High Seas Enclaves of the Western and Central Pacific

A Greenpeace Briefing to the CBD, 29 September – 2 October 2009, Ottawa, Canada

Abstract

This Briefing is intended to inform delegates to the CBD Expert Workshop of 29 September – 2 October 2009 about four high seas enclaves in the Western and Central Pacific Region (WCPR). Available scientific information is summarised to demonstrate the ways in which the selected areas meet the CBD criteria for ecologically and biologically significant marine areas. This briefing will also discuss the challenges of applying the criteria to areas for which limited information is available.

This briefing summarises the findings of a technical report on proposed Marine Reserves in the WCPR that explores in greater detail the biological and ecological characteristics of these areas (available at: http://www.greenpeace.to/publications/Pacific-CBD-report-August-2009.pdf).

Introduction

The Western and Central Pacific Region (WCPR) contains the greatest diversity of marine species in the world[1] but remains one of the least studied parts of the globe. The region includes 32 nations and territories and numerous island chains[1] and is home to the most diverse tropical coral reef ecosystems in the world[2]. However, the majority of WCPR consists of open-ocean and deep-sea habitats. The enclaves discussed here fall within the Western Pacific Warm Pool (WARM) and South Pacific Sub-Tropical Gyre (SPSG) biogeographical provinces[3]. Depths range from over 7000m in the Mussau Trench to just 45m at Horizon Bank[4,5]. Seamounts occur in each of the enclaves, including those of the Mussau Ridge, where glass sponges have been retrieved from a depth of 1520 – 1780m[6] (see fig. 2 – Mussau Ridge Seamount 1). Hydrothermal vents are known to occur in the North Fiji Basin and could potentially occur within WPMR[7]. The enclaves are connected by the South Equatorial Current, which flows westwards between 5˚N and 20˚S. The dynamic area of high tuna abundance, created by the advection of forage species from the Eastern Warm Pool Convergence Zone[8], is replicated in WOMAR, where fishing effort is higher during La Niña and neutral phases of ENSO and GOMAR, where fishing effort is higher during El Niño events[9].

WCPR is the site of the world's largest tuna fishery, accounting for 55% of global landings in 2007[9]. Total landings have increased for the past six years and the 2007 catch was the largest on record, at 2,396,815mt[9]. However there are clear signs of overexploitation. Bigeye tuna *Thunnus obesus* are overfished and stock levels are estimated to be at just 20 – 26% of unexploited biomass[10]. Biomass of yellowfin tuna *Thunnus albacares* declined steadily throughout the 1990s and overfishing is occurring[11,12]. Skipjack tuna *Katsuwonus pelamis*, which accounted for 72% of the total catch in 2007[9], has until recently been considered to be in a healthy state[13]. However, it has recently been suggested that the spawning stock of skipjack in the Pacific may have declined drastically and overfishing may be occurring[14]. There is considerable uncertainty regarding the stock size and level of fishing effort on albacore tuna[15]. It has been estimated that approximately 10% of total tuna landings are taken from the high seas enclaves[16]. The level of IUU fishing in the region has been estimated at 21 – 46%, with illegal vessels using the enclaves to take refuge on the high seas[17] The Western and Central Pacific Fisheries Commission (WCPFC) has agreed to close two of the enclaves (WOMAR and GOMAR) to purse seine vessels from January 2010[18]. New licensing arrangements implemented by the Parties to the Nauru Agreement should largely prevent longline and other fishing activities in these enclaves[19]. There is considerable support amongst Pacific Island Nations for closure of the remaining two enclaves, which will be discussed at the 6th Regular Session of the WCPFC, to be held in Tahiti, December 2009[18,20].

The proposed marine reserves in the Pacific high seas enclaves are:

1. **West Oceania Marine Reserve (WOMAR):** located between the EEZs of Papua New Guinea, Indonesia, Palau and the Federated States of Micronesia.
2. **Greater Oceania Marine Reserve (GOMAR):** located between the EEZs of the Federated States of Micronesia, Marshall Islands, Nauru, Kiribati, Tuvalu, Fiji, the Solomon Islands and Papua New Guinea.
3. **Moana Marine Reserve (MOANA):** located between the EEZs of the Cook Islands, French Polynesia and Kiribati.
4. **Western Pacific Marine Reserve (WPMR):** Located between the EEZs of Fiji, Vanuatu and the Solomon Islands.

Data availability and interpretation of the criteria

Figure 1: Location of the Pacific high seas enclaves

Direct evidence for the ecological and biological characteristics of the high seas enclaves was limited. Scientific research intensity was low relative to other regions of the world's oceans and those studies that were conducted related largely to nation's EEZs. There has been very limited sampling of seamount communities in the high seas enclaves (three species collected from one seamount – see above[6]) and studies of hydrothermal activity in the North Fiji Basin were confined largely to the Fijian EEZ.

Data availability, and therefore our understanding of the enclaves' ecological and biological characteristics, was dependent on commercial and conservation interests. A large proportion of evidence was related to commercial fisheries, including catch data[9], observer reports[21,22,23], scientific research (eg. Lehodey et al, 1998[8]) and historical whaling logbook data[24]. This lead to a dearth of data relating to areas and species of limited interest to fisheries. For example, direct evidence for the presence of sea turtles and cetaceans in the enclaves was obtained from observer data, which was distributed unevenly across the region due to the uneven distribution of fishing effort and observer coverage[21,22]. Satellite tracking studies conducted by NOAA provided some understanding of the distribution of migrating leatherback turtles *Dermochelys coriacea* in the region, and demonstrated their presence in WOMAR and GOMAR[25]. By contrast, there was no research into the distribution of pelagic sharks. This could potentially lead to a failure to recognise areas that meet some of the criteria but do not contain large numbers of commercially important or iconic species. The reliance on fisheries-related data means that an area is unlikely to be designated as ecologically and biologically significant until exploitation has reached a certain level. This limits the applicability of the naturalness criteria on the high seas, where the conservation of natural ecosystems in marine reserves is not yet a possibility.

Due to the limited availability of direct evidence, analysis of the ecological and biological significance of the high seas enclaves was partially dependant on extrapolation from physical data, as well as biological data relating to the wider WCPR. For example, the presence of seamount species assemblages was inferred from the presence of seamounts. The process of extrapolation favoured the use of some criteria over others. For example, seamounts were deemed to indicate the presence of vulnerable, productive and diverse habitats. However, in the absence of direct evidence, this line of reasoning was not extended to argue for the presence of unique (endemic) species at these sites, as this would have required two levels of extrapolation.

Ecological and biological significance of the Pacific high seas enclaves

Criteria	WOMAR	GOMAR	WPMR	MOANA
Special importance for life history stages of species	Pre- and post-nesting migratory routes of leatherback turtles that nest at Papua Barat, Indonesia and the Solomon Islands[25]. Yellowfin tuna spawning activity, indicated by the high proportion of unassociated purse seine sets[9,26]. *Juvenile leatherback turtles. Potential presence is indicated by proximity to nesting beaches and a confirmed sighting from waters to the north of WOMAR*[27].	Pre- and post-nesting migratory routes of leatherback turtles that nest at Papua Barat, Indonesia and the Solomon Islands[25]. *Migratory routes of green turtles Chelonia mydas moving between Marshall Islands and Solomon Islands, Australia and PNG. Data obtained from a passive tag retrieval study. The shortest routes between sites would pass through GOMAR*[33,34].		*Potential presence of breeding minke whales Balaenoptera acutorostrata. An above average encounter rate was recorded for the area encompassing MOANA during the month of October, coinciding with the species' peak conception period*[40].
Importance for threatened, endangered or declining species and/or habitats	Pre- and post-nesting migratory routes of leatherback turtles (CR)[28] that nest at Papua Barat, Indonesia and the Solomon Islands[25]. Papua Barat is thought to be the site of the largest remaining nesting population in the Pacific Ocean[27]. The presence of hawksbill *Eretmochelys imbricata* (CR)[28], green (EN)[28] and olive ridley *Lepidochelys olivacea* (VU)[28] turtles, and bycatch mortality, has been recorded by fishery	Pre- and post-nesting migratory routes of leatherback turtles (CR)[28], that nest at Papua Barat, Indonesia and the Solomon Islands[25]. Papua Barat is thought to be the site of the largest remaining nesting population in the Pacific Ocean[29]. The presence of olive ridley (VU)[28] and unidentified sea turtle species, and bycatch mortality, has been recorded by fishery observers[21,22]. Green turtles (EN)[28] are the most commonly recorded sea-turtle bycatch species in tropical waters and their presence is likely[22].	*Threatened/endangered/declining pelagic predatory species potentially present at Horizon Bank include: leatherback (CR)[28], loggerhead Caretta caretta (EN)[28], hawksbill (CR)[28] and green (EN)[28] sea turtles[22]; pelagic sharks, including bigeye thresher Alopias superciliosus (VU)[35], oceanic whitetip Carcharinus longimanus (VU)[35] and shortfin mako Isurus oxyrinchus (VU)[35] (all recorded as bycatch in WCP-CA[23]); cetaceans, including sperm whales (VU)[28]; and bigeye (VU)[28] and yellowfin tuna*[36].	

Importance for threatened, endangered or declining species and/or habitats, cont.	observers[21,22]. Bigeye tuna (VU)[28] and yellowfin tuna are targeted by longline and purse seine fisheries[9]. Populations of both species are declining in the western and central Pacific[10,11].	Bigeye tuna (VU)[28] and yellowfin tuna are targeted by longline and purse seine fisheries[9]. Populations of both species are declining in the western and central Pacific[10,11]. *Historically high abundance of sperm whales Physeter macrocephalus (VU)[28] is demonstrated by whaling logbook records[24]. Corresponds to the western extreme of the 'On the Line' whaling ground.*		
Vulnerability, fragility, sensitivity or slow recovery	Leatherback, hawksbill, green and olive ridley sea turtles[21,22]. *Mussau Ridge could potentially include areas of fragile and sensitive deepwater benthic habitat[30].*	Leatherback, olive ridley and unidentified sea turtles (likely presence of green turtles)[21,22]. *Historically high abundance of sperm whales[24].*	*Horizon Bank could potentially include areas of fragile and sensitive tropical coral habitat[37].* *Horizon Bank and other seamounts could potentially include areas of fragile and sensitive deepwater benthic habitat[30].* *Vulnerable pelagic predatory species potentially present at Horizon Bank include pelagic sharks, cetaceans, sea turtles and seabirds[36].*	
Biological productivity	High abundance of tropical tuna, characteristic of the Western Warm Pool biogeographical province[3], is indicated by longline and purse seine fishing effort[9]. Productive foraging area for predatory species is created by the advection of low trophic level species from the Eastern Warm Pool Convergence Zone[8]. Phytoplankton blooms in the North Equatorial Counter-Current result from upwelling associated with current meandering[31,32]. *Mussau Ridge could potentially include areas of elevated secondary productivity, associated with deepwater seamount habitat[30].*	High abundance of tropical tuna, characteristic of the Western Warm Pool biogeographical province[3], is indicated by longline and purse seine fishing effort[9]. Productive foraging area for predatory species is created by the advection of low trophic level species from the Eastern Warm Pool Convergence Zone[8].	*Pelagic productivity is potentially elevated at Horizon Bank, due to enhanced primary production and/or increased forage availability[36].* *Horizon Bank could potentially include areas of productive tropical coral habitat[37].* *Horizon Bank and other seamounts could potentially include areas of elevated secondary productivity, associated with deepwater seamount habitat[30].* *Potential presence of hydrothermal vent communities on the central spreading axis of the North Fiji Basin and/or South Pandora/Rotuma Ridge[38,39].*	
Biological diversity	*Mussau Ridge could potentially include areas of elevated species diversity associated with deepwater seamount habitat[30].*		*Potential area of high diversity at Horizon Bank, due to the combined presence of pelagic and shallow- and deep-water benthic species[37].*	

Nb. *Italics* denotes characteristics that have been extrapolated from indirect data
VU = vulnerable; EN = endangered; CR = critically endangered.

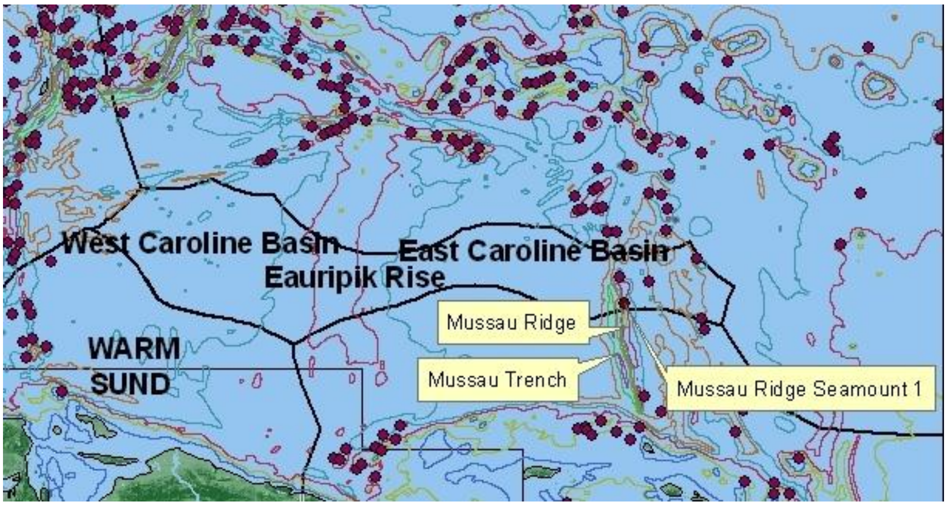


Figure 2: WOMAR

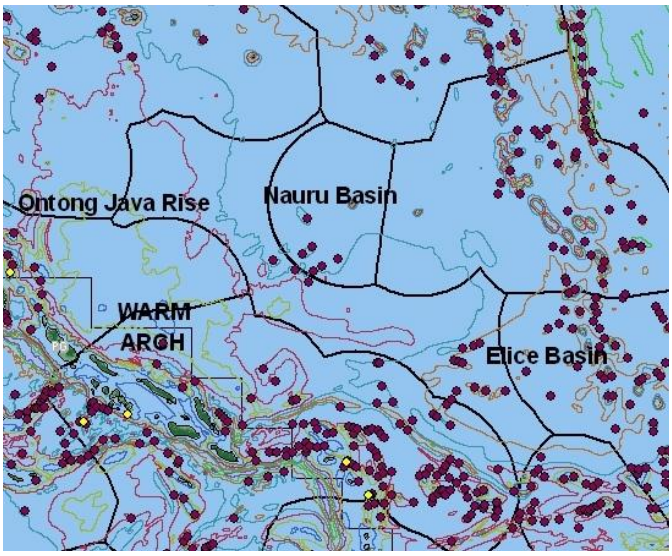


Figure 3: GOMAR

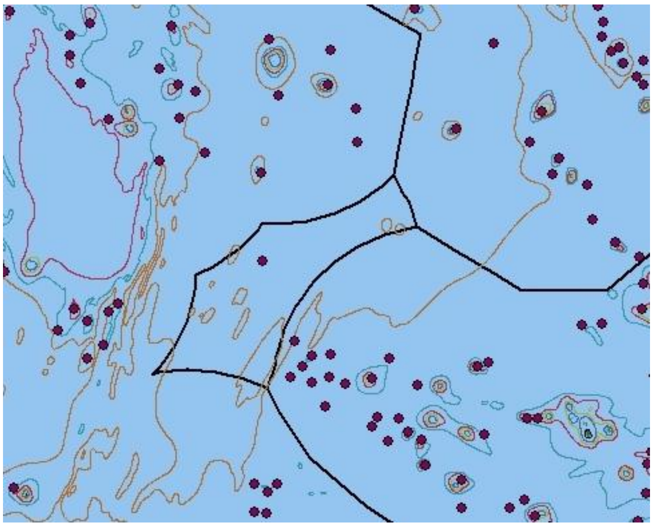


Figure 4: Moana

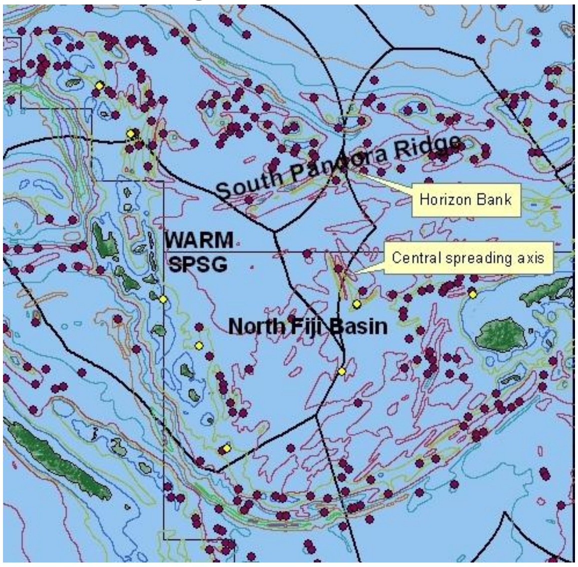
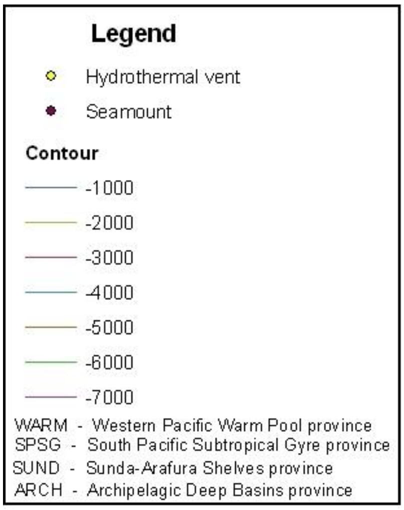


Figure 5: WPMR



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The Mediterranean Sea – Southern Balearics and the Sicilian Channel

A Greenpeace Briefing to the CBD, 29 September – 2 October 2009, Ottawa, Canada

Abstract

This Briefing is intended to inform delegates to the CBD Expert Workshop of 29 September – 2 October 2009 about two high seas areas in the Mediterranean Sea – the Southern Balearics and the Sicilian Channel. Available scientific information is summarised to demonstrate the ways in which these areas meet the CBD criteria for ecologically and biologically significant marine areas. This briefing will also discuss the issues that arise as a result of the unique circumstances of Mediterranean high seas areas.

This briefing summarises the findings of a technical report on proposed Marine Reserves in the Southern Balearics and Sicilian Channel that explores in greater detail the biological and ecological characteristics of these areas (available at: http://www.greenpeace.to/publications/Mediterranean-CBD-report-August-2009.pdf)

Introduction

The Southern Balearics and Sicilian Channel are productivity and biodiversity hotspots within the Mediterranean – a sea where temperate and subtropical influences combine to produce very high levels of biodiversity[1] in a region of intense and prolonged human activity, that is renowned as one of the birthplaces of civilisation. The Mediterranean represents only 0.7% of the area of the world's oceans, but contains 8 – 9% of known marine species – some 10,000 – 12,000 species have been recorded to date, of which 28% are endemics[1]. The unique geopolitical situation in the Mediterranean means that nations have not claimed 200nm EEZs and consequently, the high seas begin from as little as 12nm from the shoreline[2]. As a result, the Mediterranean contains some of the most complex and diverse high seas regions in the world. Proximity to the shoreline means that shallow-water species and habitats, that are absent from high seas areas elsewhere, are present in large numbers on the high seas of the Mediterranean. The topographic and bathymetric features of the coastal zone create complex oceanographic conditions that can lead to very high levels of productivity and diversity on the high seas.

The Balearic Islands is one of the most species rich marine regions in Europe, with habitats ranging from shallow-water maerl beds to abyssal plain at depths of 3000m. Complex oceanographic conditions, including fronts and eddies, result from the interaction of two water masses, with different physical characteristics, and complex topographic features[3], which include: the islands themselves; three seamounts (Emile Baudot - summit depth <100m, Monts del Oliva - summit depth ~300m and Mont Ausias Marc - summit depth ~125m[4]); a submarine volcanic field[5]; two canyon systems; and a submarine ridge[4]. The Sicilian Channel is an area of complex and high-energy oceanographic processes, where the western and eastern sub-basins of the Mediterranean meet[6]. The Channel consists of two sill systems separated by a deep basin and contains a number of canyons, trenches and seamounts[7]. Eruptions of the submarine volcano Empedocles caused the emergence of the ephemeral island of Ferdinandea during the nineteenth century – its summit is currently 6m below sea level[8]. The Southern Balearics and Sicilian Channel regions are subject to intense pressure as a result of human influence. Fishing activities include: longlining; purse-seine fishing for bluefin tuna[9]; shallow- and deep-water demersal trawling[10]; artisanal gillnetting; and recreational fisheries[11]. Other human impacts result from coastal development; noise, chemical and plastic pollution; shipping; climate change; invasive species[12]; and tourism.

The Southern Balearics and Sicilian Channel are included within a proposed network of marine reserves for the Mediterranean that was developed by Greenpeace on the basis of species and habitat distribution[13] (see figure 1). Greenpeace and WWF have proposed an area closed to tuna fishing that incorporates the Southern Balearics (see figure 2).

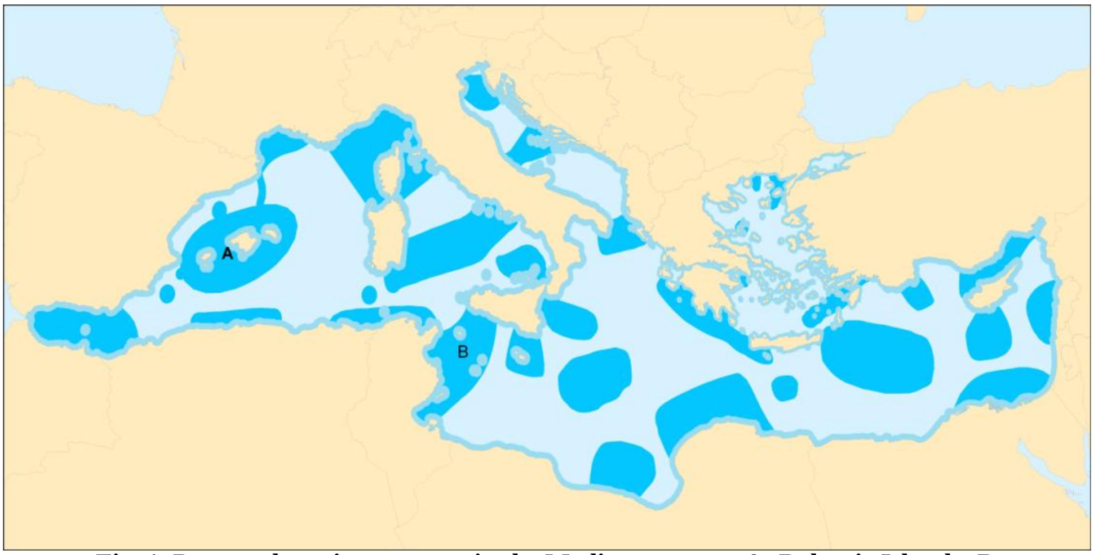

Fig. 1. Proposed marine reserves in the Mediterranean – A: Balearic Islands; B – Sicilian Channel

Data availability and interpretation of the criteria

Proximity to land has ensured that the Mediterranean is one of the most studied high seas regions in the world. A wide range of direct evidence was available to demonstrate the ecological and biological significance of the Southern Balearics and Sicilian Channel on the basis of all seven criteria. Research has been undertaken by a large number of institutions and for a range of purposes, including: fisheries research; marine reserve designation; exotic species control; endangered species conservation; and oceanography. As well as commercially important and iconic species, there was evidence for the distribution and status of less-studied species, for example Cavanagh and Gibson's (2007)[14] overview of the status of chondrichthyans in the Mediterranean. Despite the wealth of information available by comparison with other high seas areas, significant knowledge gaps remain. For example, research on the volcanic seamounts of the Sicilian Channel has been primarily oceanographic and biological knowledge of these habitats is limited[15].

The presence of a large number of rare, and less rare, habitats and species at both of these sites raised an issue with regards to the interpretation of the 'uniqueness and rarity' criteria. A number of the habitats present, for example maerl beds and deepwater coral mounds, have very wide distribution but may be rare within the regions where they occur, due partly to degradation resulting from human activity. The meaning of 'rare' should be clarified in this context, to ensure that the most important sites are recognised, without allowing either locally or globally rare species or habitats to 'fall through the gap.'

The extremely long history of human exploitation of the Mediterranean raises an issue with regards to the interpretation and applicability of the naturalness criteria. The extent to which many, particularly nearshore, areas of the Mediterranean can be considered 'natural' is questionable. In this situation, the creation of marine reserves gains added importance, as a means by which ecosystems can be allowed to recover to something more closely approximating a natural state, providing managers with a benchmark by which the rest of the Sea can be judged.

Ecological and biological significance of the Southern Balearics and the Sicilian Channel

Criteria	Southern Balearics	Sicilian Channel
Uniqueness or rarity	Habitats present that could be considered rare, dependent on the scale of observations, include: maerl beds and other coralligenous beds[16,17]; Peyssonnelia (soft red algae) beds at 40m – 80m[18]; Leptometra (crinoid) beds[16]; stands of the deepwater scleractinian corals *Lophelia pertusa* and *Mardrepora oculata*[19]; colonies of the deepwater octocoral *Isidella elongata*[16]; and *Funiculina quadrangularis* (cnidarian) communities[20]. *The potential presence of cold seep communities is indicated by pockmarks in the Ibiza and Mallorca Channels*[5]. Balearic shearwater *Puffinus mauretanicus* is an endemic species, which breeds only in the Balearic Islands[21]. It has been estimated that 25.4% of bathyal pericarid crustaceans in the Catalano-Balearic Basin are endemics[22].	Habitats/species/geomorphological features present that could be considered rare, dependent on the scale of observations, include: areas of submarine volcanic activity[8]; mud volcanoes[54]; the scleractinian coal *Cladopsammia rolandi*, which is endemic to the Mediterranean[55]; white coral mounds (known locally as 'canelleri'), composed of *Lophelia pertusa*, *Madrepora oculata* and Balanus spp. barnacles, which occur at 250 – 500m depth[56]; other habitat-building species, recorded in the Sicilian Channel by ROV survey, include the yellow tree coral *Dendrophyllia cornigera*, the octocoral *Isidella elongata*, red coral *Corallium rubrum* and *Funiculina quadrangularis* (cnidarian) communities[57]. *The potential presence of cold seep communities is indicated by pockmarks*[58]. Maltese skate *Leucoraja melitensis* is now confined largely to the Sicilian Channel. The species was previously common throughout ¼ of the Mediterranean[14]. A colony of an undescribed species of large (>20cm), deepwater oyster (Neopycnodonte sp.) has been recorded living on fossilised coral mounds in the Linosa Trough[59].

Special importance for life history stages of species	Complex oceanography creates conditions suitable for the spawning of a large number of pelagic fish species. Important spawning area for the eastern stock of Atlantic bluefin tuna *Thunnus thynnus*[23]. Other species that spawn here include: albacore *Thunnus alalunga*, bullet *Auxis rochei*, frigate *Auxis thazard* and skipjack *Katsuwonus pelamis* tuna; little tunny *Euthynnus alletteratus*; Atlantic bonito *Sarda sarda*; common dolphinfish *Coryphaena hippurus*; swordfish *Xiphias gladius*; Tetrapturus sp. (marlins and spearfish); and foragefish species including anchovy *Engraulis encrasicolus* and round sardinella *Sardinella aurita*[24,25]. The Balearic Islands contain breeding colonies of Balearic shearwater (endemic)[21]; Audouin's gull *Ichthyaetus audouinii* (one of three western Mediterranean breeding colonies, that together account for 80% of the global population, is located at Cabrera archipelago)[26]; Yelkouan shearwater *Puffinus yelkouan* (a colony of 100 – 150 pairs breeds at Minorca)[27]; Cory's shearwater *Calonectris diomedea*[28]; European shag *Phalacrocorax aristotelis* (estimated 96.6% of the Mediterranean subspecies)[29].	Reproductive and nursery grounds of the great white shark[60]. Spawning aggregations and nursery grounds of hake *Merluccius merluccius* at 100 – 200m on the Adventure and Malta Banks[61]. Nursery grounds of the greater fork beard *Phycis blennoides* at 200 – 400m on Adventure Bank and in the eastern Strait[62]. Spawning and nursery grounds of the red mullet *Mullus barbatus* to 100m on Adventure and Malta Banks[63]. Interactions of strong currents with island topography create suitable spawning conditions for a number of pelagic fish species, including: anchovy (possible Sicilian Channel subpopulation)[64]; bluefin tuna[65]; small tuna species, including Atlantic bonito, Auxis spp. and little tunny[66]; and swordfish[67]. Nesting colonies of loggerhead turtle on the islands of Lampedusa and Linosa in the Pelagie Archipelago – these are amongst the few remaining nesting sites for this species in this part of the Mediterranean[68].
Special importance for life history stages of species, cont.	Sperm whales *Physeter macrocephalus* are regularly observed in the vicinity of the Balearic Islands, where the complex oceanographic and topographic conditions are suitable for feeding[30]. Social units with calves were observed historically on a frequent basis, suggesting that calving sites could potentially occur[31]. Fin whales *Balaenoptera physalus* are sighted year-round in the vicinity of the Balearic Islands – frontal zones, such as the North Balearic Front, provide areas of high zooplankton concentration suitable for feeding[32]. A putative subpopulation of bottlenose dolphins *Tursiops truncatus* in the Balearic Islands is considered to be amongst the best preserved in the Spanish Mediterranean[33]. Important feeding area for late juvenile loggerhead turtles *Caretta caretta* from rookeries in the eastern Mediterranean and NW Atlantic[34,35]. Aggregations of basking sharks *Cetorhinus maximus* have been observed in the Balearic region[36]. Strong correlation with basking shark prey abundance suggests that this could be an important feeding area[37].	Fin whale feeding area – fin whales congregate off the coastline of Lampedusa during February and early March to feed on *Nyctiphanes couchii* euphausids[69]. Breeding colonies of Cory's shearwater on islands and rocky coastline of the Sicilian Channel[70].
Importance for threatened, endangered or declining species and/or habitats	Balearic shearwater (CR)[38] – estimated population of 3300 breeding pairs in early 1990s[39], has declined to an estimated population of <2000 breeding pairs[40]. There is a predicted 50% probability of extinction over three generations if current trends continue[41]. Yelkouan shearwater – breeding numbers are declining rapidly and has recently been upgraded to NT[27]. Bluefin tuna - populations are declining drastically as a result of overfishing[42] and a recent analysis has suggested that the Mediterranean spawning stock could be extinct by 2012[43]. Bottlenose dolphin (VU)[31]; sperm whale (EN)[38]; fin whale (EN)[38]; short-beaked common dolphin *Delphinus delphis* (EN)[44,31]; striped dolphin *Stenella coeruleoalba* (VU)[31]; *Blue shark <u>Prionace glauca</u>* (VU)[14]*;* great white shark *Carcharadon carcharias* (EN)[45,14]*;* Squatina spp. (angel shark and sawback and smoothback angel shark)[14]; the rabbitfish is classified as NT but high levels of fishing mortality have led to concerns that it may soon qualify as VU[46,14]. Loggerhead turtle (EN)[38]; leatherback turtle (CR)[47,38]. Protected species included in the annexes of the Protocol concerning Specially Protected Areas and Biodiversity in the Mediterranean (BARCOM-SPAM)[49] occur on the Emile Baudot and Aurias March seamounts, including triton snail *Charonia lampas*, elephant ear sponge *Spongia agaricina* and the carnivorous sponge *Asbestopluma hypogea* (previously	Bottlenose dolphins (VU) inhabit inshore waters around the Pelagie Archipelago[71,31]; striped dolphin (VU)[31]*;* fin whales (EN)[38]. Loggerhead turtles (EN)[38]; leatherback (CR)[38] and green turtles (EN – was listed as CR in the Mediterranean but has been delisted as Mediterranean is no longer considered to contain a distinct subpopulation[72]) are observed occasionally[73]. Maltese skate (CR)[38]; great white shark (EN)[14]; porbeagle (CR)[14]; shortfin mako (CR)[14]; sandbar shark (EN)[14]; giant devil ray (EN)[38]; and blue shark (VU)[14]. Bluefin tuna - populations are declining drastically as a result of overfishing[42] and a recent analysis has suggested that the Mediterranean spawning stock could be extinct by 2012[43].

	known only from shallow-water environments)[17]. The Balearic Islands are within the historical range of the Mediterranean monk seal *Monachus monachus* (CR), which is considered to be the world's most endangered pinniped[38].	
Vulnerability, Fragility, Sensitivity, or Slow recovery	Vulnerable and fragile benthic habitats include: maerl beds, which occur on sandy and gravelly bottom at depths to 90m[16]; maerl and other forms of red algal bio-concretion (thin sheets, 'cobbles' and large bio-concretions), which occur on the Emile Baudot and Aurias March seamounts to depths of 160m[17]; Leptometra (crinoid) beds[16]; stands of the deepwater scleractinian corals *Lophelia pertusa* and *Madrepora oculata*[19]; colonies of the deepwater octocoral *Isidella elongata*[16]; *Funiculina quadrangularis* (cnidarian) communities[20]. Species with vulnerable life histories include: Balearic shearwater; sperm whales; fin whales; bottlenose dolphins; striped dolphins; common dolphins; chondrichthyan species; loggerhead and leatherback turtles.	Vulnerable and fragile benthic habitats and species include: white coral mounds composed of *Lophelia pertusa*, *Madrepora oculata* and Balanus spp. barnacles[56]; the scleractinian coral *Cladopsammia rolandi*[55]; the yellow tree coral; the octocoral *Isidella elongata*; red coral; and *Funiculina quadrangularis* (cnidarian) communities[57]. Species with vulnerable life histories include: fin whales; numerous species of elasmobranchs; loggerhead turtles; and the occasional presence of leatherback and green turtles.
Biological productivity	Areas of high primary productivity and zooplankton concentration are created by oceanographic features that result from interaction between two water masses and complex island topography. Plankton biomass is concentrated by a strong front in the Mallorca Channel[49]. Frontal oscillations associated with the Balearic Currents create areas of high chlorophyll concentration in the Deep Chlorophyll Maximum layer[50]. Areas of elevated primary productivity result from upwelling of nutrient-rich deepwater associated with topographic features, such as canyons and seamounts[51]. Productive benthic habitats include: maerl beds; other forms of red algal bio-concretion; stands of the deepwater scleractinian corals *Lophelia pertusa* and *Madrepora oculata*; colonies of the octocoral *Isidella elongata*; *Funiculina quadrangularis* (cnidarian) communities; Peysonnelia (soft red algae) beds; Leptometra (crinoid) beds; *and cold seeps*. Seamounts and canyons create area suitable for the development of productive deepwater habitats, eg. large specimens of yellow tree coral *Dendrophyllia cornigera* have been observed on the flanks of Menorca Canyon[52].	Areas of high primary productivity and zooplankton concentration are created by oceanographic features that result from the interaction of strong currents and complex topography. Current patterns are likely to retain productivity and fish larvae in the Sicilian Channel[74]. Upwelling is driven by wind and the meandering of the Atlantic-Ionian Stream[75]. Total biomass of demersal fish species is particularly high on the Adventure Bank, to depths of 100m. This includes commercially important species, such as hake and red mullet[76]. Productive benthic habitats include: white coral mounds composed of *Lophelia pertusa*, *Madrepora oculata* and Balanus spp. barnacles[56]; deepwater coral and octocoral assemblages; *cold seeps*[58]; *Funiculina quadrangularis* (cnidarian) communities[57].
Biological Diversity	High pelagic fish species diversity, as a result of oceanographic features, which create conditions suitable for feeding and spawning[24,25]. High ichthyoplankton diversity in summer months due to the large number of pelagic fish species that spawn in the vicinity of the Balearic Islands[24,25]. Benthic habitats with high associated levels of species diversity include: maerl beds; other forms of red algal bio-concretion - ~300 species were identified at coralligenous beds on Emile Baudot and Aurias March seamounts, of which ~150 were particularly associated with that habitat[17]; stands of the deepwater scleractinian corals *Lophelia pertusa* and *Madrepora oculata*; colonies of the octocoral *Isidella elongata*, which are associated with elevated levels of invertebrate species diversity[53]; *Funiculina quadrangularis* (cnidarian) communities, which provide habitat for some commercial crustacean species[20]; Peysonnelia (soft red algae) beds; Leptometra (crinoid) beds, which provide habitat for juveniles and adults of commercially important fish species[53].	Persistent area of high demersal fish species diversity (58 species recorded) on the Adventure Bank, to depths of 100m[76]. High demersal fish species diversity also recorded at 400 – 600m in the northwest of the Sicilian Channel and on the eastern edge of the Maltese Exclusive Fishing Zone[76]. *Potential presence of shallow-water species on the summit of the submerged volcanic island of Ferdinandea.* Benthic habitats with high associated levels of species diversity include: white coral mounds composed of *Lophelia pertusa*, *Madrepora oculata* and Balanus spp. barnacles[56]; deepwater coral and octocoral assemblages; *Funiculina quadrangularis* (cnidarian) communities[57].
Naturalness		Shipwrecks create artificial refuges from trawling pressure on parts of the Adventure Bank[77].

Nb. *Italics* denotes characteristics that have been extrapolated from indirect data
VU = vulnerable; EN = endangered; CR = critically endangered.

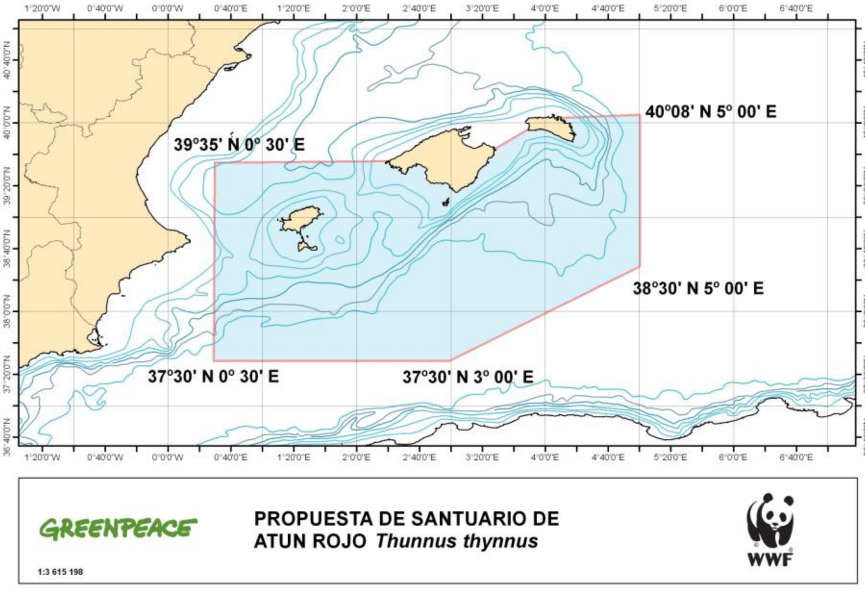

Fig. 2. Proposed closed area for tuna fishing in the Balearic Islands – Greenpeace and WWF.

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High Seas Mediterranean Marine Reserves: a case study for the Southern Balearics and the Sicilian Channel

A briefing to the CBD's Expert workshop on scientific and technical guidance on the use of biogeographic classification systems and identification of marine areas beyond national jurisdiction in need of protection

Ottawa, 29 September–2 October 2009

Greenpeace International

August 2009

Table of Contents

Abbreviations and Acronyms

ABB	Algero-Balearic Basin
AC	Algerian current
AIS	Atlantic Ionian stream
AW	Atlantic water
BC	Balearic current
BFT	Bluefin tuna
CBD	Convention on Biological Diversity
EEZ	Exclusive economic zone
EOW	Eastern Mediterranean outflow water
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
HERMES:	Hotspot Ecosystems Research on the Margins of European Seas
ICCAT	International Commission for the Conservation of Atlantic Tunas
IUCN	International Union for Conservation of Nature
LIW	Levantine Intermediate water
MAW	Modified Atlantic water
MPA	Marine Protected Area
POPs	Persistent Organic Pollutants
ROV	Remotely Operated Vehicle
SCRS	Standing Committee for Research and Statistics (ICCAT's scientific committee)
SPAMI	Specially Protected Areas of Mediterranean Importance, listed under the SPA protocol of the Barcelona Convention
SST	Sea surface temperature
WMED	Western Mediterranean

Executive Summary

The purpose of the Convention on Biological Diversity (CBD) is to ensure the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of any utilization. It covers all ecosystems, species and genetic resources and states that where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat. The CBD also underlines the need for its Contracting Parties to cooperate for the conservation and sustainable use of biodiversity in areas beyond national jurisdiction. In 2004 the CBD took a major step forwards by committing to the establishment of a global network of marine protected areas (MPAs) by 2012 as set out in decision VII/28. This decision further specifies that this network should be composed of:

> *comprehensive, effectively managed, and ecologically representative national and regional systems of protected areas that collectively … contribute to achieving the three objectives of the Convention and the 2010 target to significantly reduce the current rate of biodiversity loss .*

The CBD's Programme of Work on protected areas requires States to address the shortfall of marine sites in the global network of protected areas. Progress in areas beyond national jurisdiction, however, is limited by the lack of an overarching global legal framework defining international responsibilities in this domain and the concomitant absence of mechanisms which can be used for the identification, creation and protection of such protected areas.

Individual marine species have complex relationships both with the physical habitats in which they live and with the other species living in them. Hence, holistic protection of marine ecosystems is crucial to the preservation (and restoration) of these complex relationships in the oceans. Marine protection efforts are, therefore, increasingly becoming focused on an ecosystem approach. In turn, the need for a precautionary approach which allows for uncertainties and indeterminacies has also been widely recognised. Such approaches are useful in the protection of high seas areas and areas falling outside national jurisdiction where little may be known about specific features and overall ecosystem function. In such environments there is also a need to act over a large geographical scale since many birds, marine mammals and other species are extremely wide-ranging species. (e.g. Roberts et al. 2006).

It is becoming increasingly accepted that networks of designated marine reserves have an important role to play in the protection of marine biodiversity and in the restoration of degraded marine ecosystems. In order to be effective in this role, the networks should include large scale fully protected reserves in which anthropogenic activities are prohibited. In addition, these networks should be fully representative of the whole range of different ecosystems, habitats and communities found in the oceans. Hence, the organization of a network of marine reserves as recently advocated by the world's nations at the World Summit on Sustainable Development (Johannesburg, 2002), and later by the Convention of Biological Diversity is particularly relevant to the emerging paradigm of marine environmental management based upon marine reserves.

In the above context, this document is aimed at strengthening the case for the establishment of Marine Reserves in two areas in the Mediterranean high seas, the waters surrounding the Balearic Islands and the Sicilian Channel. In doing so it broadly follows the criteria adopted by the CBD for identifying ecologically or biologically significant areas in need of protection in open-ocean waters and deep-sea habitats (COP 9, Decision IX/20) and applies them to the evaluation if the available scientific information.

The Sicilian Channel and the Balearic Islands have some common environmental and oceanographic features. Both areas are characterized by intense geostrophic circulation of water masses. The obstructions caused by the island topography generate mesoscale eddies and convergent fronts (Oray and Karakulak 2005, López-Jurado et al., 1995, Pinot J. et al., 1995; Vélez-Belchí and Tintoré, 2001;García et al., 2003; Alemany et al., 2007). Moreover, both areas have a remarkably complex bottom topography which includes diverse undersea features such as seamounts, escarpments, banks, pockmarks and mud volcanoes. The combination of complex topography with the ocean circulation patterns found in these areas that makes them highly productive and marks them as biodiversity hotspots.

Seamounts provide a good example of biodiverse and biogeographically important features. These are undersea mountains (usually of volcanic origin) rising from the seafloor but reaching a peak below sea level (e.g. Kennish 2001). In the Balearic archipelago, three seamounts can be identified: The Mont Ausias Marc, the Mont dels Oliva and the Emile Baudot. In the Sicilian Channel five volcanic seamounts have been described: Tetide, Anfitrite, Galatea, Cimotoe and Graham. These locations are of scientific interest because they appear to support unique biological communities such as those based upon the colonies of white coral (dominated by the scleractinians *Lophelia pertusa* and *Madrepora oculata*). In addition, the local water circulation patterns induced around the seamount summits, together with the rocky substrata, provide ideal conditions for complex epifaunal assemblages such as corals, crinoids and sponges. These communities represent sensitive habitat of high biodiversity value. They include, for example, colonies of the coral *Isidella elongata*, colonies of the cnidarian *Funiculina quadrangularis* and *Leptometra* beds on the deep shelf. All of these habitats are highly susceptible to the impacts of ground contacting trawling gear.

Seamounts also feature in the life cycles of a wide range of different species. These include some of high commercial importance (and which are currently overexploited). The eastern stock of Atlantic Bluefin tuna (*Thunnus thynnus*) migrate annually from the Atlantic Ocean into the Mediterranean Sea through the Strait of Gibraltar in order to spawn. The waters off the Balearic archipelago (i.e. south of the archipelago above the Emile Baudot seamount) and the Sicilian Channel, are two of the most important known spawning grounds for the species in the Mediterranean basin. Other pelagic species that also reproduce in these waters include Albacore (*Thunnus alalunga*) and Dolphinfish (*Coryphaena hippurus*), small tuna such as Frigate (*Auxis* sp)., little tunny (*Euthynnus alleteratus*), Atlantic bonito (*Sarda Sarda*) and skipjack tuna (*Katsuwonus pelamys),* Other large large scombroids such as Swordfish (*Xiphias gladius*) (e.g. Alemany et al., 2006) and small pelagic species anchovy (*Engraulis encrasicolus*) and round sardinella (*Sardinella aurita*) also spawn in these waters To an extent, the hydrological features influence spawning egg and larval dispersal and also recruitment processes. Overall, the mesoscale hydrographic features produced by the interaction between island topography and water masses, such as fronts and eddies, increase local productivity and retention (Bakun 2006), and the spawning strategies of tuna are adapted to release eggs near these areas.

Both the Balearic Islands and Sicilian Channel include habitat required for the survival and recovery of various endangered or threatened species (i.e. breeding grounds, spawning areas, nursery areas, juvenile habitat). The Mediterranean sperm whale sub-population is listed on the IUCN red list of threatened species and recently classified as Endangered (E) (Reeves and Notarbartolo 2006). The predominance of sperm whales around the southern continental shelves of the Balearics is due to the depth and the topography of this region being conducive to successful foraging. Other species listed as endangered include the striped dolphin, the common dolphin, and loggerhead turtles. The Pelagian Islands of Lampedusa and Linosa are the last known nesting sites of the loggerhead turtle in Italy.

Seabed pockmarks are another biologically important geomorphological feature. These are defined as "circular to ellipsoidal shallow craters typically 30-40 m in diameter and 2-3 m deep which occur as isolated depressions, in groups or in association with larger structures (Uchupi et al. 1996). The importance of pockmarks lies on the existence of cold seep type communities which are the home to unique chemosynthesis-based communities (not relying on photosynthetic production). These communities are dominated by bacterial mats and particular species of bivalves and tubeworms that are associated with endosymbiotic (chemo-autotrophic) bacteria. (Cartes et al., 2004).

Finally, in shallower waters, red algae concretions are arguably among the most complex and diverse communities of the Mediterranean Sea. They are related to a number of vulnerable habitats and are of great biological interest. Coralligenous beds are comprise a habitats strongly associated with gorgonian gardens, sponge fields and aggregations, caves and grottos, etc. Various species that are characteristic of coralligenous formations, such as red and yellow gorgonians, suffer serious damage due to frequent underwater dives in certain areas. Some species that live in association with coralligenous beds are considered threatened or endangered in the Mediterranean Sea, including the algae *Chondrymenia lobata*, *Halarachnion ligulatum*, *Halymenia trigona*, *Platoma cyclocolpa*, *Nemastoma dichotomum*, *Ptilophora mediterranean*, *Schizymenia dubyi* and *Laminaria rodriguezii*, as well as some associated molluscs like the date mussel (*Lithophaga lithophaga*), echinoderms like the longspined sea urchin (*Centrostephanus longispinus*), and fish such as *Sciaena umbra* and *Umbrina cirrhosa* (BARCOM 1995).

Although the Mediterranean environment has long supported a diversity of activities from early in human history, in recent years anthropogenic pressures have intensified. Fishing, pollution, tourism, and coastal development are recognised as the main drivers of biodiversity changes, along with the exacerbating effects of climate change. The presence of important morphological features associated with high biodiversity (e.g. seamounts) and the threat of damage to vulnerable habitats and species as a result of human activities makes these areas high priorities for inclusion in any future comprehensive and fully representative network of MPAs for the Mediterranean basin.

1. Introduction

Particularities of High Seas in the Med

The Mediterranean basin is located in the temperate zone of the Northern Hemisphere between 30 and–45ºN and has a marked seasonal cycle The Mediterranean is considered to be an oligotrophic sea and annual evaporation exceeds rainfall (Hopkins, 1978; Lacombe *et al.,* 1981). The Mediterranean Sea is an important ecological region with a high environmental diversity at both regional and local scales. Its waters host a high level of biodiversity with numerous endemic species, and it also has areas critical to the reproduction of pelagic species (Abdulla *et al.,* 2008).

The wide variety of habitats in the Mediterranean Sea results in an unusually high biodiversity for a temperate sea (Bianchi 2007). This high biodiversity comprises a wide range of species, from those of boreal Atlantic origin to those that are more typical of temperate and subtropical waters (Sará, 1985).

It has been estimated that around 26.6% of the total Mediterranean marine fauna (4238 species: Fredj *et al.,* 1992) are endemic. In the case of macrofauna these endemic organisms appear to be uniformly distributed through all the deep Mediterranean Basins.

A Representative Network of Marine Reserves for the Mediterranean

In 2006 Greenpeace published a proposal for a regional network of large-scale marine reserves with the aim of protecting the full spectrum of life in the Mediterranean (Greenpeace 2006). The network of candidate sites is made up of 32 different areas stretching from Alboran Sea in the west to the Phoenician coast in the east. Both the Balearics and the Sicilian Chanel were identified as areas to be protected within the network which was drawn up with the help of experts and used a variety of data sets including distribution of species, areas important for key life stages e.g. spawning grounds, important habitats such as seamounts and sites previously identified as priority sites for protection such as SPAMIs. The key principles of marine reserve networking were applied to the network design, ensuring that it is representative of the full range of habitats found in the Mediterranean Sea, has different habitat types replicated through the network, has sufficient levels of connectivity and is made up of sites that are sufficiently large to be viable. The total coverage of the network amounts to 40% of the Mediterranean.

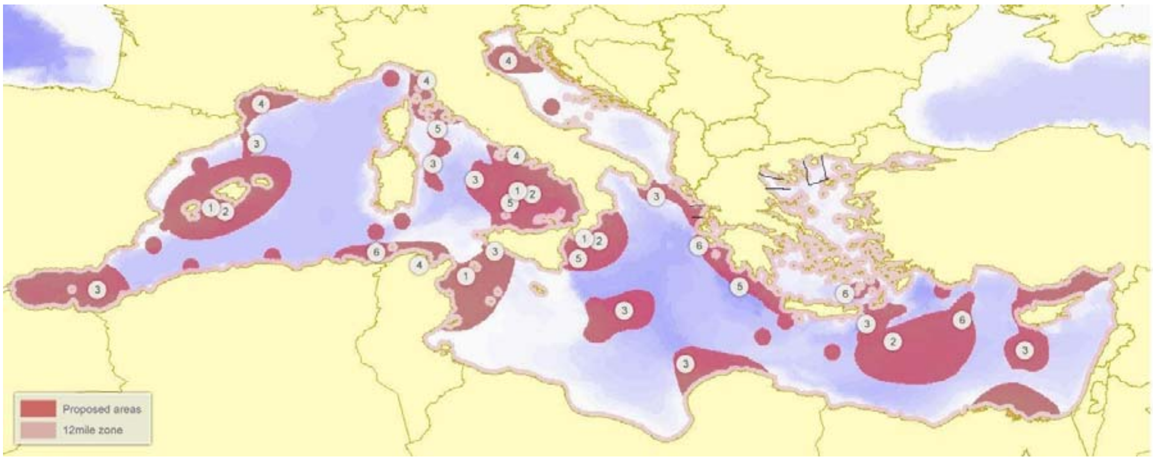


Fig. 1. Map showing Greenpeace's proposal for a network of marine reserves for the Mediterranean.

In May 2008 WWF published a proposal, supported by Greenpeace, to permanently close the waters surrounding the Balearics to fishing in order to protect the tuna spawning grounds. The report, *Spatial management to support recovery of the Atlantic bluefin tuna in the Mediterranean*, lays out the evidence for the continued importance of Balearic waters as a spawning ground for bluefin tuna and other large pelagics as well as setting out the political arguments. On the basis of the scientific evidence presented it also sets out the geographical boundaries for the area as presented in figure 2.

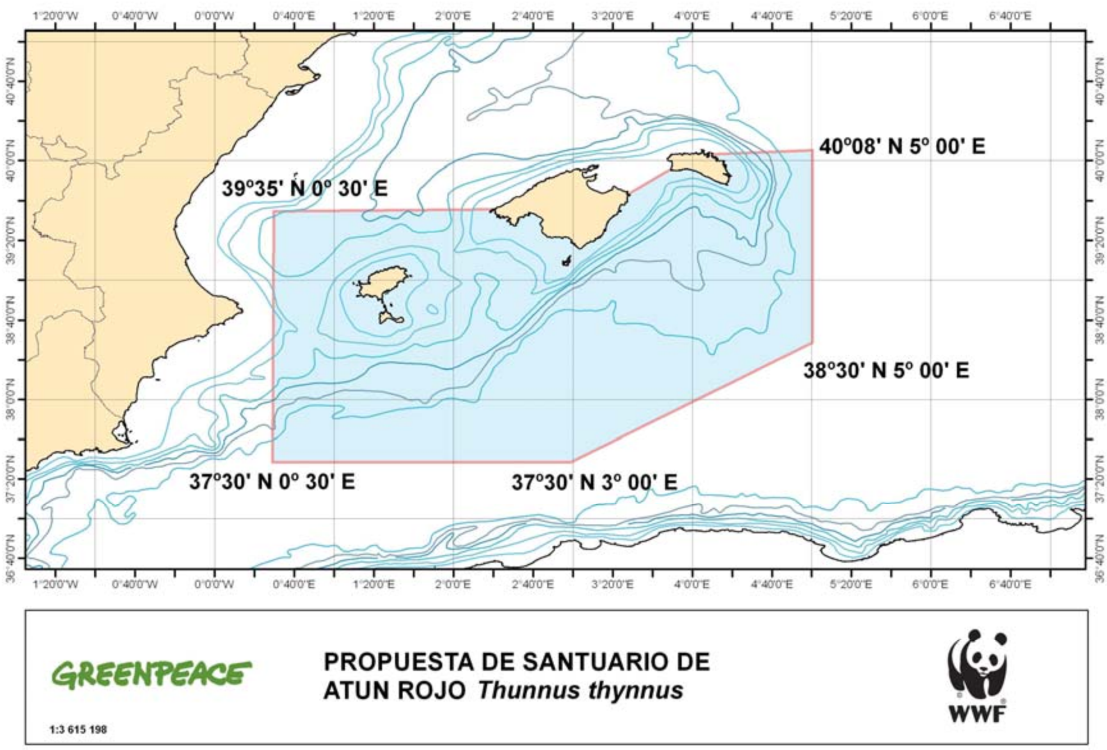


Fig. 2. Area proposed as a no-take marine reserve to protect the Balearic spawning grounds of the bluefin tuna.

Almost half of the currently designated MPAs in the Mediterranean are in the western part – 40 out of 94. However all of these are coastal with the exception of the Pelagos Sanctuary. The Pelagos Sanctuary is large-scale and covers 3.4% of the total surface of the Mediterranean Sea, however it confers little in the way of real protection. In total only 220.0 km2 or 0.01% of the Mediterranean Sea has been set aside as no-take areas and none of this is on the high seas (Abdullah et al. 2008).

The Balearic Archipelago is one of the richest European regions in terms of marine animal species diversity and is characterized by wide range of ecosystem types (e.g. maërl beds, *Leptometra* beds soft red algae communities, *Posidonia* meadows, etc) (Aguilar *et al.,* 2007) Some of these communities are rare considered on a European scale.

The Sicilian Chanel joins the west and east Mediterranean basins and hosts many species from both areas. It is highly productive and considered a biodiversity hotspot within the Mediterranean. Seamounts and deep-sea corals are found close to Sicily and the area is important to both fin and sperm whales as well as the great white shark.

Aim of this report

The aim of this report is to strengthen the case for the establishment of high seas marine reserves in the waters surrounding the Balearic Islands and the Sicilian Channel by identifying and compiling the scientific information available on the ecosystems found in these areas and then evaluating this information according to the criteria adopted by the CBD.

2. Existing research on the areas and availability of information

Current research

The Balearic Islands and the Sicilian Channel have both been subject of systematic research over a period of decades at both a national and international level. In the case of the Balearic Islands, the IEO(Spanish Oceanographic Institute – Balearic Research Centre) and IMEDEA-CSIC (Mediterranean Institute for Advanced Studies - University of the Balearic Islands) are the main Spanish research bodies with projects which embrace a wide range of disciplines (e.g. fisheries, conservation, oceanography, marine ecology, etc.). In the case of the Sicilian Channel, the ICRAM (Central Institute for Technical and Scientific Marine Research) is the main Italian research body. For both areas several Conservation Action Plans are being implemented involving National and Regional government as well as local, regional and national organizations.

At International level, CISEM (the Mediterranean Science Commission) is a relevant research body with more than 2000 marine scientists from 23 countries participating. In addition, both areas have been subject of research under various EU and Global Programmes. A selection of the most relevant are show in the table below.

Project	Funds	Aim	Main partners
MARFISH: Causes and consequences of changing marine biodiversity - a fish and fisheries perspective	Sixth EU Framework Program (2002 - 2006)	• Detect and identify mechanisms of large-scale and long-term change in biodiversity of fish and other exploited species (e. g., scallops, lobsters) • Predict consequences of changes in biodiversity of fish and other exploited communities on ecosystem functioning and human societies	MarBEF EU Network of Excellence
GLOBEC CLIOTOP	International Geosphere-Biosphere Programme IGBP	• The impact of climate change on top predators.	Scientific Committee on Oceanic Research (SCOR)
HERMES: Hotspot Ecosystems Research on the Margins of European Seas	Sixth EU Framework Program (2005 to 2009)	• Investigate Europe's deep marine ecosystems and their environment.	50 partners including 9 small companies, from 17 European and neighbouring countries.
BIOMARES	Fifth EU Framework Program (1998-2002).	• Aimed to establish a network of research sites and a series of indicators for biodiversity as the basis for long-term and large-scale marine biodiversity research in Europe	21 partners
BIOFUSE	Sixth EU Framework Program (2002 to 2006)	• Quantify the relationship between biodiversity and the functioning and stability of ecosystems with variable regimes of diversity and disturbance	MarBEF EU Network of Excellence 20 partners
MEDSURMED	Italian Ministry of Agriculture, Food and Forestry Policies	• Assessment and Monitoring of the Fishery Resources and the Ecosystems in the Straits of Sicily	FAO and representatives of Italy, Tunisia, Malta and Lybia

Gaps in current knowledge and areas for further research on the region

The Mediterranean Sea is one of the best researched. However, there are gaps of knowledge, since most of the research has been conducted responding to European interests and mainly concentrated on coastal resources. In that sense, the southernmost part of the areas proposed have received far less attention. In addition, the bulk of the research on the area has been focused on commercially valuable species. In recent years there has been more research carried out on the deep sea areas with many new discoveries. Such research has the potential to change our appreciation of their value. For many parts, the, existing information consists only of oceanographic information and there are important gaps in our understanding of the existing ecosystems. In consequence, the current report reflects such gaps.

3. Southern Balearics

3.1 Area description

One of the main features of the western Mediterranean Basin is the Balearic Promontory. It is located in the northeast of the Iberian peninsula and along this promontory are located the Balearic Islands of Ibiza, Formentera, Dragonera, Mallorca, Cabrera and Menorca. The whole promontory is 348 km length, 105 km wide and from 1000 to 2000 m high from surroundings basins (Acosta *et al.* 2004)

The Balearic Islands represent the natural limit between two sub-basins of the Western Mediterranean (WMED), the Algerian (located in the southern part) and the Balearic basins (in the north).

3.1.1 Main topographic features

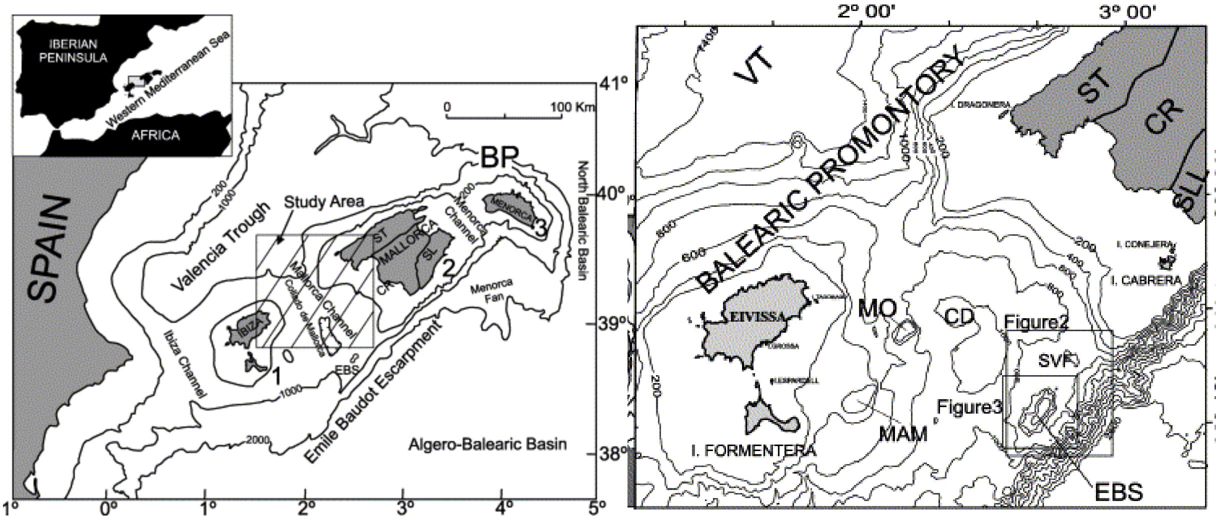
The Balearic Promontory is a major feature of the Mediterranean Basin with a very complex tectonic history. (Sábat *et al.*, 1995, Acosta *et al.,* 2002). The Balearic Islands of Ibiza, Formentera, Dragonera, Mallorca, Cabrera and Menorca are located along this promontory which is 348 km long, 105 km wide and elevated from between 1000 to 2000 m above the surrounding marine basins. (Acosta *et al.,* 2001a, 2002, 2004). The Balearic Islands represent the natural boundary between two sub-basins of the Western Mediterranean (WMED): the Algerian sub basin (located in the southern part) and the Balearic basin (located to the north). The Balearic shelf can be divided into two: the Mallorca – Menorca shelf to the east reaching up to 200m depth and the smaller Ibiza- Formentera shelf to the west, (up to 800 m depth). The sediments of the Balearic shelf are mainly biogenic sands and gravels with a high percentage of carbonates (77– 84%) and up to seven lithofacies have been identified at different depths and with different communities (Acosta *et al.,* 2002 Alonso *et al.,* 1988; Fornós and Ahr, 1997).

The Ibiza and Formentera shelf varies in width and slope. The shelf width is 2km with a slope of 4.11° to the east of Formentera, ranging up to to 25 km width with a 0.37° slope on the west side of the island (Acosta *et al.,* 2002). The Mallorca-Menorca shelf breaks at an average depth of 139 m (Amblas *et al.,* 2004). The coastline is predominantly rocky, while immediately offshore there are generally sandy bottoms with sea-grass meadows. In northern and southern Mallorca, however, embayments enlarge the shelf area and increase the presence of muddy-sand bottoms. The channels between Mallorca and Menorca and between Mallorca and Cabrera, where the maximum depth is 100 m, also effectively enlarge the continental shelf. The continental slope is steep, with an absence of submarine canyons, and the morphology is determined by emergent geological structures (Acosta *et al.,* 2001a, 2004) rather than by the input of sediment from the continental shelf.

At its deepest, the Balearic Sea can reach depths of 3000 m. Between Formentera and Mallorca a Central Depression reaches over 1000 m in depth. To the southeast of this lies the extensive SW Mallorca submarine Volcanic field which includes the Emile Baudot

Seamount and is around 500km^2 in area (Acosta *et al.*, 2001a; 2002). Two volcanic seamounts lie to the immediate east of Ibiza: Mont dels Oliva and Mont de Ausias Marc (Canals *et al.,* 1982). The Algero-Balearic Basin, (ABB) to the south of the promontory is the largest feature of the physical geography of the Western Mediterranean Basin. It covers an area of 240,000km^2 and includes the Balearic Abyssal Plain which lies to the east of Menorca (Acosta *et al.,* 2002). The ABB is bounded by the 2600 m isobath but reaches maximum depths of 2800 m (Acosta *et al.,* 2002). (See Figure 3)

Fig. 3. Bathymetry of the Balearic Promontory



NOTE: Contours of both maps are in meters
NOTE: AS = Alboran Sea; BP= Balearic Promontory; C= Corsica; CI = Columbretes Islands; CD = Central Depression; EBE= Emile Baudot Escarpment; EBS = Emile Baudot Seamount; F = Formentera; I = Ibiza; LB = Ligurian Basin; M= Menorca; MA= Mallorca; MAM= Mont Ausias Marc; MO= Mont dels Oliva; NB–PB = North Balearic– Provenc_al Basin; S = Sardinia; SB–AB = South Balearic–Algerian Basin; SBP= South Balearic Plateau; SVF= Southwest Volcanic Field; VT=Valencia Trough; ST = Serra Tramuntana, SLL= Serra Llevant, CR = Central Rift
SOURCE: Acosta et al., 2004 .

3.1.2. Currents and nutrients circulation system.

The Mediterranean Sea is considered to be a semi-closed ocean area with limited water exchange with the Atlantic Ocean through the Strait of Gibraltar. The water exchange takes place through a stratified circulation system. Atlantic water (AW) of relatively lower salinity enters via the Strait of Gibraltar at the surface and is exchanged with higher salinity Mediterranean water that flows into the Atlantic in a layer underneath the influent current. The Algerian sub-basin, therefore, receives new surface water from the Atlantic and its circulation dynamics are mainly driven by the density gradients caused by temperature and salinity differences. The Balearic sub-basin contains AW that has remained longer in the Mediterranean and which is of higher salinity. Dynamics are affected by atmospheric (mainly wind) forcings, (Hopkins 1978) making the Balearic region a transition zone where two important water masses with different physical, chemical and biological properties meet (Garcia *et al.,* 2006).The area is characterized by the intense density driven (geostrophic) circulation of water masses. Mesoscale eddies and convergent fronts arise as a result of the interactions of the circulating water with the obstructions posed by the islands (López-Jurado *et al.,* 1995, Pinot *et al.,* 1995, 2002). As a result, the hydrodynamics differ markedly between the areas of sea to the north of the Balearics and those to the south (López-Jurado *et al.,* 2008).

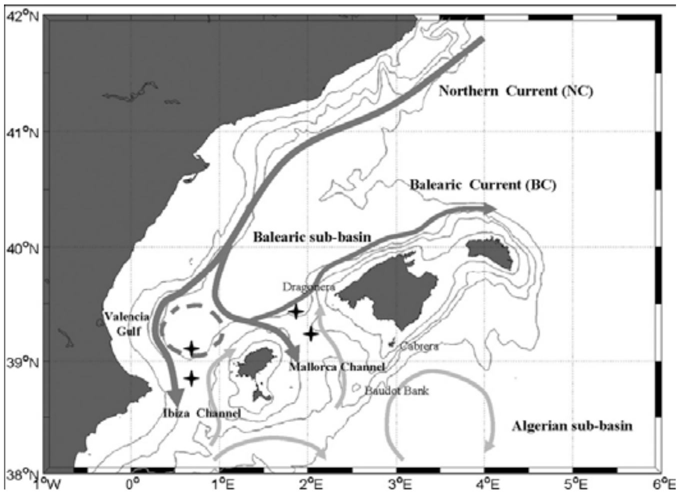


Fig. 4. The Balearic Islands and the major currents characterizing the regional circulation.
(SOURCE: López- Jurado *et al*., 2008)

Hydrodynamics in the Balearic area are very complex with several mesoscale features (e.g. eddies, fronts, etc). The southern area, in particular, generates regular anticyclonic eddies due to the bottom topography. Hence, this area effectively represents a convergence zones and, therefore, a strong retention zone (e.g. Pinot *et al.,* 2002; Millot 2005; Lòpez- Jurado *et al.,* 2008). The southern area is also influenced by the instability of the Almeria-Oran front and by mesoscale features generated from the Algerian current (AC) (Millot 2005). Blocking conditions can also be caused by the presence of large gyres located to the south of Ibiza and Formentera Islands. These gyres damp circulation through the channels and divert Atlantic surface waters towards Cabrera (south of Mallorca) and the Menorca Islands (Font *et al.,* 2004). In this area, very high salinity values (up to 38.6‰.) can be found in the intermediate layer. During the summer, the circulation of surface waters causes water of recent Atlantic origin to reach the Balearic Islands as eddies separated from the main current of Atlantic water that enters the Mediterranean through the Strait of Gibraltar. This is due to the instability of the Almeria-Oran front. Additionally, according to Acosta *et al.,* 2001b (Lòpez -Jurado personal communication) more recent measurement of the southerly flowing bottom currents suggest the presence of a cyclonic gyre towards the east of the channel. This gyre could reach a width of some 500m and could block the flow of the Mediterranean Intermediate Water. The surface waters forming the Balearic Currents (BC) are all of Atlantic origin but some are more recent Atlantic origin, i.e. have different residence times in the Mediterranean.

The presence of both new and older AW in the channels gives rise to ocean fronts that affect the ecosystem dynamics in the area. Moreover, the Mallorca and Ibiza channels play an important role in the regional circulation of this area and their topography conditions the water exchange between these two sub-basins (Pinot *et al.,* 2002). Inter-annual variations in the different water masses, as well as in their characteristic values, depths, thicknesses and areas of influence have been observed in this region (Pinot *et al.,* 2002; López-Jurado *et al.,* 2008;) These conditions influence the eventual formation of mesoscale structures and hence the regional circulation. This large scale situation defines the Balearic Archipelago, and particularly its southern part, as a convergence area, and therefore as a strong retention zone. There are high concentrations of nutrients due to the presence of fronts and mixing zones associated with reefs, canyons, seamounts and islands (Hyrenbach, 2000) that constitute physical obstacles for water masses.

3.2 Topographic Features of Remarkable Biological relevance

3.2.1. Seamounts

Seamounts rising from the seafloor support a diversity of important habitat types including maerl beds and deep sea coral communities (see: Santillo and Johnston 2003, Cartes et al., 2004) In addition seamounts support other complex benthic communities and serve as important habitat for many commercial fish species. Due to the way in which seamounts modify current regimes, rocky seamount substrata provide ideal conditions for attached epifauna such as corals, crinoids and sponges. Some deep sea corals and sponge fields may be thousands of years old and can form highly complex structures (Richer de Forges et al., 2000).

Multi-beam mapping surveys have identified three seamounts in the Balearic region: The Emile Baudot Seamount is located along the crest of the Emile Baudot Escarpment west of the Cabrera canyon and to the south of the Emile Baudot Escarpment (38°42'N and 002°20'E.). Of volcanic origin, this seamount rises more than 500m above the seafloor in waters of 650m depth and is flat-topped. The Mont Ausias Marc (northeast of Formentera) (38º.44'N and 001º.48'E.) rises from a depth of 300m and its summit lies at less than 125m depth**.** The Mont dels Oliva seamount is located east of Ibiza Island (38º.57'N and 002º.00'E) and rises from around 600 to a summit at 300m depth. (Acosta *et al*., 2001a, 2004). Like the Mont Ausias Marc, this seamount is of tectonic rather than volcanic origin. (Acosta *et al*., 2004).

Very little information has been published regarding the benthic communities that inhabit these seamounts (J. Acosta pers.commun). Nonetheless, a recent ROV survey of the three seamounts identified nearly 300 species living there. Rhodolith beds found on these mounds and seamounts reached down to 140-150 meters depth, although the most important ones were between 80m and 120m. The formations were particularly common over the top of Ausias Marc, but could also be found on Emile Baudot. Three forms of coralligenous beds were detected: (i) large bio-concretions, (ii) "cobbled" bio-concretions and (iii) thin sheets and small patches (see Aguilar *et al*., 2007).

Seamounts are particularly vulnerable to fishing and other human activities (Morato *et al.,* 2005, Stocks, 2004). The limited fixed habitat, the extreme longevity of many species (of the order of 100 years and more) and the apparently limited recruitment of organisms between seamount systems all compound the uncertainty of recovery from trawling activity which sweeps away the benthic epifaunal community as bycatch (Richer de Forges et al., 2000)

3.2.2 Pockmarks

Sea floor pockmarks are elliptical shallow depressions in the sea floor, 2-3m in depth and typically around 30-40m in diameter. They may be isolated features, occur in groups or be associated with other seafloor features. The importance of pockmarks lies on the possible existence of cold seep type communities which are the home to unique chemosynthesis-based communities (not relying on photosynthetic production).

Surveys carried out in the Ibiza Channel and on the east side of the Ibiza-Formentera platform have shown variously sized pockmarks to be present in these locations. (Acosta *et al*., 2001b). It is thought that these pockmarks have been formed by the escape of gases and water from an underlying hydrothermal field (Acosta *et al.* 2001). Large pockmarks on the seafloor of the Mallorca channel (Acosta *et al.* 2004) are attributed to venting of gases associated with the volcanic fields lying between Mallorca and Ibiza Islands and the northwards to Valencia Trough.

3.2.3 Volcanoes

Acosta et al. (2001a) have recently described a volcanic field in south Mallorca, located southeast of the Central Depression and in the vicinity of the Emile Baudot Seamount. The field includes some 118 cone-shaped volcanic structures varying from 8-501m elevating above the seafloor and with diameters of between 0.14 and 1.7km. These are though to be of igneous origin based on a sample of basalt recovered in an earlier survey of the area (Acosta *et al*. 2004b).

3.2.4 Submarine Canyons and Ridges

These geographical/geological features are considered to be key to biological and ecological processes in the Mediterranean basin. They channel energy and matter from coastal areas to the deep-sea, and also create local upwellings that are important in the life-cycles of many pelagic fish and of marine mammal species. Two main canyon systems have been identified on the continental slope of Mallorca-Menorca (Acostal *et al*., 2002), the Menorca Canyon System (MC) and the Mallorca-Cabrera canyon Biological communities linked to deep sea corals *Lophelia pertusa* and *Madrepora oculata* are present on the flanks of the canyons.

The Balearic and the Algerian basins are separated by a submarine ridge at ca.600m beneath the Mallorca channel between the islands of Ibiza and Mallorca (Acosta *et al.,* 2004b).

3.3 Rare, vulnerable and highly productive habitats present on the Southern Balearics High Seas.

The Balearic Islands are the location of rare, sensitive, vulnerable and highly productive deep water habitats which require conservation and protection. Continental slopes exhibit a mosaic of habitats with mixed soft and hard bottom faunal communities, although much of the slope seabed is covered by soft sediments (Pérès, 1985; Thistle, 2003). Maërl and Coralligenous beds have been described as areas of high diversity and two of the most productive marine ecosystems in temperate regions (Martin *et al.,* 2007). Both soft red algae and maërl beds are important for carbonate production on the Mallorca–Menorca shelf. In the clear waters off Balearic Islands these communities cover large and deep areas (up to ~80 and ~90 m, respectively) of the sea bottom (Ballesteros, 2003, 2006).

Deep-sea white coral assemblages (*Madrepora oculata*, and *Lophelia pertusa*) at the hard-bottom of the Balearic region are characterized by high-local productivity (Cartes *et al*., 2004) *Leptometra* beds in shelf-break high hydrodynamic areas with a high input of organic matter and plankton. enhances habitat heterogeneity by developing three-dimensional communities, thus allowing high rates of primary and secondary production (Massuti and Ordinas, 2006).

3.3.1 Shallow shelf habitats

Maërl

Maërl grounds have a high diversity and also support a high level of macro-benthic secondary production,. This, in turn, may be important for species which are commercially exploited. These communities have a low rate of turnover (50-75 years lifespan). They are home to a number of economically important species (fishes, cephalopods, crustaceans). This habitat is subject to different anthropogenic stresses in particular the excessive sedimentation and damage from trawling. The latter results in fragmentation, dispersing of rhodoliths, and modification of the biological community. (Barbera *et al.,* 2003).

Maerl bottoms are widespread along all Balearic coasts between 20-90m depth. The beds are mainly built up of red algae of the family Corallinacea (BALAR0502), The brown alga *Laminaria rodriguezii*, together with various species of echinoderm and ascidian is also found on these bottoms. Some trawl fishing grounds are active over these beds targeting fish associated with them. These include *Serranus cabrilla*, *Scorpaena scrofa*, *Scyliorhinus canicula*, *Pagellus erythrinus*, *Scorpena notata*, *Spicara smaris*, *Octopus vulgaris* and *Loligo vulgaris* (Massuti and Ordinas, 2006). Recently, examples of this type of bottom habitat in relatively undisturbed condition and, therefore, excellent candidates for conservation measures have been discovered southeast of the Cabrera archipelago at 50 to 80m depth). In these areas *Lithothmanion valens* is the dominant species of encrusting red alga (Aguilar *et al.,* 2007).

Soft red algae

Deep-water *Peyssonnelia* beds have a widespread distribution from 40m to 80 m depth on the Balearic continental shelf and have been studied to some degree (Ballesteros, 1994). These beds are mainly comprised of the free-living red alga *Peysonellia squamaria* in the basal layer. Corallinacea are also present, but with very much lower biomass indices. The red algae *Phyllophora nervosa* and *Osmundaria volubilis* comprise the erect stratum. These beds have very high biomass indices, and some commercially important species are more abundant in these sensitive habitats. Management of these habitats therefore needs to take into account the resilience of these habitats and their importance to the life histories of targeted species. (Ordines and Massuti 2008)

3.3.2. Deep Shelf habitats

Crinoid beds

The feather stars *Leptometra* spp.are suspension-feeding organisms which live in shelf-break areas with a high hydrodynamic activity and which have a high input of organic matter and of planktonic organisms. (Flach *et al*., 1998; Lavaleye *et al.,* 2002; Orsi Relini *et al*., 2006). They are found in the deep continental shelf and shelf-break in the western Mediterranean and represent a very important sensitive habitat (SH) (Abelló and Solá, 2006). Individual feather stars are very fragile and vulnerable to demersal trawling (Smith *et al*., 2000; Sánchez *et al.,* 2004).

High densities of *L. phalangium* form crinoid beds which act to shelter small benthic and macroplanktonic organisms. Such beds also appear to act as spawning aggregation areas for some fish species, such as *Mullus barbatus* and *Lepidorhombus boscii*. Recruits of other fish species, such as *Merluccius merluccius*, *Helicolenus dactylopterus*, *Phycis blennoides* and of the octopus *Eledone cirrhosa* ocasionally concentrate in these habitats (Colloca et al., 2004; Orsi Relini et al., 2006).

According to Massuti and Ordinas (2006) *Leptometra* beds (most commonly represented by the species *Leptometra phalangium*) are mainly distributed on the muddy-sand detritic bottoms of S and NE Mallorca and around Menorca, at between 90 and 250 m depth. In contrast to other deep shelf bottoms, these crinoid beds are characterised by a high biomass of invertebrates (mainly *Echinus* spp. and *Stichopus regalis)*. These beds have a possible role in the production of some demersal resources, such as *Merluccius merluccius* and *Mullus barbatus* (Colloca *et al.*, 2004)

White-coral communities

Located at depths of between 300 and 1000m, these benthic communities are dominated by colonies of the scleractinians *Lophelia pertusa* and *Madrepora oculata*. Their current distribution is poorly known, although they appear to have been very common in the Mediterranean at the time of the last glaciation (Arzzidone 2006). These cold-water corals form reefs which support high local biodiversity and productivity. The occurrence of live colonies of *Madrepora oculata* have been reported from the Balearic Islands (Cartes *et al.,* 2004; Tursi *et al.,* 2004).

Gorgonians (Isidella elongate) communities

The octocoral *Isidella elongata* characteristically colonises mud substrates in waters of between 500 and 1200 m. Around the Balearics, high densities of *Isidella sp.* have been reported on the continental slope off N and S Ibiza Island. Areas of both live and dead corals support commercially exploited species. For example, hake (*Merluccius merluccius)*, blue whiting (*Micromesistius poutassou*), deep water pink shrimp (*Parapenaeus longirostris*) and the giant red shrimp (*Aristaeomorpha foliacea*) are more abundant in areas with live corals over this depth range. The red shrimp *Aristeus antennatus*, which is the most important of the commercial species exploited in these habitats appears to be more abundant in areas with dead corals. In general, these octocoralline assemblages have been heavily compromised by trawl fishing. (Arzzidone 2006; Maynou and Cartes 2006).

Tall sea pen (Funiculina quadrangularis) communities

Throughout the Mediterranean, muddy deep shelf edge and upper slope areas support sometimes large colonies of the anthozoan *Funiculina quadrangularis* while other areas support the large brachipods *Gryphus vitreus*. Aguilar *et al.,*(2007) reported *Funiculina quadrangularis* communities along with other cnidarian species (e.g. *Pennatula* spp., *Pteroides griseum*, *Virgularia mirabilis*) on soft bottom substrates at many locations around the Cabrera archipelago. In common with the coral *I.elongata*, sea pen communities appear to have been seriously degraded by bottom trawling at many locations in the Mediterranean (Arzzidone 2006).

Cold-seeps

The recent discovery of sea floor pockmarks in the Ibiza Channel (Acosta *et al.,* 2001b) and in the Mallorca Channel (Acosta *et al.,* 2004b) suggests that cold seep type communities may be a feature of these areas.

3.4 Human activities and threats

3.4.1 Overfishing and impacts of fishing activities

Fishing Activity

According to data provided from the Balearic Parliament (Consellería d'Agricultura i Pesca del Govern Balear), the fishing fleet of the Balearic Islands is mainly represented by artisanal fishing boats (349 fishing boats which use gillnets as the main fishing gear). The second in importance is the bottom-trawling fleet with a total of 55 trawlers with fishing permits in the area. Others include purse seiners and longliners with 12 fishing boats active in each fishery.

BluefinTuna and Swordfish under threat

The bluefin tuna is one of the main target species for the purse seine fleets that operate to the south of Balearic Islands, southwest of Mallorca Island, between Mallorca and Ibiza (WWF 2008, Garcia *et al.,* 2003a, 2004). This is a known spawning area for this species that is now closed to purse seiners and large long-liners during the July spawning period. Long-term over-fishing and mismanagement of bluefin tuna in the Mediterranean has led to a rapid decline and the incipient collapse of the stock. Serious concerns are now attached to the long term survival of this valuable resource species.(ICCAT, 2008, WWF 2008). The Standing Committee for Research and Statistics (SCRS) for ICCAT produces a biannual stock assessment for the species. In 2008 the SCRS made an evaluation from the ICCAT vessel list and estimated a probable catch in 2007 of 47,8000t for the Mediterranean. Combined with a further 13,200t for the East Atlantic the total catch for the stock came to 61,100t. This figure is twice the legal quota which is set at 29,500t and over four times the level of 15,000t recommended by ICCAT's own scientific advisors. As acknowledged by the Committee there is also significant underreporting which is substantiated by markets data (ICCAT 2008a).

The fleet that operates around the Balearic Islands are of French and Catalan origin rather than from the local Balearic fleet.

Swordfish is also known to spawn in these waters and has been similarly over-fished with the fishery taking many large catches of small fish under three years old, many of which have never spawned. The total 2006 catch has been estimated to be around to 14,000 t. ICCAT's SCRS believes that the spawning stock level is less than half that necessary to achieve the ICCAT Convention objective and that its estimates of recent fishing mortality rates are more than twice the amount, which if allowed to continue unabated is expected to drive the spawning biomass to a very low level within a generation (ICCAT 2008b).

Use of Destructive fishing techniques – Bottom Trawling

The trawl fisheries operating around the Balearic Islands target around 104 species (Massuti *et al.,* 1996). Target species include the red shrimp (*Aristeus antennatus*), red mullet (*Mullus surmuletus)*, hake (*Merluccius merluccius*), Norwegian lobster (*Nephrops norvegicus)*, picarel (*Spicara smaris*), blue whiting (*Micromesistius poutassou*), In the Balearic Islands, there are two main fishing grounds where the fleet mainly operates: The Ibiza-Formentera and the Mallorca-Menorca channels (Canals *et al.,* 1982). Exploitation of demersal resources extends from 800m to 1000m depth in some northern areas. On the shelf break and upper slope there are two main target species: the European hake, fished at the shelf break and the beginning of the slope between 120 and 350 m depth, and the red shrimp, which is fished on the upper slope between 550m and 800m depth. Currently, the Mallorca trawl fleet operates in greater depths of water during the summer (Moranta *et al.,* 2008).

Trawling is known to have extremely marked direct impacts on the sea-bottom (Demestre *et al.*, 2000, Tudela 2004). The biological communities found in submarine canyons, cold seeps, cold-water coral reefs, seamounts and brine pools are threatened by uncontrolled bottom trawling fishing (Cartes *et al.,* 2004). Gorgonian communities (e.g. *Isidella elongata*) (which can harbour target species such as red shrimps) and other sessile organisms are immediately removed from soft bottoms by trawling. This changes the associated benthic community . Trawling on *Isidella* spp. communities causes direct impacts on the slope assemblages, by removing the habitat-forming corals. This decreases the species diversity of this habitat and shifts the biological community to one more dominated by benthophagous species (Maynou and Cartes 2006).

As a result of trawling damage, biological assemblages change from those dominated by filter feeders (e.g. sponges, brachiopods such as *Gryphus vitreus*) and low-trophic level predators (gorgonians) towards other communities dominated by deposit feeders and their predators. Trawling may also have a negative impact on colonies of other hard-bottom dwelling and rare corals (e.g. *Lophelia pertusa* and *Madrepora oculata*), living in the deep Mediterranean. Maërl beds in the channel between Mallorca and Menorca and neighbouring areas are also threatened by bottom trawling (Massuti and Ordinas 2006). In addition to the red coralline algae which slowly form the maerl, the beds also support the brown algal species *Laminaria rodriguezii*, which is well represented in the Cabrera archipelago (Aguilar *et al.,* 2007) Trawl fishery bycatch is considered to be the single greatest threat to cartilaginous fish species in the Mediterranean according to the last IUCN Red List assessment results. All species are affected or are potentially affected, although for certain pelagic species such as blue shark (*Prionace glauca*) and makos (*Isurus* spp.) the impacts may predominantly affect specific life stages. The K-selected life history characteristics of most chondrichthyan fishes render them intrinsically vulnerable to fishing pressure since thay mature slowly and produce few young. Populations, once depleted, have little capacity to recover (Cavanagh and Gibson, 2007)

Bycatch

Longline fishing gear is a significant source of seabird mortality through bycatch (Oro *et al*., 2004; Arcos et al., 2008). Turtles are also vulnerable (Aguilar et at., 1995, Tómas et al., 2002), together with sharks (Cavanagh and Gibson, 2007), and cetaceans (see: Notarbartolo di Sciara 2006)). Longline fisheries targeting swordfish and tunas also pose a great threat to susceptible chondrichthyans taken as bycatch in this fishery (ICCAT, 2001).

In addition, cetacean species may be affected by the artisanal fleet operations (Silvani *et al.,* 1992, Reeves and Nortabalo di Sciara, 2006). In the Balearic Islands, the inshore occurrence of bottlenose dolphins coupled with the fact that the local fleet is extensive and mostly operates near the coast, has made interactions between these cetaceans and fisheries particularly common. According to fishermen, interactions are particularly intense in trammel net fishing for red mullet (Mullus surmuletus). Dolphins are held responsible for damaging nets and causing significant losses to the catch. In the past, this has led to the harassment and deliberate killing of dolphins by fishermen (Silvani *et al.,* 1992).

3.4.2. Pollution

Organochlorine compounds have been identified as contaminants of the deep Mediterranean, as evidenced by both the physical detection of xenobiotic chemicals in deep water organisms and the activation of enzymes systems such as the P450 cytochrome system in contaminated organisms which indicate exposure to persistent xenobiotics. Elevated enzyme activity has been detected in deep-sea fish living between 1500-1800m depth,(Porte et al., 2000). Polluting chemicals can contaminate food resources, concentrating in animals at the top of the food chain such as marine mammals, sharks and seabirds. At high levels these chemicals can affect physiological and reproductive functioning. (UNEP MAP RAC/SPA 2003). A number of studies have shown that some Mediterranean elasmobranch fish such as the spiny dogfish (*Squalus acanthias*), have flesh concentrations of mercury high enough to render them dangerous for human consumption. Trace metals and organochlorine residues have been found in the eggs, muscles, liver and kidneys of deep sea sharks such as gulper shark (*Centrophorus granulosus*) and blackmouth catshark (*Galeus melastomus*), also confirming that deepwater species are also being affected by pollution (UNEP RAC/SPA 2002).

In addition to impacts from chemicals entering the Mediterranean Sea from land based sources, large amounts of plastic debris also enter the sea from land based activities and the operation of recreational and commercial fishing boats. Fishing gear, plastics and a variety of unidentified objects were found in many of the areas of the Cabrera Archipelago studied (Aguilar et al., 2007).

3.4.3. Alien Species

Introduced alien species are a major driver of biodiversity loss in the Mediterranean. Six of the eight marine macroalgae known to behave as invasive species in Mediterranean benthic communities have been recorded in the Balearic Islands during the last fifteen years (Hormes *et al.*, 2009). There has been an invasion of the green algae *Caulerpa taxifolia* and *Caulerpa racemosa* which outcompete seagrass species, particularly *Posidonia* meadows (Galil 2007). *Caulerpa racemosa* has not been studied as intensively, as *C. taxifolia*, but it is becoming clear that it may adopt different morphological characteristics in different regions, that it can colonise all types of substrata including rock, sand, mud and dead *Posidonia* meadows, down to 60 m depth. It can interfere with marine coastal biocenoses and its expansion in range, may alter marine habitats. A recent study involving ROV techniques conducted in the National- Maritime Park “Cabrera archipelago” (south of Mallorca Is) showed abundant presence of *Caulerpa racemosa* and the red invasive algae *Lophocladia lallemadi*, particularly in the northern and southern extremities of the studied area (Aguilar et al., 2007)

One of the invasive species that represents the greatest danger to coralligenous beds is *Womersleyella (Polysiphonia) setacea*. This species grows quickly and reduces the amount of light that reaches the constructing algae (Perez *et al.,* 2000) and also diminishes biodiversity in this community (Airoldi *et al.,* 1995). Other invasive species that can affect the growth and development of this habitat are *Lophocladia lallemandii*, *Asparagopsis taxiformis* and *Caulerpa taxifolia* (Aguilar et al., 2007). There is evidence that already degraded habitats can be more easily overwhelmed by invasive alien species. (Galil 2000, Occhipinti-Ambrogi and Savini 2003)

3.4.4 Tourism

Tourism is the main industry in Majorca and Menorca. In 2005 they together received 9.3 million visitors and there are 35,000 leisure boats registered in the islands, amounting to one boat for every 25m of coastline. Many boats anchor without any kind of control over all types of seabed habitat. In particular, frequent diving activities in areas of high ecological value can bring about serious damage from repeated anchoring in coralligenous zones. The increase of human population in coastal regions, particularly during the summer months (Blue Plan 2006) has altered breeding sites of many marine species. Some of these are listed as endangered (IUCN 2007) (e.g. Loggerhead turtle (*Caretta caretta*) and the Balearic shearwater (*Puffinus mauretanicus*). Human disturbance of birds can cause them to abandon their young. In the case of the Balearic shearwater it has been estimated that if disturbances and impacts are maintained at their current level, there is a 50% chance that the species could become extinct within the following three generations (Arcos and Oro 2003). .

3.4.5 Climate Change & Ocean Acidification

Although assessments have been made of the potential impacts of climate change within the various European regions (see: Schroter *et al* 2005), the potential changes in marine systems have not been well characterized to date. In relation to the Mediterranean, sea water temperature and salinity are likely to increase over the whole of the Mediterranean Sea, with variations existing between different regions. Modelling of the impact of such changes suggests that the deep water circulation processes in the Mediterranean Sea could be disrupted, and the intensity of winter convection decreased (Somot *et al.* 2004). Analysis of changes in the Western Mediterranean Deep Water (WMDW) circulation suggests that the WMDW could be highly sensitive to rapid climate change (Frigola *et al.* 2008).

The impacts of anthropogenically driven climate change upon biological systems remain highly speculative. Nonetheless, it is likely that they will be profound. Such impacts could include changes in the natural boundaries of the different biogeographic regions of the Western Mediterranean. Hence, some warm water species could be driven north into areas from which they were previously absent (European Science Foundation 2007). This is supported by the fact that the temperature of the western Mediterranean has been rising for the last 20 -30 years and scientists have already recorded a concomitant increase in the abundance of some thermophilic species, including algae, echinoderms and fish (Allsopp *et al.* 2009). A recent study has also concluded that the Mediterranean Sea, a hotspot of endemism, is under increasing threat from invasions of exotic fish species from further south which are benefitting from global warming by expanding their ranges northwards (Lasram and Mouillot 2009).

Large scale atmospheric variability in the North Atlantic Ocean has been shown to be a major driver of the regional meteorological variations and hydrographic patterns in the Balearic Sea area. In turn these control control the abundance of copepods both directly and indirectly (Fernández de Puelles and Molinero 2007). A 2005 study showed that the increased temperatures experienced in the western Mediterranean during the 1980s led to increases in the numbers of jellyfish. These predated upon zooplanktonic species resulting, among other things, in a strong decrease in copepod abundance (Molinero *et al.* 2005). Changes in the availability of plankton due to climate change are likely to result in significant cascade effects throughout the marine foodweb.

The favoured food of the fin whales *Balaenoptera physalus* inhabiting the Mediterranean is the coldwater euphausid species *Meganyctiphanes norvegica* and the whales' distribution appears to be closely linked to the distribution of their prey (Cotté *et al.* 2009). If environmental conditions become unsuitable for this euphausid, it is not likely to be able to adapt since its scope for northwards movement is restricted by the enclosed nature of the Mediterranean. This will have significant consequences for the fin whales and for other predators (Gambaiani et al. 2009).

The rise of atmospheric CO_2 is also predicted to make the oceans more acidic. As CO_2 is absorbed by the ocean it combines with the water resulting in the formation of carbonic acid, so lowering the pH. As the seawater becomes more acidic so the concentration of calcium carbonate in the form of calcite and aragonite decreases with serious consequences for those organisms that rely on calcification for building their shells and other skeletal structures. The marine species most likely to be affected by this acidification will be small and thin-shelled organisms that use $CaCO_3$. These include calcifying plankton (e.g. coccolithophores), coralline algae, pteropod molluscs and coral polyps (e.g. reef-building scleractinian corals) (see Turley and Findlay 2009).

Climate change and ocean acidification together pose serious threats to maërl and coralligenous beds, as changes in sea temperatures as well as in pH can affect calcification rates of the algae involved in these communities. Several episodes of mass mortality of suspension-feeding animals in large areas of coralligenous beds in the Mediterranean Sea (Ballesteros 2003) have been related to the high temperatures that were reached in these waters (Vacelet 1991).

The impacts of climate change upon migrating bird populations remain unclear. Potential changes in the migration sites and winter grounds for the endangered Balearic shearwater, for example, are poorly documented and understood (Arcos and Oro, 2004). While climate change has been considered to be a determining factor of changes in winter distribution of the species in the Atlantic (Wynn et al., 2007), this has been disputed and remains unresolved (Votier et al., 2008).

3.5 Ecological characterisation against criteria

3.5.1 Uniqueness or rarity

Unique and rare habitats.

There are a significant number of rare or unique habitats in the Southern Balearics that were described in Numeral 3.3. They include m*aërl* grounds and *Peyssonnelia* beds in the shallow shelf; and crinoid beds, white-coral communities, *Isidella elongate* communities and *Funiculina quadrangularis* communities in deeper waters. There are also a number oftopographic features of high ecological potential that require further research and that were described in numeral 3.2. These include the Emile Bardeau, Mont dels Oliva and Mont Ausias Marc seamounts; the southwest volcanic field located south of Emile Bardeau Seamount; and the probable presence of cold seep communities associated with the pockmarks located in the Ibiza Channel and Mallorca channels .

Endemic and rare species

According to Cartes and Sorbes, (1999), 25.4% of bathyal malacostracan crustacean peracarida in the Catalano-Balearic Basin can be considered as endemic. In the Algerian Basin, at depths between 249 and 1622 m, the percentage of endemic species among suprabenthic peracarida was slightly lower than in the Catalan Sea (18.2%: calculated from Cartes *et al.,* 2003). Below 2500-3000 m the number of endemic species is low, particularly in the deep bathyal domain. New sampling programmes are increasingly reporting new endemic taxa in the deep Mediterranean, and the faunal composition of deep-sea communities is far from being completely recognized, especially for small faunal groups (Cartes *et al.,* 2009).

Three species of seabirds are endemic to the Mediterranean region, and one of these, the Balearic shearwater (*Puffinus mauretanicus*), is restricted to the Balearic Archipelago,. The Balearic shearwater is the rarest Mediterranean seabird with an estimated breeding population of only 3300 pairs (Aguilar 1991). The lack of specific knowledge about this threatened shearwater is of particular concern since a good understanding of its biology is important in order to design appropriate conservation strategies (Oro *et al.,* 2009).

3.5.2 Special importance for life history stages

In order to confer adequate protection to the following species special attention will have to be given to the role of the Southern Balearics in their life histories.

Bluefin Tuna

BFT are of considerable commercial importance and the eastern stock of BFT ranges over the eastern part of the Atlantic Ocean, from Iceland to Cape Blanco off the Moroccan coasts. Migration towards the Mediterranean takes place during the reproductive season with spawning mainly taking place in June (Rodríguez-Roda, 1980). BFT appear to exhibit spawning site fidelity in both the Mediterranean Sea and the Gulf of Mexico, the two main spawning areas which have been clearly identified (Block et al., 2005; Teo *et al.,* 2007). Hence, adults born in the Mediterranean Sea return to the western and central areas to spawn.The southern Balearic area is considered one of the most important spawning sites for the species along with others which have been identified in Sicilian waters and in the eastern basin off the coasts of Turkey and northern Cyprus (García *et al.,* 2003; Karakulak *et al*., 2004).

It is thought that the complex hydrodynamic regime which exists around the Balearic Islands, particularly the southern part, resulting from the interaction between the inflowing surface Atlantic water masses (AW) and Mediterranean surface waters (MW), play a key role in the spawning of BFT (García *et al.,* 2003; Alemany *et al.,* 2005, 2006, 2007). Past surveys on BFT spawning behaviour off the Balearic archipelago imply that BFT favours the low salinity (Atlantic waters) and a specific temperature range of (23-25ºC) (Bernal and Quintanilla, 2005; García *et al.,* 2003) making the Balearic Sea conditions close to ideal for BFT spawning.

Other pelagic fish

A recent survey conducted just off the eastern coast of the Mallorca Islands found considerable numbers of billfish larvae (Alemany *et al.,* 2006). Other pelagic species that are also known to reproduce in summer around the Balearic Islands include albacore, common dolphinfish (*Coryphaena hippurus*), small tuna such as frigate tuna (*Auxis* sp.,), little tunny, skipjack tuna, Other large scombroids breeding in the area include Swordfish (*Xiphias gladius*) and *Tetrapturus* spp., (Alemany *et al.,* 2006). Small pelagic species spawning in these waters include anchovy (*Engraulis encrasicolus*) and round sardinella (*Sardinella aurita*).

Marine Mamals

In addition to species of marine mammals present throughout the year, such as the bottlenose dolphin, other marine mammals are sighted around the Balearic Islands and these waters may be important to them as possible feeding and mating ground.

The fin whale is the largest free-ranging predator found in the Mediterranean Sea. Recent studies (Cotté et al., 2009) suggest that fin whales have a year round presence to the North of the Balearic Islands with winter distribution patterns being more dispersed. It appears that whales were observed mostly within the mean cyclonic circulation in the northern part of the Western Mediterranean, limited to the north by the Northern Current and to the south by the North Balearic front (Rio et al., 2007). This species is known to favour upwelling and frontal zones with high zooplankton concentrations.

In the Mediterranean Sea, the sperm whale mostly inhabits the continental slope waters where mesopelagic cephalopods, the species' preferred prey, are most abundant (Reeves and Notarbartolo 2006). Buchan (2005) concluded that oceanographic parameters together with depth and topography were most relevant to sperm whale presence in Balearic waters. In the eastern Mediterranean, both solitary males and social units may remain in a limited area for more than a month, or may visit that area repeatedly during the same summer season, indicating that they stay in neighbouring waters (see Reeves and Notarbartolo 2006) Genetic data suggest that sperm whales in the Mediterranean constitute a separate population (see Drouot et al. (2004),

Marine Turtles

The Balearic Archipelago is an important developmental habitat for loggerhead turtles. The loggerhead turtle has a complex life cycle (Carreras et al., 2004). Large numbers of late juvenile loggerhead turtles occur all year round off the Balearic Islands (e.g. Mejías and Amengual, 2001) while juvenile loggerhead sea turtles from rookeries located in the eastern Mediterranean and the north-western Atlantic use feeding grounds in the Western Mediterranean (Carreras et al., 2006) but there they experience high levels of attrition due to long-line by-catch. A recent study of loggerhead feeding in those living near the Balearic Archipelago suggested that the bulk of the diet of turtles is represented by squid and the Mediterranean jelly, *Cotylorhiza tuberculata*. Jellyfish and squid are the staple food for immature loggerhead turtles off the Archipelago and longline bait is the most likely source of some prey species, explaining the high levels of turtle interaction with longline fisheries (Carreras et al., 2004; Revelles et al., 2007). In addition boat collision, debris ingestion, and pollution have been identified as potential threats to turtles at sea (Lutcavage et al., 1997). However available information suggests that fishing is the most important one, as some declining populations are known to have recovered once fishing mortality was reduced (NMFS-SEFSC 2001). Loggerhead by-catch off the Balearic archipelago is likely to have a detrimental effect on the numbers nesting on beaches elsewhere (Carreras et al., 2004).

Sharks

71 species of cartilaginous fishes live and breed in the Mediterranean and many of these are present in the Balearic region,(Cavanagh and Gibson 2007). For many species, there is very little information available.

Aggregations of basking shark (*Cetorhinus maximus*), have been observed in the northern Balearic region, (Walker *et al*. 2005). A strong correlation between the presence of *C. maximus*, chlorophyll concentration and prey abundance in these areas indicates that they are important feeding sites (Sims 2003; Sims *et al*. 2003).

3.5.3. Importance for threatened/endangered/declining species or habitats

Coralligenous algal beds

Protected species named in the annexes of BARCOM (1995)-SPAM and which have been recorded mainly on coralligenous beds at the Balearic seamounts include *Paramuricea clavata*, *P. macrospina*, *Anthias anthias*, *Muraena helena*, *Lappanella fasciata* and *Phycis phycis* (see Aguilar *et al.,* 2007). The carnivorous sponge *Asbestopluma hypogea* although first found in deep areas is not always associated with bio-concretions. Since the discovery of *A. hypogea*, in 1995 (Vacelet and Boury-Esnault, 1996), it has generally only been recorded in shallow caves in France and Croatia. A specimen found on Ausias Marc seamount was on a coralligenous bio-concretion at 100 meters depth (Bakran-Petricioli *et al.* (2007).

Bluefin Tuna

It is a well known fact the Atlantic bluefin tuna alarming decline (Block 2005) as presented before in section 3.4.1. However, it is considered as data deficient in the IUCN list.

Other relevant species considered

DOLPHINS				
Relevant specie	***Status***	***Features***	***Threaths***	***Source***
Delphinus delphis – *Common Dolphin* Mediterr. sub-population	EN	Widespread and abundant in much of the Mediterranean Sea until the late 1960s, and that their decline occurred relatively quickly. Dolphins remain relatively abundant in the western most portion of the basin, the Alboran Sea.	Bycatch, fisheries-related interactions, netting (past, present), Pollution (affecting habitat and/or species) Water pollution (ongoing) Global warming/oceanic warming (present, future), Changes in native species dynamics - Prey/food base (past, present).	Bearzi 2003
Bottlenose dolphin *Tursiops truncatus*	VU	Scattered throughout the Mediterranean and fragmented into small units. One unit is found around the Balearic Islands. Commonly regarded as coastal/inshore animals although regularly found near the continental slope in the Balearic seas. In the Balearic region there are a number of protected areas set up for cetaceans. Local subpopulations of bottlenose dolphins appear to be influenced by biogeographic and hydrographic features in relation to their distribution and movement patterns	The near-shore distribution of the species results in frequent interactions with trawlers. However Massutí (unpublished data) monitored 460 commercial trawling operations off Majorca from 2001 to 2004 without reporting a single incidental catch of bottlenose dolphins. Other threats include increased boat traffic and human presence during the summer tourist season.	Reeves and Notarbartolo di Sciara, 2006 Forcada *et al.*, 2004 Gonzalvo and Aguilar, 2004 Natoli *et al.* 2005 Forcada *et al.* 2004
Striped dolphin *Stenella coeruleoalba*	VU	Abundance estimates were made for the Balearic Sea for 1991 suggesting the presence of 5,826 animals (95%CI=2,193-15,476) (). The species has reference for highly productive, open waters beyond the continental shelf (e.g.). Status is still decreasing.	1990-92 epizootic due to morbillivirus infection affected Mediterranean population as a whole and resulted in many thousands of deaths PCBs and other organochlorine pollutants with potential for immunosuppression may have helped trigger the event and/or enhanced its spread and lethality Data from fishing activities are sparse but indicate that the species mortality from pelagic purse seines, longlines and gillnets is widespread and likely to be significant but no records exist for the Balearic area	Reeves and Notarbartolo 2006 Aguilar and Raga, 1993 Aguilar and Borrell, 1994 Forcada and Hammond, 1998 Gannier, 2005
PINNIPED				
Relevant specie	***Status***	***Features***	***Threaths***	***Source***
Monk seal *Monachus monachus*	CR	Only pinniped species present in the Mediterranean Sea and regarded as the world's most endangered pinniped The species has disappeared from most of its former range, including Balearic Islands.	Main threats are linked to human activities and include exploitation, bycatch and the increase of tourism causing significant disturbance to breeding colonies, as well as the risk of vessel accidents, spills, transmission of disease, and the discharge of pollutants and waste near the seals	IUCN 2000, UNEP-WCMC 2005 UNEP/MAP 1994, Aguilar 1998

NOTE: VU= Vulnerable, EN= Endangered, CR=Critically Endangered ; DD= Data deficient

Other relevant species considered (continued)

WHALES				
Relevant specie	***Status***	***Features***	***Threaths***	***Source***
Sperm whale *Physeter macrocephalus*	EN	Genetic data suggest that sperm whales in the Mediterranean constitute a separate sub-population from the Atlantic This subpopulation comprises fewer than 2,500 mature individuals and numbers of mature individuals continue to decline. No estimate of population numbers exists for the region but results from a survey in summer 2003 of a large portion of the western Med basin suggested that sperm whale numbers are significantly higher in the western basin than in the Ionian Sea	Entanglement in high seas swordfish driftnets, which has caused considerable mortality since the mid-1990s Ship strikes Noise pollution particularly linked to the intense maritime traffic but also from seismic testing equipment. Military operations, and illegal dynamite fishing	Reeves and Notarbartolo 2006 Drouot *et al.* 2004
Fin whale *Balaenoptera physalus*	DD	Estimated that there were 3,583 fin whales (S.E. 967, 95% C.I. 2,130-6,027) in a survey covering a large proportion of the western Mediterranean in 1991. Insufficient data exist to determine trends in abundance and of population-level threats		Forcada *et al.* 1996 Reeves and Notarbartolo di Sciara, 2006
CHONDRICHTHYANS (CARTILAGINOUS FISH)				
Relevant specie	***Status***	***Features***	***Threats***	***Source***
Blue shark *Prionauce glauca*	VU	Among the main commercially exploited species. It has recommended that a sustainable management programme	Fisheries either as a target species or as bycatch.	UNEP RAC/SPA
Angel shark *Squatina spp*	CR	All three European species are considered to be critically endangered by the IUCN. The low rate of exchange between isolated populations living in the waters around the Balearics, leaves them particularly to local depletion, given that recolonisation rates will be extremely low		Massutí and Moranta 2003
Rabbitfish *Chimaera monstrosa*	NT	Found at depths from 100m but is most abundant between 500–800m in depth. Several specimens have been reported from the Balearic Sea at depths of 650m No specific data on population trends over time are available.	its preferred depth exposes it to fishing activity while it also has a low reproductive capacity. When discarded it is expected to have a high mortality rate.	Sion *et al.* 2004 Baino *et al.* 2001
Great White Shark *Carcharodon carcharias*	VU global E Medit.	It is listed under Appendix II of the Bern Convention (Strictly Protected Fauna Species) and by the Barcelona Convention (Endangered or Threatened species). *C. carcharias* has a tendency to approach boats readily and to scavenge from fishing gear. This can result in accidental entrapment or in deliberate killing by commercial fishermen	Sport fishing, commercial trophy hunting or capture for human consumption. Offshore records in the Mediterranean show that white sharks in all size-classes are made by pelagic longlines, bottom trawls, driftnets and purse seines.	Fergusson *et al.* in prep Morey *et al.*, 2003 Fergusson *et al.*, 2005
SEA TURTLES				
Relevant specie	***Status***	***Features***	***Threaths***	***Source***
Loggerhead turtle	EN	Satellite tracking studies have revealed that some 80% of young loggerhead turtles found in the central and southern Mediterranean Sea spend most of their time in the open ocean areas where the water is deeper than 1400m The remaining 20% visit the continental shelf on a regular basis and are likely to have access to benthic prey and fish discarded from bottom trawlers	Marine turtles in the Mediterranean are threatened by past overexploitation, by fishing activities, coastal development and tourism, shipping and pollution	IUCN, 2004 Cardona *et al.*, 2005 Margaritoulis, 2003
Green Turtles	CR			
Leatherback turtles	CR			

NOTE: VU= Vulnerable, EN= Endangered, CR=Critically Endangered ; DD= Data deficient

Other relevant species considered (continued)

SEA BIRDS				
Relevant specie	***Status***	***Features***	***Threats***	***Source***
Balearic shearwater *Puffinus yelkouan mauretanicus*	CR	This is considered to be the most seriously threatened Mediterranean Seabird. Endemic to Balearic Islands, particularly Formentera Recent studies have estimated the population at 2,000 reproductive pairs.	Bycatch in longliner fisheries Overfishing of the main prey species Destruction of habitat Pollution and spillage Depredation by rats and feral cats Competition with *Calonectris diomedea* for breeding sites	Birdlife International, 2008, Aguilar 1991 Oro *et al.*, 2009 Arcos *et al*., 2008; Mayol *et al*., 2000 Rufino *et al.* 2009
Audouin´s gull (*Laurus audouinii)*	VU	the Cabrera archipelago southwest of Mallorca is one of the most important breeding grounds in the Mediterranean basin.	Disturbance of breeding colonies Overfishing leading to a decrease of prey species particularly during their breeding season Pollution and habitat destruction. Human settlements have dramatically reduced the availability of suitable breeding sites.	Oro and Muntaner, 2000 Oro *et al*., 2003
European shag *Phalacrocorax aristotelis*	VU	The biggest reproductive colonies of this subspecies are located in the Balearic Islands although other dispersal breeding sites exist along the Spanish Mediterranean coast including small islands. In 2000, the reproductive population in the Balearic Islands was estimated at around 1.333 breeding pairs	The bycatch of juveniles in surface longline gear and driftnets, "soltas" and almadrabas is one important threat. (Guyot and Thibault, 1985; Guyot 1990). Other threats include the overexploitation of main fish resources reducing prey availability	Muntaner and Aguilar 1995 Paracuellos & Nevado, 2000 J. Muntaner, pers. comm.)

NOTE: VU= Vulnerable, EN= Endangered, CR=Critically Endangered, DD= Data deficient

3.5.4 Vulnerability, fragility, sensitivity or slow recovery

There are a large number of vulnerable habitats in the Southern Balearics that in addition can be considered as unique or rare. They were described in Numeral 3.3. and include the coralligenous communities found both in shallow waters and in the deep sea. Associated with these coralligenous communities are many species of high commercial value, for example, fish of the genera *Diplodus*, *Epinepheleus* and *Serranus*, large crustaceans and red coral (Ardizzone 2006).

Deep water corals grow very slowly (1.0-2.5 cm per year) and have an extremely long life span (Rogers 1999). These hard bottom communities are highly vulnerable to the mechanical destruction caused by bottom trawling which takes place in these waters. Such damage invariably reduces reef extent and causes a decline in biodiversity and in the density of associated organisms. Bottom trawling on nearby soft bottoms suspends sediments and settlement of these on reef areas can stress and even kill corals (Cartes *et al.,* 2004; Palanques *et al.,* 2004). The slow growth of these deep water organisms, coupled with commercial fisheries activity targeted at red shrimp species in waters up to 1000m depth, makes them highly vulnerable (Cartes *et al.,* 2004; Gianni 2004). Importantly trawl fisheries have been limited to 1000 m depth in the Mediterranean Sea (GFCM 2005) -. a precautionary ban that aims to protect still pristine and poorly understood deep-water ecosystems.

3.5.5 Biological productivity

Both, hydrodynamic forces in the area as well as the complex topographic features in the Balearics determine its productivity, as exposed in numeral 3.1.1 and 3.1. Particularly its southern part is a convergence area and therefore a strong retention zone where there is a high concentrations of nutrients due to the presence of fronts and mixing zones associated with reefs, canyons, seamounts and islands (Hyrenbach, 2000).

The Mallorca channel acts as a meeting point of the MAW and LAW water masses and the strong frontal systems generated along the northern side of Mallorca Island could explain the higher zooplankton biomass reported there (Cartes *et al.,* 2008). In addition, the Balearic Currents are also associated with the transport of nutrients accounting for the high concentrations of chlorophyll found in open sea waters off the Balearic Islands in summer (Jansá *et al.,* 2004; Sabatés *et al.,* 2007). Other relevant mechanisms that enhance the local productivity in the Mediterranean off the Balearics Islands are associated with changes in the slope orientation, the presence of canyons and shallow seamounts that interact with the currents creating upward vertical components typically upstream from these topographic features (Font *et al.,* 1990; Masó *et al.,* 1990). The existence of these mechanisms would explain the moderate levels of primary production recorded, especially in the western basin, as well as the relatively high fishery yield (Sabatés *et al.,* 2007).

Productivity occurs all along the water column, with seasonal variations. The upper layer of the water column shifts from well mixed water during autumn & winter to a strongly stratified one during spring and summer. The development of a thermocline in spring prevents vertical water mixing and nutrient supply to the surface waters is interrupted, causing a depletion of nutrients in the surface while deep chlorophyll maximum (DCM) can be found at the bottom of the photic zone (Estrada, 1985).

3.5.6 Biological diversity

Biological Hotspots

Most of the habitats considered as unique, vulnerable and productive, area also areas of biological diversity. Zones that are potentially considered as biodiversity hotspots include seamounts , Isidella elongate communities, crinoid beds and Maërl grounds.

Seamounts are recognized as zones with high biodiversity and high rates of endemism (Richer de Forges *et al.,* 2000; Matthiessen *et al.,* 2001; Santillo and Johnson, 2003; Morato and Pauly (eds), 2004). It has long been recognized that seamounts concentrate water currents and can have their own localized tides, eddies and upwellings (Santillo and Johnson 2003). It seems that the seamounts act as a foraging habitat for pelagic species (e.g. swordfish) which are attracted by the high concentrations of zooplankton and micronekton. The plankton biomass is often high over seamounts and this combined with the constant influx of prey organisms means they can attract large numbers of pelagic top predators (some commercially important) including marine mammals, sharks, tuna and cephalopods (Worm *et al.,* 2003) and even seabirds have been shown to be more abundant in surrounding shallow seamounts. In the Southern Balearics some impressive seamounts have been identified but for which the biodiversity values are still poorly known.

Deep-sea coral mounds are considered hotspot of Mediterranean biodiversity and can represent an essential fish habitat for many commercial species since its tree- or candelabra-like structures provides ecological niches to Mediterranean deep-sea species (SGMED, 2006). As presented in numeral 3.3.2. this habitat is found in the Southern Balearics. Some commercial fishes and like hake (*Merluccius merluccius)* and blue whiting (*Micromesistius poutassou)*, as well as decapods crustaceans *Parapenaeus longirostris* and *Aristaeomorpha foliacea* are more abundant in areas with live corals over this depth range. In contrast, the deep water red shrimps *Aristeus antennatus* one of the main commercial species on this facies, is more abundant in areas with dead corals. *Isidella elongata*, also constitutes a selected habitat for other commercial deep water shrimps the *Aristaeomorpha foliacea* (Maynou and Cartes 2006).

Leptometra beds (crinoids) enhance habitat heterogeneity and consistent species richness. According to results obtained during the trawl survey BALAR 0505, *Leptometra* beds (mainly represented by the species *Leptometra phalangium*) are mainly distributed on muddy-sand detritic bottoms of S and NE Mallorca and around Menorca, between 90 and 250m depth. High concentrations of epibenthic, suspensivorous organisms occur in these grounds as a result of the occurrence of bottom currents. In contrast with other deep shelf bottoms, these crinoid beds are characterised by higher biomass of invertebrates (mainly *Echinus spp*. and

Stichopus regalis). In addition, this can also act as essential fish habitat for many commercial species including *Merluccius merluccius, Micromesistius poutassou* and *Trisopterus minutus capelanus* (Maynou and Cartes 2006). Main concentrations of juveniles *Merluccius merluccius* are found S and NE Mallorca, where *Leptometra* beds are mainly distributed as well as large specimens of *Zeus faber* and *Raja clavata* seems to be related to *Leptometra* beds (Massuti and Ordinas, 2006).

Maërl beds have been described as areas of high diversity and ecological importance (Barberá *et al.,* 2003), being two of the most productive ecosystems in temperate regions (Martin *et al.,* 2007).

Ichthyoplankton diversity

Larvae of some large migratory species, e.g. T*hunnus thynnus, Thunnus alalunga or Coryphaena hippurus*, small tuna such as *Auxis* sp., *Euthynnus alleteratus, Sarda Sarda* or *Katsuwonus pelamy*s, or other large scombroids such as *Xiphias gladius* or *Tetrapturus* sp., also reproduce in summer around the Balearic Islands (Alemany 1997; Alemany *et al.,* 2006). This implies that during spring–summer there is high ichthyoplankton diversity.

3.5.7 Naturalness

The islands and coasts of the Mediterranean have highly populated for millennia and throughout history the Mediterranean and its marine life have played a major part in the lives and cultures of the people living there. Fishing and gathering seafood have been, and continue to be, of major importance to millions of people and some of the world's busiest shipping routes are to be found in the Mediterranean. Given the multiple ocean and land based anthropogenic drivers, it is unsurprising that the global map of human impact on marine impacts drawn up by Halpern and colleagues shows the Mediterranean to be an area of high human impact (Halpern et al. 2008). It would be hard to argue that this criterion is applicable to any area in the Mediterranean and certainly not in the Western Mediterranean; this of course does not mean that areas should not be selected for protection in the Mediterranean.

4. Sicilian Channel

4.1 Area description

The Sicilian Channel is the strait of the Sea located between the island of Sicily and Tunisia where Pantelleria (Italy), Pelagie Islands and Lampedusa (Italy), and Malta, Gozo and Comino Islands (Malta) are located. It plays an important role by dividing the Mediterranean Sea into two principal sub-basins, the eastern and the western Mediterranean. The complex topography and circulation scheme makes the Sicilian Channel a highly productive area and a biodiversity hotspot within the Mediterranean. Its location means that it hosts many species from both basins.

4.1.1 Main topographic features

This Sicilian Channel has complex bottom morphology comprising two sill systems separated by an internal deep basin (Figure 5). The eastern sill system is divided in the Malta plateau and Medina Bank and it has maximum depth of about 540m and connects the Sicilian Channel with the Ionian Basin. The western sill is divided in the large Adventure Bank and the Nameless Bank (Gasparini *et al.,* 2005). These large sill systems are separated by the narrow shelf in the central part. The shape of slope is extremely irregular, incised by many canyons, trenches and steep slopes (Fiorentino *et al.,* 2006)

According to Civile *et al.* (2008), neogene rifting caused the development of three major depressions, the Pantelleria (1317-m depth), Linosa (1529-m depth), and Malta (1731-m depth), located in the central basin of the channel. The Pantelleria Trough, southeast of Pantelleria Island, is one of three narrow, steep-walled, elongate NW–SE troughs in the

Channel. Pantelleria Trough has almost straight, fault-bounded slopes, over 100 km long and 28 km wide, with depths reaching 1314 m. The western end of Pantelleria Trough is cut by two fault valleys running parallel to the southwest and northeast coasts of Pantelleria Island.

The sea bottoms of the littoral zone of the northern Tunisian coast are mainly rocky, while those of the eastern (Hammamet Gulf) and southern (Gabès Gulf) coasts are sandy to sandy-muddy (Ben Mustapha *et al.* 2002b). The rocky bottoms of the northern coast offer the best substratum for colonization by very rich coralligenous assemblages (Ben Mustapha *et al.*2002a), while in "la petite Syrte" i.e the Gulf of Gabès *sensu lato*, and in several parts of the Hammamet Gulf, the *Posidonia* meadows show their maximum geographical distribution (e.g. Ben Mustapha *et al.* 1999).

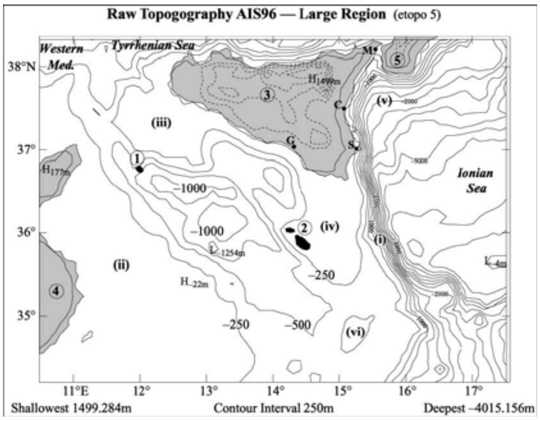


Fig. 5. Topography and geography of the Sicilian channel .

NOTE: The numbers indicate Pantelleria Island (1), Malta Island (2), Sicily (3), Tunisia (4) and Calabria (5). The (i)'s indicate topographic features (De Agostini, 1998): the Ionian slope (i), Tunisian shelf (ii), Adventure Bank (iii), Maltese plateau (iv), Messina Rise (v) and Medina Bank (vi). The letters indicate cities mentioned in the text: G for Gela, S for Siracusa, C for Catania and M for Messina.
SOURCE: *P.F.J. Lermusiaux, A.R. Robinson /Features of dominant mesoscale variability, circulation patterns and dynamics in the Strait of Sicily Deep-Sea Research I 48 (2001*)

4.1.2 Currents and nutrients circulation system

The Sicilian Channel is a high-energy site with a dynamic current system that exchanges the waters between western and eastern basins (Figure 6). Dynamically, the circulation in the Sicilian channel can be described as a two-layer exchange, the upper layer (about 200m thick) of Atlantic Water (AW) which flows eastward and the deep layer of Eastern Mediterranean Outflow Water (EOW) mainly composed of Levantine Intermediate Water (LIW here after) that flows in the opposite direction The AW splits into two branches at the entrance to the Sicilian Channel, one flowing to the Tyrrhenian Sea, the other into the Sicilian Channel. The second branch is composed by two streams, the Atlantic Ionian Stream (AIS) and the Atlantic Tunisian Current (ATC). In winter, the ATC is more pronounced. In summer, the AIS is associated with a number of well-known semi-permanent features including the intermittent northward extension of the AIS (NAIS) at the Ionian shelf break, which seems to be driven by the surface density contrast between waters of the Sicilian and the Ionian basins. (Beranger *et al.,* 2004).

In the subsurface layers the topography plays an important role. The LIW has a higher velocity due to the Bernoulli effect: LIW has a narrow area to flow in comparison the wide area available to AWAs consequence, it enables the upper layer of the Eastern Mediterranean Deep Water (EMDW) in the Ionian sea to reach the western basin (Gasparini *et al.,* 2005).

Upwelling along the eastern and southern costs of Sicily is a permanent feature. As explained by Beranger *et al.,* (2004), upwelling is governed by the south-eastward winds and by the inertia of the isopycnal domes of the AIS meanders and cyclonic vortices that can extend its influence far offshore due to the configuration of the circulation.

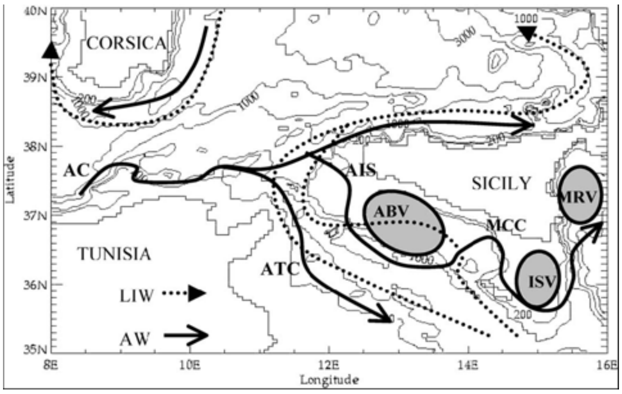


Fig. 6. Circulation of sea masses on the Sicilian channel .

NOTE: AC= Algerian Current AW= Atlantic Water; LIW= Levantine Intermediate Water; AIS=Atlantic Ionian Stream; ATC= Atlantic Tunisian Current
SOURCE: Beranger *et al.,* 2004

Many eddies of variable strength, shape and size (cyclonic and anticyclonic) are noticed in the Tunisian–Sicily region. According to Savini et al (2009 in press) between Adventure Bank and the Malta plateau, LIW forms a pair of subsurface eddies (one cyclonic, one anticyclonic) along the western flank of the Malta plateau and AIS forms a cyclonic vortex off Cape Passero.

4.2 Topographic Features of Remarkable Biological relevance

4.2.1. Seamounts

Seamounts are considered as highly productive and biodiversity hotspots, since they produce retention areas for phytoplankton and create the conditions that support a diversity of important habitat types. In the extension of the Sicilian continental shelf toward the Pantelleria Rift (Adventure Bank and Graham Bank plateaus), five volcanic seamounts have been recognized (Tetide, Anfitrite, Galatea, Cimotoe and Graham), three of which have been sampled. Two other much larger seamounts, Bannock and Nameless Bank (Banco Senza Nome), are located between the Malta and Pantelleria basins and close to the eastern border of the Nameless Bank respectively (Calanchi *et al.,* 1989).

4.2.2 Volcanic Islands and submerged volcanoes

Past volcanic activity in the Sicilian Channel has formed the islands of Pantelleria are Linosa. There is also volcanic activity underwater in the Graham Bank in the northwestern part of the channel. In the recent past, an eruption created the ephemeral Ferdinandea Island, with a diameter of about 600 m, constituted by a scoria cone that was rapidly eroded away. However, the underwater volcano, now known as a Graham Seamount or Empedocles Seamount is in fact part of a 3-km-long and 2-km-wide submerged edifice that rises from the sea-floor for about 180 m. Accordingly with Civile *et al.*(2008), at the base of the western slope, a 3-km-large and 1-km-long lava flow are recognizable and several fumaroles have been observed along the north eastern flank at depths ranging from −160 m to −50 m, following a roughly N–S direction. They are characterized by huge emissions that form well defined columns of bubble eruptions that can also be seen at the sea surface.

4.2.3 Slow-flux seeps

In research reported by Savini *et al. (*2009 *in press*) detailed acoustic mapping discovered more than 100 small-scale domes and peculiar ridges were a few miles offshore between 140 and 170 m water depth. Data collected suggest that both the domes and ridges are influenced by active slow-flux seeps. Mapped domes were found from 50 to 200 m wide and no more than 5 m high occurring on the seafloor, isolated or arranged in clusters. Ridges consisted of large tabular sub-elongated structures, elevated from 5 to 10 m from the surrounding seafloor, and had flat tops on which numerous close-set, small cones occurred, appearing in video observation as carbonate structures heavily colonized by gorgonians. There is evidence of past mud extrusion at the domes that is not longer evident and at the present time active degassing is the main process that controls the morphological and sedimentological expression of both the domes and ridges.

4.2.4 Pockmarks

Sea floor pockmarks are formed by gas discharge. They are features biologically relevant due the possible existence of unique chemosynthesis-based communities in the cold seep that are frequently found on them. According to Minisini *et al.,* (2007) structures that are interpreted as pockmarks have been found in the Sicilian Channel, at the West of the Gela Basin (the basin between Adventure Bank and the Malta Plateau).

4.3 Rare, vulnerable and highly productive habitats present on the Sicilian Channel

4.3.1 Deep coral communities

In the Sicilian Channel, there is a substantive variety of deep coral communities. The sessile benthos in the Sicilian Channel is dominated by the octocorals *Isidella elongata* and tall sea pen *(Funiculina quadrangularis*) as well as red coral (*Corallium rubrum)* (Freiwald *et al*., in press).

Areas that are difficult or impossible for sample trawling have been studied by Ragonese *et al.* (2003). According with this research, those hard bottoms are characterized by huge white coral assemblages produced by madrepores (*Madrepora oculata, Lophelia prolifera*) and barnacles (*Balanus* sp.). Another yellow coral, *Dendrophyllia cornigera* lives at higher depths (i.e. >500m), colonizing rocky substrates exposed to hydrodynamism.

Records of living colonies of white coral assemblage dominated by colonies of the scleractinian *Lophelia pertusa, Madrepora oculata* and *Dendrophyllia cornigera* were recently identified in the Linosa trough and in the nameless bank using ROV techniques as part of the recent research conducted under the HERMES project (Freiwald *et al*., in press). The most intense growth of *C. rubrum* was documented in the Linosa sample site, among the white coral habitats surveyed in the Sicilian Channel.

4.3.2 Cold seep communities

Cold seep communities are the home of unique chemosynthesis-based communities (not relying on photosynthetic production) dominated by bacterial mats and particular species of bivalves and tubeworms, that are associated with endosymbiotic (chemo-autotrophic) bacteria. The existence of pockmarks in the area points to the existence of these cold-seep type communities (Cartes *et al.,* 2004). The recent discovery of pockmarks (Minisini *et al.,* 2007) might points to the existence of these cold-seep type communities in the area. However, they have not been discovered yet and further research should be carried out to confirm the existence of these unique environments in this part of the Mediterranean deep sea.

4.4 Human activities and threats

4.4.1 Overfishing and impacts of fishing activities

Fishing Activity

The Sicilian Channel is one of the most important fishing areas of the Mediterranean Sea, where significant fleets operate with high fish production. Only in the Pelagie Islands the local fishery fleets consists of 164 fishing licenses (95 lines, 30 gillnets, 29 trawl net and 10 fish trap), In addition, the boats from the Sicilian and North African fleet are usually fishing in the Archipelago using trawl nets or purse seiners (Celoni et al., 2006). Both pelagic and demersal species are targeted.

Use of Destructive fishing techniques – Bottom Trawling

The Sicilian Channel is one of the most important demersal fishing grounds in the Mediterranean Sea and is commonly exploited by trawlers. In particular, the Mazara del Vallo trawl fishery (south-western Sicilian coast), is one of the most important in the Mediterranean Sea (about 180 trawl vessels). 21% of the trawl fleet operates in the Sicilian coastal waters with short fishing trips (1–2 days); the remaining 79% of the trawl fleet is characterised by boats that carry out deep-sea fishing and go out for long trips (21–25 days) in the Sicilian Channel (Gristina *et al.,* 2006). Some of main target species include hake *(Merluccius merluccius*), greater fork beard (*Phycis blennoides*), red mullet (*Mullus barbatus*) and anchovy (*Engraulis encrasicolus*) which have been heavily exploited in this area, causing their slow decline (Levi *et al.,* 1998, Garcia Lafuente *et al.,* 2002, Fiorentino *et al.,* 2003).

Trawling is known to have extremely marked direct impacts on the sea-bottom (Tudela 2004). Among the effects of intensive bottom-trawling is the reduction of the complexity of benthic habitats, affecting the epiflora and epifauna and reducing the availability of suitable habitats for predators and prey.

Ragonese *et al.*, (2007) presented for the first time a map of the untrawlable bottoms, drawn on the basis of the not-valid hauls recorded over almost 20 years of scientific trawl surveying in the Sicilian Channel. Results showed that grasping events are concentrated in shallower areas, i.e. on the western banks, on the eastern platform and near the coast; on the contrary, net tearing and gear damages often occurred in deeper grounds, where the “white coral assemblages” are present.

Use of Destructive fishing techniques – Illegal Drift-netting

In the past, Italy had the largest driftnet fleet (in excess of 700 vessels during the 1990’s) operating throughout a significant portion of the central Mediterranean (Scovazzi 1998).Despite the fact that drift-netting is now prohibited, illegal drift-netting still occurs (Greenpeace 2008; WWF 2005).

Chondrichthyans most vulnerable and frequently caught with driftnets include blue shark *Prionace glauca*, common thresher *Alopias vulpinus*, shortfin mako *Isurus oxyrinchus*, porbeagle *Lamna nasus*, basking shark *Cetorhinus maximus*, giant devil ray *Mobula mobular*, pelagic stingray *Pteroplatytrygon violacea*, requiem sharks *Carcharhinus* spp. and hammerheads *Sphyrna* spp. (Tudela 2004; Walker *et al*. 2005).

Moreover, the entanglement in high seas swordfish driftnets has caused considerable mortality of the Mediterranean sperm whale subpopulation since the mid-1980s (Notarbartolo di Sciara 1990; International Whaling Commission 1994). It is worth noting that during the 1990´s Italy had the largest driftnet fleet (in excess of 700 vessels) operating throughout a significant portion of the central Mediterranean (Scovazzi 1998).

The large majority of the strandings in Italy and Mediterranean Spain were caused by entanglement in driftnets, as evident from the reported presence of net fragments or characteristic marks on the whales’ bodies (see Reeves and Notarbartolo, 2006 and references herein). Cagnolaro & Notarbartolo di Sciara (1992) reported that for 83% of 347 cetaceans stranded in Italy from 1986 to 1990 (inclusive), which included 56 sperm whales, the likely cause of death was related to entanglement. Despite international and national regulations banning driftnets from the Mediterranean, illegal or quasi-legal drift-netting continues in sperm whale habitat, in (e.g., in France, Italy, and Morocco).

Stocks in decline

There is evidence of overexplotation of there is evidence of overfishing for single target stocks (Levi *et al.,* 1998), but the impact of fishing on demersal fish communities in this area has hardly been investigated.

In the Sicilian Channel, demersal fishing ground overlaps with important spawning and nursery grounds and areas occupied by larvae and juveniles of some of the most commercial fish species (e.g. hake, red mullet, anchovy and great fork beard) (Fiorentino *et al.,* 2003, Garofalo *et al.,* 2004). For example, nursery areas are situated mainly between depths of 100 and 200 m for the hake and those for the greater fork beard were found at depths greater than 200 m (Fiorentino *et al.,* 2003).

BluefinTuna and Swordfish under threat

An important fishery in the area is the longline fishery targeting swordfish and tuna species and which has increased in effort over the past three decades (Di Natale, 2006; SCRS 2008).

Bycatch

Longline fisheries in the area pose a great threat to many species including large turtles (e.g. loggerhead (*Caretta caretta*) (Baez et al. 2007). Data of fishing interaction between marine turtles and fishing activities were recorded during 12 years of activity (1994 to 2005) and results showed drifting longline as the fishing gear with the highest local impact on sea turtles (95.7%). Its peak activity is in summer period, when fishers mostly work with drifting longlines targeting swordfish and loggerhead adult females come to the pocket beach “Pozzolana di Ponente” to lay their eggs. The artisanal fleet operating in the area is mainly composed of vessels employing drifting longlines. This kind of gear results in a high number of interactions, with a mean of 40 loggerheads being hooked per year and a total of 336 specimens found with one or more hooks embedded in their flesh (see Giacoma *et al.*, 2001, Piovano *et al.,* 2001, Nannarelli *et al.,* 2007). In addition, chondrichthyans are also being taken as bycatch in the longline fishery (Cavanagh and Claudine 2007).

Within the framework Life project *DelTa* (NAT/IT/000163) a dolphin-fishery interaction study has been conducted in the Archipelago of Pelagie Islands (south Sicily). Gillnets were identified as the gear for which fishermen were complaining frequent negative dolphin´s interaction in 83% of the cases. Results showed frequent interaction was complained by 72% of long line and 100% of trawler (Celoni *et al.,* 2006). Moreover, the study highlights the existence of what was called “operational competitive interaction” (Bearzi 2002) between bottlenose dolphin and fishermen. In fact, results showed a significant reduction of fishing catches for *Mullus surmuletus* when dolphins were present (Celoni *et al.,* 2006)

4.4.2. Pollution

Oil Spills

There is evidence that the area between Sicily and Malta is a pollution hotspot regarding oil spills in the Mediterranean Sea (UNEP/EEA 1999, EC Joint Research Centre/IPSC 2006).

Heavy metals and Persistent Organic Pollutants

Pollution by persistent organic pollutants (POPs *e.g.* PCBs and DDTs) and heavy metals has spread all over the world as evidenced by their detection both in humans and wildlife although their impact on offshore ecosystems has been poorly investigated. Large fish such shark, tuna and swordfish as well as marine mammals, sea turtles and seabirds, as species occupying the higher trophic levels in the pelagic food chain, may exhibit a high potential for the accumulation of pollutants (e.g. Stefanelli *et al.,* 2002,2004; Storelli *et al.*, 2003; Storelli and Marcotrigiano, 2006)

4.4.3. Alien Species

Non-native species invasions are currently of major global concern, they are considered to be the second largest threat to biodiversity, after habitat destruction. The invasion and survival of alien species in the Mediterranean is correlated with the general sea surface temperature increase, resulting in the replacement of local fauna with new species. Such changes affect not only local ecosystems, but also the activities of the international fishing fleet when commercial species are affected (Marine Board Position Paper, 2007). Accidentally introduced into the Mediterranean Sea in 1984, the tropical alga *Caulerpa taxifolia* has spread since then, reaching the Tunisian coast. Another variety of *Caulerpa racemosa* (*Caulerpa racemosa var occidentalis*) was discovered in Tunisia and qualified as invasive (Langar et al., 2003).

4.4.4 Tourism

The growing number of tourists presents a significant threat to many coastal habitats. In fact one of the main threats to the Pelagian Island turtle population is tourist activities in the nesting sites (Giacoma and Solinas, 2001).

4.4.5 Marine Traffic

Collisions of marine turtles with boats crossing the waters of the Sicilian Channel (between Sicily mainland and Pelagie Islands) have been recorded (Life NAT/IT/000163). In addition, the Mediterranean sperm whale subpopulation may be affected by disturbance from intense maritime traffic (development of 'highways of the sea') and collisions with vessels, including high-speed ferries. More than 6% (7) of 111 sperm whales stranded in Italy (1986-1999) had died after being struck by a vessel, and 6% of 51 photo-identified individuals (22 in Italy) bore wounds or scars that were clearly caused by a collision (Pesante *et al.* 2002).

4.5 Ecological characterisation against criteria

4.5.1 Uniqueness or rarity

Unique and rare habitats.

There are a considerable number of rare habitats in the Southern Balearics that were described in Numeral 4.3. It includes white-coral communities, *Isidella elongate* communities and *Funiculina quadrangularis* communities. It is also important to consider the Sicilian Channel topographic features of high ecological potential that require further research and that were described in numeral 4.2. They include two large seamounts (Nameless Bank, Bannock); the large graham/empedocles volcanic seamount and the volcanic Tetide, Anfitrite, Galatea, Cimotoe seamounts; and the pockmarks located on the Gela Basin.

Endemic and rare species

The Maltese skate (*Leucoraja melitensis*), a Mediterranean endemic species which main range now appears to be restricted to the Sicilian Channel. It inhabits waters of depths that coincide with that of trawling activity (Cavanagh and Gibson, 2007). The Mediterranean endemic scleractinian coral *Cladopsammia rolandi* is also present in the Sicilian Channel (Zibrowius 1980).

4.5.2 Special importance for life history stages

The Sicilian Channel is one of the most important demersal fishing grounds in the Mediterranean (Fiorentino *et al.,* 2003) and also an important area for life history stages of both demersal and pelagic species, including some of high commercial interest – see below.

Bluefin Tuna (Thunnus thynnus) spawning ground

As explained in numeral 3.4.2, the Mediterranean Sea is one of the main grounds where the BFT Atlantic stock reproduces. The Sicilian waters are one of the most important spawning sites in the Mediterranean, as confirmed by Piccinetti *et al*., (1996a, b) which shows that BFT larvae are mainly concentrated all around Sicily (the Sicilian Channel, southern Tyrrhenian and northern Ionian Seas). It is important to notice that the Sicilian Channel, as the Balearics, share the formation of important frontal systems, which may favour the feeding requirements of larval tuna.

Oray *et al.,* (2005) showed the results of a 2003 and 2004 fish egg and larval survey which encompasses the BFT spawning grounds off the southern Sicilian coasts. They reported high larvae catches in 2003 and relatively low catch in 2004. Importance as spawning ground is also confirmed by previous research reported by the same author has shown the area can be considered a rather important spawning ground for the species from the tuna fishery. However, recent larval surveys carried out off the Tunisian part of the Sicilian Channel within the TUNIS II project reported no BFT larvae catches.

Swordfish spawning and nursery ground

Swordfish (*Xiphias gladius*) is the second most important large pelagic species in the Mediterranean Sea. The ICCAT considers the existence of a single Mediterranean Stock. The Sicilian Channel seems to be one of the most important spawning grounds for the species along with others sites including the Balearic Isles & central Mediterranean (Di Natale, 2006).

The spawning activity of the Mediterranean swordfish appears more strictly related to climate and oceanographic features than for other pelagic species. Observations at sea confirms that having a surface layer at about 22°C or over is sometimes enough to induce spawning even for a short period and the hypothesis that swordfish spawn on multiple occasions during a single season is to be seriously taken into account (Di Natale 2006).

Although juvenile individuals are reported everywhere in the surface longline fishery, (Di Natale 2006), the major concentrations are linked to the availability of a plentiful supply of food either close to the coast or off-shore, and can change their geographical distribution substantially from one year to the other, according to oceanographic features. Juvenile swordfish is usually present along the entire Sicilian coast including small isles, the area around Malta as well as the Balearic Isles among others

Anchovy (Engraulis encrasicolus) spawning and nursery ground

Anchovy is a short-lived pelagic species, distributed all over the Mediterranean and one of the most important resources in this region. It ranks second in abundance to the sardine (*Sardina pilchardus*), but first in terms of economic importance. However, its distribution is not regular or wide-spread and rather comprises a set of independent populations. Such could be the case of the Sicilian Channel anchovy.

The dynamics of the biomass of the anchovy population in the Sicilian Channel were addressed by two European projects (Med 96-052 and Med 98-070). Results indicated that the NW region of the southern Sicilian coast (i.e. the area off Sciacca, on the Adventure Bank) gathers the most favourable conditions for the anchovy spawning grounds (Cuttita *et al.,* 2003). According to García Lafuente et al., (2002), distribution of anchovy early stages is highly dependent on surface water dynamics. Such study shows that the highest larval concentration is located off Cape Passero, (200 km downstream of the main spawning ground). The estimated averaged age of this population, based on the length of the larvae, is 8 to 10 days, which matches the time it takes larvae that has hatched from an egg spawned off Sciacca to get Cape Passero. The cyclonic circulation of water masses provides enrichment mechanisms for larvae growth and feeding, acting as main nursery ground.

Spawning and nursery grounds for demersal species of commercial interest.

Hake (*Merluccius merluccius*) is one of the most studied demersal species because of its great importance in Mediterranean fisheries although many aspects related to the spatial scale of its biology remain little known. Fiorentino and colleagues (2006) recently found that hake occurs at all life stages in two distinct geographic areas, the Adventure and Malta Banks, well separated by a wide area where hake abundance is very scarce. The two nurseries areas were identified at the eastern side of the Adventure Bank and Malta Bank, and in both nurseries grounds extended from about 100 m to the upper slope (approx. 200m). Moreover, juveniles inhabit preferentially the eastern side of the Banks and show seasonal differences with the highest concentration of juveniles located along the eastern boundary of Malta Bank in autumn, and in Adventure Bank during spring. Spawning aggregations were also found in the south-western break of both Adventure Bank and Malta Bank in autumn.

Red mullet *(Mullus barbatus)* is another of the most important Mediterranean demersal species, mainly caught by bottom trawling on continental shelves. On the Italian side of the Sicilian Channel, this species is mainly found at depth less than 200 m and spawns in spring, and the 0-group recruits in late summer (Levi *et al.*, 2003). A space-time analysis performed by Garofalo and colleagues (2004), indicated two clearly separate spawning grounds in the area, over two banks off the Adventure Bank and the Malta both at around 100 m depth. On the Adventure Bank the distribution is characterized by several patches, some of them being in coastal waters. In contrast, a large spawning area was identified close to the Maltese territorial waters. Although the recruits were rather widely distributed throughout Sicilian coastal waters, four areas of high concentrations were identified, between 20 m and 50 m depth, which were quite stable in location.

The greater fork beard (*Phycis blennoides*) is one of the most commercially important gadoids in the Mediterranean. Little is known of the spawning period. Reproduction occurs from late summer to early winter (Massutí *et al.,* 1996; Belcari and Biagi, 1999). Two extended areas of recruit concentration (i.e. stable nursery areas) were identified on the western and eastern side of the Adventure Bank, located between 200 and 400m deeper; other nurseries were found in the easternmost part of the Sicilian Channel. Different from hake, there is large interannual variability as to the nursery areas (Fiorentino *et al.,* 2003). Hydrology does not appear to play a role in explaining the position of the spawning fish and juveniles.

Other relevant species considered

Relevant specie	***Relevance for life history***	***Description***	***Source***
WHALES			
Fin whale (*Balaenoptera physalus*)	Feeding area	Fin whales are known to congregate in late February and early March in the coastal waters of the island of Lampedusa (Italy), Sicilian Channel, to feed on the euphausiid *Nyctiphanes couchii* Nevertheless, there is limited information on the presence and habitat use for this species They favour upwelling and frontal zones with high zooplankton concentrations.	Canese *et al., in press*. Hoyt 2005
SEA TURTLES			
Loggerhead turtle *Caretta caretta*	Nesting sites	Lampedusa and Linosa (two Natura 2000 sites) are among the last known nesting sites of Loggerhead in this part of the Mediterranean where this species can lay its eggs. In the last four years, a total of 11 nests have been found on the island of Linosa and between one and five nests on the island of Lampedusa. From 1995 Rescue Centre activity has marked more than 600 sea turtles and released in these years. During this period, it has been observed that one female turtle which was captured and marked in 1996 was observed nesting again in Linosa eight years later.	(Life NAT/IT/006271 “Urgent conservation measures of *Caretta caretta* in the Pelagian Islands” and Life NAT/IT/00184 “*Del.Ta*: Dolphins and Sea Turtles Protected).
SHARKS			
White shark *Carcharodon carcharias*	productive and nursery grounds	The fact that white shark reproduces in the central Mediterranean seems to be widely accepted. The Sicilian Channel apparently represent a productive and nursery grounds	Fergusson *et al*. (in prep)
SEABIRDS			
Cory´s shearwater *Calonectris diomedea diomedea*	Nesting sites	This species breeds on the rocky coasts and islands of the Mediterranean, with Europe constituting >75% of its global breeding range. Its European breeding population is large (>270,000 pairs), 15.000-18.000 (pairs) in Italy. However it underwent a large decline between 1970 and 1990. It has been suggested that colonies in the central Mediterranean (Linosa Island and southwestern Sardinia) and the Azores formed a panmictic population, with an estimated 4-19 individuals being exchanged among colonies per generation.	Birdlife 2009

4.5.3 Importance for threatened/endangered/declining species or habitats

Bluefin Tuna

It is a well known fact the Atlantic bluefin tuna alarming decline (Block 2005) as presented before in section 3.4.1. However, it is considered as data deficient in the IUCN list.

Other relevant species considered

Relevant specie	***Status***	***Features***	***Threaths***	***Source***
WHALES				
sperm whale (*Physeter macrocephalus*)	EN	No estimate of population size exists for the region	Bycatch in fishing gear and ship strikes Entanglement in highseas swordfish driftnets, which has caused considerable mortality since the mid-1980s Disturbance, particularly related to intense maritime traffic. It is suspected that a combination of these factors has led to decline (of unknown magnitude) over the last half century	Reeves and Notarbartolo di Sciara, 2006 Notarbartolo di Sciara 1990; International Whaling Commission 1994
DOLPHINS				
Bottlenose dolphin (*Tursiops truncatus*)	vu	Bottlenose dolphin have been recorded in waters around the Pelagie Islands Local subpopulations appear to be habitat-dependent, as biogeographic and hydrographic features influence their distribution and movement pattern Four possible ecological boundaries have been proposed for the species as follows: the Gibraltar strait, the Almerìa-Oran front, the Sicilian Channel and the Turkish Straits system. Nevertheless, information on the presence and habitat use for this species in the area is limited		(Reeves and Notarbartolo di Sciara, 2006) Natoli *et al*. 2005 Hoyt 2005
SEA TURTLES				
Loggerhead (*Caretta caretta*)	EN	The most frequent chelonian in the Italian Waters and Linosa is known as an important nesting site for this species. The activity in the Pelagie Islands is focused on loggerhead conservation but also includes observations to evaluate the impact of fisheries, in particular longline fishing, on loggerhead populations in the area. In this respect, an enduring collaboration was set with a number of fishermen that come from Sicily to the Pelagie Islands during the summer season for longline fishing (targeting swordfish).	The main threats to these turtles include pollution, being accidentally caught up in fishing gear and collisions with boats crossing the waters of the Sicilian Channel.	IUCN, 2004 data unpublished see Stefano Nannarelli *et al*
Green turtle *Chelonia mydas*	CR	they have only been recorded occasionally		IUCN 2004 Russo *et al*., 2003
Leatherback turtle *Dermochelys coriacea*	CR			

Other relevant species considered (continued)

CHONDRICHTHYANS (CARTILAGINOUS FISH)				
The Maltese skate (*Leucoraja melitensis*)	CR	Endemic species that is under imminent threat of extinction. Its main range now appears to be restricted to the Sicilian Channel which is subject to heavy trawling activity It is extremely rare, in broadscale surveys of the north Mediterranean coastline from 1995–1999, recorded in only 20 out of 6,336 hauls It is also now rare off Malta and rare or absent off Tunisia, where it was previously considered moderately common Although population data are lacking, given the small range of the remaining population the potential detrimental impact of trawl fisheries is likely to be significant. Further research is also needed on the exploitation, distribution, biology and ecology of this species, as well as trends in abundance	Trawl fisheries Very rapid population declines, which are estimated to exceed 80% in three generations. It was previously found over a relatively restricted area (about ¼ of the total area of the Mediterranean Sea) in the depth range where trawl fisheries routinely operate	Ungaro *et al*. 2006. Baino *et al*. 2001; Bertrand *et al*. 2000 Bradai 2000; Schembri *et al*. 2003
White shark (*Carcharodon carcharias*) Mediterranean population	E	Evidence of declines and the likely fishery pressures placed upon their apparent reproductive and nursery grounds in the Sicilian Channel Very little is known about seasonal movements or key elements of its population biology Fergusson suggest that efforts should focus upon the Sicilian Channel and its environment in order to implement a scheme of protective management in 'critical habitats', selected by interpreting biogeographical data.	In certain regions, such as Sicily, the white shark has traditionally been viewed negatively, as a costly interference to fisheries (Fergusson *et al*. in prep.). Declines of traditional regionally- important prey such as bluefin tuna alongside threats to other important prey, including small cetaceans (Morey *et al*. 2003) and other demersal and pelagic fishes, are suspected to have had a serious impact on white sharks in the Mediterranean	(Fergusson *et al*. in prep.). (Morey *et al*. 2003; Soldo and Dulcic 2005) (Fergusson pers. Comm see in Cavanagh and Gibson, 2007). (Fergusson 2002).
porbeagle (*Lamna nasus*)	CR		Unsustainable fisheries (target and bycatch, usually by longlines) are the main threats to these species	(Cavanagh and Gibson, 2007).
shortfin mako (*Isurus oxyrinchus)*	CR			
giant devilray (*Mobula mobular*)	E			
blue shark (*Prionace glauca*)	vu			

NOTE: VU= Vulnerable, EN= Endangered, CR=Critically Endangered ; DD= Data deficient

4.5.4 Vulnerability, fragility, sensitivity or slow recovery

White coral communities

Deep water white coral communities have a very low growth rate and a extremely long-life making these hard bottoms communities very vulnerable. Trawling may not only cause physical destruction of these reefs and the complex communities made up of many organisms associated with this habitat, but can also change the local hydrodynamic and sedimentary processes. A reduction of white coral reef always leads to a consequent decline in biodiversity and density of associated organisms. Bottom trawling on the nearby bottom produces suspension of sediments that can stress and even kill corals (Cartes *et al.,* 2004; Palanques *et al.,* 2004).

Recent mapping of the Sicilian Channel seafloor involving ROV techniques has discovered the presence of vulnerable living colonies of *Lophelia pertusa, Madrepora oculata* and *Dendrophyllia cornigera* as well as other species such as *Isidella elongate,* tall sea pen *(Funiculina quadrangularis*), red coral (*Corallium rubrum*) and other gorgonians sp. (see VI Biological diversity section) (Freiwald *et al.,* in press). The HERMES ROV dives on R/V *Meteor* cruise M70-1 demonstrated that white coral communities thrive over much wider geographic areas in the central Mediterranean; however, they are difficult to sample with conventional gear —and are therefore generally unrecognized because they live beneath bedrock overhangs on steeply inclined submarine walls and escarpments.

4.5.5 Biological productivity

Patti et Al (2004) show how the surface circulation of the two-way exchange flow through the Sicilian Channel and its complex topography makes the Sicilian Channel a high productivity and retention area. Accordingly with this author, AIS enters the channel by its west side to describe a large cyclonic meander, which embraces the Adventure Bank and then approaches the shore by the middle of the southern coast of Sicily and separates again when it encounters the shelf of Malta and then encircles a second cyclonic vortex, off Cape Passero . This circulation favours the existence of "permanent" upwelling to the left of the Stream. Coastal upwelling is believed to be the main source of nutrient pumping in the area (characterized by very low levels of river discharge).

This favours spawning activity and recruitment success processes, turning this area in a recognized spawning and nursery area for species of high commercial relevance such as bluefin tuna, swordfish, hake and greater fork beard. (e.g. Garcia Lafuente *et al.,* 2002, Garofalo *et al.,* 2004). (as seen in numeral 4.5.2). The area is also includes spawning grounds of red mullet (*Mullus barbatus*) (Garofalo *et al.,* 2004) and a relatively high abundance of rays, different from the remaining region (Garofalo *et al.,* 2003). According to Fiorentino *et al.,* 2003 the existence of a frontal zone precisely in the middle of the area, in fact, may offer an ideal situation for small predatory organisms such as squid paralarvae, due to the richness of food particles concentrating at the convergence front.

Levi et al. (2003) investigated the stock-recruitment relationship for red mullet in the Sicilian Channel, including environmental information in terms of sea surface temperature (SST) anomaly as a proxy for oceanographic processes affecting recruitment. Results showed that, for a given level of spawning stock, higher levels of recruitment corresponded to SST, being warmer than average during the early life stages.

4.5.6 Biological diversity

Biological Hotspots

Most of the habitats considered as unique, vulnerable and productive, area also areas of biological diversity. Topographic setting (seamount), hydrodynamic forcing (fronts, upwelling), and the biogeochemical characteristics of the deep-sea floor may play key roles in promoting and sustaining high biodiversity along the open slopes of continental margins (Freiwald *et al.,* 2009).

As explained in the case of the Balearic Island seamounts, this feature is recognized areas de potential high biodiversity and comparable islands as far as faunal biogeography is concerned and prone to endemism. In the Sicilian Channel a considerable number of seamounts have been identified, the Graham/Empedocles/Ferdinandea seamount being one of the better known. Investigations of seamounts and other submarine volcanic features in the Sicilian Channel have been mainly geological, with biological studies relatively neglected.

Last but not least, The *Adventure Bank* supports a large ichthyoplankton diversity which is consistent with favourable environmental and hydrographic conditions.

Mesopelagic diversity

Cuttia et al. (2004) are among the first scientists to investigate the mesopelagic fish species inhabiting the Sicilian Channel. They are the most common deep-water species and their larvae are common prey for many other species, including some that are commercially important, providing a link in the energy transfer from the deep sea and the higher layers of the water column. The distribution of mesopelagic fish larvae appears to be determined by hydrographic conditions. Generally found offshore, the researchers found some concentrations located in the shelf area between Mazara and Sciacca.

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Demersal diversity

Recently the diversity of demersal fish communities (Osteichthyes and Chondrichthyes) has been studied using trawl surveys under the international MEDITS program. The greatest diversity within these communities was found at the offshore bank on the western part of the south Sicilian shelf (Adventure Bank) with a high biomass of commercially important species such as hake and red mullet present. Detailed analysis of the catches from this area shows that 58 different fish species were present i.e. about 34% of the total number of fish species collected over the entire study area. The entire area delineated was inside the 100m isobath (Garofalo *et al.,* in press). The eastern sector of the Adventure Bank was found to be far less diverse as was the central sector of the Sicilian Channel. However these areas also showed high variability.

Interestingly, the areas showing the greatest inter-annual variability of diversity are located mainly along the shelf edge, where topographically induced upwelling may occur (Lermusiaux and Robinson, 2001), and particularly along the average trajectory of the AIS (Robinson *et al.,* 1991).
The area where the AIS approaches the Sicilian coast is known to be a permanent upwelling area (Lermusiaux and Robinson, 2001) and was identified in the MEDITS study as an area persistently characterized by low diversity values (Garofalo *et al.,* 2007).

White coral communities

Deep-water coral assemblage is dominated by colonies of the scleractinian *Lophelia pertusa, Madrepora oculata* and *Dendrophyllia cornigera*. The true extent of the white coral community in the Mediterranean Sea is poorly known and with relatively few verified records of live colonies. *Lophelia pertusa* and *M. oculata* exhibit a scattered distribution pattern.

As part of HERMES project, the R/V *Meteor* recently undertook an expedition using ROV techniques to determine the status of white coral communities in the Sicilian Channel and others sites in the central Mediterranean. The team investigated three escarpments within the Sicilian Channel and discovered living colonies of deep coral waters as well as other associated species (Freiwald *et al.,* 2009). Prior to this expedition, only Schembri et al. (2007) and Zibrowius and Taviani (2005) had documented the presence of living white corals in the region.

4.5.7 Naturalness

See section 3.5.7.

5. Recommendations

This study shows that both the high seas around the Balearic Islands and the Sicilian Channel meet the majority of criteria adopted by the CBD for identifying areas for protection and therefore should be considered as high priority areas in any future network to be developed for the region.

Although better studied than many ocean areas, including the eastern basin of the Mediterranean, there are still considerable gaps in our knowledge of the distribution of different habitats and communities living in both the waters around the Balearic Islands and the Sicilian Channel and in particular in the deeper waters. Lack of information should not be used as an excuse to differ protection – the existing information is sufficient to make valid decisions.

Given the high population and the degree of anthropogenic pressure throughout the Mediterranean it is hard to see how the naturalness criterion might be applied. While it is an obvious priority to ensure protection of near-pristine areas, any future protected area networks must be comprehensive and fully representative of the whole range of habitats and ecosystems and so impacted areas should not be excluded. Marine ecosystems have great powers of regeneration and such protection can bring about restoration with resulting benefits for both conservation and fisheries. Indeed, establishing large scale marine reserves around the Balearic Islands and the Sicilian Channel is likely to be a crucial step if we are ever to reverse the precipitous decline of the bluefin tuna in the Mediterranean.

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High Seas Pacific Marine Reserves: a case study for the high seas enclaves

A briefing to the CBD's Expert workshop on scientific and technical guidance on the use of biogeographic classification systems and identification of marine areas beyond national jurisdiction in need of protection

Ottawa, 29 September–2 October 2009

A report for Greenpeace International by Eleanor Partridge

August 2009

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Abbreviations and Acronyms

B_{MSY}	Biomass at maximum sustainable yield
CBD	Convention on Biological Diversity
CPMR	Central Pacific Marine Reserve
DSL	Deep scattering layer
EEZ	Exclusive economic zone
ENSO	El Niño/Southern Oscillation
EU	European Union
EUC	Equatorial Undercurrent
F_{MSY}	Fishing mortality at maximum sustainable yield
FAD	Fish aggregation device
FAO	Food and Agriculture Organisation of the United Nations
FFA	Pacific Islands Forum Fisheries Agency
FSM	Federated States of Micronesia
GEF	Global Environment Facility
GOMAR	Greater Oceania Marine Reserve
ISA	International Seabed Authority
IUCN	International Union for Conservation of Nature
IWC	International Whaling Commission
IWP	Indo-West Pacific
MOANA	Moana Marine Reserve
NECC	North Equatorial Counter-Current
NOAA	U.S. National Oceanic and Atmospheric Administration
PIR	Pacific Islands Region
PNG	Papua New Guinea
SEC	South Equatorial Current
SECC	South Equatorial Counter-Current
SMS	Seabed massive sulphide
SPC	Secretariat of the Pacific Community
SPC-OFP	Oceanic Fisheries Programme of the Secretariat of the Pacific Community
SPREP	Pacific Regional Environment Programme
SPRFMO	South Pacific Regional Fisheries Management Organisation
SPSG	South Pacific Subtropical Gyre biogeographical province
SPWS	South Pacific Whale Sanctuary
SST	Sea surface temperature
UV	Ultraviolet
WARM	Western Pacific Warm Pool biogeographical province
WCP	Western and Central Pacific
WCP-CA	Western and Central Pacific Convention Area
WCPFC	Western and Central Pacific Fisheries Commission
WOMAR	West Oceania Marine Reserve

Executive Summary

This report summarises available scientific information to demonstrate the ways in which the high seas enclaves of the Pacific Islands Region (PIR) meet the criteria for ecologically or biologically significant marine areas, developed by the Convention on Biological Diversity (CBD). The report also summarises evidence to support the inclusion of the high seas enclaves in a representative network of marine reserves, on the basis of representativity, connectivity, replicated ecological features and adequacy and viability. The PIR high seas enclaves are: the proposed West Oceania Marine Reserve (WOMAR); Greater Oceania Marine Reserve (GOMAR); Moana Marine Reserve (MOANA); and Western Pacific Marine Reserve (WPMR).

Human impacts on the open ocean ecosystem of the PIR are largely the result of industrial tuna fisheries, which have expanded dramatically in recent decades. Purse seine and longline and, to a lesser extent, pole and line and troll fishing vessels, target skipjack *Katsuwonus pelamis*, yellowfin *Thunnus albacares*, bigeye *Thunnus obesus* and albacore *Thunnus alalunga* tuna in national waters and on the high seas (Williams and Terawasi, 2008). Skipjack tuna accounted for over 72% of total landings in 2007and has, until recently, been considered to be in a healthy state (Langley and Hampton, 2008). However, it has recently been suggested that the spawning stock of skipjack in the Pacific may have declined drastically and overfishing may be occurring (OPRT, 2009). Overfishing of bigeye and yellowfin tuna is occurring and bigeye tuna are in an overfished state (Langley et al, 2007; NMFS, 2006; Langley et al, 2008). Bycatch accounts for approximately 35% of longline catch and includes threatened, vulnerable and declining species, such as oceanic whitetip *Carcharhinus longimanus* and blue *Prionace glauca* sharks; several species of sea turtle; and cetaceans, including rare and poorly understood species of beaked whale (Molony, 2007). The open ocean ecosystem of the PIR, and the nature of human impacts in the region, could change significantly in the future due to the effects of anthropogenic climate change. The impacts of climate change on the biodiversity, ecosystem functions and coastal economies of the region are not yet understood but are likely to include shifts in the distribution and abundance of prey and predator species, including commercially important tuna species (SPC, 2009).

A number of features support the designation of the PIR high seas enclaves as ecologically or biologically significant marine areas in need of protection. Key life history stages in the enclaves include: migrating leatherback turtles *Dermochelys coriacea*; the possible presence of juvenile leatherback turtles; yellowfin tuna spawning activity; migrating green turtles *Chelonia mydas*; and breeding minke whales *Balaenoptera acutorostrata*. Threatened, endangered or declining species present in the enclaves include: leatherback, green, olive ridley *Lepidochelys olivacea* and hawksbill *Eretmochelys imbricata* sea turtles; bigeye tuna; sperm whales *Physeter macrocephalus*; and potential aggregations of threatened and declining species, including pelagic sharks, in the vicinity of the Horizon Bank, a shallow seamount in WPMR. Vulnerable, fragile and sensitive species/habitats include: sea turtles; seamounts; sperm whales; the potential presence of tropical corals; and pelagic predatory species. Biologically productive areas include: areas of high tropical tuna abundance; upwelling associated with the North Equatorial Counter-Current; seamounts; the Horizon Bank; and possible hydrothermal vent locations. Biologically diverse areas include: seamounts; and the Horizon Bank.

1. Introduction

This report will demonstrate the ways in which the four high seas enclaves of the Pacific Islands Region (PIR) meet the criteria for the identification of ecologically or biologically significant open ocean and deep-sea marine areas in need of protection, developed by the Convention on Biological Diversity (CBD) (CBD, 2007).

For the purposes of this report, the high seas enclaves will be referred to by the names of proposed marine reserves chosen by winners of a public competition held in the PIR: West Oceania Marine Reserve (WOMAR); Greater Oceania Marine Reserve (GOMAR); Moana Marine Reserve (MOANA); and the Western Pacific Marine Reserve (WPMR), a name selected for this report only. See figure 1 for the locations of the high seas enclaves in the PIR.

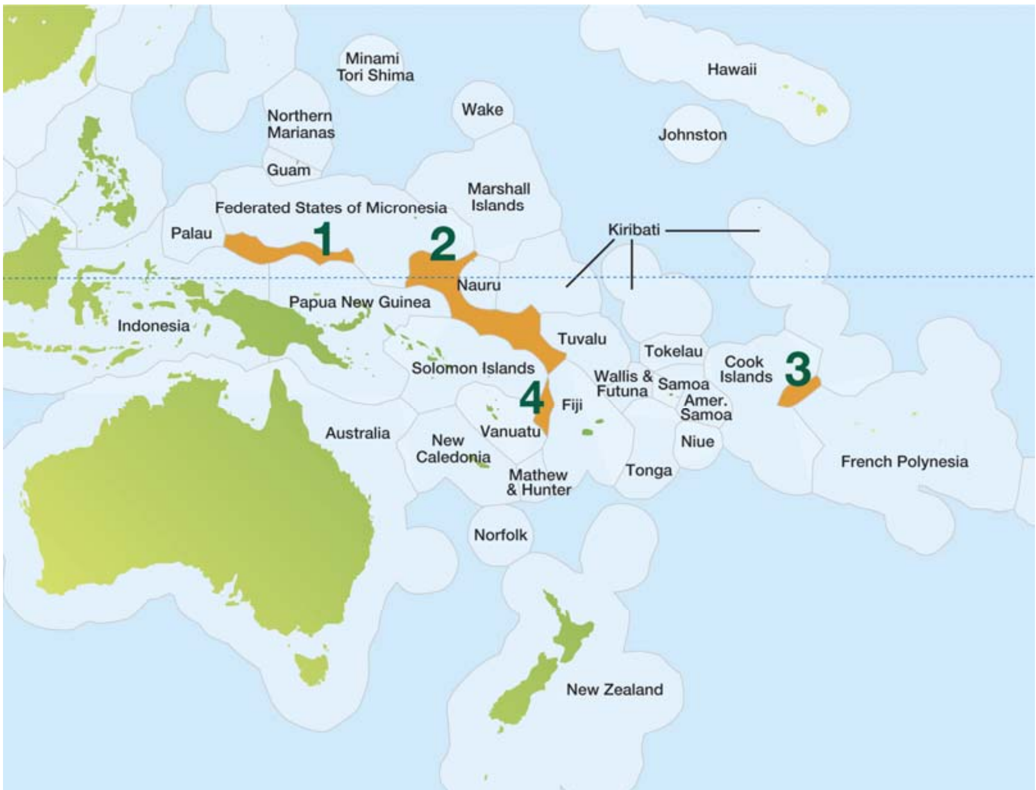


Fig. 1. Pacific Islands Region high seas enclaves 1: WOMAR; 2: GOMAR; 3: MOANA; 4: WPMR

The identification of ecologically and biologically significant marine areas is an essential first step towards the creation of high seas marine reserves, which are an essential tool in our efforts to conserve marine ecosystems and rebuild global fish populations. Overfishing is now recognised as the greatest threat facing the world's oceans – total global fisheries landings have been declining since the late 1980s (Pauly et al., 2002) and one paper has predicted the collapse of all currently-fished species by 2048, in the absence of effective action (Worm et al., 2006). Marine reserves offer a way to rebuild depleted fish stocks, conserve biodiversity and genetic variability, protect vulnerable and important habitats and enhance ecosystem resilience (Roberts et al., 2005). There is a large body of evidence for the fisheries benefits of marine reserves, which can increase catch levels in adjacent areas through 'spillover' of adult and juvenile fish and export of eggs and larvae (Gell and Roberts, 2003). Most evidence to date has been obtained from coastal ecosystems, however there is increasing support for the creation of open-ocean marine reserves to aid in the conservation of highly migratory species, including tuna, sea turtles and sharks (Norse et al, 2005). Marine reserves are also an important tool in the conservation of the deep-sea (Probert, 1999). The expansion of fisheries into the deep-sea in recent decades has resulted in the serial depletion of vulnerable fish species and the destruction of fragile seamount habitats (Koslow et al., 2000).

The designation of the enclaves as high seas marine reserves would contribute to considerable progress already being made towards the creation of large-scale marine reserves in the Western and Central Pacific (WCP). The Phoenix Islands Protected Area, currently the world's largest, encompasses 410,500km^2 around Kiribati's Phoenix Islands, including eight coral atolls and vast expanses of open-ocean and deep-sea habitat (PIPA, 2009). The Papahānaumokuākea Marine National Monument, in Hawaii, covers 357,000km^2, including thousands of square kilometres of some of the world's least disturbed coral reefs (PMNM, 2009). Australia's Great Barrier Reef Marine Park encompasses 345,000km^2, of which approximately 33% is fully protected (GBRMPA, 2003). A campaign is currently underway for the creation of a Coral Sea Heritage Park, which would protect over 1,000,000km^2 of Australian waters between the eastern boundary of the Great Barrier Reef Marine Park and the maritime borders with Papua New Guinea (PNG), the Solomon Islands and New Caledonia (Pew, 2009). France has recently committed to protect 10% of its EEZ in marine reserves by 2020, with a 700,000km^2 potential site already identified in the Marquesas Islands of French Polynesia (Le Grenelle de la Mer, 2009). The high seas enclaves are connected to the Phoenix Islands Protected Area and the proposed marine reserves in the Coral Sea and Marquesas Islands by the South Equatorial Current (SEC), which flows westwards between ~5°N and 20°S, and could potentially form a part of a functioning reserve network in the WCP. This would contribute to the implementation of the Pacific Islands Regional Oceans Policy, which calls amongst other things for the development of precautionary management regimes; a transboundary approach to marine ecosystem management; and the conservation of biodiversity at local, national and regional scales (CROP, 2005).

The southern hemisphere portions of the marine reserves would fall within the boundaries of the proposed South Pacific Whale Sanctuary (SPWS), which extends north to the equator (DEWHA, 2007). Australia and New Zealand have campaigned for the SPSW at the International Whaling Commission (IWC) since 2000 (SPREP, 2006). The proposal is endorsed by members of the Pacific Regional Environment Program (SPREP) and Pacific Forum leaders but failed to win the ¾ majority required for establishment by the IWC (SPREP, 2006). Nevertheless, there is continued support for a SPWS and high seas marine reserves could potentially form highly protected zones within the sanctuary, should it become a reality. High seas marine reserves in the PIR could also complement the protection of whale species that migrate between feeding grounds in the Southern Ocean Whale Sanctuary and breeding grounds in the tropical and subtropical Pacific (SPREP, 2006).

There is already considerable support from Pacific Island Nations for the closure of the high seas enclaves to fishing vessels. The Western and Central Pacific Fisheries Commission (WCPFC) has agreed to close WOMAR and GOMAR to purse seine vessels from January 2010 (WCPFC, 2008). Under the terms of the Parties to the Nauru Agreement Third Implementing Arrangement, any fishing activity in WOMAR and GOMAR will be forbidden to vessels fishing under license from a Nauru Agreement signatory, which should largely eliminate longlining and other fishing methods (Nauru Agreement, 2008). Closure of WPMR and MOANA to purse seine fishing will be discussed at the 6th Regular Session of the WCPFC, to be held in Tahiti, December 2009 (WCPFC, 2008).

2. Existing research on the areas and availability of information

Direct evidence for the ecological and biological characteristics of the high seas enclaves is limited. Scientific research intensity is low in the PIR, relative to other regions of the world's oceans, and those studies that were conducted related largely to nations' EEZs. For example, reports on cetaceans (Miller, 2007) and seabirds (Watling, 2003) focused on distribution within EEZs reflecting, in part, the paucity of observations from high seas areas. Due to the limited availability of direct evidence, analysis of the ecological and biological significance of the high seas enclaves was partially dependant on extrapolation from physical data, as well as biological data relating to the wider PIR. For example, the presence of seamount species assemblages was inferred from the presence of seamounts. However, in the absence of direct evidence for the presence of seamount species assemblages, the extrapolation was not extended to argue for the presence of endemic species, despite known high levels of endemism in seamount communities. This also applies to discussion of the hydrothermal vent communities that could potentially occur in WPMR. As a result, the lack of direct evidence for the characteristics of the high seas enclaves is reflected in the criteria used to justify their ecological and biological significance.

Direct and indirect evidence for the ecological and biological characteristics of the high seas enclaves was taken from a number of sources. The Oceanic Fisheries Programme of the Secretariat of the Pacific Community (SPC-OFP) collects fisheries landings data and data gathered by national fishery observer programmes in the PIR. SPC-OFP conducts stock assessments of target species and produces research relating to oceanic fisheries in the PIR. Research relevant to the high seas enclaves is also conducted by the Pelagic Fisheries Research Programme of the University of Hawaii. NOAA researchers are active in the PIR and conducted the leatherback turtle *Dermochelys coriacea* tracking studies utilised in this report. A number of oceanographic cruises have collected data in the North Fiji Basin, of which the WPMR forms a part: STARMER (France and Japan, 1987 – 1992); HYFIFLUX (France and Germany, 1995 – 1998); and the Fiji/Lau Expedition conducted by the Monterey Bay Aquarium Research Institute (2005). A number of global databases contain information relating to the high seas enclaves of the PIR, including: Seamounts Online (COML, 2009); Seamount Biogeosciences Network (EarthRef, 2009); NOAA Vents Programme (2009); and the ISA Atlas of the International Seabed Area and its Resources (ISA, 2009).

Much of the data utilised in this report indicates the potential presence of ecologically and biologically significant marine areas in the Pacific high seas enclaves. However, until further research is conducted it will not be possible to fully understand, or conclusively demonstrate, the ways in which the high seas enclaves meet the CBD criteria for significant marine areas. The findings of this report demonstrate the need to adapt or interpret the CBD criteria for application to data-scarce regions of the worlds' oceans, in order to provide an opportunity for the protection of potentially significant marine areas about which little is known.

3. Human activities and threats in the Pacific Islands Region

The WCPFC Convention Area (WCP-CA) is the site of the world's largest tuna fishery, accounting for 55% of global and 84% of Pacific tuna landings in 2007 (Williams and Terawasi, 2008). In 2007: 73% of total landings was taken by purse seine vessels, which target skipjack *Katsuwonus pelamis* and yellowfin *Thunnus albacares* tuna close to the equator; 10% was taken by longline vessels, which target yellowfin, bigeye *Thunnus obesus* and albacore *Thunnus alalunga* tuna; 9% by pole and line fishing, which occurs primarily in national waters; and 8% by trolling and artisanal fishing, which occurs primarily in the vicinity of eastern Indonesia and the Philippines (Williams and Terawasi, 2008). See figure 2 for the distribution of purse seine tuna catch by species, 2006 – 2007. See figure 3 for the distribution of longline tuna catch by species in 2006. 4869 longline fishing vessels, from 21 countries, fished in the WCP-CA in 2007, although the majority of effort was accounted for by the large-vessel, distant-water fleets of Japan, Korea and Taiwan (Lawson, 2007). The five main purse seine fleets operating in the WCP-CA are: the FSM Arrangement (combined Pacific Islands fleets); Japan; Korea; Taiwan; and U.S (Lawson, 2007). The level of IUU fishing in the Western and Central Pacific region has been estimated at 21 – 46%, much of which occurs in EEZs with illegal vessels using the enclaves to take refuge on the high seas (MRAG and FERR, 2008). The designation of the enclaves as marine reserves could facilitate a reduction in the level of IUU fishing, with benefits for the fishing industries of Pacific Island Nations, as well as marine ecosystems. It has been estimated that approximately 10% of total tuna landings from the WCP-CA are taken from the high seas enclaves (Hampton, pers. comm.).

The WCP tuna fisheries are managed collaboratively by the WCPFC, the SPC-OFP and the Pacific Islands Forum Fisheries Agency (FFA). WCPFC was founded in 2004 and is the central, decision-making body for tuna fisheries management (WCPFC, 2009). SPC-OFP conducts scientific research into offshore tuna fisheries, including stock assessments (Preston, 2005). FFA works to develop regional fishery management arrangements and strengthen the capacity of Pacific Island nations' fisheries by providing economic, policy and legislative advice (Preston, 2005). The South Pacific Regional Fisheries Management Organisation (SPRFMO) is currently under consultation prior to full establishment and will oversee the management of the region's non-highly migratory fish stocks (SPRFMO, 2009). SPREP supports environmental management and conservation in the region (Preston, 2005).

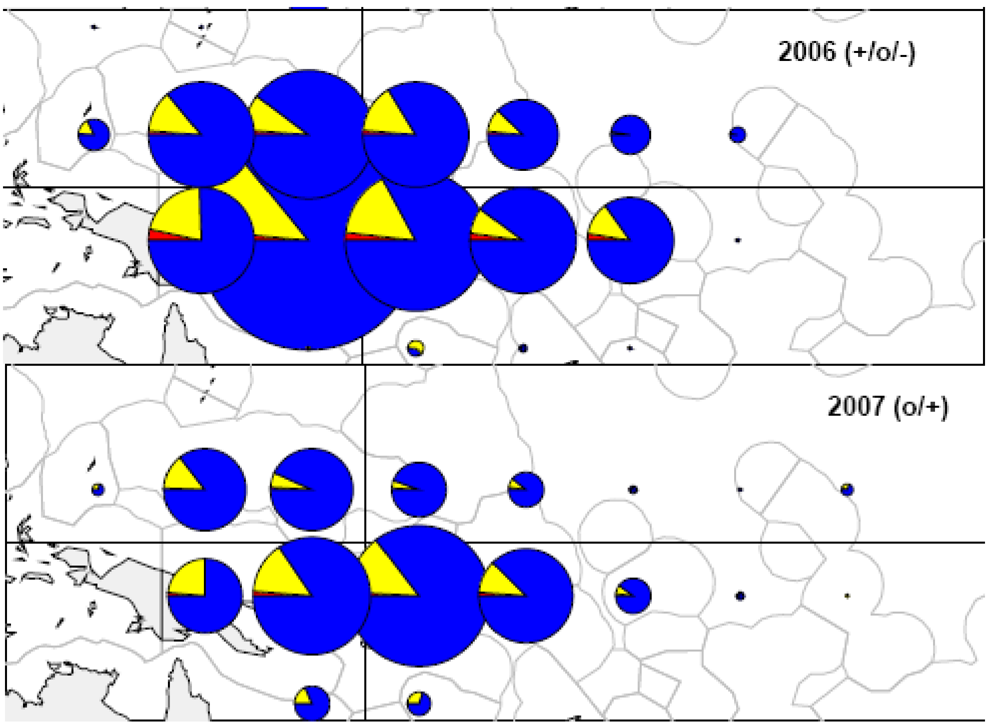


Fig. 2. Distribution of purse seine skipjack/yellowfin/bigeye tuna catch, 2006 – 2007. (Blue – skipjack; yellow – yellowfin; red – bigeye). ENSO periods are denoted by "+": La Niña; "-" : El Niño; "o": transitional period. Source: Williams and Terawasi, 2008.

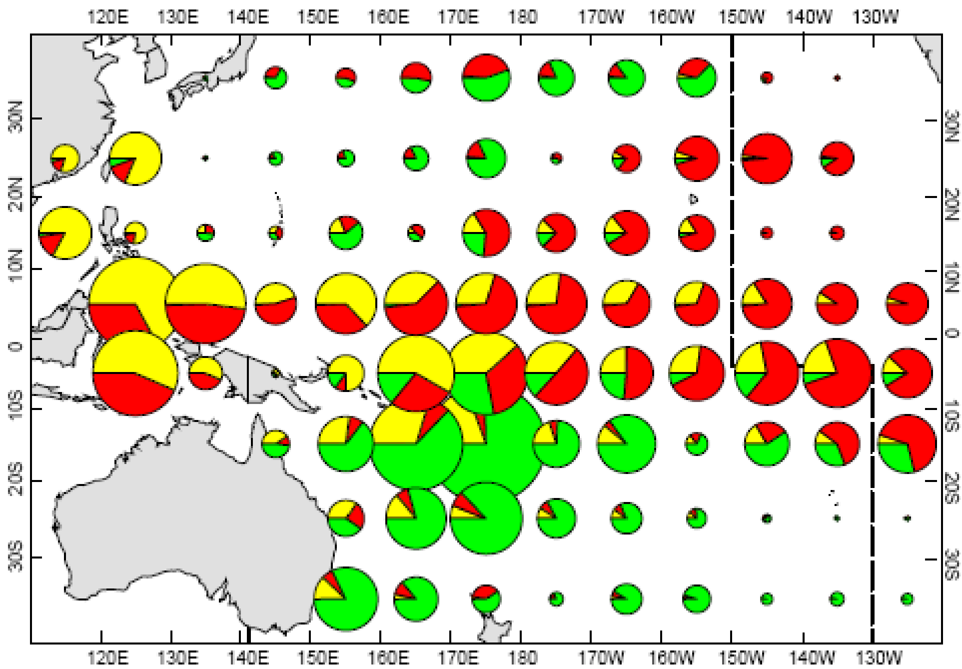


Fig. 3. Distribution of longline tuna catch by species during 2006 (*provisional*). (Yellow – yellowfin; red – bigeye; green – albacore). Source: Williams and Terawasi, 2008.

Tuna landings increased steadily throughout the 1980s, due to the expansion of the purse seine fleet, and remained stable until 1998, when they increased sharply. Landings have been increasing for the past six years. Record total landings of 2,396,815mt was recorded in 2007, 120,000mt higher than the 2006 record. This included record landings of skipjack tuna and the second highest recorded landings of bigeye tuna, which was attributed to the increased use of fish aggregating devices (FADs) by purse seine vessels (Williams and Terawasi, 2008).

Purse seine vessels target feeding schools of tuna in ‘unassociated’ sets or make ‘associated’ sets on logs and drifting or anchored FADs. Associated sets catch a higher proportion of bycatch species, including sharks and sea turtles, as well as juvenile bigeye and yellowfin tuna (Molony, 2007). The majority of yellowfin and bigeye caught in associated purse seine sets are below the size at first reproduction and it has been suggested that purse seining impacts are contributing to overfishing of these species. It is estimated that the recent impact of associated sets by purse seine vessels has reduced the total biomass of bigeye tuna by more than 20% and total biomass of yellowfin by more than 10% (Molony, 2007). The proportion of associated sets has declined in recent years, possibly as a result of the La Niña/neutral state of ENSO, which concentrates fishing effort further westwards, where feeding schools are more available (Williams and Terawasi, 2008). However, the increase in the level of total fishing effort means that landings of juvenile tuna have increased in recent years. The impact of associated sets on bigeye and yellowfin tuna could increase in the future if rising fuel prices lead to an increase in the use of FADs (FFA, 2008). An El Niño event began in early 2009 and is predicted to strengthen and last through the northern hemisphere winter of 2009/2010, which could further increase the impact of associated sets on bigeye and yellowfin tuna (NOAA, 2009).

Bigeye tuna are currently being overfished in the WCP-CA and adult biomass may have been below B_{MSY} for several years. It is estimated that total biomass of bigeye tuna had declined by ~0.5 by 1970. Stock levels are now thought to be at 20 – 26% of unexploited biomass, following a period of particularly rapid decline from the mid-1980s (Langley et al, 2008). It has been suggested that a period of elevated recruitment has maintained the bigeye stock at its current size and the stock will decline rapidly if the recruitment level returns to the long-term average and fishing effort is not reduced (Langley et al, 2008). Yellowfin tuna biomass declined steadily throughout the 1990s and overfishing is currently thought to be occurring (Langley et al, 2007; NMFS, 2006). Skipjack tuna has until recently been considered to be in a healthy state (Langley and Hampton, 2008). However, it has recently been suggested that the spawning stock of skipjack in the Pacific may have declined drastically and overfishing may be occurring (OPRT, 2009) There is considerable uncertainty regarding the current stock size and level of fishing mortality on albacore tuna (Hoyle et al, 2008). There is a swordfish longline fishery active in the WCP-CA. However, effort is concentrated in the waters around Australia and New Zealand and in the east of the convention area and landings are not significant in the high seas enclaves (Kolody et al, 2006). There are currently no deep-sea fisheries operating in the vicinity of the high seas enclaves. Interim measures adopted by parties to the SPRFMO state that bottom fishing will not expand into new areas where it is not currently occurring, including the high seas enclaves, whilst those measures are in force (SPRFMO, 2007).

A number of studies have attempted to quantify the broader impacts of fisheries on open ocean ecosystems, although knowledge in this area remains limited. Ward and Myers (2005) compared records from longline surveys in the tropical Pacific before and after intense fishery exploitation. Their results showed a decline in the mean body mass of most large, predatory species and a decline in the abundance and total biomass of all large, predatory species. Total biomass of several small species increased, due to a combination of increases in abundance and mean body mass. Several smaller species increased in relative total biomass over the study period, including skipjack tuna, which moved from tenth to third ranked position. They suggest that these changes are the result of fishing pressure, which has reduced the size and abundance of large predators, resulting in predator release of smaller species, such as skipjack tuna and pelagic rays *Dasyatis violacea* (Ward and Myers, 2005). Sibert et al. (2006) analysed Pacific fisheries data and found that biomass of the species studied ranged from 36% to 91% of unexploited levels, with no detectable decline in community trophic level. They suggested that the impact of fisheries on the ecosystem of the Pacific is less catastrophic than is often assumed although their results did find that tuna of fork length greater than 175cm had declined to less than 17% of unexploited biomass. However, their calculations were based on fisheries data, which was restricted to tuna species and one stock of blue shark *Prionace glauca* and therefore did not account for declines in other large, predatory species (Sibert et al, 2006).

Bycatch of non-target species accounted for 35% of longline catches and 1.8% of purse seine catches between 1995 and 2004 (Molony, 2007). Since 1990, observers have recorded catches of 279 species and 79 higher taxonomic groups (Molony, 2007). Observed encounter rates were low for all species groups except for pelagic sharks and related species. Low observer coverage of vessels fishing in the WCP-CA, combined with unreliable logbook data, means that estimates of bycatch mortality have wide margins for error and data is not sufficient to estimate the population status of non-target species (Molony, 2007). Observer coverage rates averaged 0.65% for longline vessels and 3.59% for purse seine vessels between 1993/4 and 2004, although coverage was distributed unevenly between fleets (Molony, 2007). Data is collected by national observer programmes. SPC-OFP and FFA support the development of active observer programmes in Pacific Island nations, using funding from the Global Environment Facility (GEF) and the EU (SPC, 2009a).

Sharks and related species are the most commonly encountered bycatch group and blue sharks the most commonly encountered species (Molony, 2007). Annual shark catch in the WCP-CA is over 667,000 by longline vessels since 1990, and 2000 – 80,000 by purse seine vessels between 1994 and 2004 (Molony, 2007; Molony, 2005). Shark catches are currently increasing. Mortality is estimated to be ~100% due to the high value of shark fins, which are sold primarily to markets in Singapore, Hong Kong and Malaysia (Molony, 2005). It has been suggested that 'shark fin revenue can double the normal wage of some crews,' and longline vessels deliberately target sharks in some parts of the WCP-CA (Williams, 1999; Molony, 2007). The species most commonly taken by longline vessels are blue, silky *Carcharhinus falciformis* and oceanic whitetip *Carcharhinus longimanus* sharks and pelagic rays (Molony, 2007). Observer data suggests that blue sharks are taken at a rate of 1.6 per thousand hooks, which is lower than the figure for temperate longline fisheries (Molony, 2005). The species most commonly taken by purse seine vessels are silky and oceanic whitetip sharks and unidentified species of manta rays (Molony, 2007). Overfishing is the primary threat to pelagic sharks and rays, which are significantly more threatened as a group than chondrichthyans as a whole (Camhi et al, 2009). A recent report has found that, of the 64 known species of pelagic sharks and rays, 6% are classified as endangered, 26% as vulnerable and 24% as near threatened (Camhi et al, 2009). See Table 1 for IUCN status of the main identified bycatch species in the WCP-CA.

Common name	**Scientific name**	**IUCN status**
Blue shark	*Prionace glauca*	Near threatened
Oceanic whitetip shark	*Carcharhinus longimanus*	Vulnerable
School shark (mainly coastal- and bottom-associated)	*Galeorhinus galeus*	Vulnerable
Silvertip shark	*Carcharhinus albimarginatus*	Near threatened
Silky shark	*Carcharhinus falciformis*	Near threatened
Shortfin mako shark	*Isurus oxyrinchus*	Vulnerable
Grey reef shark (coastal)	*Carcharhinus amblyrhynchos*	Near threatened
Thresher shark	*Alopias vulpinus*	Vulnerable (DD in Indo-West Pacific)
Porbeagle	*Lamna nasus*	Vulnerable (NT in Southern Hemisphere)
Crocodile shark	*Pseudocarcharhias kamoharai*	Near threatened
Pelagic stingray	*Dasyatis violacea*	Least concern
Bigeye thresher shark	*Alopias superciliosus*	Vulnerable
Hammerhead shark	*Sphyrna sp.*	Engangered/vulnerable

Table 1. The most commonly recorded elasmobranch bycatch species in WCP-CA with IUCN status. Source: Molony, 2007; Camhi et al, 2009.

33 species of cetacean are thought to be resident or typically migrant in the PIR (excluding the EEZs of Australia and New Zealand) (Miller, 2007). Sperm whales *Physeter macrocephalus* are the most widely reported species (SPREP, 2006). A number of species are taken as bycatch in the WCP-CA. Cetacean mortality in the longline fisheries is estimated to have been 265 per annum from 1990 to 2004, although catch rates are decreasing with an estimated mortality of less than 200 per annum since 2000 (Molony, 2007). Cetacean mortality in the purse seine fishery is estimated to have been less than 10 in total since 1998 (Molony, 2007). Table 2 lists the IUCN status of the main bycatch species in the WCP-CA. There has been a perceived increase in fishery depredation by cetaceans in recent years, leading to the use of harmful dispersal techniques, including shooting, harpooning and

‘tuna bombs’ (Miller, 2007). It has been suggested that there may be indirect competition between cetaceans and fisheries for primary production in the Pacific Ocean, which could lead to a reduction in food available to cetaceans if fishing effort continues to increase (Trites et al, 1997). Historical whaling, including commercial hunts in the PIR, led to the depletion of several cetacean species, including sperm, blue *Balaenoptera musculus*, fin *Balaenoptera physalus*, sei *Balaenoptera borealis*, Bryde’s *Balaenoptera brydei*, minke *Balaenoptera acutorostrata* and humpback *Megaptera novaeangliae* whales (SPREP, 2006). Japanese ‘scientific whaling’ in the Southern Ocean continues to target populations of minke whales that may overwinter in the Pacific Islands Region (Miller, 2007).

Common name	**Scientific name**	**IUCN status**
Bottlenose dolphin	*Tursiops truncatus*	Least concern
Short-beaked common dolphin	*Delphinus delphis*	Least concern
Spinner dolphin	*Stenella longirostris*	Conservation dependent
Dusky dolphin	*Lagenorhynchus obscurus*	Data deficient
Risso’s dolphin	*Grampus griseus*	Data deficient
Humpback whale	*Megaptera novaeangliae*	Least concern (EN in Oceania)
Short-finned pilot whale	*Globicephala macrorhynchus*	Conservation dependent
Sperm whale	*Physeter macrocephalus*	Vulnerable
‘Blackfish’	*Multiple species*	DD/LC/CD

Table 2. The most commonly recorded cetacean bycatch species in WCP-CA with IUCN status. Source: Molony, 2005; Miller, 2009.

Five of the seven species of sea turtle are found in the open ocean of the WCP-CA and all are taken as bycatch by longline and purse seine fisheries. See Table 3 for a list of the turtle bycatch species in WCP-CA and IUCN status. Sea turtle mortality in the longline fisheries is estimated to have been 918 per annum from 1990 to 2004, although rates declined towards the end of that period (Molony, 2007). Purse seine fisheries are estimated to have resulted in fewer than 500 sea turtle interactions per annum from 1994 to 2004, with a low estimated mortality rate (Molony, 2007). Of the observed instances of sea turtle bycatch between 1990 and 2004, 21% were olive ridley turtles *Lepidochelys olivacea*, 17% were green turtles *Chelonia mydas* and 10% were leatherback turtles (Molony, 2007). Species was not identified in the majority of interactions. Sea turtle bycatch in the WCP-CA is more common in tropical waters, where green turtles are the most regularly encountered species (SPC-OFP, 2001).

Common name	**Scientific name**	**IUCN status**
Olive ridley turtle	*Lepidochelys olivacea*	Vulnerable
Green turtle	*Chelonia mydas*	Endangered
Leatherback turtle	*Dermochelys coriacea*	Critically endangered
Loggerhead turtle	*Caretta caretta*	Endangered
Hawksbill turtle	*Eretmochelys imbricata*	Critically endangered

Table 3. Sea turtle species recorded as bycatch in the WCP-CA with IUCN status. Source: Molony, 2005; IUCN, 2009.

39 species of seabird breed on the tropical Pacific islands of the SPC (excluding Australia, New Zealand and Hawaii) and a further 17 species migrate through the region (Watling, 2002). However, recorded levels of seabird bycatch are extremely low. Seabird mortality in the longline fisheries is estimated at fewer than 100 per annum since 1998 and there has been only one recorded instance of seabird bycatch in the purse seine fishery since 1994 (Molony, 2007). Albatross and large petrels, the species considered most vulnerable to bycatch in longline fisheries, occur only as wandering vagrants in the region (Watling, 2002). Watling (2002) identifies four known bycatch species that occur in EEZs

of the PIR (excluding Australia, New Zealand and Hawaii), as well as seven species deemed potentially vulnerable to fisheries bycatch on the basis of their body mass (>400g). See Table 4 for a list of bycatch and potential bycatch species in the PIR. The high proportion of potentially vulnerable species that are classified as threatened by IUCN suggests that fisheries bycatch could be a more significant issue than is currently thought, particularly in light of the very low rate of observer coverage (Watling, 2002). Two critically endangered seabird species, the Fiji petrel *Pseudobulweria macgillivrayi* and Beck's petrel *Pseudobulweria becki*, breed in the region but are not thought to be at risk of bycatch due to their small body size (Watling, 2002).

Anthropogenic climate change is predicted to affect the open ocean ecosystem of the PIR in a number of ways. Shifting ocean temperatures and current patterns are predicted to affect primary productivity and O_2 concentration, leading to shifts in the availability and distribution of prey species (SPC, 2009). These effects could lead to changes in the pelagic food web and alter patterns of predator production and migration. Sea level rise and ocean acidification may cause the death, or slow the growth, of tropical corals, where these occur on seamount summits (Miller, 2007). Ocean acidification may also lead to reduced growth of deepwater coral species. Migratory species will be affected by climate change impacts outside the region. For example, reduced krill abundance in the Southern Ocean could negatively affect populations of great whales that overwinter in the PIR (Miller, 2007). Daufresne et al. (2009) found that temperature increase due to climate change resulted in reduced body size of ectotherms, including marine fishes, at the individual and community levels. Halpern et al's (2008) model of human impacts on marine ecosystems found high levels of human impact related to sea surface temperature increase, ocean acidification and UV radiation in open-ocean areas of the PIR (NCEAS, 2008). The multiple effects of climate change are likely to combine with the effects of other human activities in the region, with synergistic and unpredictable negative consequences for marine ecosystems.

Common name	**Scientific name**	**Bycatch occurrence**	**Occurrence in SPC region**	**IUCN status**
Pink-footed shearwater	*Puffinus creatopus*	Potentially vulnerable	Vagrant in eastern part of SPC region	Vulnerable
Wedge-tailed shearwater	*Puffinus pacificus*	Known bycatch species	Common breeder	Least concern
Flesh-footed shearwater	*Puffinus carneipes*	Known bycatch species	Rare, annual passage migrant	Least concern
Sooty shearwater	*Puffinus griseus*	Known bycatch species	Common passage migrant	Near threatened
Short-tailed shearwater	*Puffinus tenuirostris*	Known bycatch species	Common passage migrant	Least concern
Christmas shearwater	*Puffinus nativitatis*	Potentially vulnerable	Uncommon breeder	Least concern
Newell's shearwater	*Puffinus newelli*	Potentially vulnerable	Rare vagrant	Endangered
Heinroth's shearwater	*Puffinus heinrothi*	Potentially vulnerable	Breeds New Britain & Solomon Islands	Vulnerable
Dark-rumped/Hawaiian petrel	*Pterodroma phaeopygia/ sandwichensis*	Potentially vulnerable	Common in eastern part of SPC region	Critically endangered/ vulnerable
Juan Fernandez petrel	*Pterodroma externa*	Potentially vulnerable	Eastern part of SPC region	Vulnerable
Murphy's petrel	*Pterodroma ultima*	Potentially vulnerable	Breeds French Polynesia	Near threatened

Table 4. Seabird bycatch and potential bycatch species present in PIR EEZs (excluding Australia, New Zealand and Hawaii). Source: Watling, 2002; IUCN, 2009.

4. West Oceania Marine Reserve

4.1 Area description

The West Oceania Marine Reserve (WOMAR) is a high seas enclave in the tropical Western Pacific, bordered by the EEZs of PNG, Indonesia, Palau and the Federated States of Micronesia (FSM). It falls within FAO fishing area 71. See figure 4 for a map of WOMAR and its key features.

WOMAR is located within the Western Pacific Warm Pool (WARM) biogeographical province, which is characterised by oligotrophic, low salinity water with sea surface temperatures at or above 29°C throughout the year (Longhurst, 2006). Equatorial upwelling occurs during neutral and La Niña phases of ENSO but only results in enhanced primary productivity during periods of strong westward wind stress due to the extreme depth of the nitracline (Longhurst, 2006). This effect narrows progressively westwards. Shoaling of the thermocline and nitracline during El Niño events can lead to enhanced vertical flux of nutrients into surface waters and increased primary productivity (Longhurst, 2006). However, this effect was ephemeral during the 1986 – 1987 El Niño (Longhurst, 2006). Surface currents are dominated by the SEC, which flows westwards between ~5°N and 20°S and extends to ~100 – 150m below the surface. The North Equatorial Counter-Current (NECC), which flows eastwards north of 5°N, may also influence surface water flow in WOMAR.

WOMAR contains a number of distinct bathymetric features, with a large depth range likely to provide habitat suitable for a diverse range of deep-sea organisms. Features present include: the Eauripik Rise, an area of elevated topography rising to depths of less than 2000m; the Mussau Trench, with a maximum depth of ~7200m; and the Mussau Ridge chain of seamounts, with summit depths less than 2000m (ISA, 2009; EarthRef 2009).

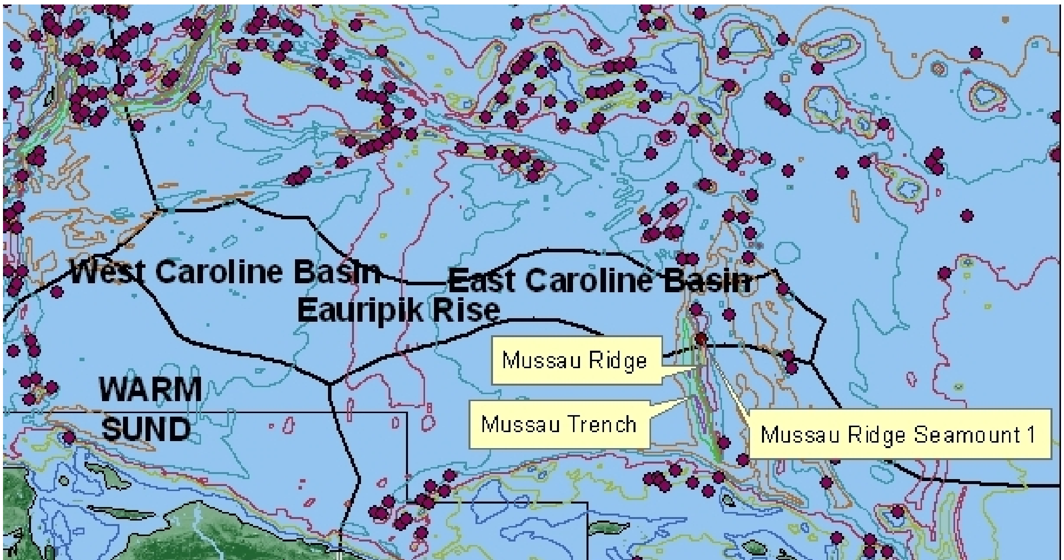
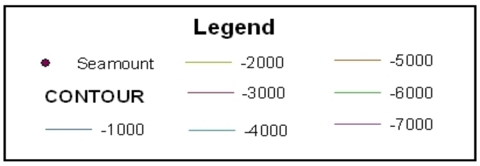


Fig. 4. WOMAR[1]



4.2 Human activities and threats

Purse seine and longline fishing vessels are active in WOMAR, targeting skipjack, yellowfin and bigeye tuna. The majority of purse seine effort consists of unassociated sets, with a significant number of sets also made on logs and a lesser proportion on drifting FADs (Williams and Terawasi,

[1] Map data sourced from GEBCO (2008), Allain et al (2008), COML (2009) and COML Maps (2009).

2008). A higher proportion of yellowfin, relative to skipjack, landings are taken from unassociated sets, which are often made on feeding schools of tuna (Williams and Terawasi, 2008). The proportion of bigeye taken in relation to yellowfin is small compared to other areas, which may reflect the relatively low proportion of sets on FADs (see figure 2). Purse seine fleets active in the vicinity of WOMAR in 2006 – 2007 were: Japan; Korea; Taiwan; and the FSM Arrangement fleet; with an extremely low level of fishing effort by the U.S. fleet (Williams and Terawasi, 2008).

The majority of longline fishing effort is by foreign-offshore fleets from Japan, China and Taiwan, with the remainder undertaken by domestic and distant-water fleets (Williams and Terawasi, 2008). Target species are yellowfin and bigeye tuna (see figure 3).

The level of commercial shipping activity in WOMAR is low on a global scale but regionally high, with potential implications for cetaceans (NCEAS, 2008). Noise pollution as a result of shipping is thought to be the primary cause of the doubling of background levels of ocean noise every decade for the past 60 years and it has been suggested that the PIR could be in line with this global average (Miller, 2007). Sub-lethal levels of noise pollution caused by shipping can affect cetaceans by disrupting feeding and mating behaviour, migratory routes and call patterns. 12 species of cetacean are reported to have suffered ship strikes in the PIR (Miller, 2007).

There is currently no mining activity in WOMAR. However, it is conceivable that noise pollution from exploratory mining of seabed massive sulphide (SMS) deposits in the Bismarck Sea, a process that began in 2005, could affect cetaceans on the high seas (Miller, 2007). Noise pollution as a result of mining can be lethal to cetaceans and the noise produced by seismic air guns is estimated to flood a region up to 300,000km^2 (Miller, 2007). There is a possibility that mining could take place in the future, as the summit depth of the Mussau Ridge falls within the 800 – 2500m optimum range for the formation of cobalt-rich ferromanganese crusts (ISA, 2008a). Both the Mussau Ridge and Eauripik Rise are the subject of an extended continental shelf claim, submitted jointly to the UN by PNG and FSM (SOPAC, 2009).

4.3 Ecological characterisation against criteria

Special importance for life history stages

WOMAR forms part of the pre- and post-nesting migratory route for leatherback turtles that nest at Papua Barat, Indonesia and the Solomon Islands (Benson et al, unpublished). Leatherbacks nesting here are thought to forage primarily in the North Pacific, including foraging grounds off the central Californian coastline (Benson et al, 2007). Of nine leatherbacks tagged by Benson et al. (2007) in 2003, 6 travelled northward or northeastward, passing through WOMAR, and one of these was tracked as far as the waters off California. Figure 5 shows the migratory pathways of leatherbacks tagged at Jamursba-Medi, Papua, Indonesia and coastal central Californian foraging grounds and tracked using satellite telemetry.

WOMAR may also be an important area for juvenile leatherback turtles, although there is no direct evidence for their presence. Juvenile leatherbacks, less than 100cm in length, have only been recorded in waters warmer than 26°C (Eckert, 2002). Of the 98 confirmed sightings worldwide, one was from an area just to the north of WOMAR (Eckert, 2002) Combined with its proximity to leatherback nesting beaches, this suggests that WOMAR could be an important area for the post-hatching migration of juvenile leatherbacks.

WOMAR may be an important spawning area for yellowfin tuna. Yellowfin spawning takes place continuously in the tropical waters of the Western Pacific (Itano, 2000). The temporal and spatial distribution of spawning activity is patchy, possibly reflecting forage availability. A positive relationship between localised areas of high forage abundance, high reproductive rates and heightened vulnerability to surface fisheries has been noted for yellowfin tuna (Itano, 2000). Yellowfin from active feeding aggregations, or 'foaming' schools, of the sort targeted by purse seine vessels in unassociated sets, have been found to be reproductively active with high spawning frequencies (Itano, 2000). The high proportion of unassociated sets by purse seine vessels suggests that spawning/feeding behaviour may be common in WOMAR. One study found that 'Japanese fishermen have been aware for several years that foaming schools are especially common in the area to the north of PNG during October to December,' (Itano, 2000).

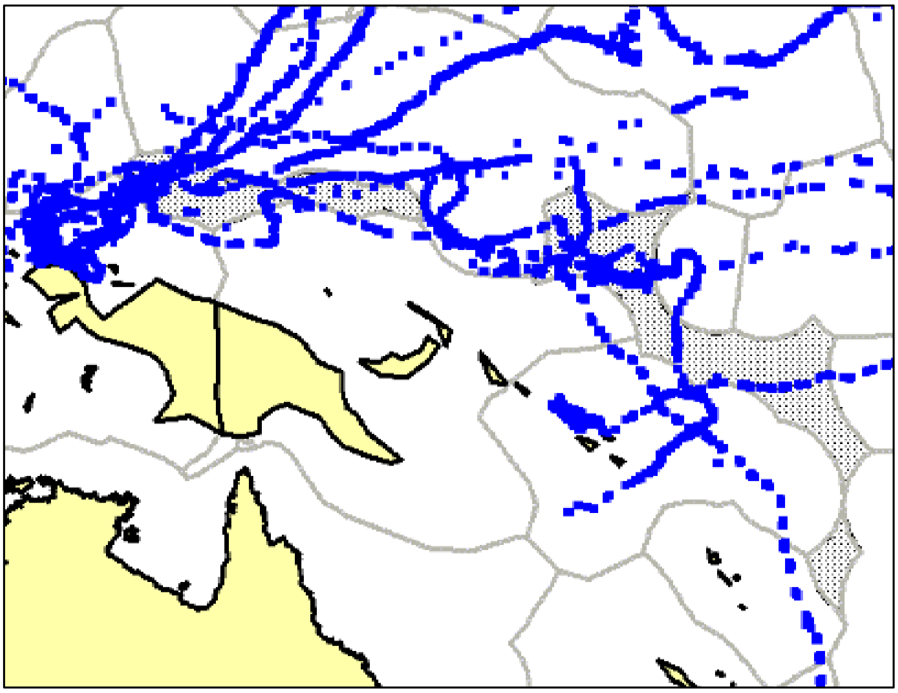


Fig. 5. Movements through Western Pacific high seas pockets by leatherback turtles approaching and departing nesting beaches in Papua Barat, Indonesia and Solomon Islands. Source: Benson et al, unpublished.

Threatened/endangered/declining species or habitats

WOMAR forms part of the pre- and post-nesting migratory route for critically endangered leatherback turtles (see figure 5). Leatherback numbers have declined precipitously in recent years and the effect has been particularly pronounced in the Pacific Ocean, where numbers have collapsed at once important rookeries in Mexico and Malaysia (Dutton et al, 2007). An analysis of published estimates suggests a reduction in the global population of adult females of 70% in less than one generation (IUCN, 2009). Many of the leatherbacks that migrate through WOMAR nest on the northwest coast of Papua, Indonesia. Although this population shows evidence of long-term decline, the effect has been less pronounced than at other nesting sites, and it is now thought to constitute the largest remaining nesting population in the Pacific (Hitipeuw et al., 2007). A number of factors have been implicated in the dramatic decline of leatherback turtles, including poaching of eggs, bycatch in longline and driftnet fisheries, targeted hunting and pollution. Whilst there is some dispute over the level of leatherback bycatch, mortality rates are probably unsustainable and a reduction in the number of leatherback interactions with fishing vessels is a conservation priority. Lewison et al. (2004) estimated that 20,000 leatherbacks were caught as bycatch by pelagic longliners in the Pacific in 2000, with mortality of 1000 – 3200. Hays et al. (2003) used data from satellite tracking studies to reach an estimated mortality rate of 0.31 for all marine turtle species in interactions with fisheries worldwide. The level of leatherback bycatch or mortality in WOMAR is not known, however the high level of longline fishing effort and the presence of migrating leatherbacks suggest that fisheries interactions are likely to occur.

Observer data demonstrates the presence of critically endangered hawksbill turtles, endangered green turtles and vulnerable olive ridley turtles in WOMAR (Molony, 2005; SPC-OFP, 2001; IUCN, 2009). A review of data from 1990 to 2000 showed a relatively high rate of sea turtle bycatch, by purse seine and longline vessels, in WOMAR (SPC-OFP, 2001). Longline bycatch was particularly concentrated in an area of equatorial waters in the vicinity of the easternmost portion of WOMAR.

Bigeye tuna are taken in WOMAR by longline and purse seine fisheries. Bigeye tuna are classified as vulnerable by the IUCN and their numbers are declining in the WCP-CA, where the stock is overfished (IUCN, 2009; Langley et al, 2008). The biomass of yellowfin tuna in the WCP-CA declined steadily throughout the 1990s and overfishing is occurring (Langley et al, 2007; NMFS, 2006). See 'Human activities and threats in the Pacific Islands Region' for details of bigeye and yellowfin tuna declines.

Vulnerability, fragility, sensitivity or slow recovery

A number of species of sea turtle are present in WOMAR. All species of sea turtle are highly vulnerable to human impacts and have a slow recovery time as a result of their life history characteristics. All species share a common life history pattern, with high fecundity, slow growth, late age at maturation, longevity and low adult mortality (Davenport, 1997). The age at first reproduction varies from 6 – 10 years for hawksbills and ridley turtles to 20 – 50 years for green turtles, which can live for over 100 years (Davenport, 1997). Leatherback turtles have a high growth rate relative to cheloniids, probably due to their warm-blooded physiology, and are thought to reach maturity more quickly (Musick, 1999). However, all species of sea turtle have an intrinsic annual rate of population increase (r) below 10%, which puts them at particular risk of depletion due to human impacts (Musick, 1999).

The Mussau Ridge could potentially include areas of fragile and sensitive habitat. Whilst there has been very little surveying of seamounts in this region, the depth range and topography of the Mussau Ridge are potentially suited to colonisation by sessile epibenthic organisms, including gorgonians, antipatharians and sponges. Whilst the majority of scleractinians and stylasterids are found at depths of 100 – 1000m, gorgonians and antipatharians are more commonly found at depths greater than 1200m, and could potentially occur on the Mussau Ridge (Rogers et al, 2007). Sampling at Mussau Ridge Seamount 1 (see figure 4) by the Soviet vessel Akademik Mstislav Keldysh, in 1984, revealed the presence of three species of hexactinellid sponge at depths of 1520 – 1780m: *Pheronema megaglobosum* Tabachnick and *Eurete lamellina* Tabachnick, which are recorded as occurring only at this location by the Seamounts Online database; and *Tretopleura styloformis* Tabachnick, which has been recorded at a number of locations in the Western Tropical Pacific (COML, 2009). Gorgonians, sponges and antipatharians create 'islands' of complexity in the deep-sea that provide habitat for a number of invertebrate and associated vertebrate species (Samadi et al, 2007). Some species can form dense stands in areas where currents sweep the summits and flanks of seamounts (Rogers et al, 2007). Deep-sea habitat builders are highly vulnerable to the impacts of deepwater fisheries and have a slow recovery time due to their life history characteristics, which include slow growth and extreme longevity. Gorgonian colonies over 500 years old have been found on seamounts in New Zealand and an individual of the hexactinellid sponge genus Monoraphis has been estimated at 440 years old (Samadi et al, 2007). Growth is extremely slow in the low-energy, deep-sea environment and one species of sponge has been estimated to grow at a rate of only 11mm per century (Samadi et al, 2007). A number of studies have documented the dramatic impacts of deepwater fisheries on seamount habitats and associated species (Clark and O'Driscoll, 2003; Probert et al, 1997; Koslow et al, 2001).There are currently no deep-water fisheries operating in WOMAR, however there is potential for the destruction of vulnerable habitats, should this activity develop in the future.

Biological productivity

WOMAR is located in the Pacific Warm Pool, an area of elevated pelagic predator abundance (Longhurst, 2006). The Warm Pool meets the nutrient-rich, upwelling waters of the Pacific Cold Tongue at the Eastern Warm Pool Convergence Zone, a dynamic area of high primary productivity located in equatorial waters (Picaut et al, 2001). It is thought that low tropic level species are advected westwards, creating a productive foraging area for tuna and other pelagic predators, including sea turtles, sharks and cetaceans, downstream of the convergence zone (Lehodey et al, 1998). This is supported by the distribution of purse seine fishing effort, which is concentrated in equatorial waters of the Warm Pool (see figure 2). The location of the convergence zone varies with ENSO. Productivity, forage and fishing effort are concentrated further westwards during neutral and La Niña phases, when relative fishing effort in WOMAR increases (Lehodey, 2001).

Phytoplankton blooms in the eastwards flowing NECC can lead to increased levels of primary productivity in WOMAR at certain times (NASA, 2009). Elevated chlorophyll levels are observed in the western portion of the NECC during the winter, spring and summer and are particularly pronounced during El Niño events (Christian et al, 2004). This effect is attributed primarily to upwelling associated with current meandering (Christian et al, 2004).

The Mussau Ridge could potentially include areas of elevated benthic productivity. Productive seamount habitats are created where sessile suspension feeders, including scleractinian corals, octocorals and sponges, colonise areas of hard substrate created by the flow of currents over seamount summits and flanks (Rogers et al, 2007). The intensification of near bottom currents in the vicinity of seamounts can substantially enhance the allochthonous food supply to deepwater planktivores, leading to elevated secondary productivity relative to surrounding areas (Genin and Dower, 2007). This effect is most pronounced on deep seamounts, such as the Mussau Ridge, where food supply is the major factor limiting productivity (Genin and Dower, 2007). Pelagic productivity is unlikely to be influenced by the Mussau Ridge, as the relatively deep summits do not penetrate the euphotic zone or the deep scattering layer (DSL) (Pew, 2007).

Biological diversity

The Mussau Ridge could potentially include areas of benthic habitat with elevated levels of species diversity. Complex structures created by scleractinian corals, octocorals and sponges on the summits and flanks of seamounts provide habitat for a number of species, including sessile and mobile invertebrates and fish (Samadi et al, 2007). Stands of gorgonians have been found to be inhabited by shrimp, galatheid lobsters and other crustaceans, crinoids, basket stars, sponges and other corals (Rogers et al, 2007). These habitats provide shelter for fish species that employ the feed-rest strategy, conserving energy by sheltering from strong currents amongst corals and sponges between periods of active feeding (Genin and Dower, 2007). Available data suggests that the overall (γ) species diversity of seamounts may be similar to that of the deep-sea as a whole and species richness on equatorial seamounts may be low relative to those at higher latitudes, although this could be an artefact of low sampling effort (Stocks and Hart, 2007; Rogers et al, 2007). However, the availability of complex habitat combined with elevated productivity results in relatively high local (α) species diversity on seamounts colonised by sessile suspension feeders (Rogers et al, 2007).

5. Greater Oceania Marine Reserve

5.1 Area description

The Greater Oceania Marine Reserve (GOMAR) is a high seas enclave in the tropical Western Pacific, bordered by the EEZs of FSM, Marshall Islands, Nauru, Kiribati, Tuvalu, Fiji, the Solomon Islands and PNG. It falls within FAO fishing area 71. See figure 6 for a map of GOMAR and its key features.

GOMAR is located within the WARM biogeographical province, which is characterised by oligotrophic, low salinity water with sea surface temperatures at or above 29°C throughout the year (see 'West Oceania Marine Reserve' for a description of physical conditions in WARM) (Longhurst, 2006).Surface currents in the vicinity of GOMAR are dominated by the SEC. Within the SEC, the weaker South Equatorial Counter-Current (SECC) flows eastwards between 7°S and 14°S.

GOMAR encompasses a section of the Ontong Java Rise, where depths rise to less than 2000m. The abyssal plain sinks to depths greater than 4000m in the Nauru Basin and sinks below 5000m in the Elice Basin. 14 seamounts have been identified in GOMAR, with summit depths ranging from 2412m to 4300m (Allain et al, 2008).

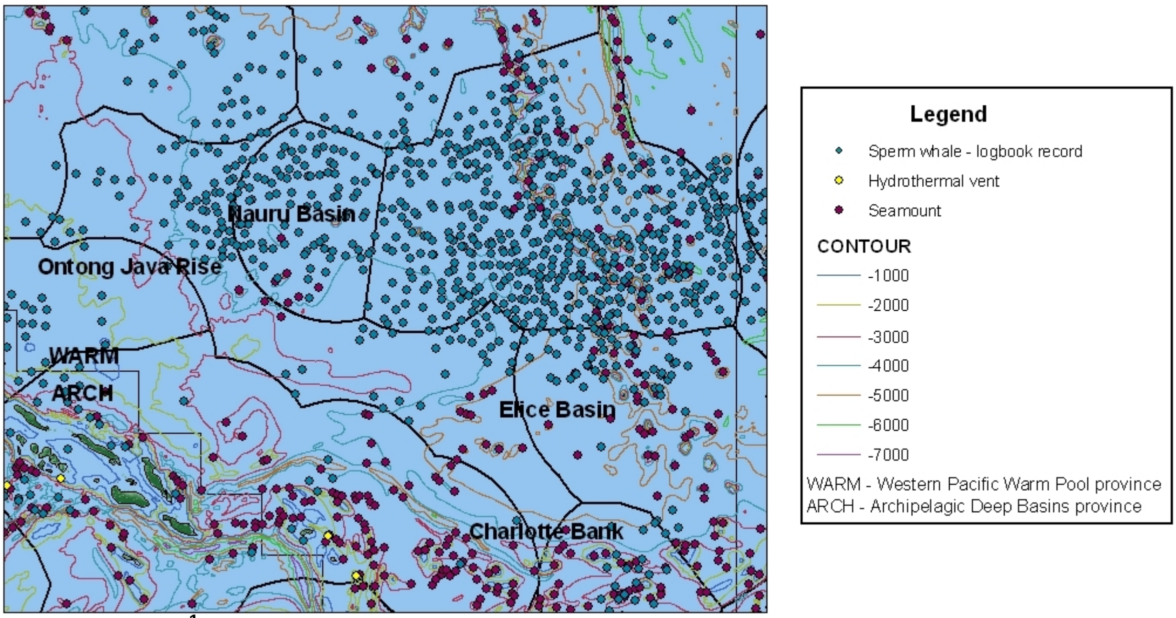


Fig. 6. GOMAR[1]

5.2 Human activities and threats

Purse seine and longline fishing vessels are active in GOMAR, targeting skipjack, yellowfin, bigeye and albacore tuna. Purse seine vessels make unassociated sets and sets on logs and drifting FADs. No one method dominates and the relative proportions vary annually (Williams and Terawasi, 2008). Skipjack tuna account for the majority of purse seine landings, with the remainder composed of yellowfin and a small proportion of bigeye tuna (see figure 2). Purse seine fleets active in the vicinity of GOMAR in 2006 – 2007 were: Japan, Korea, Taiwan, the FSM Arrangement fleet and the U.S. fleet (Williams and Terawasi, 2008).

The majority of longline fishing effort in the vicinity of GOMAR is by distant-water fleets from Japan, Korea and Taiwan, with the remainder undertaken by foreign-offshore and domestic fleets (Williams and Terawasi, 2008). Target species are yellowfin, bigeye and albacore tuna (see figure 3).

The Ontong Java Rise is the subject of an extended continental shelf claim, submitted jointly to the UN by PNG, FSM and the Solomon Islands (SOPAC, 2009). The Charlotte Bank, in the southernmost portion of GOMAR, is the subject of an extended continental shelf claim submitted jointly to the UN by Fiji and the Solomon Islands (SOPAC, 2009).

5.3 Ecological characterisation against criteria

Special importance for life history stages of species

GOMAR forms part of the pre- and post-nesting migratory route for leatherback turtles that nest at Papua Barat, Indonesia and the Solomon Islands (see 'West Oceania Marine Reserve').

There is some evidence to suggest that GOMAR may form part of a migratory route for green turtles moving between the Marshall Islands and the Solomon Islands, Australia and PNG. Data obtained from a passive tag retrieval study conducted over a period of 14 years showed green turtles moving between these locations (Klain, pers. comm.; McCoy, pers. comm.). Whilst this does not provide direct evidence for their presence, the shortest routes would pass through GOMAR, suggesting that the presence of migrating green turtles is likely.

[1] Map data sourced from GEBCO (2008), Allain et al (2008), NOAA Vents Program (2009), WCS (2007) and COML Maps (2009).

Threatened/endangered/declining species or habitats

GOMAR forms part of the pre- and post-nesting migratory route for critically endangered leatherback turtles that nest at Papua, Indonesia and the Solomon Islands (see 'West Oceania Marine Reserve'). The level of leatherback bycatch or mortality in GOMAR is not known, however the high levels of longline fishing effort and the presence of migrating leatherbacks suggest that fisheries interactions are likely to occur.

Observer data demonstrates the presence of vulnerable olive ridley turtles, as well as unidentified marine turtles, in GOMAR (Molony, 2005; SPC-OFP, 2001). Records show that green turtles are the species most commonly caught in tropical waters, suggesting that this species may also be taken as bycatch in GOMAR (SPC-OFP, 2001). A review of data from 1990 to 2000 showed that longline bycatch was particularly concentrated in an area of equatorial waters that included the northernmost portion of GOMAR (SPC-OFP, 2001).

Bigeye tuna are taken by longline and purse seine fisheries in GOMAR. Bigeye tuna are classified as vulnerable by the IUCN and their numbers are declining in the WCP-CA, where the stock is overfished (IUCN, 2009; Langley et al, 2008). The biomass of yellowfin tuna in the WCP-CA declined steadily throughout the 1990s and overfishing is occurring (Langley et al, 2007; NMFS, 2006). See 'Human activities and threats in the Pacific Islands Region' for details of bigeye and yellowfin tuna declines.

Historical records compiled from whaling logbooks show an area of high sperm whale catches in the northernmost portion of GOMAR (WCS, 2007). This corresponds to the western extreme of the 'On the Line' whaling ground and may indicate an area of historically high sperm whale abundance (Taei, pers. comm.). Sperm whales are classified as vulnerable by IUCN and have suffered significant global declines as a result of intensive exploitation during two periods of commercial whaling – 'open boat' whaling from the early 18^{th} to early 20^{th} centuries and 'modern' whaling during the 20^{th} century, particularly from the 1950s to 1980s (Whitehead, 2002). The population status of sperm whales in the PIR is uncertain, however it has been estimated that the global population is at ~32% of unexploited abundance (Whitehead, 2002).

Vulnerability, fragility, sensitivity or slow recovery

Leatherback and olive ridley sea turtles are present in GOMAR and the presence of green turtles is likely. All species of sea turtle are highly vulnerable to human impacts and have a slow recovery time as a result of their life history characteristics (see 'West Oceania Marine Reserve').

Historical records compiled from whaling logbooks suggest that sperm whales may have been historically abundant in GOMAR (WCS, 2007). Sperm whales are highly vulnerable to human impacts and have a slow recovery time as a result of their life history characteristics, which include low fecundity, late age at maturation and longevity (Chivers, 2002). Sperm whales' age at first reproduction varies from 7 to 13 years for females to 20 years for males and individuals can live for over 70 years. Sperm whales give birth to single calves in a reproductive cycle that can last for over three years, including a 12 – 17 month gestation period and 2 – 3 year lactation period (Chivers, 2002).

Biological productivity

GOMAR is located in the Pacific Warm Pool, an area of elevated abundance of tuna and other pelagic predatory species (see 'West Oceania Marine Reserve'). High secondary productivity is indicated by the relatively high levels of longline and purse seine fishing effort in GOMAR (see figures 2 and 3). Productivity, forage and fishing effort are concentrated further eastwards during El Niño phases of ENSO, when relative fishing effort in GOMAR increases (Lehodey et al, 1998).

6. Moana Marine Reserve

6.1 Area description

The Moana Marine Reserve (MOANA) is a high seas enclave in the Central Pacific, bordered by the EEZs of the Cook Islands, French Polynesia and Kiribati. It falls within FAO fishing area 77. See figure 7 for a map of MOANA and its key features.

MOANA is located within the South Pacific Subtropical Gyre (SPSG) biogeographical province. SPSG is one of the most uniform and least studied regions of the open oceans and is characterised by warm, salty, oligotrophic surface water (Longhurst, 2006). Surface currents in the vicinity of MOANA are dominated by the SEC, within which flows the weaker SECC (see 'Greater Oceania Marine Reserve).

The bathymetry of MOANA is relatively uniform and is dominated by the abyssal plain at a depth of approximately 5000m. Allain et al. (2008) record one seamount in MOANA with a summit depth of 3201m.

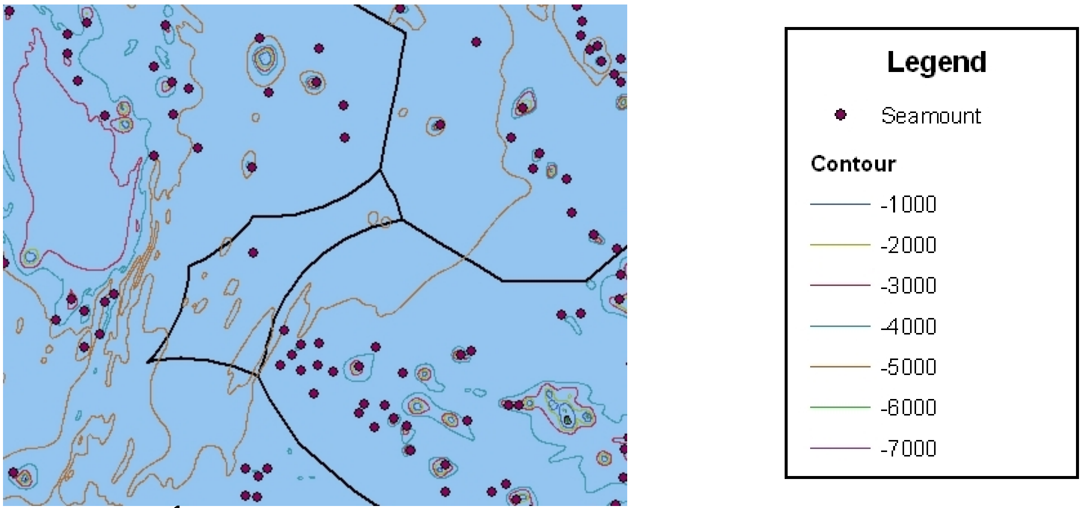


Fig. 7. Moana[1]

6.2 Human activities and threats

Longline fishing vessels are active in MOANA, although fishing intensity is low relative to other areas of the WCP-CA (see figure 3). Landings consist primarily of albacore tuna, with lesser proportions of yellowfin and bigeye tuna also taken. Fishing effort is by distant-water and domestic fleets (Williams and Terawasi, 2008). There is no purse seine or demersal fishing effort.

The ISA (2009) records the presence of polymetallic nodules in MOANA. Polymetallic nodules are rock concretions formed of concentric layers of iron and manganese hydroxides (ISA, 2008b). Found scattered on the abyssal plain of all ocean basins, polymetallic nodules have been the focus of intense mining interest. Commercially viable mining of polymetallic nodules is not economically or technologically feasible at present, however mining could potentially take place in MOANA in the future (Glasby, 2000).

[1] Map data sourced from GEBCO (2008) and Allain et al (2008).

6.3 Ecological characterisation against criteria

Special importance for life history stages of species

MOANA occurs in an area that may be important for breeding minke whales. Kasamatsu et al. (1995) recorded an above average encounter rate with southern minke whales in waters between 10°S and 20°S and 150°W and 160°W during the month of October. Southern minke whales are thought to breed in open ocean areas north of 30°S, with a peak conception period between August and October. Therefore it was suggested that the area of increased sightings incorporating MOANA could form an important breeding area for minke whales in the Western South Pacific (Kasamatsu et al, 1995).

7. Western Pacific Marine Reserve

7.1 Area description

The Western Pacific Marine Reserve (WPMR) is a high seas enclave in the Western Pacific, bordered by the EEZs of Fiji, Vanuatu and the Solomon Islands. It falls within FAO fishing area 71. See figure 8 for a map of WPMR and its key features.

WPMR straddles the boundary between the WARM and SPSG biogeographical provinces. Both provinces are characterised by oligotrophic water, with higher salinity in the SPSG province due to lower rates of precipitation. SST is higher in the WARM province, which is delimited by the 29°C isotherm (Longhurst, 2006). Surface currents in the vicinity of WPMR are dominated by the SEC, within which flows the weaker SECC (see 'Greater Oceania Marine Reserve').

The WPMR is located in the North Fiji Basin, a back-arc basin with a depth of ~3000m. The North Fiji Basin is limited by the Vitiaz Lineament subduction zone to the north; the Matthew Hunter fracture zone to the south; the Fiji Plateau to the east; and the New Hebrides Arc and subduction zone to the west (Dèsbruyeres et al, 1994). The basin is spreading actively at a rate of ~7.2cmy^{-1} and contains areas of hydrothermal activity (Nojiri et al, 1989). The northern portion of the basin's central spreading axis, oriented 160°N, is located in WPMR (Auzende et al, 1990). This portion of the axis is bathymetrically complex and consists of a double ridge, separated by a graben reaching depths of over 4000m (Auzende et al, 1990). The South Pandora/Rotuma Ridge, which trends east-northeast in the northern part of the basin also passes through WPMR (Lagabrielle, 1995) It has been suggested that the ridge may be a new active spreading centre and piston core samples taken from its vicinity show anomalously high levels of Fe, Mn, Cu and Zn, indicating proximity to hydrothermal vent activity (Exon, 1983). No hydrothermal vent sites have been identified within WPMR. However, the presence of two active spreading ridges suggests that hydrothermal vent activity could potentially occur. A number of vents have been studied at the triple-plate junction of the central spreading axis, located within the Fijian EEZ, including the White Lady, LHOS, Pére Lachaise and Mussel Valley vents and the Sonne 99 vent field (NOAA Vents Program, 2009; MBARI, 2005; Géoazur, 2005; Halbach et al, 1995). Nojiri et al. (1989) detected a megaplume, a short-term, massive release of hydrothermal fluids, at 173°30'E, 18°50'S.

The South Pandora/Rotuma Ridge rises to a summit depth of 45m at Horizon Bank, a drowned atoll located in the north of WPMR (Allain et al, 2008). Henry W. Menard, an oceanographer at Scripps Institution of Oceanography, described the discovery of Horizon Bank during the 1967 Nova Expedition in *Anatomy of an Expedition* (1969): '*The bottom kept going up and up and up as we changed scale on the depth recorder until it levelled at 70 feet, deepened slightly and then rose again to 70 feet before dropping abruptly into water two miles deep. What we had just discovered was a drowned atoll…There is always a bonus in discovering a mountain – you get to name it…Considering everything it seemed appropriate to name it after the ship, "Horizon Bank," following a common custom…banks are hard to find these days and we thought she deserved one last tribute*.' Allain et al. (2008) identify a further four seamounts in WPMR, with summit depths ranging from 2328m to 1470m.

WPMR is the subject of an extended continental shelf claim, submitted to the UN by Fiji (SOPAC, 2009).

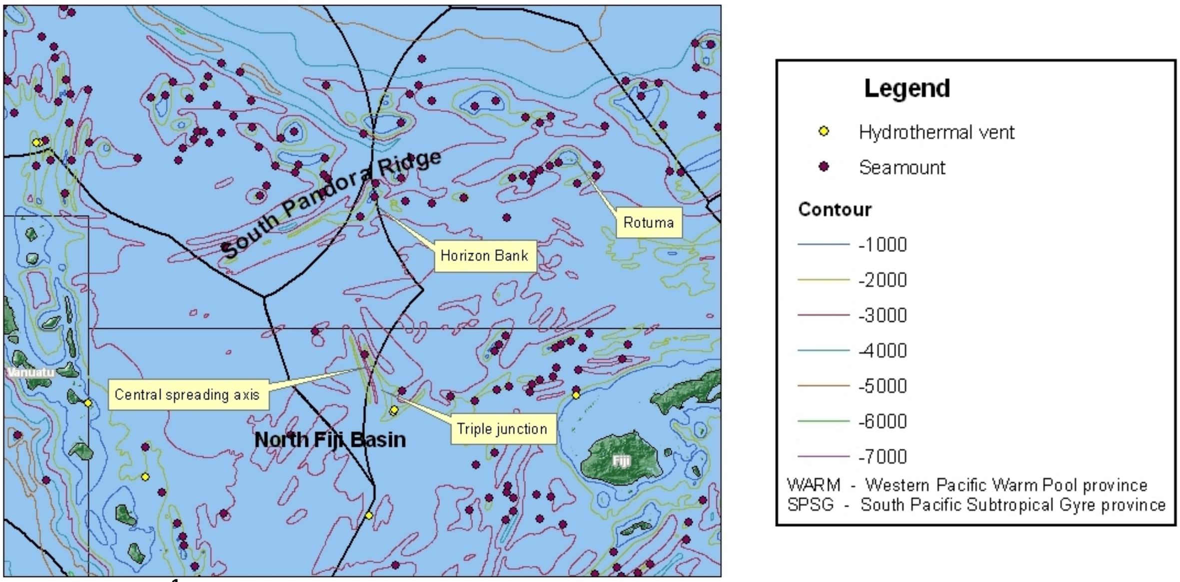


Fig. 8. WPMR[1]

7.2 Human activities and threats

Longline fishing vessels are active in WPMR, targeting albacore, yellowfin and bigeye tuna. Albacore tuna account for the majority of landings (see figure 3). Fishing effort is dominated by domestic fleets, with some activity by foreign-offshore and distant-water vessels (Williams and Terawasi, 2008). There is limited purse seine effort in WPMR. There is currently no evidence for demersal fishing activity in WPMR, however there is potential for shallow- and deepwater demersal fisheries to develop in the future.

The elevated abundance of pelagic predators in the vicinity of shallow seamounts, such as Horizon Bank, can increase the impacts of fisheries on target and non-target species. Catches taken from the vicinity of seamounts often contain relatively high proportions of juveniles as well as non-target species, including sea turtles and seabirds (Holland and Grubbs, 2007). Species' vulnerability to fishery impacts is increased by aggregating behaviour, which leads to preferential targeting of seamounts in many fisheries (Holland and Grubbs, 2007). It has been suggested that fishery removals of pelagic species could affect benthic communities due to bentho-pelagic coupling, as the supply of energy from surface waters may be reduced (Pew, 2007). There is some evidence for the depletion of commercial stocks due to preferential targeting of seamounts. Campbell and Hobday (2003) suggested that declining landings in the eastern Australian swordfish fishery were partly attributable to the serial depletion of seamount-associated stocks, which were preferentially targeted by fishing vessels.

Rotuma and its surrounding islets, located ~400km east of Horizon Bank, on the South Pandora/Rotuma Ridge, support breeding colonies of seabirds, suggesting that seabird numbers and the consequent risk of longline interactions could be high in the vicinity of Horizon Bank. J. W. Boddam-Whetham, the nineteenth century author of *Pearls of the Pacific* (1876), described an islet near Rotuma where, '*immense quantities of seabirds congregate*.' Frigatebirds *Fregata sp.* and brown boobies *Sula leucogaster* were regularly observed by Zug et al. (1988) in their study of Rotuman fauna. Boobies are amongst the bird groups vulnerable to longline bycatch in the PIR and account for 22% of seabird bycatch in the tropical Peruvian artisanal longline fishery (Watling, 2002; Jahnke et al, 2001). Frigatebird bycatch has been recorded by observers on Taiwanese longline vessels in the WCP-CA (Huang et al, 2008). It seems possible, therefore, that levels of seabird bycatch could be elevated in the vicinity of Horizon Bank.

[1] Map data sourced from GEBCO (2008), Allain et al (2008), NOAA Vents Program (2009) and COML Maps (2009).

Human activities undertaken at hydrothermal vent sites include mining, bioprospecting and scientific research. If hydrothermal vents are discovered in WPMR in the future, there is potential for these activities to develop. SMS deposits, found at the site of collapsed 'black smoker' vent chimneys, are currently the focus of exploratory ventures by mining companies, including in the EEZ of PNG (Glasby, 2000). SMS deposits are targeted for the very high concentrations of metal sulphides, including copper, gold, zinc and silver, which they contain (Glasby, 2000). Bioprospecting at hydrothermal vents is currently focused on thermophilic and hyperthermophilic bacteria and archaea, which have a range of applications in industry (Leary, 2004). At least seven companies are currently working with vent organism derivatives, of which three have products on the market. All sampling work to date has been undertaken by scientific research vessels (Leary, 2004).

7.3 Ecological characterisation against criteria

Threatened/endangered/declining species or habitats

Shallow seamounts, such as Horizon Bank, are associated with elevated densities of pelagic predatory species, including sea turtles, cetaceans and pelagic sharks (Genin and Dower, 2007). A number of the species that could potentially occur at Horizon Bank are threatened, endangered or declining. Horizon Bank is within the distribution range of leatherback, loggerhead *Caretta caretta*, green and hawksbill sea turtles, which are classified as vulnerable to critically endangered by IUCN (IUCN, 2009). Horizon Bank is also within the range of several of the threatened species of pelagic shark that have been recorded as bycatch in the WCP-CA, including bigeye thresher *Alopias superciliosus*, oceanic whitetip and short-fin mako *Isurus oxyrinchus* sharks, all of which are classified as vulnerable by IUCN (IUCN, 2009). Threatened cetaceans potentially found in the vicinity of Horizon Bank include sperm whales, which are classified as vulnerable by IUCN (IUCN, 2009). Tropical tuna, including yellowfin and bigeye tuna, are known to associate with shallow seamounts. A study of Cross Seamount found that bigeye tuna, which are classified as vulnerable by IUCN, remained resident for an average of 32 days, double the recorded residence time of yellowfin tuna (Holland et al, 1999). This may be explained by the ability of bigeye tuna to feed at depth and therefore take full advantage of enhanced foraging opportunities at shallow seamounts (Holland and Grubbs, 2007).

Vulnerability, fragility, sensitivity or slow recovery

The Horizon Bank has a summit depth of 45m and therefore penetrates the euphotic zone and may provide conditions suitable for colonisation by tropical corals and associated species (Maragos, pers. comm.). Tropical coral communities are vulnerable to a range of human impacts, including overfishing, the effects of demersal fishing gear and anthropogenic climate change. The growth rate of tropical coral species decreases with depth, suggesting that tropical coral reefs on Horizon Bank would recover very slowly, if at all, from damage due to human impacts (Kaiser et al, 2005).

Horizon Bank, and other seamounts and complex ridge areas located within WPMR, could potentially include areas of fragile and sensitive deepwater habitat. The depth range of Horizon Bank is suitable for colonisation by scleractinians, stylasterids, gorgonians, antipatharians and sponges (Rogers et al, 2007). Other seamounts identified in WPMR are within the depth range of gorgonians, antipatharians and sponges. Deepwater, habitat-building species are highly vulnerable to human impacts due to their fragility and life history characteristics, which include slow growth and extreme longevity (see 'West Oceania Marine Reserve').

Shallow seamounts, such as Horizon Bank, are associated with elevated densities of pelagic predatory species, which are thought to visit for feeding and navigational purposes (Holland and Grubbs, 2007). Shallow seamounts provide enhanced foraging opportunities and may act as navigational waypoints, detectable by their magnetic signatures (Holland and Grubbs, 2007). Many pelagic predators are vulnerable to human impacts as a result of their life history characteristics, which can include low fecundity, slow growth, late age at maturation, longevity and low adult mortality. Elasmobranchs are known to be highly vulnerable to fishery impacts due to their k-selected life history traits (Musick, 1999). Longline surveys conducted at seamounts in the Eastern Pacific and Eastern Atlantic demonstrated pelagic shark abundance up to 20x greater than in surrounding waters (Litvinov, 2007). Aggregations consisted primarily of large blue sharks and may have been for breeding purposes. Cetacean-seamount interactions have been largely unstudied but it has been suggested that spinner dolphins *Stenella longirostris* and beaked whales may visit seamounts to take advantage of enhanced foraging opportunities (Kaschner, 2007). One report found that encounters with Baird's beaked whale *Berardius bairdii* were more common in the vicinity of submerged escarpments and seamounts (Kaschner, 2007). Sea turtles may also associate with seamounts although evidence to date has been gathered primarily from the Azores (Santos et al, 2007).

Biological productivity

Shallow seamounts, such as Horizon Bank, are associated with elevated pelagic productivity, due to a combination of enhanced primary productivity and elevated abundance of predators, including tuna, billfish, cetaceans, sea turtles, seabirds and pelagic sharks. Enhanced primary productivity has been observed from some, but not all, shallow seamounts and does not appear to be a permanent feature where it has been recorded (White et al, 2007). High primary productivity occurs as a result of upwelling caused by oceanographic processes, including: isopycnal doming; the creation of Taylor columns and cones – large, stationary eddies formed over the summits of seamounts; and the effects of seamount topography on deep-sea currents and tides (White et al, 2007). Elevated predator abundance at seamounts where no increase in primary productivity has been observed is explained by the effect of seamount topography on the organisms of the DSL (Genin and Dower, 2007). It has been suggested that DSL organisms may become trapped by the summits of seamounts in the course of their diel migrations, creating areas of elevated prey species abundance that are targeted by pelagic predators. Enclosed water circulation patterns may also help to retain prey species in the vicinity of seamounts (Genin and Dower, 2007). An acoustic study conducted at Cross Seamount revealed that unidentified species of beaked whale hunt in the vicinity of the seamount almost every night and hypothesised that whales may have been taking advantage of the reduced dive times required to hunt mesopelagic species trapped by the seamount (Johnston et al, 2008). Analysis of the stomach contents of tuna taken at Cross Seamount revealed that bigeye tuna, which are able to hunt to depths of 500m, gained a significant trophic advantage from association with the seamount and fed on a wide range of species (Holland and Grubbs, 2007). Yellowfin tuna, which hunt in shallow waters, did not gain a significant trophic advantage from seamount association and had fed on fewer species. Morato et al's (2009) analysis of tuna longline logbook data suggested that at least 5 – 10% of seamounts in the Pacific are associated with a significantly elevated CPUE of at least one tuna species. The horizontal extent of the impact of shallow seamounts on pelagic productivity is not fully understood. However, a study conducted at Horizon Seamount found some effect on pelagic productivity up to 100km distant (Pew, 2007).

Horizon Bank, and other seamounts and complex ridge areas located within WPMR could potentially include areas of elevated benthic productivity. Productive seamount habitats are created where sessile suspension feeders, including scleractinian corals, octocorals and sponges, colonise areas of hard substrate created by the flow of currents over seamount summits and flanks (see 'West Oceania Marine Reserve'). Horizon Bank may provide conditions suitable for colonisation by tropical corals and other species. Tropical coral reefs are amongst the most productive ecosystems in the oceans, with primary productivity approaching levels found in upwelling systems (Kaiser et al, 2005).

WPMR may contain hydrothermal communities, which show elevated levels of productivity in relation to other deep-sea habitats (Bachraty et al, 2009). Hydrothermal vent communities consist of a small number of species that are dependent on symbiotic relationships with chemoautotrophic bacteria as well as associated heterotrophic species (Bachraty et al, 2009). Hydrothermal vents in the Southwest Pacific, including sites studied in the North Fiji Basin, are dominated by mytilid bivalves of the genus Bathymodiolus, which contain thioautotrophic and methanotrophic bacteria in their gill tissue and are also capable of ingesting organic materiel (Dubilier et al, 1998). Associated species observed at hydrothermal vent sites in the North Fiji Basin include: Alviniconcha and Ifremeria gastropods; limpets; barnacles; crabs; bresiliid shrimp; chirostylid and galatheid lobsters; annelid and polychaete worms; sponges; dumbo octopus (Grimpoteuthis sp.); vampire squid (*Vampyroteuthis infernalis);* vestimentiferans; chimaera; gorgonians; and crinoids (Dubilier et al, 1998; Desbruyères et al, 1994; MBARI, 2005; Halbach et al, 1995).

Biological diversity

Shallow seamounts, such as Horizon Bank, are amongst the most diverse areas in the high seas, due to the combined presence of pelagic and shallow- and deep-water benthic species. Dr Jim Maragos (pers. comm.), Coral Reef Biologist at the U.S. FWS Pacific Remote Islands National Wildlife Refuge Complex explained that, '*In the high seas arena it is these shallow water formations, to depths of 500m or less, that support the greatest biodiversity…These are the features warranting the most protection in the high seas because they offer habitat for a variety of attached as well as related (demersal) fishes and other deep-sea creatures hovering just above the bottom or sides of these formations*.' Tropical and deepwater corals and other sessile epibenthic organisms provide habitat suitable for a large number of associated species and represent diversity hotspots in the open ocean and the deep sea (see 'West Oceania Marine Reserve'). The concentration of pelagic predators for feeding and navigational purposes can lead to increased levels of local (α) species diversity in the vicinity of shallow seamounts.

8. A Representative Network of Marine Protected Areas

8.1 Representativity

The high seas enclaves contain a range of the pelagic and benthic biota and habitats present in the PIR and could form a portion of a representative network of marine protected areas. WOMAR and GOMAR are located in the WARM biogeographical province and MOANA is located in the SPSG biogeographical province. WPMR is located on the dynamic boundary between these two provinces. All four commercially important tuna species are present in the high seas enclaves. Skipjack and yellowfin tuna biomass is concentrated in WARM; albacore tuna are present in SPSG; and bigeye tuna are present in all four enclaves.

Benthic surveying has been extremely limited in the deep-sea of the PIR, however the range of benthic biota and habitat types present in the high seas enclaves can be inferred from their bathymetry. The enclaves incorporate a number of different bathymetric features, including: the Mussau Ridge; Mussau Trench; Eauripik Rise; Ontong Java Rise; South Pandora/Rotuma Ridge, including Horizon Bank; North Fiji Basin, including the central spreading axis; and abyssal plain at depths ranging from ~3000m to >5000m. Between them, the enclaves potentially provide habitat for tropical coral species; deepwater seamount assemblages; hydrothermal vent communities; and species of the abyssal plain. Taking depth as a proxy measurement for species present, the extremely large depth range of the enclaves, from 45m at Horizon Bank to >7000m in the Mussau Trench, as well as the large range of seamount summit depths, from 45m to 4300m, suggest that a broad range of benthic species are present.

8.2 Connectivity

The high seas enclaves are connected by the SEC, which flows westwards between ~5°N and 20°S. GOMAR, WPMR and MOANA are also connected by the SECC, which flows weakly eastwards between ~7°S and 14°S. These oceanographic features, and in particular the stronger SEC, provide a means by which plankton, larvae and pelagic species could potentially be transported between the enclaves. Lehodey et al. (2003) suggest that tuna larvae are advected by currents during the first quarter of their lives, raising the possibility that the enclaves are connected by transport of larval tuna. Skipjack, yellowfin and bigeye tuna larvae occur throughout WARM and could therefore be transported between GOMAR and WOMAR (Longhurst, 2006). Albacore tuna larvae occur between 5°S and 20°S and could therefore be transported between MOANA, WPMR and GOMAR (Murray, 1991).

Adults of some pelagic species are thought to use ocean currents in the course of their life histories. Luschi et al. (2003) highlight the role of ocean currents in the life histories of sea turtles. All species (with the possible exception of the flatback turtle *Natator depressus*) are thought to become sequestered in oceanic currents during the hatchling and early juvenile phases. Whilst migrations between breeding and feeding areas usually involve active swimming towards a fixed target, turtles may utilise ocean currents during some parts of their journey. Leatherback and olive ridley turtles are primarily pelagic species that may occasionally utilise oceanic currents during the course of their migrations and 'wanderings.' There are examples of sea turtles utilising oceanic currents in the PIR, although there is no direct evidence for use of the SEC. Benson et al. (2007) tracked two leatherback turtles which travelled in the eastwards flowing NECC during post-nesting migrations from Papua, Indonesia. Polovina et al. (2004) tracked olive ridley turtles using the North Equatorial Current (NEC) and NECC.

A number of the pelagic species found in the PIR undertake active migrations or travel extremely long distances, during the course of which they are likely to travel through more than one of the high seas enclaves. Leatherback turtles that nest at Papua Barat, Indonesia and the Solomon Islands are known to travel through WOMAR and GOMAR in the course of their post-nesting migrations (see figure 5). Tuna are known to be capable of travelling extremely long distances. Tagging studies have shown that yellowfin tuna can travel >1000nm and a skipjack tuna has been recovered ~9000km from where it was tagged, distances which could potentially take tuna between the enclaves (Sibert and Hampton, 2003; Sund et al, 1981). However, Sibert and Hampton (2003) found that, whilst some tagged tuna do travel extremely long distances, the median lifetime displacement is just 420 – 470nm for skipjack tuna and 20% less for yellowfin tuna. This finding suggests that, whilst there may be some migration of adult tuna between the high seas enclaves, the level of exchange is likely to be limited.

8.3 Replicated ecological features

Certain key habitat types and biota are replicated within the four high seas enclaves. Seamounts and areas of abyssal plain occur in all four enclaves. Bigeye and yellowfin tuna are present in all four enclaves, whilst skipjack tuna are present in WOMAR and GOMAR and albacore are present in WPMR and MOANA. Many of the pelagic predatory species found in the PIR, including sharks, cetaceans and sea turtles, have wide distributions and are likely to occur in some or all of the enclaves.

The equatorial area of high tropical tuna productivity indicated by concentrated fishing effort and catch is replicated in WOMAR and GOMAR, and shifts from the vicinity of one to the other in accordance with ENSO. During La Niña and neutral phases of ENSO, tuna biomass and fishing effort are concentrated further westwards, including in the vicinity of WOMAR. During El Niño events, tuna biomass and fishing effort are concentrated further eastwards, including in the vicinity of GOMAR (Lehodey et al, 1998).

8.4 Adequate and viable sites

The high seas enclaves are adequate and viable sites for the creation of marine reserves. Stationary features, which are likely to receive adequate protection within the enclaves, include: seamounts; abyssal plain habitat; possible hydrothermal vent communities; and the tropical corals and pelagic species that may be present at Horizon Bank. Further conservation measures will be required to ensure the adequate protection of highly mobile species, including sea turtles and tuna. Sibert and Hampton (2003) suggest that the creation of marine reserves in the enclaves could enhance regional tuna management. They calculate that the high level of fishing pressure in WOMAR and GOMAR means that the ‘half-life’, or the amount of time taken for populations to decrease by half, of tuna is ~2 months in WOMAR, although somewhat longer in GOMAR. This is considerably lower than the median figure of 6 months for all EEZs in the region. They suggest that closing WOMAR and GOMAR to fishing could bring the tuna ‘half-life’ of these enclaves into line with the regional average, with significant benefits for tropical tuna populations in the PIR. It has been calculated that closure of the four high seas enclaves could reduce overfishing of bigeye tuna by 10.7% (SPC-OFP, 2008).

By their nature, high seas enclaves are buffered from many of the human impacts that have contributed to environmental degradation in inshore and continental shelf areas, including nutrient pollution, small-scale and recreational fisheries and sedimentation as a result of coastal development.

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Appendix 2: List of contacts and contact details

Valerie Allain, SPC (valeriea@spc.int).
Transform Aqorau, FFA (transform.aqorau@ffa.int). Emphasised that arguments for the closure of the high seas enclaves have been based on the need for a reduction in total tuna mortality. Suggested that broader ecological arguments would not be sufficiently strong by themselves to support the closure of these areas.
Robin Baird, Cascadia Research Collective (rwbaird@cascadiaresearch.org).
George Balazs, NOAA NMFS Pacific Fisheries Science Center (gbalazs@honlab.nmfs.hawaii.edu).
Jim Barry, MBARI (barry@mbari.org).
Mike Batty, SPC (mikeb@spc.int). Emphasised the role of economic concerns and IUU fishing in the decision to close the high seas enclaves. The enclaves are 'subject to intense fishing activity in a productive area for surface tuna' and their closure should have conservation benefits. Could be described as important for juvenile stages, as tuna spawn throughout the Pacific. However, archpelagic waters of the Philippines, Indonesia and PNG are likely to be of greater importance in this regard.
Lui Bell, SPREP (luib@sprep.org).
Scott Benson, NOAA Southwest Fisheries Science Center (scott.benson@noaa.gov). Provided unpublished data showing the movement of leatherbacks through high seas enclaves. Emphasises the need to consider transfer of ecological footprint if the enclaves are closed.
Andrew Brooks, UCSB (brooks@lifesci.ucsb.edu).
Bill Chadwick, NOAA Vents Program (bill.chadwick@noaa.gov).
Paul Dalzell, Western Pacific Regional Fishery Management Council (p.dalzell@noaa.gov). Stated that the enclaves have no particular biological significance, and the 'island effect' means that EEZ waters are probably more important for aggregating tuna. 'Any benefits from fixed high seas area closures are going to be ephemeral at best' due to the ENSO-driven movements of tuna stocks.
Gerry Davis, NOAA NMFS Pacific Regional Office (gerry.davis@noaa.gov).
Mike Donoghue, New Zealand Department of Conservation (mdonoghue@doc.gov.nz).
Scott Eckert, Wider Caribbean Sea Turtle Conservation Network (seckert@widecast.org).
Jack Frazier (kurma@shentel.net).
Karen Frutchey, NOAA NMFS Pacific Islands Regional Office (Karen.frutchey@noaa.gov).
Alexandre Gannier, Groupe de Recherche sur les Cétacés (a_o.gannier@club-internet.fr).
Peter Gill, Blue Whale Study Inc. (petegill@bigpond.com). Discussed a potential blue whale winter breeding area in the Solomons Sea.
Kristina Gjerde, IUCN (kgjerde@eip.com.pl).
Ben Halpern, UCSB (halpern@nceas.ucsb.edu).
Mario Hernandez, UNESCO (m.hernandez@unesco.org).
Dave Johnston, Duke University (david.johnston@duke.edu). Emphasised the importance of seamounts for the distribution of pelagic predators.
Benjamin Kahn, APEX Environmental (bkahn@apex-environmental.com). Suggests that the high seas enclaves are likely to contain a diverse array of oceanic cetaceans, including migratory and residential species, but may be no more important than EEZ waters. Explained the use of outstanding habitat features to map PPH (persistent pelagic habitats) for future surveying. Suggested that the closure of the enclaves offers a way to increase the consistency of management plans implemented in EEZs.
Iain Kerr, Ocean Alliance (iaink@oceanalliance.org).
Jeffrey Kinch, SPREP (jeffreyk@sprep.org).
Sarah Klain (s.klain@gmail.com) . Former Peace Corps volunteer in Palau. Provided maps for the results of sea turtle tagging projects in Palau and the Marshall Islands.
Corinne Knutson, SeaWeb (cknutson@seaweb.org).
Willy Kostka, Micronesia Conservation Trust (mctdirector@mail.fm).
Trina Leberer, The Nature Conservancy (tleberer@tnc.org).
Andrew Lewin (Andrew.lewin@sympatico.ca).
Jim Maragos, U.S. Fish and Wildlife Service Pacific/Remote Islands National Wildlife Refuge Complex (jim_maragos@fws.gov). Provided information on biogeography of the region and warm-water coral communities on shallow seamounts. Suggests that the University of Hawaii Underwater Research Laboratory or National Geographic Society might be interested in selective exploration of 'these truly last frontiers on the globe,' to make a better case for their lasting protection.
Gerald McCormack, Cook Islands Biodiversity and Natural Heritage (Gerald@nature.gov.ck).

Mike McCoy, Gillett, Preston and Associates (mmc@aloha.net). Provided information regarding the tagging of green turtles in the Marshall Islands (see **Sarah Klain**).
Cara Miller, Whale and Dolphin Conservation Society (cara.miller@wdcs.org).
Michael Milne, Sea Turtle Restoration Project (Michael@tirn.net). Emphasised the importance of this area for Pacific leatherbacks and concern at the impacts of bycatch in the region.
Craig Osenberg, University of Florida (osenberg@ufl.edu).
Jennifer Palmer, IUCN (jpalmer@iucnus.org).
Samuel Pooley, NOAA NMFS Pacific Islands Fisheries Science Center (Samuel.pooley@noaa.gov).
Norman Quinn (Norman.quinn@gmail.com).
Scott Radway, SeaWeb (sradway@seaweb.org).
Kesaia Tabunakawai, WWF South Pacific Programme (ktabunakawai@wwfpacific.org.fj).
Sue Taei, Conservation International (s.taei@conservation.org). Provided summary literature review conducted for Phoenix Islands Protected Area and information regarding 'On-the-line' whaling grounds.
Ana Tiraa, SPREP (anat@sprep.org).
Verena Tunnicliffe, University of Victoria (verenat@uvic.ca).
Bryan Wallace, Conservation International (b.wallace@conservation.org). Emphasised leatherback conservation issues in the region.