University of Algarve
Faculty of Sciences and Technology

Master's thesis in Aquaculture and Fisheries

Marine Protected Area of Isole Tremiti: analyses of present protection scheme and proposal of alternative conservation settings including ecological criteria and human dimension.

Nuno Sales Henriques
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Resumo
O Mar Mediterrâneo, apesar de cobrir menos de 1% da superfície oceânica, este alberga 6-8% das espécies marinhas descritas, o que o torna numa região prioritária de conservação. Os impactos e a pressão humana nesta região são elevados, de entre os quais se destacam a elevada pressão de pesca, zonas costeiras densamente populosas, a introdução de espécies invasoras e poluição. Factores como estes têm vindo a alterar a biodiversidade e os ecossistemas nesta região. De facto, a perda e destruição de habitats, como pradarias marinhas, bancos de maerl, bancos de ostras etc, é considerado como o segundo impacto mais importante presente no Mediterrâneo. Com a perda e destruição de habitats complexos como bancos de ostras ou pradarias marinhas, tem-se vindo a verificar o aumento de "coralline barrens" que são habitats com reduzida biodiversidade e com fraco valor ecológico.
Até agora, estratégias para contrariar a perda e destruição de habitats, tem-se mostrado ineficiente, e recentemente a UE estabeleceu uma nova meta, para o ano de 2020, de contrariar a perda de biodiversidade.
Áreas Marinha Protegidas (AMPs) são hoje em dia consideradas por uma crescente comunidade cientifica, como uma útil ferramenta na conservação marinha. AMPs são zonas cujo nível de protecção pode variar, desde as zonas cuja protecção é máxima onde nenhuma actividade extractiva e não-extractiva podem ocorrer, nalgumas são zonas cujo acesso é interdito; zonas de nível intermédio em que algumas actividades não-extractivas podem ocorrer; e as zonas de menor protecção onde podem-se realizar actividades lúdicas e algumas extractivas, como a pesca artesanal e pesca recreativa. Estas áreas são ferramentas que protegem os habitats, a variabilidade genética, servem como ferramenta de recuperação, protecção e gestão de stocks de pesca e de determinadas espécies.
Apesar das evidentes e provadas vantagens das AMPs, estas não podem ser consideradas como a única forma de proteger os oceanos, visto que diversas formas de impactos não podem ser mitigadas por estas ferramentas, tais como poluição proveniente de terra, espécies invasoras e alterações climáticas.
Com o objectivo de aumentar os benefícios provenientes das AMPs, tais como a conservação da biodiversidade ou dos stocks de pesca, estas áreas em vez de serem planeadas de forma isolada, devem ser planeadas tendo em conta as outras identidades que possam ser afectadas por estas áreas, tais como do turismo, da pesca, aquaculturas, desenvolvimento costeiro, etc. Planear uma AMP com uma abordagem que inclua a dimensão humana é uma estratégia que reduzirá os conflitos provenientes da implementação de uma área protegida. Daí a inclusão das AMPs como ferramentas numa abordagem EBM (ecosystem-based management) deve ser imperativo, visto que o principal objectivo da abordagem EBM é gestão dos ecossistemas tendo como objectivo a manutenção da qualidade destes, ao mesmo tempo que os seres humanos possam usufruir dos serviços que estes fornecem, como alimentação, qualidade da água, protecção contra tempestades etc.
No Mediterrâneo o número de AMPs é elevado, mas apesar disso, a representatividade das diversas características naturais dentro destas áreas, não é bem conseguida, assim como a distância entre áreas protegidas é demasiado grande para permitir a conectividade entre elas. Abdulla *et al.* (2008) demonstrou que cerca de metade das áreas protegidas no Mediterrâneo sofrem de má gestão, que pode dever-se à falta de planos de gestão da respectiva área, como à falta de informação relativa aos recursos naturais, à pouca vigilância destas áreas e à falta de informação ecológica relativamente a estas AMPs. Áreas Marinhas Protegidas que sofram de má gestão e manutenção podem não cumprir com os seus principais objectivos, tornando-se num mau exemplo que poderá levar a diversas entidades a descartar as AMPs como uma ferramenta de conservação/gestão.
O envolvimento de diversas entidades no planeamento e criação de AMPs é fundamental para que estas possam tornar-se em exemplos de sucesso. Para que a AMP possa vir a cumprir os seus objectivos ecológicos, esta tem que ser desenhada e planeada com base em dados científicos e para que o conflito proveniente desta implementação seja o menor, é fundamental incluir também a dimensão sócio-económica no planeamento da área protegida. AMPs bem implementadas e que cumpram os seus objectivos tornar-se-ão em exemplos de sucesso,

convertendo a opinião publica para uma maior aceitação destas áreas, dando então maiores hipóteses de sucesso para outras futuras AMPs.
O meu estudo refere uma AMP (Isole di Tremiti) situada no Mar Adriático que foi implementada em 1989 e que após 22 anos não se verificam respostas significativas à protecção. A implementação desta AMP foi feita sem o mapeamento detalhado da respectiva área e em 2002, foi feito o levantamento cartográfico de todo o arquipélago.
Com base nos resultados cartográficos, o objectivo deste trabalho: foi avaliar a distribuição dos diversos habitats dentro da AMP; produzir diversos cenários de protecção a nível de habitat, usando diversos valores de "conservation targets" que foram decididos com base numa revisão de literatura e de acordo com o valor ecológico de cada tipo de habitat; avaliar o efeito de incluir as actividades humanas nos cenários acima enunciados. Para a produção destes cenários foi usado o software MARXAN.
Após o mapeamento dos habitats presentes na área de estudo, e comparando com a localização das diversas actividades humanas, verificou-se que a zona central do arquipélago é muito usada como zona de ancoragem. Nesta zona esta um dos habitats mais sensíveis, importantes e de menor área, as pradarias de *Posidonia oceanica*. Os impactos causados pelas ancoras e respectivas correntes são dos factores que mais contribuem para o declínio deste tipo de habitats dominados por ervas marinhas.
Como os habitats variam em níveis de biodiversidade e biomassa, uns são mais sensíveis aos impactos causados pelas actividades humanas e outros têm uma maior representatividade dentro da área de estudo, com base nestes factores e numa revisão de literatura dos últimos 10 anos, foram atribuídos diversos valores de conservação dependendo do tipo de habitat. Foram atribuídos valores de conservação de 10, 20, 30 ,40 e 100% dependendo do tipo de habitat.
Através da revisão de literatura pôde-se observar que estudos e iniciativas de conservação não têm sido bem distribuídas ao longo do globo. Verificou-se que zonas tropicais têm obtido mais atenção do que as zonas temperadas. Também se verificou que o "conservation target" mais usado é o de proteger 20% de cada tipo de habitat.
Como o MARXAN é uma ferramenta de suporte à decisão de onde implementar uma AMP e não uma ferramenta de decisão, foi importante, saber quais as zonas de maior importância para que os "conservation targets" possam ser atingidos. Para isso foram estudados os valores de "irreplaceability" das diversas unidades de planificação (UPs) para os dois cenários- incluindo ou excluindo as actividades humanas. No cenário onde não foram incluídas as actividades humanas somente as unidades de planificação que coincidem com o habitat cujo "conservation target" era 100% (*Cymodosea nodosa*) foram consideradas "100% irreplaceable", quase todas as restantes UPs foram consideradas aleatoriamente seleccionadas. Isto significa que sem a presença de actividades humanas, é fácil de obter um cenário de protecção onde os "conservation targets" podem ser todos atingidos.
No cenário onde as actividades humanas foram adicionadas ao estudo, os valores de "irreplaceability" foram diferentes. Igualmente verificou-se os valores para a área onde o habitat de *Cymodocea nodosa* se encontra. Com a exclusão da análise de UPs coincidentes com zonas onde actividades humanas estão presentes, verificou-se que nem todos os "conservation targets" foram atingidos. De facto dos 14 tipos de habitat a serem protegidos, somente 11 conseguiram atingir o seu "conservation target". Deste 3 tipos de habitat que não atingiram o objectivo, dois deles são habitats de elevado valor de conservação. Como estes habitats têm uma reduzida distribuição dentro da área de estudo e como a sua localização coincide com um zona fortemente disturbada pelas actividades humanas, com a exclusão desta área da análise, não é possível incluir a área desejada destes habitats no sistema de reserva.
O principal resultado deste estudo demonstra que depois de 20 anos de regulamentação, o design inapropriado desta AMP é uma das principais causas para o seu insucesso. Actividades danosas como ancoragem e actividades turísticas estão localizadas na mesma área onde habitats sensíveis, de baixa representatividade e de elevado valor ecológico (pradarias de *Posidonia oceanica*). Isto demonstra claramente que o planeamento desta AMP foi inapropriado, com a consequência de as actividades humanas estarem em conflito com habitats sensíveis e de elevado valor ecológico. A isto se deve à falta de informação ecológica, relativa à distribuição

dos habitats aquando a implementação desta AMP, como acontece em muitas outras AMPs em todo o mundo.
O conhecimento antecipado das características ecológicas de uma determinada área onde uma área protegida está para ser implementada é imperativo para que esta cumpra com os seus objectivos ecológicos.
O planeamento de AMPs baseado somente em critérios científicos, numa área dominada por actividades humanas traria diversos conflitos sócio-económicos. Planos eficientes de conservação devem explicitamente informar como o plano de gestão irá afectar as outras entidades que são afectas à implementação de uma AMP. Por isso, a integração da dimensão humana com os critérios científicos no planeamento de uma área marinha protegida é fundamental para que os conflitos sócio-económicos sejam reduzidos ao máximo. O planeamento e design de uma AMP deve ser integrada numa abordagem EBM, onde entidades de várias áreas, como do turismo, comunidade científica, do desenvolvimento costeiro, das pescas, aquacultura, transportes marítimos, etc, participam levando à melhor compreensão entre as diversas entidades e consequentemente à maior probabilidade de sucesso das AMPs.
AMPs bem implementadas e geridas, somente podem ter um efeito benéfico a nível local, mas a soma do total de todas AMPs implementadas dentro de um contexto estratégico mais alargado, trará melhores resultados levando a uma abordagem EBM eficiente.
Apesar do interesse da comunidade científica nas questões de conservação ter vindo a crescer ao longo dos últimos anos, somente um-terço dos trabalhos publicados advêm com um plano de conservação. Este problema é conhecido pelas ciências de gestão como "*knowing-doing gap*". Este estudo representa uma excepção: durante a realização deste trabalho, a entidade responsável pela AMP Isole di Tremiti, o Parco Nazionale del Gargano, decidiu com base nos resultados deste trabalho em reestruturar a regulamentação das zonas de ancoragem, onde se verifica que os habitats referentes às pradarias marinhas de *P. oceanica* estão desta forma protegidos desta actividade.
Áreas marinhas protegidas já deram provas do seu valor como ferramentas de conservação, e o uso destas é apoiado por uma crescente comunidade científica. No entanto AMPs não podem ser consideradas como a solução para todos os problemas ocorrentes nos oceanos e se a implementação destas não incluir os devidos dados científicos e sem a inclusão dos factores socioeconómicos, o mais provável é que as AMPs não irão cumprir os seus objectivos e os conflitos com as entidades afectadas pela AMP irão dar uma imagem de insucesso destas ferramentas, o que poderá influenciar as entidades responsáveis a descartar as AMPs como ferramentas de conservação/gestão.
No caso de as AMPs forem bem implementadas, com os devidos estudos científicos e com a inclusão da dimensão humana no planeamento destas áreas, elas podem cumprir com os seus objectivos ecológicos e socioeconómicos, tornando-se em exemplos de sucesso. Este sucesso converteria a opinião pública para uma maior aceitação destas áreas, permitindo que outras AMPs tivessem maiores hipóteses de sucesso no futuro.

Este estudo foi submetido e aceite para apresentação no "World Conference on Marine Biodiversity" de 26 a 30 de Setembro de 2011, em Aberdeen, Escócia (UK).

Abstract

The Mediterranean Sea is a region with top conservation priority, due to its richness in biodiversity. Nonetheless this area is being severely changed due to the increasing human presence. Stressors like fishing activities, habitat destruction, introduced species and pollution are changing the ecosystems and habitat loss is considered the second most pervasive issue at basin scale. Well designed and enforced marine protected areas (MPAs) have been recognised as a useful tool to halt some of the ocean's problems such as habitat loss, and decreasing fish stocks and biodiversity. Still MPAs are not an ultimate tool to solve all the oceans problems and if these areas are inadequately implemented, they can be ineffective, affecting their reputation as another argument against their implementation.

In order to properly design an effective MPA, ecological information of the area is needed and the inclusion of the socio-economic dimension in the planning of a reserve system is imperative in order to reduce conflicts with the users of the area. As already mentioned MPAs cannot solve all the ocean's problems such as land source pollution and introduced species. MPAs should be implemented as a tool in an Ecosystem Based Management (EBM) approach, where entities such as fisheries management, stakeholder, coastal development and scientists participate in the decision and the planning of the reserve system.

The MPA of "Isole di Tremiti" was implemented in 1989, considered a reasonable time to show responses to protection. However, recent studies showed no responses from benthic assemblages. With data gathered in 2002 on the distribution and total area of the habitats present within the study area, we analysed the distribution of human activities and compared them with the distribution of the habitats. With the site selection algorithm (MARXAN) we set scenarios of protection using habitat types as conservation features and with a range of conservation targets that were decided either from their conservation value through expert opinion or from a review of literature from the last 10 years of conservation plans and theoretical studies. With the selected conservation targets we evaluate the inclusion of human activities in the planning of the reserve system.

Results showed that the planning of the study area was generally inappropriate, and pervasive activities such as anchorage are allowed in areas of high conservation value. The review of the literature showed how conservation plans and theoretical studies have been mainly focused in tropical areas and that the most used conservation target still is 20%, a value decided without specific scientific studies, and set on the base of fishery management purposes. MARXAN was run on the data set, considering two different scenarios, with and without the inclusion of human activities. Results illustrated how, with the present protection regime, conservation targets could not be always achieved, with two of the three habitats with high conservation values not appropriately protected (i.e. they did not achieve the target).

Our results stress that good science, combined with the inclusion of the human dimension in the planning and designing of an MPA are critical aspects for an adequate design and implementation of these areas to achieve their objectives.

This study was submitted and accepted for presentation at the "World Conference on Marine Biodiversity" in Aberdeen, Scotland (UK) 26-30 of September, 2011.

Introduction

The Mediterranean hosts 6-8% of described marine species despite covering less than 1% of the global ocean (Bianchi and Morri, 2000; Lejeusne *et al.*, 2010). This alone makes this marine region a top conservation priority. Human pressure on these rich and unique marine ecosystems is high, with intense fishing pressure, densely populated coastlines (~450 million people, supplemented by an additional 220 million tourists that are projected to double by 2025; UNEP/MAP 2005) and an increasing number of introduced species, over 600 (Boudouresque *et al.*, 2005). Such intense pressure has resulted in major alterations of Mediterranean ecosystems (Airoldi and Beck, 2007; Lotze *et al.*, 2006). Climate induced stressors further contribute to changes in the Mediterranean biodiversity, driving the basin to potentially unchartered territories (Coll *et al.*, 2010; Lejeusne *et al.*, 2010).

In this rapidly degenerating scenario, local management tools, such as isolated Marine Protected Areas (MPAs), can be insufficient. Suitable strategies for conservation and sustainable management of marine biodiversity require large-scale integrated regulation of the exploitation of marine resources (Allison *et al.*, 1998; Lubchenco *et al.*, 2003). Unfortunately, the fragmented geopolitical scenario characterizing the Mediterranean basin still leads to weak, uncoordinated, conflicting, or non-existent regulatory frameworks, policy mechanisms and enforcement. Ecosystem-based management (EBM) frameworks are invoked as sensible strategies(Lester *et al.*, 2010), but single-sector management strategies are still the rule. Examples of effective EBM are rare: (Pergent-Martini *et al.*, 2006) describe a case study of *Posidonia oceanica* meadows (seagrass beds) along the Corsican coastline (Mediterranean Sea) to exemplify the usefulness of ecological data to EBM programs.

Structurally complex habitats such as seagrass meadows, macroalgae assemblages, coral reefs, among others, are decreasing at local, regional and global scales, d mainly due to bottom trawling and dredging (Gray *et al.*, 2006; Lotze *et al.*, 2006; Perkol-Finkel and Airoldi, 2010; Reise, 2005; Thrush and Dayton, 2002). The decrease of water quality and overfishing also contribute to the decline of habitats like kelps forests and macroalgae habitats, as has been observed in various countries around the world (Benedetti-Cecchi *et al.*, 2001; Graham, 2004; Gray *et al.*, 2006): in Europe, the reduction of seagrasses and wetlands, during the period from 1960 to 1995, exceeded 50% of the original area, and in many cases more than 80%, (Airoldi and Beck, 2007).

The European Council (2001) followed by the International Union for Conservation of Nature (IUCN) (2004) and by the Eighth Ordinary Conference of the Parties to the Convention on Biological Diversity (CBD) (2006) promoted the commitment to achieve by 2010 a significant reduction of the current rate of biodiversity loss at global, regional and national levels, with the aim of protecting the 10-30% of marine habitats. Also, the World Summit on Sustainable Development (WSSD) in 2002 and the Fifth World Parks Congress (WPC) in 2003

stressed the need to establish representative networks of MPAs by 2012 (Abdulla *et al.*, 2008; Wood *et al.*, 2008).

Coll *et al.* (2010) considered marine habitat loss or destruction as the second most important human impact presently occurring throughout the Mediterranean Sea, preceded by overexploitation and followed by eutrophication, introduced predators, disease, and general disturbance. Temperate reefs are probably among the most threatened habitats worldwide (Barbera *et al.*, 2003) and in the Mediterranean Sea, the degradation and the loss of habitats, is one of the main threats to biodiversity (Claudet and Fraschetti, 2010). Coastal development, sediment loading and pollution reduced the extent of important habitats for marine diversity, like oyster reefs, maërl banks, seagrass meadows and macroalgal beds (Beck *et al.*, 2011; Coll *et al.*, 2010; Turley, 1999). From the degradation and loss of complex habitats, it has been observed the increase of coralline barrens, which are habitats with low biodiversity and with poor ecological value (Irving and Witman, 2009; Ling, 2008; Micheli *et al.*, 2005; Witman, 1985). Overexploitation of marine resources, invasion of species and climate change, are also important threats in this region (Coll *et al.*, 2010).

So far, strategies to halt habitat loss have been largely ineffective (Perkol-Finkel and Airoldi, 2010). In the last EU report on the Progress Towards the European 2010 Biodiversity Target (EEA, 2009), terrestrial systems received most attention. The report includes generic comments on the alarming status of commercial fisheries and the spreading of invasive marine species, lacking updated information on the threats to Mediterranean marine ecosystems. The estimates of marine habitat loss between 1990 and 2000 seem unrealistic (< 1%), especially when compared with data coming from other the scientific literature (Airoldi and Beck, 2007; Benedetti-Cecchi *et al.*, 2001; Claudet and Fraschetti, 2010). The report concluded that "the target of halting biodiversity loss in Europe by 2010 will not be achieved". Having failed with their 2010 target, EU ministers recently set a new biodiversity deadline of 2020, and the 27 governments agreed to try to do more to halt biodiversity loss. The lack of quantitative information on the extent of major habitats, together with a lack of knowledge about the potential connectivity between sites to be networked, also make 2012 an unrealistic deadline (Abdulla *et al.*, 2008).

No-take reserves and, more in general, Marine Protected Areas (MPAs) have already shown their conservation benefits, and, currently, the use of marine reserves is supported by a growing scientific community (Browman and Stergiou, 2004; Halpern, 2003). MPAs are specific management zones and they can have different levels of protection, where the higher level of protection is based on either no-take zones or no-access zones, where extractive and non-extractive activities are prohibited and in case of no access zone, human presence is forbidden. Zones with an intermediate level of protection allow non-extractive activities, like recreational activities, while still extractive activities, like fishing are restricted. In zones with

the lowest level of protection, some extractive activities might be allowed, like recreational and artisanal fisheries.

Marine reserves are considered a useful tool to manage and protect the ocean environment by protecting habitats, genetic diversity, recovery and protecting overexploited stocks and species, preserving ecosystem functioning and for fishery management (Bohnsack, 1998; Browman and Stergiou, 2004; Halpern *et al.*, 2010; Roberts, 2001; Roberts *et al.*, 2003). In contrast to fisheries management approaches, MPAs provide a refuge in space and are implemented over smaller spatial scales. Marine protected areas focus on the ecosystem, since they aim to manage and protect not only the resources, but also the habitats and several other components of the ecosystem, like humans and ecosystem services (Fraschetti *et al*. in press). However, as already stated, marine reserves cannot be considered an ultimate tool to solve all the oceans problems. Several sources of impact cannot be mitigated by this tool, such as invasive species, land-based source of pollution and climate change (Halpern *et al.*, 2010), even though, there is evidence that under effectively protected conditions, biodiversity can better cope with human disturbances (Bevilacqua *et al.*, 2006).

To achieve the goals of a MPA, including improving benefits such as fisheries and/or conservation purposes, instead of planning the implementation of single, isolated reserves, MPAs will be most successful at meeting their goals if they are planned in coordination with other management initiatives, in charge of fisheries, coastal development, aquaculture, waste-waters discharge, shipping, coastal and offshore oil and gas extraction (Halpern *et al.*, 2010). By doing this, it also would decrease the conflicts associated with MPA implementation, associated with the increasing intensity and diversity of ocean uses. Including the human dimension in the effort of managing the oceans is thus a profitable strategy. Therefore, the inclusion of the MPAs as a tool within the framework of an ecosystem-based management (EBM) approach, should be a requirement (Panetta, 2003). The overall target of the EBM is to manage the ecosystems, taking into account the ecosystem health and human well-being and providing a range of ecosystem services, like seafood, water quality, protection from storms, recreational and renewable energy (Rosenberg and McLeod, 2005).

From the development of the EBM, numerous variations of this theme have emerged, like area-based management, ecosystem-based-fisheries-management (EBFM), marine spatial planning, ocean zoning and others. The approach based on area-based management, includes a large number of tools, from no-take reserves to other types of regulations that focus primarily on conservation or fisheries management purposes by restricting the use of those areas. They also may focus on comprehensive marine spatial planning and ocean zoning, that account both for multiple-use objectives and protection (Halpern *et al.*, 2010).

The number of MPAs in the Mediterranean Sea has rapidly increased since recent times (Juanes, 2001) and according to Abdulla *et al*. (2008), there are 97 MPAs in the Mediterranean.

Despite the high number of marine reserves, the representativeness (i.e. the protection of the full range of natural characteristics of a region within a protected area) (Awimbo *et al.*, 1996) is poorly met, and the distance among MPAs is too wide to allow connectivity (larval exchange for marine species and populations between these protected areas)(Figure 1)(Abdulla *et al.*, 2008).

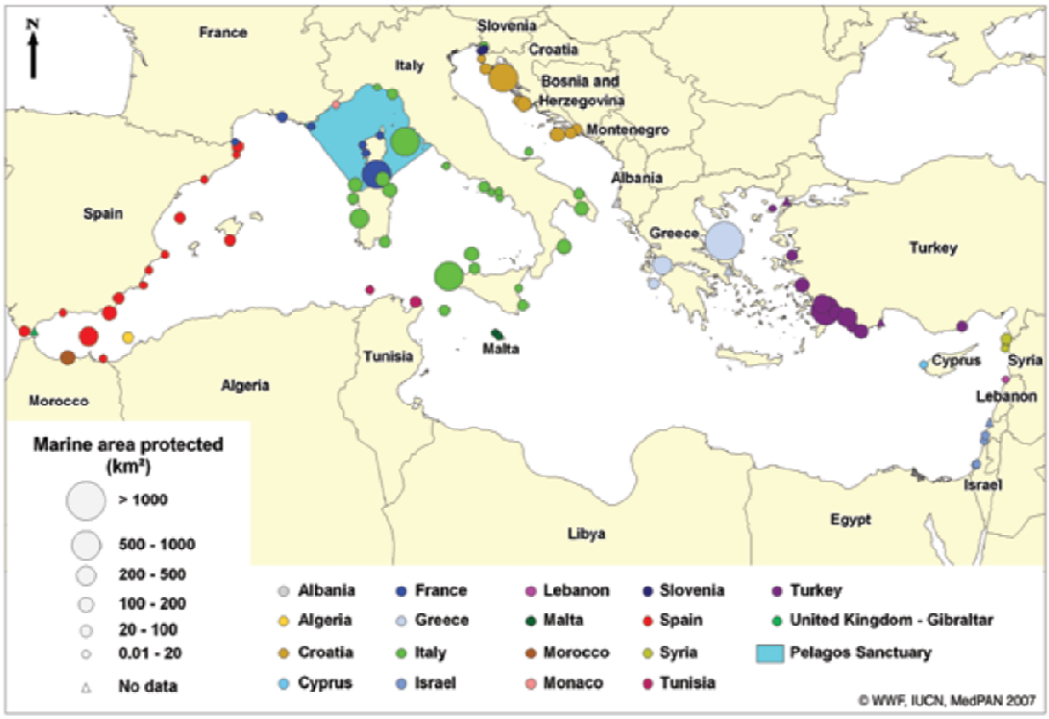

Figure 1. Distribution of MPAs in the Mediterranean Sea. Size of each MPA is illustrated according to different classes of size. Different colours represent different countries. (Abdulla *et al.*, 2008)

In the survey carried out by Abdulla *et al.* (2008), it is shown that in the Mediterranean region approximately half of the MPAs share an inadequate management. This might be caused by several factors, such as the lack of management plans and information about the natural resources, poor enforcement and surveillance with a significant decrease of key habitats and species. The lack of ecological information is also an important aspect causing a poor management of the protected areas.

The consequence is that, despite the known benefits coming from MPAs implementation, many reserves do not meet their ecological goals, and this information is mostly underreported in the literature (Halpern and Warner, 2002). Inappropriate MPA design and ineffective enforcement are the main causes of failure of marine reserves (Fraschetti *et al.*, 2005; Mora *et al.*, 2006; Sala, 2002; Villa *et al.*, 2002). A study carried out by Guidetti *et al.* (2008), where the ecological effectiveness of 15 Italian MPAs was evaluated, demonstrated that marine reserves with higher enforcement had positive results, whereas reserves with lower enforcement levels did not fulfil their ecological objectives. Marine reserves that fail in achieving their purposes, may induce stakeholders and policy makers to dismiss MPAs as a

conservation/management tool, since the socio-economic conflicts, resulting from their creation, cannot be argued against by any benefits (Guidetti *et al.*, 2008).

The involvement of stakeholders and the community is a fundamental aspect to reduce the conflicts that may arise from the implementation of a MPA (Friedlander *et al.*, 2003; Guidetti *et al.*, 2008) and the design of marine reserves based on scientific criteria is an imperative so they may accomplish their ecological goal (Fraschetti *et al.*, 2005). Therefore, in order to establish an ecologically effective MPA, with the lowest socio-economic conflict, we must combine scientific and socio-economic criteria in the planning of a protected area. Well-designed and enforced MPAs can meet their ecological and socio-economic goals, as they can turn into an example of success, converting the public opinion into a broader acceptance, and consequently increasing the chances of success for other MPAs (Agardy *et al.*, 2003; Friedlander *et al.*, 2003; Guidetti *et al.*, 2008).

MPA networks are a new perspective in conservation planning, allowing that two crucial ecological components of conservation, connectivity and representativity, might be better achieved than an isolated MPA. By creating a network of marine reserves, the representativity of the diverse habitat types, and species, might be much better accomplished. The same might happen for the connectivity between MPAs, if the planning of these areas is within a MPA network plan (McCook *et al.*, 2010; Sundblad *et al.*, 2011).

Here, I report on the case study of the Tremiti MPA, which is situated in the central Adriatic Sea, in the Apulia region (Italy). It was implemented in 1989, and 22 years of regulation is considered a reasonable time to show responses to protection (Halpern and Warner, 2002). However, recent analyses showed that benthic assemblages do not show any sign of effective protection (e.g. changes in assemblage structure, increasing diversity).

When the MPA was initially implemented, zoning of the MPA (e.g. subdivision of the Archipelago in three zones, A, B, and C with a different regulation) had been decided without a detailed mapping of the area, so that restrictions have been decided without knowing the real distribution of biodiversity. In 2002, within the framework of a project funded by the Ministry of the Environment, the Consorzio Nazionale Interuniversitario per le Scienze del Mare (http://www.conisma.it/it.html) produced a detailed cartography of the whole Archipelago. On the base of the results obtained in the project, the aims of my study are to:

1- analyse the distribution of the diverse habitat assemblages within the MPA;
2- produce scenarios of protection at the habitat level using a range of conservation targets. Targets have been decided through a literature review and considering the ecological features of the different habitat types found in the MPA;
3- evaluate the effects of including human activities in the above scenarios.

As mentioned above, we anticipate that combining ecological data with data on human activities can be a powerful tool to optimize the conservation and the management of this area, providing a baseline for future changes in managing the spatial distribution of human threats according to the distribution of biodiversity within the MPA.

MARXAN (Ball and Possingham, 2000; Possingham et al., 2000) (http://www.uq.edu.au/marxan/) is a decision support tool that relies on a algorithm to prioritize sites to include within an MPA. MARXAN is a freely available conservation planning software. It provides decision support to a range of conservation planning problems, including: the design of new reserve systems, reporting on the performance of existing reserve systems, developing multiple-use zoning plans for natural resource management. I used this software in my analyses in order to identify more effective scenarios of protection in this MPA, trying to solve issues possibly faced also by other MPAs around the world.

Materials and Methods

Study area

The Tremiti Archipelago, is a group of five islands called S. Nicola, San Domino, Capraia, Cretaccio and the most remote and isolated Pianosa which is located 11 nm from the main group. This archipelago is situated in the Adriatic Sea, 12 nm north of the headland of Gargano in the Apulia region (www.pugliaturismo.com) (Fig.2).

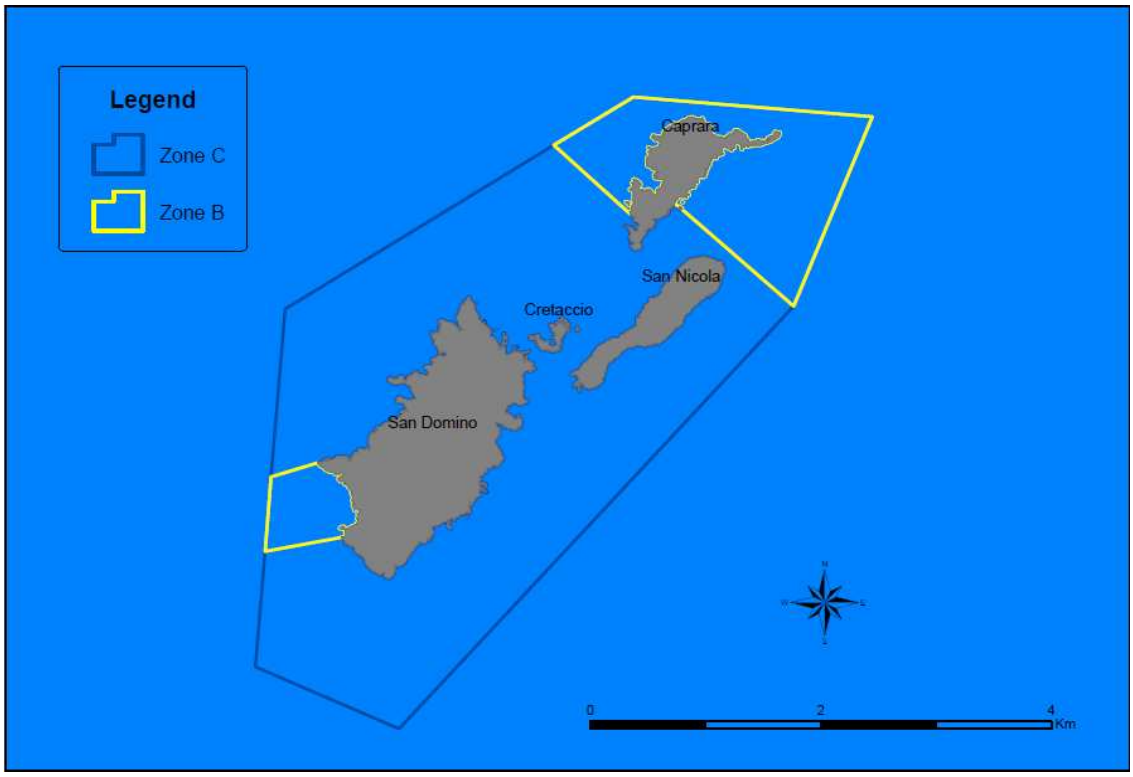

Figure 2. The main group of islands of the Tremiti Archipelago is composed of 4 main islands: San Domino and San Nicola which are inhabited; Caprara and Cretaccio are not inhabited. The study area is divided in two zones with different levels of protection: zone B, with an intermediate level of protection and zone C with the lowest level of protection.

According to the web site www.leisoletremiti.it, 350 people represent the resident population, but permanent residents are much less. During summer months the number of inhabitants may grow up to 3 or 4 times the resident population due to the tourist affluence to this archipelago.

The whole group of islands is included in the MPA, where the zone with the highest protection, the A zone (a restricted zone, no take, no man area) is confined to the inhabited and remote Pianosa island. The zones with intermediate and low protection regimes (B and C zone respectively) are located around the main group of the archipelago (www.leisoletremiti.it; (Fraschetti *et al.*, 2002). The main group of the archipelago with 1286 ha (www.minambiente.it/AMP_isole_tremiti.html) represents my study area.

Bathymetry and habitat mapping

Mapping of the sea floor around the Tremiti archipelago was done in a previous oceanographic survey by CoNISMa (http://www.conisma.it/it.html), during the period of 1 - 9 June 2007. For a detailed collection of georeferenced data, a differential GPS system with SkyFix receivers, connected to the navigation software PDS2000, which verifies in real time the GPS position, and relative precision was used. To create a grid-based map, the shoreline was

digitalized from a 1:15000 scale map. Morpho-bathymetric data were recorded by a continuous digital echo sounder. At shallow depth (0-30m), data were recorded with a single beam echo sounder equidistant by 1m. At depths ranging from 35 to 105 m, data were recorded with a Multibeam Reson Seabat 8160 echo sounder with an equidistance of 5m.

Habitat mapping was conducted through a series of transect perpendicular to the coast line and in each point geographic coordinates, depth, substrate and habitat type were collected. On the bathymetric layer from 0 to 30m, data collection was carried out by free divers, while between 30 to 90m, the habitat identification was carried out by ROVs (Remotely Operated underwater Vehicles) and through dredging activities. In total, about 3000 sampling points were obtained. The habitats were classified according to their biotic and abiotic features. 17 habitat types were identified following the classification proposed by RAC/SPA- Regional Activity Centre for Spatially Protected Areas (www.rac-spa.org of Tunis). Table 1 shows the list of habitat types found in the Archipelago.

To create a detailed map of the habitats, information was included in a GIS (Geographic Information System) software, the ArqGIS v.9.2, and then superimposed with the orthophoto of the study area. The software allows calculating the surface area of each habitat patch, combining data from bathymetry and habitat mapping.

Some of the habitats identified in this first survey were then grouped into categories sharing geological/functional features for analyses through site-selection algorithms, (e.g. Coastal Detritic & Coastal Detritic with *C. caespitosa* and *S. granularis*) (Table 1).

Table 1. Habitat identified and classified according to RAC/SPA from the campaign of 2002 and the habitat groups created in the present study from the previous habitats.

RAC/SPA habitat groups	**Present study habitat groups**
Biocenosis of well sorted fine sands: Association with *Cymodocea nodosa* on well sorted fine sands	*Cymodocea nodosa*
Coralligenous biocenosis Biocenosis of infralittoral algae with Facies and association of Coralligenous biocenosis (in enclave)	Coralligenous formations
Pre-coralligenous biocenosis Biocenosis of infralittoral algae with Facies and association of Pre-coralligenous biocenosis (in enclave)	Pre-coralligenous formations

Biocenosis of infralittoral algae Biocenosis of infralittoral algae: Overgrazed facies with encrusting algae and sea urchins	Infralitoral algae & mosaic of infralitoral algae and sea urchins
Biocenosis the coastal detritic bottom Biocenosis the coastal detritic bottom with Facies with *Cladocora caespitosa* and *S. Granularis*	Coastal Detritic & Coastal Detritic with *Cladocora caespitosa* and *S. granularis*
Biocenosis the coastal detritic bottom: Association with rhodolithes	Coastal Detritic with Rhodolithes banks
Biocenosis the coastal detritic bottom with large ramified Briozoans	Coastal Detritic with large ramified Briozoans
Biocenosis of the muddy detritic bottom	Muddy detritic
Facies of dead « mattes » of *Posidonia oceanica* without much epiflora	*Posidonia oceanica* (dead rhizomes)
Biocenosis of infralittoral algae: Overgrazed facies with encrusting algae and sea urchins	Barrens
Mosaic of *Posidonia oceanica* and biocenosis of coarse sands and fine gravels under the influence of bottom currents	*Posidonia oceanica* and Assemblages of Coarse Sand and Fine Gravels under Bottom Currents
Posidonia oceanica meadows	*Posidonia oceanica* meadows
Biocenosis of coarse sands and fine gravels under the influence of bottom currents	Coarse Sand and Fine Gravels under Bottom Currents

The information relative to the distribution of marine caves was not initially collected in the survey run by CoNISMa (http://www.conisma.it/it.html). It was added in this study, before running data analyses. Marine caves were included since they are an important component of the Archipelago and they are vulnerable habitats deserving conservation priorities (EEC, 1992) where tourist frequentation is very strong. Georeference data on marine caves were obtained from Cicogna *et al*., (2003). This geographic information was in the Italian coordinate system Gauss-Boaga - Datum Roma 1940, and was transformed into the UTM-WGS 84 coordinate system through a precise conversion algorithm: Traspunto(www.traspunto.mondogis.com).

In running MARXAN, habitats were the only conservation feature considered, as they were used as surrogates for biodiversity.

Distribution of human activities

Human activities were mapped during the period of 29 of June, to 2 of July of 2010, by conducting *in situ* surveys by boat, with the use of a GPS. Locations of harbours, ramps, zones of anchorage and zones of boating activities were mapped, together with sewage outfalls, and zones with high tourism frequentation. To complement this information, the harbour office was contacted and data regarding anchorage zones, underwater conducts, diving spots and the routes of the ferry boats were obtained from several documents produced for human activities regulation (see the supplementary material Termoli nr31/2007). Data were in the Datum Roma 1940 coordinate system, and also in this case, these coordinates were transformed using Traspunto (www.traspunto.mondogis.com). The distribution of the anthropogenic activities was added to the map in the ArcGIS v9.2 when transformed in the same coordinate system (UTM-WGS 84) of all the other data.

Conservation Targets selection

Conservation targets indicate how much of a biodiversity feature has to be conserved. These features can be represented by species, communities, ecosystem services and habitat types (Egoh *et al.*, 2007; Pressey *et al.*, 2003).

One of the most applied methods to stratify units of diversity is to use habitat maps. Habitats are directly used as surrogates for diversity (Fernandes *et al.*, 2005) and this vast usage is due to the difficulty in sampling species composition across a region, in order to protect or represent as many species as possible within a certain region, which is the main aim of most conservation plans(Mumby *et al.*, 2008). In our study, we used habitat types as conservation features, since the loss of a habitat increases the probability of extinction of species, and the efficiency of an ecosystem function may be reduced when a number of species in that habitat falls below a given threshold (Huggett, 2005). Habitat maps are often the core of spatially consistent data sets on

which marine reserve networks are designed even though their efficacy as surrogates for species richness is poorly understood. The surrogate efficacy varies as a function of the spatial and temporal scales of observation, accuracy of surrogate classification and degree to which the processes driving the distribution of the surrogates extend to the conservation features (Mumby *et al.*, 2008).

Therefore, setting the conservation target on the amount of habitat to be protected above the threshold of species extinction is ideal, so as to reduce the probability of losing ecosystem functions (Rondinini and Chiozza, 2010).

The protection of 20% of each area has been repeatedly used as the best conservation target. Despite the wide usage of this value as a conservation target, its selection can be considered totally arbitrary, with still no agreement of what value conservation targets should have (Sale *et al.*, 2005; Stewart *et al.*, 2007).

Depending on the habitat type, species accumulate at different rates (Gaston, 2000). Therefore conservation targets should be set for each habitat type, avoiding the choice of selecting a single target for all habitat types. By doing this, we can set higher conservation goals to more ecologically important habitats and lower goals to habitats possibly having a lower ecological value. This might have the advantage of reducing the size of the protected area, reducing the socio-economic conflicts, while maintaining the conservational goal.

In this study, highest conservation values (30%, 40% and 100%) were given to high priority habitats, characterized by high species richness, fragile, long-lived species and with rare, unique fauna and ecological features, like seagrass meadows, coralligenous formations and marine caves. Low priority habitats were characterized by relatively common habitats, with short-lived species and/or with low biotic cover and diversity, like sandy bottoms, barrens and shallow algal assemblages. To these habitats was given the lowest conservation values, 10% and 20% (Table 2).

Review of the literature

To support our selection of conservation targets for each habitat type, a review of the published literature was conducted by using all databases of the ISI Web of Knowledge searching for studies addressing explicitly the issue of conservation targets at the habitat level, covering only marine ecosystems and during the period from 2000 to 2010.

A specific search was carried out within the ‘‘Topic” field, with a factorial combination of key-words “conservation target” or “conservation planning” and “target” or “representation target” or “objective and conservation planning” or “representation and conservation planning” or “conservation objective” with “MPA design” or “marine reserve design” or “marine”.

To complement the systematic search by keywords, the literature cited by the papers retrieved by the keywords was also analysed, and added if suitable. With the preliminary review

of the initial literature, a decision tree was constructed, to maintain focus on the main objective of this study (Fig. 3). For each selected paper, the conservation target/s for each habitat type was kept. Data are shown in the Supplementary Material. A matrix of 15 samples × 10 variables was built, where samples were represented by habitats and variables the corresponding value of conservation target used for that habitat in each paper found in the literature. Principal-components analysis (PCA) was carried out on the whole data set, to visualize potential patterns in habitat grouping according to the contribution of the different conservation targets to the PC axes.

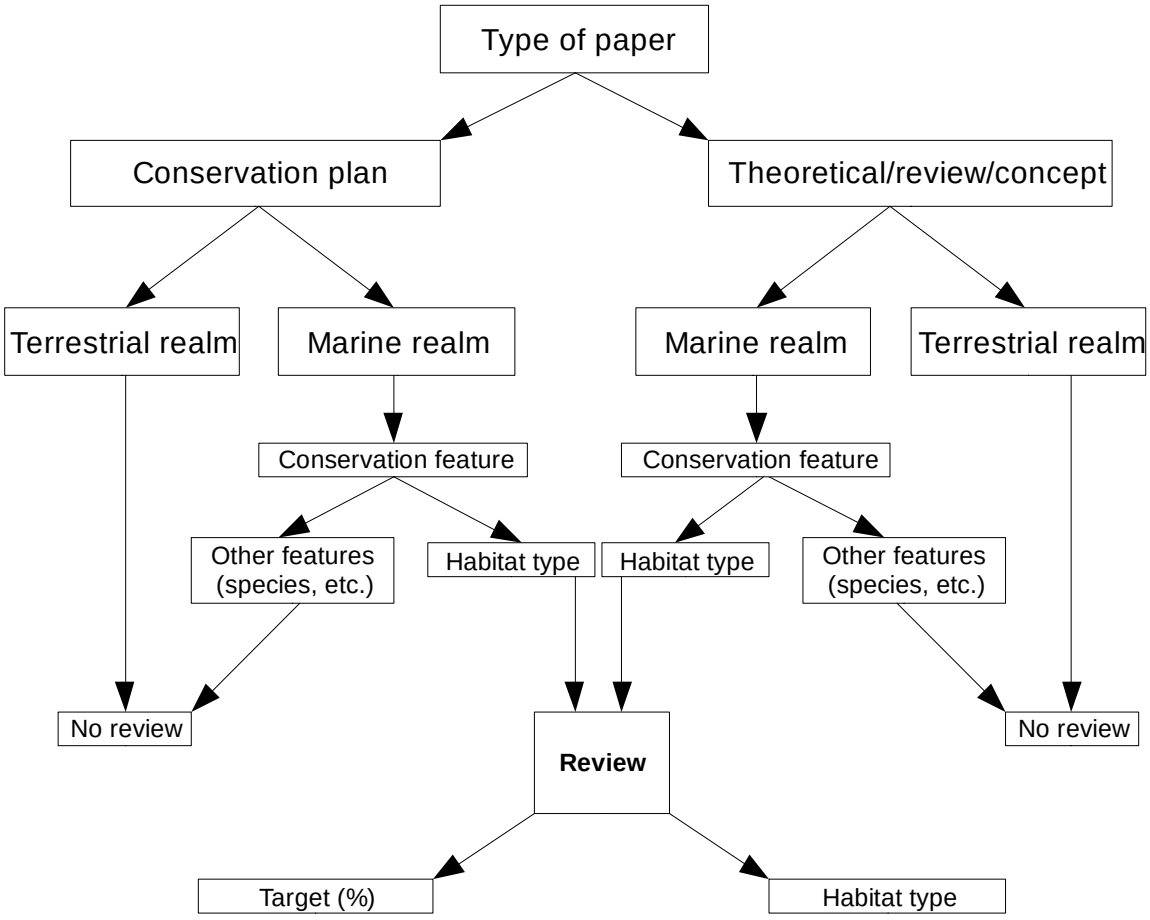

Fig 3. Decision tree to screen the collected literature and for further selection to review. Theoretical/review/concept papers, refers to concept or review papers that deal with the issue of conservation targets. Conservation plan papers refer to applied papers that deal with conservation targets.

Site selection algorithms

We used MARXAN (Ball and Possingham, 2000; Possingham *et al.*, 2000) which is a software with an algorithm that relies on static distributions of biodiversity features, like static species, habitats and landscape types to identify, prioritise and select candidate sites for MPAs. This software has the advantage of meeting the desired fixed targets for biodiversity conservation, while minimising as much as possible the area or the number of sites of the MPA. It can also be used either for terrestrial, marine or freshwater environments (Fraschetti *et al.*,

2009). In order to easily run the MARXAN, we used the stand-alone software PANDA (Protected Areas Network Design Application)(Riolo, 2005) PANDA (Protected Areas Network Design Application) is a stand-alone application developed using Visual Basic and ArcObjects. It was developed to provide a user friendly framework for systematic protected areas network design to ArcGIS users. Through the use of PANDA the designer can explore different hypothetical configurations of a system of protected areas in the planning area. Conservation achievements and associated costs of each scenario are based on the available data and knowledge. The designer can edit the scenario by interactively modifying the status of the planning units among 4 managed categories (Included, Protected, Available, Excluded). He can then explore the target table to see the resulting changes in conservation achievements of the new scenario and the associated costs. PANDA allows interacting with the software MARXAN by providing an easy way to run it over the current scenario and display the results into ArcGIS format. ArcGIS data files are converted to and from MARXAN data files in the background. The user can then use PANDA main interface to refine Marxan solutions.

To efficiently design an MPA, i.e. with the goal of minimising the economic losses while meeting the desired conservation targets, we decided to follow indications from Stewart & Possingham (2005), in order to design an MPA considering both ecological and pressure factors. The motivating idea is designing a MPA at the lowest cost, while meeting the conservation goals, so that solutions may be best accepted by the communities dependent on the study area.

MARXAN was run with the adaptive annealing and interactive improvement algorithms and 1000 repeat runs performed for each reserve design scenario. After each run, MARXAN generated a summary data that included the objective function score, together with the number of planning units and the boundary reserve length.

The planning scenario

The study area was divided into 5700 hexagonal planning units (PUs) with 2500m^2 using Repeating Shapes for ArcGIS (Jenness, 2009), and their size was decided according to the size of the area under investigation (Fraschetti *et al.*, 2009). All the PUs included one or more habitat types in addition to the presence/absence of the human activities.

As mentioned above, we set the conservation targets according to the ecological value of each habitat type (Table 2) together with the consideration of conservation targets set by the literature.

The cost of each planning unit was set equal to its area, so the total cost of the reserve system has been expressed as its total area. The other input parameters, like the algorithm type was the simulated annealing and interactive improvement; the number of simulations were 1000 with 1000 000 interactions per simulation; the number of temperature decreases per simulation was 10 000; and the choice of the initial temperature and cooling factor was set as adaptive.

With the aim to study the effect of the human presence in the design of an MPA, MARXAN analysis was carried out twice: with and without taking into account human presence.

In the scenario accounting for human presence, PUs that coincided with the areas of intense human usage (anchorage areas, navigation areas and underwater conduct) were excluded from the analyses. In the PU file, the STATUS field was set as excluded for the PUs that coincided with those areas, in order that they would not be selected by the algorithm.

The BLM calibration

The BLM (Boundary Length Modifier) is a variable that controls the length of the boundary of the reserve system. When we set the BLM at zero, or with a low value, the algorithm will drive the result in order to reduce the cost, in our case, the area. With higher values of BLM, the algorithm will be driven to minimize the boundary length, and therefore form a more clustered and compact reserve system (Ball and Possingham, 2000; Stewart and Possingham, 2005).

To determine an appropriate BLM value (i.e. a reasonably compact reserve system, while meeting all the conservation targets), it is necessary to consider the effect of increasing the BLM on minimizing the boundary length of the reserve system.

In order to determine the proper BLM value, for both scenarios, we ran the MARXAN performing 1000 repeat runs, with increasing values of BLM, starting from one to 3500 and 6000 for the scenarios with and without the PUs excluded, respectively (See Supplementary material: Table B1 & B2). The best BLM value is obtained when we have the minimal increase in area for the higher spatial compactness (i.e. minimum boundary length) (Fig. 4) (Stewart and Possingham, 2005).

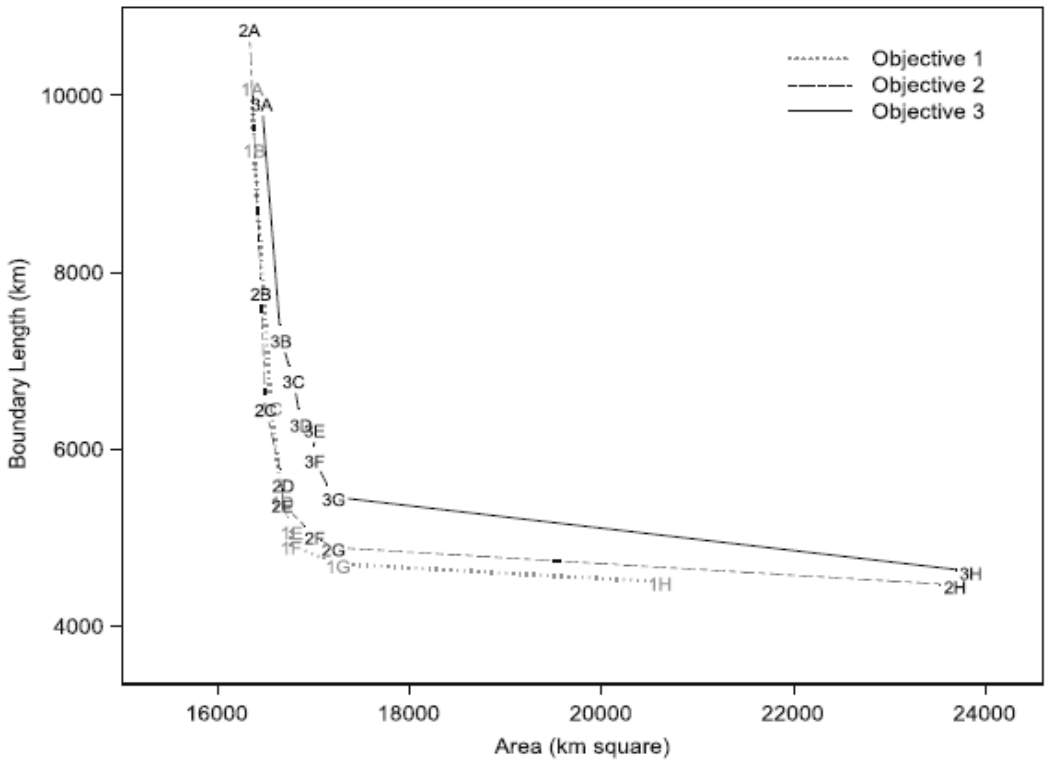

Figure 4. Trade-offs in marine reserve design, highlighting the trade-off between minimizing boundary length and minimizing the total reserve system area, through the alternation of the BLM values for three exploratory scenarios: objective 1- all planning units have the same cost (n =1); objective 2- planning units with the costs equal to their area; objective 3- PU cost as a measure of foregone harvest. After (Stewart and Possingham, 2005).

Figure 4 represents the trade-off in marine reserve design. Here the trade-off in minimising the boundary length and minimising the area of the reserve system is highlighted. The best reserve scenario is when the gain of area is minimal while the spatial clustering largely increases. In this case, the scenario with no impacts is highlighted (i.e. no PUs were excluded).

Identification of priority areas

Beside the identification of the best marine reserve system, it is also useful to know about the importance of each planning unit for conservation, so that priority areas within the study area can be identified. We assigned the irreplaceability values of each planning unit through their selection frequency, throughout the 1000 repeated runs. A planning unit is considered irreplaceable if it is selected more than it would be expected from a random sampling alone (Stewart and Possingham, 2005). So assuming that every planning unit has the same probability (p) of being selected, then:

$$p = (C - R) / (T - R)$$

where C is the mean combination size (Ferrier *et al.*, 2000), which is the average number of planning units contained in the reserve system over a number of runs. T is the total number of

planning units (n = 5700) and R represents the number of planning units excluded from the selection. In the analyses where human activities were not included, the R value was set to 0, while in the analyses with human activities the number of planning units excluded was 564 (R=564). If after 1000 runs, the probability p of planning unit selection is purely random, then they will have a binominal distribution. Under this assumption, we can determine Turkey's 95% confidence limits on the predicted selection frequency. Planning units with selection frequencies greater than the 95% confidence limit are regarded as irreplaceable, as they were unlikely to be selected for the reserve system, due to random sampling alone. Planning units for which selection was no better than random, are described as *ad hoc* (Pressey and Tully, 1994).

Results

With the data obtained from the campaign of CoNISMa in 2002 and 2007, it was possible to produce a detailed habitat map, enabling us to calculate the total area of each habitat type. As described in the materials and methods section, several habitats were merged (see Table 1 and text for the criteria used), values of the new extension of the merged habitats were calculated (Table 2) and a new habitat map was produced according to the new list of habitats (Figure 5).

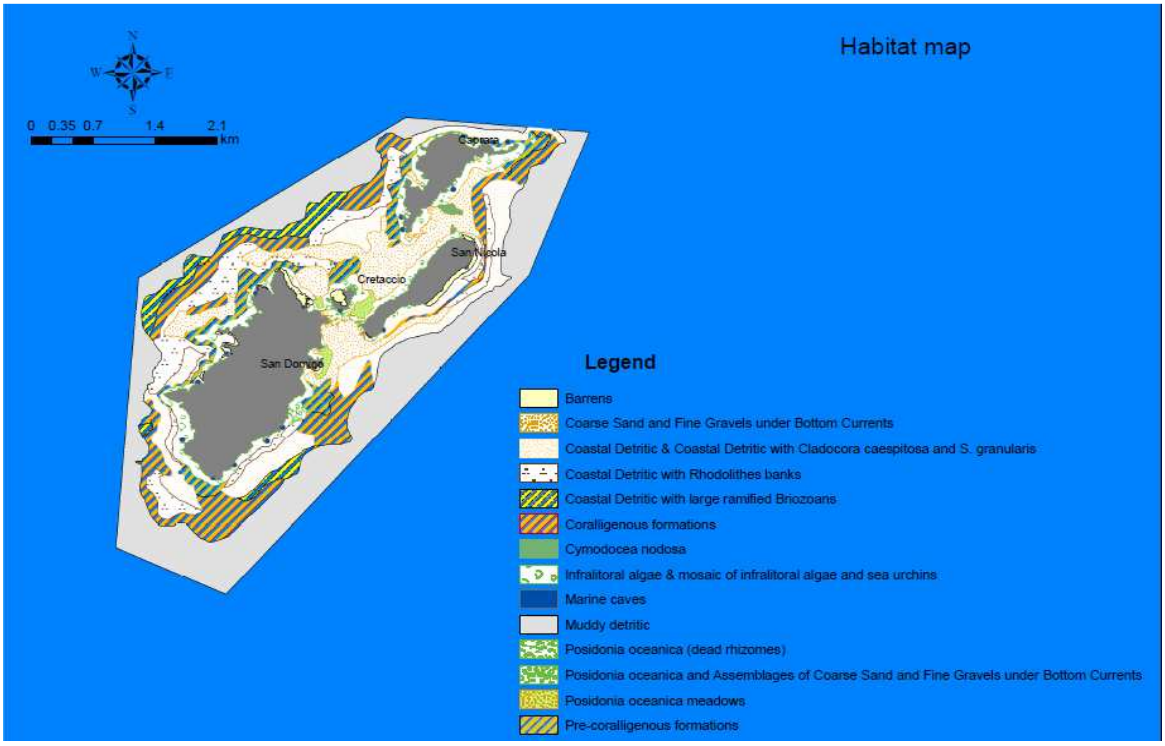

Figure 5. Map with the distribution of the 14 conservation features (habitat types) within the study area.

Table 2 highlights the total area of each habitat type after the habitat merging explained in Table 1. For each habitat, the value of the targeted area for protection (conservation target) coming from the application of the desired percentage of inclusion within the MPA is also shown.

Table 2. The table shows the total area covered by each habitat within the MPA, the conservation targets (%) applied for each habitat types with the relative areas (in m^2) to be protected (targeted area) according to the selected %.

Habitat type	**Total area (m^2)**	**Conservation target (%)**	**Targeted area (m^2)**
Cymodocea nodosa	27483	100	27483
Coralligenous formations	1671241	30	501372
Pre-coralligenous formations	682022	20	136404
Infralitoral algae & mosaic of infralitoral algae and sea urchins	1187252	10	118725
Coastal Detritic & Coastal Detritic with *C. caespitosa* and *S. granularis*	1466881	20	293376
Coastal Detritic with Rhodolithes banks	1169702	30	350910
Coastal Detritic with large ramified Briozoans	475741	30	142722
Muddy detritic	4702836	20	940567
Posidonia oceanica (dead rhizomes)	33530	10	3353
Barrens	132245	10	13224
Mosaic of *Posidonia oceanica* and Assemblages of Coarse Sand and Fine Gravels under Bottom Currents	32528	30	9758
Posidonia oceanica meadows	88272	30	26481
Coarse Sand and Fine Gravels under Bottom Currents	1432615	20	286523
Marine caves	40297	40	16118

After the local survey, conversation with stakeholder and local people and the consultation of data provided by the harbour's office, gathered data were included in the GIS system to provide a map of human activities (Figure 6). It can be observed that the distribution of these activities around the archipelago is quite widespread and the central area of the archipelago (i.e. between San Domino's and San Nicola's Islands) is heavily used by boating and anchoring activities.

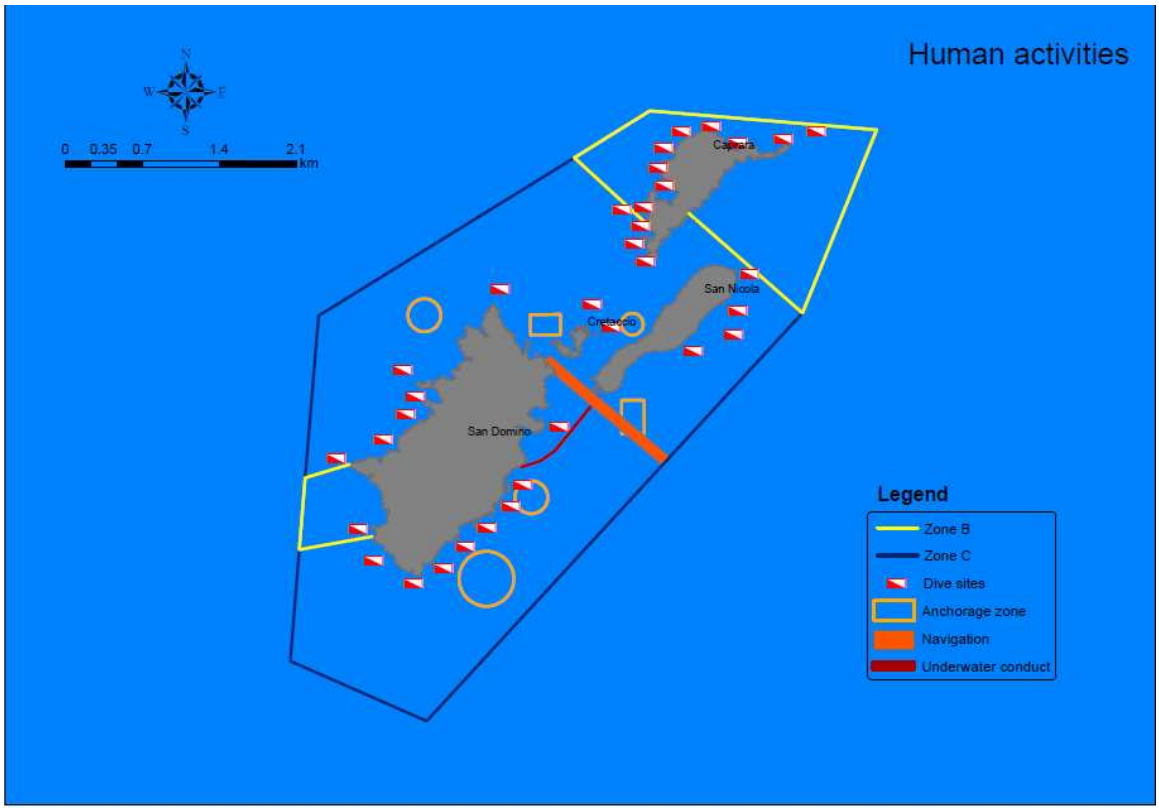

Figure 6. Map of human activities and the zonation with the gradient of protection in the study area (zones B and C).

Review

In total, 34 studies were retained for review after the initial selection followed by the decision tree (Figure 3). Since the aim was to analyse the conservation targets given to specified habitat types in the literature, only the papers that specifically mentioned the habitats and their respective target were kept for the final analyses. Therefore, 21 papers were used in this study. From these, I got 153 nominations of habitats and 59 conservation target values (see the Supplementary material: Table A).

In order to simplify data analyses and interpretation of results, I reduced the number of habitat categories from the literature research and labelled the values of the conservation targets. Conservation targets expressed as percentages were used, considering the following intervals: 5%; 10% - 19%; 20% -29%; 30% -39%; 40% -49%; 50% -59%; 60% -69%; 70% -79%; 80% - 90% and 100%.

Grouping of habitat types was based on their functional and morphological similarities and, in some cases, the region where the study was carried out helped in the decision of where to include the different habitats within the groups. Some habitat types were cited only occasionally (e.g. Tidal fresh grass), and excluded from the analyses; in total 29 habitat types were excluded. At the end, 124 habitat nominations were included and grouped into the categories. For example, the Coral reef was the most populated group and was composed by:

Acropora palmata, barrier reef terrace, black coral beds, coral reefs, coral communities and benthos, crests, deep habitats, dense patch reefs, exposed habitats, forereef, fringing coral reefs, leeward slopes, *Lobophora* and *Montastraea* reefs, patch reefs, reef flats, rocky reefs, shallow forereefs, sheltered habitats, small patch reefs and tidal reef flats. For the other habitat groups see Supplementary material: Table A.

Table 3. Table with the habitat groups *vs*. the respective targets and the number of times that a certain conservation target was attributed to one habitat

Habitat Group \ **Target group**	**5%**	**10% - 19%**	**20% - 29%**	**30% - 39%**	**40% - 49%**	**50% - 59%**	**60% - 69%**	**70% - 79%**	**80% - 90%**	**100%**
Barrens		2		2						
Bioconstructions		5	9	8	6	5		2		
Coral reef	2	11	27	23	6	3	3	1	1	1
Estuaries	5	6	7	1						
Kelps				3	1					
Macroalgae		3	4	3	1	1		1		
Mangroves	1	7	4	3	2	2			2	1
Marine caves				1		1				
Nursery habitats			2							1
Rocky substrates	13	14	15	1	1					
Saltmash	1	2	4	2	2	1				
Sand	3	5	9	3	2					
Seagrass		17	9	14	1	4	1	2		1
Soft substrates	11	11	13	1						
Special feature				1						2

The analysis of the collected data (Table 3) shows that some habitats and regions have received more attention from research and conservation initiatives. Coral reef and Seagrass have been highly considered in conservation initiatives throughout the last 10 years, indicating that tropical areas had received more attention to conservation than other regions, such as polar and temperate areas. It can be also observed that conservation targets range between 10 and 40%, suggesting different approaches and attempts to the conservation of these habitats. PCA

graphical representation (Figure 7) confirms that these habitats, together with bioconstructions, received a wider range of conservation targets, when compared with the other groups. Conversely, the Rocky and Soft substrates habitats received the lowest range of conservation targets. For the rest of the habitat groups, there is no evident difference between them, and the range of conservation values that were mostly attributed to these habitats varied between 10 to less than 30%. The most commonly used and proposed conservation target was 20% (Sale *et al.*, 2005) supporting my decision of using for some of the habitats present in the Archipelago this value (Supplementary material Table A).

It has been already observed that, in this framework, most of the attention has been directed to the tropical areas, while several other important habitats have not received as much attention. A clear example are marine caves, which is an habitat characterized by unique ecological and faunistic features (Bussotti *et al.*, 2006; Harmelin, 1997) and since they are vulnerable habitats, they do deserve proper protection (Habitat Directive 92/43/EEC).

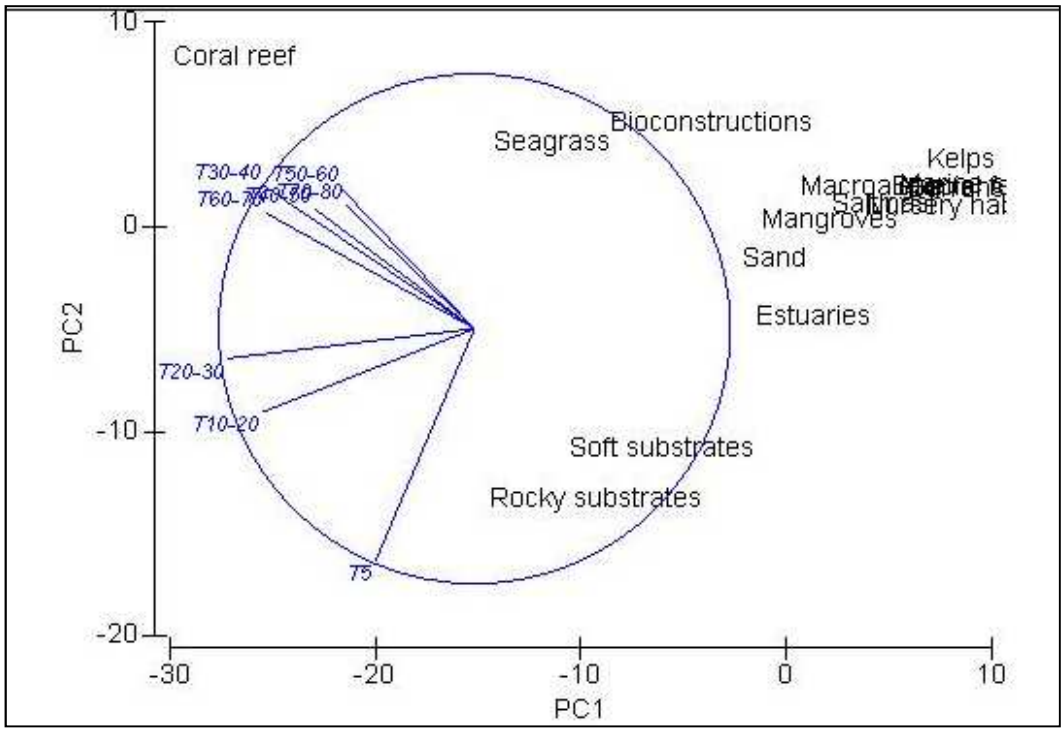

Figure 7. Two-dimensional PCA ordination of the habitat groups according with the conservation targets.

Like marine caves, several other habitats with a known ecological importance, like estuaries, kelp forests, mangroves, seamounts, spawning and aggregation sites, among others, have not received the same attention as the coral reefs or the seagrass habitats.

Table 4. Comparison between the conservation targets coming from the literature (expressed as averages) and the conservation targets used in the present analysis. Empty cells correspond to a lack of match between habitat groups coming from the literature and the habitats present in this study.

Habitat as defined by the literature	Habitat found in the present study	CT from the literature	CT used in the present study
Seagrass	*Cymodocea nodosa*	28.61	100
Coral reefs	Coralligenous formations	29.56	30
Coral reefs	Pre-coralligenous formations	29.56	20
	Infralitoral algae & mosaic of infralitoral algae and sea urchins		20
	Coastal Detritic & Coastal Detritic with *C. caespitosa* and *S. granularis*		10
Bioconstructions	Coastal Detritic with Rhodolithes banks	33.13	30
Bioconstructions	Coastal Detritic with large ramified Briozoans	33.13	30
	Muddy detritic		20
Seagrass	*Posidonia oceanica* (dead rhizomes)	28.61	10
Barrens	Barrens	20	10
Seagrass	Mosaic of *Posidonia oceanica* and Assemblages of Coarse Sand and Fine Gravels under Bottom Currents	28.61	30
Seagrass	*Posidonia oceanica* meadows	28.61	30
Sand	Coarse Sand and Fine Gravels under Bottom Currents	20	20
Marine caves	Marine caves	40	40

In Table 4 are shown the conservation targets selected for the analyses of this study. The target of 100% for the habitat of *Cymodocea nodosa* was set, due to the small portion of this habitat and because it is located in one single spot around the entire study area (Table 2 and Figure 5). The uniqueness of this habitat within the study area is thus the reason behind the selection of this conservation target. For most of the habitat types, the value of conservation target obtained from the literature was used, except for the Pre-coralligenous formation: in this case a target of

20% of protection was attributed while the average from the literature was about 30%. A target of 10% was attributed to *Posidonia oceanica* (dead rhizomes), considered a low priority habitat. In general, the average of conservation targets obtained from the literature for habitats composed by seagrasses was near 30%, but here this habitat is composed by dead seagrasses. Barrens were also labelled as a low priority habitat, and for that reason, a low conservation value (10%) was set, instead of the average of 20% coming from the literature.

Site selection algorithms

BLM calibration

. BLM calibration was done by running different scenarios with different BLM values. The effect caused by the increasing the BLM value in the area and clustering (i.e. reduction of the boundary length) of the reserve system either for the scenarios with and without the human impacts is shown in Figure 8, where the assumption is that the best BLM value is the one that provides the maximum compactness (minor boundary length) while the increase in the reserve system area is minimal. Therefore, through this analysis, I could select the best BLM value for each marine reserve system scenario. For the scenario without the human impacts, the best BLM value was 100 and for the scenario with human activities the selected BLM value was 150.

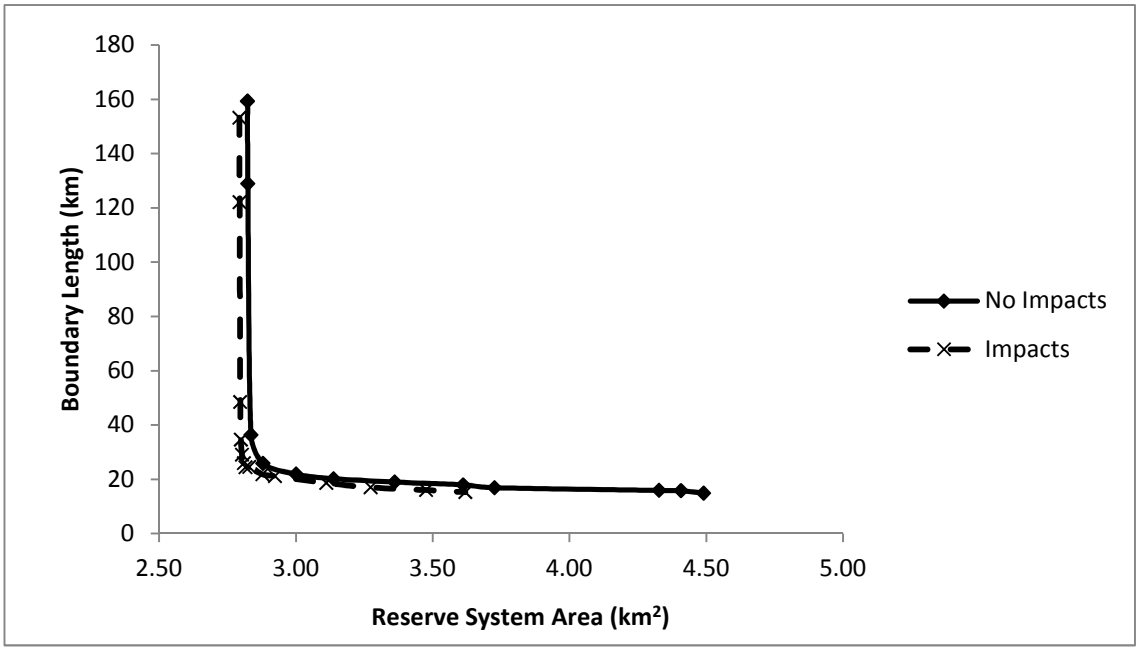

Figure 8. Trade-offs in marine reserve design. Different scenarios, always with the same cost (equal to area), with different BLM values, are examined to select a compact and efficient marine reserve system. Here the trade-off in minimising the boundary length and minimising the area of the reserve system is highlighted. Traced line – scenario with human activities; full line – scenario without human activities.

Identification of priority areas

PUs that had a selection frequency higher than a random selection were considered irreplaceable, which means that irreplaceable PUs may be considered as priority areas.

Firstly, I identified the priority areas within the scenarios without including the information about the distribution of human activities, i.e. none of the planning units were excluded from the analyses (Figure 9).

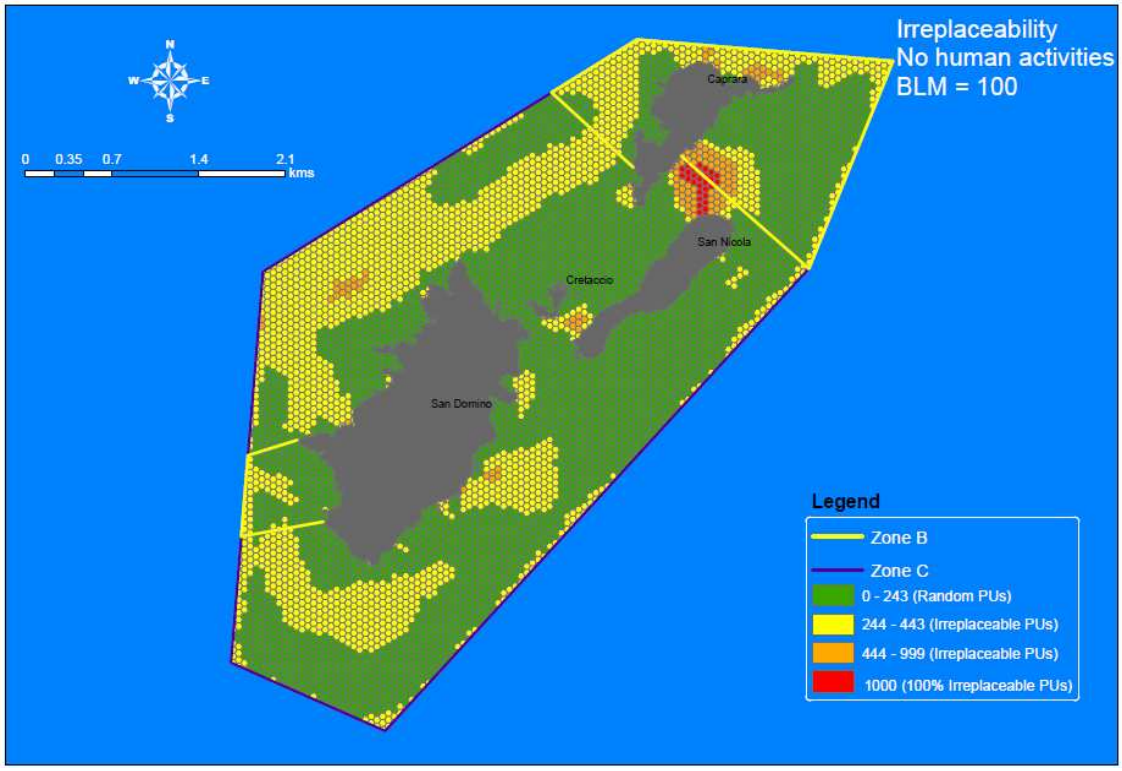

Figure 9. Scenario without the human activities (BLM = 100), with the irreplaceability values for each planning unit; planning units selected 0 to 243 times out of 1000 runs, were considered as random, those who were selected between 244 and 999 times out of 1000 runs were considered as irreplaceable and planning units that were selected 1000 times were considered as 100% irreplaceable.

PUs that were selected between 0 to 243 times in 1000 runs were considered as random or *ad hoc*, while those who were selected 244 times to 999 times in 1000 runs were considered as *irreplaceable* and the planning units that were selected 1000 times (i.e. 100% of the times) were considered as 100% irreplaceable. Figure 9 shows that the only PUs selected 100% of the times were those corresponding to the area where *Cymodosea nodosa* is present. Throughout the rest of the study area, the number of irreplaceable PUs with a high selection frequency is low, so that it does not represent a serious constraint to achieving all the conservation targets. Also, by analyzing the number of times PUs selected among the 1000 runs in the Summed Solution Scenario (See supplementary material – Figure A), beside the area corresponding to the feature with 100% target, few PUs were selected more than 500 times out of 1000 runs. This result suggests that without the consideration of human activities, obtaining a scenario where it is

possible to achieve all the conservation targets is an easy task and that different combinations of PUs can be used to achieve the requested output.

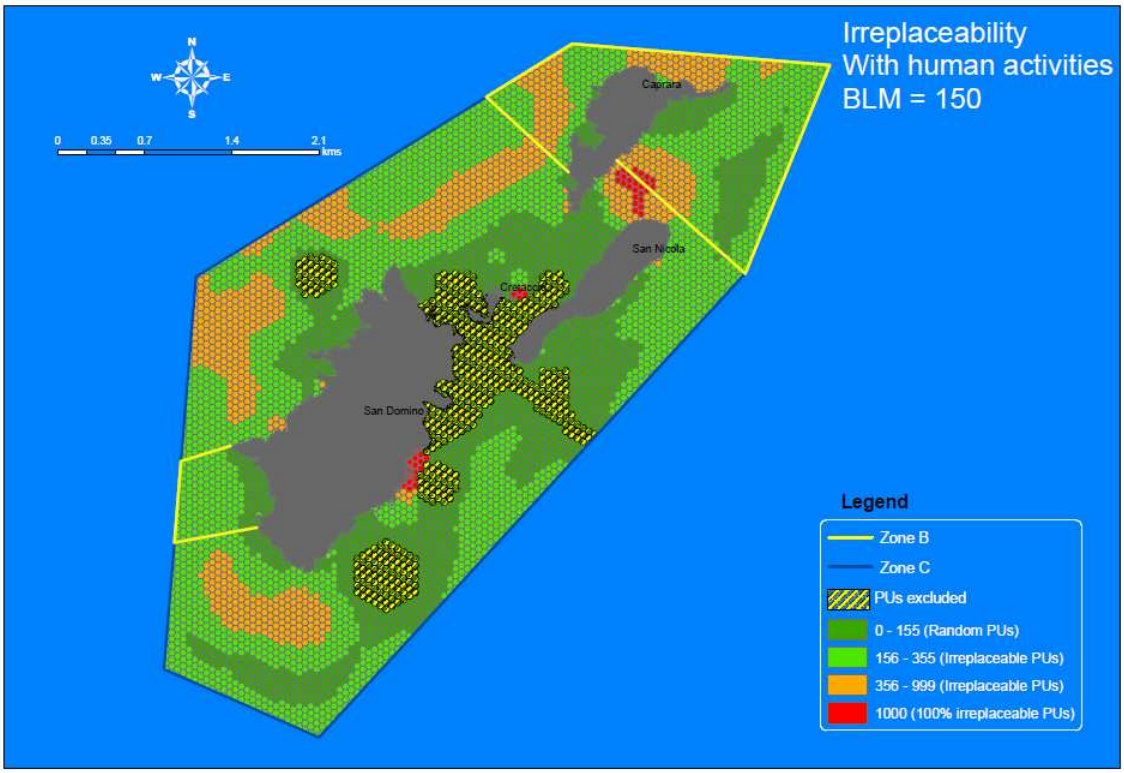

Figure 10. Scenario with the inclusion of human activities (BLM = 150), with the irreplaceability value for each planning unit. Planning units selected 0 to 155 times out of 1000 runs were considered as random, planning units selected 156 to 999 times out of 1000 runs were considered as irreplaceable. The planning units selected in all the 1000 runs were considered as 100% irreplaceable.

In the scenario where human activities were included (Figure 10), and where a number of planning units were excluded (n = 564), the irreplaceability values were rather different. Planning units with selection frequencies below 156 times out of 1000 runs were considered as randomly selected while planning units that were selected 156 to 999 times, were considered as irreplaceable, since their selection frequency is higher than a random selection alone. Planning units that were selected in every run were considered as 100% irreplaceable. In this scenario, the increasing number of 100% irreplaceable planning units was observed. In the summed solution for the same scenario, an increasing number of planning units with a higher selection frequency was observed (See supplementary material: Figure B).

Best scenarios

In the scenario where no human activities were considered, as expected, all the conservation targets were achieved, since no constraints were present in this analyses. For this scenario, 1240 planning units were selected, and the total cost, i.e. the total area of the marine reserve system, was 2.89 km^2(Figure 11 and Table 5).

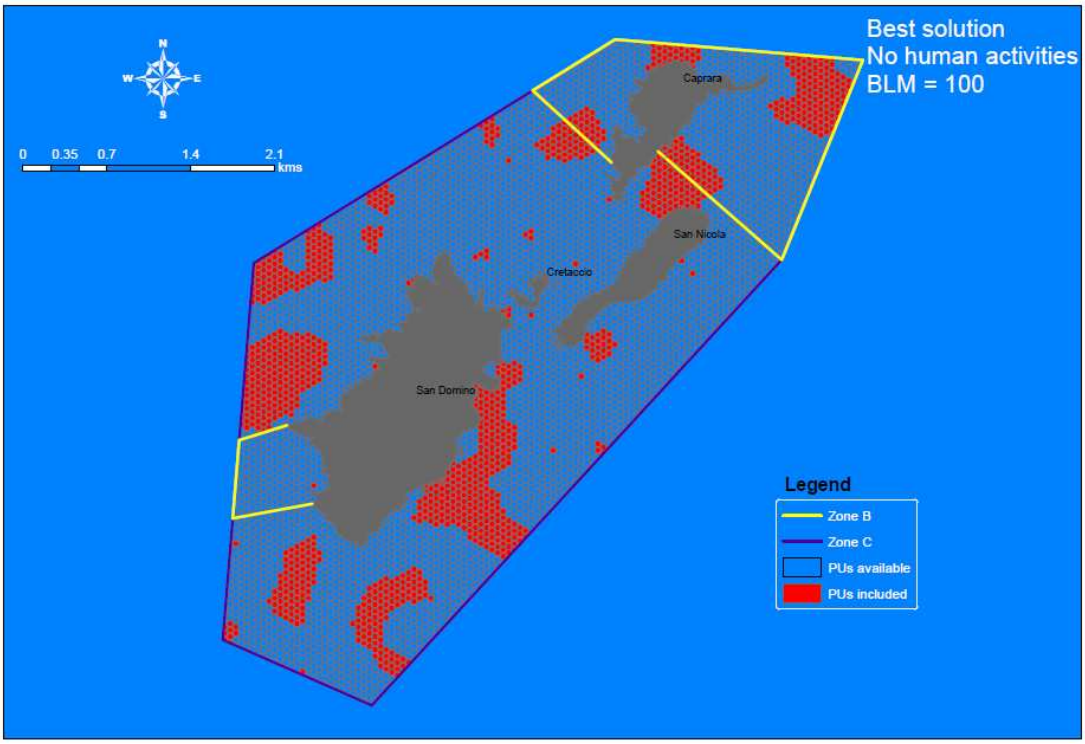

Figure 11. Best solution scenario without human activities and with a BLM equals to 100. As expected all the conservation targets were achieved with the inclusion of 1240 planning units out of 5700, resulting in an area of 2.89 km^2.

Table 5. Result after the analyses with MARXAN in the scenario where no human activities were included. Conservation features (habitat types) with their respective targeted areas and the percentage in the achievement of the respective conservation targets.

Habitat	Total area (m^2)	Target area (m^2)	Conserved area (m^2)	Percentar (%)
Cymodocea nodosa	27483	27483	27483	100
Coralligenous formations	1671241	501372	502265	100
Pre-coralligenous formations	682022	136404	136411	100
Infralitoral algae & mosaic of infralitoral algae and sea urchins	1187253	118725	134580	113.4
Coastal Detritic & Coastal Detritic with *Cladocora caespitosa* and *S. granularis*	1466882	293376	293803	100.1
Coastal Detritic with Rhodolithes banks	1169702	350911	352073	100.3
Coastal Detritic with large ramified Briozoans	475742	142723	142820	100.1
Muddy detritic	4702837	940567	941506	100.1
Posidonia oceanica (dead rhizomes)	33531	3353	4043	120.6
Barrens	132246	13225	13622	103
Mosaic of *Posidonia oceanica* and Assemblages of Coarse Sand and Fine Gravels under Bottom Currents	32528	9758	12720	130.3
Posidonia oceanica meadows	88272	26482	28155	106.3
Coarse Sand and Fine Gravels under Bottom Currents	1432616	286523	287026	100.2
Marine caves	40297	16119	16453	102.1

In the more realistic scenario (Figure 12 and Table 6) where human activities were considered in the analyses, leading to the exclusion of 564 planning units, only 11 conservation features out of 14 achieved their targets. Of these three features, one of them was a low priority habitat (conservation target = 10%): *Posidonia oceanica* (dead rhizomes), that could not be included in the reserve system (i.e. 0% conserved). The other two habitat types that did not achieve their target were high priority habitats (conservation target = 30%): *Posidonia oceanica* meadows (7% conserved); and *Posidonia oceanica* and Assemblages of Coarse Sand and Fine

Gravels under Bottom Currents that achieved 91% of the conservation target. The total cost (area) of the reserve system was 2.86 km^2 (1253 planning units).

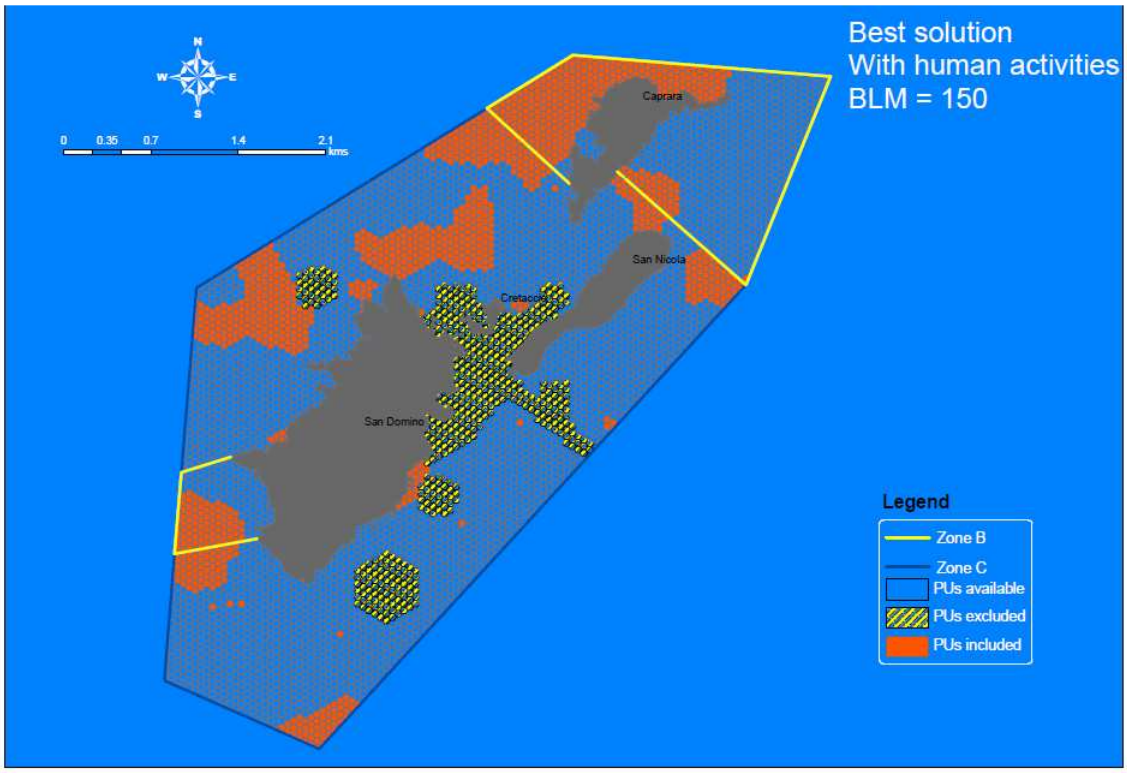

Figure 12. Best solution scenario with the inclusion of the human activities and with BLM = 150. In the zones where these activities were present, planning units were excluded from the analyses (*n* = 564). Only 11 conservation targets were achieved and 2 of the missing targets correspond to high priority habitats. This scenario includes 1253 planning units, making a total cost (i.e. total area) of 2.86km^2.

Table 6. Result of the analyses with MARXAN in the achievement of the conservation targets (targeted area) for each habitat type (conservation feature), in the scenario where human activities were included.

Habitat	Total area (m2)	Target area (m2)	Conserved area (m2)	Percentar (%)
Cymodocea nodosa	27483	27483	27483	100
Coralligenous formations	1671241	501372	502639	100.3
Pre-coralligenous formations	682022	136404	136454	100
Infralitoral algae & mosaic of infralitoral algae and sea urchins	1187253	118725	139249	117.3
Coastal Detritic & Coastal Detritic with *Cladocora caespitosa* and *S. granularis*	1466882	293376	293840	100.2
Coastal Detritic with Rhodolithes banks	1169702	350911	351113	100.1
Coastal Detritic with large ramified Briozoans	475742	142723	143134	100.3
Muddy detritic	4702837	940567	940828	100
Posidonia oceanica (dead rhizomes)	33531	3353	0	0
Barrens	132246	13225	13288	100.5
Mosaic of Posidonia oceanica and Assemblages of Coarse Sand and Fine Gravels under Bottom Currents	32528	9758	8862	90.8
Posidonia oceanica meadows	88272	26482	1849	7
Coarse Sand and Fine Gravels under Bottom Currents	1432616	286523	286893	100.1
Marine caves	40297	16119	16140	100.1

Three conservation targets were not achieved in the analyses where human activities were included, which means that theses habitat types are in the region where planning units were excluded. Indeed, the high priority habitats that did not reach their targets are located in an area where the anchorage, boating activities, and the underwater conducts occur. This means that there is a clear conflict between human activities and a possible reasonable conservation plan, since these habitats must be protected due to their ecological importance. Including and

closing this area in the reserve system would bring conflicts between stakeholders and the conservation plan.

Discussion

Our study represents an important tool to improve the conservation of this area. Through the combination of knowledge of habitat distribution and extent and the information about the use of territory around the archipelago, it has been possible to evaluate what habitats are presently more exposed to damaging activities. The usefulness of properly including ecological criteria within coastal zone management initiatives has already been demonstrated (Pergent-Martini *et al.*, 2006). Also, the identification of priority areas with the use of ecological criteria is an important element to meet the main goals of marine spatial planning (Agardy *et al.*, 2011). This information combined with the distribution of human activities is particularly important since, at present, in Italy, no MPA is featured by a spatial zoning regulating the variety of activities allowed within the boundaries of the protected area, potentially causing relevant impacts to protected habitats and assemblages. Outside the Mediterranean Sea, few examples of marine spatial planning have been attempted, but results are promising (Ogden, 2010).

As far as our results are concerned, firstly, most of the habitat types observed within the study area have a large area of occurrence and a wide distribution, but some habitats like *Posidonia oceanica* meadows and *Cymodocea nodosa* cover a smaller area with a limited extension, deserving a specific protection due to their uniqueness within the study area, reducing the resilience of these habitats and the species living on them, and increasing the probability of local extinction (Wilson *et al.*, 2010). Other habitat types, like "Pre-coralligenous formations" or "Coastal Detritic with large ramified Briozoans", have a higher and wider representation within the study area, giving the potential of providing alternative conservation scenarios.

Results also show that high priority habitats such as "*Posidonia oceanica* meadows" and "mosaics of *Posidonia oceanica* and assemblages of coarse sand and fine gravels under bottom currents" are located in areas where activities such as boating and anchorage are extremely intense. In coastal areas with high recreational activities, anchorage and the consequent dragging of anchors and scraping anchor chains on the

bottom are the major causes of the decrease of meadows cover and shoots density (Francour *et al.*, 1999).

As already introduced, a relevant aspect of this study relies on the decision of setting different conservation targets to different habitat types since they vary in biodiversity and biomass richness (Gaston, 2000), some are more sensitive to human disturbances and some have a higher representation within the study area. In other words, habitats with a low amount of area and limited distribution within this area are more liable to local extinction, therefore the rarity and uniqueness of these habitats within the study area were leading to the selection of the conservation targets.

The highest conservation value (100%) was given to the habitat of *Cymodocea nodosa* (Table 2). From the review, seagrasses have been the focus of several conservation attempts, with an average conservation target near 30% (Table 4). In this study, the 100% conservation target was used for *Cymodocea nodosa* because of its limited and clustered distribution. Protecting only 30% of a small patch of a sensitive habitat would probably be insufficient to ensure its protection and recovery. The other habitats mainly composed of seagrasses, like "*Posidonia oceanica* meadows" and "Mosaic of *Posidonia oceanica* and Assemblages of Coarse Sand and Fine Gravels under Bottom Currents" were given the targets obtained from the literature review. These two habitats had a bigger total area and were more widespread than the *Cymodocea nodosa* habitat. The habitat represented by dead *Posidonia oceanica* (dead rhizomes) was not considered a top priority for conservation, and for that reason only 10% of protection was set for this habitat.

Marine caves are structurally complex habitats featured by unique patterns of compositional diversity. Significant differences can be observed between caves tens of meters from each other, in term of species richness and assemblage structure, both of benthos and fish (Bussotti et al., 2006; Harmelin, 1997). They have been included within the list of habitats deserving special protection (Habitat Directive 92/43/EEC). Due to their uniqueness and vulnerability to human activities together with the average value of protection obtained from the literature, marine caves received a high value of conservation (40%).

The average target obtained from the review of the habitats dominated by bioconstructions was 33.13%. In this study, two bioconstruction dominated habitats (Coastal Detritic with Rhodolithes banks and Coastal Detritic with large ramified Briozoans) were considered as high priority habitats and therefore also received the

target of 30% in this case according to the literature and because of their structural and functional features (Fraschetti *et al.*, 2009). Another habitat considered of high conservation value was the Coralligenous formations. The target was set at 30% due to the similarities of this habitat with coral reefs. Coral reefs habitats were the most cited in the review and due to their known ecological goods and services they provide, such as renewable resources, structure, biotic, biogeochemical services among others (Moberg and Folke, 1999), we applied the same target also to coralligenous formations. The conservation target for Pre-coralligenous formations was lower (20%) considering the consequences in terms of the total cost of the MPA. The conservation targets coming from the literature for the Sand habitat group served as a model for the habitats present in the study area and 20% was set for these habitat types. As far as barrens, the lowest conservation value, i.e. 10% (Table 2), was set since the ecological value of these areas is extremely low (Irving and Witman, 2009; Ling, 2008; Micheli *et al.*, 2005; Witman, 1985) and it was out of the scope of this study to produce scenarios also leading to the recovery of disturbed assemblages.

Our review putting in relation conservation targets and marine habitats showed that conservation initiatives have not been homogeneously distributed around the world (Airoldi and Beck, 2007; Wood *et al.*, 2008). Most of the research done in this framework has been carried out in tropical areas. Habitats cited most times and with wider and higher conservation values are the Coral reefs and Seagrasses, followed by bioconstructions (see also Supplementary material Table A). Habitat protection around the world is inadequately distributed (Game *et al.*, 2009). Studies about habitat loss and fragmentation in coral reefs and mangroves have improved our understanding of the status of tropical marine ecosystems, and have influenced the support for tropical science, conservation and management (Airoldi and Beck, 2007). Unfortunately, this understanding in temperate habitats is less advanced and therefore few scientific institutions, organizations and non-governmental organizations (NGOs) have focused on this issue in temperate areas: productive, unique and diverse habitats like Estuaries, Macroalgae, Kelps, Marine caves and Saltmarshes have not received the same attention as tropical habitats. In contrast, temperate areas like the Mediterranean Sea are often characterised by a high human pressure, with intense fishing, densely populated coastlines, and increasing number of introduced species. Thus, more focused studies on the application of restrictive conservation targets should be a priority, especially on

coastal and estuarine habitats that are among the most productive and diverse ecosystems on Earth (Edgar *et al.*, 2000; Suchanek, 1994).

Analyzing the range of conservation targets cited throughout the literature in the past 10 years, it is clear that the most commonly used range of targets is between 10 - 40% and as expected, the most used value of conservation is 20% (See supplementary material Table A). This value has been widely used, but still, it is an arbitrary value, since it assumes that protecting 20% of a certain area will protect 20% of the spawning stocks and this value will prevent recruitment overfishing (Roberts, 1997; Sale *et al.*, 2005). This value has been proposed with fishery management purposes while the aim of both conservation plans and theoretical studies is not always to enhance fisheries. Recently, other conservation targets values have been proposed, but always with the aim of enhancing fisheries (Sale *et al.*, 2005). However, the aim of this study was not to assess the performance of different conservation targets on different habitats, but rather to stress the range of different and not justified conservation targets used in the literature and the fact that the adoption of properly selected values would greatly enhance the conservation of biodiversity. Also, the selection of only one conservation target for all habitat types within a certain study area, might be a shallow approach to an efficient conservation initiative, since habitat types do vary in species richness and ecological value (Gaston, 2000; Mumby *et al.*, 2008). Still, the inclusion of all habitat types is fundamental because some species might be present in some habitat types and absent in others (Wilson *et al.*, 2010) and in this way the representativeness is better achieved.

Since MARXAN is a decision support tool and not a decision maker tool, it is important to know how many times PUs were selected after a defined number of runs, in order to be aware of top priority areas to achieve the targets. These irreplaceability values were calculated for both scenarios, with and without human activities, and notoriously irreplaceable values varied between scenarios. In the first scenario where no human activities were included (Figure 9), it is observed that a small number of PUs were considered as irreplaceable, and only the planning units that coincided with the area with *Cymodosea nodosa*, were selected in every run. This is due to the conservation target for *Cymodosea nodosa:* planning units including this feature were selected in all of the 1000 runs. Throughout the rest of the study area, most of the PUs were considered as randomly selected, which means that planning reasonable scenarios of protections, with no human activity present in the analyses, all achieving the defined conservation targets is also a feasible task with a variety of alternative possibilities.

In the scenario where human activities were included, the results were rather different. With the exclusion of the planning units where human activities take place, not all the conservation targets were achieved. In fact, only 11 out of 14 features achieved their conservation target. Of the three features that did not achieve their target, one of the features was completely excluded from the reserve system, while for the other two only part of their targeted area was kept in the reserve system. These last two habitat types were considered as high priority habitats ("*Posidonia oceanica* meadows" and "Mosaic of *Posidonia oceanica* and Assemblages of Coarse Sand and Fine Gravels under Bottom Currents").

The main outcome of the study is that after 20 years from the implementation of the studied MPA, the inappropriate reserve design is one of the main causes of MPA failure and shortcomings (Agardy *et al.*, 2011; Fraschetti *et al.*, 2005; Mora *et al.*, 2006; Sala, 2002; Villa *et al.*, 2002). Pervasive activities, like anchoring, boating and tourist activities are located in the same areas where sensitive and valuable habitats are present (i.e. *Posidonia oceanica*). This clearly shows how planning of the present MPA was inappropriately done, with the consequence that the distribution of human activities conflicts with the distribution of habitats with high conservation value. The lack of knowledge of the habitat distribution around the study area, when the MPA was instituted, is the main reason for the failure of this MPA in fulfilling its ecological objectives, as is the case in several MPAs around the world (Agardy *et al.*, 2011). The advanced knowledge of the ecological features of the area where an MPA is to be instituted is imperative to design an MPA that achieve its ecological goals (Fraschetti *et al.*, 2005). The information about the ecological features, distribution and amount would help in the zonation and consequent spatial distribution of human activities in the reserve system. Designing an MPA based only on scientific criteria, in a human dominated area would bring several socio-economic conflicts. Efficient conservation planning must explicitly inform how proposed management will affect stakeholders (Giakoumi *et al.*, 2011). Therefore, the combination of the human dimension with the scientific criteria in MPA planning is needed to reduce the conflict that would result from an MPA design that does not take into account the human activities. Planning and design of MPAs must be integrated in a EBM approach, where, besides the scientific community, other management initiatives, like coastal development, fishing industry, shipping and aquaculture entities, would participate (Halpern *et al.*, 2010) leading to the best understanding between the diverse entities and consequently to more successful

MPAs. It has to be stressed, however, that although well designed marine reserves, alone, can solve localized conservation and management problems, the sum of the total MPAs implemented within the context of a wider strategic marine plan will have better results, leading to an effective ecosystem-based-management (Agardy *et al.*, 2011).

Although the focus of the scientific community on conservation issues has been growing over the last years, only one-third of the published assessments delivered conservation plans. This problem is recognised as "*knowing-doing gap*" and is widely recognized in management science (Knight *et al.*, 2008). This study represents an exception: during the realization of it, the entity responsible for the MPA of Isole di Tremiti (Parco Nazionale del Gargano) decided upon a new anchorage regulation within the study area (Figure 13) based on our results. It can be seen in this new proposal that the information about habitat distribution has been taken into account, since the area where the habitat "*Posidonia oceanica* meadows"and the "Mosaic of *Posidonia oceanica* and Assemblages of Coarse Sand and Fine Gravels under Bottom Currents", two habitats with high conservation value are now protected from the destructive activity of anchoring.

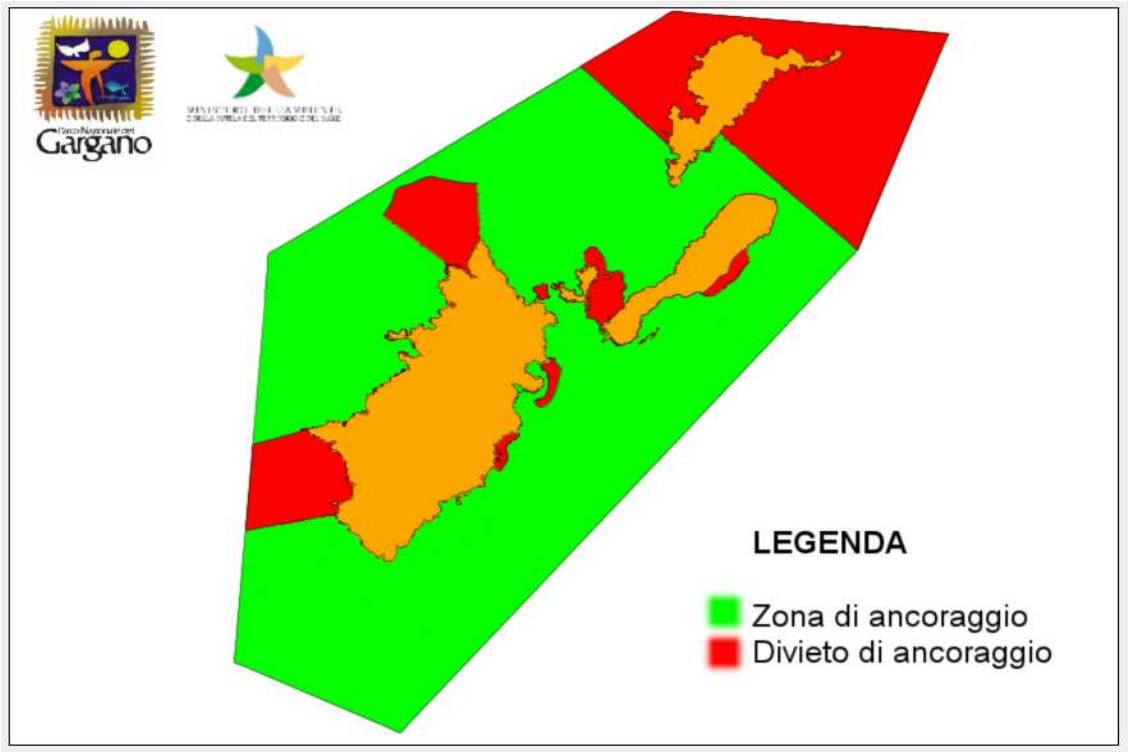

Figure 13. New proposal for the areas where it is allowed to anchor (green) and where anchoring is forbidden (red), from the entity responsible for the management of the MPA of Isole di Tremiti.

Marine protected areas have already proved their conservation benefits and the usage of MPA is supported by a large scientific community (Browman and Stergiou, 2004; Halpern, 2003). Still, MPAs cannot be considered as the solution for all problems in the ocean (Halpern *et al.*, 2010) and if the implementation of these areas does not take into account proper scientific criteria and the socio-economic dimension, most probably MPAs will not achieve their objectives and the conflicts with stakeholders and other entities around the MPA will give a poor image of marine reserves, which could make policy makers and stakeholders give up on the use of MPAs as a management/conservation tool (Guidetti *et al.*, 2008). On the other hand, if MPAs are well established, with proper scientific background, with the inclusion of the human dimension in the planning of the reserve system and are also well enforced, they can meet their ecological and socio-economic goals, turning into an example of success. This would convert public opinion into a broader acceptance, allowing other future MPAs to have better chances of success (Agardy *et al.*, 2003; Friedlander *et al.*, 2003; Guidetti *et al.*, 2008).

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Supplementary material

Table A. Literature review; Habitats as named in the literature (Habitat - literature), grouping (Habitat group) and conservation targets for each habitat as reported in the literature.

Habitat (Literature)	Habitat group	Target (%)	Author	Title
Barrens	**Barrens**	10	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Barrens with algae	**Barrens**	10	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Barrens	**Barrens**	30	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Barrens with algae	**Barrens**	30	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Sparce gorgonians	**Bioconstructions**	10	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Dense gorgonians	**Bioconstructions**	10	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Dense gorgonians	**Bioconstructions**	10	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Oyster	**Bioconstructions**	20	Beck, 2001	Ecoregional planning in marine environments: identifying priority sites for conservation in the northern Gulf of Mexico
Sponges/soft coral	**Bioconstructions**	20	Beck, 2001	Ecoregional planning in marine environments: identifying priority sites for conservation in the northern Gulf of Mexico
Bivalve reef (Oyster)	**Bioconstructions**	20	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida
Annelid worm reef (Sabellariidae)	**Bioconstructions**	20	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida
Rodolith beds	**Bioconstructions**	20	Sala E. et al 2002	A general model for designing networks of marine reserves
Sparce gorgonians	**Bioconstructions**	20	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Dense gorgonians	**Bioconstructions**	20	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Sponges reef	**Bioconstructions**	30	Ban N. et al, 2009	Minimum data requirements for designing a set of MPAs
Bioconstructions	**Bioconstructions**	30	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Bioconstructions and sand	**Bioconstructions**	30	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Sparce gorgonians	**Bioconstructions**	30	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Dense gorgonians	**Bioconstructions**	30	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Algal bioconstructions	**Bioconstructions**	30	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Algal bioconstructions and sand	**Bioconstructions**	30	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Bivalve reef (Oyster)	**Bioconstructions**	40	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida

Annelid worm reef (Sabellariidae)	**Bioconstructions**	40	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida
Gorgonians	**Bioconstructions**	45	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Gorgonians	**Bioconstructions**	45	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Bioconstructions	**Bioconstructions**	50	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Bioconstructions and sand	**Bioconstructions**	50	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Algal bioconstructions	**Bioconstructions**	50	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Algal bioconstructions and sand	**Bioconstructions**	50	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Sparce gorgonians	**Bioconstructions**	12.2	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Dense gorgonians	**Bioconstructions**	17.3	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Sparce gorgonians	**Bioconstructions**	23.8	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Dense gorgonians	**Bioconstructions**	25.2	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Sparce gorgonians	**Bioconstructions**	38.3	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Dense gorgonians	**Bioconstructions**	41.7	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Dense gorgonians	**Bioconstructions**	43.8	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Sparce gorgonians	**Bioconstructions**	55.5	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Sparce gorgonians	**Bioconstructions**	75.8	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Gorgonians	**Bioconstructions**	76	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Fringing coral reef, narrow	**Coral reef**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Fringing coral reef, wide	**Coral reef**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Fringing coral reef, narrow	**Coral reef**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Fringing coral reef, wide	**Coral reef**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Montastraea reef	**Coral reef**	10	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Acropora palmata reef	**Coral reef**	10	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Patch reef	**Coral reef**	10	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design

Dense patch reef	**Coral reef**	10	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Lobophora	**Coral reef**	10	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Shallow forereef	**Coral reef**	10	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Fringing reefs	**Coral reef**	10	Weeks R. et al 2009	Shortcuts for marine conservation planning: the effectiveness of socioeconomic data surrogates
Coral reef	**Coral reef**	20	Dalleau M. et al 2010	Use of Habitats as Surrogates of Biodiversity for Efficient Coral Reef Conservation Planning in Pacific Ocean Islands
Fringing coral reef, narrow	**Coral reef**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Fringing coral reef, wide	**Coral reef**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Coral reef	**Coral reef**	20	Bohnsack J.A., et al 2000	A rationale for minimum 20-30% no-take protection
Montastraea reef	**Coral reef**	20	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Acropora palmata reef	**Coral reef**	20	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Patch reef	**Coral reef**	20	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Dense patch reef	**Coral reef**	20	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Lobophora	**Coral reef**	20	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Shallow forereef	**Coral reef**	20	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Coral reef (incl. deep Oculina Banks)	**Coral reef**	20	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida
Coral reef (incl. deep Oculina Banks)	**Coral reef**	20	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida
Black coral beds	**Coral reef**	20	Sala E. et al 2002	A general model for designing networks of marine reserves
Deep habitats	**Coral reef**	20	Dalleau M. et al 2010	Use of Habitats as Surrogates of Biodiversity for Efficient Coral Reef Conservation Planning in Pacific Ocean Islands
Exposed habitats	**Coral reef**	20	Dalleau M. et al 2010	Use of Habitats as Surrogates of Biodiversity for Efficient Coral Reef Conservation Planning in Pacific Ocean Islands
Sheltered habitats	**Coral reef**	20	Dalleau M. et al 2010	Use of Habitats as Surrogates of Biodiversity for Efficient Coral Reef Conservation Planning in Pacific Ocean Islands
Coral reef benthos	**Coral reef**	20	Green et al, 2009	Designing a resilient network of marine protected areas for Kimbe Bay, Papua New Guinea
Coral reef fish	**Coral reef**	20	Green et al, 2009	Designing a resilient network of marine protected areas for Kimbe Bay, Papua New Guinea
Reef flat	**Coral reef**	25	Beech T. et al 2008	A stochastic approach to marine reserve design: Incorporating data uncertainty
Reef flat patches	**Coral reef**	25	Beech T. et al 2008	A stochastic approach to marine reserve design: Incorporating data uncertainty
Tidal reef flats	**Coral reef**	25	Beech T. et al 2008	A stochastic approach to marine reserve design: Incorporating data uncertainty
Lagoon side small patch reefs	**Coral reef**	25	Beech T. et al 2008	A stochastic approach to marine reserve design: Incorporating data uncertainty
Barrier reefs terrasse	**Coral reef**	25	Beech T. et al 2008	A stochastic approach to marine reserve design: Incorporating data uncertainty

Montastraea reef	**Coral reef**	25	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Coral reef	**Coral reef**	30	Dalleau M. et al 2010	Use of Habitats as Surrogates of Biodiversity for Efficient Coral Reef Conservation Planning in Pacific Ocean Islands
Coral reef	**Coral reef**	30	Bohnsack J.A., et al 2000	A rationale for minimum 20-30% no-take protection
Montastraea reef	**Coral reef**	30	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Acropora palmata reef	**Coral reef**	30	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Patch reef	**Coral reef**	30	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Dense patch reef	**Coral reef**	30	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Lobophora	**Coral reef**	30	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Shallow forereef	**Coral reef**	30	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Rocky reef (granite)	**Coral reef**	30	Klein C. et al 2008	Striking balance between biodiversity conservation and socioeconomic viability in the design of marine protected areas
Rocky reef (sandstone and shale)	**Coral reef**	30	Klein C. et al 2008	Striking balance between biodiversity conservation and socioeconomic viability in the design of marine protected areas
Rocky reef (Franciscan complex)	**Coral reef**	30	Klein C. et al 2008	Striking balance between biodiversity conservation and socioeconomic viability in the design of marine protected areas
Coral reef	**Coral reef**	30	Yusuf C. et al, 2008	The Use of MARXAN to Re-Zone MPA (Study Case : Gili Sulat – Gili Lawang, Lombok)
Deep habitats	**Coral reef**	30	Dalleau M. et al 2010	Use of Habitats as Surrogates of Biodiversity for Efficient Coral Reef Conservation Planning in Pacific Ocean Islands
Exposed habitats	**Coral reef**	30	Dalleau M. et al 2010	Use of Habitats as Surrogates of Biodiversity for Efficient Coral Reef Conservation Planning in Pacific Ocean Islands
Sheltered habitats	**Coral reef**	30	Dalleau M. et al 2010	Use of Habitats as Surrogates of Biodiversity for Efficient Coral Reef Conservation Planning in Pacific Ocean Islands
Patch reef	**Coral reef**	40	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Forereef	**Coral reef**	40	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Small patch reefs	**Coral reef**	50	Beech T. et al 2008	A stochastic approach to marine reserve design: Incorporating data uncertainty
Patch reef	**Coral reef**	60	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Coral communities	**Coral reef**	100	Sala E. et al 2002	A general model for designing networks of marine reserves
Acropora palmata	**Coral reef**	15.6	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Patch reef	**Coral reef**	18.9	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Acropora palmata	**Coral reef**	21.5	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve

				planning
Patch reef	**Coral reef**	22.7	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Montastraea reef	**Coral reef**	24.4	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Patch reef	**Coral reef**	31	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Acropora palmata	**Coral reef**	33.5	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Crest	**Coral reef**	34	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Patch reef	**Coral reef**	36	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Forereef	**Coral reef**	36	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Forereef	**Coral reef**	37	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Leeward slope	**Coral reef**	38	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Crest	**Coral reef**	38	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Leeward slope	**Coral reef**	42	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Crest	**Coral reef**	42	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Patch reef	**Coral reef**	47.7	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Acropora palmata	**Coral reef**	47.9	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Leeward slope	**Coral reef**	51	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Montastraea reef	**Coral reef**	59.4	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Patch reef	**Coral reef**	61.7	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Acropora palmata	**Coral reef**	63.3	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Montastraea reef	**Coral reef**	71.7	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Montastraea reef	**Coral reef**	82.5	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Inclined mixed fines flat, narrow	**Estuaries**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information

Inclined mixed fines flat, wide	**Estuaries**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Mixed fines flat, wide	**Estuaries**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Steep mixed fines flat	**Estuaries**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Gravel flat, wide	**Estuaries**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Estuary habitats	**Estuaries**	10	Neely A.& Zajac R. 2009	Applying marine protected area design models in large estuarine systems
Inclined mixed fines flat, narrow	**Estuaries**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined mixed fines flat, wide	**Estuaries**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Mixed fines flat, wide	**Estuaries**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Steep mixed fines flat	**Estuaries**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Gravel flat, wide	**Estuaries**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Estuarine communities	**Estuaries**	20	Green et al, 2009	Designing a resilient network of marine protected areas for Kimbe Bay, Papua New Guinea
Estuary habitats	**Estuaries**	20	Neely A.& Zajac R. 2009	Applying marine protected area design models in large estuarine systems
Inclined mixed fines flat, narrow	**Estuaries**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined mixed fines flat, wide	**Estuaries**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Mixed fines flat, wide	**Estuaries**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Steep mixed fines flat	**Estuaries**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Gravel flat, wide	**Estuaries**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Estuaries	**Estuaries**	30	Klein C. et al 2008	Striking balance between biodiversity conservation and socioeconomic viability in the design of marine protected areas
Kelps	**Kelps**	30	Ban N. et al, 2009	Minimum data requirements for designing a set of MPAs
Kelp forest (*Macrocystis pyrifera)*	**Kelps**	30	Klein C. et al 2008	Striking balance between biodiversity conservation and socioeconomic viability in the design of marine protected areas
Kelp forest (*Nereocystis lutkeana)*	**Kelps**	30	Klein C. et al 2008	Striking balance between biodiversity conservation and socioeconomic viability in the design of marine protected areas
Kelp forest	**Kelps**	42	Parnell P. 2006	Marine reserve design: optimal size, habitats, species affinities, diversity and ocean microclimate
Algal-dominated habitat	**Macroalgae**	10	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Algae	**Macroalgae**	20	Dalleau M. et al 2010	Use of Habitats as Surrogates of Biodiversity for Efficient Coral Reef Conservation Planning in Pacific Ocean Islands
Algal-dominated habitat	**Macroalgae**	20	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Sargassum beds	**Macroalgae**	20	Sala E. et al 2002	A general model for designing networks of marine reserves

Algae	**Macroalgae**	30	Dalleau M. et al 2010	Use of Habitats as Surrogates of Biodiversity for Efficient Coral Reef Conservation Planning in Pacific Ocean Islands
Algal-dominated habitat	**Macroalgae**	30	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Algal assemblages on rocks	**Macroalgae**	30	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Algal assemblages on rocks	**Macroalgae**	50	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Macroalgal dominated	**Macroalgae**	16.7	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Macroalgal dominated	**Macroalgae**	18.8	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Macroalgal dominated	**Macroalgae**	26.7	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Macroalgal dominated	**Macroalgae**	47.7	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Macroalgal dominated	**Macroalgae**	71.3	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Mangroves	**Mangroves**	5	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Mangroves	**Mangroves**	10	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Mangroves	**Mangroves**	10	Weeks R. et al 2009	Shortcuts for marine conservation planning: the effectiveness of socioeconomic data surrogates
Fringing mangroves	**Mangroves**	15	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Mangroves	**Mangroves**	15	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Mangrove forest	**Mangroves**	20	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida
Mangroves	**Mangroves**	20	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Mangrove habitats	**Mangroves**	20	Stewart R. & Possingham H. 2005	Efficiency, costs and trade-offs in marine reserve
Mangroves forests	**Mangroves**	25	Beech T. et al 2008	A stochastic approach to marine reserve design: Incorporating data uncertainty
Fringing mangroves	**Mangroves**	30	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Mangroves	**Mangroves**	30	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Mangroves	**Mangroves**	30	Yusuf C. et al, 2008	The Use of MARXAN to Re-Zone MPA (Study Case : Gili Sulat – Gili Lawang, Lombok)
Mangrove forest	**Mangroves**	40	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida
Mangroves	**Mangroves**	40	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems

Nurseries (mangroves)	**Mangroves**	50	Sala E. et al 2002	A general model for designing networks of marine reserves
Mangroves	**Mangroves**	50	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Mangroves	**Mangroves**	100	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Fringing mangroves	**Mangroves**	15.5	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Fringing mangroves	**Mangroves**	17.8	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Fringing mangroves	**Mangroves**	18.3	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Mangroves	**Mangroves**	83	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Mangroves	**Mangroves**	86	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Marine caves	**Marine caves**	30	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Marine caves	**Marine caves**	50	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Marine benthic habitats	**Non specified habitat**	5	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Non specified habitat	**Non specified habitat**	10	Ballantine W.J., et al 2008	Marine Reserves: the need for systems
Non specified habitat	**Non specified habitat**	10	Ban N. et al, 2009	Comparing and Integrating Community-Based and Science-Based Approaches to Prioritizing Marine Areas for Protection
Non specified habitat	**Non specified habitat**	10	Leslie H. et al, 2003	Using sitting algorithms in the design of marine reserve network
Non specified habitat	**Non specified habitat**	10	Richardson E. et al 2006	Sensitivity of marine-reserve design to the spatial resolution of the socioeconomic data
Marine benthic habitats	**Non specified habitat**	10	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Non specified habitat	**Non specified habitat**	15	Ban N. et al, 2009	Systematic marine conservation in poor-data regions: Socioeconomics is essential
Marine benthic habitats	**Non specified habitat**	15	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Non specified habitat	**Non specified habitat**	20	Ballantine B. 1997	Design Principles for systems of non-take marine reserves
Non specified habitat	**Non specified habitat**	20	Ballantine W.J., et al 2008	Marine Reserves: the need for systems
Non specified habitat	**Non specified habitat**	20	Bank S. and Skilleter G., et al 2007	The importance of incorporating fine-scale habitat data into the design of an intertidal marine reserve system
Non specified habitat	**Non specified habitat**	20	Fernandes L. et al 2005	Establishing Representative No-Take Areas in the Great Barrier Reef: Large-Scale Implementation of Theory on Marine Protected Areas

Non specified habitat	**Non specified habitat**	20	Game E. et al, 2008	Planning for persistence in marine reserve
Non specified habitat	**Non specified habitat**	20	Leslie H. et al, 2003	Using sitting algorithms in the design of marine reserve network
Non specified habitat	**Non specified habitat**	20	Lombard A.T. 2007	Conserving patterns and process in the Southern Ocean- designing a Marine Protected Area for the Prince Edward Islands
Non specified habitat	**Non specified habitat**	20	Roberts C. M., et al 2003	Ecological criteria for evaluating candidate sites for marine reserves
Non specified habitat	**Non specified habitat**	20	Roberts C. M., et al 2005	The role of marine reserves in achieving sustainable fisheries
Non specified habitat	**Non specified habitat**	20	Stewart R. & Possingham H. 2005	Efficiency, costs and trade-offs in marine reserve
Marine benthic habitats	**Non specified habitat**	20	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Non specified habitat	**Non specified habitat**	30	Airamé S. et al 2003	Applying ecological criteria to marine reserve design: a case study from the California Channel Islands
Non specified habitat	**Non specified habitat**	30	Ballantine B. 1997	Design Principles for systems of non-take marine reserves
Non specified habitat	**Non specified habitat**	30	Ballantine W.J., et al 2008	Marine Reserves: the need for systems
Non specified habitat	**Non specified habitat**	30	Ban N. et al, 2009	Comparing and Integrating Community-Based and Science-Based Approaches to Prioritizing Marine Areas for Protection
Non specified habitat	**Non specified habitat**	30	Klein C. et al 2009	Spatial marine zoning for fisheries and conservation
Non specified habitat	**Non specified habitat**	30	Leslie H. et al, 2003	Using sitting algorithms in the design of marine reserve network
Non specified habitat	**Non specified habitat**	30	Richardson E. et al 2006	Sensitivity of marine-reserve design to the spatial resolution of the socioeconomic data
Non specified habitat	**Non specified habitat**	30	Roberts C. M., et al 2005	The role of marine reserves in achieving sustainable fisheries
Marine benthic habitats	**Non specified habitat**	30	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Marine benthic habitats	**Non specified habitat**	40	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Non specified habitat	**Non specified habitat**	50	Airamé S. et al 2003	Applying ecological criteria to marine reserve design: a case study from the California Channel Islands
Non specified habitat	**Non specified habitat**	50	Ballantine W.J., et al 2008	Marine Reserves: the need for systems
Marine benthic habitats	**Non specified habitat**	50	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
KBA- key biodiversity areas	**Non specified habitat**	100	Edgar G. et al 2008	Key biodiversity areas as globally significant target sites for the conservation of marine biological diversity
KBA- key biodiversity areas	**Non specified**	100	Edgar G. et al 2008	Conservation of threatened species in the Galapagos MarineReserve through identification and protection of marine

	habitat			key biodiversity areas
Fish spawning aggregation sites	**Nursery habitat**	20	Green et al, 2009	Designing a resilient network of marine protected areas for Kimbe Bay, Papua New Guinea
Nesting area for marine turtles	**Nursery habitat**	20	Green et al, 2009	Designing a resilient network of marine protected areas for Kimbe Bay, Papua New Guinea
Spawning aggregation sites	**Nursery habitat**	100	Sala E. et al 2002	A general model for designing networks of marine reserves
Beach rock platform, wide	**Rocky substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Beach rock ramp, narrow	**Rocky substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Beach rock ramp, wide	**Rocky substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Boulder cliff	**Rocky substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined boulder field, narrow	**Rocky substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined boulder field, wide	**Rocky substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Flat boulder field, wide	**Rocky substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Rock cliff	**Rocky substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Rock platform, narrow	**Rocky substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Rock platform, wide	**Rocky substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Rock ramp, narrow	**Rocky substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Rock ramp, wide	**Rocky substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Rock wall	**Rocky substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Beach rock platform, wide	**Rocky substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Beach rock ramp, narrow	**Rocky substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Beach rock ramp, wide	**Rocky substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Boulder cliff	**Rocky substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Flat boulder field, wide	**Rocky substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined boulder field, narrow	**Rocky substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined boulder field, wide	**Rocky substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Boulders	**Rocky substrates**	10	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Rock cliff	**Rocky substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Rock platform, narrow	**Rocky substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Rock platform, wide	**Rocky substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information

Rock ramp, narrow	**Rocky substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Rock ramp, wide	**Rocky substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Rock wall	**Rocky substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Beach rock platform, wide	**Rocky substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Beach rock ramp, narrow	**Rocky substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Beach rock ramp, wide	**Rocky substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Boulder cliff	**Rocky substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Flat boulder field, wide	**Rocky substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined boulder field, narrow	**Rocky substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined boulder field, wide	**Rocky substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Rock cliff	**Rocky substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Rock platform, narrow	**Rocky substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Rock platform, wide	**Rocky substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Rock ramp, narrow	**Rocky substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Rock ramp, wide	**Rocky substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Rock wall	**Rocky substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Marine hardbottom	**Rocky substrates**	20	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida
Rocky habitat	**Rocky substrates**	20	Sala E. et al 2002	A general model for designing networks of marine reserves
Boulders	**Rocky substrates**	30	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Marine hardbottom	**Rocky substrates**	40	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida
Coastal salt march	**Saltmarsh**	5	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Coastal salt march	**Saltmarsh**	10	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Coastal salt march	**Saltmarsh**	15	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Coastal salt march	**Saltmarsh**	20	Stewart R. & Possingham H. 2005	Efficiency, costs and trade-offs in marine reserve
Saltmarsh	**Saltmarsh**	20	Beck, 2001	Ecoregional planning in marine environments: identifying priority sites for conservation in the northern Gulf of Mexico
Salt marsh	**Saltmarsh**	20	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida
Coastal salt march	**Saltmarsh**	20	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve

				Systems
Marsh grasses	**Saltmarsh**	30	Ban N. et al, 2009	Minimum data requirements for designing a set of MPAs
Coastal salt march	**Saltmarsh**	30	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Salt marsh	**Saltmarsh**	40	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida
Coastal salt march	**Saltmarsh**	40	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Coastal salt march	**Saltmarsh**	50	Stewart R. et al 2007	The Effect of Incremental Reserve Design and Changing Reservation Goals on the Long-Term Efficiency of Reserve Systems
Inclined sand beach, narrow	**Sand**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Sand flat, narrow	**Sand**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Sand flat, wide	**Sand**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined sand beach, narrow	**Sand**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Sand flat, narrow	**Sand**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Sand flat, wide	**Sand**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Sand	**Sand**	10	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Sandy substrata	**Sand**	10	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Inclined sand beach, narrow	**Sand**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Beach/surf zone	**Sand**	20	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida
Beaches and bars	**Sand**	20	Beck, 2001	Ecoregional planning in marine environments: identifying priority sites for conservation in the northern Gulf of Mexico
Tide flats	**Sand**	20	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida
Sand flat, narrow	**Sand**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Sand flat, wide	**Sand**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Sand	**Sand**	20	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Sand	**Sand**	20	Sala E. et al 2002	A general model for designing networks of marine reserves
Sand Cays	**Sand**	25	Beech T. et al 2008	A stochastic approach to marine reserve design: Incorporating data uncertainty
Sand	**Sand**	30	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Sandy substrata	**Sand**	30	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Sandy or soft ocean bottoms	**Sand**	30	Klein C. et al 2008	Striking balance between biodiversity conservation and socioeconomic viability in the design of marine protected areas
Beach/surf zone	**Sand**	40	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida

Tide flats	**Sand**	40	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida
Sparce seagrass	**Seagrass**	10	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Medium-dense seagrass	**Seagrass**	10	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Dense seagrass	**Seagrass**	10	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Sparce seagrass	**Seagrass**	10	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Sparce seagrass	**Seagrass**	10	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Sparce seagrass	**Seagrass**	10	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Medium-dense seagrass	**Seagrass**	10	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Medium-dense seagrass	**Seagrass**	10	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Seagrass	**Seagrass**	10	Weeks R. et al 2009	Shortcuts for marine conservation planning: the effectiveness of socioeconomic data surrogates
Dense seagrass	**Seagrass**	15	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Submerged aquatic vegetation	**Seagrass**	20	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida
Seagrass	**Seagrass**	20	Beck, 2001	Ecoregional planning in marine environments: identifying priority sites for conservation in the northern Gulf of Mexico
Seagrass	**Seagrass**	20	Dalleau M. et al 2010	Use of Habitats as Surrogates of Biodiversity for Efficient Coral Reef Conservation Planning in Pacific Ocean Islands
Sparce seagrass	**Seagrass**	20	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Medium-dense seagrass	**Seagrass**	20	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Dense seagrass	**Seagrass**	20	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Seagrass communities	**Seagrass**	20	Green et al, 2009	Designing a resilient network of marine protected areas for Kimbe Bay, Papua New Guinea
Eelgrass	**Seagrass**	30	Ban N. et al, 2009	Minimum data requirements for designing a set of MPAs
Surf grasses	**Seagrass**	30	Ban N. et al, 2009	Minimum data requirements for designing a set of MPAs
Seagrass	**Seagrass**	30	Dalleau M. et al 2010	Use of Habitats as Surrogates of Biodiversity for Efficient Coral Reef Conservation Planning in Pacific Ocean Islands
Sparce seagrass	**Seagrass**	30	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Medium-dense seagrass	**Seagrass**	30	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Dense seagrass	**Seagrass**	30	Edwards H. et al 2010	Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design
Seagrass and rocks	**Seagrass**	30	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Seagrass and sand	**Seagrass**	30	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape

Eelgrass beds	**Seagrass**	30	Klein C. et al 2008	Striking balance between biodiversity conservation and socioeconomic viability in the design of marine protected areas
Surfgrass beds	**Seagrass**	30	Klein C. et al 2008	Striking balance between biodiversity conservation and socioeconomic viability in the design of marine protected areas
Seagrass bed	**Seagrass**	30	Yusuf C. et al, 2008	The Use of MARXAN to Re-Zone MPA (Study Case : Gili Sulat – Gili Lawang, Lombok)
Seagrass and bioconstructions	**Seagrass**	30	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Deep seagrass	**Seagrass**	35	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Submerged aquatic vegetation	**Seagrass**	40	Geselbracht L. et al, 2009	Identification of a spatially efficient portfolio of priority conservation sites in marine and estuarine areas of Florida
Seagrass and rocks	**Seagrass**	50	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Seagrass and sand	**Seagrass**	50	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Seagrass and bioconstructions	**Seagrass**	50	Fraschetti et al., 2009	Design of marine protected areas in a human-dominated seascape
Shallow seagrass	**Seagrass**	60	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Seagrass beds	**Seagrass**	100	Sala E. et al 2002	A general model for designing networks of marine reserves
Sparce seagrass	**Seagrass**	10.3	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Sparce seagrass	**Seagrass**	13.3	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Dense seagrass	**Seagrass**	15.5	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Medium-dense seagrass	**Seagrass**	16.7	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Dense seagrass	**Seagrass**	17.8	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Dense seagrass	**Seagrass**	18.3	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Medium-dense seagrass	**Seagrass**	18.9	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Medium-dense seagrass	**Seagrass**	21.7	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Dense seagrass	**Seagrass**	26.7	Harborne, 2009	First among equals: why some habitats should be considered more important than others during marine reserve planning
Deep seagrass	**Seagrass**	33	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Deep seagrass	**Seagrass**	68	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Shallow seagrass	**Seagrass**	73	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information

Shallow seagrass	**Seagrass**	79	Friedlander A. et al, 2003	Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Columbia, Based on ecological and Sociological Information
Inclined cobble beach, narrow	**Soft substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined cobble beach, wide	**Soft substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined gravel beach, narrow	**Soft substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined gravel beach, wide	**Soft substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Steep cobble beach	**Soft substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Flat cobble beach, wide	**Soft substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined mixed fines flat, narrow	**Soft substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined mixed fines flat, wide	**Soft substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Mixed fines flat, wide	**Soft substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Steep mixed fines flat	**Soft substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Gravel flat, wide	**Soft substrates**	5	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Flat cobble beach, wide	**Soft substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined cobble beach, narrow	**Soft substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined cobble beach, wide	**Soft substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined gravel beach, narrow	**Soft substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined gravel beach, wide	**Soft substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Steep cobble beach	**Soft substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined mixed fines flat, narrow	**Soft substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined mixed fines flat, wide	**Soft substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Mixed fines flat, wide	**Soft substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Steep mixed fines flat	**Soft substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Gravel flat, wide	**Soft substrates**	10	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Flat cobble beach, wide	**Soft substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined cobble beach, narrow	**Soft substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined cobble beach, wide	**Soft substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined gravel beach, narrow	**Soft substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information

Inclined gravel beach, wide	**Soft substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Steep cobble beach	**Soft substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined mixed fines flat, narrow	**Soft substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Inclined mixed fines flat, wide	**Soft substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Mixed fines flat, wide	**Soft substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Steep mixed fines flat	**Soft substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Gravel flat, wide	**Soft substrates**	20	Banks S. et al, 2005	Intertidal habitat conservation: Identifying conservation targets in the absence of detailed biological information
Tidal fresh marsh	**Soft substrates**	20	Beck, 2001	Ecoregional planning in marine environments: identifying priority sites for conservation in the northern Gulf of Mexico
Sedimentary-dominated habitats	**Soft substrates**	20	Dalleau M. et al 2010	Use of Habitats as Surrogates of Biodiversity for Efficient Coral Reef Conservation Planning in Pacific Ocean Islands
Sedimentary-dominated habitats	**Soft substrates**	30	Dalleau M. et al 2010	Use of Habitats as Surrogates of Biodiversity for Efficient Coral Reef Conservation Planning in Pacific Ocean Islands
Seamounts	**Special features**	20	Sala E. et al 2002	A general model for designing networks of marine reserves
Submarine canyons	**Special features**	30	Klein C. et al 2008	Striking balance between biodiversity conservation and socioeconomic viability in the design of marine protected areas
Seamounts	**Special features**	100	Green et al, 2009	Designing a resilient network of marine protected areas for Kimbe Bay, Papua New Guinea
Seamounts	**Special features**	100	Lombard A.T. 2007	Conserving patterns and process in the Southern Ocean- designing a Marine Protected Area for the Prince Edward Islands

Table B1. BLM calibration – scenario without the human activities

BLM	Cost/Area (km2)	NºPUs	Boudary Lenght (km)
1	2.87	1292	159.97
10	2.87	1266	130.91
50	2.87	1247	56.32
100	2.89	1247.5	38.86
150	2.92	1264.5	32.39
250	2.98	1291	27.46
350	30.6	1331.5	24.87
500	3.13	1370.5	22.85
750	3.3	1442	20.59

Table B2. BLM calibration – Scenario with human activities

BLM	Cost/Area (km^2)	NºPUs	Boudary Lenght (km)
1	2.81	1268	152.02
10	2.81	1251	120.98
50	2.81	1241.5	48.52
100	2.81	1238.5	33.06
150	2.81	1236	28.09
250	2.83	1239	24.26
350	2.87	1257	22.35
500	2.94	1283.5	20.56
750	3.06	1336.5	19.13

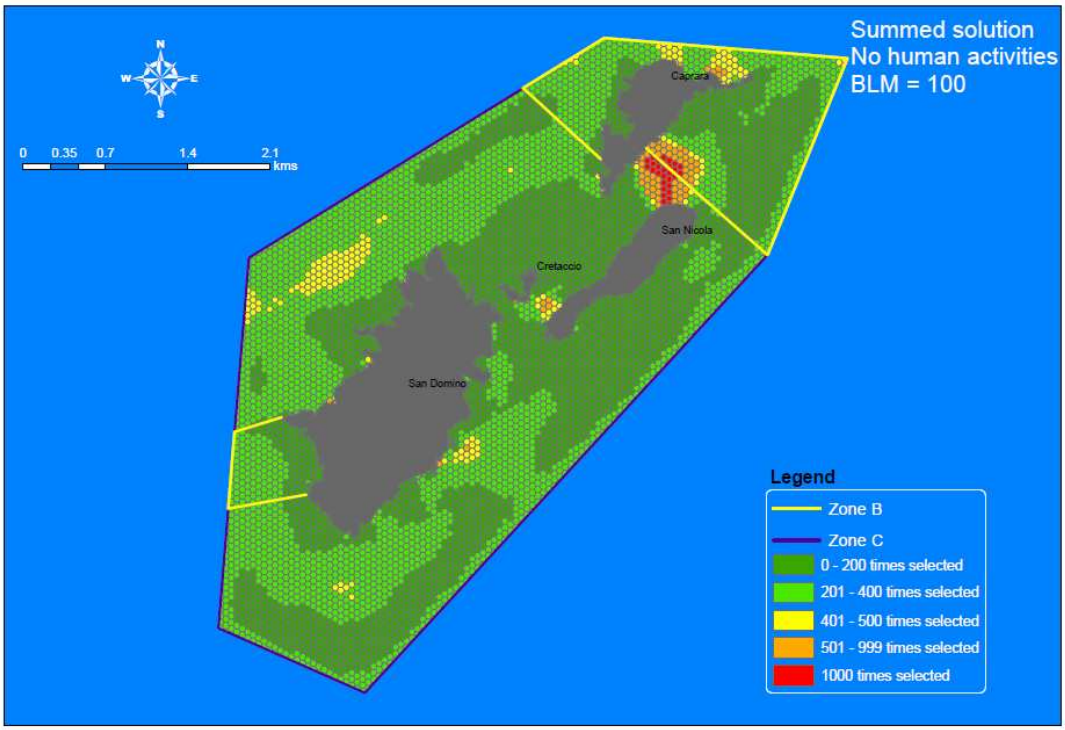


Figure A. Summed solution for the scenario where no human activities were included with BLM = 100

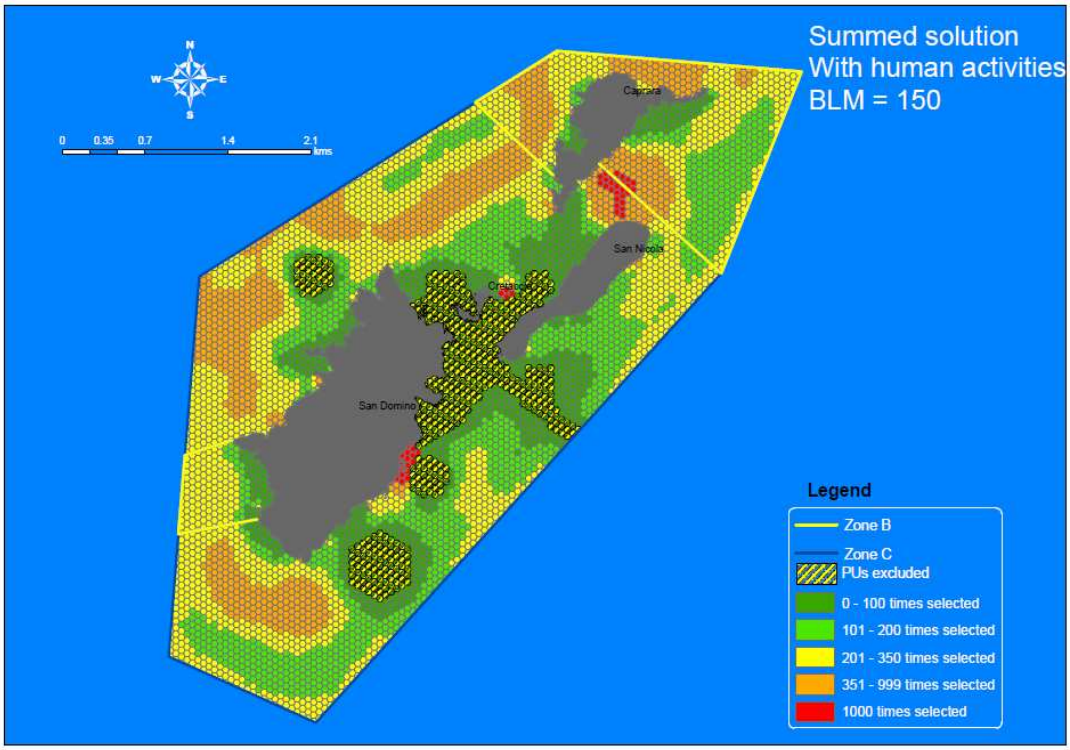


Figure B. Summed solution for the scenario where human activities were included with the BLM =150

Termoli 31/2007 – Document regarding the regulation of anchorage zones, underwater conduct and navigation route in the archipelago of Isole di Tremiti.

86039 Termoli, li 20 LUG. 2010
p.e.c. T.V. (CP) A. CHIRIZZI Tel. 0875/705484 fax 0875/707336

Ministero delle infrastrutture e dei trasporti
Capitaneria di Porto di Termoli

Al PARCO NAZIONALE DEL GARGANO
Via Sant'Antonio Abate, 121
Monte Sant'Angelo (FG)
e-mail: ampisoletremiti@parcogargano.it

Servizio Sicurezza della Navigazione e Portuale
Sezione Tecnica e Sicurezza Portuale
Indirizzo Telegrafico: COMPAMARE TERMOLI
Prot. n. 02.02.17/ 12289

Argomento: Gestione Riserva Naturale Marina Isole Tremiti. Richiesta informazioni

(Spazio riservato a protocolli, visti e decretazioni)

Riferimento: foglio n° 4686 in data 07 Luglio 2010

In relazione a quanto richiesto con il foglio in riferimento si inviano, in allegato, le seguenti Ordinanze emesse da questa Capitaneria di Porto:

- N° 31/2007, integrata dalla n° 04/10 (Zone di ancoraggio Isole Tremiti);
- N° 04/2010 (Zona di interdizione per presenza condotta sottomarina di convogliamento dei liquami dall'Isola di San Nicola all'Isola di San domino)
- N° 16/2010 (Zona di interdizione per rinvenimento relitto aereo)
- N° 10/2009 (Ordinanza di Sicurezza Balneare)
- N° 13/2010 (Limiti velocità nelle acque del Compartimento Marittimo di Termoli)

ENTE PARCO NAZIONALE DEL GARGANO
26.07.10 005140
MONTE SANT'ANGELO

Si comunica infine che le specifiche rotte di navigazione delle unità navali non sono oggetto di disciplina da parte di questa Autorità Marittima.

Ad ogni buon fine si allega uno stralcio cartografico riportante le rotte di massima assunte dalle navi passeggeri in collegamento di linea sulla tratta Termoli-Isole Tremiti.

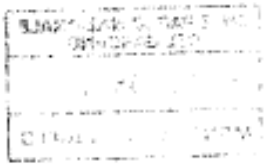
Dallo stesso si evince come durante le fasi di arrivo le unità assumono rotta intorno a 075°, per poi accostare – una volta giunte a

F:\Lettere Parco Nazionale del Gargano.doc

1

circa un miglio dal traverso di punta del diavolo dell'Isola di San Domino - sino a circa 050°, proseguendo lungo la costa a non meno di 0.6/0.7 miglia di distanza dalla stessa e successivamente assumendo per l'ingresso rotta di circa 320°.

d'ordine
IL CAPO SERVIZIO
T.V.(CP) Andrea CHIRIZZI



MINISTERO DEI TRASPORTI

CAPITANERIA DI PORTO DI TERMOLI

ORDINANZA N. 31/2007

IL CAPITANO DI VASCELLO (CP) LUCA SANCILIO, CAPO DEL CIRCONDARIO MARITTIMO E COMANDANTE DEL PORTO DI TERMOLI

Visti gli articoli 17, 30, 62, 63, 65 e 81 del Codice della Navigazione e gli articoli 59, 63, 64, 65, 75, 78, 79, 80 e 81 del relativo Regolamento di Esecuzione;

Visto il decreto interministeriale del 14 luglio 1989, con il quale è stata istituita e regolamentata la Riserva marina delle Isole Tremiti;

Visto il Regolamento del Porto di Termoli approvato con Ordinanza 06/2002 in data 09.05.2002;

Viste le Ordinanze n. 04/2004 e 06/2004 rispettivamente datate 02.04.04 e 04.06.04 dell'Ufficio Circondariale Marittimo di Vieste;

Visto il proprio foglio n. 01.01.04/6337 del 03.08.2007 avente ad oggetto "Zone d'ancoraggio Isole Tremiti";

Visto il parere espresso dalla Delegazione di Spiaggia delle Isole Tremiti con foglio n. 653 in data 06.08.2007;

Visti gli atti d'ufficio;

Ritenuto opportuno procedere ad una riorganizzazione delle zone d'ancoraggio esistenti al fine di renderle più confacenti alle esigenze dei naviganti e della popolazione locale;

ORDINA:

ARTICOLO 1
ZONE D'ANCORAGGIO

L'ancoraggio delle navi e dei galleggianti in attesa di ormeggio presso le banchine degli approdi delle Isole Tremiti ovvero in temporanea sosta nelle acque antistanti l'arcipelago è consentito esclusivamente all'interno delle zone indicate di seguito e nel rispetto delle disposizioni contenute nella presente Ordinanza e delle vigenti normative nazionali e internazionali.

- Zona circolare "N1" avente centro nel punto di coordinate 42° 07.450'N – 015° 30.375E e raggio 100 metri;
- Zona rettangolare "N2" coordinate:
  A. 42° 07.075'N – 015° 30.300E;

da inserire nel sito

B. 42° 07.075'N – 015° 30.450E;
C. 42° 06.910'N – 015° 30.450E;
D. 42° 06.910'N – 015° 30.300E.

- Zona rettangolare "D1" coordinate:
  A. 42° 07.500'N – 015° 29.700E;
  B. 42° 07.500'N – 015° 29.900E;
  C. 42° 07.400'N – 015° 29.900E;
  D. 42° 07.400'N – 015° 29.700E.

42° 06.970 N - 015° 28.470 E

- Zona circolare "D2" avente centro nel punto di coordinate ~~42° 06.900'N – 015° 28.675E~~ e raggio 150 metri;
- Zona circolare "D3" avente centro nel punto di coordinate 42° 06.600'N – 015° 29.700E e raggio 150 metri;
- Zona circolare "D4" avente centro nel punto di coordinate 42° 06.200'N – 015° 29.400E e raggio 250 metri.

(Tutte le coordinate sono riferite al Datum Roma 1940)

ARTICOLO 2
RICHIESTA ASSEGNAZIONE PUNTO D'ANCORAGGIO

Le navi ed i galleggianti diretti alle zone d'ormeggio di cui al precedente articolo, devono richiedere l'autorizzazione all'ormeggio nelle suddette zone a mezzo radio VHF, con chiamata sul canale 16, alla Delegazione di Spiaggia delle Isole Tremiti ovvero, nei casi di accentramento dei servizi interessi il citato Ufficio minore, alla Sala Operativa della Capitaneria di Porto di Termoli, comunicando l'ora del previsto arrivo con almeno 30 minuti d'anticipo.

In caso di particolari contingenti situazioni direttamente e/o di riflesso connesse a superiori interessi pubblici e/o sicurezza della navigazione nella sua accezione più ampia, l'Autorità Marittima potrà disporre il cambio del punto di fonda.

ARTICOLO 3
COMUNICAZIONI ALL'ARRIVO E ALLA PARTENZA

Tutte le navi mercantili in arrivo nelle acque del Circondario Marittimo di Termoli dirette alle zone d'ancoraggio delle Isole Tremiti devono comunicare, fatte salve le ulteriori comunicazioni previste dalla vigente normativa in materia di navigazione marittima, alla Delegazione di Spiaggia delle Isole Tremiti ovvero, nel caso di chiusura della stessa, alla Sala Operativa della Capitaneria di Porto di Termoli, via radio con chiamata su canale 16 ovvero a mezzo telegramma od ogni altro sistema di comunicazione sicuro, i seguenti dati:

- Nome della nave e nominativo internazionale;
- Bandiera, numero e porto d'iscrizione;
- Porto di provenienza e di destinazione;
- Tipo e quantità del carico a bordo (se vuota , dovrà comunicare i dati dell'ultimo carico trasportato);
- Ora d'ancoraggio e previsto tempo di sosta;
- Numero delle persone a bordo;
- Motivo dell'ancoraggio;
- Eventuali anomalie e/o deficienze che possono pregiudicare, in maniera diretta o indiretta, la sicurezza della nave e della navigazione, la salvaguardia della vita umana in mare, nonché la tutela dell'ambiente marino.

ALLEGATO 1

MARE ADRIATICO – ITALIA

I. TREMITI E PIANOSA

DAGLI ELEMENTI IN POSSESSO DALL'ISTITUTO IDROGRAFICO DELLA MARINA AL 1992

La topografia terrestre è stata ricavata dalla carta dell'Istituto Geografico Militare

Proiezione Gnomonica

Le altezze, in metri, sono riferite al livello medio del mare

I fondali, in metri, sono riferiti al livello medio delle basse maree sizigiali

Le posizioni geografiche sono riferite al Roma 1940 Datum

Per passare le coordinate geografiche riferite all'European Datum aggiungere ... alle latitudini ... alle longitudini come da numero sopra.

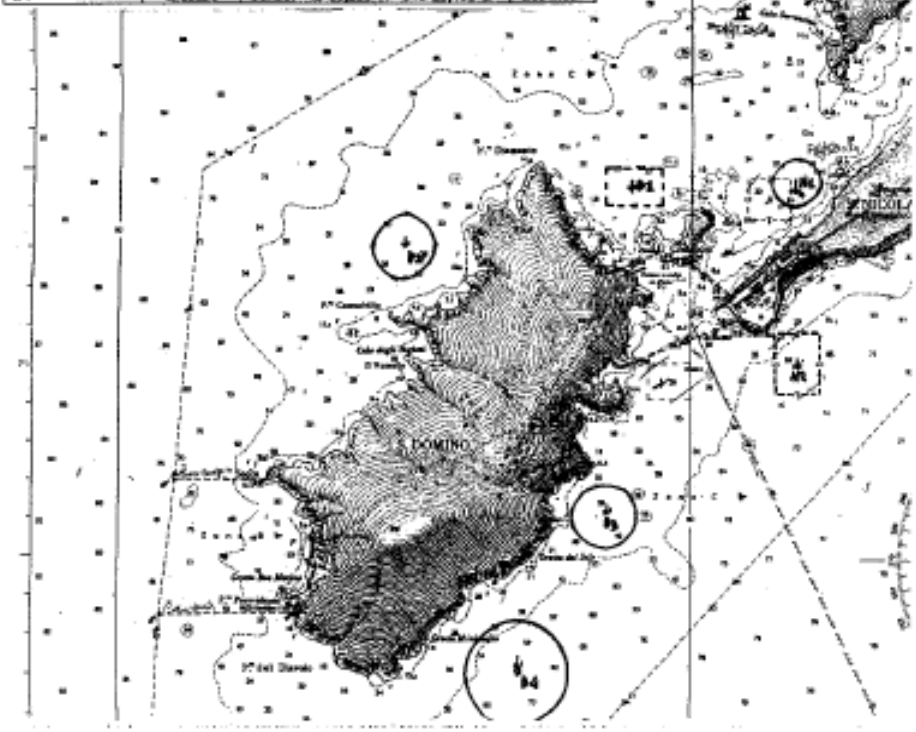
Le posizioni indicate non possono in nessun caso sostituire quelle ufficiali.

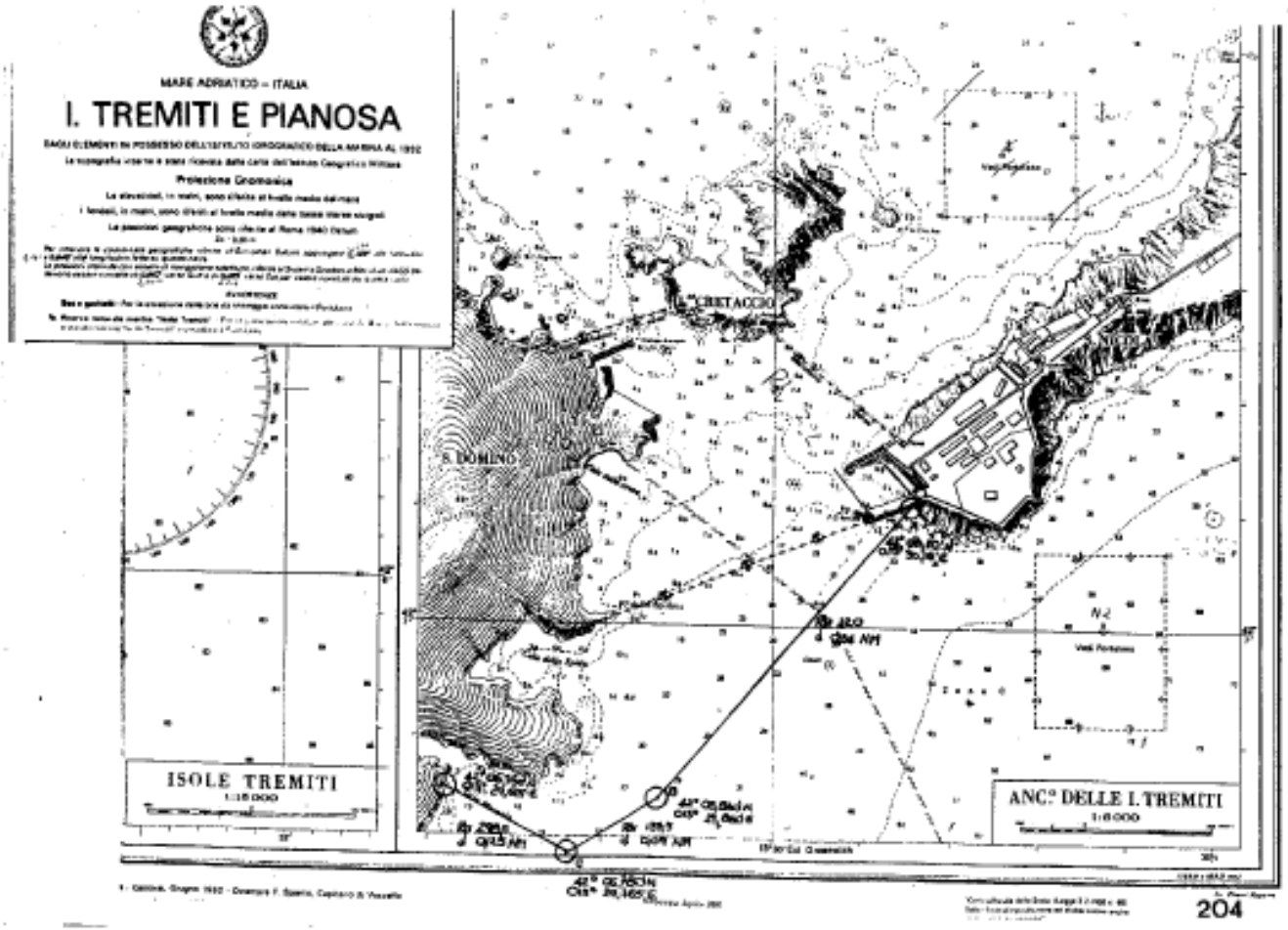
AVVERTENZE

Box e gavitelli - Per la situazione delle box di ormeggio consultare il Portolano.

Riserva naturale marina "Isole Tremiti" - Per le prescrizioni relative alle zone A, B e C delle riserve consultare il Portolano.

ZONA D'ANCORAGGIO	TIPOLOGIA	COORDINATE	RAGGIO
N1	circolare	Centro: 42°07,450'N - 015°30,375' E	100 metri
N2	rettangolare	A: 42°07,075' N - 015°30,300' E B: 42°07,075' N - 015°30,450' E C: 42°06,910' N - 015°30,450' E D: 42°06,910' N - 015°30,300' E	
D1	rettangolare	A: 42°07,500' N - 015°29,700' E B: 42°07,500' N - 015°29,900' E C: 42°07,400' N - 015°29,900' E D: 42°07,400' N - 015°29,700' E	
D2	circolare	Centro: 42°07,500' N - 015°29,300' E	150 metri
D3	circolare	Centro: 42°06,500' N - 015°29,700' E	150 metri
D4	circolare	Centro: 42°06,200' N - 015°29,400' E	250 metri




MARE ADRIATICO – ITALIA
I. TREMITI E PIANOSA
Proiezione Gnomonica
S. DOMINO
CRETACCIO
ISOLE TREMITI
1:25.000
ANC.° DELLE I. TREMITI
1:6.000
204

Ministero delle Infrastrutture e dei Trasporti

Capitaneria di Porto di Termoli
Servizio Sicurezza della Navigazione e Portuale
Sezione Tecnica – Sicurezza e Difesa Portuale
e-mail: tecnico@guardiacostiera.it - tel. 0875/706484 – 0875/7121

ORDINANZA N. 04 /10

Argomento: condotta sottomarina di convogliamento dei liquami dall'Isola di San Nicola all'Isola di San Domino (Isole Tremiti).
Località: Isole Tremiti.

Il Capitano di Fregata (CP) sottoscritto, Capo del Circondario Marittimo e Comandante del Porto di Termoli:

VISTA la concessione rilasciata al Comune di Isole Tremiti registrata al n° 04/2009 (Repertorio n° 130/2009) in data 11.06.2009 relativa all'occupazione di uno specchio acqueo per il posizionamento ed il mantenimento di una condotta sottomarina di convogliamento dei liquami dall'Isola di San Nicola all'Isola di San Domino;

VISTO l'iter istruttorio della suddetta concessione, con i relativi pareri espressi dalle varie Amministrazioni/Enti;

VISTA la Circolare n° 82/084929/II in data 10.12.01 del Comando Generale del Corpo delle Capitanerie di Porto;

CONSIDERATA la necessità di dover interdire l'ancoraggio, la pesca a strascico e ogni altra attività incompatibile con la presenza della condotta sottomarina;

VISTI gli artt. 30 e 81 del Codice della Navigazione.

RENDE NOTO

che nella zona di mare compresa tra l'Isola di San Nicola e quella di San Domino, meglio evidenziata nello stralcio della Carta Nautica n° 204 dell'Istituto Idrografico della Marina denominata "Isole Tremiti e Pianosa", è posizionata una condotta sottomarina di convogliamento dei liquami nelle sotto-elencate coordinate:

1° tratto: A (radice) => B

Coordinate punto A	Coordinate punto B	Datum	Lunghezza	Orientamento vero
42°07,110' N 015°30,160' E	42°06,830' N 015°29,860' E	Roma 1940	0,34 NM	220

2° tratto: B => C

Coordinate punto B	Coordinate punto C	Datum	Lunghezza	Orientamento vero
42°06,830' N 015°29,860' E	42°06,780' N 015°29,765' E	Roma 1940	0,09 NM	137,5

3° tratto: C => D (testata)

Coordinate punto C	Coordinate punto D	Datum	Lunghezza	Orientamento vero
42°06,780' N 015°29,785' E	42°06,860' N 015°29,625' E	Roma 1940	0,125 NM	298,5

Pertanto,

ORDINA

Articolo 1.

(divieto)

Con decorrenza immediata, nello specchio acqueo di cui al **RENDE NOTO** è vietato a qualunque unità navale, l'ancoraggio, la pesca a strascico e tutte quelle attività incompatibili con la presenza della condotta sottomarina in parola, per una distanza di 100 metri per lato dalla stessa.

Articolo 2.

(punitivo)

I contravventori alla presente Ordinanza, ove il fatto non costituisca diverso e/o più grave reato e fatte salve, in tal caso, le maggiori responsabilità loro derivanti dall'illecito comportamento, saranno puniti ai sensi degli articoli 1174 e 1231 del Codice della Navigazione.

Articolo 3.

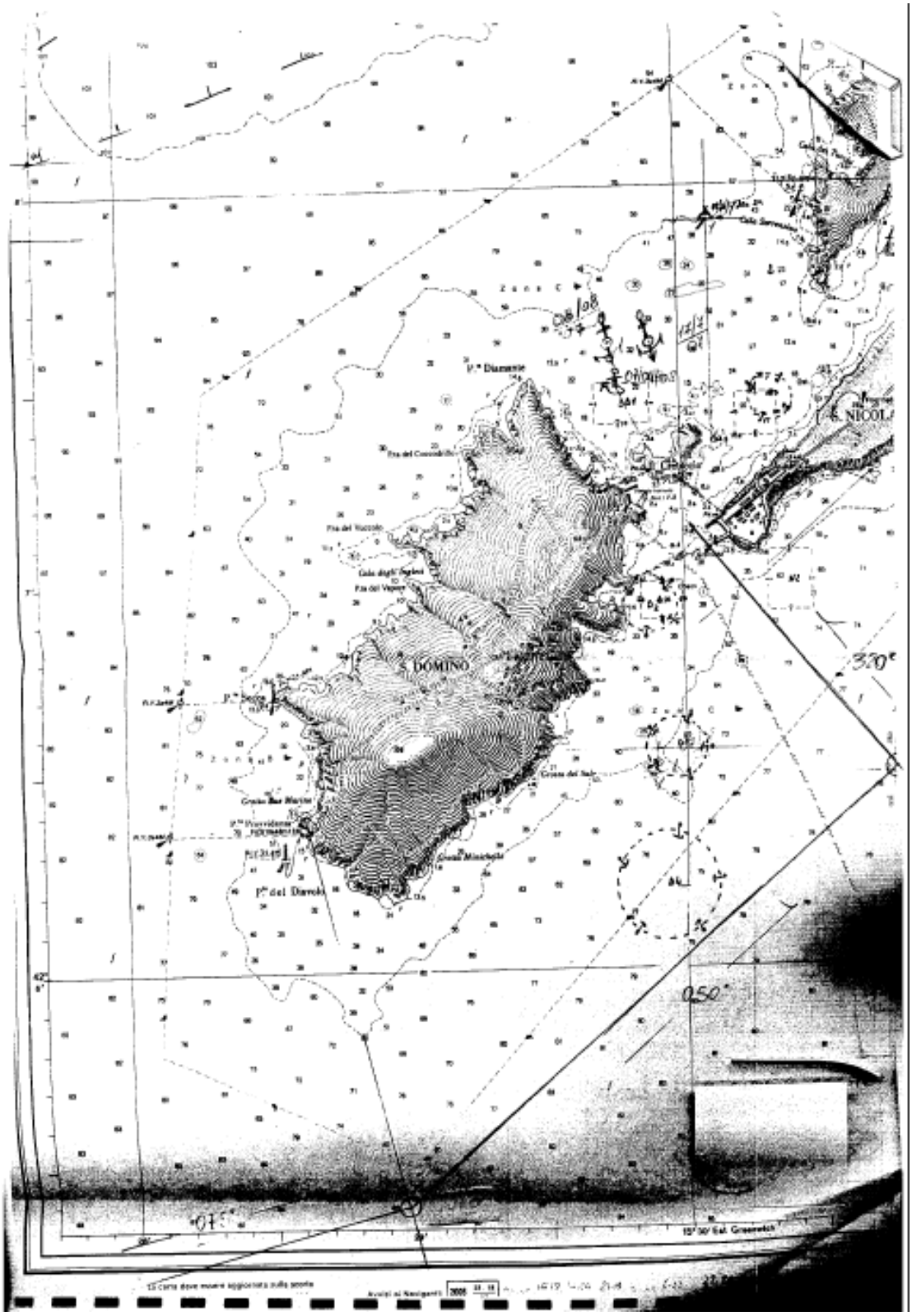
(pubblicità)

E' fatto obbligo a chiunque spetti di osservare e far osservare la presente Ordinanza, la cui pubblicità verrà assicurata mediante l'affissione all'albo dell'Ufficio, l'inclusione alla pagina "ordinanze" del sito istituzionale www.guardiacostiera.it e la diffusione tramite gli organi d'informazione.

Termoli, li 24.02.2010

f.to IL COMANDANTE
C.F.(CP) Raffaele ESPOSITO

L'originale è stata firmata dal Comandante
Il Capo Sezione
Tecnica – Sicurezza e Difesa Portuale
1° Maresciallo Np. CATALDO Angelo


DOMINO
P.ta del Diavolo
S. NICOLA
030°
070°