or entangled in sink gill nets (Angliss & DeMaster 1998).

There are published reports of Mediterranean monk seals found dead in gill, trammel nets, trawls and longlines; although very few report the interaction properly (Sergeant *et al.* 1978, Woodley & Lavigne 1991, Panou *et al.* 1993, Wickens 1995, Androukaki *et al.* 1999). Entanglement is considered as an important component of seal mortality and one of the most serious threats for the Mediterranean monk throughout their range (Israels 1992, Reinjders *et al.* 1993). The central-eastern Atlantic, especially the area over the continental shelf, it is one of the most intensively fished waters in the world. A wide variety of gears are used there, including nets, seines, liners and trawlers (Maigret 1994, FAO 1997). Although there has been no in-depth study in the region, available information indicates that incidental capture of marine mammals in West Africa is from gill-nets and trawler fisheries or entanglement in marine debris (Maigret 1994). There are some specific data on incidental entanglement and capture of monk seals. For example, Soriguer (1976) reports a dead seal entangled in a piece of net in 1972 in the *Cabo Blanco* beach and three seals accidentally trapped in fishing nets and later freed. That author mentioned that trawlers and gillnets are the main cause of mortality in the *Cabo Blanco* colony. Avellá and González (1984) recorded some cases of monk seals captured by Spanish fishermen in the same area between 1947 and 1981. Marchessaux and Aouab (1988) estimated that 10-20 seals were captured per year in the area from 1983-1986, with a 10% mortality rate. Maigret (1990, 1994) cites cases of seals that had drowned in monofilament gillnet in Mauritania and Morocco. In 1994 the first interviews performed to some *Cabo Blanco* fishermen show that 85, 5% of them knew of a seal entangled in the fishing gears. About 80% also said that the interaction would kill the animal (own data). In 2000, an adult male corpse was found stranded on a beach with one flipper mutilated and a piece of mesh in its stomach (CBD-Habitat 2004). In *Cabo Blanco*, the decrease in the number of monk seal corpses found stranded on beaches after 2001 (Figure 12), is linked to the beginning of effective coastal surveillance around the breeding caves. Another cause for concern is the large amount of marine debris in surrounding water (CBD-Habitat 2004). According to Marchessaux (1989), the recovery of the colony coincided with the cessation of fisheries activities in the area due to the war which lasted from 1977 to 1981.

The captures of monk seals in fishing gears has been reported in Madeira in tuna hooks in 1961 (Sergeant *et al.* 1978), and gillnets in 1978 and 1984 (Neves & Pires 1999). The drastic decline of the remaining monk seal population in *Desertas* islands in the 1980s was related to the use of gillnets. The current recovery is linked to the absence of fishing activity around the islands (Neves & Pires 1999).

Ecological interactions

Marine mammals are generally located near or at the top of marine food webs, and appear to have had a considerable impact on the structure of pelagic ecosystems (Kaschner *et al.* 2002). Hence, the status of marine mammal populations may reflect the health of an ecosystem and may indicate the sustainability of management practises (Trites 1997).

In the past fifty years, most marine mammal populations have diminished in size. In many cases it has been speculated that human fishing activities may be one of the main factors affecting recovery rates (Reinjders *et al.* 1983, Beddington *et al.* 1985, Northridge & Hofman 1999). The monk seal range in the Eastern Atlantic is included in the FAO fisheries region 34.1.3., one of the most intensively exploited areas in the last century (FAO 1997). There has also been a dramatic fluctuation in fish and fisheries in the last 10-years (trend 1990-1999) in the same region (FAO 1997, 2003), with a decline in catch (from 2.3 million tons in 1990 to 1.8 million tons in 1999), including the majority of prey-species for the monk seal. There were sharp decreases in 1992, 1993, and 1994. According to reports of fisheries captures, there is a high variability in the area, driven by the upwelling regime (Bas 1993). In the 1980s, about 68% of the fisheries were either “mature” or “senescent”, indicating that the region was fully fished in 1980s (Garibaldi & Grainger 2002). Thus, the region is considered to be severely affected by overfishing (Roy & Curry 2003).

Ecological interactions between fisheries and seals can also have adverse effects on the latter, if important prey species are depleted by fishing activities, mainly in pinnipeds where there is high overlap between diet/fisheries (Kaschner *et al.* 2002). The number of *Sparidae* in the Saharian bank, a potential prey species for monk seals, appears to have fallen drastically since the 1950s in benefit of other groups, such as cephalopods (Guenette *et al.* 2002; Balguerias *et al.* 2000, 2002). The ecological effects of fisheries on monk seals are unknown (e.g. competition for prey or alteration of prey assemblages by removal of key predator fishes) unknown. However, changes in the appearance of prey species in seal stomachs (see section..) , could be linked to changes in the abundance of prey-species. Data gathered in the 1970s and 80s in *Cabo Blanco* Peninsula indicate that the Mauritanian Lobster *Panulirus regius* makes up an important part of the diet (Soriguer 1979, Marchessaux 1989) (see Table I). Nevertheless, stomach analyses from the 1990s found no lobster remains, suggesting a change in diet (Forcada *et al.* 1999, ULPGC 1995-99). This could be produced by lobster overfishing. According to several authors, it has been overfished since the 1950s (Maigret 1978, Fernandez de Larrinoa 2004). A similar situation was described for the monk seal in Hawaii, *Monachus schauinslandi*, where there is a correlation between the exploitation of a lobster fishery (that makes up the diet) and the lack of feed for juveniles and breeding females of each species (NMFS 2003).

Pollution

Toxic substances

The levels of tDDT and tPCB found in samples of bubbler from 31 monk seals carcasses washed ashore on *Cabo Blanco* are relatively low, and fall within the range commonly detected in other marine mammals, which display normal reproductive and survival rates (Borrel *et al.* 1997).

Oil tankers containing thousands of tons of hydrocarbons regularly sail through the monk seal distribution range in the Atlantic. Maritime traffic involving transport of hydrocarbons is intense in this region. In 1994 there was an oil spill on the Island of Porto Santo (Madeira), close to the *Desertas* islands, although it did not have negative effects on the habitat of the *Desertas* Natural Reserve. In August 2003, a bulk carrier drifted into the beach of the Satellite Reserve of *Cabo Blanco*. It was quite large but empty at the time of the accident, so the only danger of hydrocarbon pollution in the protected area was from its own fuel. These accidents show the vulnerability of the monk seal populations to intense maritime traffic. Moreover, this traffic will probably increase in the near future, when Mauritania begins exploiting recently discovered marine oilfields (Kloff & van Spanje 2004).

Impact of human disturbance

There has been a long history of human disturbance on monk seal populations throughout their range (Sergeant *et al.* 1979, Johnson & Lavigne 1999b). Seems to be that in the absence of human disturbance, seals can recolonize breeding habitats, as in the *Desertas* islands, where immature-size females reoccupied open beaches for breeding habitat, improving the reproductive success of the colony (Pires & Neves 2000).

Human disturbance in the *Cabo Blanco* colony has increased progressively since the colony was discovered in 1945 (Fernandez de Larrinoa & Cedenilla 2003). From the 1940s to the 1970s, disturbance from land was mainly from the people that collected pups and young to provide zoos and aquarium (Rigas & Ronald 1986); eg. between 1973 and 1975, at least six pups/young were lived captured from this colony (Soriguer 1976) and from militaries or hunters that fire or shoot the seals from the cliffs, it was reported bullets remains in the cliffs above the caves (Maigret *et al.* 1976, Marchessaux 1989) and some individuals founded dead in the beaches had holes similar produced by guns bullet (Maigret *et al.* 1976, Soriguer 1976). In this period Trotignon (1979) reported the shooting by one hunter above the caves cliffs, of at least twelve seals, some were died and others injured. Moreover during the 1970s, locals began harvesting goose barnacles, descending from cliff-tops to many different locations, including monk seal breeding caves (Soriguer 1976). Barnacle harvesting continues to this day, but access to breeding caves is impeded by terrestrial surveillance (Fernández de Larrinoa *et al.* 2002)..

In the last two decades, in the southern part of the current monk seal range in the Sahara, the population of Nouadhibou has increased exponentially due to the immigration from the interior of Mauritania and southern Sahelian countries. This has had an impact on the coast of the *Cabo Blanco* peninsula, including the breeding colony and its surroundings. There are more goose barnacle pickers and more people fishing from cliff-tops and beaches. A new artisan fishing-harbour has been created on the Atlantic coast (*Las Ballenas*) and fishing pressure is higher, with new, more dangerous fishing techniques.

On the northern part of the coast, two artisan-fishing harbors in *D'Khila* (*Vialobos la Vieja*) and *Corbeiro* (*Los castilletes de Vialobos la Nueva*) were used for fishing until 2001. The presence of fishermen could have increased human presence by land over potential habitat for monk seals around *Cabo Corbeiro* and *Vialobos la Vieja*. However, the presence of land mines probably dissuaded human activity in the area. Today, artisan-fishing is concentrated in *Lamhiriz* harbour, at the southern limit of the coastline to *Cabo Barbas*, which is also potential habitat for monk seals.

The increase in human presence and settlements will increase economic development. If not properly controlled, new activities may have a direct or indirect impact on the seal habitat and

population, including habitat deterioration and loss, and more direct deaths due to human persecution or interaction with fisheries.

In this context, there is great concern regarding the continuous growth of Nouadhibou, and new settlements planned in the north (new *Bir Gandouz*, proposal or the creation of the new *La Güera*).

The International Conference on Population and Development (Cairo, 1994) recognised that there is a direct link between population growth, environmental deterioration, material wealth and social development. It was suggested that population growth should be decreased, especially in countries with high population growth rates, while stressing that the best way to achieve this goal is to respond to the most urgent social needs and ensure equitable use of resources.

3. CONSERVATION EFFORTS

Several actions included in this Plan have been implemented since the elaboration of the first draft (2000). The Plan was adopted in 2003 by Morocco and Mauritania during the 3rd meeting of the Morocco-Mauritania Higher Commission of Fisheries (Rabat, 18 February 2003) and by Portugal and Spain. It was also a boost for a series of new activities that can, in a coordinated manner, improve expectations for a more efficient application of conservation measures for this species. The main conservation efforts are listed below.

Conservation efforts by countries

Portugal

A Monk Seal Conservation and Monitoring Programme were established at the Natural Park of Madeira in 1988. The *Desertas* Islands were also declared a Natural Reserve in 1990 by regional decree (23/05/90). Hostile fishing activities were banned in the Nature Reserve and compensation was provided to fishermen who were forced to change their fishing area and practices (Neves & Pires 2000). In addition, regular boat surveillance was arranged on the islands to ensure effective protection of seals and their habitat. Simultaneously, a monk seal-monitoring programme was established. Seals started to use open beaches in the Nature Reserve nine years after the start of the protection programme.

The *São Lourenço Peninsula* was the last place where monk seals were regularly sighted on Madeira Island (Melo Machado 1979). It was included in the Natural Park of Madeira as a Natural Reserve. Part of the northern cliffs of Madeira island, the *Rocha do Navio*, with potential habitats and sightings was declared a Natural Reserve in 1997 (*Decreto Reg. 11/97/M*) (Figure 14). Recently, these areas and the adjacent marine area (to a depth of 50 m) were included in the Natura 2000 network as a Site of Community Importance.

Morocco

A reserve was created in 1993 on the Atlantic coast of the *Cabo Blanco* Peninsula to protect monk seals from interactions with fisheries and to restore the marine ecosystem.

The regulation was renewed in 1999 for ten more years (*Arrêté n° 1430-99, du 13 jourmada II 1420*). The Reserve extends from 21°23'00"N to 20°54'40"N and from the coast to 12 miles off shore. All fishing activities are forbidden and surveillance is carried out by the Royal Navy.

Another complementary resolution, included in the Octopus Management Plan approved in 2001 (Idrissi 2003), is the ban on trawling in the 12 mile section between *Cabo Bojdour* (26° 45'N) and *Cabo Blanco* and a southern limit of 22°10'00"N latitude (near *Lamhiriz*) for artisanal fisheries and fishermen settlements on the coast (Figure 14).

Mauritania

There are two protected areas with monk seals in Mauritania: the *Satellite Reserve of Cap Blanc* and the *National Park of Banc d'Arguin* (Banc d'Arguin National Park 1988).

The *Reserve Satellite of Cap Blanc* was created in 1986 by decree (86-080) with FIBA/WWF support (Marchessaux 1986). It is administered by the National Park of the Banc de Arguin and was specifically set up to preserve the monk seal (PNBA 1988). The coast is 4.2 km long and the reserve has an area of 210 ha, including a fringe of 400 m seawater where fishing is prohibited (Figure 15) (Marchessaux 1986). This protects hauling-out habitat of several adult males.

The National Park of Banc d'Arguin, established in 1976, includes a large marine area of 6.245 km² where artisan fishing activities can be performed by traditional fishermen that live in the park (Figure 18). The park seems to be important as a foraging area for the monk seal.

In addition to the reserves, the fishing regulations in the *Baie de Levrier* and *Baie de L'Etoile* (Figure 19) also favour monk seals, as well as the ban on monofilament fishing gears in Mauritanian waters.

Spain

In the area considered in the plan, the Canary Islands are the only place in Spain where monk seals occasionally occur. There are a number of conservation sites with various degrees of protection (National Parks and Marine Reserves). Most have already been chosen to be included in the "Natura 2000" network (Figure 20). Some sites are considered potential habitats for recolonisation (Hernández, 1986, Espino *et al.* 1998).

Therefore, in the above context, the contribution of Spain was directed towards the assistance and financial support of monk seal conservation actions in the Saharan distribution range of the species, including social development projects with NGOs and the support of local and national authorities. This included coordination of WGAMS meetings and the elaboration and preparation of documents (Fernández de Larrinoa *et al.* 2002, Fernández de Larrinoa & Cedenilla 2004).

Criteria for evaluating monk seal recovery

The PHVA (Gonzalez *et al* 2002a) suggested that the abovementioned efforts to recover monk seals in the region should include objective criteria to evaluate progress. The suggested criteria were:

1) The use of counts and trends in counts (of monk seals older than pups) for a population size index or estimates based on capture-recapture surveys using photo-identification data. It has been suggested that these criteria could consider the current population in relation to the carrying capacity of the *Cabo Blanco* peninsula and *Desertas*. Although there is no information about the natural carrying capacity of the different Atlantic populations, given their low densities, the upper limits would probably accurately represent the limits of recent population growth (Forcada *et al* 2002). Thus, the PHVA established an initial benchmark population of around 600 and 75 individuals for each population, respectively, which is an estimate of their carrying capacity (Forcada *et al.* 2002). Those carrying capacities assume a limit which is similar to the upper 95% confidence limit of the highest abundance estimate from 1993-1996 (Forcada *et al.*1999). However, that figure could be changed if necessary, or after a more comprehensive analysis.

Complementary counts and trends in counts for pups (a pup production index), could provide independent verification of abundance and population trends. Annual pup counts were carried out for first time on *Desertas* in 1989 (Neves 1991) and on *Cabo Blanco* in 1994 (González *et al.* 1997).

2) The distribution and trend of monk seal numbers in other areas. One way to evaluate the recovery of the species could be to compare recolonization of their distribution area in relation to relatively recent and reliable data. In this context, monk seal distribution in the 1980s (see section B) was quite regular, especially in *Las Cuevecillas* and *Desertas* areas, in the *Guerguerat-Vialobos* coast (Morocco) and *Ponta de Sao Lourenço* (Madeira). Monk seal recolonization in these two areas should be considered important sign of the recovery of the species in the region.

4. CONCLUSIONS

Many thousands of monk seals were killed for commercial harvest in the past, and human disturbance also appears to have contributed to that decline, as well as other factors, such as large scale environmental changes. Census data is available from most of the species range in the Atlantic in the past 20 years and the main threats have been identified, but there is no information about the kind of population fluctuations before that period. Data on the abundance of monk seals in the eastern Atlantic are not comprehensive enough, but there was a major population decline compared to the past. Recently, the most dramatic event was the mass-mortality in 1997.

Increased human presence in marine and terrestrial environments disturbs important habitats. The development and expansion of commercial fisheries throughout the species range may have had negative effects on food resources. Although, there is little information about the factors that have contributed to the decline of the monk seal in recent times, there is an urgent need to take immediate action to safeguard against further decreases. This includes reducing human-caused mortality to the lowest possible level, protecting important habitats and ensuring an appropriate food supply.

The Mediterranean monk seal is one of the most endangered animals and should be a high priority for conservation efforts. Conservation is an important way to avoid a decrease in biodiversity, especially since monk seals are a flagship for threatened species. The monk seal is also a key part of a healthy ecosystem, so it could even be used as an indicator of the sustainability of fisheries in the area. Monk seals can also be a potential economic resource to the people of the area if a National Park or other protected area is declared to properly regulate and control human impact. The species is also important scientifically, as one of the most primitive living seals or "living fossils". It has characteristics and exhibits behaviours which form the basis for the evolution of other Phocids. Some aspects of their biology and ecology have been interpreted as an adaptation to environmental conditions in warmer latitudes.

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Table 1. Analysis of stomach contents from Cabo Blanco monks seal carcasses

Date	Age-class	Result	Author
1975	Adult	2 <i>Panulirus regius</i>	Soriguer 1979
1975	Subadult	1 <i>Palinuridae</i> indet..	Soriguer 1979
winter 1976	Subadult	2 <i>Panulirus regius</i> fishes remains	Soriguer 1979
12/ 1985	Adult	2 <i>Dicentrarchus punctatus</i> 3 othol. <i>D. Punctatus</i> 1 <i>Dentex canariensis</i> 1 <i>Mugil</i> sp. 4 othol. indet.. 2 beaks cephalopods	Marchessaux 1989
02/ 1986	Adult	1 <i>Epinephelus guaza</i> 1 <i>Mustelus mustelus</i> 2 beaks cephalopods remains <i>Palinuridae</i>	Marchessaux 1989
07/1986	Adult	1 <i>Epinephelus guaza</i> 1 <i>Raja</i> sp. Fishes remains 2 othol. indet.	Marchessaux 1989
1993-94	-	20 <i>Octopus vulgaris</i> 1 <i>Sepia officinalis</i>	Univ. Las Palmas
1993-94	-	1 <i>Octopus vulgaris</i>	Univ. Las Palmas
1993-94	-	4 <i>Octopus vulgaris</i>	Univ. Las Palmas
11/ 1997	Adult	1 <i>Octopus vulgaris</i> 1 <i>Pseudolithus senegalensis</i> 3-4 <i>Unbrina</i> sp. 1 <i>Sparidae</i>	Univ. Las Palmas
199?	-	1 fish indet.	Univ. Las Palmas
2000	Adult	1 <i>Octopus vulgaris</i> 3 <i>Merluccius</i> sp.	CBD-Habitat 2004
2001	Adult	Fishes remains	CBD-Habitat 2004
2001	Subadult	3 <i>Octopus vulgaris</i>	CBD-Habitat 2004
2001	Young	10 <i>Octopus vulgaris</i> 2 <i>H. didactylus</i> 1 <i>Plectorinchus mediterraneus</i> 1 <i>Sepia officinalis</i> 2 fishes indet.. crustaceans remains	CBD-Habitat 2004

Table 2. Estimates of abundance of Mediterranean Monk Seal at the colony of Cap Blanc from 1993 to 1998, estimated from independent capture-recapture experiments. Also detailed are the proportions of identifiable seals (d , with Standard error in parentheses, the estimated coefficients of variation of the abundance estimate and its log-normal 95% confidence intervals (Forcada *et al.* 1999)

Year	Proportion identifiable (d)	Abundance (\hat{N})	Coefficient of variation	Log-normal 95 % confidence interval	
				Low limit	High limit
1993	0.61 (0.17)	322	0.46	149	783
1994	0.68 (0.09)	311	0.15	240	426
1995	0.76 (0.07)	316	0.10	263	394
1996	0.78 (0.06)	317	0.16	237	447
1997	0.58 (0.06)	109	0.14	86	145
1998	0.58 (0.04)	103	0.17	77	148

Figure 1. Distribution range of the Mediterranean Monk Seal in the Eastern Atlantic

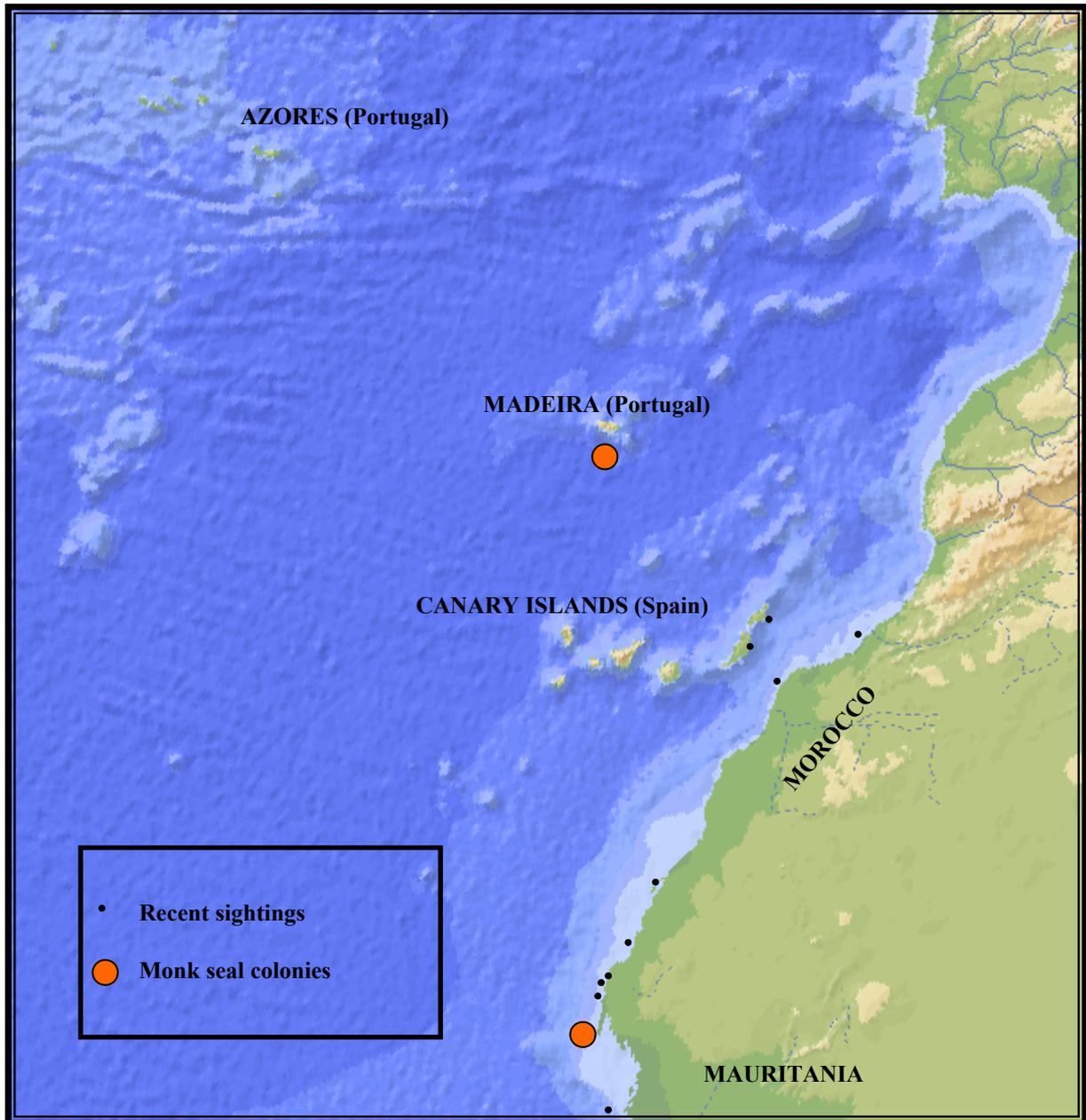


Figure 2. Map of the Cabo Blanco peninsula with the main topographic references (Gonzalez *et al* 1997)

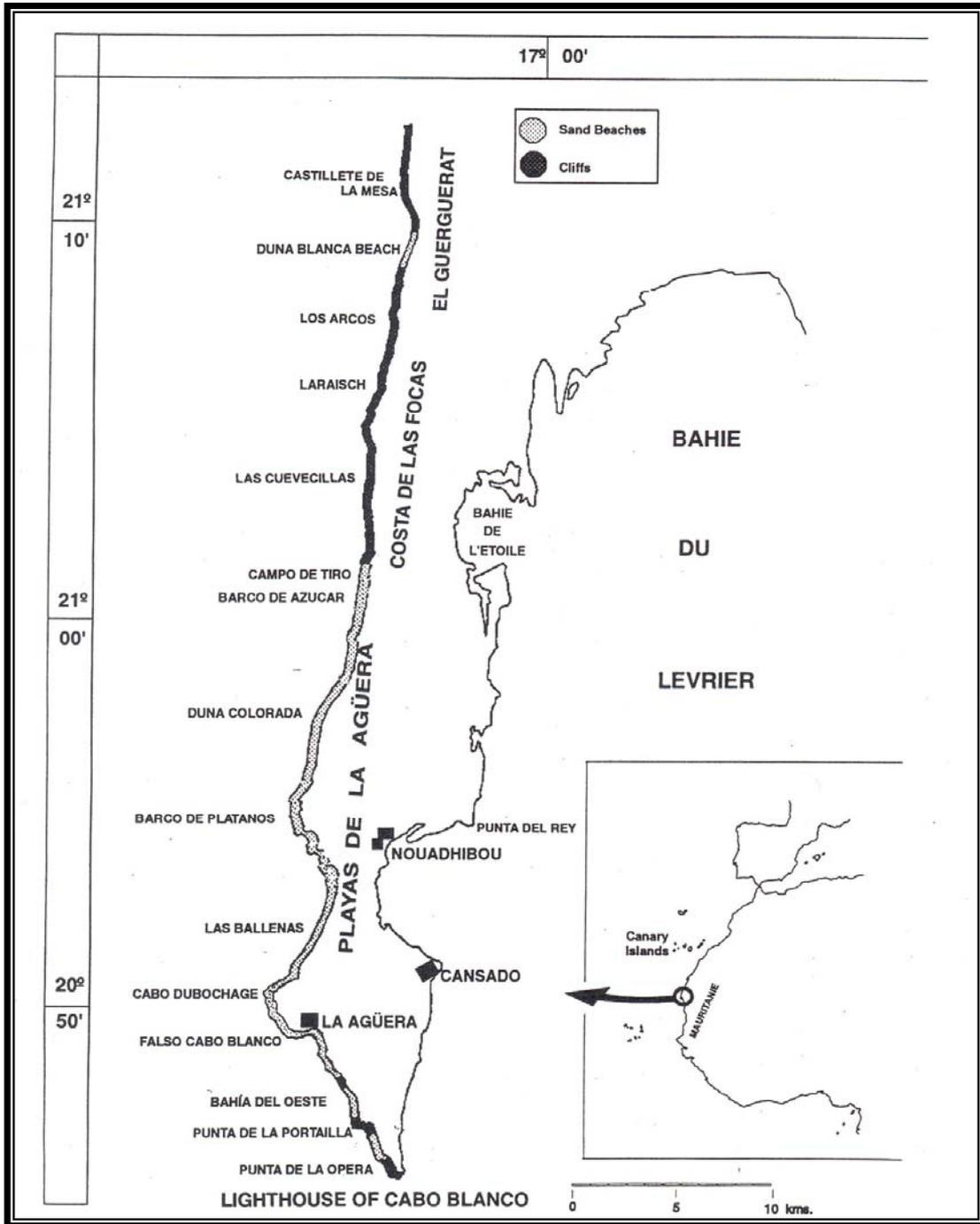


Figure 3. Map of Madeira main island and the Desertas islands (from Karamanlidis et al. 2004)

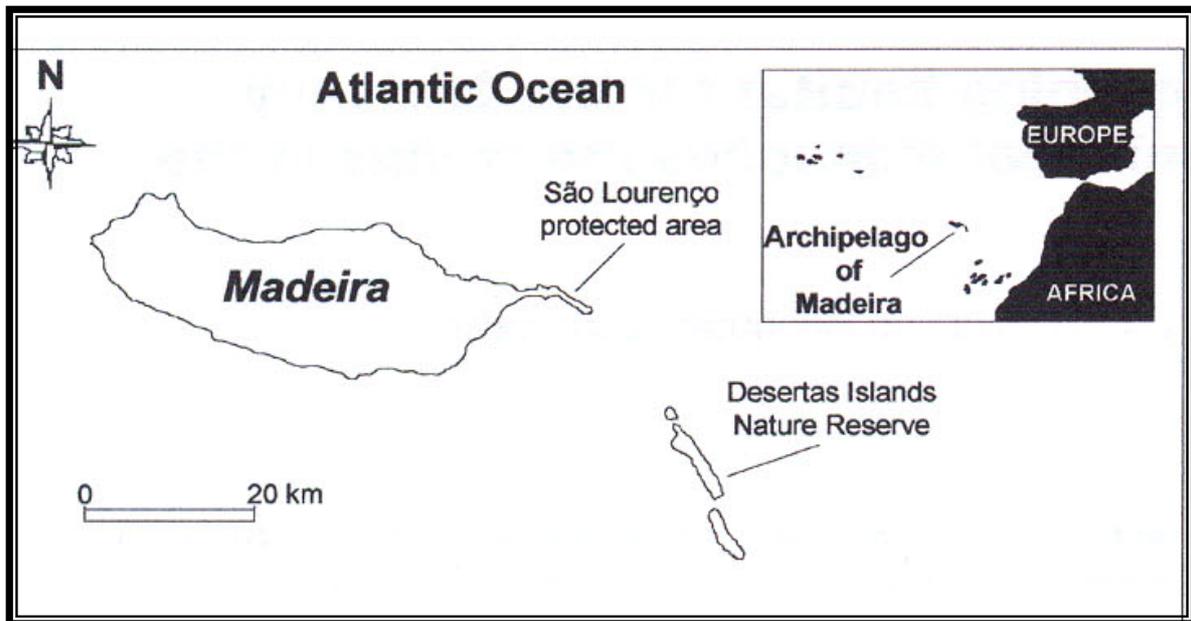


Figure 4. Satellite tracking of the monk seal "Amrigue" in 1997 (from ULPGC 1997-1998)

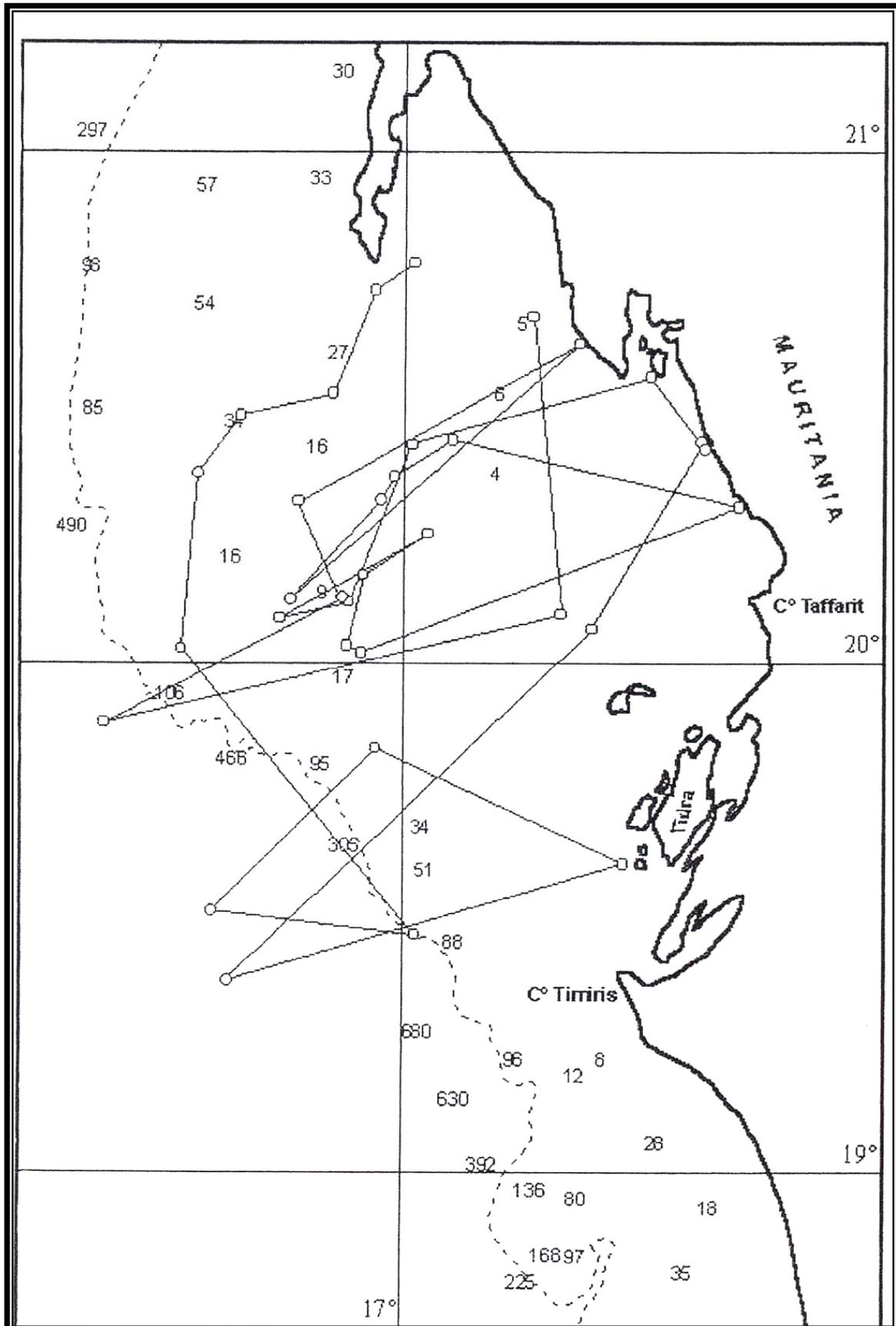


Figure 5. Satellite tracking of the monk seal “Wean” in 2002 (from CBD-Habitat 2002)

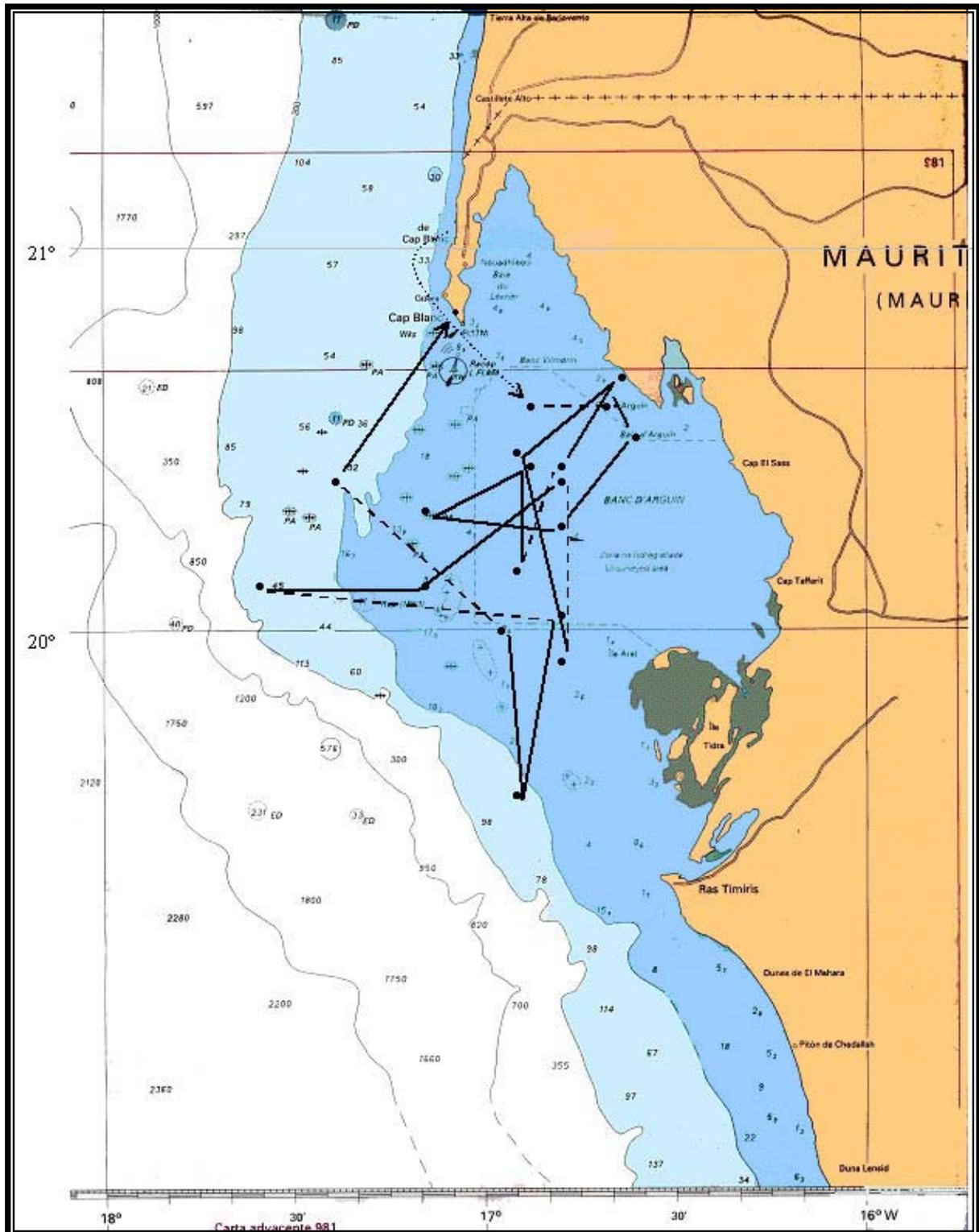


Figure 6. Map of Ponta de São Lourenço showing caves (individually coded) that have been considered that offer good pupping conditions under all weather conditions (AW) (from Karamanlidis et al. 2004)

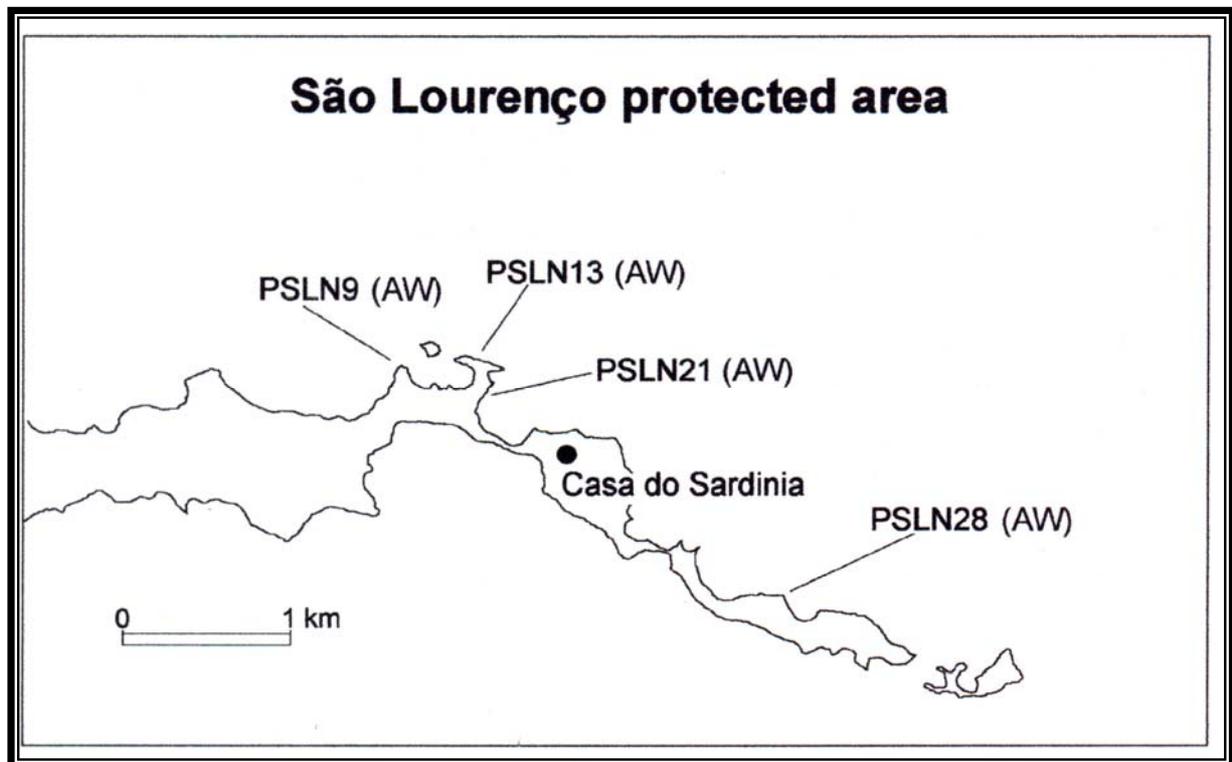


Figure 7. Monk seal sightings around Madeira main island in the period 1998-2000 (Pires 2001)

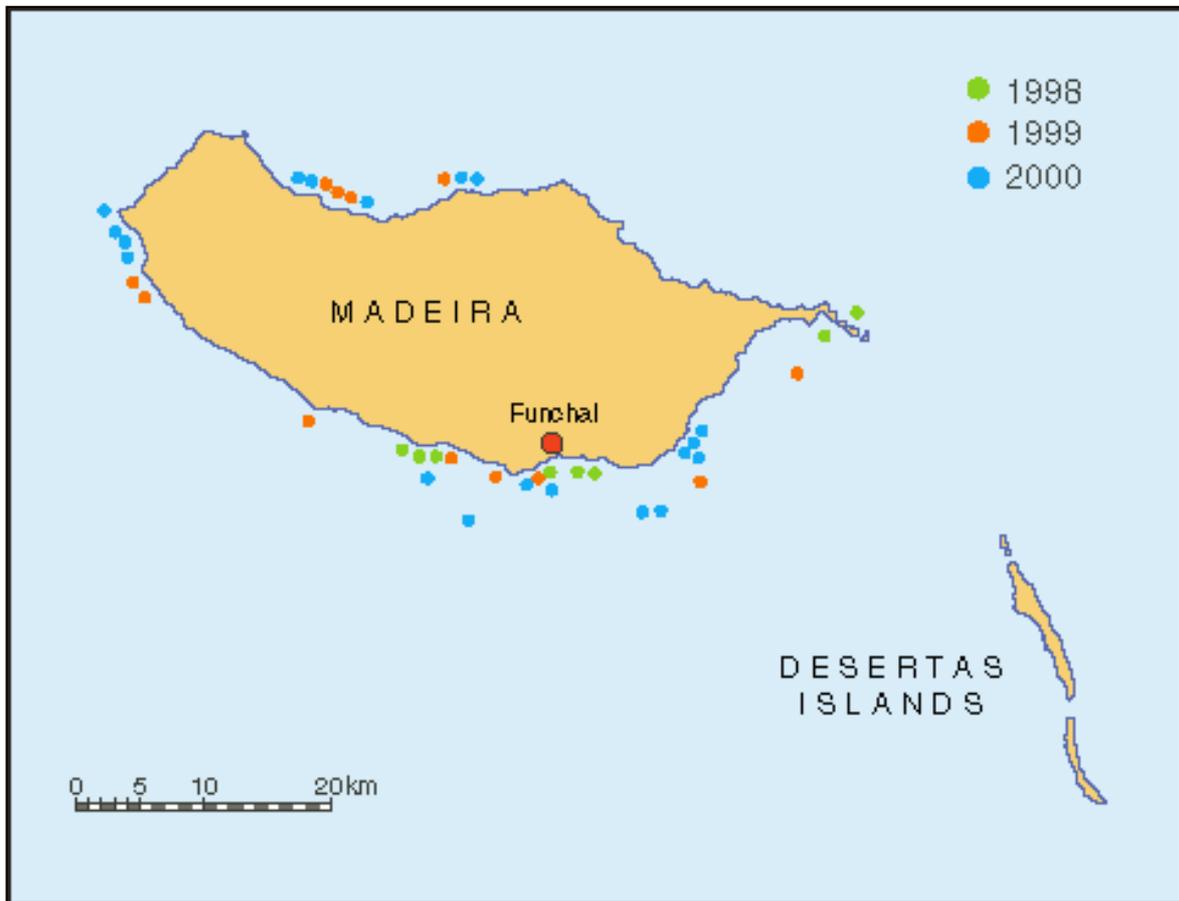


Figure 8. Map of Desertas Islands showing caves (individually coded) that have been considered that offer good pupping conditions under all weather conditions (AW), or good pupping conditions only by during calm weather (CW) (see for details Karamanlidis et al. 2004)

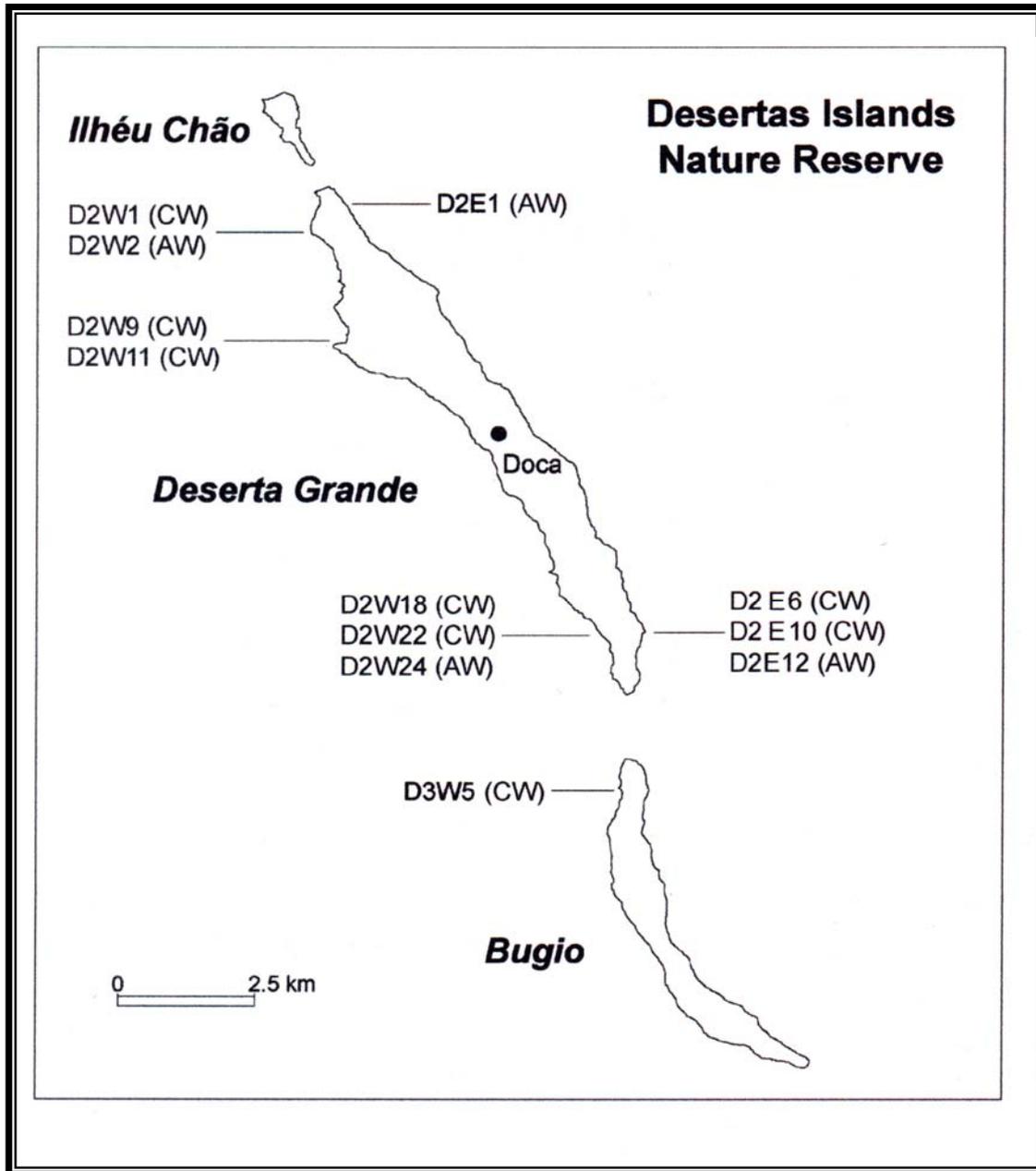


Figure 9. Abundance estimates of Mediterranean monk seals in Cap Blanc from 1993 to 1998, with log-normal 95% confidence intervals. The exponential regression line corresponds to the fitted least-squares model to the natural logarithm of the point estimates from 1993 to 1996, weighed by the inverse of their log-transformed variances. (From Forcada et al. 1999)

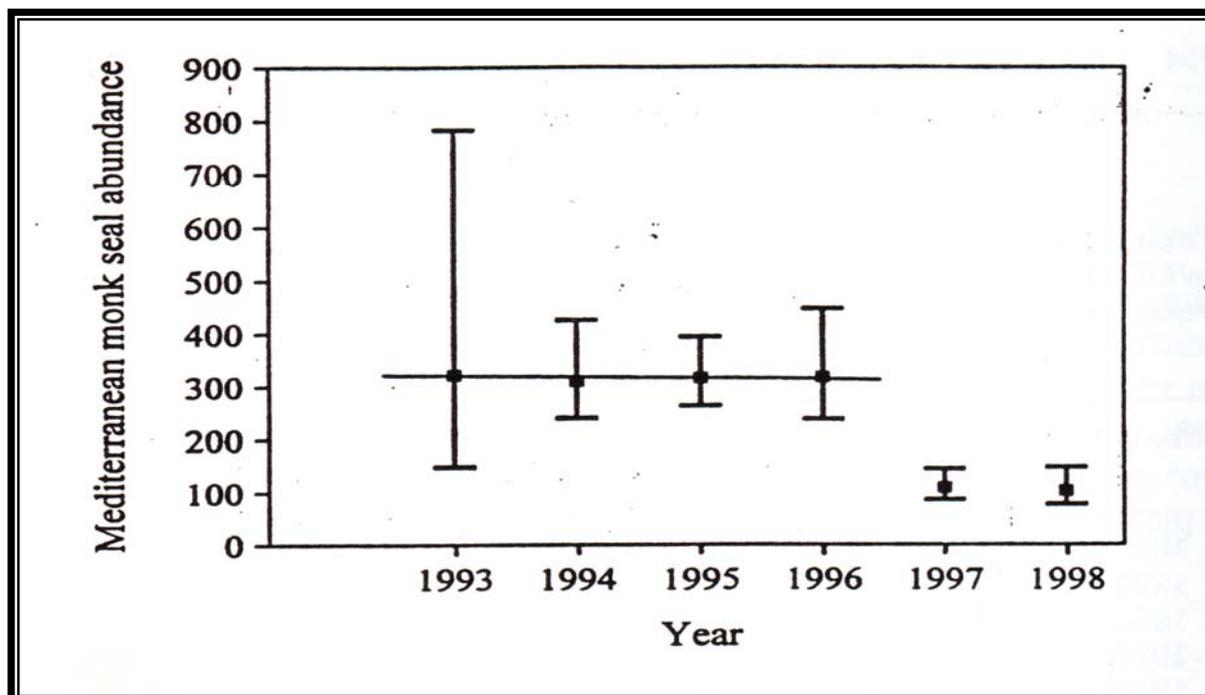


Figure 10. Trend in counts (guindola index) of individuals hauling-out (older than pups) in the Cabo Blanco breeding caves between 1985–2004 (CBD-Habitat, 2004)

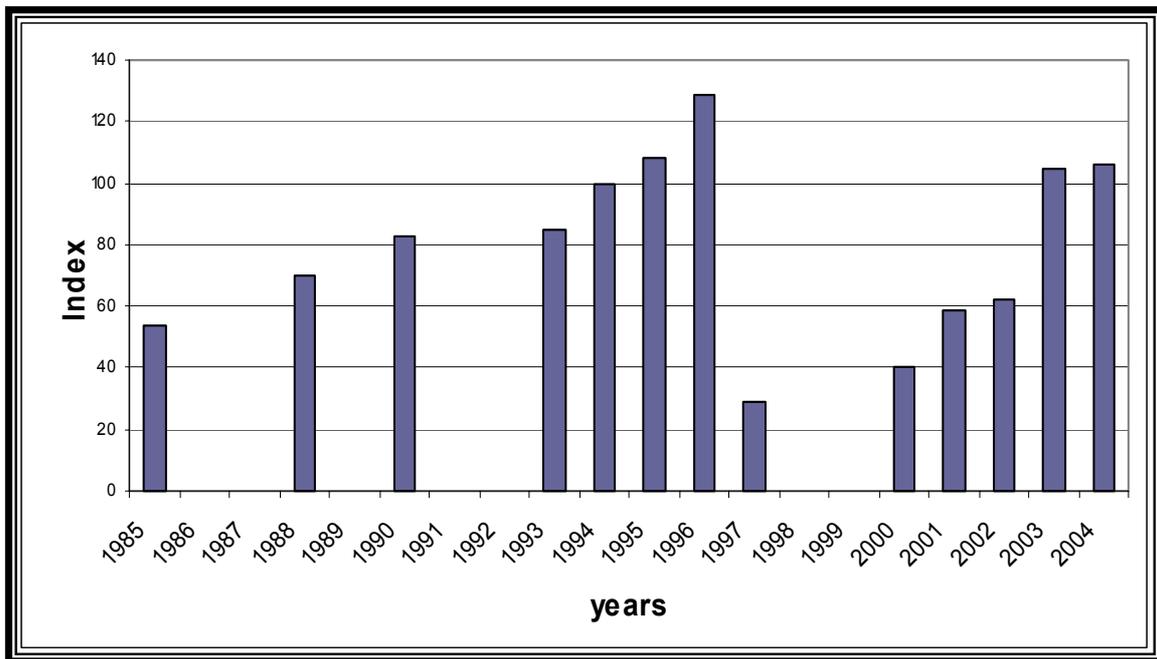


Figure 11. Evolution of the recovery of the Desertas monk seal population (Costa Neves and Pires 1999)



Figure 12. Trend of the monk seal corpses (older than pups) found at Cabo Blanco beaches in 1994-2004 (CBD-Habitat, 2004)

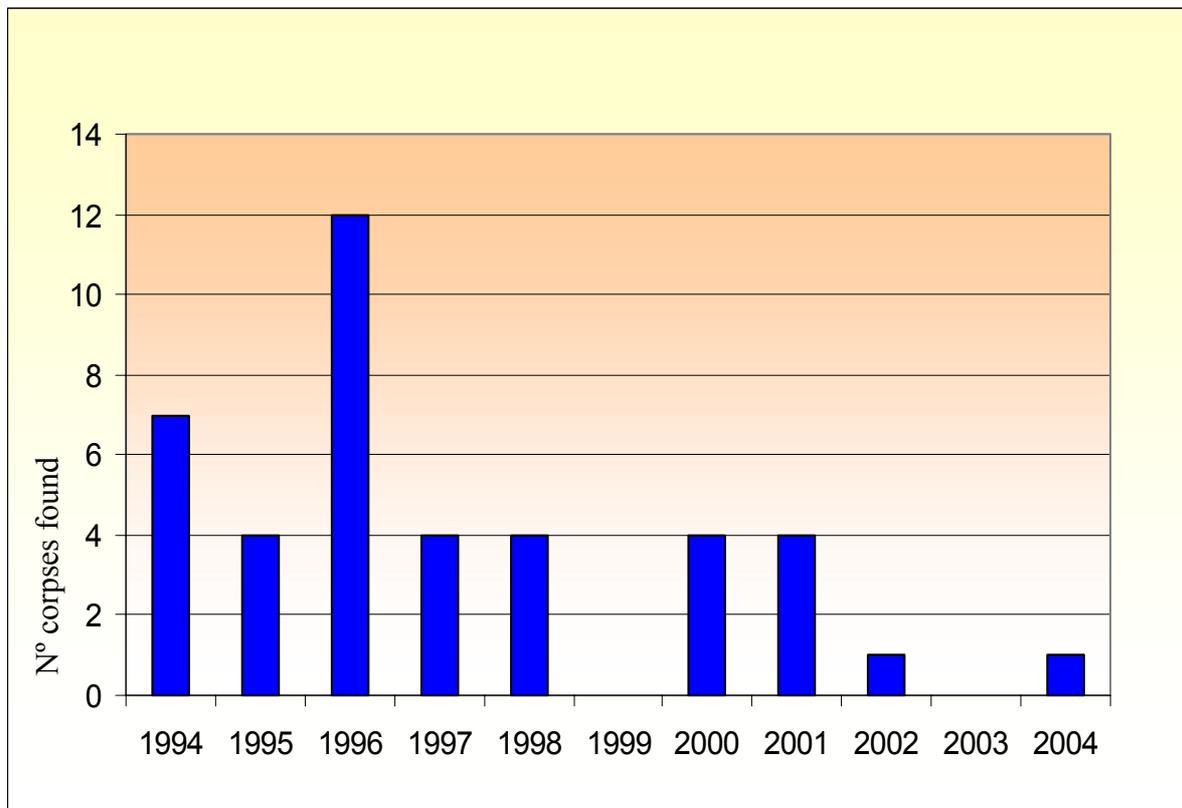


Figure 13. Map of the Madeira archipelago and its protected areas

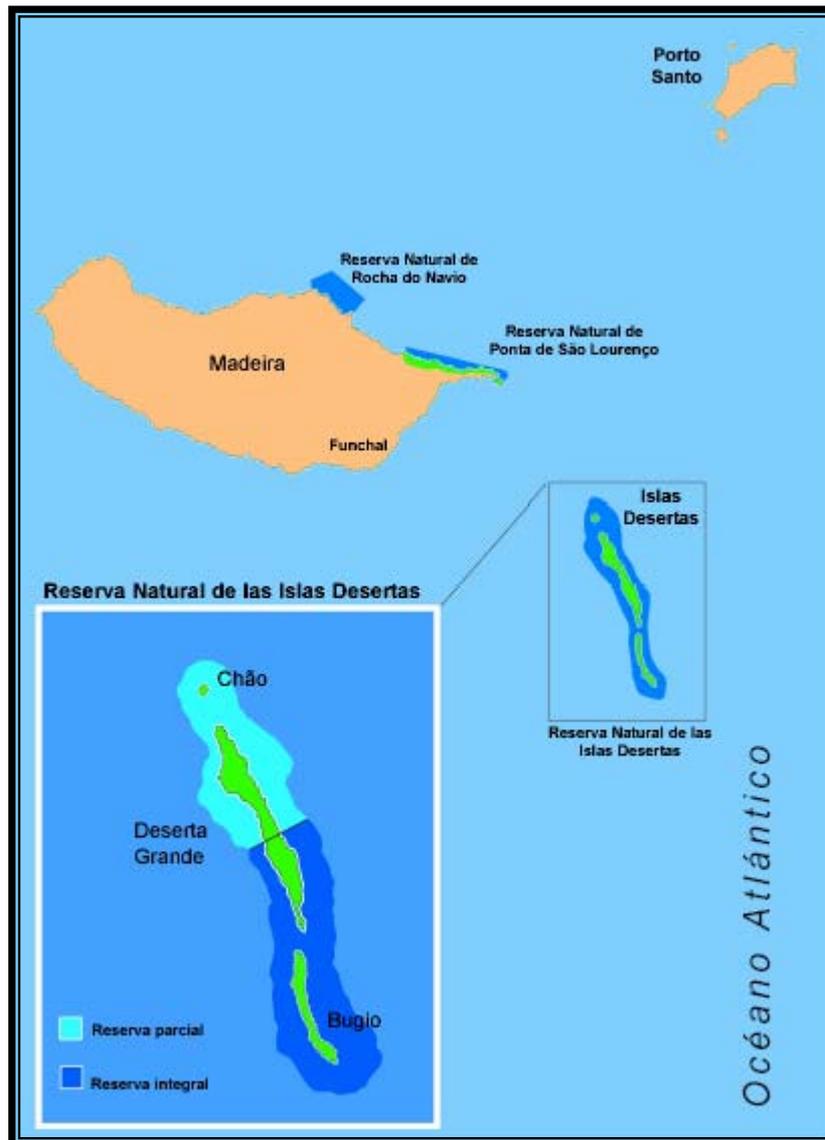


Figure 14. Protected areas in the Aguerguer region

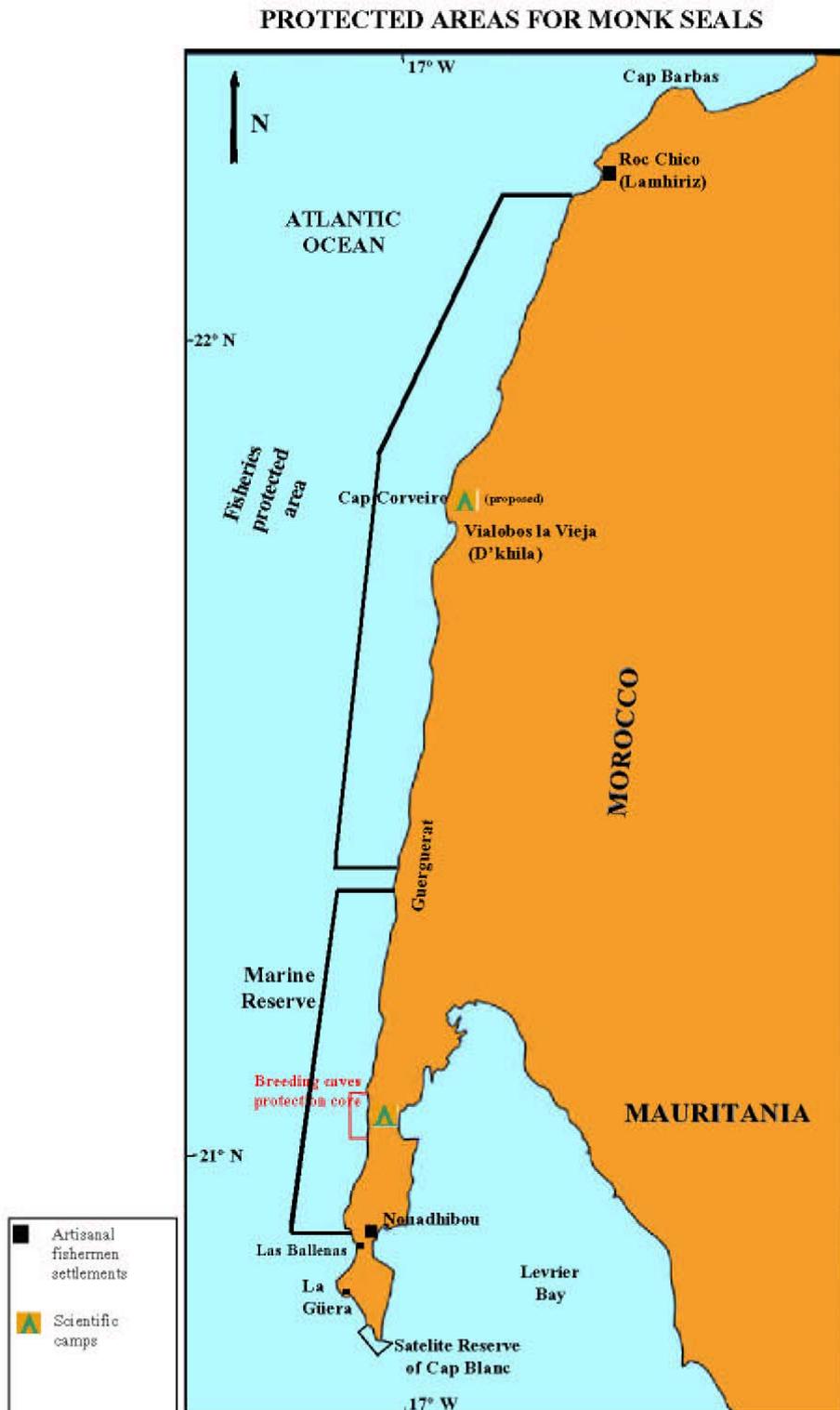


Figure 15. Cabo Blanco Satellite Reserve (GÉOMER UMR 6554 et FR2195). Obtained from PRCM (2003)

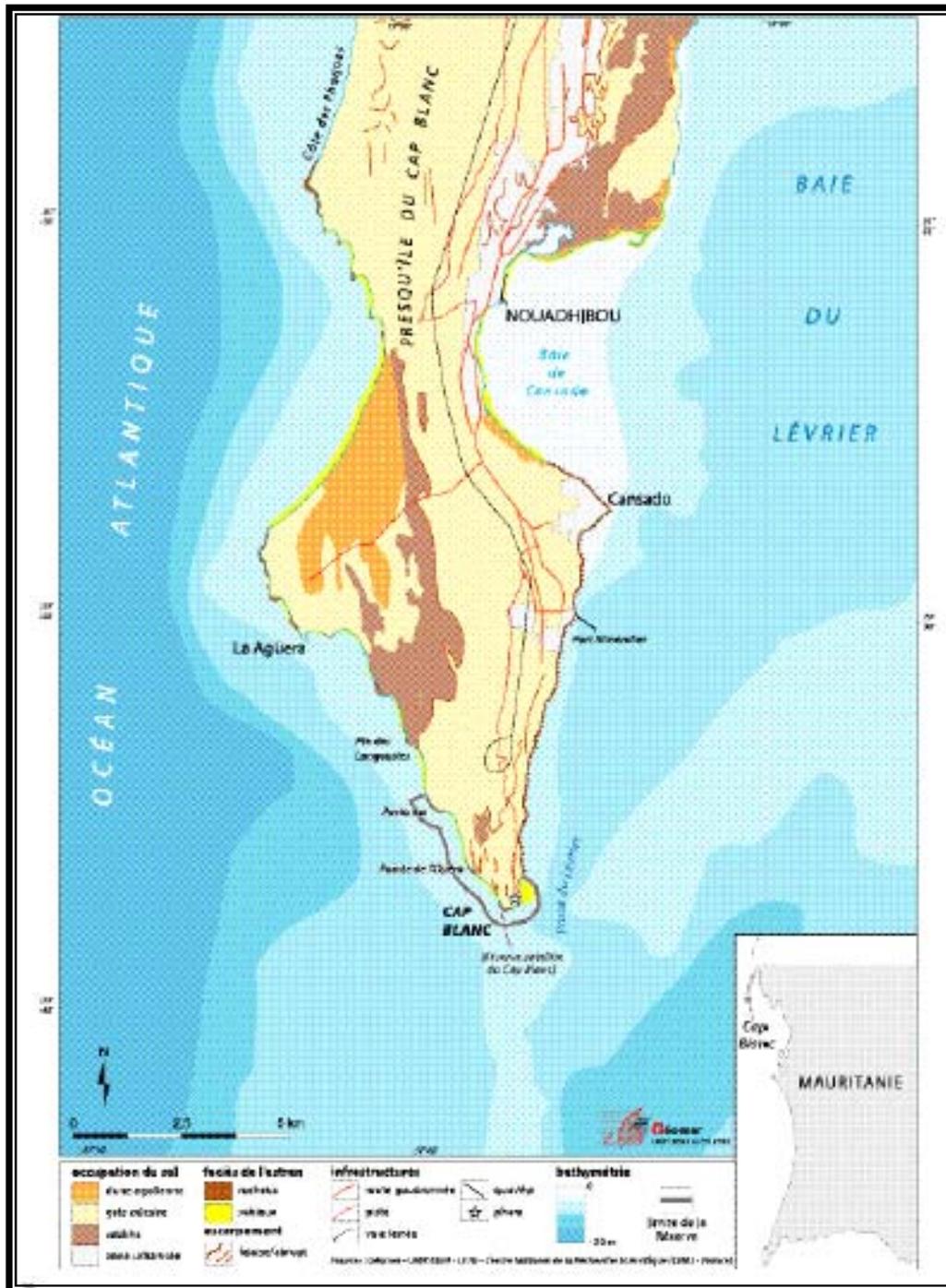


Figure 16. Banc D'Arguin National Park (GÉOMER UMR 6554 et FR2195). Obtained from PRCM (2003)

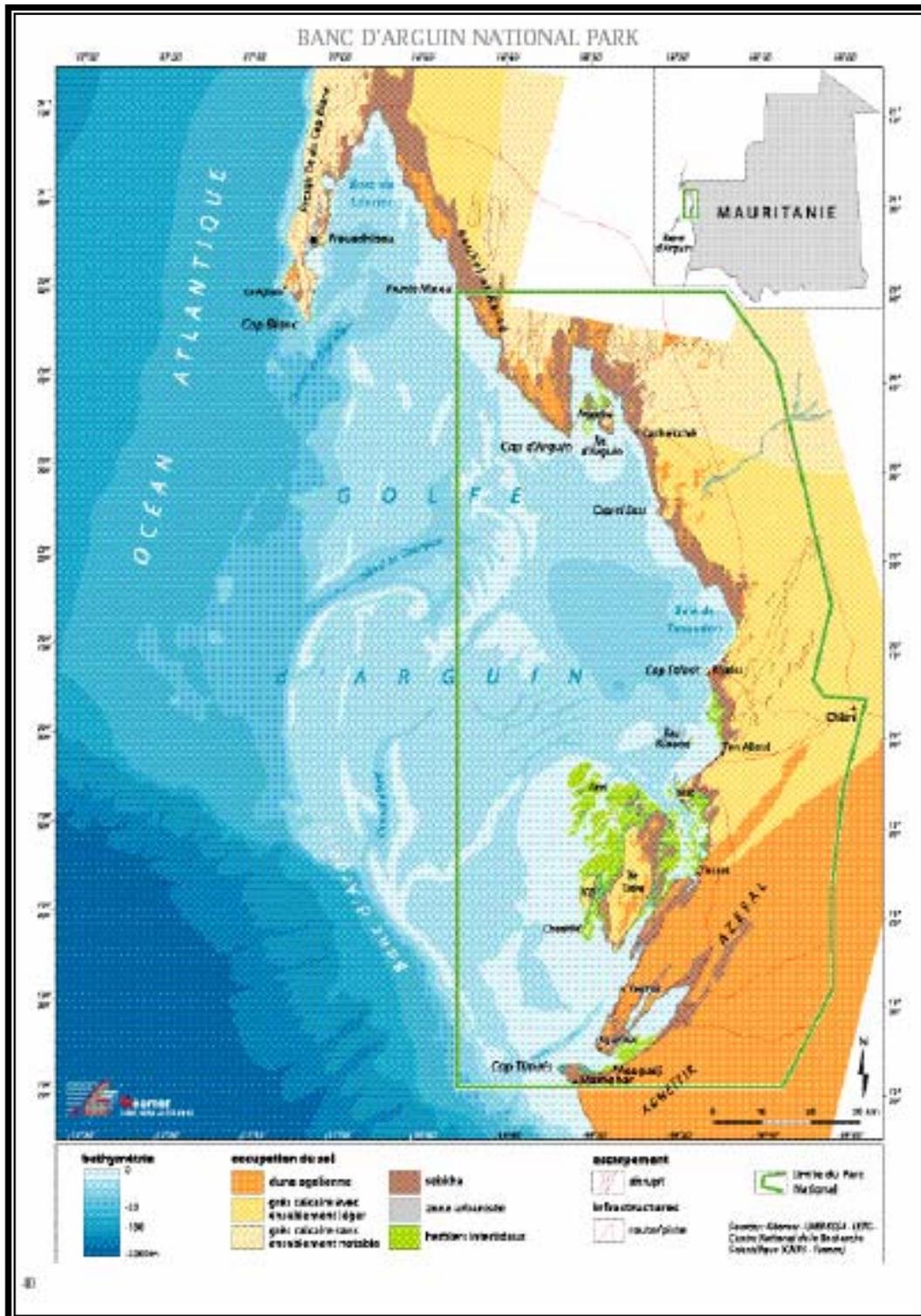


Figure 17. Protected Areas in the Selvagem islands (Portugal) and in the Canary islands (Spain), including SSC Nature 2000 network

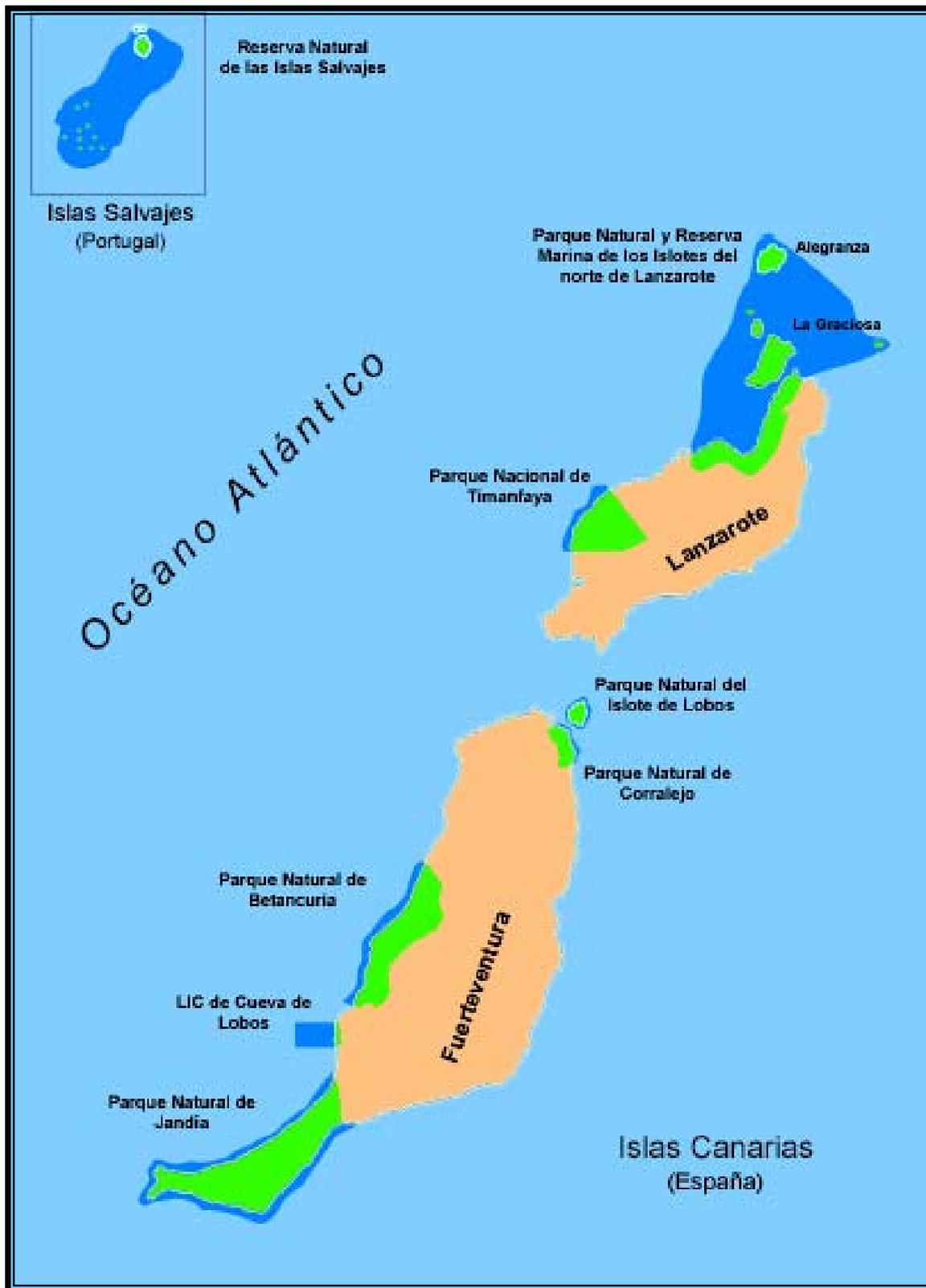
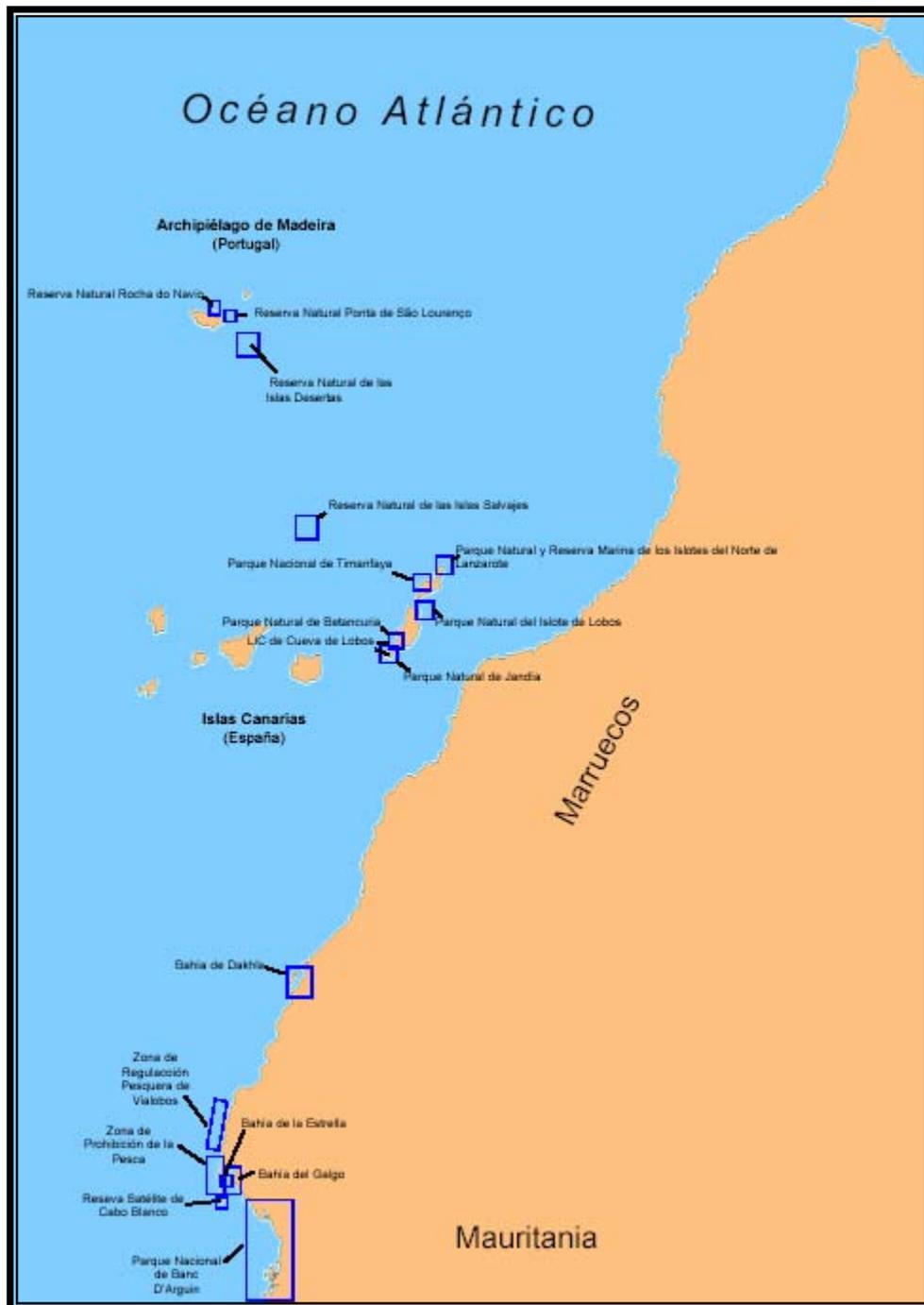


Figure 18. Special Areas for the Conservation of Monk Seals (SACMS) in the Eastern Atlantic



PART II RECOVERY ACTIONS

PART II

1. RECOVERY ACTIONS

A. Goal and Objectives

The long-term and overall goal of this Plan is to promote the recovery of the Mediterranean monk seal in the eastern Atlantic at a level considered as “favourable conservation status”. To achieve this goal the Plan includes a set of actions with short-term objectives, that well applied could reduce the impact of human activities that negatively affect or limit the survival and recovery of the monk seal population and their habitat.

The short-term objectives are: to improve the international coordination and provide adequate financial and human resources, to identify factors that are limiting population recovery and promote actions to stop the population decline and to allow the population to increase.

B. Definitions

According the definitions of the European Directive on protection of habitats and wild fauna Directive, *conservation status* of the species means the sum of the influences acting on the monk seal and their natural habitat that may affect the long-term distribution and abundance of its populations, and the conservation status for the species will be taken as ‘*favourable*’ when:

- Population data on the monk seal indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats
- Their natural range is neither being reduced nor is likely to be reduced for the foreseeable future, and
- There is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

C. Plan structure and list of actions

According the objectives of the Plan, this is structured in six groups of actions. Within each groups, the actions are arranged in order of priority. Independently of this and taking into account the relationships between groups of actions, there are two groups according to their degree of intervention. The success of the second group depends largely on the extent to which the first are successfully implemented. In the first group are:

- A) Establish mechanisms to co-ordinate update and finance the strategies and actions.
- B) Surveying, monitoring and furthering knowledge of population status, habitat and problems affecting the species

And in the second group are:

- C) Reducing and minimize causes of mortality

- D) Enhancing the level of protection for the species and its habitat
- E) Information, awareness raising, participation and social support
- F) Making specific action plans available for emergencies

When the explanation or description of the actions is generic and not detailed, the WGAMS should develop specific plans or action protocols that explain the content of the actions recommended in this report.

List of Actions

A) Establish mechanisms to co-ordinate and finance the conservation actions set out in the Plan.

1. Foster technical co-ordination between public administrations, managers, NGOs, interested social sectors, etc.
 - 1.1. Create and maintain the Working Group of the Mediterranean monk seal in the Eastern Atlantic (WGAMS).
 - 1.2. Establish fluid communication mechanisms
 - 1.3. Revise and update the accomplishment and success of the Plan.
2. Provide human and financial resources needed to implement the Plan.

B) Actions concerning population monitoring and follow-up and to further knowledge about the species, its habitat and the problems affecting it.

3. Population and life history monitoring and surveying.
 - 3.1. Standardising monitoring techniques
 - 3.2. Population monitoring and surveying
 - 3.3. Determining the status of the Mediterranean monk seal in the north of the *Cabo Blanco* Peninsula as far as *Cabo Barbas*
 - 3.4. Determining demographic parameters
 - 3.4.1. Status and population trends
 - 3.4.2. Annual productivity, age structure, sex ratio and survival by age-class
 - 3.5. Health monitoring
 - 3.5.1. Establish a surveillance and control unit
 - 3.5.2. Monitoring and breakdown of cases of disease in live seals
 - 3.5.3. Determine pathologies and causes of death
 - 3.5.4. Monitor the presence and effects of morbillivirus
4. Evaluating and monitoring interactions between fisheries and seals
 - 4.1. Seal trophic requirements and feeding strategies
 - 4.2. Status and geographical and seasonal distribution of prey species populations
 - 4.3. Impact of fisheries
 - 4.3.1. Evaluate and describe the characteristics of incidental and deliberately caused mortality
 - 4.3.2. Effects of fisheries on prey species populations
 - 4.4. Analysis and evaluation of material damage and financial losses caused by seals in the fishing sector.
5. Information on habitat and monitoring of environmental conditions
 - 5.1. Coastal habitat

- 5.1.1. Evaluating the risk of collapse of breeding and resting caves at *Cabo Blanco*
 - 5.1.2. Description and characteristics of current and historical breeding and resting habitat
 - 5.1.3. Identifying and listing habitats of interest for monk seal conservation in the eastern Atlantic.
 - 5.2. Marine environment
 - 5.2.1. Characteristics of the maritime climate
 - 5.2.2. Characteristics of pollution and physical and chemical parameters of the water
 - 5.2.3. Monitoring the phytoplankton and detecting “blooms” of toxic phytoplankton
 - 5.2.4. Describing the biota associated with monk seals
 - 6. Genetic variability in the Mediterranean monk seal
 - 6.1. Determining genetic variability between and within populations
 - 6.2. Evaluating the viability of a programme for genetic improvement of the populations
- C) Actions to reduce seal mortality.
- 7. Regulating fishing
 - 7.1. Applying and reinforcing measures governing fishing operations that pose a threat to seals or their trophic resources: zones, types of fishing gear and fishing seasons.
 - 7.2. Following up the recommendations contained in the Behaviour Code for Responsible Fishing (FAO 1995).
 - 8. Neonatal mortality
 - 8.1. Rescue, rehabilitation and reintroduction of threatened pups to the wild
 - 8.1.1. Rescuing and handling threatened pups in accordance with existing procedures and protocols
 - 8.1.2. Drawing up a joint action protocol that includes establishing criteria for rescue, rehabilitation and reintroduction methodology defined in a specific seminar
 - 8.1.3. Rescue, rehabilitation, reintroduction and monitoring threatened pups in accordance with the new protocol
 - 8.1.4. Evaluate the reliability of the new protocol
 - 9. Promote the occupation of beaches as breeding and resting habitat
 - 9.1. Eliminate risks and disturbance at current breeding and resting sites
 - 9.1.1. Restrict people’s access to caves and open coastal areas where seals are present
 - 9.1.2. Co-ordinate and monitor research activities to minimise disturbance
 - 9.2. Eliminate risks and disturbance in coastal habitats of interest for recolonization
 - 9.3. Viability study to improve potentially recolonisable coastal habitats

D) Habitat protection actions

10. Legal protection for habitat and support for its enforcement

10.1. Protect the *Cabo Blanco* seal colony and its habitat

10.1.1. Support and strengthen the enforcement of Morocco's marine reserve in the waters of the *Cabo Blanco* Peninsula to protect the adjacent maritime-terrestrial zone

10.1.2. Support and strengthen the enforcement of the *Cabo Blanco* Satellite Reserve

10.2. Equip and maintain the protected natural areas hosting seals with the necessary material, human and financial resources.

10.3. Create a network of Special Areas of Conservation for the Monk Seal (SACMS) in the area consisting of habitats declared of interest for the species (See Action 5.1.3.).

10.3.1. Participating states designate SACMS.

10.3.2. Draft management plans and establish the conservation measures needed to maintain the SACMS.

E) Information actions, awareness raising and social support

11. Information, awareness raising and social support.

11.1. Develop and execute campaigns targeting, above all, the public powers, activity sectors related with the monk seal and local people.

11.2. Establish mechanisms of public participation and social support.

11.3. Devise and implement specific information and awareness-raising campaigns targeting the fishing sector.

11.4. Implement education strategies for local people.

11.5. Material compensation for the fishing sectors of local populations, preferably with co-operation funds for development or similar funds.

F) Draft a protocol for co-ordinated action in emergencies

12. Establish common bases for drafting specific emergency measures for the *Cabo Blanco* area and the Madeira archipelago.

12.1. Draft a common protocol for action to deal with emergencies.

12.2. Create an international alarm network to determine and co-ordinate implementation of the emergency plan.

12.3. Prepare the infrastructure needed to implement the emergency plan.

D. DESCRIPTION OF THE PLAN

The specific measures that should make it possible to halt the Mediterranean monk seal's decline and recover its populations were set out in the previous section. The methodologies that must be applied in most cases as well as the reasoning behind the actions proposed are described below.

A) Establish mechanisms to co-ordinate and finance the conservation actions set out in the Plan.

Action 1. Develop technical co-ordination among public administrations, managers, NGOs, interested social sectors, etc.

The actions that must be carried out to recover the monk seal in the Atlantic cover several degrees of urgency and affect numerous public and private sectors of the four countries involved so efforts need to be co-ordinated in order to achieve a greater degree of effectiveness.

The Plan must be recognised as the appropriate technical instrument to tackle the implementation of monk seal conservation tasks. The actions currently in force should be reviewed, taking the current Plan as a framework and heeding its guiding criteria. These revisions shall be carried out by the states once the Plan has been approved.

The Plan will include a system of priorities that guarantee that the financing and human resources available tackle the main threats first.

Participation in non-governmental organisations (NGOs) devoted to environmental matters should be fostered, and, to that end, appropriate frameworks and mechanisms that allow active participation in the Plan should be created.

With the aim of fostering and boosting technical co-ordination between states, local administrations, social sectors and NGOs, a Working Group will be set up and will be assigned the following tasks:

- Evaluate the results of the conservation actions undertaken and the Plan's level of attainment
- Establish and review the priorities for conservation, management and research
- Actively collaborate in drafting the protocols included in the current Plan
- Inform the Scientific Council and Secretariat of the Bonn Convention of all conservation initiatives that might affect the species
- Promote the search for sources of joint finance for overall actions and actions of general interest in seal conservation
- Anticipate opportunities for reviewing and adapting the Plan
- Identify Habitats of interest for the monk seal
- Make the currently available information accessible to all sectors involved by fostering their participation in debates.

Temporary commissions for specific tasks can be set up to achieve greater efficiency in the Working Group

A full-time co-ordinator of recognised professional prestige should be appointed to facilitate the Plan's co-ordinating action. National co-ordinators should also be appointed.

The Plan shall be in force indefinitely, and will be reviewed thoroughly every 4 years.

In this context we also recommend to:

- Create a coordinating body on a national level and designate a coordinator;
- Develop a work budget on a national level;
- Promote and develop bilateral meetings between research and conservation institutions through mediation with national coordinators;
- Encourage and develop bilateral meetings between managers of the ZSCPM (*Zones Spéciales de Conservation du Phoque Moine*, Special conservation areas for the monk seal), especially between neighbouring areas where the problems are similar;
- Create a follow-up committee on a regional level to apply the conservation plan for the monk seal. It will include national coordinators, representatives from NGOs and from the fishing sector, scientists and veterinarians, etc.;
- Create an executive secretary (first it will be based at Nouadhibou since it is close to the seal populations);
- Create a computer network to facilitate the exchange of information and coordination (the executive secretary will be responsible for setting this up).

Action 2. Human and financial resources needed to implement the plan

The financial resources needed to ensure initiation and implementation of the Plan and the regional strategies in each country shall be identified and evaluated. The costs must be assumed by the sectors involved in their implementation, chiefly the states, the European Union and the international community. Ways must be sought of incorporating the new financial resources.

In the context we also recommend to

2.1 Financial resources:

- Find the international financial support (the cost of supporting the institutions for research, conservation and surveillance may be higher than the financial possibilities of some countries);
- Develop a budget on a national level which includes a description of the requirements to carry out the actions in the scope of the plan, most importantly in terms of research, surveillance, conservation and training;
- Coordinate the actions on a regional level so that the committee and the executive secretary can contact the donor agencies.

The overall budget should be presented as a modular project following the topics of the action plan in order to facilitate financial support.

2.2 Human resources:

- Hire enough qualified personnel;
- Improve the ability to exchange experiences among several initiatives on a national level;
- Reinforce bilateral cooperation to improve specific competencies;
- Take into account the need for training in national projects and the financial mechanisms in the framework of bilateral (regional and international) cooperation.

B) Population monitoring and surveying actions and actions to further knowledge about the Mediterranean monk seal, its habitat and the problems affecting it

Action 3. Population monitoring and surveying

Action 3.1. Standardising monitoring techniques

For population monitoring and studies of monk seal biology, non-invasive techniques shall be used, avoiding actions that would involve disturbance to seals at breeding and resting sites. As a general rule, access to the interior of the seals' breeding and resting caves will be forbidden. This rule does not apply in the case of catastrophes (epidemics, red tides, cave collapse, oil slicks, etc.) or situations that involve an action to resolve a threat to seals.

As far as possible, a similar methodology should be used in both the *Desertas* and the *Cabo Blanco* populations to gather data on demographic parameters.

Action 3.2. Population monitoring and surveying

Given that there are only two localised breeding colonies (*Cabo Blanco* Peninsula and Madeira archipelago) and bearing in mind their vulnerability, a permanent unit of teams and surveillance patrols should be maintained to monitor the situation on the ground in both colonies and to keep the surrounding areas under surveillance. The aim is to ensure breeding colonies remain free from disturbance, to raise the alarm in the event of unforeseen circumstances, natural catastrophes, etc., and to obtain basic information on seal presence, behaviour, breeding, etc. This action complements the habitat protection action.

Action 3.3. Determining Mediterranean monk seal status in the north of the Cabo Blanco Peninsula as far as Cabo Barbas

The coastal zone between *Cabo Barbas* and *El Guerguerat* has remained few unaltered by human activity and may still offer abundant potential habitat for monk seals. The features of this stretch of coastline are strategic to guarantee enough habitats

Reconnaissance missions need to be carried out to determine precisely monk seal status and the problems currently facing them in the area so that the necessary measures to protect and/or recover new populations can be undertaken

In the context we also recommend

- Increasing the study area of *Cabo Blanco* to the north, up to Dakhla.

Action 3.4. Determining demographic parameters

Size and population trends in each colony will be regularly estimated using the most appropriate methods in each situation (e.g. on the basis of individual photo-identification sessions). It would be advisable to gather data on the age structure of each colony. Lists of the individuals in each subpopulation will be produced and regularly updated. The number of births will be determined via regular inspections of the breeding areas using remote control cameras and by direct observation. Each pup will be identified and listed according to the differences in the pigmentation pattern on its ventral patch. Individualised monitoring will then be carried out until the first moult (at approximately two months old) to determine the survival rate up to that age.

Rescued and handled pups should be tagged in an appropriate and lasting way. The tagged seals will be identified via observation sessions to estimate survival rates of moulting pups and juveniles. In this way, information will also be obtained on development and sexual maturity.

In this context we also recommend

- In the case where other populations have been sighted, the same studies be carried out to determine their demographic parameters, in the same way and with the same technology used to date.

Action 3.5. Health monitoring

There will be a unit for regular monitoring on the *Cabo Blanco* Peninsula and in Madeira. The beaches and coast near the breeding and resting caves will be regularly surveyed to locate dead beached seals from the colony. Ongoing monitoring of the seals' normal behaviour from the health point of view will also be carried out using video cameras. .

Every time dead, sick or wounded seals are found, the causes will be investigated following existing protocols. The samples obtained will be analysed in anatomopathology and toxicology laboratories with recognised experience in their respective fields of research. The morbillivirus in the Atlantic populations should be

monitored using seals corpses beached along the coast and rescued and rehabilitated seals. Blood samples are advisable in such cases.

In this context we also recommend

- Carrying out seminars, work meetings and training courses regarding autopsies and monitoring ;
- Develop a guide to standardise health monitoring and autopsies, according to the model for the monk seal in Hawaii, with necessary adjustments for the monk seal in the Mediterranean.

Action 4. Evaluating and monitoring interactions between fisheries and seals

Action 4.1. Trophic requirements and feeding strategies

Although it is difficult and complex to ascertain the monk seal diet, an approximation is possible on the basis of the analysis of the stomach contents of dead seals. This information can be complemented with direct observations and surveys among fishermen. As a complementary measure, time depth recorders (TDRs) linked to position recorders will be used to determine feeding areas and strategies. Rescued and rehabilitated seals will be used in all cases.

In this context we recommend

- Evaluation of the nutritional requirements of the monk seal;
- Monitoring of feeding behaviour.

Action 4.2. Status and geographical and seasonal distribution of prey species populations

Once the most important monk seal prey species are known, information on these species will be compiled and analysed. Existing studies will be used as well as studies being conducted on the state of those populations in the marine areas around both colonies. Should shortcomings or a lack of information be detected, specific studies may be proposed. In that regard, regular monitoring of the state of the stocks of monk seal prey species should be conducted to detect variations in numbers and geographical distribution.

In this context we recommend

- Evaluation of the abundance of prey species in the feeding areas of the monk seal populations. To carry this out, analyse the data collected by research vessels from Morocco and Mauritania;
- Study and monitor the presence of heavy metals and hydrocarbons in the prey population of the monk seal.

Action 4.3. Impact of fisheries

Reducing monk seal interactions with fisheries is an essential feature of this conservation strategy. The monitoring work and information gathering on incidental and deliberate mortality in seals must continue.

Types of interaction, the fishing gear that poses the greatest risk and the areas of greatest conflict must be urgently identified. The cost of the impact of fisheries on monk seal prey species populations in relation to the benefits of conserving the monk seal itself should be determined.

In this context we also recommend

- Developing models that superimpose the areas and depths of fisheries and the areas and depths of feeding by monk seals, taking into account seasonal variations;
- Taking advantage of the presence of European observers on fishing vessels (where they are present) to collect information about accidental captures, seal presence and the interactions between seals and boats;
- Recording the current interactions, including their type (wounds, death, etc.) with the help of scientific observations and reliable sampling;
- Land expeditions to locate wounded or dead animals and, when possible, determine the cause of death;
- Evaluating the number of animals dead or wounded after interactions with fisheries;
- Analysing the competition for resources between fisheries and seals.
Establish captures/species/area+consumption/species/area=abundance/species/feeding area.

Action 4.4. Analysis and evaluation of material damage and economic losses caused by seals in the fishing sector

To boost the effect of the awareness-raising and education campaigns in the fishing sector, the financial cost incurred by monk seals on fishing gear needs to be assessed in order to adopt possible compensation measures.

In this context we recommend

- An analysis to evaluate the eventual economic impacts caused by the species. If necessary, this study could consider the damage to fishing vessels and other influences, such as disturbance to fish.

<i>Action 5. Information on habitat and monitoring environmental conditions</i>
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Action 5.1. Coastal habitat

A geological study of the cliffs of *Cabo Blanco* is crucial to preventing currently occupied breeding caves or others of potential interest from collapsing

A descriptive analysis of monk seal habitat at different times in the past should be carried out to gain insights into its requirements and the current availability of coastal habitat.

Habitats of interest for monk seal conservation are those geographical areas that are well defined by abiotic and biotic factors and with a clearly delineated surface area where the species currently engages in one or more stages of its biological cycle. Furthermore, this consideration includes the coastal and marine areas occupied by monk seals in the past and which meet the conditions for future recolonization.

Action 5.2. Marine environment

As the state of the sea is closely related to pup survival, the most directly related variables (height, wave direction and frequency, tide, wind speed and direction, etc.) should be recorded daily. Automatic maritime climate recording stations should be set up in the *Cabo Blanco* and *Desertas* colonies to conduct more objective and accurate monitoring.

Pollution levels and the physical and chemical parameters of the water must be sampled regularly in accordance with a protocol that must be drawn up. This is important in the *Cabo Blanco* region, where maritime transport (iron, oil, etc.) goes on just a few kilometres from the colony. The iron levels in the water need to be ascertained and their possible relationship with the phytoplankton blooms in the area investigated. Research on the meteorological aspects of aerial transport of terrestrial materials in connection with the appearance of phytoplankton blooms (specifically via a hydro-climatic study) is recommended.

An in-depth study of the ecology and base levels of toxin-producing phytoplankton species in the geographical ambit of the Plan should be carried out, and the risk of the appearance of "blooms" of toxic algae and the possible causal factors should be investigated. A monitoring and early warning unit must be set up in the area and a good prevention alert system developed that can detect algal blooms and keep them under surveillance via satellite.

In this context we also recommend

- Training courses to obtain a precise set of data;
- Evaluation and continuous monitoring of health levels in the marine environment (pollution, hydrocarbons, heavy metals, biological contaminants, etc.);
- Beginning, as a priority, a study on changes in wind regimes and their influence on upwelling ;
- Monitoring water quality ;
- That research centres closest to the area take the responsibility of monitoring these parameters. (*Along these lines, we recommend inter-calibration among centres*)

Action 6. Genetic variability in Mediterranean monk seal

Samples will be taken from dead seals or those handled for rescue and rehabilitation for in-depth genetic variability studies.

Information must be obtained on the *Desertas* colony for comparison with data that already exist on *Cabo Blanco*. Comparative studies with the rest of the species's distribution range (Mediterranean) should also be initiated.

An analysis of the viability of a genetic improvement programme for the subpopulations is recommended to avoid their undergoing further genetic impoverishment.

In this context we also recommend

- Continuing with sampling efforts (animals found dead, saved or rehabilitated).

C. Actions to reduce seal mortality

Action 7. Regulating fisheries

Once the dangerous fishing gear and the zones where seals come into conflict with fisheries have been identified, the range states should establish fishing regulations in accordance with updated information about the problems affecting the species, especially in the *Cabo Blanco* region. Always taking into account the need to avoid accidents involving seals, these regulations should establish zonal and time restrictions on fishing operations or the type of gear used. In this regard, the FAO's *Code of Conduct for Responsible Fishing* should be adopted as an initial measure. Each state shall develop and implement said regulations for critical monk seal areas in waters within its jurisdiction and on the boats operating under its flag. The fishing regulations must be flexible enough to enable them to adapt to new situations and to new information on problems.

Action 8. Neonatal mortality

Action 8.1. Rescue, rehabilitation and reintroduction to the wild of threatened pups*

**refers to specific situations in the field, not status*

Bearing in mind, on the one hand, the critical situation of the species, and, on the other, the ever increasing value of each individual seal, as well as the important social and educational repercussion of the rescue, rehabilitation and reintroduction of threatened pups, and despite the controversy over to what extent pups that have been handled by people can contribute to population recovery, it is important to make all

possible efforts not to let any threatened pup die, thereby increasing the species's chances of survival.

- An action protocol on handling threatened pups shall be agreed by consensus and drawn up. This protocol will set out the criteria for the rescue and the rehabilitation and reintroduction methodology within the framework of an expert workshop. The rescue protocol will evaluate each pup's chances of survival.
- At least in the *Cabo Blanco* colony, each pup born will be subject to monitoring and surveillance, as will environmental factors in order to detect and evaluate situations that threaten its survival.
- Seals that go astray outside the caves will be returned to their cave of origin as long as such action is feasible (state of the sea) and there are sufficient guarantees of success. When that is not possible, they will be rehabilitated in accordance with current protocols and information. They will then be monitored continuously and kept under surveillance until the situation returns to normal and there is no longer any risk.
- Sick or wounded pups or those deprived of maternal care will be transported to a rehabilitation centre set up for that purpose, and will be rehabilitated with assistance and technical support from specialised teams of veterinarians.

In this context we also recommend :

- Clarifying the reasons why the survival rate of pups is so low (research on environmental conditions, behaviour, physiological and genetic conditions, infectious diseases, etc.) ;
- Establishing an action protocol for the rescue, rehabilitation and liberation (or reintroduction) of animals at sea, with the support of all the available know-how and experiments already carried out in this field;
- Incorporating the information from the seminar "*Rehabilitation in theory and practice: protocols, techniques, cases*" that took place in Liège (Belgium), in 2002
- Improving the rehabilitation centre for seals that already exists and planning more (cf. Action 12).

Action 9. Promote occupation of beaches as breeding and resting habitat

Sightings of young females breeding and resting outside the caves in *Desertas* in 1997 and 1999, and open beaches being used by some seals at *Cabo Blanco*, point to a real possibility of seals returning to coastal habitats outside the caves, i.e open beaches and places sheltered from waves and land predators, which are better for pup survival. The actions outlined below will be initiated with the above idea in mind.

- Ensure that beaches in current and potential areas and breeding and resting areas are protected and quiet. To achieve this, access by people should be controlled and a surveillance unit set up to prevent activities that may cause disturbance to seals. As a general rule, access to resting and breeding caves will be forbidden.

Emergencies and natural catastrophes (epidemics, “red slicks” cave collapse, etc.) will be exempted from this rule.

- Study the availability of potential habitats that possess the right characteristics for seal recolonization, and promote their occupation. Foster viability studies for the improvement of coastal habitat in potentially recolonizable areas.

In this context we also recommend:

- Promoting the use of beaches as breeding ground (eliminate nuisance, exclude predators and identify the best locations) ;
- Investigating why certain caves are occupied and others are not;
- Improving the environmental conditions in caves that are not occupied, if research results indicate that it could have a positive effect.

D. Actions for habitat protection

Action 10. Legal protection of habitat and support for its implementation

With the aim of ensuring international protection for the species given its cross-border nature, a network of protected areas or *Special Areas of Conservation for Monk Seal (SACMS)* will be set up in the area (see Figure 18). The previously identified *Habitats of Interest for the Monk Seal* (Action 5.1.3.) will form part of the network once they have been provided with legal protection mechanisms and resources.

A preliminary list of areas drawn up according to the data currently available is given below.

1. North coast of Madeira (Portugal)
 - *Rocha do Navio* Nature Reserve
 - *Ponta de San Lourenço* Nature Reserve
2. *Desertas* Islands (Portugal)
 - *Desertas* Islands Special Protection Area
3. *Selvagem* Islands (Portugal)
 - *Selvagem* Islands Nature Reserve
4. North and West Coast of Lanzarote (Spain)
 - Nature Park and Marine Reserve of the Islets of Northern *Lanzarote*
 - *Timanfaya* National Park
5. North and West Coast of Fuerteventura (Spain)
 - *Lobos* Island Natural Park
 - *Betancuria* Natural Park
 - *Cueva de Lobos* Site of Community Interest
 - *Jandía* Natural Park

6. Dakhla-Cabo Barbas-Cabo Blanco :
 - *Dakhla Bay Marine Reserve (Morocco)*
 - Fisheries protected area of *Vialobos- Guerguerat (Morocco)*
 - *Cabo Blanco Peninsula Marine Reserve (Morocco)*
 - *Cabo Blanco Satellite Reserve (Mauritania)*

7. Banc d'Arguin (Mauritania)
 - *The Levrier Bay*
 - *Banc d'Arguin National Park*

The SACMS will be designated by the member states via any of the existing procedures. Management plans will be drafted, and the conservation measures needed to maintain SACMS aims would be drawn up.

Morocco shall reinforce the establishment of a maritime zone around *Cabo Blanco Peninsula* for the implementation of protection measures for the adjacent maritime-terrestrial zone.

It will thereby boost implementation of the surveillance and control measures in the existing protected marine zones.

As a complementary measure to the above, each state should make efforts to maintain and improve the level of protection in the protected areas containing monk seals that have already been declared (the *Desertas Islands* and *Cabo Blanco Peninsula*) by improving their installations and maintenance, above all, at national level.

In this context we also recommend

- Speeding up the establishment of a National Park between *Cap Barbas* and *Cabo Blanco*; by carrying out a feasibility study based on the existing Zoning Plan with reference to socioeconomic aspects, and including the fisheries sector and local communities to favour the establishment of the park;
- Identifying the habitats used by the species now and in the past;
- Reviewing the literature for specific references on the presence or abundance of the monk seal in the Atlantic, its biological characteristics or hunting methods used;
- Establishing a protocol to identify the remaining habitats that are favourable for the monk seal, identify the surviving populations, prepare an inventory of all the anthropomorphic or natural nuisances that are present throughout the geographic range in the plan action. Write a report that summarises all these points.
- Creating a work group to identify and define, in terms of habitat, the essential needs and natural expansion of the monk seal in the Eastern Atlantic.

E. Information, awareness-raising and social support actions

Action 11. Information, awareness-raising and social support

Specific information and awareness-raising campaigns and social support projects will be developed to foster a change in attitudes and facilitate the social support and participation needed to achieve the Plan's aims. Any action along these lines shall take into account each country's particular socio-economic and cultural features.

Efforts will be directed at:

- drafting strategic educational plans
- making people aware and involving them in conservation efforts
- drawing up compensation systems for affected local communities in the target zones: the inshore fishing sectors. To implement this action, funds for development co-operation and other similar funds available in this context will be employed.

The main social sectors targeted by the information campaigns are outlined below.

- Schools within the ambit of the Plan.
- Activity sectors related with the species, mainly fishing, with the aim of fostering acceptance of the Plan and avoiding their coming into conflict with seals. The information gathered via surveys among fishermen and onboard surveys (Action 4.3.) will make it possible to devise specific information and awareness-raising campaigns targeting fishing-related groups involved in negative interactions. A campaign of this kind must fit the characteristics of the target population, so the specific methodology to be used in each case will vary according to those characteristics.
- Groups taking part in the various tasks involved in implementing this Plan, in particular managers, technical personnel and surveillance staff.

The flow of information to Society on the Plan's aim and contents and on the most socially relevant conservation and management actions should be promoted. Actions that involve benefits for local people and for activity sectors related with monk seals will be fostered.

In this context we also recommend:

1. Communication strategies.

- Inform professionals from the fishing sector about the importance of monk seal preservation and establishing protected areas for the fishing resources ;
- Inform and meet with official authorities that are in charge of surveillance ;
- Inform the local population and official organisms;
- Set up training programs in educational centres directed towards teachers from high schools and elementary schools. Provide educational material.
- Inform other groups of the population in question (equally important): part time angler, collectors of coastal resources (glasswort, shells, etc.). These sectors of the population are often marginalised (social aspect) and require support;

- Inform the international community about the need for financial support to carry out this plan.

2. Strategies for social aid directed towards artisan fishermen and the general population.

- Promote cooperation regarding sustainable development of the local community. Establish cooperation projects in different areas (health, environment, education, promotion of economic fabric, etc.) ;
- Establish contacts among the local institutions and organisms and institutes involved with environmental technologies to favour collaboration with infrastructures and cooperative developmental projects ;
- Consider that material support leads to positive results and facilitates sensitization and awareness (for example, replacing harmful fishing nets).
- Support local authorities in establishing social support actions to fishermen and affected populations.

Priority recommendations:

- The campaigns to promote sensitization, information and social aid should achieve the associate the local population and allow them to participate and contribute to the work and conservation actions for the monk seal.

In the case of Madeira, the campaign carried out by the Natural Park is encouraging:

- Education in schools, temporary expositions, conferences, visits to desert islands, contact with the media.
- Preparation of a campaign for data collection in ports and the strategic locations where fishermen and sailors are located.

F. Drafting a co-ordinated Action Protocol for emergencies

Action 12. Establishing common bases for the drafting of specific emergency measures for the Cabo Blanco area and the Madeira archipelago.

Taking past experience into account, a series of needs or particular actions have been identified to draw up an emergency plan for new catastrophes such as epidemics, red tides, oil slicks, cave collapse, etc.

In this regard, a common Action Protocol that takes into account that the information and material means are dispersed over various localities around the world should be drafted. To this end, an alert network should be set up comprising experts from different institutions so they can bring their knowledge to bear or tackle a crisis. They should be invited to take part or be available for this alert network and their knowledge and resources should be subject to the emergency plan unit.

There will be a co-ordinator or body to co-ordinate this alert network and to update the experts' databank. The network's co-ordination office will inform the

Working and Co-ordination Group of changes, and in the event of an alert, the office shall be responsible for raising funds, sounding the alarm and co-ordinating actions. The office should make sure the preliminary work is carried out beforehand.

Furthermore, the countries involved should ensure the funds; staff and infrastructures needed to implement the plan are made ready.

The plan will be equipped with human, material and financial resources, which should be made available as soon as possible.

In this context we also recommend:

- Informing the countries involved in the Plan and suggesting to begin the process of classifying the marine areas between *Cap Barbas* and *Cabo Timiris* in terms of PSSA (Zone Marine Particulièrement Sensible, *Particularly sensitive sea area*) in the framework of protocols and clauses of the International Maritime Organisation;
- Asking participating countries to prohibit the passage of single hull oil tankers through their territorial waters in accordance with current international legislation;
- Informing about the urgent need for an Emergency Plan to be deal with catastrophes that have an affect on the species (especially pollution from hydrocarbons), and, in this regard, take the following actions :
- Create a team for preliminary intervention and another intervention team for emergencies.

Team for first intervention:

- Made up of representatives from different ministries, as well as teams in charge of the follow up and surveillance of populations (p.44 Final report PHVA).
- Emergency intervention team: one representative from different areas (biology, medicine, environmental monitoring, logistical support) proposal for internal organisation of the team and roles (PHVA 2001).

The identified risks involve infectious diseases, spills of pollutants, toxic algae, collapse of caves, nuisances in the habitat, interaction with fisheries, unknown causes. For each of these threats, we define the effects on the population, the expected frequency of the emergency situation, the methodology required to identify the emergency, the appropriate response and applicable preventive measures (1 PHVA 2001).

Risk Assessment and Population Modeling

Jaume Forcada, National Marine Fisheries Service / NOAA, United States

Ingrid Mozetich, Fundación CBD – Habitat, Spain

Phil Miller, Conservation Breeding Specialist Group, USA

Introduction

Two Mediterranean monk seal populations currently exist in the eastern Atlantic, one in the Desertas Islands (Madeira), and the other on the Cap Blanc peninsula. The colony at Cap Blanc, with an estimated average population of 317 seals in the mid 1990s, was affected by a severe mass mortality event in 1997, which reduced its numbers to 103 individuals (as estimated in 1998, Forcada *et al.* 1999). The age composition was also changed as a result of the mass mortality, significantly increasing the proportion of young seals. The sub-population in Madeira was composed of about 50 animals in the late 70s and severely reduced in size over the next two decades. The population size is currently estimated to be around 24 seals (Costa-Neves, personal communication). Both populations are presently exposed to a number of potential threats that could compromise their persistence in the Atlantic.

The population modeling group assembled baseline demographic and population data to build risk assessment models and assess the viability of these two populations. The data were used to construct population models and assess current population trends. Sensitivity analysis was employed to assess the impact of measurement uncertainty in demographic rate estimation on population performance. Finally, the group developed a procedure to identify and quantify current threats to populations and habitats, and a survey on potential threats was conducted among the different working groups (see form at the end of this document).

Population Viability Analysis of the Mediterranean Monk Seal of the Eastern Atlantic

Population viability analysis (PVA) can be an extremely useful tool for assessing current and future risk of wildlife population decline and extinction. In addition, the need for and consequences of alternative management strategies can be modeled to suggest which practices may be the most effective in conserving the Mediterranean monk seal in its wild habitat in the eastern Atlantic. *VORTEX*, a simulation software package written for population viability analysis (see final pages of this report), was used here as a mechanism to study the interaction of a number of Mediterranean monk seal life history and population parameters treated stochastically, to explore which

demographic parameters may be the most sensitive to alternative management practices, and to test the effects of selected island-specific management scenarios.

The *VORTEX* package is a Monte Carlo simulation of the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on wild populations. *VORTEX* models population dynamics as discrete sequential events (e.g., births, deaths, sex ratios among offspring, catastrophes, etc.) that occur according to defined probabilities. The probabilities of events are modeled as constants or random variables that follow specified distributions. The package simulates a population by stepping through the series of events that describe the typical life cycles of sexually reproducing, diploid organisms.

VORTEX is not intended to give absolute answers, since it is projecting stochastically the interactions of the many parameters used as input to the model and because of the random processes involved in nature. Interpretation of the output depends upon our knowledge of the biology of the Mediterranean monk seal, the environmental conditions affecting the species, and possible future changes in these conditions. For a more detailed explanation of *VORTEX* and its use in population viability analysis, refer to Miller and Lacy (1999) and Lacy (2000).

Input Parameters for Stochastic Population Viability Models

Species: *Monachus monachus*

Species distribution in the eastern Atlantic: Currently, there are only two known breeding subpopulations in the Atlantic: A colony at Cap Blanc, western Africa, and a colony in the Desertas Islands, Madeira, Portugal.

Breeding System: Polygynous. The degree of polygyny is likely to be very low at Cap Blanc, if it really exists. For the purpose of the simulation exercise we assume that it is polygynous.

Age of First Reproduction: *VORTEX* precisely defines reproduction as the time at which offspring are born, not simply the age of sexual maturity. In addition, the program uses the mean age rather than the earliest recorded age of offspring production. At Cap Blanc, the age of first reproduction (only known for a limited number of animals, Gazo *et al.* 2000) is assumed to be 4 years on average. The same age is applied for Madeira.

Age of Reproductive Senescence: *VORTEX* generally assumes that animals can reproduce (at the normal rate) throughout their adult life. We assume that monk seals do not experience reproductive senescence; consequently, we assume that individuals reproduce until they die. Field observations suggest that monk seals may live to be 40 years of age.

Offspring Production: Available information on natality rates of the Mediterranean monk seal at Cap Blanc (Gazo *et al.* 1999, González *et al.* 2002) are found to be biased by the population modeling working group. Published estimates are expressed as the ratio of observed number of pups to total number of reproductive females in the population. The observed number of pups used is biased because it does not account for those unobserved. The corrected number of reproductive females in Gonzalez *et al.* is biased because it is produced with a derived estimate of adults in the population

from Forcada *et al.* 1999, subsequently corrected with a biased estimate of sex-ratio which does not account for unobserved individuals. We use a better estimate based on multi-stage capture-recapture modeling of photo-identification data derived by modeling breeding propensity, and observed numbers of breeding and non-breeding females in the colony during the period 1993-1998 and their corresponding recapture probabilities (Forcada *et al.*, unpublished data). The modeling indicates that 51.9% (SD = 12.4%) on average reproduce each year (University of Barcelona, unpublished data). This reproductive rate is largely influenced by the breeding energetics of adult females. In other words, the percentage of adult females that successfully reproduce from year to year will range from about 30% to 70%.

Natality rates for the Mediterranean monk seal in Madeira are not currently available. The working group produced an estimate from available information provided by researchers currently working in the area. The estimate is the ratio of the observed average number of pups born in each year (3) to the estimated number of reproductive females in the population. This number is obtained from the observed number of adults corrected by an assumed sex-ratio of 1:1. This gives an estimated number of 0.43. Because of the limited information available, the group could not produce an estimate of standard error, but assumed a variation between 20 and 60%.

Mediterranean monk seal females produce only 1 pup per litter, and the sex ratio of males and females is assumed 1:1, since the estimated value is not significantly different of this ratio. The same values are assumed for the population in Madeira.

Male Breeding Pool: In many species, some adult males may be socially restricted from breeding despite being physiologically capable. This can be modeled in *VORTEX* by specifying a portion of the total pool of adult males that may be considered “available” for breeding each year. The working group assumed that 50% of the males were involved in the reproduction, allowing for a variation between 25 and 75% for the sensitivity analysis.

Age-Specific Mortality: Age specific mortality was obtained from unpublished survival estimates (Forcada *et al.*) and by modeling the recapture histories of seals from the period 1993-1998. Modeling of several effects, including age, 1997 mass mortality, sampling effort, year and additional covariates allowed for estimates of age specific survival rates. The sampling scheme and subsequent modeling, based on Pollock’s robust design, was also used to test for immigration, emigration and presence of transients in the population. The lack of migratory movements was shown by the best modeling options. Since emigration was insignificant, estimated survival rates were the complement of mortality rates. It also indicated independence between the population of Cap Blanc and Madeira. An analysis of variance components using random effects models was used to separate sampling error from process variation, and process variation was used to derive standard errors (Table below).

Mortality, % (SD)

<i>Age Class</i>	Females	Males
0 – 1	59.0 (10.5)	59.0 (10.5)
1 – 2	20.8 (5.7)	20.8 (5.7)
2 – 3	10.0 (0.9)	10.0 (0.9)
3 – 4	10.0 (6.1)	3.4 (0.34)
Adult (4+)	10.0 (6.1)	3.4 (0.34)

Mortality rates for pups and juveniles at Madeira were inferred from the observed number of dead animals. Juvenile and adult mortality rates were assumed to be the same as in Cap Blanc.

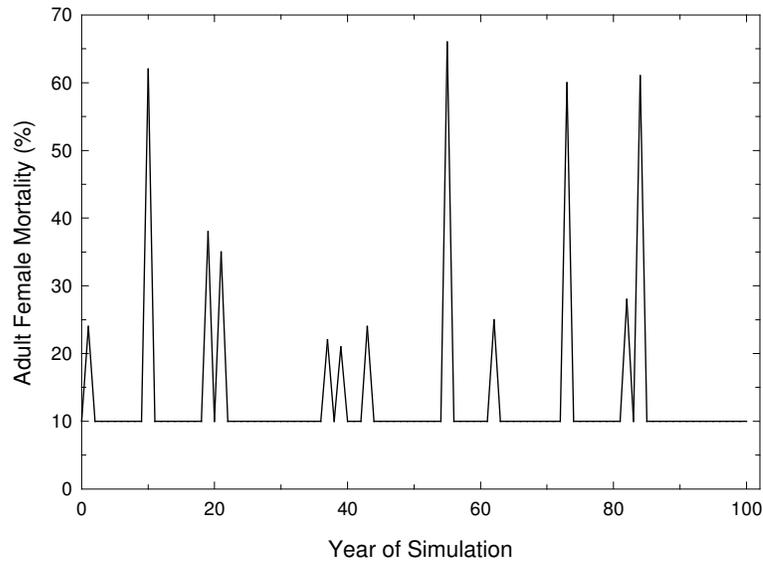
Inbreeding Depression: *VORTEX* includes the ability to model the detrimental effects of inbreeding through reduced survival of pups through their first year. The severity of inbreeding depression is expressed as the number of lethal equivalents per diploid genome in a given population. In the absence of specific data on the impacts of inbreeding on juvenile survival in Mediterranean monk seals, we used the median value of 3.14 lethal equivalents derived from analysis of 45 captive mammal populations in North America by Ralls *et al.* 1988. In addition, we assume that about 50% of the genes responsible for inbreeding depression are lethal and can be eliminated from the population over time through exposure and selection in homozygotes produced through inbreeding.

Catastrophes: Catastrophes are singular environmental events that are outside the bounds of normal environmental variation affecting reproduction and/or survival. Natural catastrophes can be tornadoes, floods, droughts, disease, or similar events. These events are modeled in *VORTEX* by assigning an annual probability of occurrence and a pair of severity factors describing their impact on mortality (across all age-sex classes) and the proportion of females successfully breeding in a given year. These factors range from 0.0 (maximum or absolute effect) to 1.0 (no effect), and are imposed during the single year of the catastrophe, after which time the demographic rates rebound to their baseline values.

We focused on developing a catastrophe scenario based on the recent mass mortality event that reduced the size of the Cap Blanc population by nearly 70%. Continued analysis of this event leads most researchers to conclude that a severe toxic algal bloom triggered the seal mortality event. These events are beginning to occur across a wider geographic area, and with greater frequency (Joe Geraci, personal communication). For our Mediterranean monk seal analysis we assumed that this type of toxic bloom occurs about every 10 years. In addition, we assumed that the severity of a bloom could be highly variable as it is a function of prevailing environmental conditions and geographic proximity to the affected seal population. Finally, we assumed that the impact of this event is restricted to the adult age class, as adults tend to feed on the affected fish with greater frequency. We assumed that catastrophe mortality could be as high as 70% in adults, with the actual severity drawn from a uniform distribution according to the following *Vortex* functional form (see Miller and Lacy (1999) for details on the syntax):

$$\text{Mortality} = 10 + [(60 * \text{SRAND}(Y + (R * 100))) * (\text{SRAND}(Y + (R * 200)) < 0.1)]$$

This function generates the following graph of adult female mortality over time:



Note that, in the plot above, both the timing and severity of the event is random. The precise timing and severity of the catastrophe will be different for each scenario that is modeled.

Initial Population Size: Initial population size by age group was obtained from capture-recapture estimates of abundance using photo-identification data for the colony at Cap Blanc in 1996 (Forcada *et al* 1999). Estimates were rescaled by the proportion of individuals in each age group, and estimated proportions were corrected by unobserved animals using recapture rates estimated by photo-identification and other marking methods (Jaume Forcada, unpublished data).

Photo-identification and count data from Madeira was used to estimate the initial population size by age groups.

Carrying Capacity: The carrying capacity, K , for a given habitat patch defines an upper limit for the population size, above which additional mortality is imposed randomly across deaths of individuals and total population numbers all age classes in order to return the population to the value set for K . Given the low numbers of Mediterranean monk seals in Cap Blanc and Madeira, K was simulated as a population ceiling, of 600 and 75 individuals respectively

Iterations and Years of Projection: All scenarios were simulated 250 times, with population projections extending to 50 years. This time period corresponds to approximately 6 monk seal generations. All simulations were conducted using *VORTEX* version 8.41 (June 2000).

Results of Simulation Modeling

1. Baseline Cap Blanc Population Analysis: Inbreeding and Algal Toxin Catastrophe

Figure 1 shows the 50-year projection of our simulated Cap Blanc population with our best estimates of population variables. In the absence of the catastrophic mortality event and inbreeding effects (the solid line), our baseline model results in a rate of population growth (r) of -0.034. In other words, the simulated population is expected to decline in size at a rate of about 3.5% per year. Recent population trend analysis (Forcada *et al.* 1999) suggests that the Cap Blanc population was neither increasing nor decreasing in size before the 1997 mortality event; however, the short time period of observation on a small population makes the detection of a significant change in population size difficult at best. Moreover, high variability surrounding population size estimates – as was the case for the 1993 population estimate – further reduces the power to detect a decline. With this in mind, we conclude that the rate of decline observed in our model is within reason for the Cap Blanc population. Even without considering the devastating impacts of a mass mortality event, this population may be impacted by a variety of negative factors – reduced pup survival through cave wash-outs, interactions with local fisheries, reduced availability of suitable breeding sites, etc. – that can collectively act to drive the population into decline.

Additional inspection of Figure 1 and Table 1 indicates that the effects of inbreeding appear to be quite low; moreover, if any effects are seen they are expected to show up only in the long term. Detailed analysis of the model results reveals that the mean level of inbreeding in this population is only 0.007 after 100 years. Such a low degree of inbreeding will not typically generate levels of homozygosity that are necessary to display inbreeding depression (unless the severity of inbreeding depression is extremely high). Workshop participants expressed some concern that this was not realistic, since it is likely that the Cap Blanc population has experienced one or more major contractions in size (also known as “population bottlenecks”) during the past decades and would therefore be expected to show low levels of genetic variation and some inbreeding depression. This population does in fact show a low observed natality rate, and the level of genetic variability is amongst the lowest observed in pinnipeds (Pastor *et al.* 1999). Participants also noted that the apparent lack of proper maternal care and associated low pup viability in some animals at Cap Blanc could result from inbreeding depression.

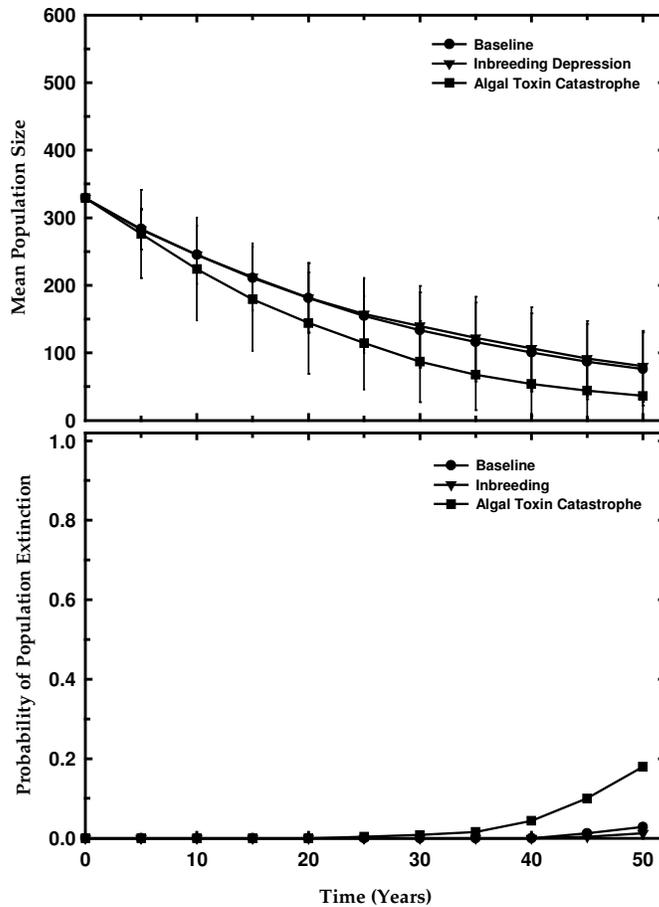


Figure 1. Fifty-year projections of mean population size (\pm SD) (top panel) and risk of population extinction (bottom panel) for a simulated Cap Blanc population of Mediterranean monk seals with best estimates of demographic parameters based on field data from 1993 – 1997. Inbreeding depression (defined here as an increase in pup mortality) severity is considered to be “typical” for a mammal (Ralls *et al.* 1988). Catastrophe (annual frequency of occurrence of 10%) results from large bloom of toxic algae that reach adult seals through the food chain. See accompanying text for additional details.

On the other hand, it is also possible that population bottlenecks and the resulting higher levels of inbreeding would purge lethal genes through a combined process of forced inbreeding and strong selection. As a result, inbreeding depression would be expected to decrease over time as these genes are gradually removed from the population. Unfortunately, virtually nothing is known about the extent of inbreeding in Mediterranean monk seals and the severity of its consequences. While difficult to conduct in the field, additional research on inbreeding in monk seal colonies of the eastern Atlantic would be a valuable tool to assist both population research and conservation.

Finally, we wanted to investigate the impact of a catastrophe similar to the 1997 mass mortality event, likely derived from a toxic algal bloom near the Cap Blanc breeding colony. As seen in Figure 1 and Table 1, the population growth rate is reduced further from a baseline value of -0.034 to -0.056 , and the risk of population extinction increases from 1-2% to nearly 20% over the simulation timeframe of 50 years. A catastrophic event like this one can clearly have a major impact on monk seal population dynamics and persistence. It is interesting to note that, despite the significant rate of mean population decline, individual simulations may show periods of stable population numbers and perhaps even marked population growth (see Figure 2). This result lends further support to the notion that, even if the long-term population growth rate is

expected to be negative, field researchers may observe shorter periods of population growth that do not necessarily reflect long-term trends.

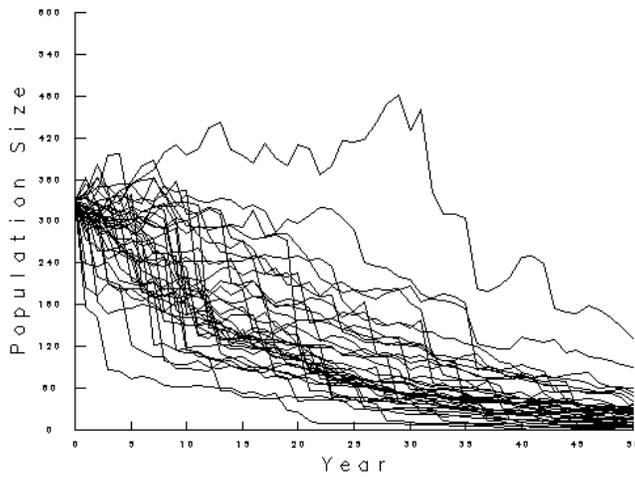


Figure 2. Selected set of the 250 iterations comprising the baseline Cap Blanc monk seal population model, with the addition of a toxic algal bloom catastrophe. Note the infrequent periods of population stability of even growth in the time intervals between catastrophic events despite a long-term average population decline.

Table 1. Stochastic growth rate, probability of extinction, mean size at 50 years for those populations remaining extant at the end of the simulation, mean time to extinction, and final population heterozygosity for the base Cap Blanc population simulations discussed in this section.

Model conditions	r_s (SD)	P(E)	N_{50} (SD)	Mean T(E)	H_{50}
Baseline	-0.034 (0.055)	0.028	76 (54)	45.6	0.972
Baseline / Inbreeding depression	-0.032 (0.055)	0.012	80 (52)	47.3	0.958
Baseline / Catastrophe	-0.056 (0.114)	0.180	36 (36)	43.3	0.938

The carrying capacity used to model population trajectories was assumed to be a population ceiling, similar in value to the upper 95% confidence limit of the highest abundance estimate during the period 1993-1996. There is no available information on the natural carrying capacity of the different Atlantic populations, and for the purpose of simulation, and given the low densities of animals throughout its range, population ceilings are likely to accurately represent recent population growth upper limits. Further investigation would be adequate in a comprehensive PVA analysis.

2. Demographic Sensitivity Analysis

During the development of the baseline input dataset presented above, it quickly became apparent that a number of estimates of Mediterranean monk seal population demographics are estimated with varying levels of uncertainty. This type of measurement uncertainty, which is distinctly different from the annual variability in

demographic rates due to extrinsic environmental stochasticity and other factors, impairs our ability to generate precise predictions of population dynamics with any degree of confidence. Nevertheless, an analysis of the sensitivity of our models to this measurement uncertainty can be a valuable aid in identifying priorities for detailed research and/or management projects targeting specific elements of the species' population biology and ecology.

To conduct this demographic sensitivity analysis, we identify a selected set of parameters from the baseline model whose estimate we see as considerably uncertain. We then develop biologically plausible minimum and maximum values for these parameters (see Table below).

Estimate

Parameter	Minimum	Baseline	Maximum
Longevity	30	40	50
% Females breeding	30	50	70
% Males breeding	25	50	75
Pup Mortality (%)	50	59	70
Adult Female Mortality (%)	5	10	15
Adult Male Mortality (%)	2	3.4	10

For each of these parameters we construct two simulations, with a given parameter set at its prescribed minimum or maximum value, with all other parameters remaining at their baseline value. With the seven parameters identified above, and recognizing that the aggregate set of baseline values constitute our single baseline model, the table above allows us to construct a total of 12 alternative models whose performance (defined, for example, in terms of average population growth rate) can be compared to that of our starting baseline model.

For all models comprising this analysis, we used an initial population size of 329 individuals, and a carrying capacity of 600.

The result of our sensitivity analysis, expressed as the mean stochastic population growth rate for each of the 13 sensitivity models, is shown graphically in Figure 3 and numerically in Table 2. It is clear from the figure that overall female breeding characteristics are a more important determinant of population dynamics than those corresponding parameters for males. In addition, while not as significantly different, our models show slightly greater sensitivity to uncertainty in juvenile mortality when compared to a similar level of uncertainty in adult mortality. Despite this small difference, it is clear that accurate and realistic models of Mediterranean monk seal population demography will depend upon accurate estimates of female breeding and survival schedules.

Figure 3. Demographic sensitivity analysis of a simulated Mediterranean monk seal population on the Cap Blanc peninsula. Stochastic population growth rate for a set of models in which the specified parameter is varied across a range of biologically plausible values. The baseline model growth rate of -0.034 is given by the central data point for each parameter. The general model of monk seal population dynamics is most sensitive to uncertainty in those parameters giving the widest range in simulated population growth rate. See accompanying text for additional details.

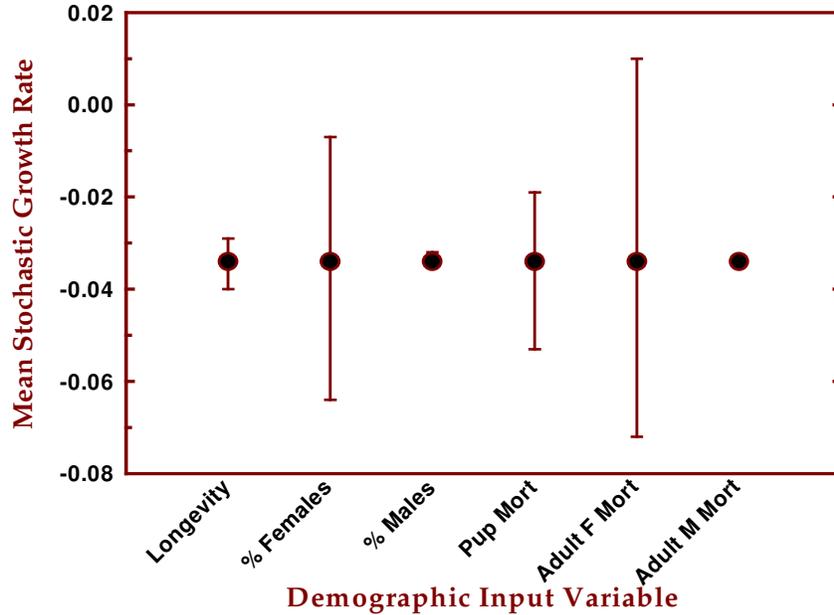
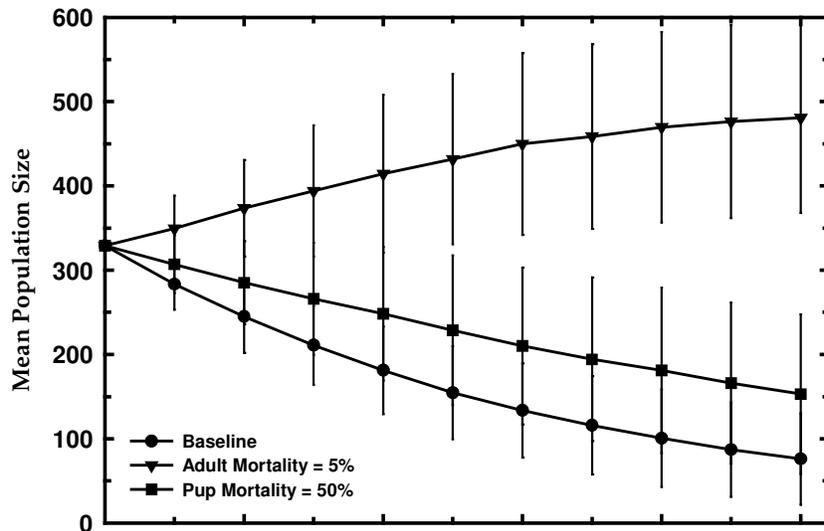


Table 2. Stochastic growth rate, probability of extinction, mean size at 50 years for those populations remaining extant at the end of the simulation, mean time to extinction, and final population heterozygosity for sensitivity analysis based on the Cap Blanc population model discussed in this section. Boxed data indicates those parameters to which our model is most sensitive, with the baseline model showing greatest sensitivity to uncertainty in adult female mortality.

Model conditions	r_s (SD)	P(E)	N_{50} (SD)	Mean T(E)	H_{50}
Baseline	-0.034 (0.055)	0.028	76 (54)	45.6	0.972
Longevity = 30 years	-0.040 (0.065)	0.044	60 (41)	45.8	0.959
Longevity = 50 years	-0.029 (0.049)	0.020	92 (57)	44.4	0.979
% Females Breeding = 30%	-0.064 (0.060)	0.228	18 (11)	43.8	0.930
% Females Breeding = 70%	-0.007 (0.061)	0.000	262 (140)		0.986
% Males Breeding = 25%	-0.032 (0.055)	0.016	82 (50)	47.8	0.973
% Males Breeding = 75%	-0.031 (0.054)	0.012	83 (49)	47.3	0.974
Pup Mortality = 50%	-0.019 (0.056)	0.000	153 (95)		0.982
Pup Mortality = 70%	-0.053 (0.058)	0.088	31 (19)	46.3	0.951
Adult Female Mortality = 5%	0.010 (0.056)	0.000	481 (113)		0.992
Adult Female Mortality = 15%	-0.072 (0.059)	0.576	14 (7)	38.5	0.908
Adult Male Mortality = 2%	-0.034 (0.047)	0.040	75 (46)	44.0	0.974
Adult Male Mortality = 10%	-0.033 (0.084)	0.008	80 (57)	45.5	0.963

Figure 4 shows the consequences of large sensitivity of the population growth rate to comparatively small changes in adult female mortality. Given the current set of parameters used in the simulations, which represent the projected population trends from Cap Blanc before the 1997 mass mortality, only minor increases in adult female mortality are required for a positive population growth. In contrast, a large decrease in pup mortality (30%) will not be sufficient for the long term persistence of the population. While much attention has been given recently to the impact of high mortality among pups at Cap Blanc on general population dynamics, this type of analysis also points out that adult mortality, especially among females, must be carefully evaluated for its effect on overall growth dynamics of the Cap Blanc and other monk seal breeding populations.

Figure 4. Fifty-year projections for a simulated Cap Blanc population of Mediterranean monk seals. Plots show the projection (\pm SD) using the best estimates of demographic parameters based on field data from 1993 – 1997, as well as other lines in which the pup or adult female mortality are changed from their baseline values to the indicated values. The comparative sensitivity of our baseline model to changes in adult female mortality is evident in this comparison. See text for additional details.



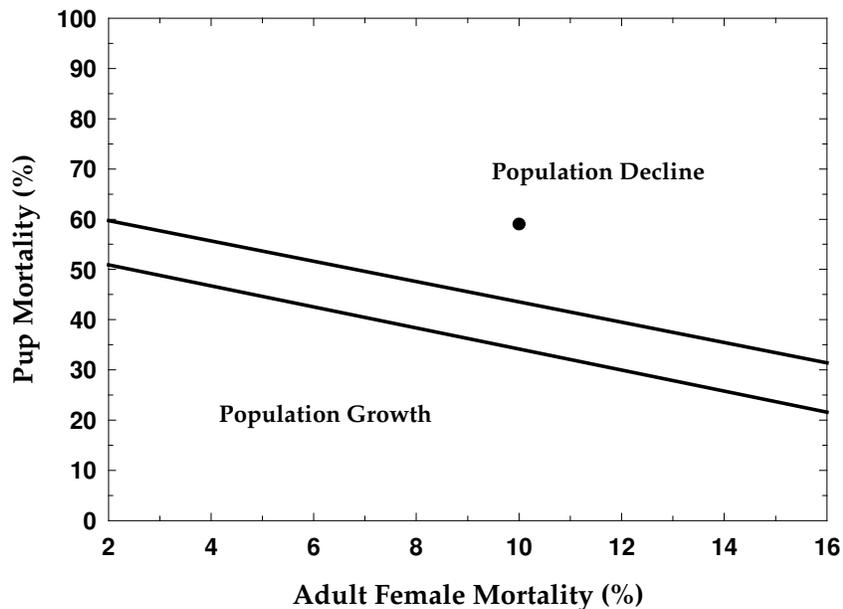
4. Cap Blanc Mortality Analysis

With the results of the sensitivity analysis in hand, our group decided to conduct a more thorough investigation of the relationship between juvenile (pup) mortality, adult mortality, and general population growth dynamics. Specifically, we wanted to identify those combinations of mortality values that would result in positive population growth ($r_s > 0.0$).

To do this, we developed a series of 25 models that spanned the plausible ranges of values for female pup and adult mortality, with the remaining values maintained at their

baseline values. The results were then analyzed using regression analysis to determine the precise combinations of mortality that would yield $r_s = 0.0$. The process was repeated with the inclusion of the toxic algal bloom catastrophe so that we could examine its effect on the identification of the critical mortality values.

Figure 5. Mortality analysis for a simulated Cap Blanc population of Mediterranean monk seals. The lines indicate values of adult female and pup mortality that, in combination and together with the other baseline parameters discussed in the text, give a stochastic population growth rate of 0.0. The lower line separating regions of population growth from decline includes an algal toxin bloom catastrophe, while the upper line does not. The region between the lines indicates the minimum decrease in pup mortality required to allow population recovery between catastrophic events. The recent estimates of pup and adult female mortality in this population are indicated by the circle. See text for additional details.



The results of this analysis are shown in Figure 5. In agreement with the sensitivity analysis in Figure 3, a small increase in adult female mortality must be compensated by a relatively larger decrease in pup mortality in order to maintain a stationary population trajectory. As an example, an increase of just 1% in adult female mortality requires a 2.03% decrease in pup mortality in order to maintain a mean population growth rate of 0.0. Note that, with the inclusion of the algal bloom catastrophe, the $r = 0.0$ threshold line is depressed relative to the catastrophe-free line. We assumed that this bloom catastrophe affects adults preferentially, so the results of the catastrophe can be seen in the context of this mortality analysis as the minimum reduction in pup mortality required to maintain $r = 0.0$ in the presence of this catastrophe. To illustrate, if we assume a basic adult female mortality rate of 10.0%, the threshold pup mortality rate is 43.5% without the catastrophe but declines to 34.1% in the presence of the catastrophe. This particular simulation exercise is useful to reply to questions, similar to those asked by workshop participants, related to extent to which the survival of pups must be increased in order to compensate for recent population declines. It is also very useful to investigate these same questions in the context of adult female mortality. Further

simulations can consider other combinations of parameters, in agreement with the consequences of the different conservation actions proposed.

Recommended Actions

As an action step, the group recommends the meeting of a working group of specialists as a follow up of this workshop. The working group would further investigate the implications of various potential threats to the species in the Atlantic.

Particular tasks of this group include a more detailed sensitivity analysis of the threats identified during the workshop, and a population viability analysis. The PVA should take into account each of the proposed conservation actions included in the action plan, and a new set of fine tuned demographic and genetic parameters. Most of the required data is pending from analysis, or even in contained in unpublished manuscripts. These and further materials should taken into consideration in a further PVA exercise.

The working group should also have population assessment experts (population ecologists, statisticians) to design appropriate monitoring and sampling schemes to effectively evaluate in the near future the consequences of the implementation of conservation actions.

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