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State of knowledge of the geographical distribution of the coralligenous and other calcareous bio-concretions in the Mediterranean

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EXECUTIVE SUMMARY

The present document synthesizes the activities conducted, within the framework of the RAC/SPA – ICRAM "*Avenant N° 3/2008/RAC/SPA*", on coralligenous habitats and other calcareous bioconcretions in the Mediterranean. The objectives of the presently outlined project consisted in carrying out a Mediterranean bibliographic census, characterised by cartographic information of such habitats, and in the creation of layer within a specific Geographical Information System (GIS) containing all the available cartographic data on such assemblages with the aim of identifying their distribution on a regional scale. The scope of this specific GIS database was to support RAC/SPA in obtaining a global information on all the cartographic published/public maps so as to plan future measures of monitoring and conservation and new research activities.

The coralligenous habitats and biogenic assemblages that were considered for the purpose of the present work are the following: the pre-coralligenous, coralligenous, the association with rhodolithes - *Facies* of *Mäerl,* the association with rhodolithes - Facies of *Prâlines*, the association with rhodolithes - Facies of *Lithothamnion minervae*, the association with *Peyssonnelia rosa-marina* - *Facies* of free Peyssonneliaceae, and the *Facies* of large Briozoans of the coastal detritic bottoms**.** A bibliographical search was carried out, through the use of specific marine bibliographical databases and internet research engines, so as to collect cartographic data on the distribution of the coralligenous biocoenoses and other bioconcretions in the Mediterranean sea. National and international networks of marine scientists and marine protected area managers were also contacted so as to further census and obtain the abovementioned datasets and cartographies.

The entire list of documents were analysed so as to identify the location of each study area and determine the overall distribution of the assemblages according to four Mediterranean sub-regions. The documents were also analysed in terms of their thematic focus so as to describe the type of research which has been conducted on such habitats. All the documents containing cartographic data, were catalogued and archived in a relational database specifically designed in order to organize, store and easily consult and retrieve the collected information. The collected cartographic data was implemented into a GIS. Information on the implemented cartographic material was portrayed both as a detailed map layout as well as a synthetic data sheet.

Overall, the bibliographic data set is composed of 524 scientific documents. Four hundred and three documents (77 %) provided information on the study areas thereby allowing to locate their sub-regional and country distribution. The western

Mediterranean appears to be the most largely studied sub-region, followed by the Ionian sub-region, while very few studies were censused in the Adriatic and Aegean-Levantine sub-regions. The majority of studies focused on ecological themes, followed by aspects concerning “Species distribution” and “Threats, management and conservation”. A lower number of contributions regarded research involving “Taxonomy” and “Age and growth”, and very little interest appears to have been devoted to studies dealing with “Reproduction”, “Physiology and biochemistry” and “Genetics”.

The censused bibliographic data set, comprehends 46 studies containing cartographic information, that is maps, some of which were implemented on the GIS. On the overall, the geographical distribution of the mapped areas is mostly located in the western Mediterranean sub-region while a lower number is located in the Adriatic and the Ionian sub-regions. Only one study derives from research carried out in the Aegean-Levantine sub-region. Several difficulties were encountered in the implementation of some of the censused cartographic studies into the GIS. In fact, of the 46 maps, it was impossible to implement 21 maps in the GIS layer for various reasons. The highest quantity of mapped cartographic information regards the bioconcretions of the biocoenosis of the coastal detritic bottoms (58.3%), followed by the coralligenous biocoenosis (38.9 %) and the pre-coralligenous assemblage (2.8 %). No cartographic information was found on the assemblages characteristic of the biocoenosis of coarse sands and fine gravels under the influence of bottom currents where the association with rhodolithes - *facies* with *Mäerl* can instead occur. The highest degree of habitat level definition (association/*facies)* was not specified in many cases (41.6%) while the most represented is the association with rhodolithes - *facies* with *Mäerl* (47.1%).

The bibliographical search of all the studies and cartographies on the coralligenous biocoenosis and other bio-concretions demonstrated that the majority of studies are located in the western Mediterranean sub-region. The presently outlined census indicates that though qualitatively valuable, the collected cartographic data are limited in number and distribution. The cartographic studies which were implemented in the GIS were mostly derived from studies conducted during the last 8 years which also confirms that adequate mapping standards and initiatives are at an initial step and that this trend must be increased and strengthened through appropriate measures. Results also indicate that future mapping initiatives should incentivate the creation of adequate digital map products that may be shared within the scientific community. Furthermore, the large predominance of studies, and consequent production of maps, exclusively on certain *facies* of the coastal detritic bottoms (namely the *Maërl* association) and of the coralligenous *facies* characterized by

gorgonian species indicates the need to conduct more investigative efforts on the other *facies*/association.

The main gaps emerging from the above described analysis suggest the need of new research effort devoted to:

a) The completion of the cartography of the coralligenous assemblages at a Mediterranean scale, enhancing in particular the knowledge on their distribution in the less studied areas, to identify sites of particular interest.

b) Region wide mapping initiatives and synergies capable of stimulating an automatic reporting procedure on the studies of these assemblages. At the same time however, the working schemes should be compliant to universally agreed standards both in terms of data acquisition methodologies (i.e. standards for sampling) useful to provide sufficient details of information using agreed benthic habitat terminology referring to a universally recognized habitat classification list, and leading up to the production of georeferenced digital maps with adequate geographic resolution and scale.

c) New studies on ecological and physiological aspects, considering also specific inventories, along the eastern and the southern Mediterranean coasts, so as to identify/evaluate the possible presence of differences / trends related to oceanographic aspects.

d) Urgent start-up of monitoring activities in the most relevant sites (SPAMIs, Natura 2000 sites and other MPAs), both to monitor possible changes due to the effects of the management (on waste water discharges, anchoring, fishing, diving) and to evaluate the trends in the long term evolution of the assemblages, to assess the effects of the global warming (i.e. the deepen of the summer thermocline) and of the invasive species.

e) Stringent start-up of procedures for the future establishment of protected/conservation areas, identified as a consequence of point a) and b) above, useful to mitigate the different threats affecting the various assemblages are known to be exposed to.

It is to be pointed out that the present document should be considered as a starting point for the collection of cartographic information regarding the distribution of coralligenous and other bio-concretions in the Mediterranean Sea. Considering that an alphanumeric or cartographic data base, is, by its very exclusive nature, outdated the day after it is delivered, it is crucial that it be kept functioning through its continuous update and expansion. It is therefore hoped that the enactment of a detailed series of activities on the implementation of the Action Plan, be carried out also in light of the conclusions listed above, so as to allow the future enrichment of the cartographic database to the benefit of an increased knowledge on these habitats' distribution and most critical conservation needs.

RESUME EXECUTIF

Ce document synthétise les activités accomplies dans le cadre de "*l'Avenant N° 3/2008/RAC/SPA*" du CAR/ASP – ICRAM, relatif aux habitats coralligènes et autres bio-concrétions calcaires en Méditerranée. L'objectif de ce projet visait à effectuer un recensement bibliographique méditerranéen, des informations cartographiques relatives à ce type d'habitat et à créer une couche de données dans le cadre d'un système d'information géographique (SIG), comprenant l'ensemble des données cartographiques disponibles sur ces concrétionnements, afin d'appréhender leur répartition géographique au plan régional. L'enjeu de cette base de données SIG spécifique est d'assister le CAR/ASP dans l'obtention d'informations sur l'ensemble des cartes publiées/publiques, en vue de planifier les futures mesures de surveillance et de conservation, de même que les nouvelles activités de recherche.

Les habitats coralligènes et les bio-convcrétions qui ont été pris en compte dans le cadre de ces travaux sont les suivants : les peuplements pré-coralligènes, le coralligène de plateau, l'association à rhodolithes – faciès *de maërl*, l'association à rhodolithes – faciès à *pralines*, les associations à rhodolithes – f*aciès à Lithothamnion minervae,* association à *Peyssonnelia rosa-marina* – faciès de Peyssonneliaceae libre et le faciès de grands bryozoaires des fonds détritiques côtiers. Une recherche bibliographique a été effectuée, grâce à l'utilisation de bases de données bibliographiques marines spécifiques et de moteurs de recherche sur l'Internet, en vue de recueillir des données cartographiques relatives à la distribution des biocénoses coralligènes et autres bio-concrétions en Méditerranée. Les réseaux nationaux et internationaux de spécialistes des sciences de la mer et de gestionnaires d'aires marines protégées ont également été contactés afin d'approfondir le recensement et d'obtenir les données et les cartographies mentionnés plus haut.

Tous les documents ont été analysés afin d'identifier la localisation de chaque zone d'étude et de déterminer la distribution générale des concrétions en fonction de quatre sous-régions méditerranéennes. Ces documents ont également été analysés en termes d'objectifs thématiques pour décrire le type de recherche qui a été effectué sur ces habitats. Tous les documents comprenant des données cartographiques ont été classés et archivés dans une base de données relationnelle conçue spécifiquement afin d'organiser, de stocker et de retrouver et consulter facilement les informations recueillies. Les données cartographiques recueillies ont été mises en place dans un SIG. Les informations relatives au matériel cartographique sont présentées tant sous forme de tracé de cartes détaillées que sous forme de fiche technique synthétiques.

De façon générale, le groupe de données bibliographiques se compose de 524 documents scientifiques. Quatre cent trois documents (77%) ont fourni des informations relatives aux zones d'étude, permettant ainsi de localiser leur distribution sous-régionale et nationale. La Méditerranée occidentale semble être la sous-région la plus étudiée, suivie de la sous-région ionienne, alors que très peu d'études ont été recensées dans les sous-régions adriatique et égéenne et levantine. La majorité des études a mis l'accent sur des thèmes écologiques, suivis par les aspects relatifs à la "distribution des espèces" et les questions relatifves aux "menaces, gestion et conservation". Quelques rares contributions ont concerné la recherche impliquant la "taxonomie" et "l'âge et la croissance" et très peu d'études ont été consacrées à la "reproduction", à la "physiologie et à la biochimie" et à la "génétique".

Le groupe de données bibliographiques recensées comprend 46 études contenant des informations cartographiques, c'est-à-dire des cartes, dont certaines ont été mises en place dans le SIG. De façon générale, la distribution géographique des zones cartographiées se situe essentiellement dans la sous-région de Méditerranée occidentale alors qu'un nombre plus faible se situe dans les sous-régions adriatique et ionienne. Une seule étude émane de la recherche effectuée dans la sous-région égéenne et levantine. Plusieurs difficultés ont été rencontrées dans la mise en œuvre de certaines des études cartographiques recensées dans le SIG. En fait, sur les 46 cartes, il n'a pas été possible de mettre en place que 21 cartes dans la couche de SIG pour diverses raisons. Le plus grand nombre d'informations cartographiques concerne les bio-concrétions de la biocénose des fonds détritiques côtiers (58,3%), suivi de la biocénose coralligène (38,9%) et des concrétions pré-coralligènes (2,8%). Il n'y a eu aucune information cartographique relative aux concrétions caractéristiques de la biocénose des sables grossiers et des graviers fins sous l'influence des courants des fonds marins dans lesquels l'association à rhodolithes – faciès à maërl peuvent se produire. Dans de nombreux cas (41,6%), le degré le plus élevé de définition de niveau d'habitat (association/*faciès*) n'était pas spécifié, alors que l'association à rhodolithes – *faciès* à maërl est le plus représenté (47,1%).

La recherche bibliographique de l'ensemble des études et des cartographies sur la biocénose coralligène et les autres bio-concrétions a indiqué que la majorité des études se situait dans la sous-région de Méditerranée occidentale. Ce recensement indique que bien qu'elles soient valables au plan qualitatif, les données cartographiques recueillies sont limitées en nombre et en distribution. Les études cartographiques qui ont été mises en place dans le SIG ont essentiellement émané des études effectuées au cours de ces huit dernières années, ce qui confirme également que des normes et des initiatives appropriées en termes de cartographie

se trouvent encore au stade initial et qu'il convient d'accroître et de renforcer cette tendance au moyen de mesures adéquates. Les résultats révèlent également que les futures initiatives de cartographie devraient inciter à la création de produits de cartes numériques adéquates qui pourraient être partagées au sein de la communauté scientifique. En outre, la forte prédominance des études et la production de cartes qui en découle, exclusivement sur certains *faciès* des fonds détritiques côtiers (en particulier l'association de maërl) et de faciès coralligènes caractérisés par des espèces de gorgonaires, indique la nécessité de déployer davantage d'efforts de recherche sur d'autres faciès/associations.

Les principales lacunes qui émergent de l'analyse décrite ci-dessus suggèrent la nécessité de nouveaux efforts de recherche consacrés à :

- a) L'achèvement de la cartographie des concrétionnements coralligènes à l'échelle méditerranéenne, en facilitant notamment les connaissances relatives à leur distribution dans les zones les moins étudiées, en vue d'identifier les sites d'intérêt particulier.
- b) Les initiatives et les synergies en matière de cartographie au plan régional, à même de stimuler une procédure de notification automatique sur les études de ces concrétionnements. Parallèlement, toutefois, les systèmes de travail devraient être conformes aux normes convenues en terme de méthodologies d'acquisition de données (c'est-à-dire les normes d'échantillonnage) utiles pour fournir suffisamment d'informations détaillées, utilisant la terminologie convenue relative à l'habitat benthique faisant référence à une liste de classification universellement reconnue des habitats et débouchant sur la production de cartes numériques géo-référencées, accompagnées d'une résolution et d'une échelle géographiques adéquates.
- c) De nouvelles études sur les aspects écologiques et physiologiques, tenant compte également des inventaires spécifiques, tout au long du littoral de Méditerranée orientale et du sud, en vue d'identifier/d'évaluer la présence possible de différences/tendances relatives aux aspects océanographiques.
- d) Le démarrage urgent des activités de surveillance dans les sites les plus pertinents (ASPIM, sites de Natura 2000 et autres AMP), tant pour surveiller les changements possibles dus aux effets de la gestion (sur le rejet des eaux usées, le mouillage, la pêche, la plongée) que pour évaluer les tendances de l'évolution à long terme de ces concrétions, afin d'analyser les effets du réchauffement planétaire (c'est-à-dire l'approfondissement de la thermocline d'été) et des espèces envahissantes.

- e) Le démarrage énergique de procédures pour la création future d'aires protégées/de conservation, identifiées en conséquence des points a) et b) ci-dessus, utiles pour atténuer les diverses menaces qui affectent les différents concrétionnements qui y sont exposés.

Il convient de noter que ce document devrait être considéré comme un point de départ pour le recueil d'informations cartographiques relatives à la distribution du coralligène et des autres bio-concrétions de Méditerranée. Considérant qu'une base de données alphanumérique ou cartographique est, de par sa nature très exclusive, dépassée dès le moment où elle est présentée, il est essentiel de faire en sorte qu'elle continue à fonctionner en l'actualisant et en la développant continuellement. Il est par conséquent espéré que la mise en vigueur d'une série détaillée d'activités sur l'exécution du Plan d'action, sera effectuée également à la lumière des conclusions présentées ci-dessus, en vue de permettre l'enrichissement de la base de données cartographique à l'avenir, au profit d'une meilleure connaissance de la distribution des habitats et des besoins les plus essentiels en termes de conservation.

1. INTRODUCTION

1.1. PROJECT OBJECTIVES AND CONSERVATION ASPECTS INVOLVING THE CORALLIGENOUS ASSEMBLAGE AND BIOGENIC CONCRETIONS

Mediterranean coralligenous assemblages and several other biogenic calcareous formations are considered amongst the Mediterranean benthic habitats of high conservation interest for a number of reasons, amongst which their biogeographic uniqueness, the highly diversified physical structure resulting from the bioconstructing process which leads to the presence a high species biodiversity, their very diversified occurrence stratified throughout the different benthic marine zones and their slow growth. Such assemblages and formations are also a matter of conservation concern because of the various man-made threats to which they are exposed, amongst which the physical damage incurred by human recreational and extractive activities (*i.e.* physical breakage due to contact with trawl or set nets, poaching and mechanical disturbance of recreational divers etc.) as well as the water quality and habitat degradation resulting from distant source activities (*i.e.* smothering effects due to increased/altered sedimentation rates caused by far-ranging bad coastal zone management practices, altered thermic stratification due to coastal thermal discharges) (Ballesteros, 2006). To this effect, various EC and international instruments have, over the course of the last decades, identified special protection measures to protect such assemblages whether it be through the establishment of marine protected/conservation areas that can be identified by the presence of such assemblages (i.e. Special Protected Areas of Mediterranean Importance within the framework of the Barcelona Convention's Protocol concerning specially protected areas and biological diversity in the Mediterranean – SPA/BD, or Sites of Community Interest within the framework of the EC 92/43 Habitats Directive) or through the banning of specific fishing gears (*i.e.* trawling ban on coralligenous or *Mäerl* beds within the framework of the EC Council Regulation 1967/2006). The protection of a specific habitat type cannot, however, be put in place without the enforcement of specific control and monitoring plans.

Numerous initiatives, formulated during the last decade within the framework of the United Nations Environment Programme - Mediterranean Action Plan (UNEP MAP) Regional Activity Centre for Specially Protected Areas (RAC/SPA), have put an emphasis on the study and identification of coralligenous and biogenic formations throughout the Mediterranean sea. In particular, the "Action Plan for the Protection of the Coralligenous and other Calcareous Bio-concretions in the Mediterranean", which was recently approved in October 2007 by the MAP Focal Points to the Barcelona Convention (UNEP/MAP, 2007), highlights the need to conduct specific conservation

activities on the coralligenous habitats intended as the coralline algal frameworks that grow in dim light conditions and in relatively calm waters (Ballesteros, 2006). The Action Plan includes the various *facies* and associations of the coralligenous biocoenosis as well as *Mäerl* beds, which represent calcareous formations built by several species of calcified red algae, whose main constitutive characteristic is the presence of a carbonate layer and which thrive in the same or similar light conditions as the coralligenous assemblages. Medio and infralittoral water calcareous frameworks such as the *Dendropoma petraeum* and *Lithophyllum byssoides* rims, and non-calcareous deep-water *Cystoseira* species are instead not considered by the Action Plan, since they are object of conservation attention through the enactment of activities listed in the UNEP/MAP RAC/SPA Marine Vegetation Action Plan.

The Action Plan on Coralligenous and Calcareous Bio-Concretions identifies, amongst its priority actions, the need to compile all existing information at all levels and scales on the distribution of coralligenous assemblages and M*aërl* beds in the Mediterranean sea. The present document synthesizes the activities conducted, within the framework of the RAC/SPA – ICRAM "*Avenant N° 3/2008/RAC/SPA*", on coralligenous habitats and other calcareous bioconcretions in the Mediterranean as defined by the above mentioned Action Plan. The objectives of the presently outlined project consisted in carrying out a Mediterranean bibliographic census, characterised by cartographic information of such habitats, and in the creation of a specific Geographical Information System (GIS) containing all the available cartographic data on such assemblages with the aim of identifying their distribution on a regional scale. The scope of this specific GIS database is to support RAC/SPA in obtaining a global information on all the cartographic published/public maps so as to plan future measures of monitoring and conservation and new research activities.

1.2. CORALLIGENOUS HABITAT AND BIOGENIC ASSEMBLAGES

The below listed coralligenous habitats and biogenic assemblages were considered for the purpose of the present work. Each habitat is hereby briefly defined according to the descriptions available in the principal scientific literature on Mediterranean benthic habitats (Peres & Picard, 1964; Augier, 1982; Meinesz *et al*., 1983; Bellan Santini *et al*. 1994; Bellan-Santini *et al.*, 2002; Bressan & Babbini, 2003; Giaccone, 2007).

1.2.1. Pre-coralligenous

This assemblage is considered by some authors as an actual impoverished *facies* of the coralligenous biocoenosis (Bressan & Babbini, 2003) due to the fact that it is

found at lower depths where light is more intense which determines the presence of an impoverished calcareous Rhodophycean species diversity. The assemblage has been identified as “Hard bottom circalittoral assemblage without Bioconcretions” (*Peuplements des susbtrats durs circalittoraux sans bioconcretionnement*; reported as pc, *sensu* Meinesz *et al*., 1983) and considered an aspect of the coralligenous biocoenosis. Other authors (Bellan-Santini *et al.*, 1994, 2002) consider this as a distinct assemblage from the circalittoral coralligenous biocoenosis since the assemblage often occurs at shallower depths and as such is more proper to the infralittoral zone and has in fact been placed in the list of habitats of the biocoenosis of the infralittoral algae and coined as “*facies* and associations of the coralligenous biocoenosis (in *enclave*)” (UNEP/MAP, 1999). It is often defined as a transitional assemblage, occurring, at a depth range of 15-40 m, and lying between the infralittoral photophilous communities and the deeper coralligenous biocoenosis (Bellan-Santini *et al.*, 1994). Regardless of whether it is considered as an impoverished *facies* of the circalittoral coralligenous biocoenosis or a distinct assemblage *per se*, the pre-coralligenous differentiates itself from the coralligenous because it is located in conditions with more light which determines a low quantity of the typically coralligenous rhodophycean bioconstructing species (the most common coralline species observed in the pre-coralligenous is *Mesophyllum lichenoides*) and a higher quantity of sciaphilous soft algae (Augier, 1982), namely *Halimeda tuna*, *Udotea petiolata* (=*Flabellia petiolata*) and *Pyessonnelia bornetii* (Meinesz *et al*., 1983). The pre-coralligenous assemblage is composed of the vegetal association coined as *Flabellio-Peyssonnelietum squamarie* Molineri 1958, community (habitat III.6.1.32 of the Barcelona marine habitat classification list, reported by UNEP/MAP, 1999) described by Giaccone *et al.* (1994). The community is also characterized by a lower number of invertebrate species with respect to the coralligenous biocoenosis. The faunal component can be composed of the Bryozoan *Scrupocellaria reptans*, the sponge *Chondrilla nucula* and the Gorgonians *Eunicella singularis* and *E. cavolinii.* The former species can give rise to *facies* which occur in higher light intensity than that of other Gorgonian facies (Weinberg, 1991) while the latter species is most often found on vertical rocky cliffs or under steep inclines of feeble depths. Hew precoralligenous can also be observed on the rhizomes of deep seagrass meadows or in tightly packed meadows, in the fissures of superficial rocky cliffs and in the shadier area formed by the *Lithophyllum tortuosum* belt which is composed of conglomerates of different Melobesie on which *Udotea*, *Halimeda* and *Peyssonnelia* then implant (Peres & Picard, 1964).

Facies* with *Eunicella cavolinii i

It is to be noted that the *facies* of *E. singularis,* although considered by certain authors as indicative of the pre-coralligenous assemblage (Morri *et al.*, 1986), is considered a *facies* belonging to the circalittoral coralligenous biocoenosis according to the marine habitat classification list formulated under the auspices of the UNEP-MAP SPA/BD protocol (UNEP/MAP, 1999). This entails that different bibliographic studies may consider this *facies* as belonging to “pre-coralligenous assemblage” as well as “coralligenous biocoenosis”.

1.2.2. Coralligenous

This biocoenosis is dominated by sciaphilous algae which thrive in specific environmental conditions of the circalittoral zone such as a reduced light intensity (0.1-1% of the surface light), low and constant temperature and moderate sedimentation rate. The coralligenous biocoenosis is typical of the circalittoral zone but can also be found as an *enclave* in the Infralittoral zone. The habitat occurs between 20-25 m down to more than 60 m depth in the western Mediterranean and until 140 m in the eastern part of the basin, but can also occur at shallower depths in special topographic features such as the entrance of caves or in the dimly lit underpart of large boulders (Bressan & Babbini, 2003). This assemblage is composed of the combined bioconcretion resulting from different calcareous algal Corallinacea species of which the most dominant are: *Mesophyllum lichenoides (Mesophyllum alternans)*, *Lithophyllum strictaeforme (*subnom*. Pseudolithophyllum expansum), Neogoniolithon mamillosum* (Bressan & Babbini, 2003) as well as faunal species (*Eunicella cavolinii, Paramuricea clavata, Haliclona mediterranea, Adeonella*

calveti) (Meinesz *et al*., 1983). The coralligenous biocoenosis can be observed in two basic and substantially different conditions:
a) the coralligenous formations occurring on the lower horizon of the littoral rock (CH IRL *sensu* Meinesz *et al.*, 1983) such as that of rocky vertical cliffs, with concretions of differing thicknesses based on the inclination of the rocky plane on which it lies and
b) the coralligenous formations which develop over large horizontal surfaces, on soft bottoms of the continental platform (*Coralligene du plateau*, CP, *sensu* Meinesz *et al.*, 1983). The latter is usually composed of large clumps created by the bioconcretion activities of Corallinacea and Peyssonneliaceae species.

The habitat classification list formulated under the auspices of the UNEP-MAP SPA/BD Protocol (UNEP/MAP, 1999) recognizes the following *facies* and associations as occurring in this biocoenosis amongst which:
(III.6.1.) Biocoenosis of infralittoral algae
(III.6.1.35.) *Facies* and associations of the coralligenous biocoenosis (in *enclave*)
(IV.3.1.) Coralligenous biocoenosis
(IV.3.1.1.) Association with *Cystoseira zosteroides*
(IV.3.1.2.) Association with *Cystoseira usneoides*
(IV.3.1.3.) Association with *Cystoseira dubia*
(IV.3.1.4.) Association with *Cystoseira corniculata*
(IV.3.1.5.) Association with *Sargassum spp*. (indigenous species)
(IV.3.1.6.) Association with *Mesophyllum lichenoides*
(IV.3.1.7.) Association with *Lithophyllum frondosum* and *Halimeda tuna*
(IV.3.1.8.) Association with *Laminaria ochroleuca*
(IV.3.1.9.) Association with *Rodriguezella strafforelli*
(IV.3.1.10.) *Facies* with *Eunicella cavolinii*
(IV.3.1.11.) *Facies* with *Eunicella singularis*
(IV.3.1.12.) *Facies* with *Lophogorgia sarmentosa*
Facies with large *Porifera*
(IV.3.1.13.) *Facies* with *Paramuricea clavata*
(IV.3.1.14.) *Facies* with *Parazoanthus axinellae*
(IV.3.1.15.) Coralligenous platforms
(Note: the numbers in parenthesis refer to the systematic numbering given to the various associations within the systematic ordering of the marine habitat classification).

Coralligenous in the Al Hoceima coastal area (Morocco)

1.2.3. Association with rhodolithes

The rhodolith association is composed of biogenic concretions created by the Rhodophycean calcareous algae belonging to the order Corallinales (amongst which: *Lithophyllum incrustans, L. stictaeforme, L. racemus, Neogoniolithon brassica-florida, N. mammillosum, Spongites fruticulosus, Lithothamnion corallioides, L. mineravae, L. philippi, L. crispatum, Mesophyllum alternans, M. lichenoides, Phymatolithon calcareum*) and other crustose red algae belonging to the family Peyssonneliaceae. Such concretions are generally found in free-living form on the soft bottoms of the infralittoral and circalittoral zone, in the presence of strong currents, and dim light. The concretions develop as a result of the algae's attachment to particles of different sediment types (detritic sand, coarse sand, fine gravel, fine mud) and lead to the formation of nodules of various typologies and dimensions, the basic characteristic of which lies in the fact that at least 50% of the nodule volume is composed of the algal concretion. On the basis of the density of the free living forms of rhodolithes, the latter may end up coming in contact with each other and anchoring themselves one against the other thereby giving rise to specific bioconstructions (Bressan & Babbini, 2003). The habitat characterised by free living forms of calcareous algae in the Mediterranean was first described by Giaccone in 1965 and officially identified as the association *Phymatolitho-Lithothamnietum corallioidis* Giaccone 1965 (Bressan & Babbini, 2003) because of the preferential dominant species observed in the *Mäerl* beds. However, further research has also recently identified that besides the preferential species, other calcareous algae present in the coastal detritic bottoms can create differential *facies* of the same association which are determined on the basis of differing values of various factors such as hydrodynamism, sediment rate,

temperature, and light (Bressan & Babbini, 2003). These differential associations/*facies* may be summed up as follows:

- Association with rhodolithes - *Facies* of *Mäerl*

The *facies* with *Mäerl* consists of an association of two multi-branched calcareous algae: *Lithothamnion corallioides* (=*Mesophyllum corrallioides*) (sub nom. *Lithophyllum solutum*) and *Phymatolithon calcareum* (sub nom. *Lithothamnium calcareum*), which are found unattached on sediments composed of coarse sand and gravels and a high proportion of detritic components. This *facies* can in fact be found in the “infralittoral biocoenosis of coarse sands and fine gravels under the influence of bottom currents” as well as in the “circalittoral biocoenosis of the coastal detritic bottom” (DC/M *sensu* Meinesz *et al*., 1983). The multi-branched shape of these Lithothamnia species do not contribute to the formation of bioconstructions.
The habitat classification list formulated under the auspices of the UNEP-MAP SPA/BD Protocol (UNEP/MAP, 1999) recognizes the *Mäerl facies* as occurring in the following biocoenosis:

- Biocoenosis of coarse sands and fine gravels under the influence of bottom currents
- (III.3.2.1) *Facies* of *Mäerl*
- Biocoenosis of coastal detritic bottoms
- (IV. 2.2.2) *Facies* of *Mäerl*

- Association with *Peyssonnelia rosa-marina* - *Facies* of free Peyssonneliaceae

This *facies* is found in the biocoenosis of the coastal detritic bottoms and is composed of a rich proliferation of free thalli belonging to Peyssonneliacea species and in particular *Peyssonnelia rosa-marina*. The *facies* is found in bays and inlets characterized by a sediment of fluid mobile muds and turbulent currents often associated to heavy storms. The calcareous thalli of these Peyssoneliacean algae are distributed in a single layer on the sediment (Augier, 1982). The thalli have a globular aspect resulting from their rolling motion on the substrate and may have leaflike expansions resulting from secondary growth phases during which the bottom portion of the thallus basculates on the muddy sediment (Peres & Picard, 1964). The *facies* has been coined as: *facies* with free Squamariacea (Peres & Picard, 1964) and as *facies* with free calcified Peyssonneliacea of the biocoenosis of coastal detritic bottoms (DC/p *sensu* Meinesz *et al*., 1983)
The habitat classification list formulated under the auspices of the UNEP-MAP SPA/BD Protocol (UNEP/MAP, 1999) recognizes this habitat as occurring within the following habitat types:

- (IV.2.2.3) Association with *Peyssonnelia rosa-marina*

Coralligenous in the Elba Island

- Association with rhodolithes - *Facies* of *Prâlines*

This habitat, identified as a *facies* (*facies à pralines de la biocénose des fonds détritiques cotiers*, DC/PRAL) by Meinesz *et al.* (1983) and by Peres & Picard (1964), is characterized by rhodolithes with a very regular round/globular shape, a few centimeters in thickness, which are mostly formed by *Lithophyllum racemus* and *Lithothamnion valens.* These nodules are usually monospecific. The *facies* can be observed preferentially in the infralittoral "biocoenosis of coarse sands and fine gravels under the influence of bottom currents", but can also be found in the "biocoenosis of coastal detritic bottoms". *Lithophyllum racemus* pralines generally occur in conditions with intense diffused light with coarse sands and fine gravels associated to bottom strong currents, while *Lithothamnion valens* generally occur in medium diffused light conditions on coarse sands and fine gravels associated to laminar bottom currents with occasional peaks. The hydrodynamism is characterized by laminar bottom currents with occasional peaks of strong turbulent currents in the presence of very clean waters. In some situations, the endemic algae *Laminaria rodriguezii*, can install itself on the surface of the largest concretions. In such cases the species diversity of the biocoenosis of the coastal detritic bottoms seems to be impoverished, while the faunal diversity associated to this *facies* in the coarse sands and fine gravels under the influence of bottom currents seems to be elevated (especially with *Venus casina* L.) (Bressan & Babbini, 2003).

The habitat classification list formulated under the auspices of the UNEP-MAP SPA/BD Protocol (UNEP/MAP, 1999)does not specifically take into account this *facies* that could be considered as occurring in the following biocoenosis:

- Biocoenosis of coarse sands and fine gravels under the influence of bottom currents
- (III.3.2.2.) Association with rhodolithes
- Biocoenosis of coastal detritic bottoms
- (IV. 2.2.1.) Association with rhodolithes

- Association with *rhodolithes* - *Facies* of *Lithothamnion minervae*

The *facies* of *Lithothamnion fruticulosum* (=*L. minervae*) is characterized by globular rhodoliths covered by short ramifications or stunt-like outgrowths. In some cases the *facies* can be observed in reduced/occasional hydrodynamism such as that occurring in areas where rolling is limited by the presence of obstacles. In such conditions large rhodolithes can form stratified and cavernous structures, more or less covered by sediment, due to the juxtaposition of different algal species. Other species observed in these assemblages are: *Spongites fruticulosus, Neogoniolithon brassica-florida and Mesophyllum lichenoides*. In these cases the structures formed by these species are called “boxwork rhodolithes” and can occur in strong hydrodynamic conditions characterized by pulsating and oscillating currents in spatially restricted areas such as channels and straits connecting basins to open seas or even in *Posidonia* inter-*matte* channels (Bressan & Babbini, 2003). This *facies* can be associated to the *facies a petits massifs concretionnés de la biocenose des fonds detritiques cotiers* (DC/c, sensu Meinesz *et al.* 1983).

The habitat classification list formulated under the auspices of the UNEP-MAP SPA/BD Protocol (UNEP/MAP, 1999) does not specifically take into account this *facies*, which can however be considered as occurring in the following biocoenosis:

- Biocoenosis of coastal detritic bottoms
- (IV. 2.2.1.) Association with rhodolithes

- *Facies* of large Briozoans of the Coastal Detritic bottoms

The *facies* occurs in the circalittoral biocoenosis of the costal detritic bottoms and is characterised by the presence of calcified arborescent bryozoans such as: *Turbicellepora avicularis, Frondipora verrucosa, Pentapora fascialis, Smittina cervicornis, Rhynchozon* spp. The bryozoans represent a minor form of bioconcretion together with rhodolithes which may also be present. The bivalve *Pecten maximus*, the echinoderm *Spatangus purpureus*, and the serpulid *Salmacina dysteri* may be observed in the detritic bottom. A stratum of erect gorgonians may also be observed composed of specimens belonging to the following species *Eunicella singularis, Eunicella verrucosa* and *Leptogorgia sarmentosa* (Augier, 1982; Bellan Santini *et al*., 1994).

The habitat classification list formulated under the auspices of the UNEP-MAP SPA/BD Protocol (UNEP/MAP, 1999) recognizes the large Briozoan *facies* as occurring in the following habitat type of the circalittoral:

- (IV.2.2.10.) *Facies* of large ramified Bryozoans

Facies* with *Eunicella singularis

2. MATERIALS AND METHODS

2.1. DATA COLLECTION

A bibliographical search was carried out so as to collect cartographic data on the distribution of the coralligenous biocoenoses and other bioconcretions. National and international networks of marine scientists and marine protected area managers were also contacted so as to census and obtain the abovementioned datasets and cartographies.

2.1.1. Bibliographical search

The bibliographic search was performed by consulting the ASFA (Aquatic Sciences and Fisheries Abstracts) database, containing scientific publications since 1971, and the CASPUR (*Consorzio Interuniversitario per le Applicazioni di Supercalcolo Per Università e Ricerca*) service, which lists a large number of the marine biological journals edited by the principal scientific publishing houses such as Elsevier Science, Blackwell Publishing, Springer, etc. A search was also carried out with the internet research motors (Google and Google scholar) so as to collect any “grey literature” that would otherwise remain unfound in the scientific bibliographic databases unreported by the main bibliographic databases. The bibliographic research was performed using a trilingual (Italian, English and French) approach consisting in a list of keywords (Table 1) and taxa (Table 2).

Table 1 - List of keywords used for the bibliographic search.

Coralligeno, coralligenous, coralligène
Precoralligeno, precoralligenous, précoralligène
Cartografia, cartography, cartographie
Carta biocenotica, biocoenotic map, carte biocénotique
Carta bionomica, bionomic map, carte bionomique
Gorgonie/Gorgonari, gorgonians, gorgonaires
Alghe coralline, coralline algae, algues corallien
Pralines
Maërl
Distribuzione popolamenti bentonici, benthic assemblages distribution, distribution peuplements benthiques
Spugne, sponges, éponge
Rodoliti, rhodolithes

Table 2 - List of taxa used for the bibliographic search.

Lithothamnion coralliodoides
Phymatolithon calcareum
Cystoseira corniculata
Cystoseira dubia
Cystoseira usneoides
Cystoseira zosteroides
Sargassum spp.
Laminaria ochroleuca
Rodriguezella strafforelli
Eunicella cavolinii
Eunicella singularis
Lophogorgia sarmentosa
Paramuricaea clavata
Corallium rubrum
Axinella spp.
Peyssonnelia spp.

Parazoanthus axinellae

2.1.2. Scientific networks

Contacts were established with the authors of the publications identified in the paragraph mentioned above so as to enquire about secondary publications or grey

literature which could have been bypassed through the bibliographic search. Members of the coralligenous working group of the *Società Italiana di Biologia Marina* (SIBM) and scientists of the International Commission for the Scientific Exploration of the Mediterranean (CIESM) as well as the network of managers of Marine Protected Areas in the Mediterranean (MedPAN) were also contacted to census and collect pertinent bibliographic and cartographic data. Each contacted group was specifically asked to provide bibliographic and cartographic data on the following coralligenous assemblages and *facies*: pre-coralligenous, coralligenous, *facies* with Peyssonneliaceae, *Mäerl*, Pralines, and *facies* with large Bryozoa of the coastal detritic (DC/c, DC/p, DM/m, DC/pral. E DC/b *sensu* Meinesz *et al*., 1983). The list of specialists which were contacted is contained in annex I.
The list of documents collected through the bibliographic search was then integrated with that produced by Ballesteros (2006) and Giaccone (2007) and with 193 international scientific publications on coralligenous assemblages contained within a previously existing RAC/SPA database.

2.2. ANALYSIS OF THE WHOLE SCIENTIFIC PUBLICATIONS DATA SET

The entire list of documents present in the bibliographic dataset described above were analysed so as to identify the location of each study area and thereby provide additional information on the distribution of the coralligenous assemblages and bioconcretions. The geographical distribution of the studies was considered according to Mediterranean sub-regions (western Mediterranean, Adriatic, Ionian, Aegean-Levantine) (Fig.: 1) and to country of occurrence.

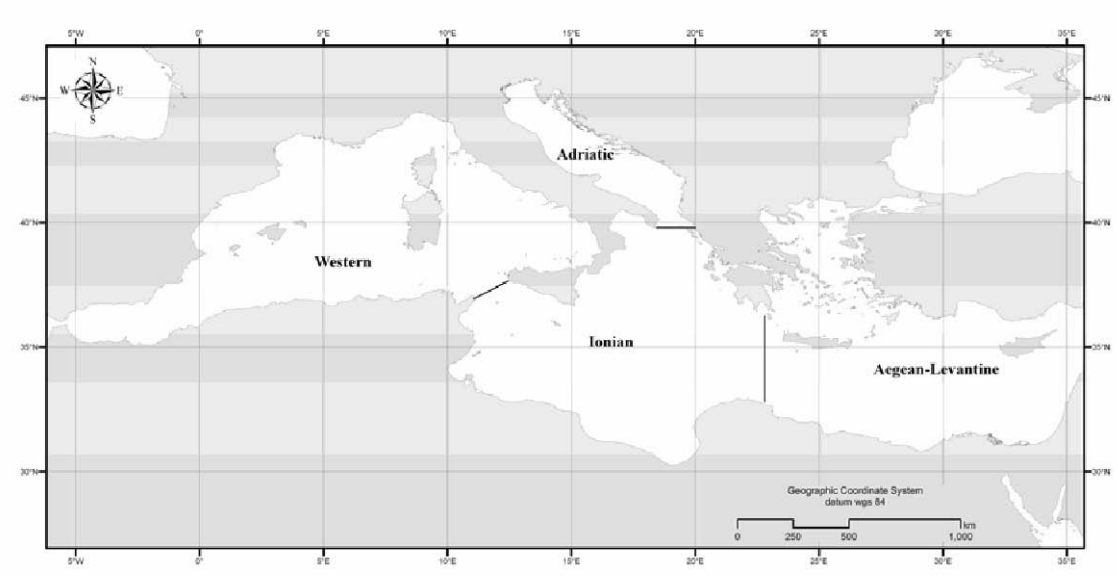


Figure 1 - Distribution of the identified sub-regions in the Mediterranean Sea.

Mediterranean sub-regions were identified on the basis of the three ICES

Mediterranean eco-regions (ICES, 2004) with the addition of a fourth region resulting from the split of the Adriatic-Ionian eco-region which was dictated on the basis of the peculiar oceanographic features of the Adriatic Sea (Cushman-Roisin *et al.*, 2001).
The documents were also analysed in terms of the thematic area on which the study was based so as to allow a better overall understanding of the type of research that has been conducted on such habitat types. In some cases the thematic category and the location of the investigated area were inferred only by their title keywords and abstracts.
The following categories were used to classify the documents: Taxonomy, Ecology, Distribution, Physiology and biochemistry, Genetics, Threats, management and conservation, Reproduction, Age and growth. Such category differentiation implied that different themes were attributed to each category as reported below:

- Taxonomy – species identification and description, taxonomic revision, nomenclature;
- Ecology – population dynamics, community structure, species composition and diversity, spatio-temporal variations and distributions, habitat use, feeding behaviour, interspecific relationships, environmental factors, recovery, ecosystem resilience;
- Distribution – coralligenous species and/or biocoenosis geographical distributions (at various spatial scales, with or without cartography);
- Physiology and biochemistry - biochemical composition, enzymatic activity, biogeochemical cycle, energy flow, molecular structure, ecophysiology, biological rhythms, biological stress;
- Genetics - genetic drift, population genetics, racial studies, gene expression; genetic diversity, genetic structure, phylogeny, endemic species, genetic markers, inbreeding, genetic isolation;
- Threats, management and conservation – Marine Protected Areas, ecosystem disturbance, chemical pollution; ecosystem management; human impact; resource management, overexploitation, extinction;
- Reproduction – individual recruitment, sexual and asexual reproduction, sex ratio, reproductive cycle, fecundity;
- Age and growth - colonies and individuals morphology, population growth, age, morphometry.

The total number of studies for each Mediterranean sub-region, countries and thematic categories was calculated so as to highlight the distribution pattern of their geographical location and thematic area. This information was then crossed to obtain a description of the distribution of the studies per sub-region according to thematic category. Furthermore, since the assessment of the assemblages' distribution and their threats, management and conservation are indeed of primary importance in the implementation of the RAC/SPA Action Plan on coralligenous and calcareous

bioconcretion, special attention was made to identify such features. Studies pertaining to the thematic categories “distribution” and “threats, management and conservation” were therefore further elaborated to obtain their distribution at a country level.

2.3. TREATMENT OF THE PUBLISHED CARTOGRAPHIC INFORMATION

2.3.1.Data storage

General objectives

All the documents containing cartographic data, were catalogued and archived in a relational database specifically designed in order to organize, store and easily consult and retrieve the collected information.
The database provides bibliographic, geographic, cartographic, bionomic and methodological informations on the cartographic collection that was censused.

Data base

Data base structure

The relational data base was developed using Microsoft Access software. The basic structure of this database is composed of four tables from hereon described with the following titles: “bibliography”, “location”, “cartography” and “data”.
The “bibliography” table is the principal central table of the system and is connected with the other remaining tables in a one-to-many relationship. The “bibliography” table, as the name itself implies, contains basic bibliographic information on each cartographic record present in the database, as described in Table 3.
There are three specific items in this table which are worth mentioning since they allow to pinpoint essential aspects on the usability of each cartographic dataset for GIS elaboration and spatial planning purposes and these are: availability, electronic format, and GIS implementation.

The “cartography” table contains information on the cartographic features of each map as defined in Table 4.

The “location” table, summarizes the basic geographical information (table 5).

Table 3 - Bibliography table.

Field name	Field type	Field description
ID	Counter	Identification number of the cartographic dataset record (Primary key of the table)
Author	Text	Author(s) of the document
Title	Text	Title of the document
Year	Number	Year of publication of the document
References	Text	Reference details for documents not published in journals (i.e. report, monographs, book chapters)
Journal	Text	Name of the journal
Volume	Text	Volume number of the journal
Pages	Text	Page number of the document
Availability	Yes/No	Map availability in paper format
Electronic format	Yes /No	Map availability in electronic format
GIS Implementation	Yes/No	Cartographic implementation in the GIS
Compiler	Text	Name of the compiler
Update	Date	Date of the last update
Notes	Memo	Miscellaneous information concerning the document

Table 4 - Cartography table.

Field name	Field type	Field description
ID	Counter	Identification number of this table's dataset record (Primary key of the table)
ID_Biblio	Number	Number obtained from the ID field of the "Bibliography" table for the specific cartographic dataset record. This number allows to relate these two tables containing information referring to the same record.
Format	Text	Type of map format (i.e. paper or electronic)
Size	Text	Map size (i.e. A4, A3, etc.)
Typology	Text	Digital data typology (i.e. vectorial, raster, CAD)
Topology	Text	Digital data topology (i.e. polygon, line, point)
Projection	Text	Original projection of the map
Scale	Number	Original scale of the map
Notes	Memo	Miscellaneous information concerning the document

The "data" table summarizes the biological and methodological information concerning each cartographic record (Table 6). Information on the names of the biocoenosis and/or respective *facies* or associations are indicated in the "biocoenosis" and "*facies*/ association" fields following a standardisation layout described in paragraph 2.3.2. which accounts each habitat type according to the different biocoenosis within which it may be found, the name of the specific *facies*/assemblage and its relevant characterising species as attested by a close

examination of the contents of the specific cartography and its respective bibliographical text.

Table 5 - Location table.

Field name	Field type	Field description
ID	Counter	Identification number of this table's dataset record (Primary key of the table)
ID_Biblio	Number	Number obtained from the ID field of the "Bibliography" table for the specific cartographic dataset record. This number allows to relate these two tables containing information referring to the same record.
Country	Text	Name of country(ies) where the study area is located
Locality	Text	Name of the local site
Sub-region	Text	Name of sub-region (Western Mediterranean, Adriatic, Ionian, Aegean-Levantine)
Protected Areaa	Text	Name of the eventual area of high environmental value that may be present in the dataset record (i.e. MPA, SCI/SPZ or SAC etc.)
Notes	Memo	Miscellaneous information concerning the document

Table 6 - Data table.

Field name	Field type	Field description
ID	Counter	Identification number of this table's dataset record (Primary key of the table)
ID_Biblio	Number	Number obtained from the ID field of the "Bibliography" table for the specific cartographic dataset record. This number allows to relate these two tables containing information referring to the same record.
Biocoenosis	Text	Name of each biocoenosis reported in the map
Depth_bio	Text	Depth range of each biocenosis reported in the map/dataset record
Facies/Association	Text	Name of each *facies* and/or association reported in the map
Depth_*facies*	Text	Depth range of each *facies*/assemblage reported in the map/dataset record
Species	Text	Name of each dominant or characteristic species reported in the map/dataset record
Year of data	Text	Year(s) of data sampling
Sampling methods	Text	Brief description of the sampling method(s)
Notes	Memo	Miscellaneous information concerning the document

Data base functions

The database's functionality was enhanced, in terms of data reliability and speed in the data entry procedure, through the production of a database design specifically created and customized for entering and viewing the data with ease. The speed of use of an effective database is, in fact, dependent on a design that helps the user to easily access all the data and should not contain features such as very large tables which would otherwise hinder the relationship traceability between a particular record and a specific field during the data entry process. The electronic database therefore presents itself through a specific mask inlay (named "Biblio") in which all the updatable fields belonging to the different tables, listed above, are visible and accessible (Fig. 2).

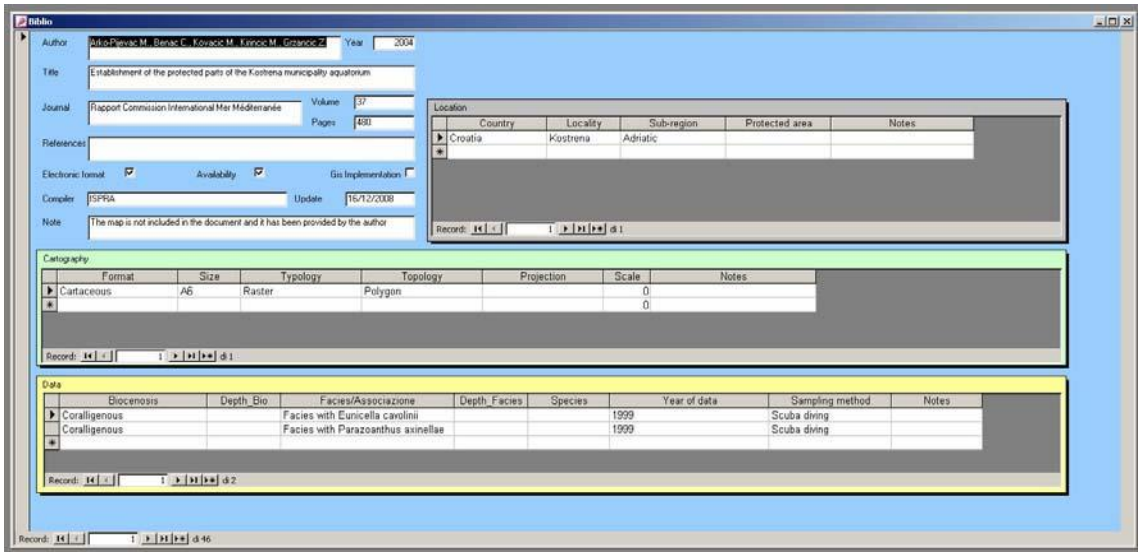


Figure 2 - Example of mask inlay of the electronic database reporting information on the four tables.

Geographic Information System: a brief description

The term GIS (Geographic Information System) is currently applied to computerized information storage, processing and retrieval systems whose hardware and software are specifically designed to handle geographically referenced spatial data and their corresponding attribute information. The spatial data, also known as geospatial data or geographic information, is the data or information that identifies the geographic location of features and boundaries on Earth, such as natural or constructed features and infrastructure, like oceans, roads or ports etc. Spatial data is usually stored as coordinates and topology, and is data that can be mapped. The spatial data is commonly organised in the form of "layers", which may represent different sets of information which, in the marine environment, may regard aspects such as: topography, coastline, bathymetry, sediments, currents, biocoenoses (see Fig. 3).

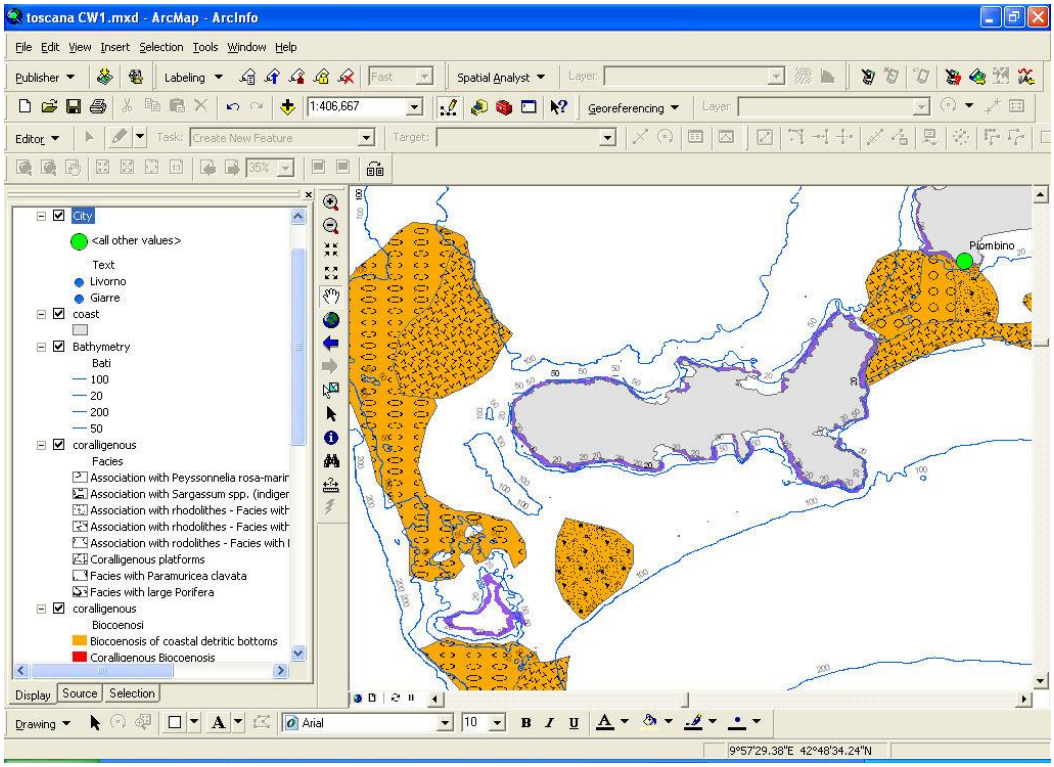


Figure 3 - Example of spatial information (layers) found in a GIS maps.

There are two methods used to store data in a GIS: vector and raster. When using vector data, the basic units (features) of spatial information are points, lines (arcs) and polygons and each of these units is linked to an attribute table where one or more information can be stored. In a raster the area is divided into rows and columns, which form a regular grid structure. Each cell must be rectangular in shape, but not necessarily square. Each cell within this matrix contains location co-ordinates as well as one attribute value. These two methods can be easily converted one into the other (raster to vector and *vice versa*), in fact the procedure is reversible, even though the choice between these two methods has its advantages and disadvantages (Table 7).

Table 7 - Advantages (√ and disadvantages (X) of raster and vector data models.

	Raster	Vector
precision in graphics	X	√
traditional cartography	X	√
data volume	X	√
topology	X	√
computation	√	X
update	√/X	√/X
continuous space	√	X
discontinuous	X	√

In this regard, it is important to define the data storage method in the beginning of a GIS project.

GIS tools allow to see and analyse information in a quick and agile way, making the decision taking process on specific matters easier. The advantages of its use are evident, amongst them we can highlight the following:

• Greater accessibility to data. These are in a digital format, homogeneous and can be compared.

• Facilitates the possibility of carrying out complex analysis, combining different map layers, both of the current reality, as well as future reality, being able to carry out predictive models.

• Facilitates the creation of cartography for different uses and for different level of users (e.g. managers, technicians etc.).

In essence, GIS is a data base management system (DBMS) specifically designed for simultaneous processing of spatial and related attribute data. In addition to DBMS, GIS also has many capabilities similar to automated map making and computer graphics systems. However, as well as having a powerful capability for processing graphics, GIS must also be able to process non-graphic attributes, such as statistical data, in conjunction with the spatial data to which they are related. For example, if the user modifies the spatial data, the GIS will make the necessary modifications in the related statistical database automatically. This link between the two types of data must be present if a system is to be considered a true GIS.
In summary, although GIS differs from other tools, such as tabular data base management systems, computer graphics, and automated map making, each of these other systems is, in fact, a component of GIS and what a GIS does is integrate them all in one operation.

The design

For a correct setting up of a GIS project a careful design at the beginning of a project will help to avoid hours of unnecessary work and redundant tasks. The GIS project belonging to the present work is directed at data collection, input, and integration of different sources of data concerning coralligenous cartographies. The GIS software used in the present project is ArcGIS Version 9.1 by ESRI. Five main steps were followed for the set up of the GIS project and may be explained according to the below mentioned sets of questions and answers:

1. <u>Research question and project goal.</u>
   What is the purpose of the project? What is the research question? What is the spatial extent (total area) and grain size (ground resolution) of the study?

The coralligenous map at regional scale (Mediterranean sea) with the most precise resolution (e.g. the one reported in the original data) is the synthetic answer to these questions.

2. Information needs.
What type of spatial data do we need to achieve the goal? What are the sources of these data, and what are the appropriate types of data to answer these questions?
All the cartographic data dealing with this subject and having sufficient geographical information in order to be correctly loaded into the system.

3. Data.
What type of data shall be collected? What procedure will be adopted for data having different original format?
Data that is already in digital format, if available. In the case of paper maps a specific implementing procedure is envisaged.

4. Accuracy assessment of the implemented datasets.
How can the different levels of data accuracy pertaining to different data sets be indicated in the system?
A specific code showing the level of geographic accuracy of the cartographic data sets is defined.

5. Layout.
How can the contents of the data stored with the maps prepared by the GIS be adequately communicated? *Optimize layout scale, choice of proper basic cartography, comprehensible colours and symbol for the thematic layers, etc.*

Data capture

Data capture, or in other words the process of entering information into the system, is one of the most time consuming activity during the set up of a specific GIS. There are a variety of methods, depending on the original format, used to enter data into a GIS where they are stored in a digital format. As mentioned above, the information on the presence and distribution of coralligenous assemblages and bioconcretions in the Mediterranean basin was collected through two sources: bibliographical material (articles, technical reports, proceedings, maps) and digital files (raster or shape files).

Scanning

Cartographic information contained in paper maps, such as that found in articles or reports, was scanned so as to convert the graphic information into an importable digital image format. The data capturing process involves an evaluation of the degree

of accuracy (relative or absolute) required in the acquisition process, as this will influence data interpretation as well as the cost and file dimension of the captured data. The best quality/size ratio was therefore chosen in the scanning process of data acquired for the present project, so as to obtain an image that could be easily handled during the ensuing implementation steps and that could easily allow recognition of the different textures and lines needed to produce vector data that were then processed in the subsequent implementation steps.

Georeferencing

Scanned maps were subsequently georeferenced, or aligned, before digitizing information from them or using them as visual displays in the maps. Prior to doing this, however, the digital images were examined so as to determine, in advance, the control points. The latter consist in known x,y coordinates or points that can be found on both the digital image and on the already georeferenced GIS data layers. The control points must be evenly distributed around the image, for example one at each corner and one in the middle of the selected area; or several around each side and several more in the middle. The control points are fundamental for the data alignment of the image.

Digitizing

Digitization is the procedure by which a scanned map is converted in the vector model. In the present project, geographic features were digitized manually by tracing polygon, lines and points from the image file directly displayed on the computer screen. This type of digitizing procedure was chosen for its good level of accuracy, reduced time involved in the acquisition phase, and in the ensuing editing procedures that usually occur quite frequently with automated digitizing procedures In fact, after entering data into a GIS, the data usually requires additional editing, to remove errors, or further processing. Vector data must be "topologically correct" before they can be used for some advanced analysis. In the present project, for instance, when information was reported as points this was converted into a small polygon using the buffer process.

In addition to collecting and entering spatial data, attribute data is also entered into the related table of the layer. For the vector data, this includes additional information about the objects represented in the system. Table 8 shows the respective information attributes archived in the related table.

All collected data were then used for the construction of the final shape file. This product, together with the electronic bibliographic database, provides an efficient tool for data fruition on coralligenous assemblages and bioconcretions.

Table 8 - Description of all fields inserted in the shapefile.

Field	Type	Description
ID_mdb	Short Integer	Unique Identification Number; sequential value. It is the same number of stored in the ID of database tables.
Biocoenosi	Text	Standardized description of the biocoenosis / assemblage (see Table 10)
Facies	Text	Standardized description of the association-*facies* (see Table 10)
Source	Text	Initial source typology: paper, power point presentation, report, shapefile, thematic map, poster, raster, etc.
Typology	Text	Original biocoenoses description, as reported in the field of the shapefile or in the legend
Author	Text	Author of the dataset
Reference	Text	Bibliographical reference
Year	Short Integer	Year of the publication
Area	Integer	Surface of the polygon expressed in m^2
Geo_accu	Short Integer	1 to 5 code showing the accuracy of the coralligenous representation in the map (see following paragraph)
Notes	Text	Miscellaneous additional information

Accuracy assessment

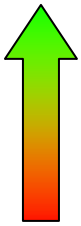
The accuracy of the acquired data is linked to the quality of the original source. In fact, besides differences due to the source of data (i.e. shapefile origin as opposed to paper map) maps can also have differing definition characteristics which influence the quality of the reported data. Maps found in some articles (or in the technical reports), for instance, can be well defined, both in terms of the projection and their scale of representation, or totally not defined. In the latter case the “reliability” of the representation present in the GIS would result being lower. Based on such an assumption, a specific code value (from 1-5) was given to the final resulting map product in order to indicate the accuracy consistency level of the cartographic information present in a given cartographic record (Table 9).

Projection

Given the wide extension of the study area, and therefore of the cartographic database, two possible geographic projections were initially considered appropriate to use:

- LCC - Lambert Conformal Conic
  datum ETRS 1989 (European Terrestrial Reference System)
- CGS - Geographic Coordinates System
  datum WGS 84 (World Geodetic System)

Table 9 - Codes linked to the geographic accuracy of the cartographic representation, expressed in the geo_accu field of the shapefile.

Geo_accu	Description	Level of accuracy
1	Shape file and raster map already georeferenced	+ 
2	Map with defined projection information	
3	Map with an undefined projection information but easily positionable due to its scale or dimension	
4	Map with an undefined projection but which can be approximately positioned by using selected terrestrial control points	
5	Source characterised by very approximate cartographic products	

LCC projection is useful because its metric system allows an appropriate area estimation. However, this coordinate system is not used on a widespread basis and was considered likely to prevent the possibility to easily share the GIS product to the entire scientific community. This consequently led to the decision to convert all acquired data to the CGS(WGS84) coordinate system, a solution which also seemed appropriate given the natural projection of the RAC-SPA GIS.

2.3.2. Data standardization

Standardization is a process by which all elements in a data field are forced to conform to a standard. There are many benefits to this process. The first clear benefit is the conformity for comparison purposes. A great heterogeneity in terminology use was expected for the present project given that a unique and univocal benthic classification scheme is not always recognisable from one scientific study to another (i.e. same terms used to define habitats according to biocoenosis/assemblages/*facies* definition). To this effect, all the coralligenous habitats and biogenic assemblages described in the introduction, and which were object of a specific census, were organized in a tabular format (see Table 10) for standardisation purposes. The table reports the name of each biocoenosis/assemblage; the name of the various association-*facies*, and the respective equivalent UNEP-MAP SPA/BD protocol benthic habitat codes of those habitats which are included in the Coralligenous Action Plan. The standardisation process thereby consisted in analysing data fields and records so as to attribute them either to a specific biocoenosis or association/*facies* listed in the table and this information was transposed both in the layer (“biocoenoses” and “*facies*” fields) and in the database (“biocoenosis” and “*facies*/association” fields of the table “data”).

Table 10 - Benthic habitat classification terminology used for the standardisation process of coralligenous assemblages and bioconcretions [UNEP-MAP SPA/BD protocol benthic habitat codes, within which an assemblage may be included, appear in square brackets; when an assemblage occurs in more than one habitat code it is indicated with 1) and 2) depending on the biocoenosis].

Biocoenosis/assemblage	Name of association-*facies*
Pre-coralligenous assemblage	
1) Coralligenous biocoenosis (in *enclave*) in the infralittoral [III.6.1.35.] 2) Coralligenous biocoenosis [IV.3.1.]	• Association with *Cystoseira zosteroides* [IV.3.1.1.] • Association with *Cystoseira usneoides* [IV.3.1.2.] • Association with *Cystoseira dubia* [IV.3.1.3.] • Association with *Cystoseira corniculata* [IV.3.1.4.] • Association with *Sargassum spp*. (indigenous spp.) [IV.3.1.5.] • Association with *Mesophyllum lichenoides* [IV.3.1.6.] • Association with *Lithophyllum frondosum* and *Halimeda tuna* [IV.3.1.7.] • Association with *Laminaria ochroleuca* [IV.3.1.8.] • Association with *Rodriguezella strafforelli* [IV.3.1.9.] • *Facies* with *Eunicella cavolinii* [IV.3.1.10.] • *Facies* with *Eunicella singularis* [IV.3.1.11.] • *Facies* with *Lophogorgia sarmentosa* [IV.3.1.12.] • *Facies* with large *Porifera* • *Facies* with *Paramuricea clavata* [IV.3.1.13.] • *Facies* with *Parazoanthus axinellae* [IV.3.1.14.] • Coralligenous platforms [IV.3.1.15.]
1) Biocoenosis of coarse sands and fine gravels under the influence of bottom currents 2) Biocoenosis of coastal detritic bottoms	• Association with rhodolithes - *Facies* with *Mäerl* [1) III.3.2.1.; 2) IV.2.2.2.]
	• Association with rhodolithes - *Facies* with *Prâlines* [1) III.3.2.2.; 2) IV.2.2.1.]
Biocoenosis of coastal detritic bottoms	• Association with rhodolithes - *Facies* with *Lithothamnion minervae* [IV.2.2.1.]
	• Association with *Peyssonnelia rosa-marina* - *Facies* with free Peyssonneliaceae [IV.2.2.3.]
	Facies with large Briozoans of the coastal detritic bottoms [IV.2.2.10.]

2.3.3. Layout template definition

An overview layout containing the whole Mediterranean basin was designed. It is to be noted, however, that the generally small extension of the biocoenoses does not allow the correct visualization of the polygon features at this scale. To this effect, a new shape file (having point features) was generated in order to improve the readability of this type of layout which could then be used as key maps.

The resulting layout consists in three different levels of layout: one macroscopic layout depicting the groups of information derived from more than one source, an intermediate level in which the extension of the areas from a same source are portrayed in more detail, and a third at a finer scale in which the distribution of the assemblages at the maximum level of scale are portrayed.

The following basic cartographic layers were used for such layouts:

• Coastline: Coastline: Vector based coastline data layer, NOAA-online Coastline extractor, World Vector Shoreline (WVS+) 1:250,000, public domain version downloadable http://rimmer.ngdc.noaa.gov/mgg/coast/getcoast.html

• Bathymetry: partially derived by the nautical chart n° 360 “Mediterranean and Black sea” scale 1:4.200.000 produced by the *Istituto Idrografico della Marina* (I.I.M.) and the General Bathymetric Chart of the Oceans (GEBCO).

Information on the cartographic material on coralligenous assemblages was portrayed both as a detailed map layout as well as a data sheet in which a series of information was included. This double type of representation allows a very detailed description in which both cartographic and bibliographic information is immediately conveyed to the reader. Fig. 4 summarises the information typology reported in the data sheet whose basic structure is organised according to the layout used by RAC/SPA in a previous project with minor changes made to allow better reporting of information on coralligenous assemblages.

Map detailed layouts were created using the following basic cartographic layers, whose function is to properly frame, from a geographical point of view, the coralligenous thematic layer:

Coastline: Vector based coastline data layer, NOAA-online Coastline extractor, World Vector Shoreline (WVS+) 1:250,000, public domain version downloadable http://rimmer.ngdc.noaa.gov/mgg/coast/getcoast.html

Bathymetry (Italy): partially derived by the nautical charts scale 1:100,000 produced by the Istituto Idrografico della Marina (I.I.M.)

Bathymetry (Mediterranean sea): The General Bathymetric Chart of the Oceans (GEBCO)

Municipalities (Italy and Mediterranean countries): partially derived by free products available on the web

The maps’ readability was graphically enhanced by using solid colours for the depiction of the biocoenosis/assemblages and a textured shaded background for the depiction of the various association/*facies* thereby avoiding potential background colour overlap.

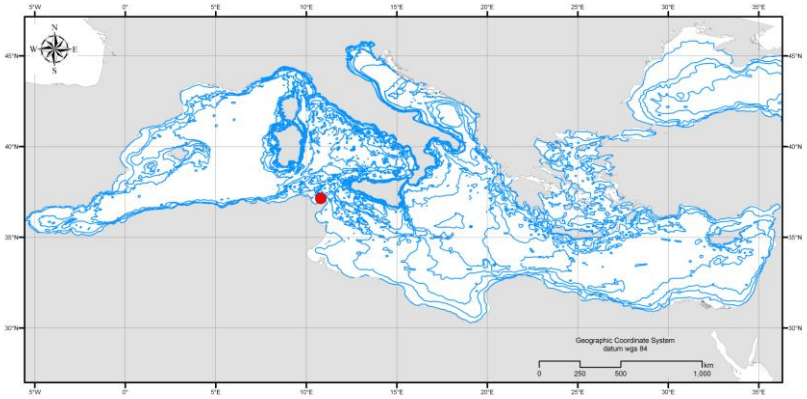
Data sheet_000

Reference document source

[Complete document reference]

Location

[Mediterranean Sub region, Nation, Locality….]
[A Mediterranean key map indicating the location]



[Example of a key map]

Sampling date

[Sampling date]

Sampling method

[Method used for data collection]

Original scale

[Original scale of the map (e.g. 1: xxxxx)]

Layout

[Number of layouts prepared for each dataset]

Data base ID

[Identification number of the cartographic dataset record. See figure below]

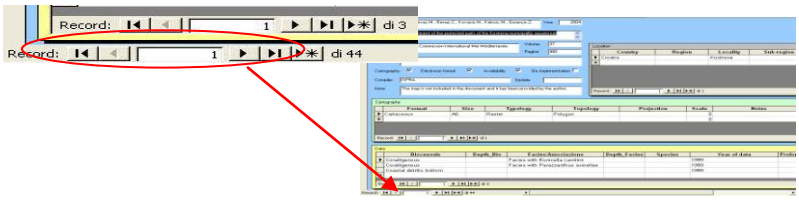


Figure 4 - Basic structure of the data sheet containing bibliographical and geographical information of each cartographic data set implemented in the GIS.

3. RESULTS

3.1. RESULTS OF THE BIBLIOGRAPHICAL REVIEW

Overall, the bibliographic data set is composed of 524 scientific documents (see Annex II for the complete list). Four hundred and three documents (77 %) provided information on the study areas thereby allowing to locate their sub-regional and country distribution. The study area of some documents was spread over more than one countries and/or sub-regions. Figures 5 and 6 indicate the respective distribution of the studies per sub-region and per country.

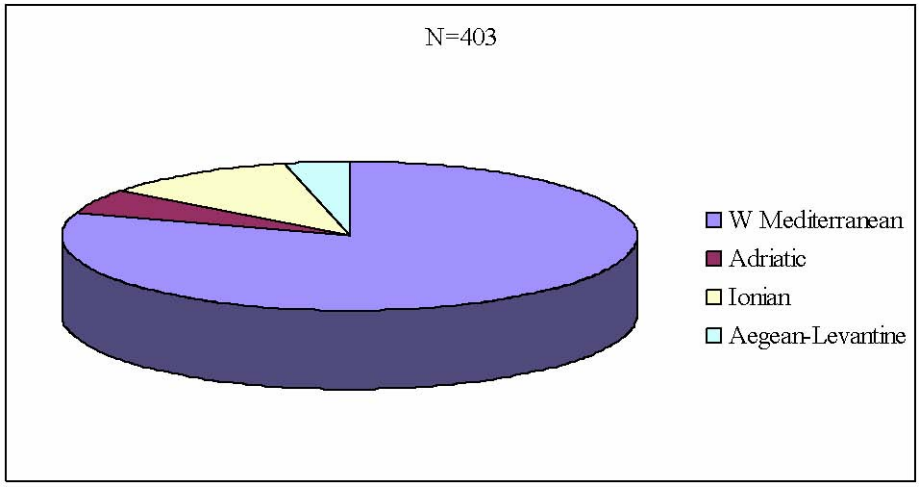


Figure 5 - Distribution of studies per sub-region. N= total number of studies.

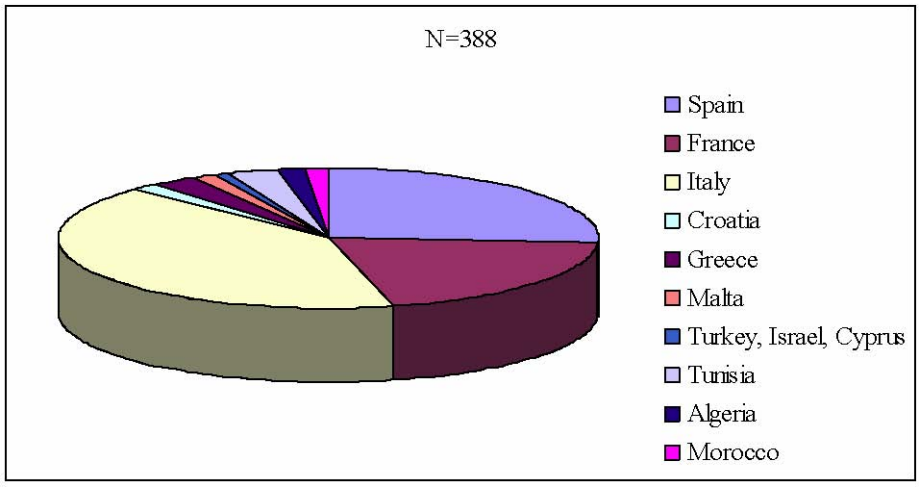


Figure 6 - Distribution of studies per country. N= total number of studies.

The western Mediterranean appears to be the most largely studied sub-region, with Italy, Spain and France contributing with the largest number of studies while the Ionian sub-region has been subject to an intermediate number of studies, mostly

carried out in Italian waters. Very few studies were censused in the Adriatic and Aegean-Levantine sub-regions. Scientific research in the latter occurs in Greek, Turkish, Cypriot and Israeli waters.

Figure 7 indicates the quantitative distribution of the studies *per* thematic category and sub-region. When summed up, the number of studies *per* thematic category is higher than that of the whole bibliographic data set due to the multi-disciplinary nature of most studies. The majority of studies focused on ecological themes. Fewer number of studies were conducted on aspects concerning “Species distribution” and “Threats, management and conservation” (116 and 118 studies, respectively). An even lower number of contributions regarded aspects such as “Taxonomy” and “Age and growth”, whereas very little interest appears to have been devoted to studies dealing with “Reproduction”, “Physiology and biochemistry” and “Genetics”. It is also noteworthy of mention that “Reproduction” and “Genetic” were themes studied only in the western Mediterranean.

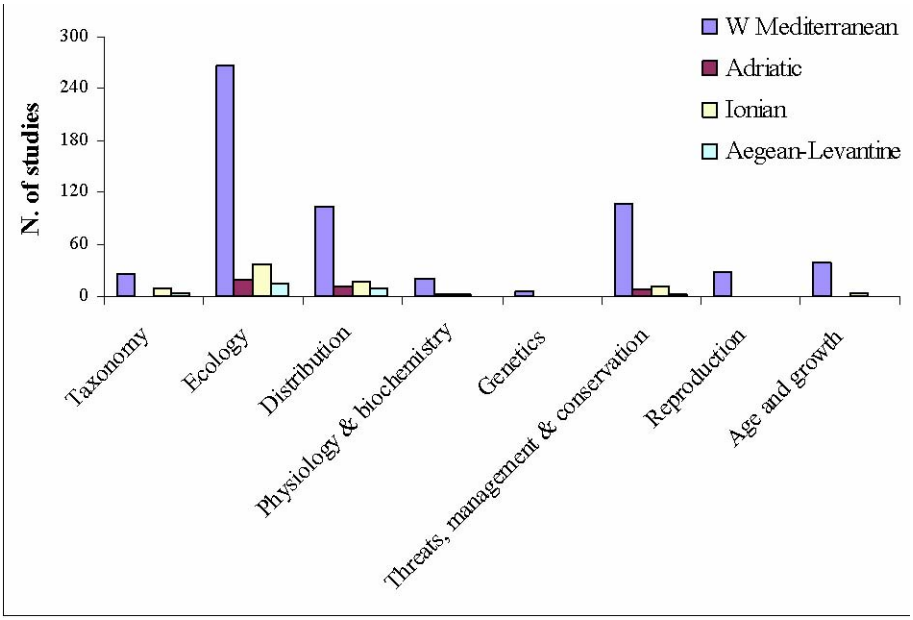


Figure 7 - Number of studies per thematic category and sub-region.

Much of work dealing with the coralligenous distribution and its threats, management and conservation, RAC/SPA priority themes, was mainly carried out in Italy, France and Spain and other western Mediterranean countries, such as Tunisia, Algeria and Morocco, whereas almost negligible number of contributions were recorded from the remaining Mediterranean countries (Fig.8).

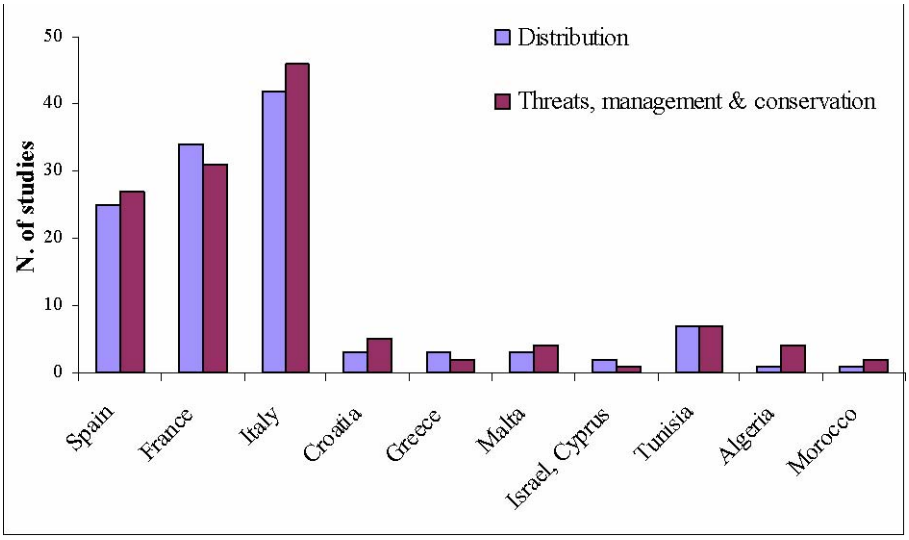


Figure 8 - Number of studies on "distribution" and "Threats, management and conservation" per country.

3.2. CARTOGRAPHIC STUDIES ON CORALLIGENOUS ASSEMBLAGES AND BIOCONCRETIONS

3.2.1. Censused Cartographic Studies

The censused bibliographic data set, composed of 524 scientific documents, comprehends 46 studies containing cartographic information, that is maps, some of which were implemented on the GIS (see Annex III for the electronic format of the database and the coralligenous GIS layer). These 46 studies pertain to 14 scientific papers published in scientific journals, 25 research project technical reports, and 7 other documents (1 poster, 1 congress contribution, 2 published maps, 3 CD Roms). The cartographic data that was analysed and implemented into the GIS is that which was collected until the end of October 2008 and amounts to 25 studies.

Most of the mapped areas have an extension that is exclusively limited to a single Mediterranean sub-region, with the exception of two maps located in the Sicilian and Apulian waters which, given their position, extend across two sub-regions. Most of the study areas are also described by a single study, with the exception of three areas (the Liguria region in Italy and Cap de Creus in Spain) which are described by respectively three and two studies.

On the overall, the geographical distribution of the mapped areas is mostly located in the western Mediterranean sub-region (N=31). A lower number of mapped areas is located in the Adriatic (N= 6) and the Ionian (N=6) sub-regions. Only one study derives from research carried out in the Aegean-Levantine sub-region. Forty-three percent of the mapped areas occur in protected areas, and most specifically in 14 marine protected areas and 6 Natura 2000 sites.

The habitat types that are most frequently encountered in the maps are: the coralligenous (41 areas), followed by the biocoenosis of coastal detritic bottoms characterised by the presence of bioconcretions (14 areas) and the pre-coralligenous (9 areas). The most highly represented assemblages of the coralligenous are those dominated by the gorgonians *Paramuricea clavata*, *Eunicella cavolinii* and *E. singularis* (respectively 8, 6 and 6 areas) and *Cystoseira zosteroides* (4 areas), while those of the coastal detritic bioceonosis are those belonging to the association with rhodolithes - *facies* with *Maërl* (13 areas), association with rhodolithes- *facies* with *Prâlines* (6 areas) and the association with *Peyssonnelia rosa-marina* - *facies* with free Peyssonneliaceae (2 areas).
Information on the sampling period is not always indicated in the cartographic studies. In fact, only up to 48% of the cartographic studies contain information on the sampling date. Most papers are based on data collected in the ‘90s and from 2000 onwards while only 3 studies were carried out before 1990.

3.2.2. Cartographic studies implemented in the GIS layer

Several difficulties were encountered in the implementation of some of the censused cartographic studies into the GIS. In fact, of the 46 maps, it was impossible to implement 19 maps (representing 41% of the overall censused cartographic studies) in the GIS layer for various reasons. In some cases this was due to referencing information, such as grid reference or detailed reference points, which was insufficient, while in others the biocoenosis distribution was clearly described as being derived only through geostatistical interpolation and, still in other cases, the original sampling data quality and procedures used to map the distribution of a specific habitat were admittedly scarce. In addition, in 12 French continental and Corsican coastal waters where bionomic maps are known to be present, the low resolution of the only available coralligenous cartographic information (see Fig. 9) prevented their implementation into the GIS layer. The distribution of the censused coralligenous cartographies is indicated in Fig. 10. This figure reports the distribution of all the cartographies implemented in the GIS layer as well as the location of the cartographies that were either not available or not implemented. Two maps have been inserted in the latter category, namely, the bionomic map of the Medes islands (Spain) and the bionomic map of Gaiola (Italy), which is to be attributed to the late acquisition date of the maps with respect to the time in which the GIS implementation procedure and analysis was conducted for the present study. The 25 maps (54%) included in the GIS layer comprehend 10 cartographic studies which were collected through the networking established with the international and national research groups, while the remaining others were obtained through the bibliographical research.

The high level of heterogeneity of the information implemented can be due to the different source of the data, which could influence the level of implementation accuracy, to the values of the original scale and to the publication' year of the map.

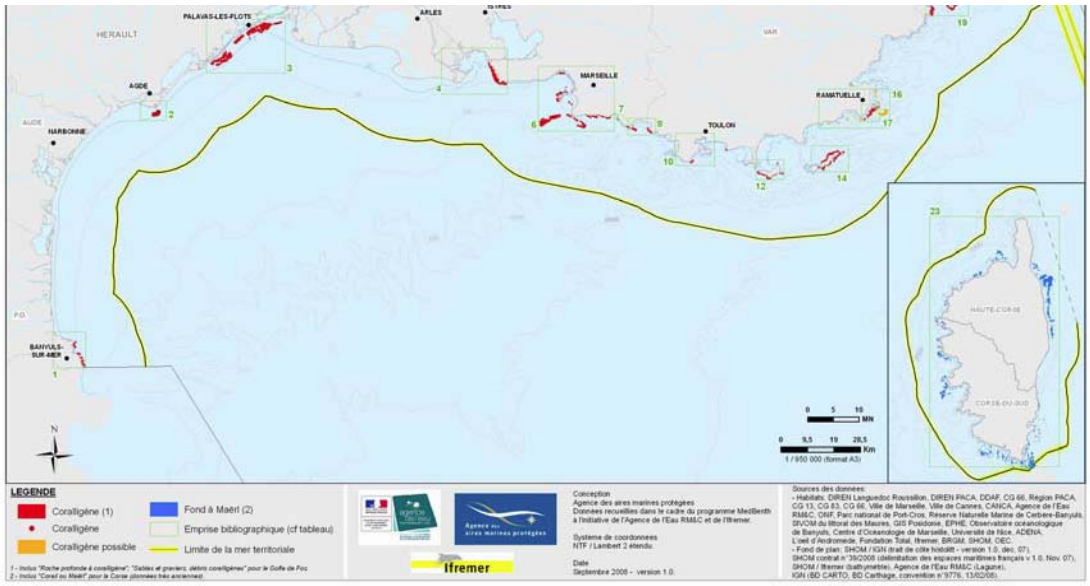


Figure 9 - Map Prepared by the France "Agence des aires marines protégées".

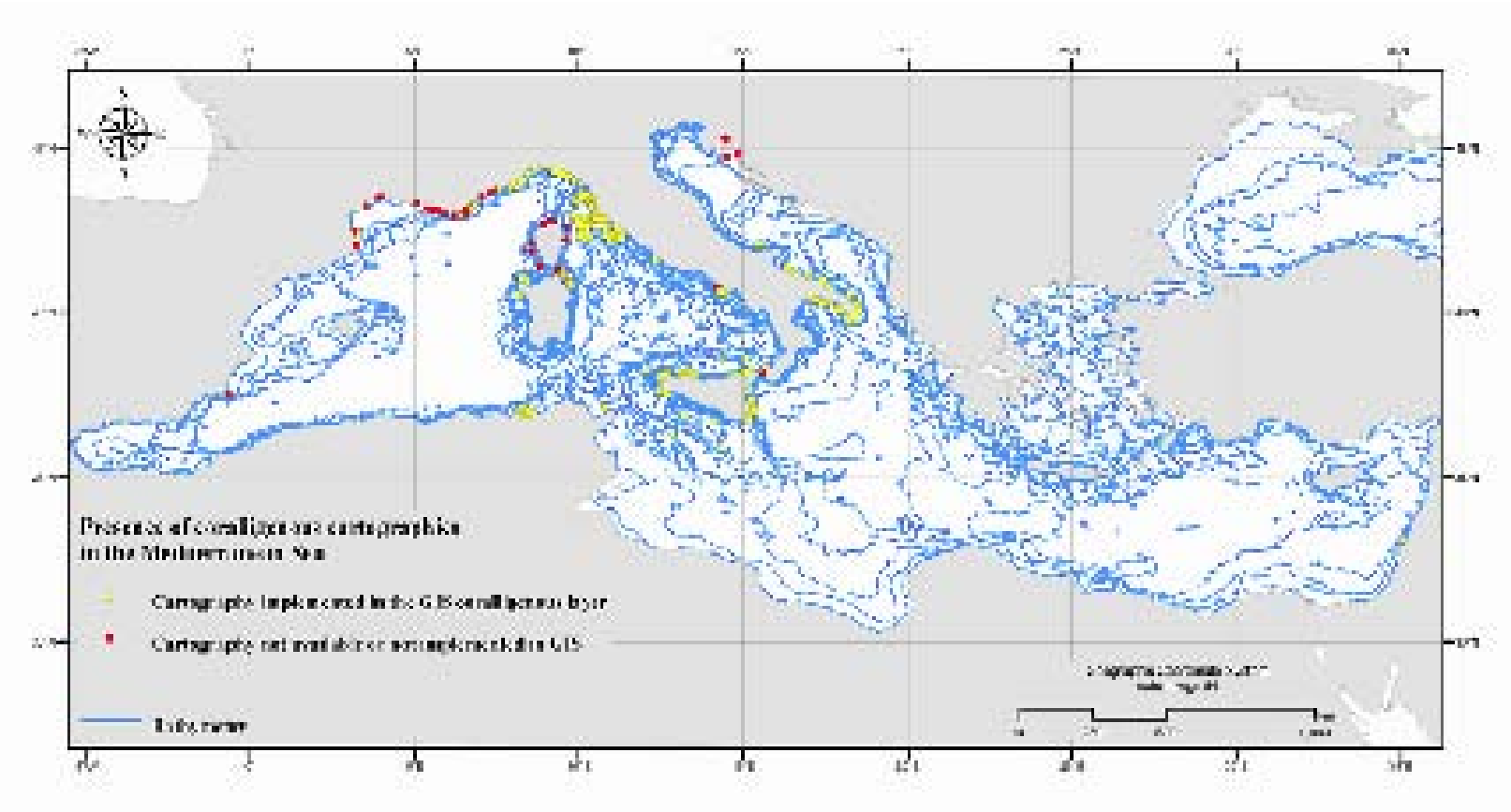


Figure 10 : Presence of coralligenous cartographies in the Mediterranean Sea.

Fig. 11 indicates the data source percentages of the maps. The majority of the implemented data were printed directly on thematic maps (32%) whereas other maps were contained in scientific papers (24%) or technical reports (21%). The data received as shape file represent 21%.

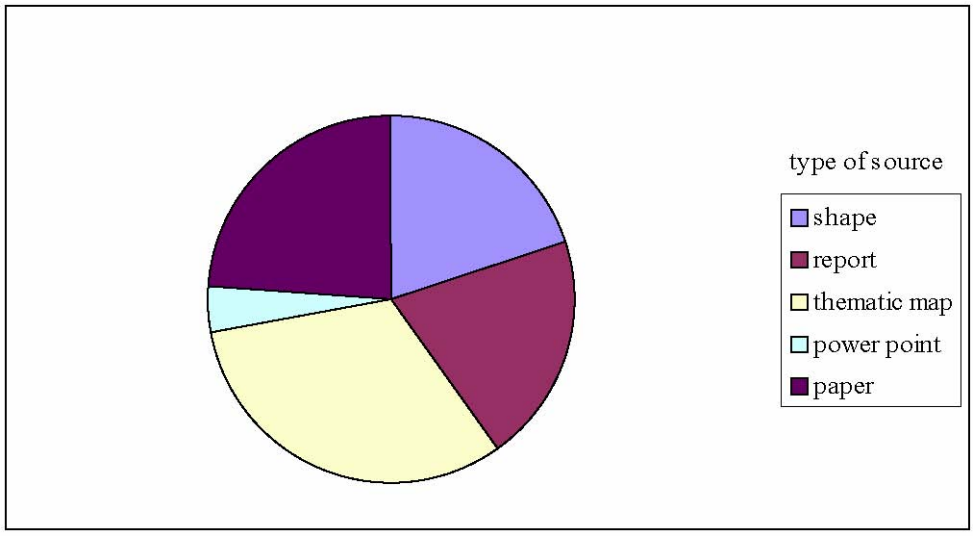


Figure 11 - Data source percentage of the implemented data.

The degree of implementation accuracy of the maps implemented in the GIS layer is indicated in Fig.12.

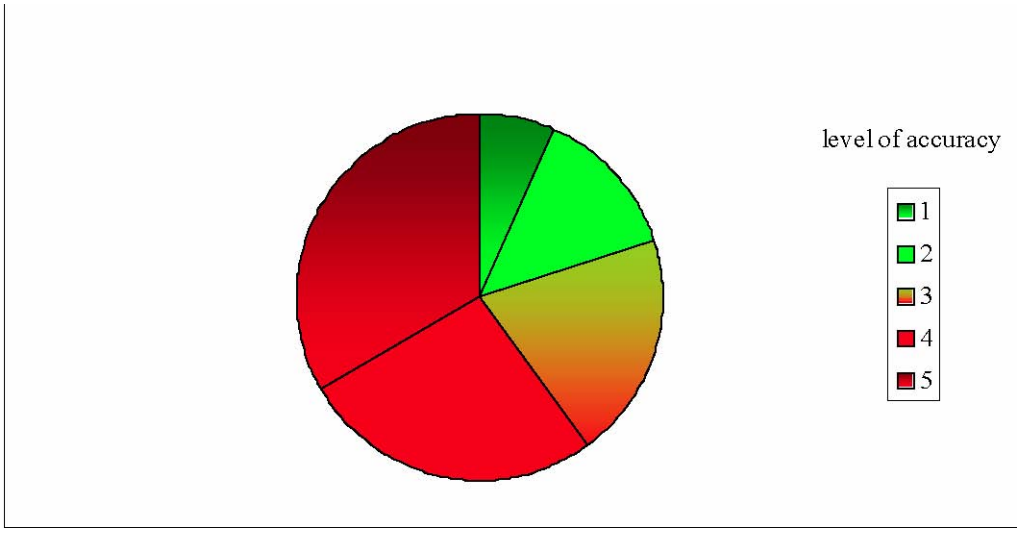


Figure 12 -Level of implementation accuracy percentage of the maps implemented in the GIS layer.

Unfortunately the majority of the maps have a low level of implementation accuracy. In fact more than one half (60%) of the information was been

classified at levels 5 and 4, whereas the intermediate level (level 3) and higher levels (level 1 and 2) each represent respectively 20%.

The original scale was reported only in 36% of the implemented maps and, when present, the values range between 1:2,500 and 1:500,000. This is quite typical considering that the implemented information came from different typology of studies for which the produced map has different goals (i.e. MPA biocoenosis maps or wide area bionomic cartographies). The publication' year of the documents containing implementable maps belong to the '90s and '00s (respectively 5 and 15 documents) whereas only 3 studies are dated before 1990. For the information whose data source are a poster and a power point presentation no publication' year was detected.

The coralligenous layer amounts to 1185 polygons for a total surface area extension of 3182.19 $Km^{2.}$. The polygon with the smallest surface is 8 m^2 while the biggest measures about 400 km^2. Table 11 indicates the estimated area for each biocoenosis and *facies* implemented in the layer. It is important to mention that the standardization process was fundamental to compare the collected data, in fact almost all the cartographic studies used different biocoenosis/assemblages and *facies* terminology.

Table 11 - Estimated areas (Km^2) of each biocoenosis and respective *facies* according the standardized classification.

Facies	**Biocoenosis**			**Total**
	Pre-coralligenous assemblage	Coralligenous biocoenosis	Biocoenosis of coastal detritic bottoms	
Not specified	90.34	1234.63		1324.97
Association with *Sargassum spp*. (indigenous spp.)		0.02		0.02
Facies with *Paramuricea clavata*		0.52		0.52
Facies with large Porifera		1.57		1.57
Coralligenous platforms		0.86		0.86
Association with rhodolithes - Facies with Mäerl			1500.50	1500.50
Association with rhodolithes - Facies with Prâlines			46.63	46.63
Association with rhodolithes - Facies with Lithothamnion minervae			58.88	58.88
Association with rhodolithes			1.69	1.69
Association with *Peyssonnelia rosa-marina* - Facies with free Peyssonneliaceae			246.56	246.56
Total	90.34	1237.60	1854.25	3182.19

The highest quantity information falls within the biocoenosis of the coastal detritic bottoms (58.3%), followed by the coralligenous biocoenosis (38.9 %) and the pre-coralligenous assemblage (2.8 %). No cartographic information was found on the assemblages characteristic of the biocoenosis of coarse sands and fine gravels under the influence of bottom currents where the association with rhodolithes - *facies* with *Mäerl* can instead occur. In most cases, the highest degree of habitat level definition (association/*facies)* was not specified in many cases (41.6%) while the most represented is the association with rhodolithes - *facies* with *Mäerl* (47.1%).

3.2.3. Implemented Cartographic studies : data sheet and layout

The data sheet and one or more layout, for each data set implemented in the layer, are contained in Annex IV. For a simple reading of the map, the legend used for each layout corresponds only to the information reported in the layout itself. The complete legend is illustrated in Fig. 13.

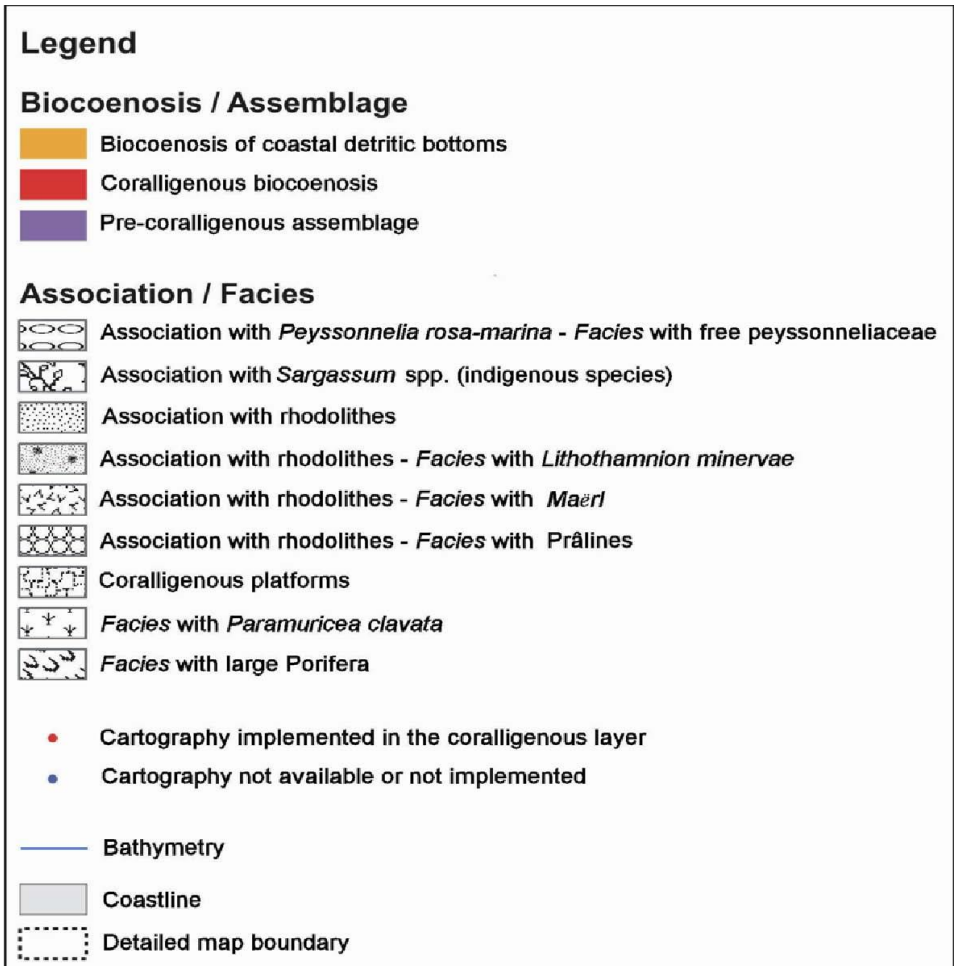


Figure 13 - Legend describing all the colours, shades and symbols used to represent thematic and basic layer.

The general distribution of the implemented data and the relative number of the data sheet is given in Fig.14, in order to guide the search for a specific data set.

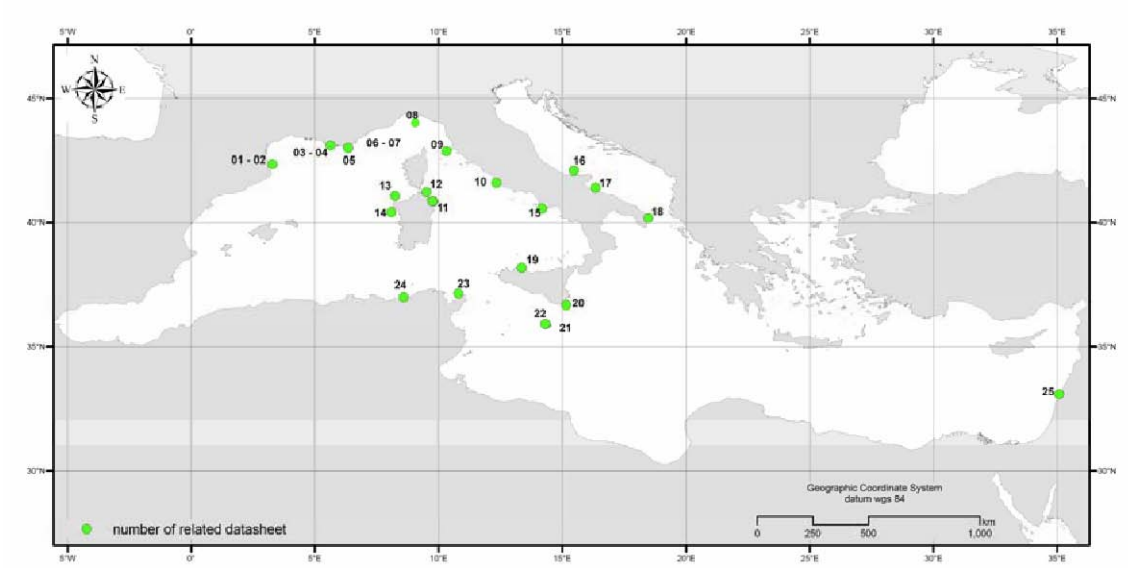


Figure 14 - Key map of the data sheet. Green points indicate the approximate location of the implemented data set.

4. CONCLUSIONS AND DISCUSSION

The bibliographical search of all the studies and cartographies on the coralligenous biocoenosis and other bio-concretions demonstrated that the majority of studies are located in the western Mediterranean Sub-region. The presently outlined census indicates that though qualitatively valuable, the collected cartographic data are limited in number and distribution. In fact, despite the large body of scientific literature on the coralligenous biocoenosis and its inhabitants, very few studies, almost exclusively limited to the western Mediterranean sector, have focused on the collection of spatial data that are suitable for implementation in a cartographic GIS layer. Furthermore, most of these cartographic studies have been carried out within marine protected areas, where a bionomic characterization of sea bottoms is considered the preliminary step to support zoning and resource management plans.

An attempt was made to overcome the limit in number of observed cartographic studies by directly contacting scientists operating within national and international scientific networks. This collaboration allowed to collect cartographic material that would have gone undetected, even though much data is likely to be still missing. It is important to point out that the deficiency of available cartographic information for many areas does not necessarily imply that the coralligenous and other bio-concretions are actually absent. In fact, the absence of cartographic information on the distribution of coralligenous and other bio-concretions can be sometimes partially due to other factors other than a knowledge gap. Several documents containing biocoenotic maps are “grey literature” (e.g. technical or final reports, posters, unpublished manuscripts) which is usually not inventoried in the most comprehensive bibliographic databases. This implies that many unpublished documents are likely to have been excluded from our census and will continue to be so unless a specific Mediterranean reporting system is devised in the future.

The cartographic studies which were implemented in the GIS were mostly derived from studies conducted during the last 8 years which also confirms that adequate mapping standards and initiatives are at an initial step and that this trend must be increased and strengthened through appropriate measures. The fact that 41% of the maps could not be implemented in the GIS also points out two aspects: data collection efforts are carried out with insufficient detail to the detriment of their implementation in geospatial management tools such as GIS, and/or maps are not available. These aspects together with the aspect that more than 75% of maps were not in a shapefile format, which would allow direct implementation in GIS, confirms the need to incentivate and direct future

mapping initiatives, so that they may always provide adequate digital map products and, most importantly, that they may be shared within the scientific community. The original maps implemented within the GIS layer were highly heterogeneous in terms of scale, precision, resolution and biological information detail. This together with a great deal of discrepancy in usage of the benthic habitat classification terminology and the fact that over 40% of the maps did not provide the maximum level of habitat definitions (i.e. *facies*/assemblage) underlines the need for greater harmonisation in the process of scientific elaboration of the studies on a region-wide scale. Such a process could possibly benefit from the launching of international capacity building initiatives within the scientific community working on benthic habitats. Furthermore, the large predominance of studies, and consequent production of maps, exclusively on certain *facies* of the coastal detritic bottoms (namely the *Maërl* association) and of the coralligenous *facies* characterized by gorgonian species indicates the need to conduct more investigative efforts on the other *facies*/association, as well as on the rhodolith associations occurring in the biocoenosis of coarse sands under bottom currents. On the other hand, the high percentage of surface area estimated for the biocoenosis of the coastal detritic bottoms having different bioconcretions can be due to the fact that it is generally found on horizontal soft bottoms, whereas the coralligenous biocoenosis is mainly found on steep rocky substrates. In this scenario the two dimensional data representation of a GIS can provide a more realistic area estimation of the biocoenosis of the coastal detritic bottoms rather than that of the coralligenous biocoenosis.

Despite the high study effort in the western Mediterranean sub region, the availability of public cartographic data for some countries, like Spain for instance, is surprisingly low. The bibliographical search also allowed to highlight areas where this issue is generally understudied (southern and eastern part of the basin) which is in accordance with the low cartographic data availability in this region. A large study gap was observed for the coralligenous formations of the Aegean-Levantine sub-region, where these assemblages are known to be present (Laborel, 1961). The above considerations are in line with the situation illustrated already by Ballesteros (2006). In fact, an analysis of the censused bibliographic documents published after 2005, in terms of their distribution in the Mediterranean, shows that the same trend in geographical knowledge gap is still present.

In addition to providing an idea of the geographical location of the investigated areas, the present work also analysed their ecological value, allowing to define areas of special interest because of the presence of these biocoenosis, and to

support the future planning of cartographic studies. In a similar way the analysis of the distribution of such studies indicates that the Adriatic, the Ionian and the Aegean-Levantine are sub-regions characterized by ecological and conservation-linked knowledge gaps. All these elements highlight that the action plan priorities should focus on specific studies to identify the distribution of these relevant assemblages and improve the level of knowledge on biological aspects and the main threats to which the assemblages are exposed, which can help to identify the most relevant conservation measures that need to be enacted.

The main gaps emerging from the above described analysis suggest the need of new research effort devoted to:

a. The completion of the cartography of the coralligenous assemblages at a Mediterranean scale, enhancing in particular the knowledge on their distribution in the less studied areas, to identify sites of particular interest;

b. Region wide mapping initiatives and synergies capable of stimulating an automatic reporting procedure on the studies of these assemblages. At the same time however, the working schemes should be compliant to universally agreed standards both in terms of data acquisition methodologies (i.e. standards for sampling) useful to provide sufficient details of information using agreed benthic habitat terminology referring to a universally recognized habitat classification list, and leading up to the production of georeferenced digital maps with adequate geographic resolution and scale;

c. New studies on ecological and physiological aspects, considering also specific inventories, along the eastern and the southern Mediterranean coasts, so as to identify/evaluate the possible presence of differences / trends related to oceanographic aspects;

d. Urgent start-up of monitoring activities in the most relevant sites (SPAMIs, Natura 2000 sites and other MPAs), both to monitor possible changes due to the effects of the management (on waste water discharges, anchoring, fishing, diving) and to evaluate the trends in the long term evolution of the assemblages to assess the effects of the global warming (i.e. the deepen of the summer thermocline) and of the invasive species.

e. Stringent start-up of procedures for the future establishment of protected/conservation areas, identified as a consequence of point a) and b) above, useful to mitigate the different threats affecting the various assemblages are known to be exposed to.

It is to be pointed out that the present document should be considered as a starting point for the collection of cartographic information regarding the

distribution of coralligenous and other bio-concretions in the Mediterranean Sea. Considering that an alphanumeric or cartographic data base, is, by its very exclusive nature, outdated the day after it is delivered, it is crucial that it be kept functioning through its continuous update and expansion. It is therefore hoped that the enactment of a detailed series of activities on the implementation of the Action Plan, be carried out also in light of the conclusions listed above so as to allow the future enrichment of the cartographic database to the benefit of an increased knowledge on these habitats' distribution and most critical conservation needs.

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ANNEX 1 : Marine scientists, networks of marine scientists, public research institutes and agencies and environmental organization contacted

The search of the cartographic material has been carried out involving the following international and national networks of marine scientists, public research institutes and agencies and environmental organizations:

- CIESM (Commission pour l'Exploration Scientifique de la mer Méditerranée)
- GIS Posidonie (France)
- SIBM (Società Italiana di Biologia Marina) coralligenous working group (Italy)
- Agence des aires marines protégées (France)
- ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale) (Italy)
- MEDPAN (The Network of Managers of Marine Protected Areas in the Mediterranean)
- WWF (World Wildlife Found) Mediterranean
- WWF (World Wildlife Found) Spain

Within the framework of the above mentioned networks, the following people have been directly contacted:

ABELLARD Olivier, ACUNTO Stefano, ARKO-PIJEVAC Milvana, BABBINI Lorenza, BALATA David, BANKS Andy, BARBATO Fabio, BAVA Simone, BEJAOUI Nejla, BELLAN-SANTINI Denise, BELLUSCIO Andrea, BIANCHI Carlo Nike, BOERO Ferdinando, BOUDOURESQUE Charles François, BRESSAN Guido, BRIAND Frederic, CALVO Sebastiano, CANTONE Grazia, CARRADA Giancarlo, CASELLATO Sandra, CATTANEO-VIETTI Riccardo, CECERE Ester, CERRANO Carlo, CHEMELLO Renato, CHESSA Lorenzo, CINELLI Francesco, COCITO Silvia, CORRIERO Giuseppe, COSSU Andrea, DAMIER Elodier, DENEUX Frédéric, DI MARTINO Vincenzo, DIVIACCO Giovanni, GARCÍA-CARRASCOSA A. Manuel, GARCÍA-VARAS José Luis, GIACCONE Giuseppe, GILI Josep-Maria, GIOVANARDI Otello, IKRAM Irathni, LASRAM Frida, LLORET Javier, LLORET Josep, MASSUTÍ Enric, MATARRESE Alfonso, MAZZOLA Salvo, MICCIO Antonio, MISTRI Michele, MOLINARI Andrea, MORRI Carla, MOSCHELLA Paola, NAVONE Augusto, NICOLETTI Luisa, NONNIS Carlotta, ORFANIDIS Sotiris, ORSI Lidia, ÖZHAN Erdal, PANAYOTIDIS Panayotis, PERGENT Gerard, PETROCELLI Antonella, PIANTE Catherine, PIAZZI Luigi, PICCINETTI Corrado, PISCITELLI Gaetano, POME Alessandra, PONTI Massimo, PRONZATO Roberto, RAMOS-ESPLÁ

Alfonso, RELINI Giulio, RIGGIO Silvano, ROSSIN Pietro, RUSSO Giovanni Fulvio, SANTANGELO Giovanni, SCHEMBRI Patrick J., SIMBOURA Nomiki, TERLIZZI Antonio, TOCCACELI Marco, TORCHIA Giovanni, VACCARELLA Raffaele.

ANNEX 2 : Censused bibliography

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« Document d'objectif site Natura 2000 « Posidonies de la Côte des Albères » Phase I : Inventaire et analyse de l'existant », 2004, Réserve Naturelle Marine de Cerbère-Banyuls, Conseil Général des Pyrénées-Orientales, GIS Posidonie, Ecole Pratique des Hautes Etudes, Observatoire océanologique de Banyuls, ADENA.

« Document d'objectif du site Natura 2000 « Posidonies du Cap d'Agde » - Atlas », Janvier 2008, ADENA, DIREN Languedoc-Roussillon, Agence de l'Eau RM&C, Conseil général du Languedoc-Roussillon, Université de Nice, CNRS-EPHE Université de Perpignan.

« Etude et cartographie du milieu marin du site NATURA 2000 « Posidonies de la côte palavasienne » », *2008, ANDROMEDE ENVIRONNEMENT 2008.* Rapport final. Contrat DIREN & Andromede Environnement. *Andromede publ*., Fr. : 1-104 + annexes.

« Fonds et recouvrement sédimentaire du golfe de Fos et ses annexes », 1975, Centre national pour l'exploitation des océans, Centre d'Océanologie de Marseille, Laboratoire de géologie marine et sédimentologie appliquée, J.J. BLANC, M. ROUX, E. VERNIER

« Cartographie de habitats marins – Plan de gestion de la rade de Marseille », 2007, Ville de Marseille, Agence de l'Eau RMC, Région PACA.

« Etude et cartographie des biocénoses marines du sous site Natura 2000 « Cap Canaille – Grand Caunet » », 2006, Office National des forêts, GIS Posidonie, Ifremer, COM.

« Etude du patrimoine marin environnant les domaines départementaux de l'île verte et du Mugel – phase 1 (Etat de la connaissance) », 2003, Conseil général des Bouches du Rhône, GIS Posidonie, Ifremer.

« Contrat de baie de la rade de Toulon – Etude et cartographie des biocénoses », 2001, Toulon Provence Métropole, Région PACA, DIREN PACA, CG du Var, Agence de l'Eau RMC, GIS Posidonie, Ifremer

« Etude et cartographie des biocénoses du milieu marin de l'île de Porquerolles (Var – France) », 2007, Parc national de Port-Cros, Fondation Total, Ifremer, GIS Posidonie.

« Etude et cartographie des biocénoses du milieu marin de l'île du Levant (Var – France) », 2007, Parc national de Port-Cros, Fondation Total, Ifremer, GIS Posidonie.

« Etude préalable à la mise en place de l'Observatoire marin du littoral des Maures le long des côtes de Ramatuelle – Etat de la connaissance du milieu, synthèse bibliographique », 2004, SIVOM du Littoral des Maures, Agence de l'Eau RMC, SAFEGE CETIIS.

« Cartographie des biocénoses marines sur le site Natura 2000 des 3 caps », 2007, SIVOM du littoral des Maures, Région PACA, Gis Posidonie.

« Cartographie des biocénoses marines - Contrat de baie de cannes », 2008, Ville de Cannes, Conseil général des Alpes-Maritimes, Région PACA, Agence de l'Eau RMC.

« Cartographie et analyse des biocénoses marines entre Antibes et Cap d'Ail – Etude complémentaire au contrat de baie », HOLON F., DESCAMP P., 2007, Contrat Communauté d'Agglomération Nice-Côte d'Azur.

« Cartes historiques de nature des fonds et faciès secondaires des plates-formes de la Corse élaborées à partir de levés hydrographiques, pour le SHOM, au plomb suiffé, entre 1884 et 1891, numérisées dans le cadre du programme LIMA *(« LIMA – Cartographie des plates-formes sous-marines de la Corse entre 0 et 100m de profondeur – Etude réalisée dans le cadre des opérations du service public du BRGM 2000-2001 - LIT-204 », Novembre 2001, BRGM, Office de l'Environnement de la Corse, DIREN Corse*) sous le contrôle de l'EPSHOM Brest.

ANNEX 3 : Data sheets and layout

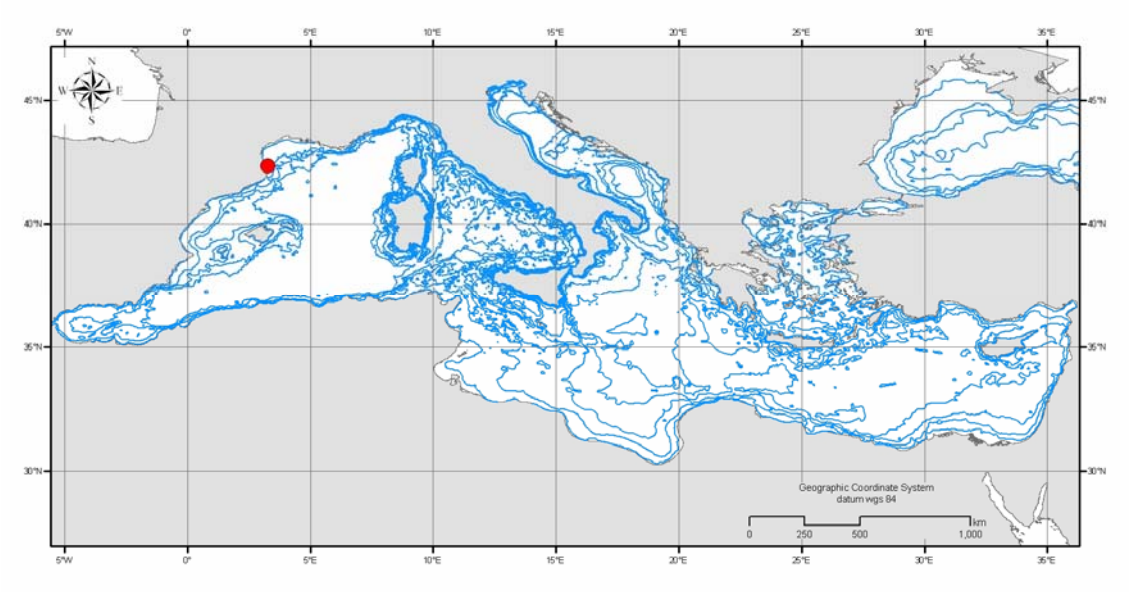
Data sheet 01

Reference document source

PARC NATURAL DE CAP DE CREUS, DEPARTAMENT DE MEDI AMBIENT I HABITATGE, CSIC. Hàbitats marins del Parc Natural de Cap de Creus. Poster.

Location

Western Mediterranean, Spain, Cap de Creus.



Sampling Date

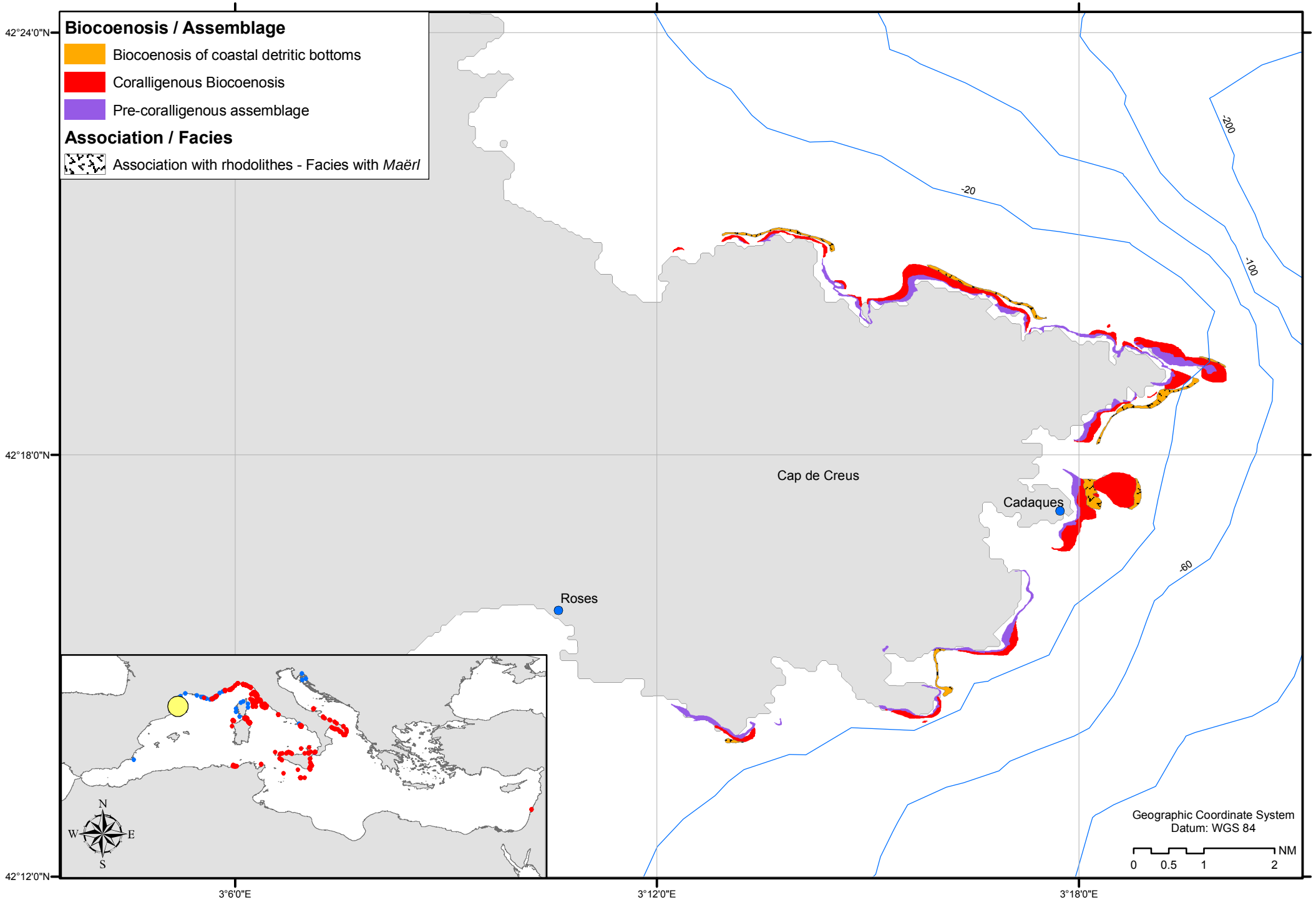
Sampling method

Original scale

Layout

Number of layouts: 1

Database ID


Biocoenosis / Assemblage
Biocoenosis of coastal detritic bottoms
Coralligenous Biocoenosis
Pre-coralligenous assemblage
Association / Facies
Association with rhodolithes - Facies with Maërl
42°24'0"N
42°18'0"N
42°12'0"N
3°6'0"E
3°12'0"E
3°18'0"E
-20
-100
-200
-60
Cap de Creus
Cadaques
Roses
N
W
E
S
Geographic Coordinate System
Datum: WGS 84
NM
0
0.5
1
2

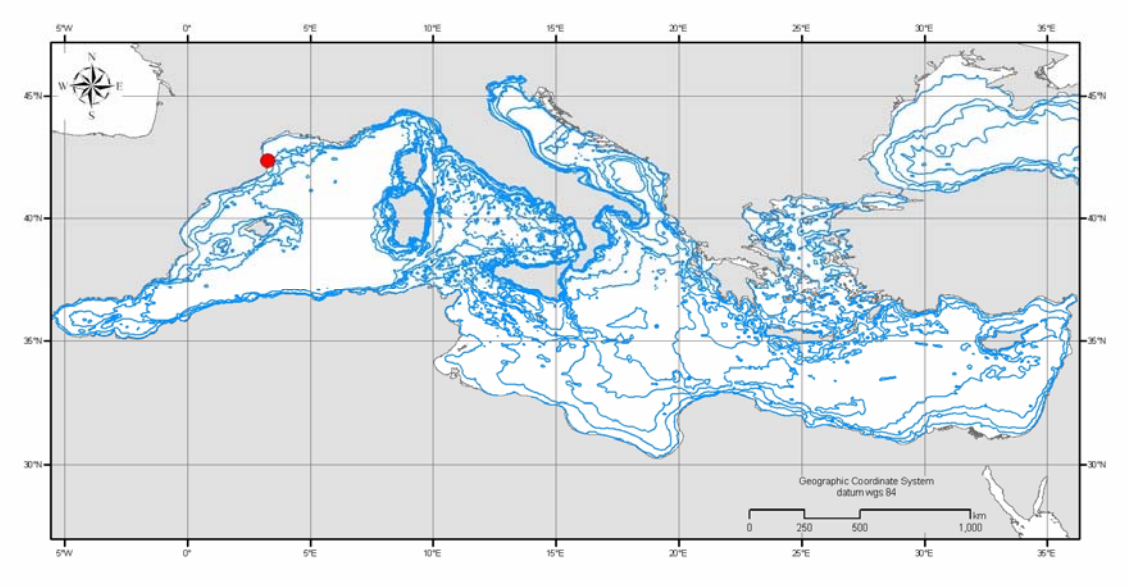
Data sheet 02

Reference document source

GILI J.M., SARDÀ R., ROSSI S. - Caracterització bionòmica del bentos marí del Cap de Creus. Project Interreg III A - CSIC

Location

Western Mediterranean, Spain, Cap de Creus.



Sampling Date

Sampling method

Original scale

Layout

Number of layouts: 1

Database ID

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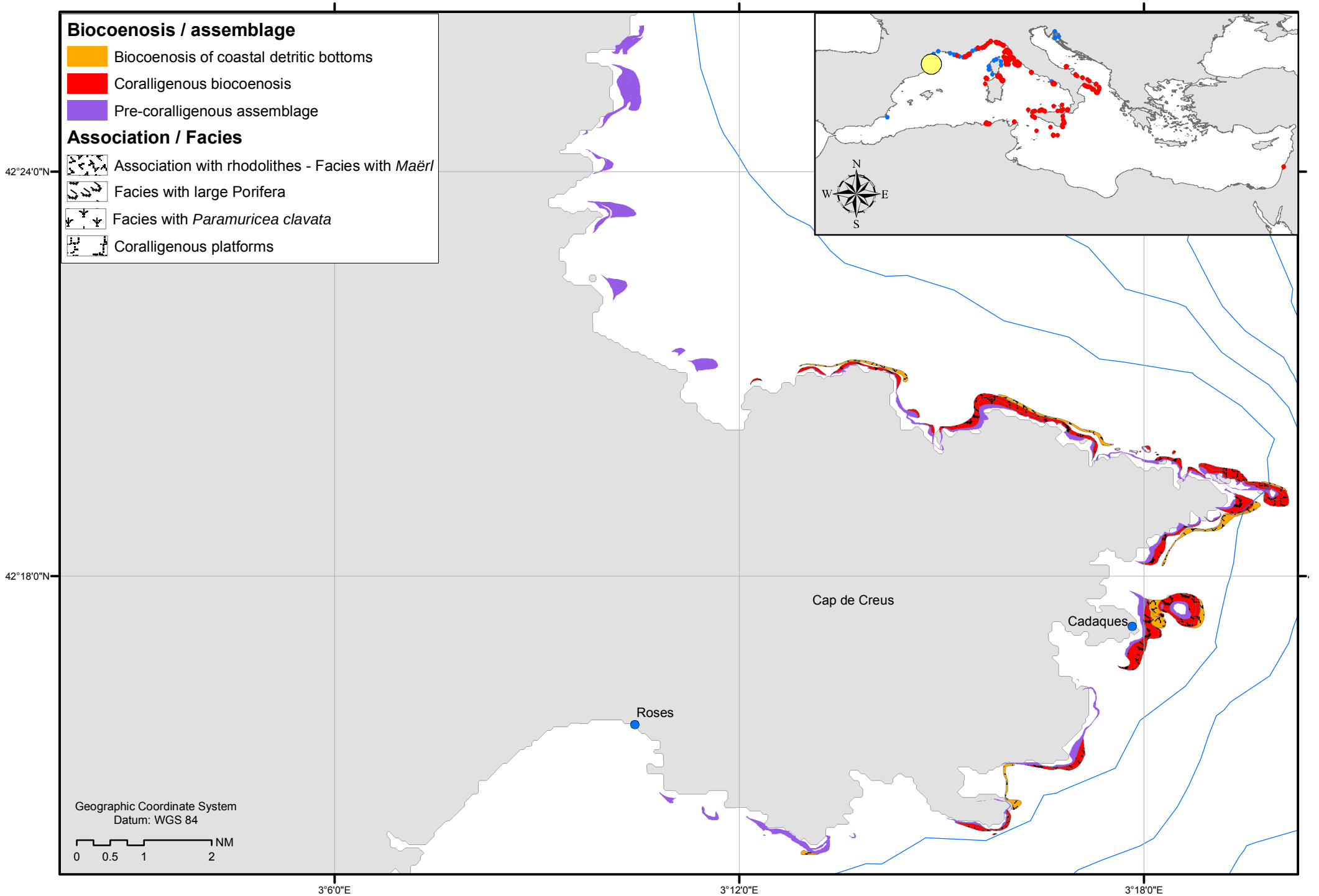

Biocoenosis / assemblage
Biocoenosis of coastal detritic bottoms
Coralligenous biocoenosis
Pre-coralligenous assemblage
Association / Facies
Association with rhodolithes - Facies with Maërl
Facies with large Porifera
Facies with Paramuricea clavata
Coralligenous platforms
N
W
E
S
42°24'0"N
42°18'0"N
Cap de Creus
Cadaques
Roses
Geographic Coordinate System
Datum: WGS 84
0 0.5 1 2 NM
3°6'0"E
3°12'0"E
3°18'0"E

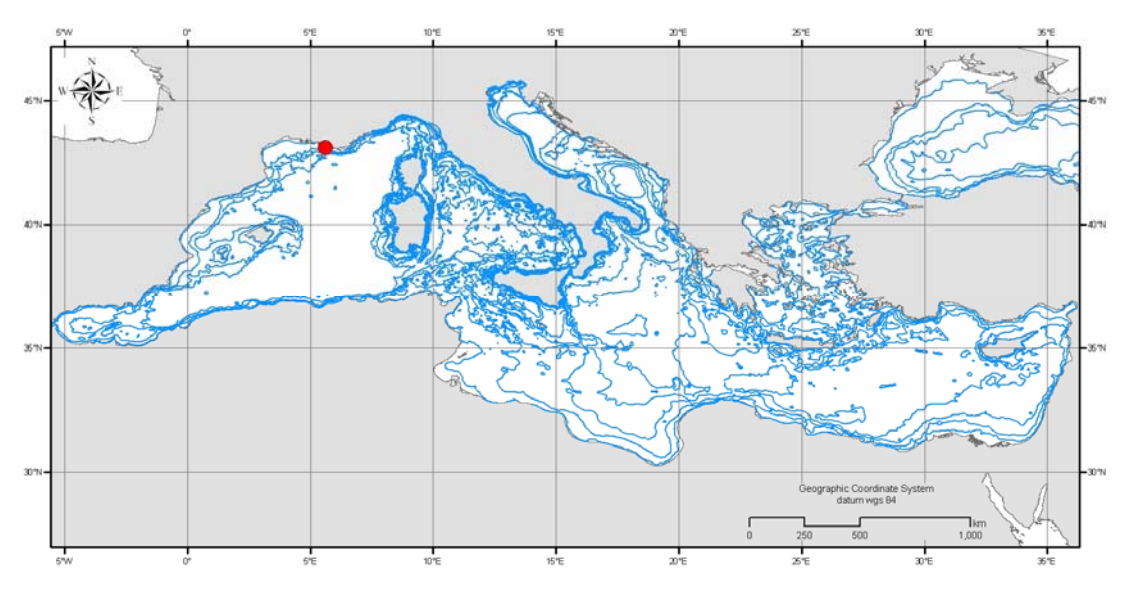
Data sheet 03

Reference document source

BONHOMME P., BOUDOURESQUE C.F., BERNARD G., VERLAQUE M., CHARBONNEL E.,CADIOU G. (2001) – Espèces, peuplements et paysages marins remarquables de la Ciotat, de l'ile Verte à la calanque du Capucin (Bouches du Rhône, France). *Contrat RAMOGE & GIS Posidonie*, *Gis Posidonie publ., Fr.* 132 pp.

Location

Western Mediterranean, France, La Ciotat.



Sampling Date

2000

Sampling method

Scuba diving

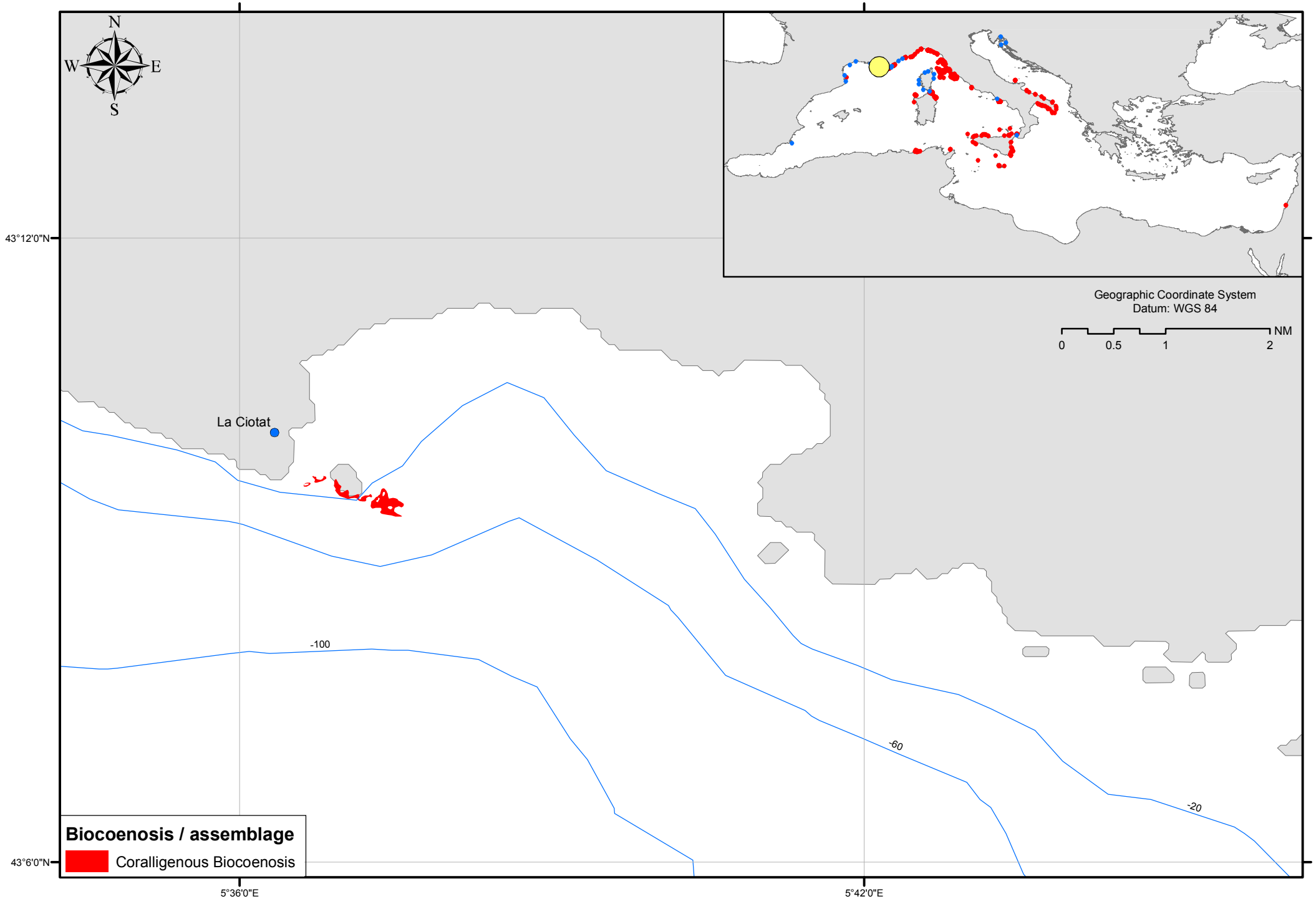
Original scale

Layout

Number of layouts: 1

Database ID

25


N
W
E
S
43°12'0"N
43°6'0"N
5°36'0"E
5°42'0"E
La Ciotat
-100
-60
-20
Geographic Coordinate System
Datum: WGS 84
0
0.5
1
2
NM
Biocoenosis / assemblage
Coralligenous Biocoenosis

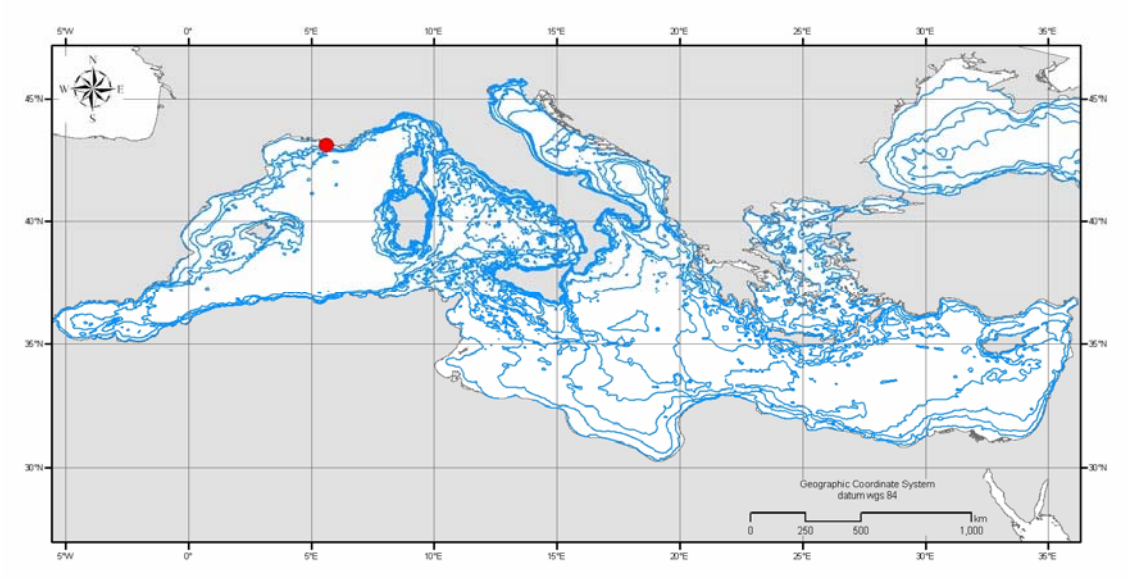
Data sheet 04

Reference document source

BOISSERY P., ANDRAL B., MEDIONI E., BEUROIS J., DURAND B. (2005) – La cartographie des habitats marins dans les plans de gestion de la rade de Marseille et du secteur de l'ile Verte et du Mugel (LaCiotat). La cartographie des habitats marins dans la gestion intégrée du littoral en France. Colloque Mesh-Malo – Ifremer Dyneco/Vigies, Saint-Malo les 8 et 9 novembre 2005
http://www.ifremer.fr/mesh-malo/pdf/8_habitats_marins_rade_Marseille_Ciotat.pdf

Location

Western Mediterranean, France, Marseille, Ile Verte, La Ciotat.



Sampling Date

Sampling method

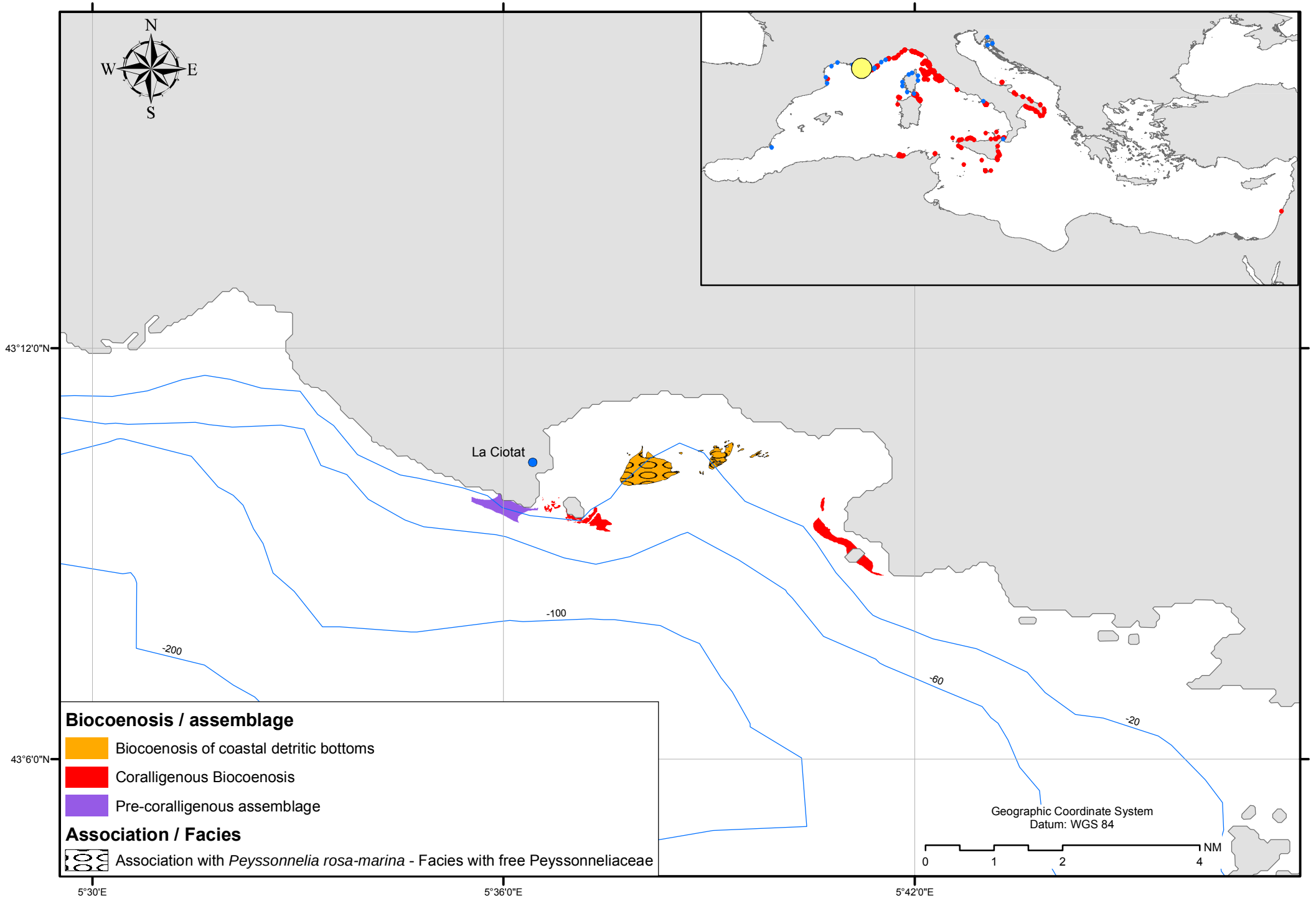
Scuba diving, side scan sonar

Original scale

Layout

Number of layouts: 1

Database ID


N
W
E
S
43°12'0"N
43°6'0"N
5°30'E
5°36'0"E
5°42'0"E
La Ciotat
-100
-200
-60
-20
Biocoenosis / assemblage
Biocoenosis of coastal detritic bottoms
Coralligenous Biocoenosis
Pre-coralligenous assemblage
Association / Facies
Association with Peyssonnelia rosa-marina - Facies with free Peyssonneliaceae
Geographic Coordinate System
Datum: WGS 84
0
1
2
4
NM

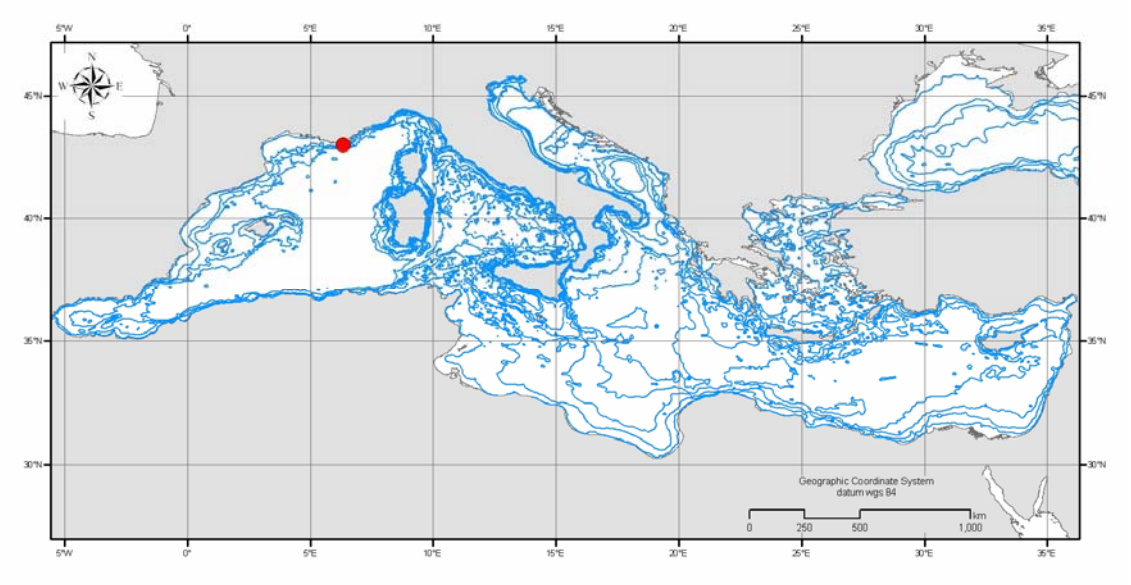
Data sheet 05

Reference document source

BOURCIER M. (1982) – Nouvelles localisations et délimitation fine de quelques faciès de la biocénose des fonds détritiques côtiers du Parc national de Port-Cros *Trav. Sci. Parc Natl. Port-Cros*, **8**: 19-23.

Location

Western Mediterranean, France, Port-Cros.



Sampling Date

1980

Sampling method

Grab sampler

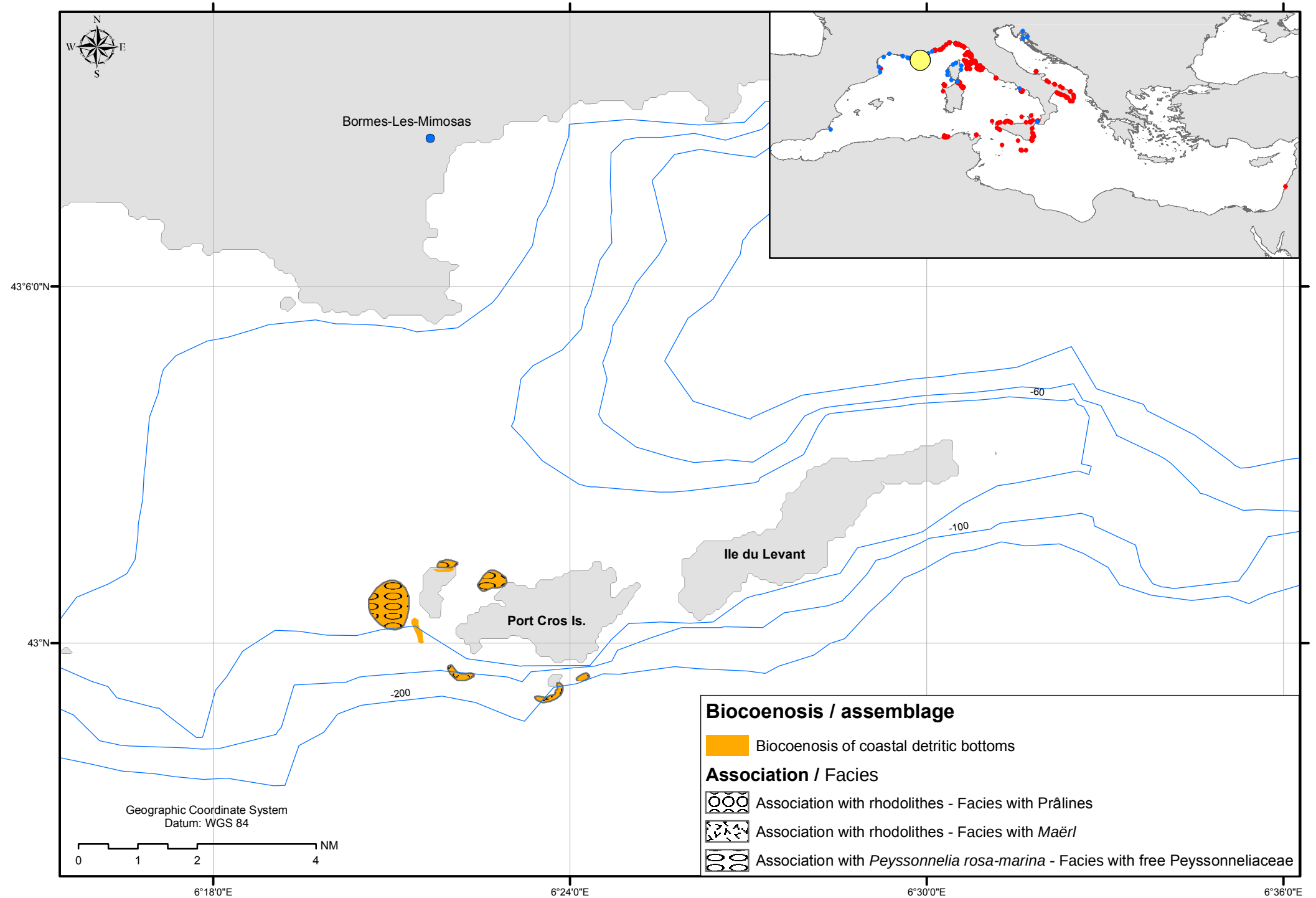
Original scale

Layout

Number of layouts: 1

Database ID

6


N
W
E
S
Bormes-Les-Mimosas
43°6'0"N
43°N
6°18'0"E
6°24'0"E
6°30'0"E
6°36'0"E
-60
-100
-200
Ile du Levant
Port Cros Is.
Geographic Coordinate System
Datum: WGS 84
0
1
2
4
NM
Biocoenosis / assemblage
Biocoenosis of coastal detritic bottoms
Association / Facies
Association with rhodolithes - Facies with Prâlines
Association with rhodolithes - Facies with Maërl
Association with Peyssonnelia rosa-marina - Facies with free Peyssonneliaceae

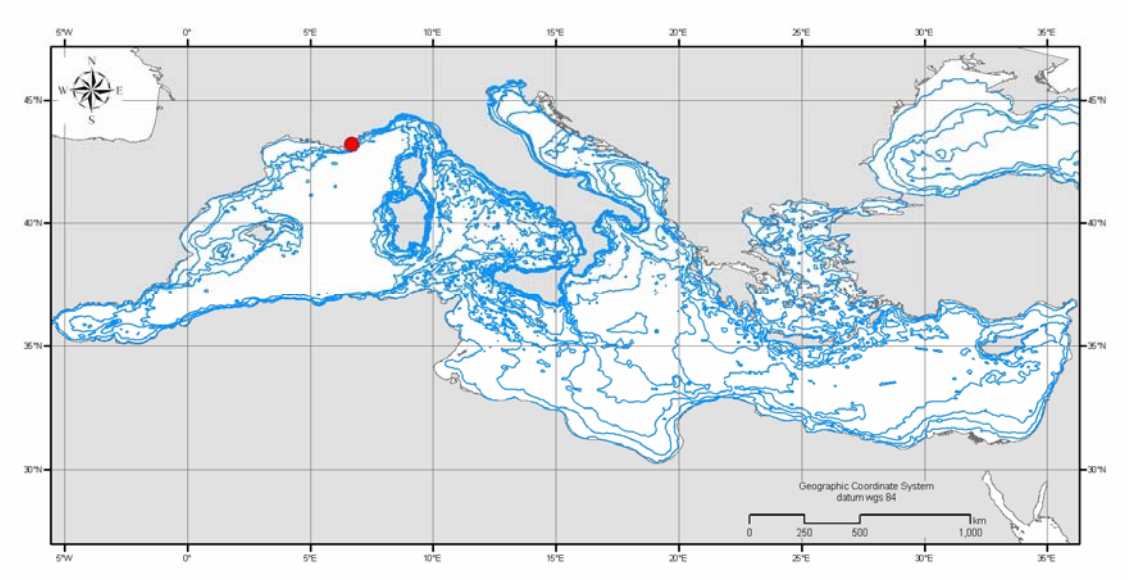
Data sheet 06

Reference document source

SAFEGE CETIIS, DEPARTEMENT OCEANOGRAPHIE - ENVIRONNEMENT (2004) - Étude réalable à la mise en place de l'observatoire marine du littoral des Maures le long des côtes de Ramatuelle. Rapport final (I902-OR-10/99). 170 pp.

Location

Western Mediterranean, France, Cap Taillat



Sampling Date

1999

Sampling method

Scuba diving, remotely-operated vehicle (ROV)

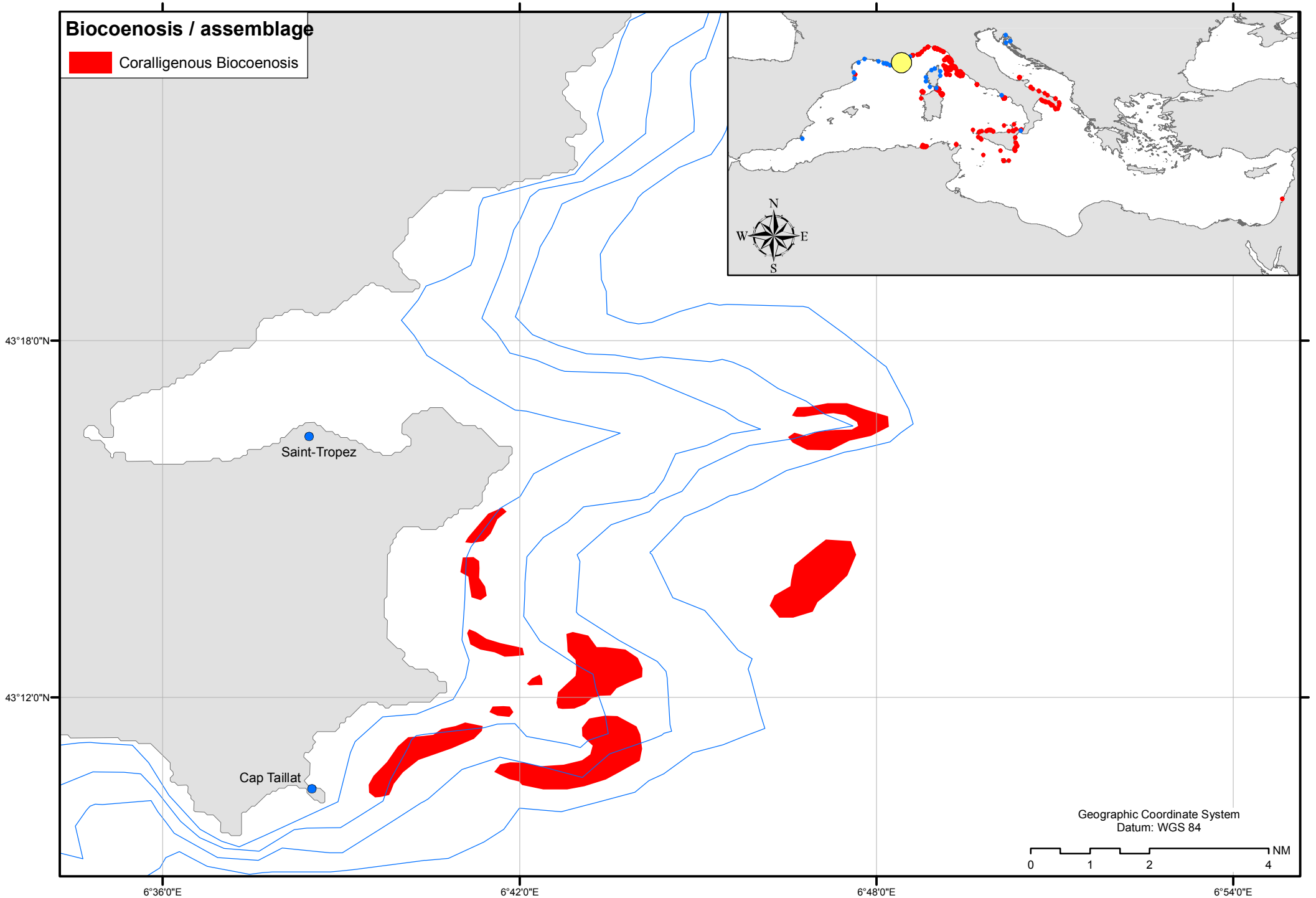
Original scale

Layout

Number of layouts: 1

Database ID

18


Biocoenosis / assemblage
Coralligenous Biocoenosis
N
W
E
S
Saint-Tropez
Cap Taillat
43°18'0"N
43°12'0"N
6°36'0"E
6°42'0"E
6°48'0"E
6°54'0"E
Geographic Coordinate System
Datum: WGS 84
0
1
2
4
NM

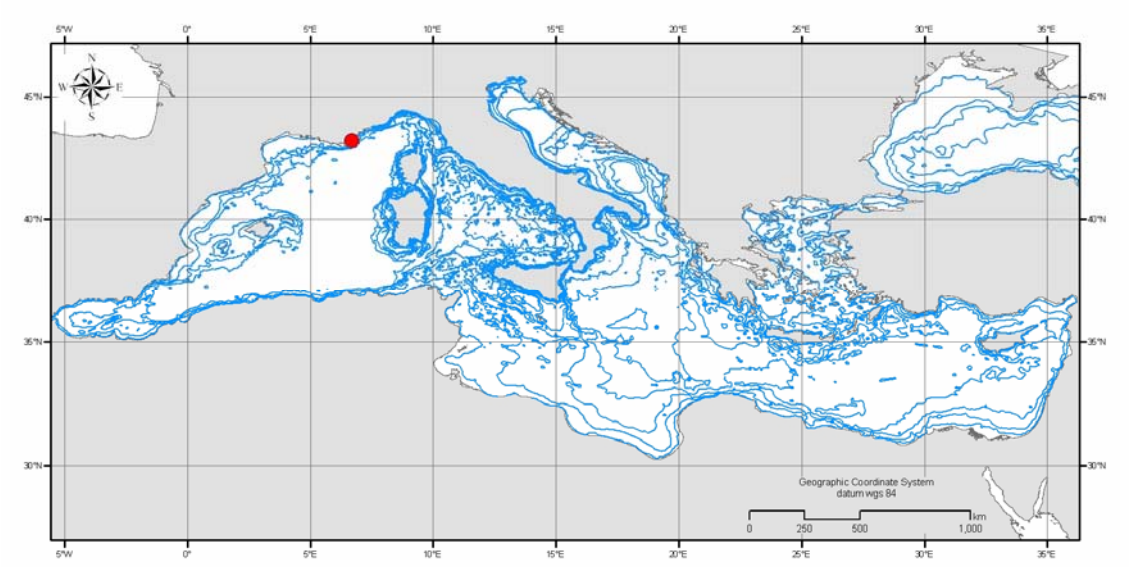
Data sheet 07

Reference document source

RUITTON S., BONHOMME D., ASTRUCH P., BONHOMME P., DONATO M., GRAVEL R. (2007) - Etude et cartographie des biocénoses marines de la zone Natura 2000 des 3 Caps (Var, France). *Rapport final. Contrat SIVOM du littoral des Maures & GIS Posidonie. Gis Posidonie publ., Fr.* 1-188 pp.

Location

Western Mediterranean, France, Cap Lardier.



Sampling Date

2007

Sampling method

Scuba diving, side scan sonar

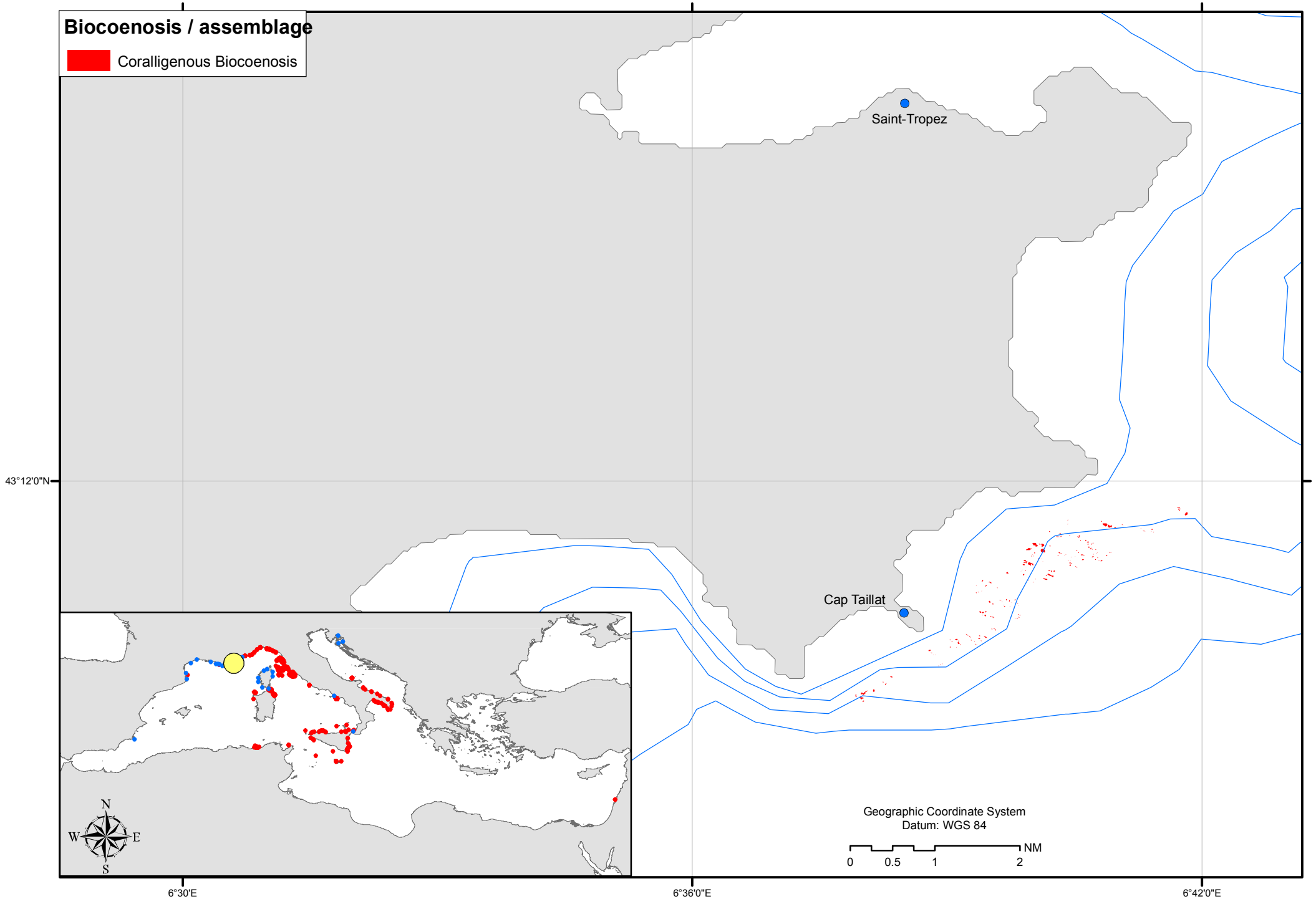
Original scale

Layout

Number of layouts: 1

Database ID

37


Biocoenosis / assemblage
Coralligenous Biocoenosis
Saint-Tropez
Cap Taillat
43°12'0"N
6°30'E
6°36'0"E
6°42'0"E
N
W
E
S
Geographic Coordinate System
Datum: WGS 84
0
0.5
1
2
NM

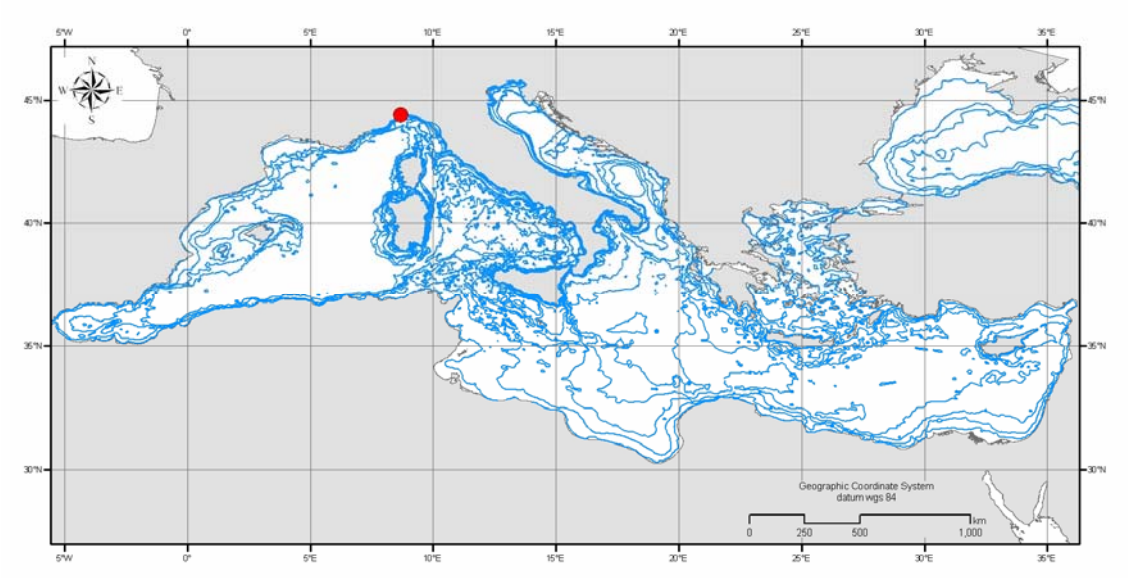
Data sheet 08

Reference document source

DIVIACCO G., COPPO S. (2006) – A*tlante degli habitat marini della Liguria - descrizione e cartografia delle praterie di Posidonia oceanica e dei principali popolamenti marini costieri.* Collana cataloghi dei beni culturali n. 6, regione Liguria. 205 pp. + 80 tavole.

Location

Western Mediterranean, Northern Tyrrhenian, Ligurian Sea, Italy.



Sampling Date

2002 - 2006

Sampling method

Scuba diving, side scan sonar, trawled underwater video camera

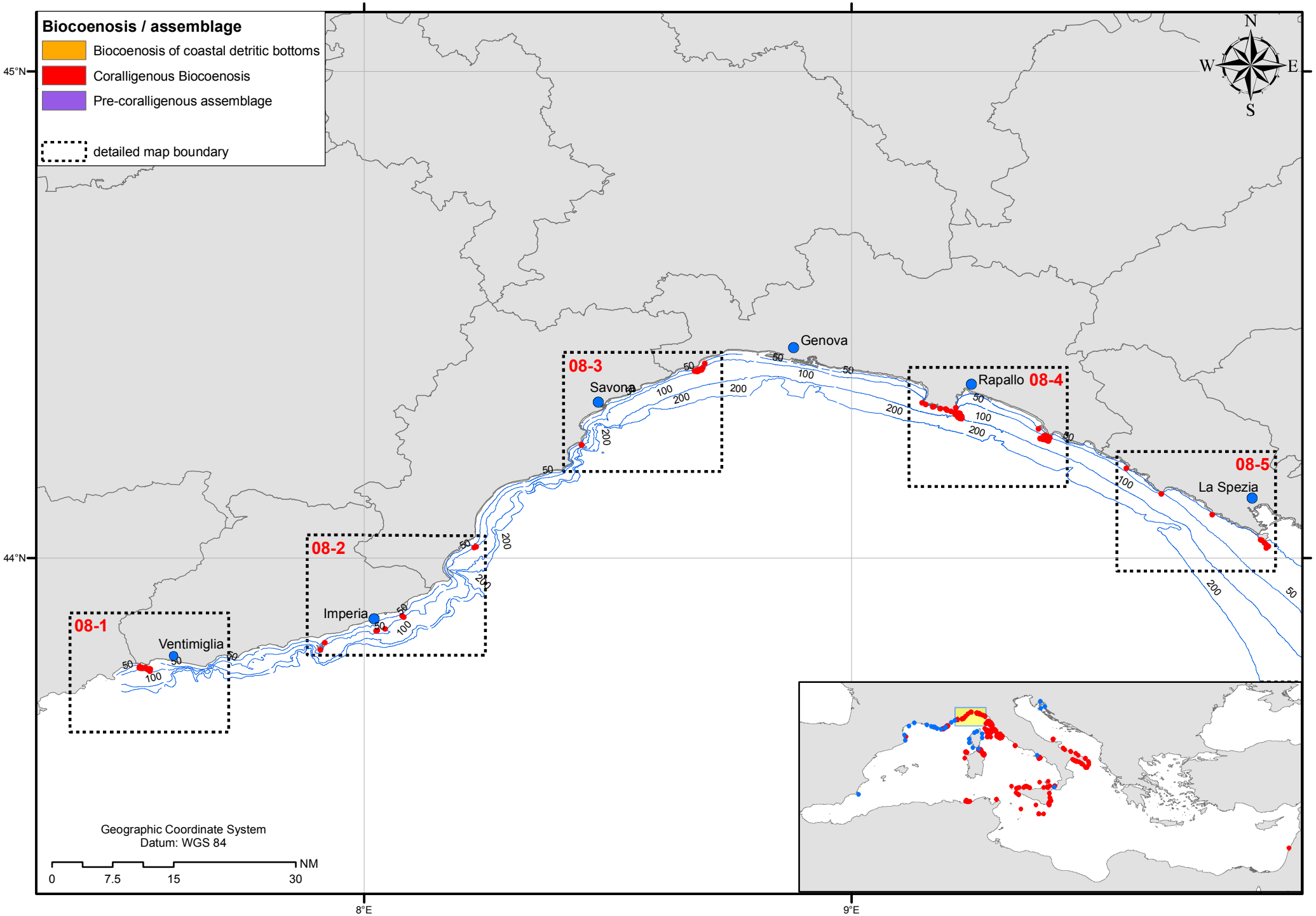
Original scale

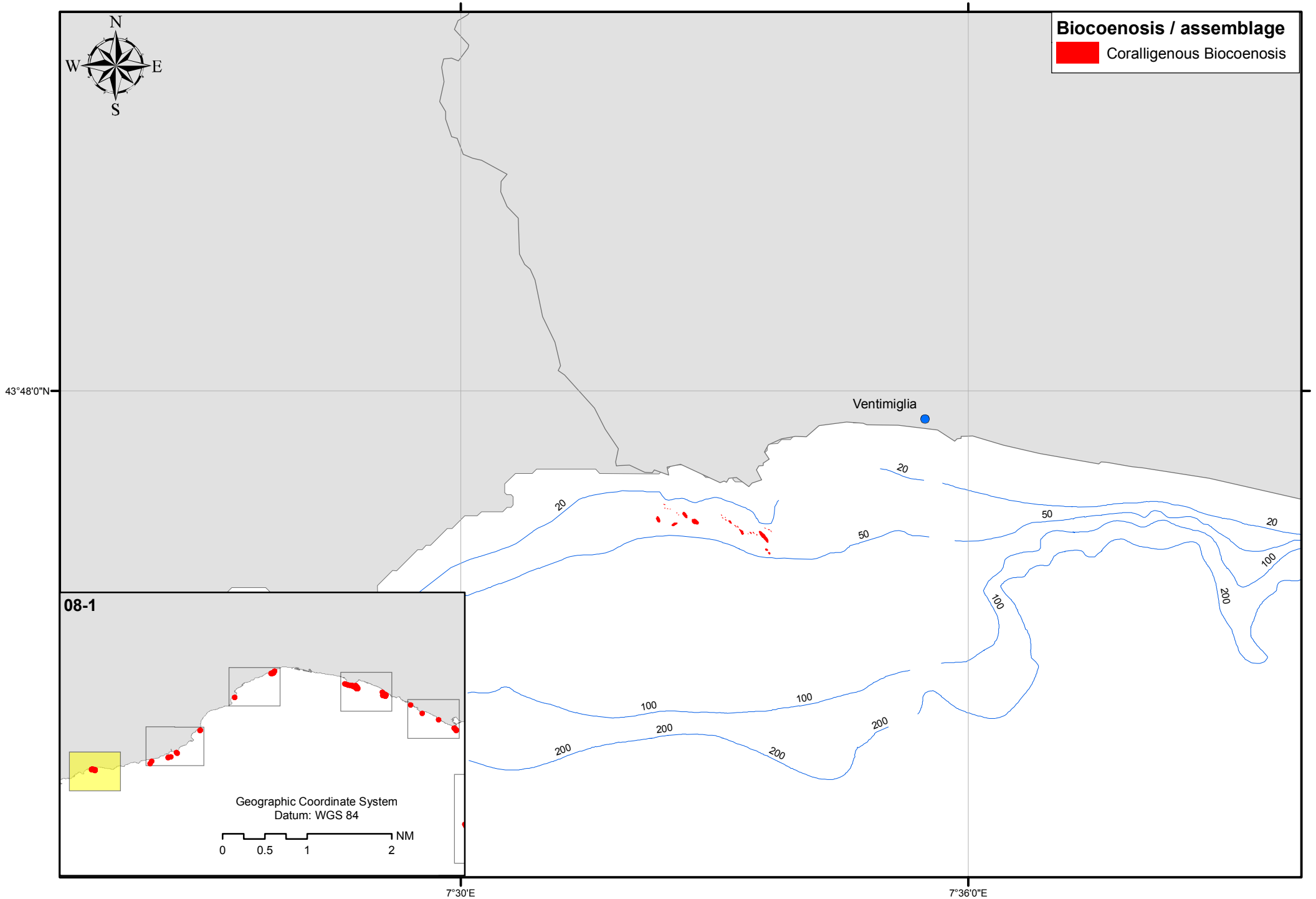
Layout

Number of layouts: 6

Database ID

21


Biocoenosis / assemblage
Biocoenosis of coastal detritic bottoms
Coralligenous Biocoenosis
Pre-coralligenous assemblage
detailed map boundary
N
W
E
S
45°N
44°N
8°E
9°E
Genova
Savona
Rapallo
La Spezia
Imperia
Ventimiglia
08-1
08-2
08-3
08-4
08-5
50
100
200
Geographic Coordinate System
Datum: WGS 84
0
7.5
15
30
NM


N
W
E
S
Biocoenosis / assemblage
Coralligenous Biocoenosis
43°48'0"N
Ventimiglia
20
50
100
200
08-1
Geographic Coordinate System
Datum: WGS 84
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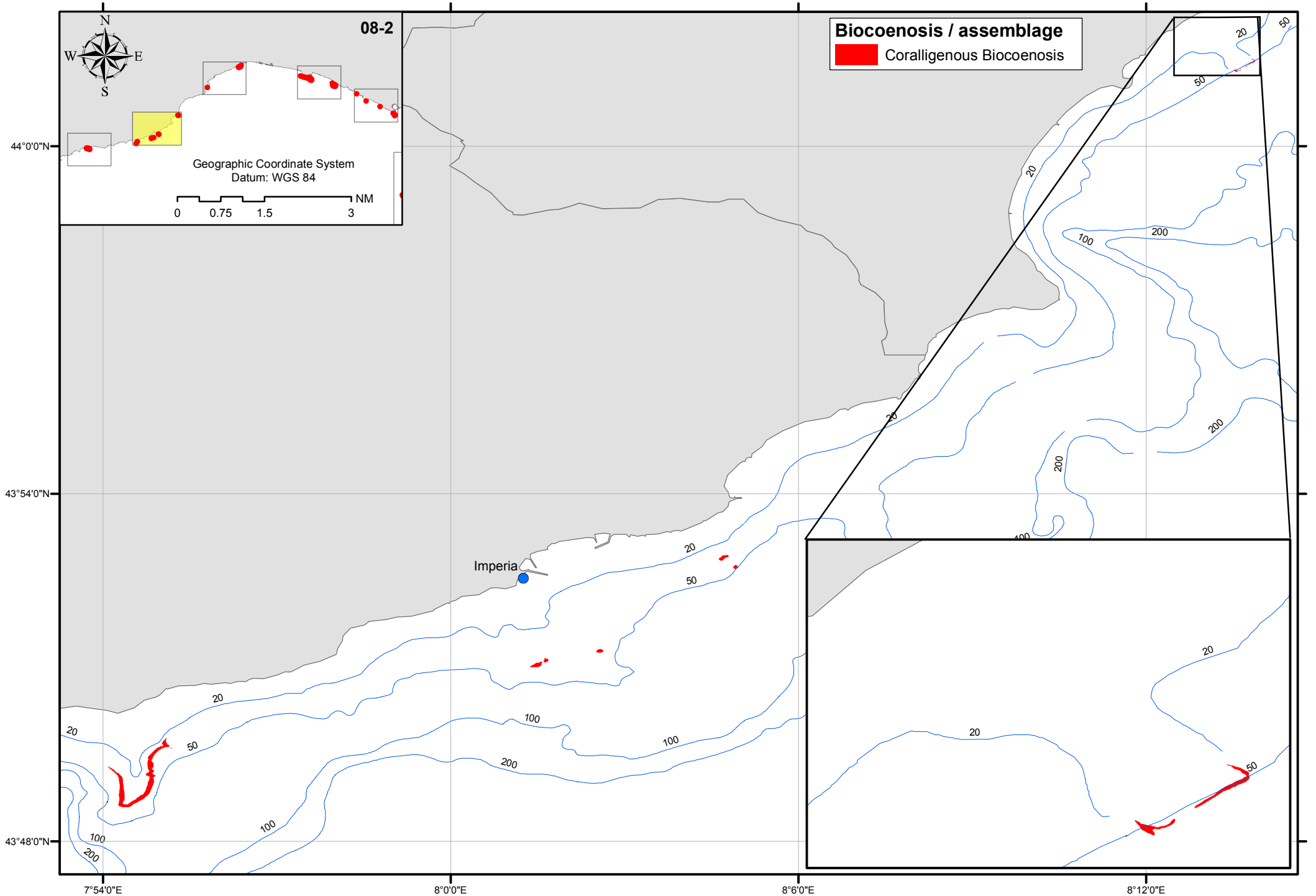
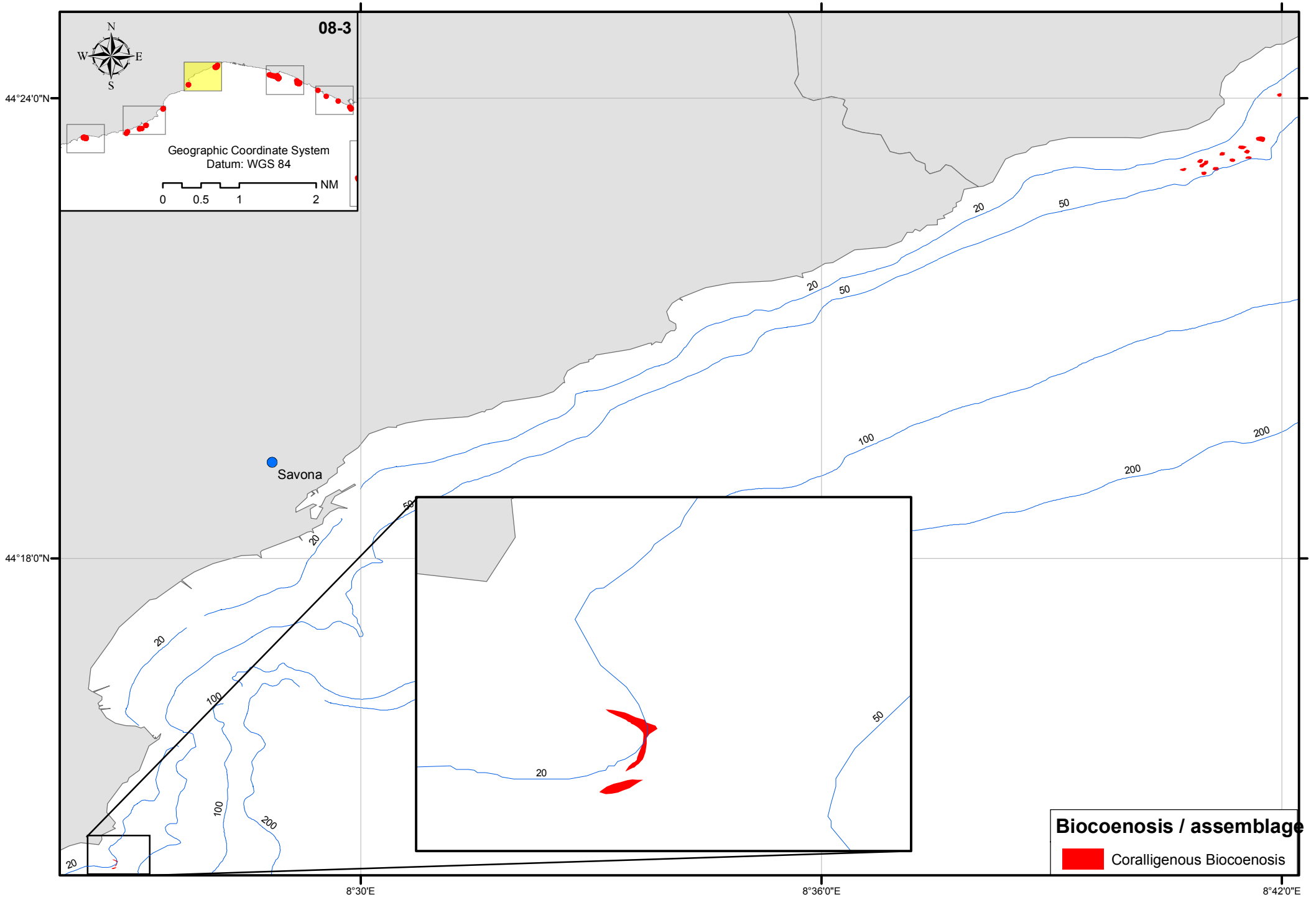
0.5
1
2
NM
7°30'E
7°36'0"E


08-2
N
W
E
S
Geographic Coordinate System
Datum: WGS 84
0
0.75
1.5
3
NM
Biocoenosis / assemblage
Coralligenous Biocoenosis
Imperia
44°0'0"N
43°54'0"N
43°48'0"N
7°54'0"E
8°0'0"E
8°6'0"E
8°12'0"E
20
50
100
200


08-3
N
W
E
S
Geographic Coordinate System
Datum: WGS 84
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NM
44°24'0"N
44°18'0"N
8°30'E
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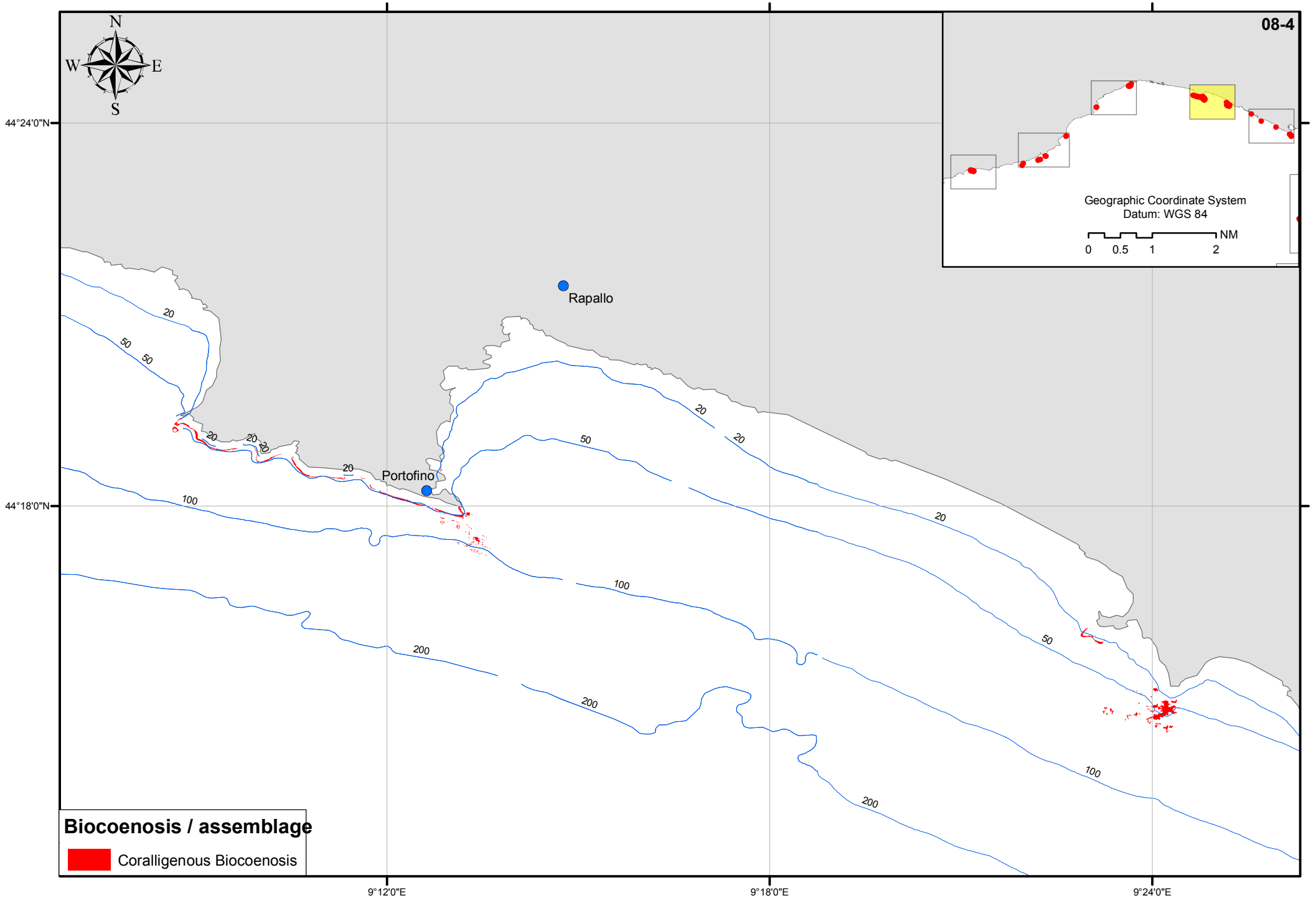
8°42'0"E
Savona
20
50
100
200
Biocoenosis / assemblage
Coralligenous Biocoenosis


08-4
N
W
E
S
Geographic Coordinate System
Datum: WGS 84
0 0.5 1 2
NM
Rapallo
Portofino
20
50
100
200
44°24'0"N
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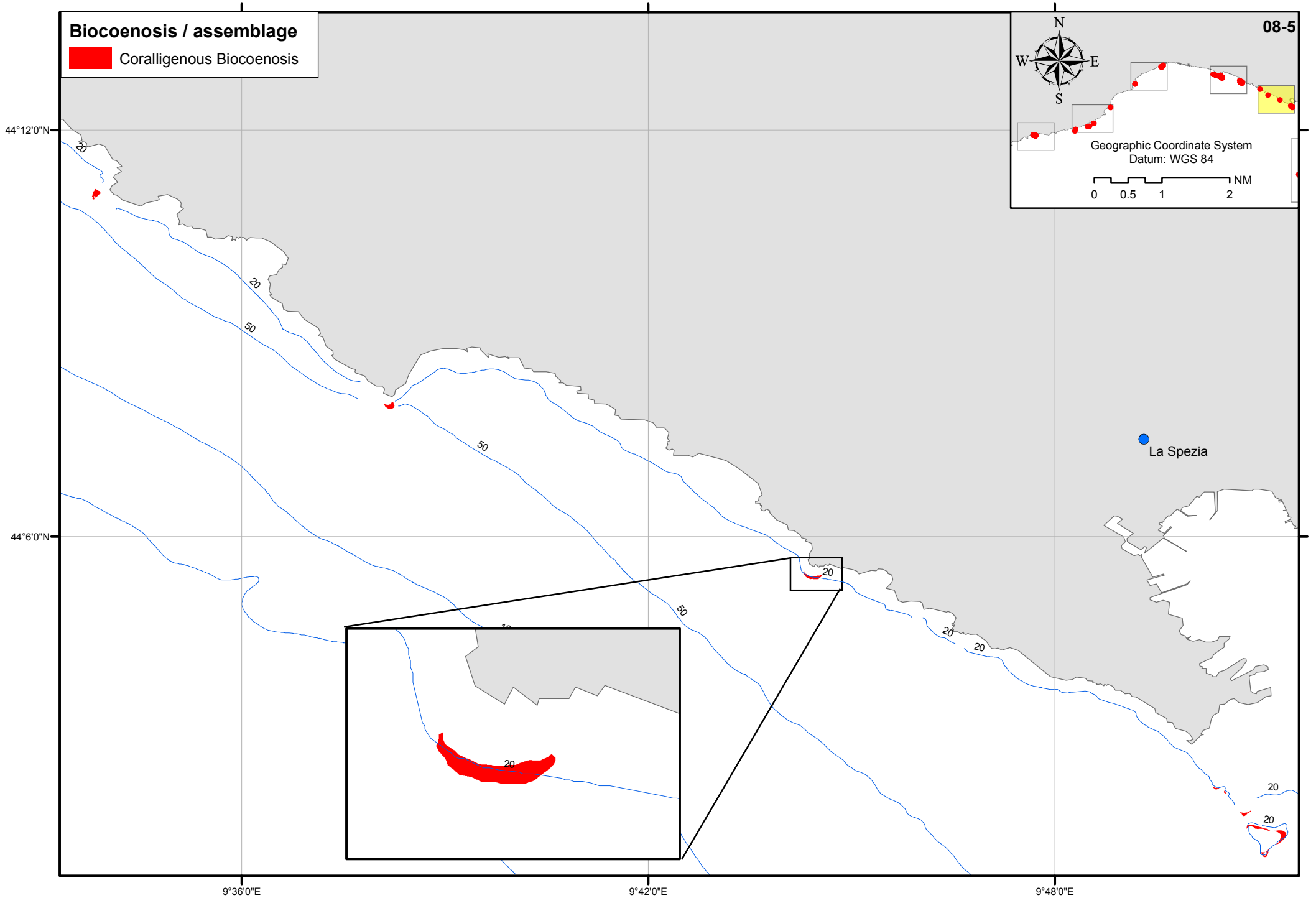
9°12'0"E
9°18'0"E
9°24'0"E
Biocoenosis / assemblage
Coralligenous Biocoenosis


Biocoenosis / assemblage
Coralligenous Biocoenosis
08-5
N
W
E
S
Geographic Coordinate System
Datum: WGS 84
0 0.5 1 2 NM
La Spezia
44°12'0"N
44°6'0"N
9°36'0"E
9°42'0"E
9°48'0"E
20
50

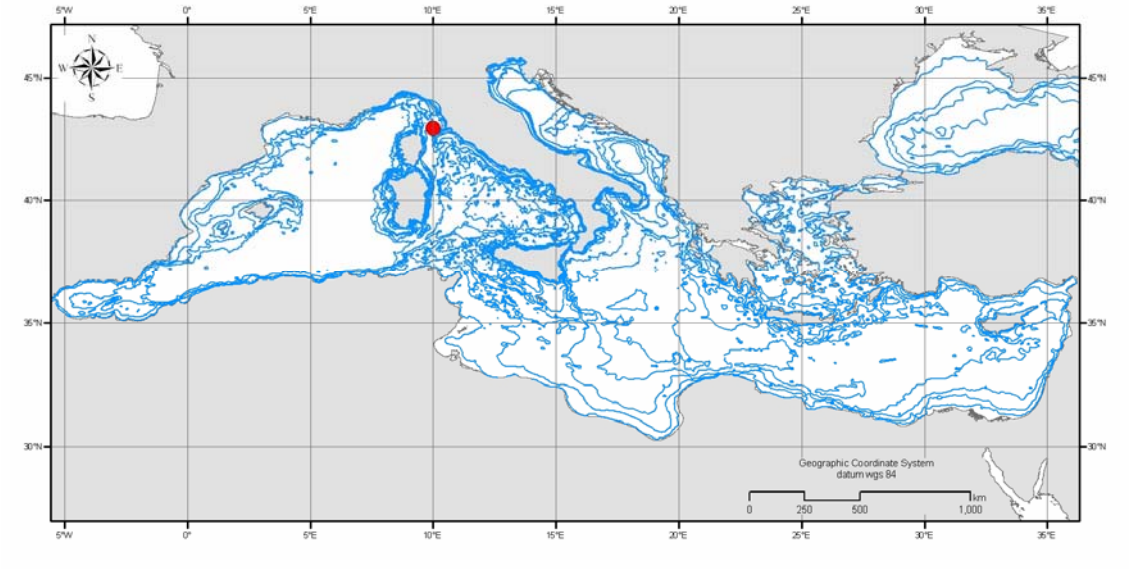
Data sheet 09

Reference document source

BIANCHI C.N., CINELLI F., MORRI C. (1996) – La carta bionomica dei mari toscani: introduzione, criteri informativi e note esplicative. *Atti Soc. toscana Sci. Nat., Mem., Ser. A.* **112** (suppl.): 255-270.

Location

Western Mediterranean, Northern Tyrrhenian, Italy.



Sampling Date

1985-1987, 1990, 1992, 1993

Sampling method

Dredge, grab sampler

Original scale

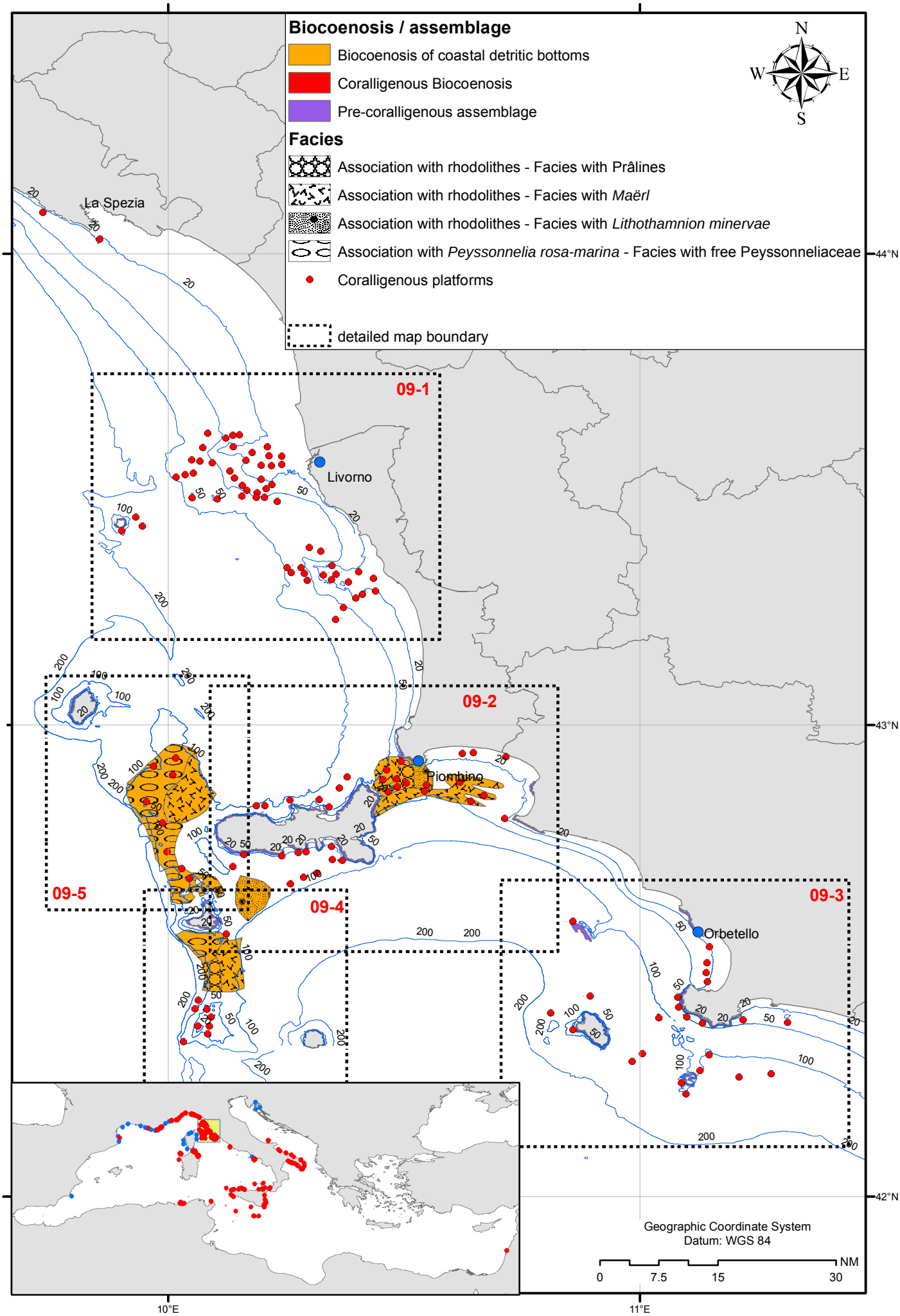
Scale: 1:250.000

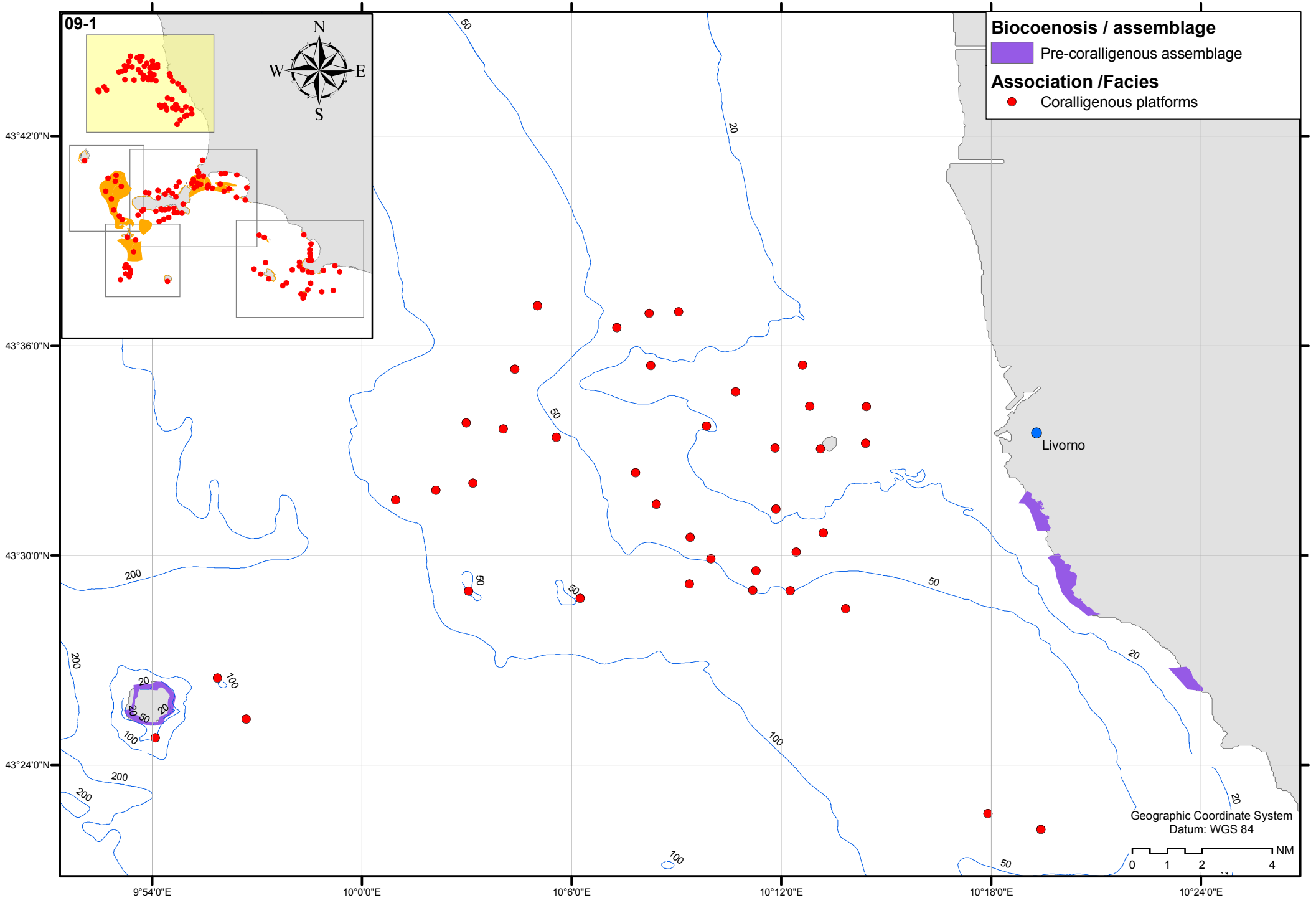
Layout

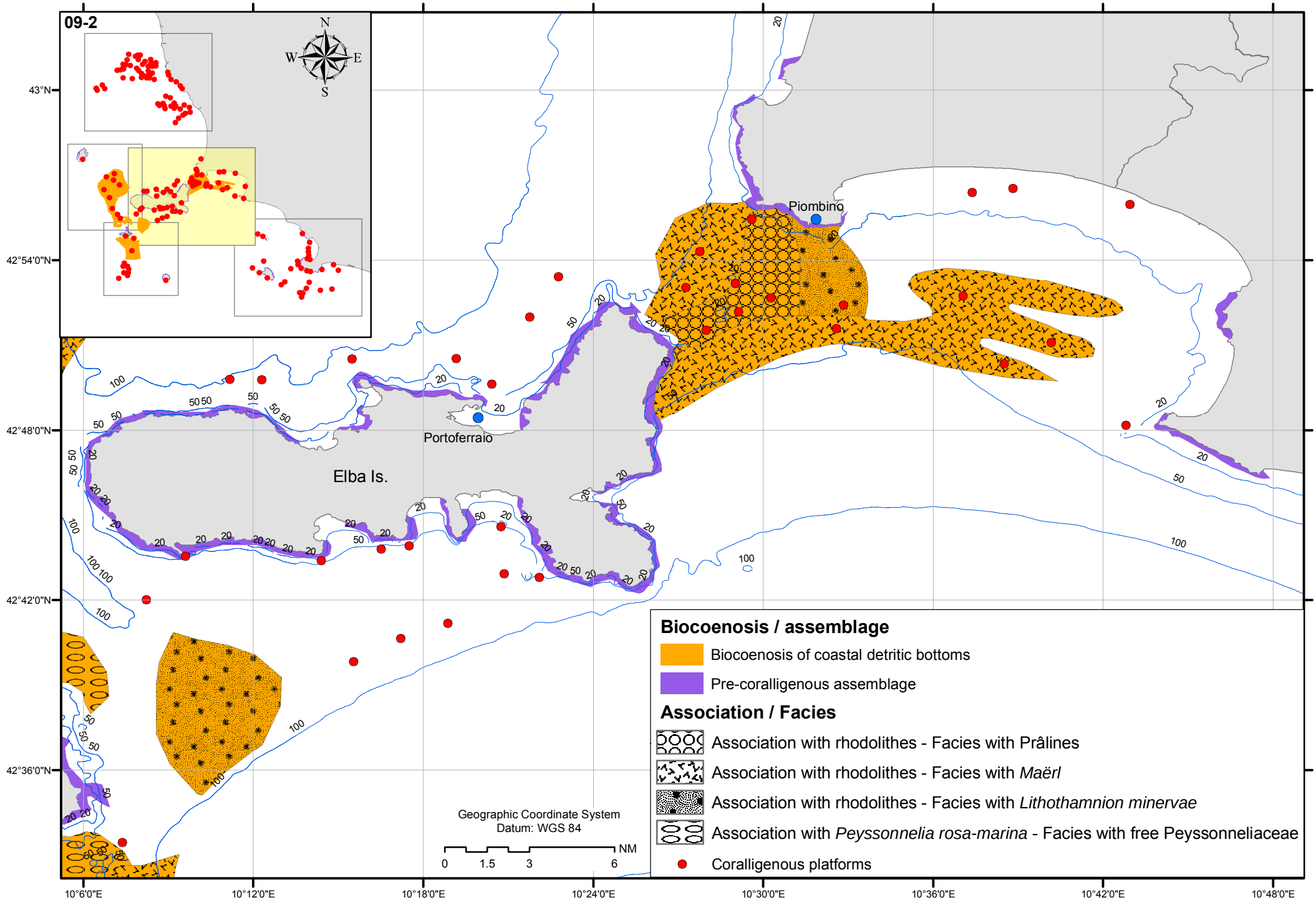
Number of layouts: 6

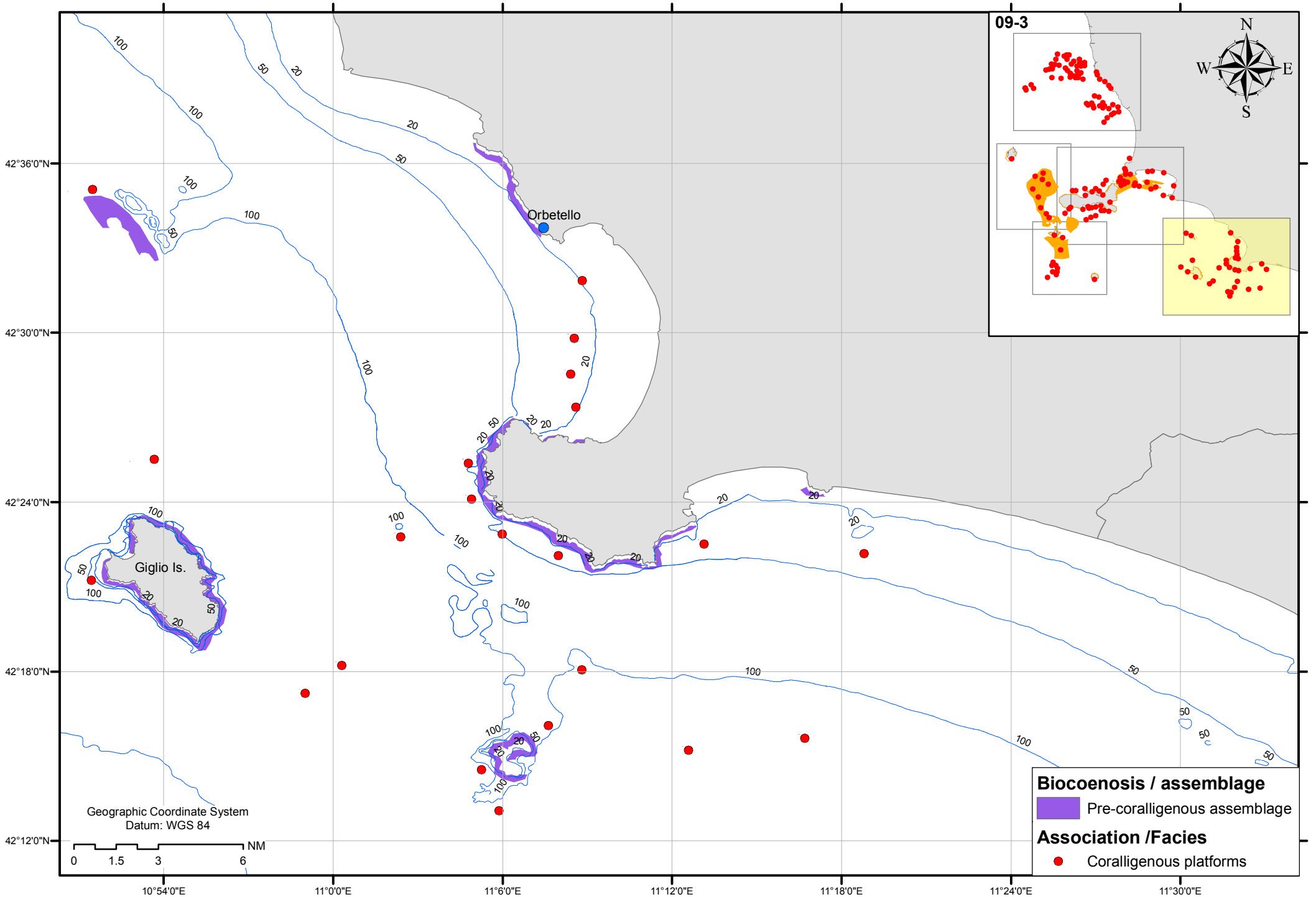
Database ID

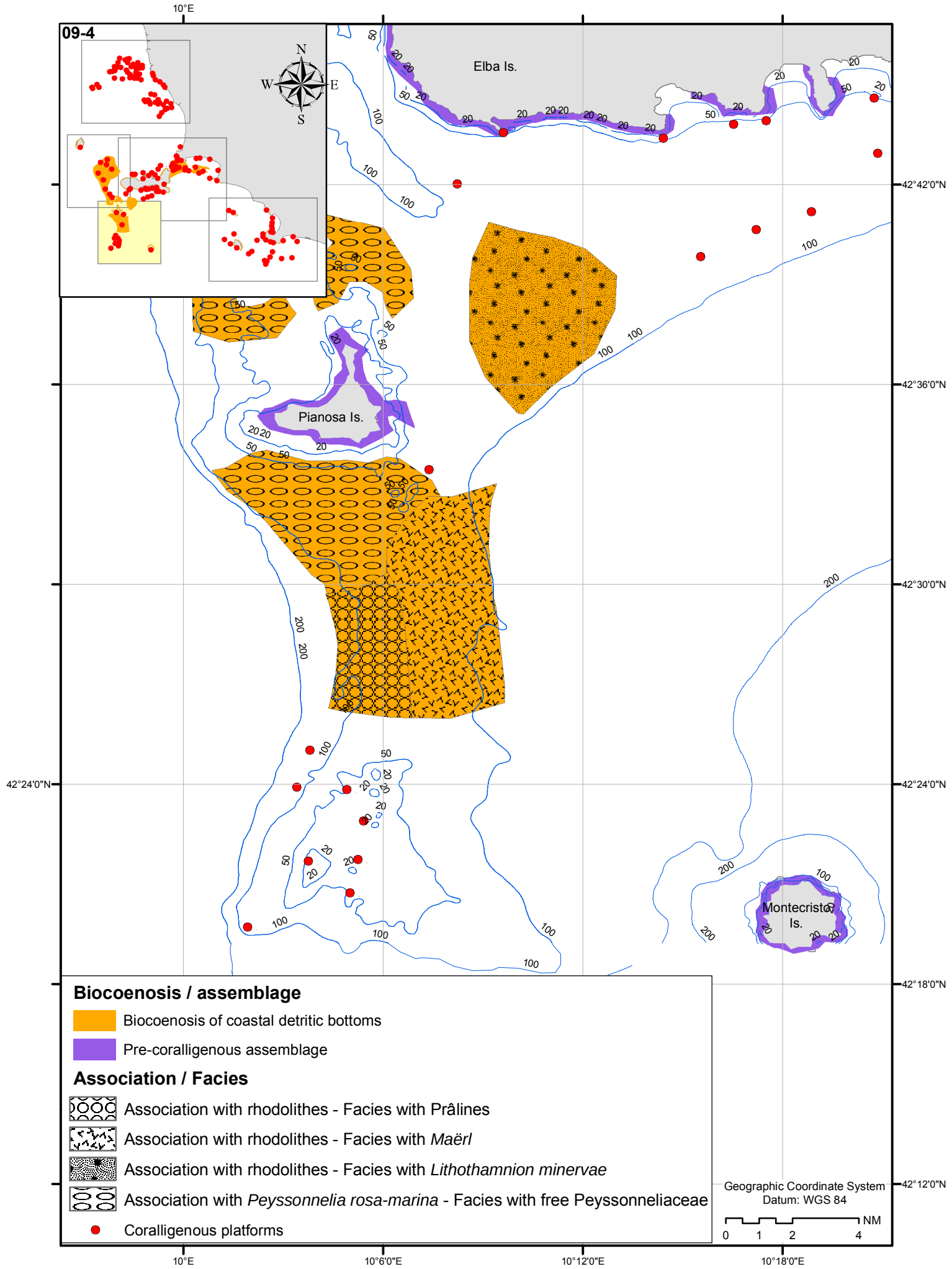
13

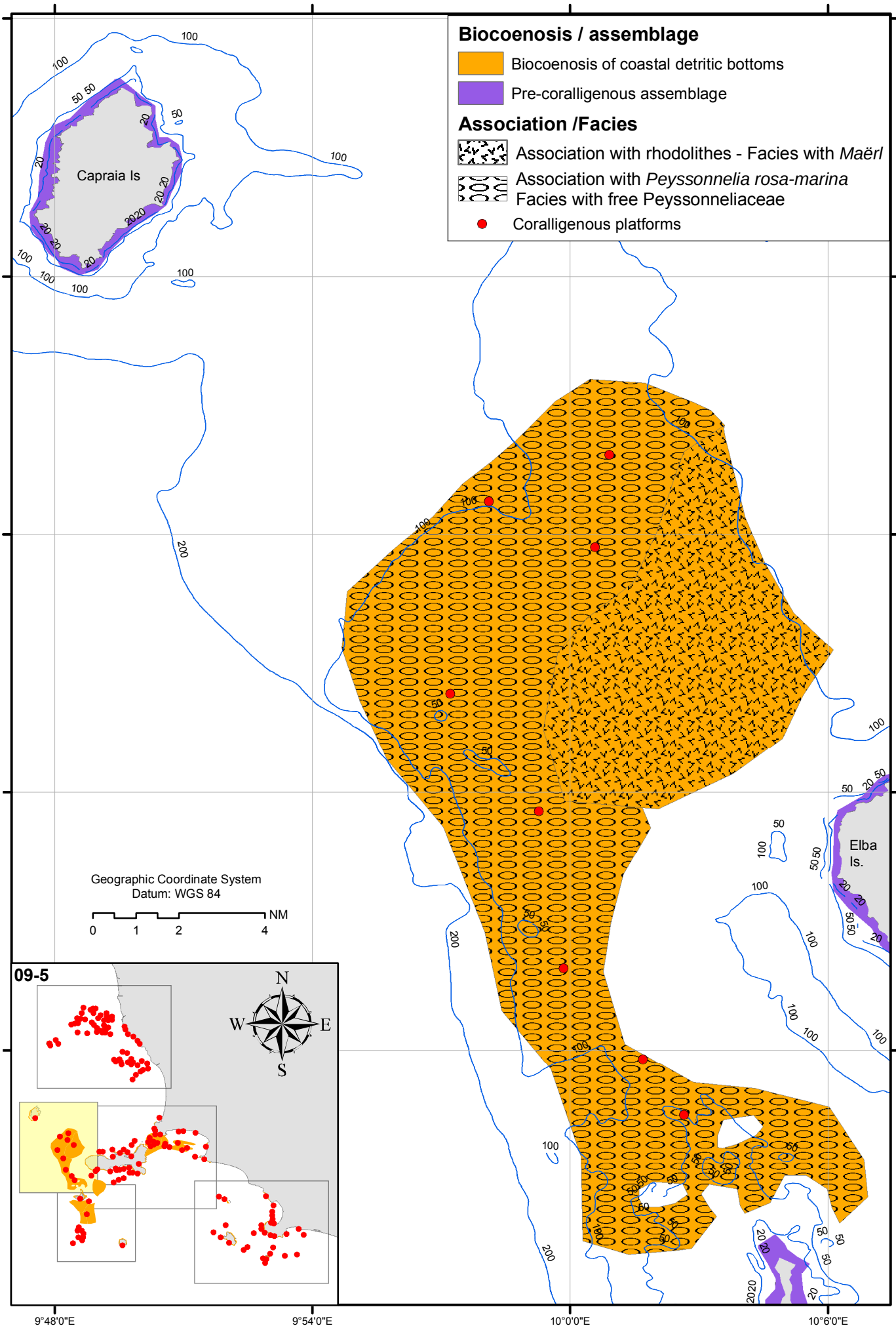

Biocoenosis / assemblage
Biocoenosis of coastal detritic bottoms
Coralligenous Biocoenosis
Pre-coralligenous assemblage
Facies
Association with rhodolithes - Facies with Prâlines
Association with rhodolithes - Facies with Maërl
Association with rhodolithes - Facies with Lithothamnion minervae
Association with Peyssonnelia rosa-marina - Facies with free Peyssonneliaceae
Coralligenous platforms
detailed map boundary
N
W
E
S
La Spezia
Livorno
Piombino
Orbetello
09-1
09-2
09-3
09-4
09-5
44°N
43°N
42°N
10°E
11°E
Geographic Coordinate System
Datum: WGS 84
0
7.5
15
30
NM


09-1
N
W
E
S
Biocoenosis / assemblage
Pre-coralligenous assemblage
Association /Facies
Coralligenous platforms
Livorno
43°42'0"N
43°36'0"N
43°30'0"N
43°24'0"N
9°54'0"E
10°0'0"E
10°6'0"E
10°12'0"E
10°18'0"E
10°24'0"E
Geographic Coordinate System
Datum: WGS 84
NM
0 1 2 4


09-2
N
W
E
S
Piombino
Portoferraio
Elba Is.
43°N
42°54'0"N
42°48'0"N
42°42'0"N
42°36'0"N
10°6'0"E
10°12'0"E
10°18'0"E
10°24'0"E
10°30'0"E
10°36'0"E
10°42'0"E
10°48'0"E
Geographic Coordinate System
Datum: WGS 84
0
1.5
3
6
NM
Biocoenosis / assemblage
Biocoenosis of coastal detritic bottoms
Pre-coralligenous assemblage
Association / Facies
Association with rhodolithes - Facies with Prâlines
Association with rhodolithes - Facies with Maërl
Association with rhodolithes - Facies with Lithothamnion minervae
Association with Peyssonnelia rosa-marina - Facies with free Peyssonneliaceae
Coralligenous platforms


09-3
N
W
E
S
Orbetello
Giglio Is.
42°36'0"N
42°30'0"N
42°24'0"N
42°18'0"N
42°12'0"N
10°54'0"E
11°0'0"E
11°6'0"E
11°12'0"E
11°18'0"E
11°24'0"E
11°30'0"E
Geographic Coordinate System
Datum: WGS 84
0 1.5 3 6 NM
Biocoenosis / assemblage
Pre-coralligenous assemblage
Association /Facies
Coralligenous platforms


09-4
N
W
E
S
Elba Is.
Pianosa Is.
Montecristo Is.
10°E
42°42'0"N
42°36'0"N
42°30'0"N
42°24'0"N
42°18'0"N
42°12'0"N
10°6'0"E
10°12'0"E
10°18'0"E
Biocoenosis / assemblage
Biocoenosis of coastal detritic bottoms
Pre-coralligenous assemblage
Association / Facies
Association with rhodolithes - Facies with Prâlines
Association with rhodolithes - Facies with Maërl
Association with rhodolithes - Facies with Lithothamnion minervae
Association with Peyssonnelia rosa-marina - Facies with free Peyssonneliaceae
Coralligenous platforms
Geographic Coordinate System
Datum: WGS 84
NM
0 1 2 4


Biocoenosis / assemblage
Biocoenosis of coastal detritic bottoms
Pre-coralligenous assemblage
Association /Facies
Association with rhodolithes - Facies with Maërl
Association with Peyssonnelia rosa-marina
Facies with free Peyssonneliaceae
Coralligenous platforms
Capraia Is
Elba
Is.
Geographic Coordinate System
Datum: WGS 84
NM
0
1
2
4
09-5
N
W
E
S
43°6'0"N
43°0'0"N
42°54'0"N
42°48'0"N
42°42'0"N
9°48'0"E
9°54'0"E
10°0'0"E
10°6'0"E

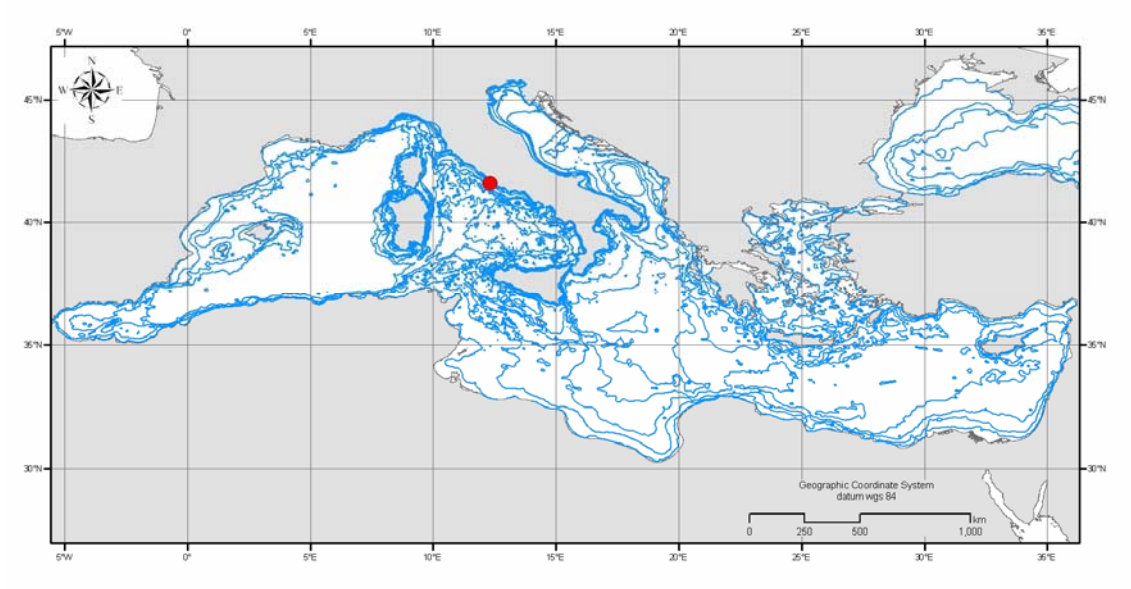
Data sheet 10

Reference document source

ARDIZZONE G.D., BELLUSCIO A., GRAVINA F., SCHINTU P., MARTINI N., SOMASCHINI A. (1999) - Environmental characteristics and fishing resources of the Tor Paterno bank (Central Tyrrhenian Sea). *Biol. Mar. Medit.*, **5** (3): 736-744.

Location

Western Mediterranean, Central Tyrrhenian, Tor Paterno bank.



Sampling Date

1992

Sampling method

Scuba diving (scrabbing), underwater video camera

Original scale

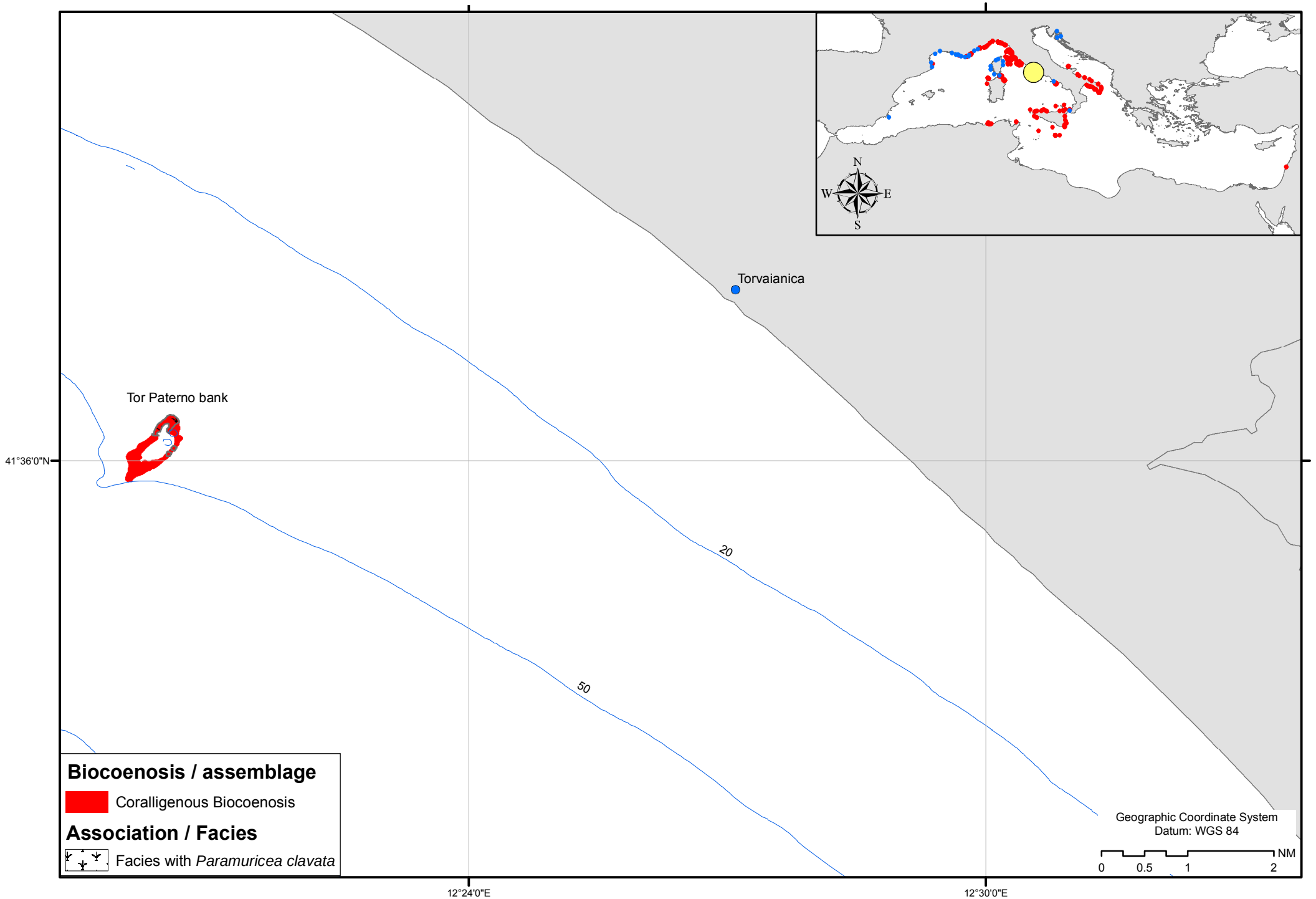
Scale: 1:10.000

Layout

Number of layouts: 1

Database ID

5


Torvaianica
Tor Paterno bank
41°36'0"N
12°24'0"E
12°30'0"E
20
50
N
W
E
S
Biocoenosis / assemblage
Coralligenous Biocoenosis
Association / Facies
Facies with Paramuricea clavata
Geographic Coordinate System
Datum: WGS 84
0
0.5
1
2
NM

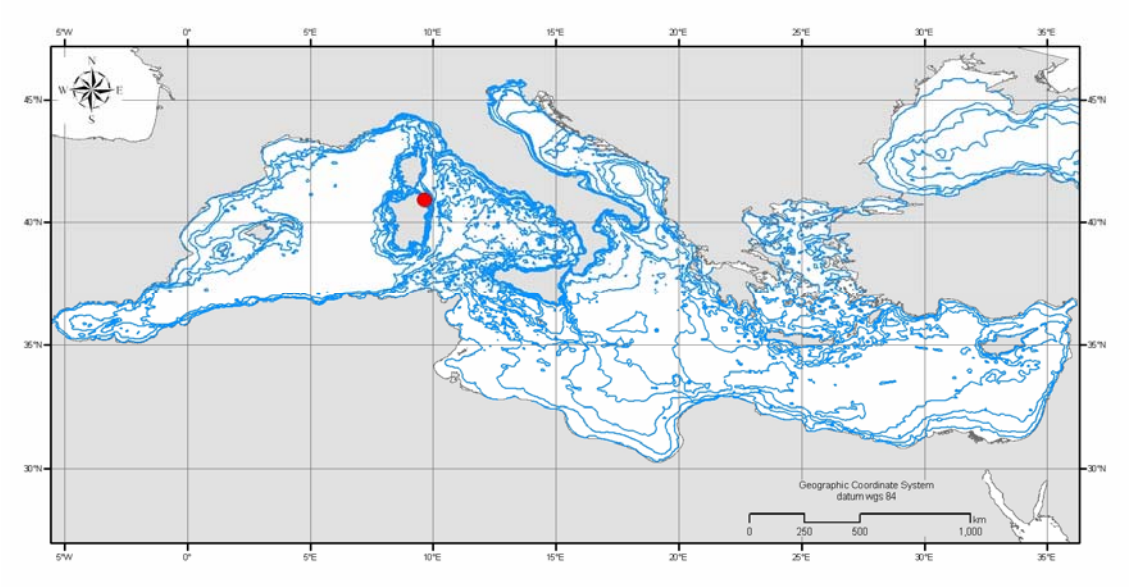
Data sheet 11

Reference document source

DI.PTE.RIS UNIVERSITÀ DI GENOVA. (2006) - Carta Bionomica dei Fondi Marini - Area Marina Protetta di Tavolara-Punta Coda Cavallo

Location

Western Mediterranean, Northern Tyrrhenian, Italy, Tavolara-Punta Coda Cavallo.



Sampling Date

1989 - 2005

Sampling method

Scuba diving

Original scale

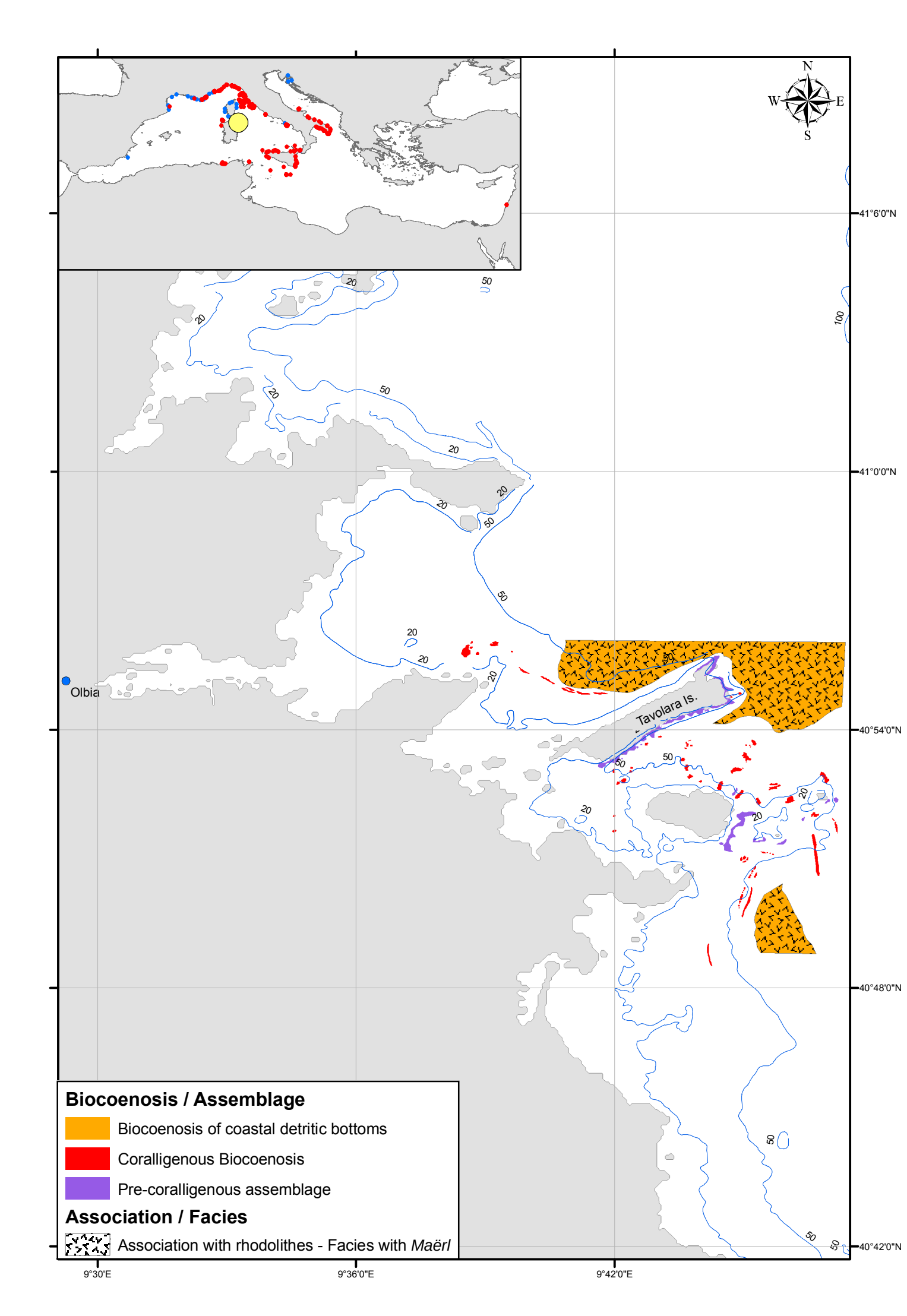
Scale: 1:25.000

Layout

Number of layouts: 1

Database ID

20


N
W
E
S
41°6'0"N
41°0'0"N
40°54'0"N
40°48'0"N
40°42'0"N
9°30'E
9°36'0"E
9°42'0"E
Olbia
Tavolara Is.
20
50
100
Biocoenosis / Assemblage
Biocoenosis of coastal detritic bottoms
Coralligenous Biocoenosis
Pre-coralligenous assemblage
Association / Facies
Association with rhodolithes - Facies with Maërl

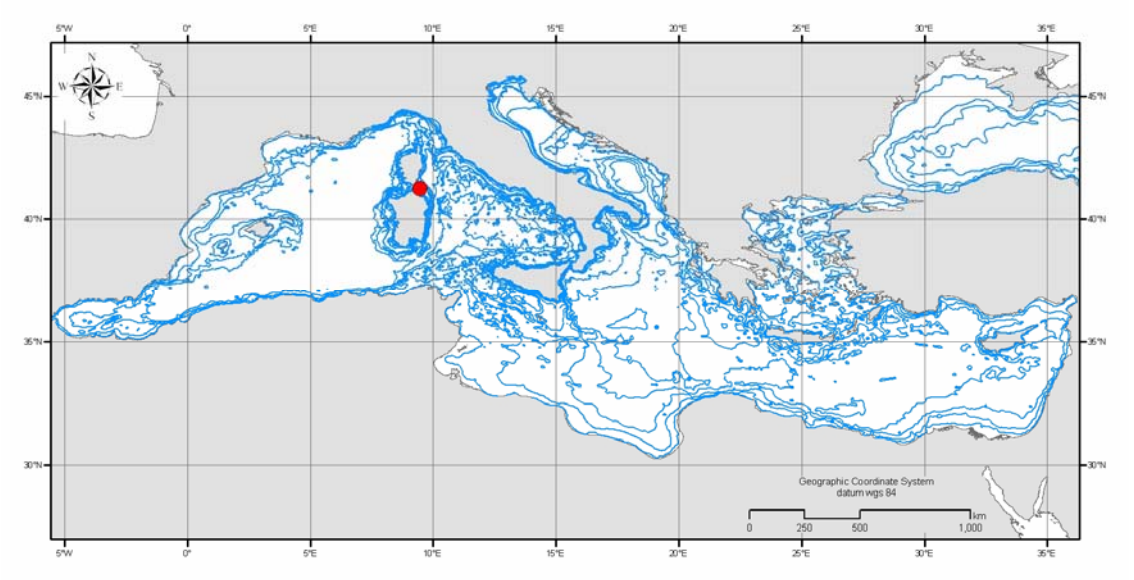
Data sheet 12

Reference document source

ICRAM (1999) - Studio di fattibilità per l'istituzione dell'area marina protetta dell'Arcipelago della Maddalena prevista dall'articolo 36 della Legge Quadro sulle aree protette n. 394/91. Ministero dell'Ambiente. 3 volumi.

Location

Western Mediterranean, Central Tyrrhenian, Italy, La Maddalena Islands.



Sampling Date

1998

Sampling method

Scuba diving, side scan sonar, trawled underwater video camera

Original scale

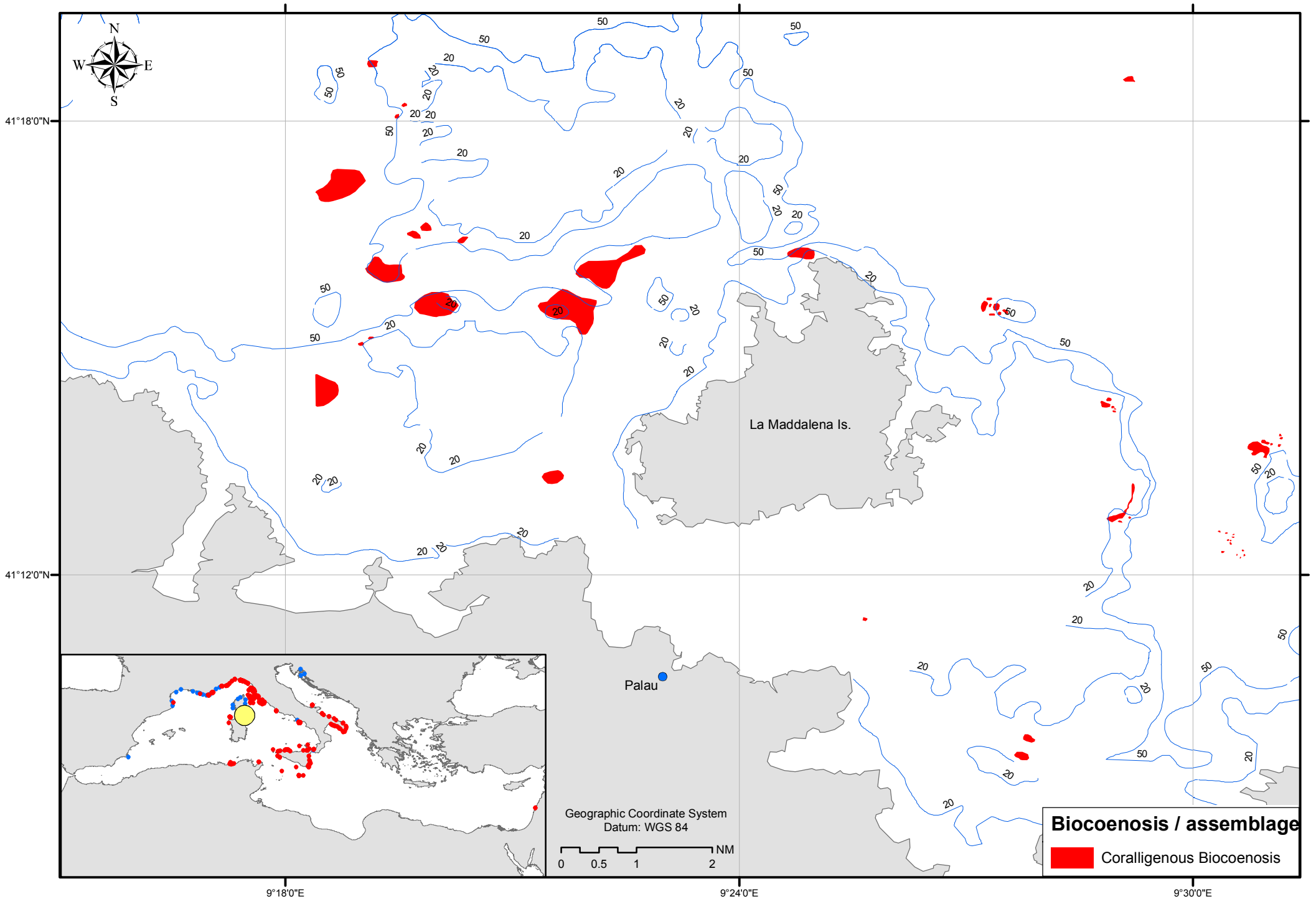
Scale: 1:25.000

Layout

Number of layouts: 1

Database ID

15


N
W
E
S
41°18'0"N
41°12'0"N
9°18'0"E
9°24'0"E
9°30'0"E
La Maddalena Is.
Palau
Geographic Coordinate System
Datum: WGS 84
0 0.5 1 2 NM
Biocoenosis / assemblage
Coralligenous Biocoenosis

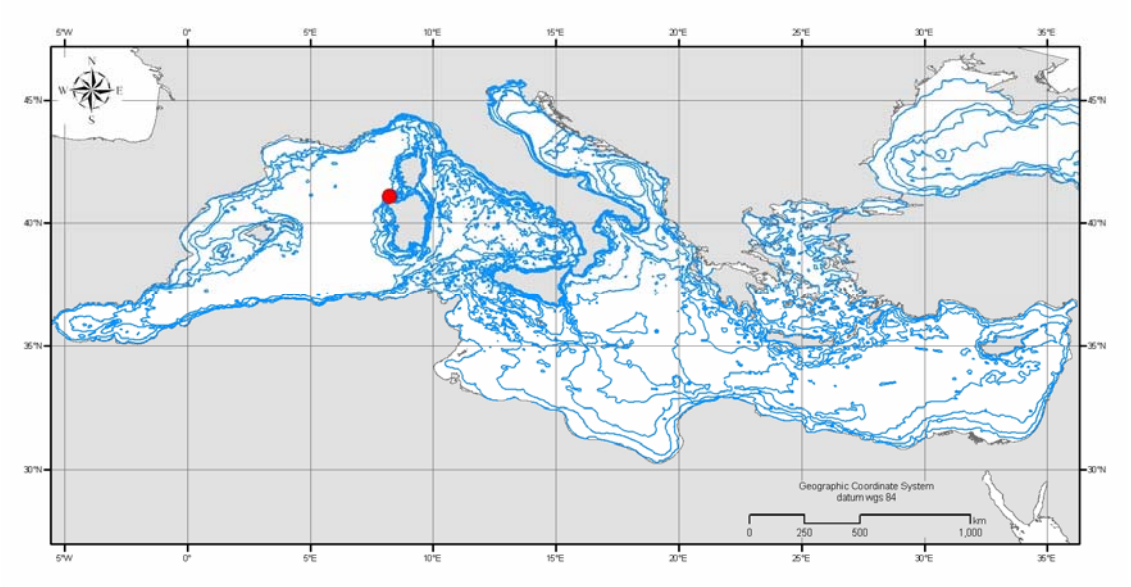
Data sheet 13

Reference document source

ICRAM (1999) - Studio di fattibilità per l'istituzione dell'area marina protetta dell'Isola dell'Asinara prevista dall'articolo 36 della Legge Quadro sulle aree protette n. 394/91. Ministero dell'Ambiente. 3 volumi.

Location

Western Mediterranean, Central Tyrrhenian, Italy, Asinara Island.



Sampling Date

1998

Sampling method

Scuba diving, side scan sonar, trawled underwater video camera, underwater photos, redge (circalittoral biocoenoses)

Original scale

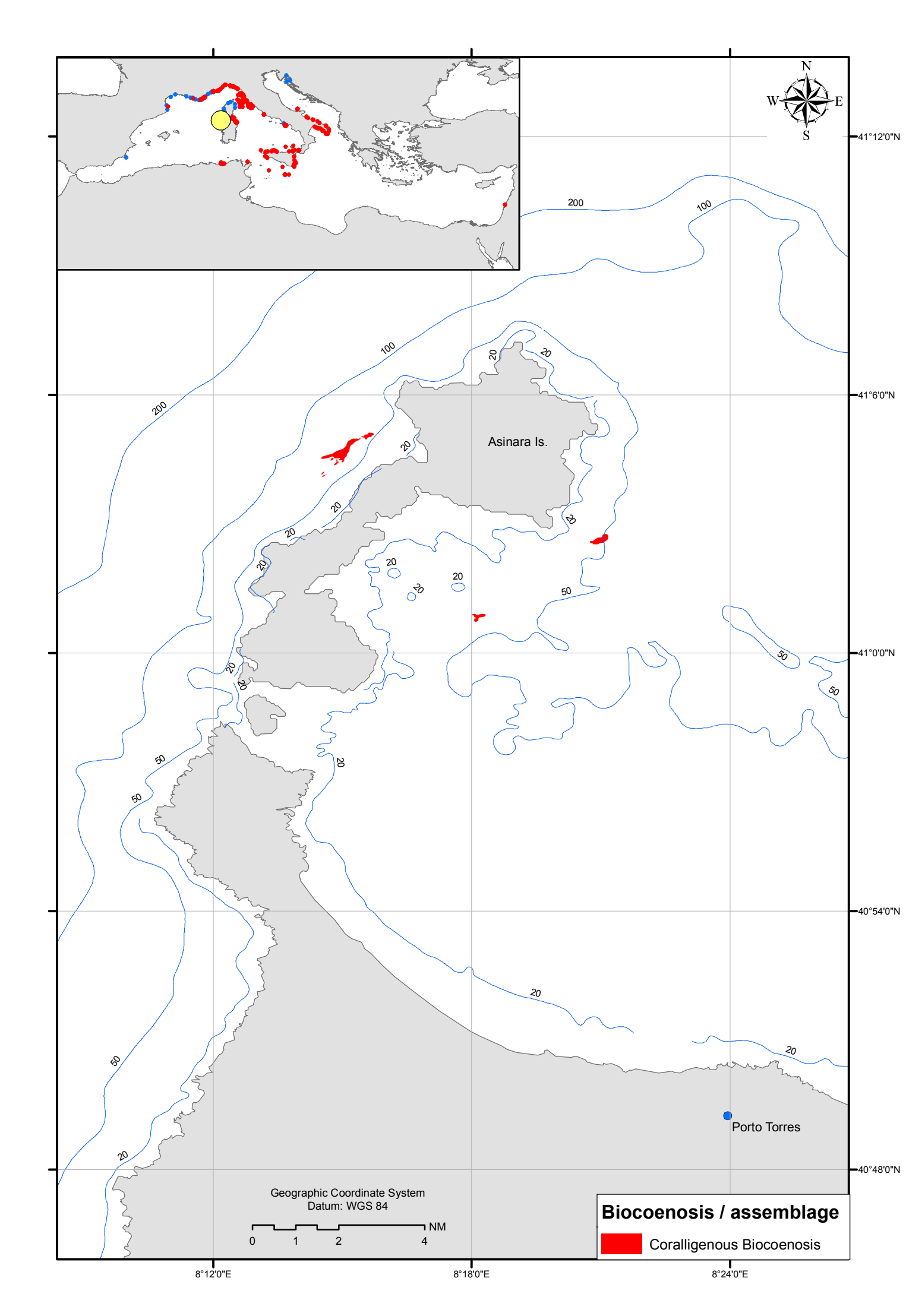
Scale: 1:25.000

Layout

Number of layouts: 1

Database ID

14


N
W
E
S
41°12'0"N
41°6'0"N
41°0'0"N
40°54'0"N
40°48'0"N
8°12'0"E
8°18'0"E
8°24'0"E
Asinara Is.
Porto Torres
200
100
50
20
Geographic Coordinate System
Datum: WGS 84
0
1
2
4
NM
Biocoenosis / assemblage
Coralligenous Biocoenosis

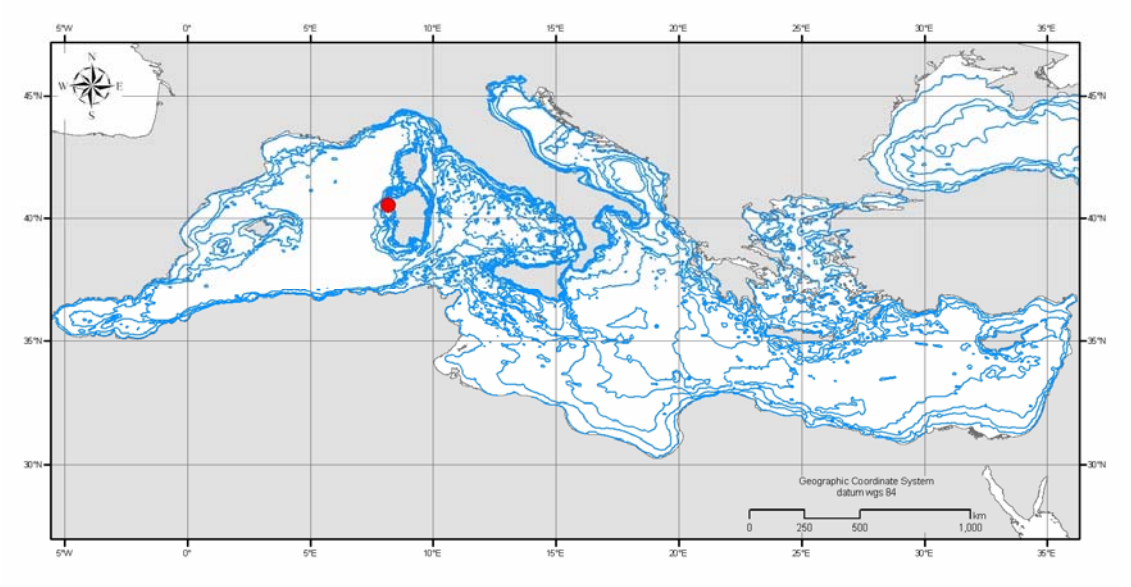
Data sheet 14

Reference document source

COSSU A., GAZALE V., ORRÙ P., PINTUS C. (2000) - Carta fisionomica e biocenotica dei fondi marini settore marino costiero Capo Caccia-Baia di Porto Conte-Punta Giglio (Sardegna NO). Amministrazione provinciale di Sassari; Università di Sassari, Dipartimento di botanica ed ecologia vegetale

Location

Western Mediterranean, Central Tyrrhenian, Italy, Capo Caccia.



Sampling Date

1988, 1997-1998

Sampling method

Scuba diving, side scan sonar, underwater video camera

Original scale

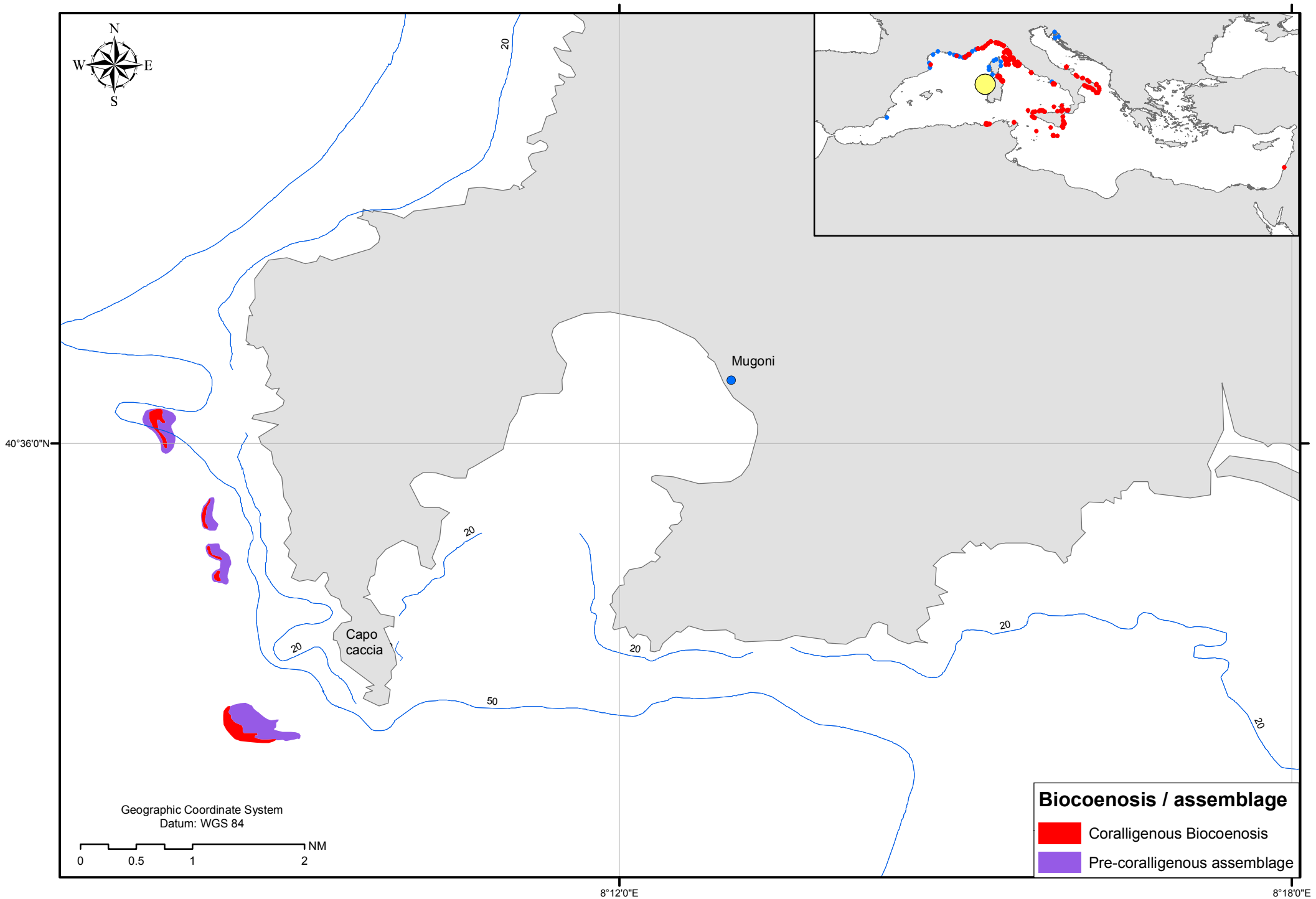
Scale: 1:20.000

Layout

Number of layouts: 1

Database ID

42


N
W
E
S
20
Mugoni
40°36'0"N
20
Capo
caccia
20
20
50
20
20
Geographic Coordinate System
Datum: WGS 84
0
0.5
1
2
NM
8°12'0"E
8°18'0"E
Biocoenosis / assemblage
Coralligenous Biocoenosis
Pre-coralligenous assemblage

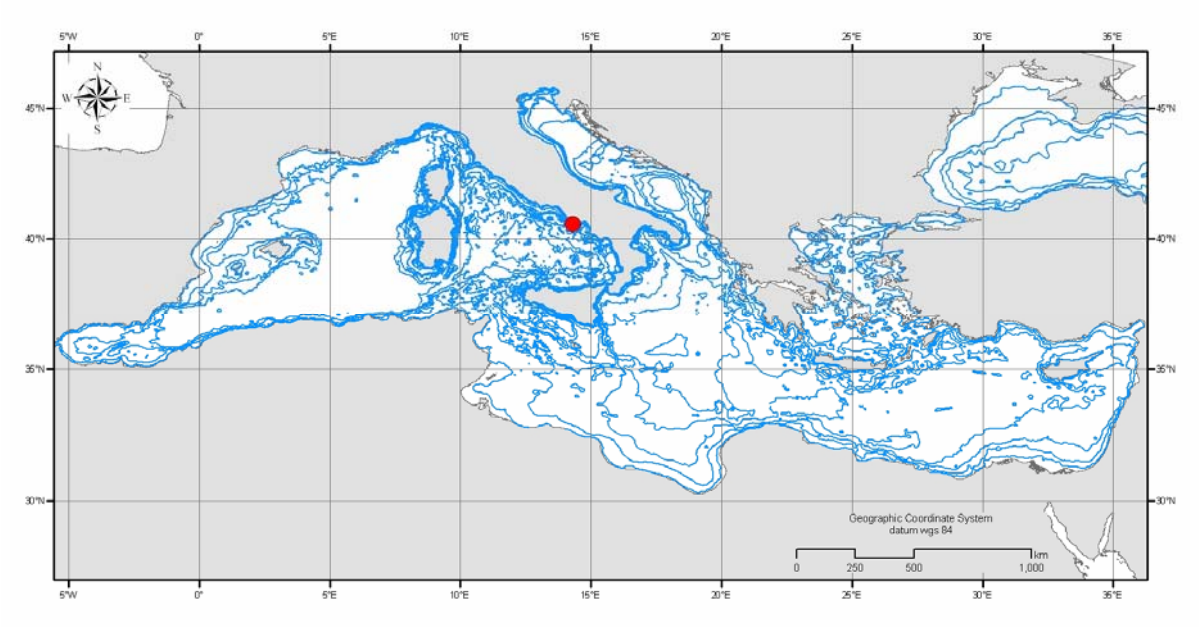
Data sheet 15

Reference document source

RUSSO G.F. (2004) - Realizzazione del Sistema Informativo Gegrafico (GIS). AMP di Punta Campanella. CONISMA - Università Parthenope di Napoli.

Location

Western Mediterranean, Southern Tyrrhenian, Italy, Punta Campanella.



Sampling Date

2000

Sampling method

Scuba diving

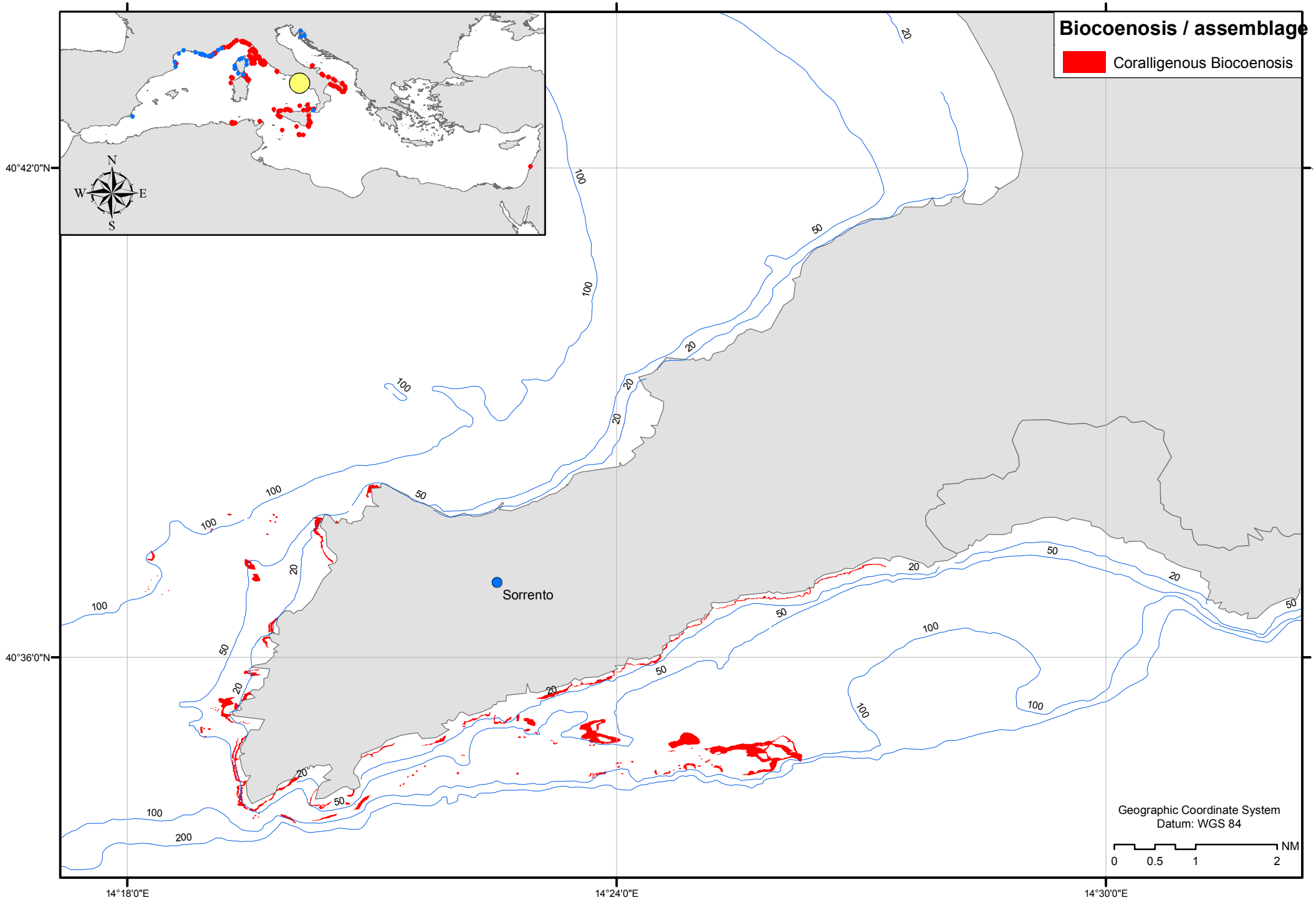
Original scale

Layout

Number of layouts: 1

Database ID

16


Biocoenosis / assemblage
Coralligenous Biocoenosis
Sorrento
40°42'0"N
40°36'0"N
14°18'0"E
14°24'0"E
14°30'0"E
N
W
E
S
Geographic Coordinate System
Datum: WGS 84
NM
0
0.5
1
2
20
50
100
200

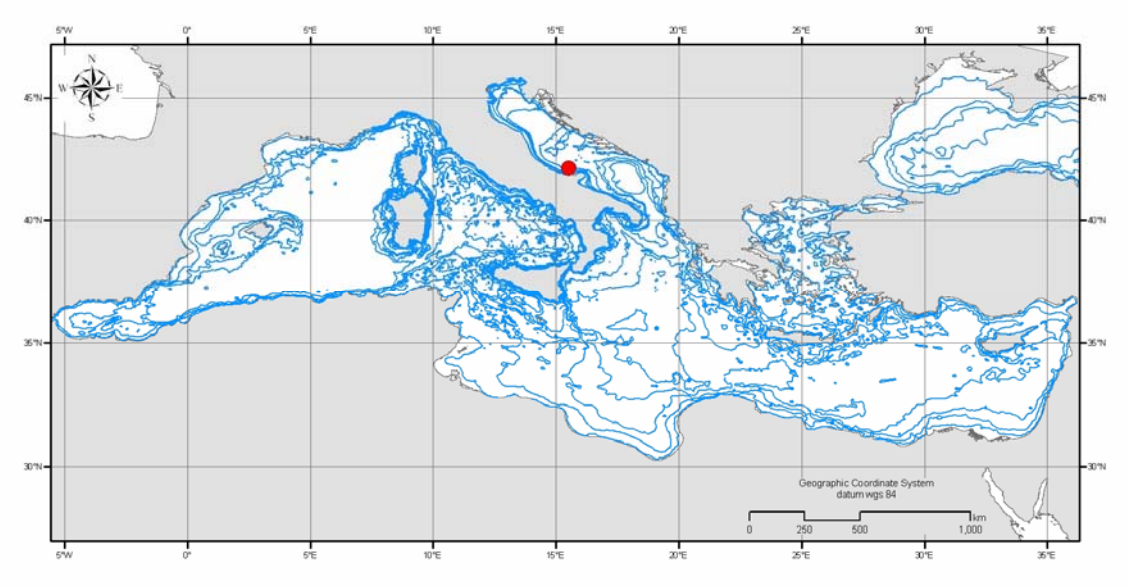
Data sheet 16

Reference document source

MATARRESE A., PANZA M., MASTROTOTARO F., COSTANTINO G. (2000) - Preliminary benthic charting of Tremiti Islands (Adriatic Sea). *Biol. Mar. Medit.*, **7** (1) pt. 2: 590-593.

Location

Adriatic Sea, Italia, Tremiti Islands.



Sampling Date

1997 - 1998

Sampling method

Scuba diving, underwater video camera, dredge, grab sampler

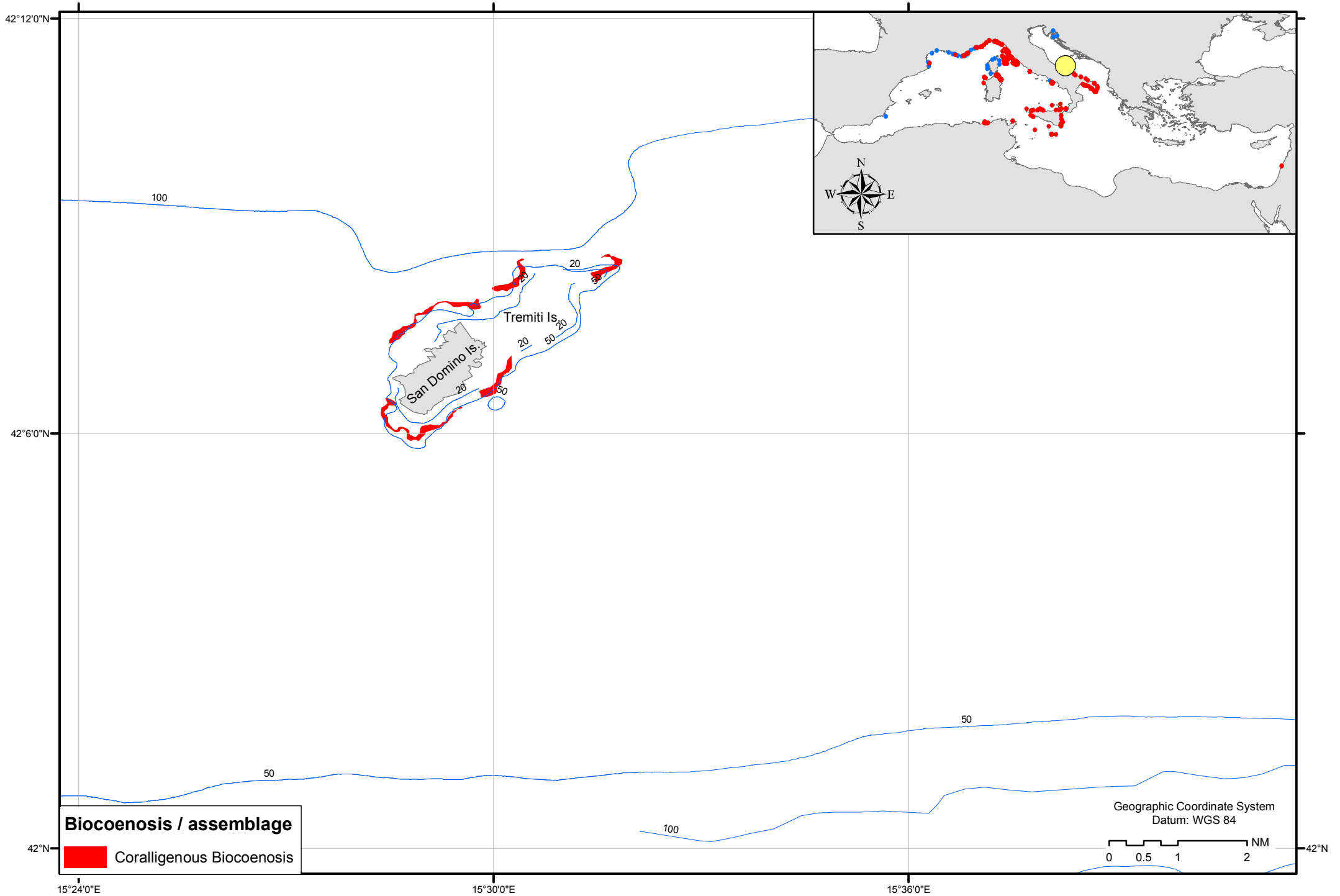
Original scale

Layout

Number of layouts: 1

Database ID

3


42°12'0"N
42°6'0"N
42°N
15°24'0"E
15°30'0"E
15°36'0"E
100
50
20
Tremiti Is.
San Domino Is.
N
W
E
S
Biocoenosis / assemblage
Coralligenous Biocoenosis
Geographic Coordinate System
Datum: WGS 84
NM
0
0.5
1
2

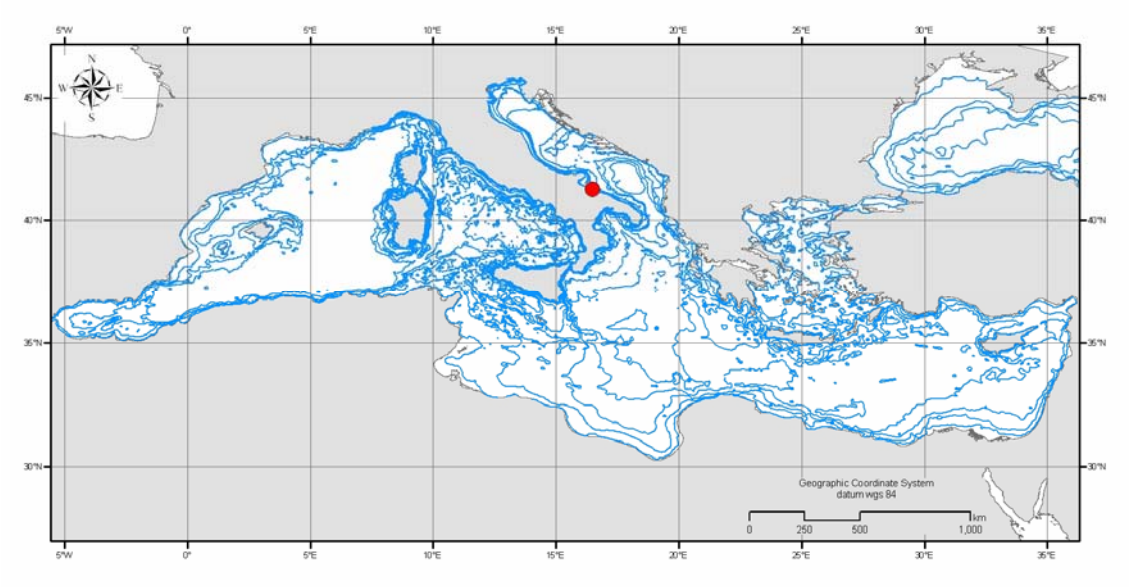
Data sheet 17

Reference document source

SARA' M. (1971) - Le peuplement du coralligène des Pouilles. *Rapp. Comm. Int. Mer Médit.*, **20**: 235-237.

Location

Adriatic Sea, Italy.



Sampling Date

Sampling method

Scuba diving, dredge

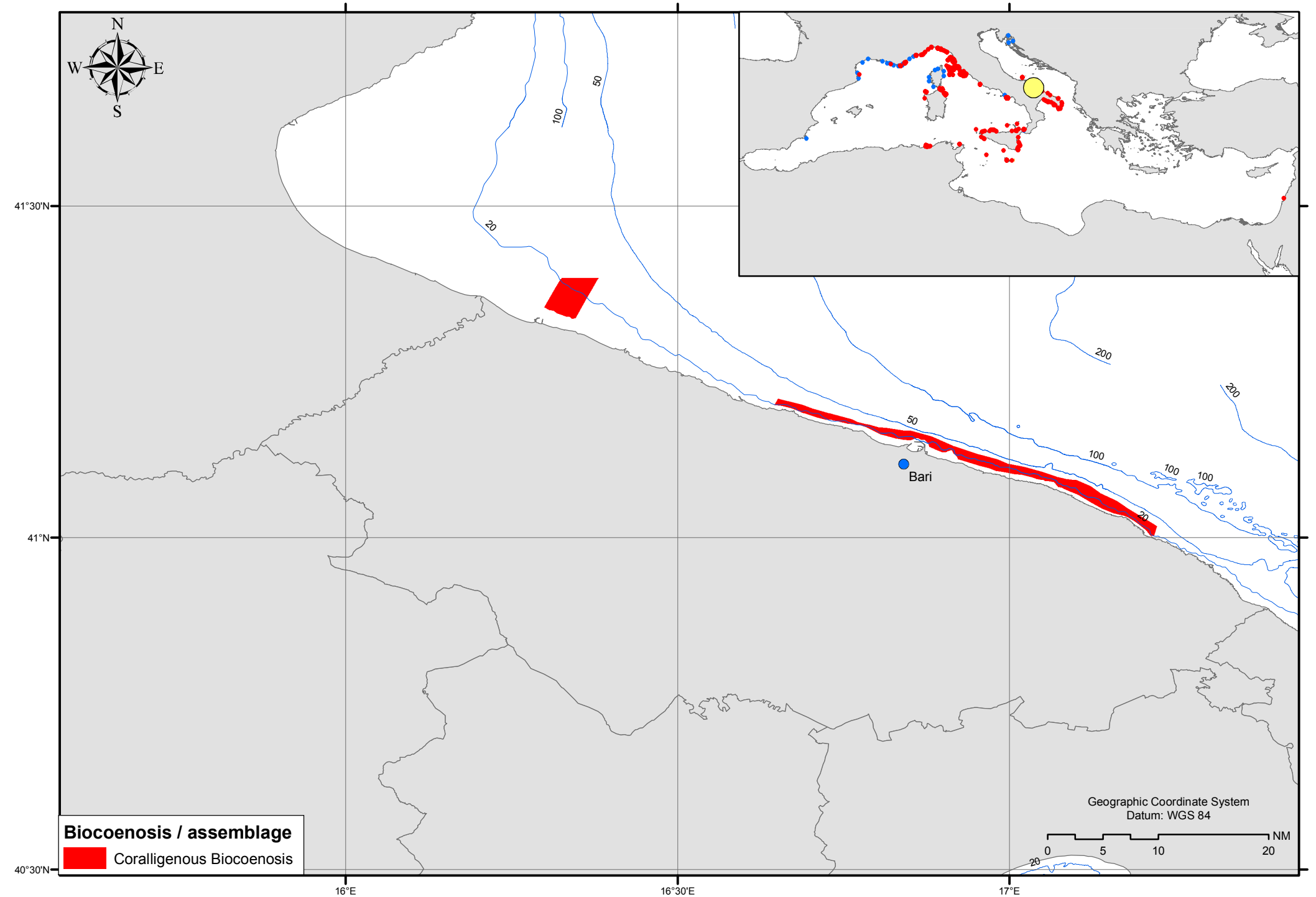
Original scale

Layout

Number of layouts: 1

Database ID

2


N
W
E
S
41°30'N
41°N
40°30'N
16°E
16°30'E
17°E
20
50
100
200
Bari
Biocoenosis / assemblage
Coralligenous Biocoenosis
Geographic Coordinate System
Datum: WGS 84
0
5
10
20
NM

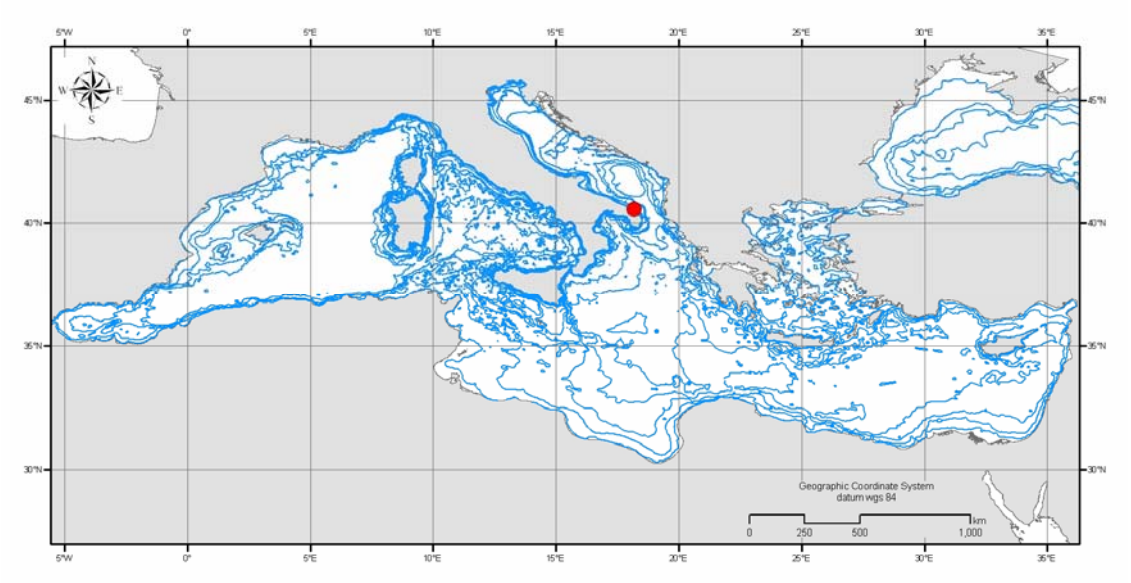
Data sheet 18

Reference document source

DAMIANI V., BIANCHI C.N., FERRETTI O., BEDULLI D., MORRI C., VIEL M., ZURLINI G. (1988) – Risultati di una ricerca ecologica sul sistema marino costiero pugliese. *Thalassia Salent.*, **18**: 153-169.

Location

Ionian Sea, Italy.



Sampling Date

1982 - 1984

Sampling method

Original scale

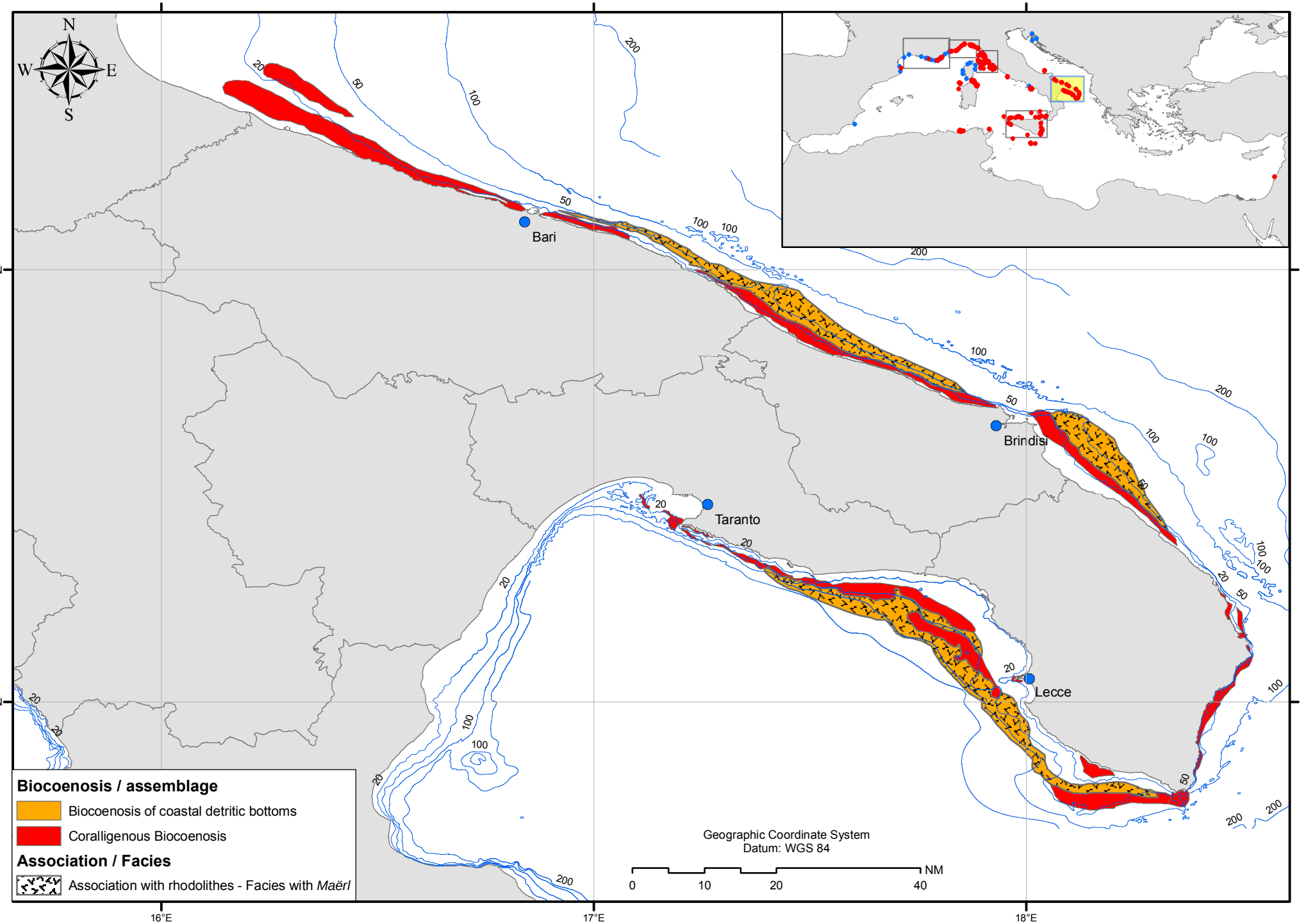
Scale: 1:500.000

Layout

Number of layouts: 1

Database ID

12


N
W
E
S
Bari
Brindisi
Taranto
Lecce
41°N
40°N
16°E
17°E
18°E
Biocoenosis / assemblage
Biocoenosis of coastal detritic bottoms
Coralligenous Biocoenosis
Association / Facies
Association with rhodolithes - Facies with Maërl
Geographic Coordinate System
Datum: WGS 84
0
10
20
40
NM

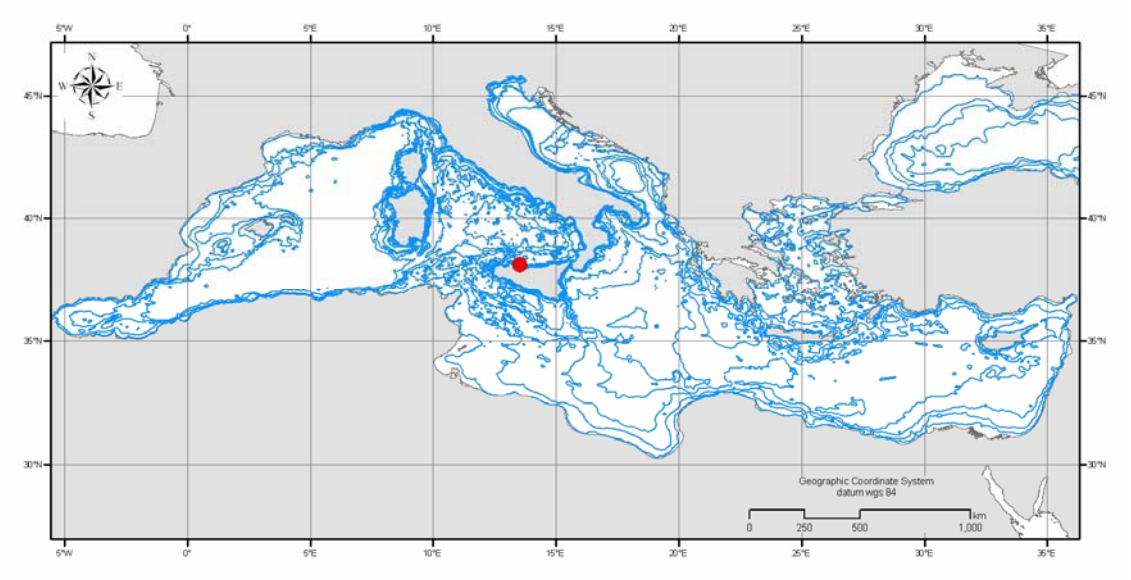
Data sheet 19

Reference document source

AA.VV. (2005) - *GIS Natura: il GIS delle conoscenze naturalistiche in Italia*. DVD. Politecnico di Milano. Ministero dell'Ambiente e della Tutela del Territorio, Direzione Protezione della Natura.

Location

Western Mediterranean and Ionian Sea, Italy.



Sampling Date

Sampling method

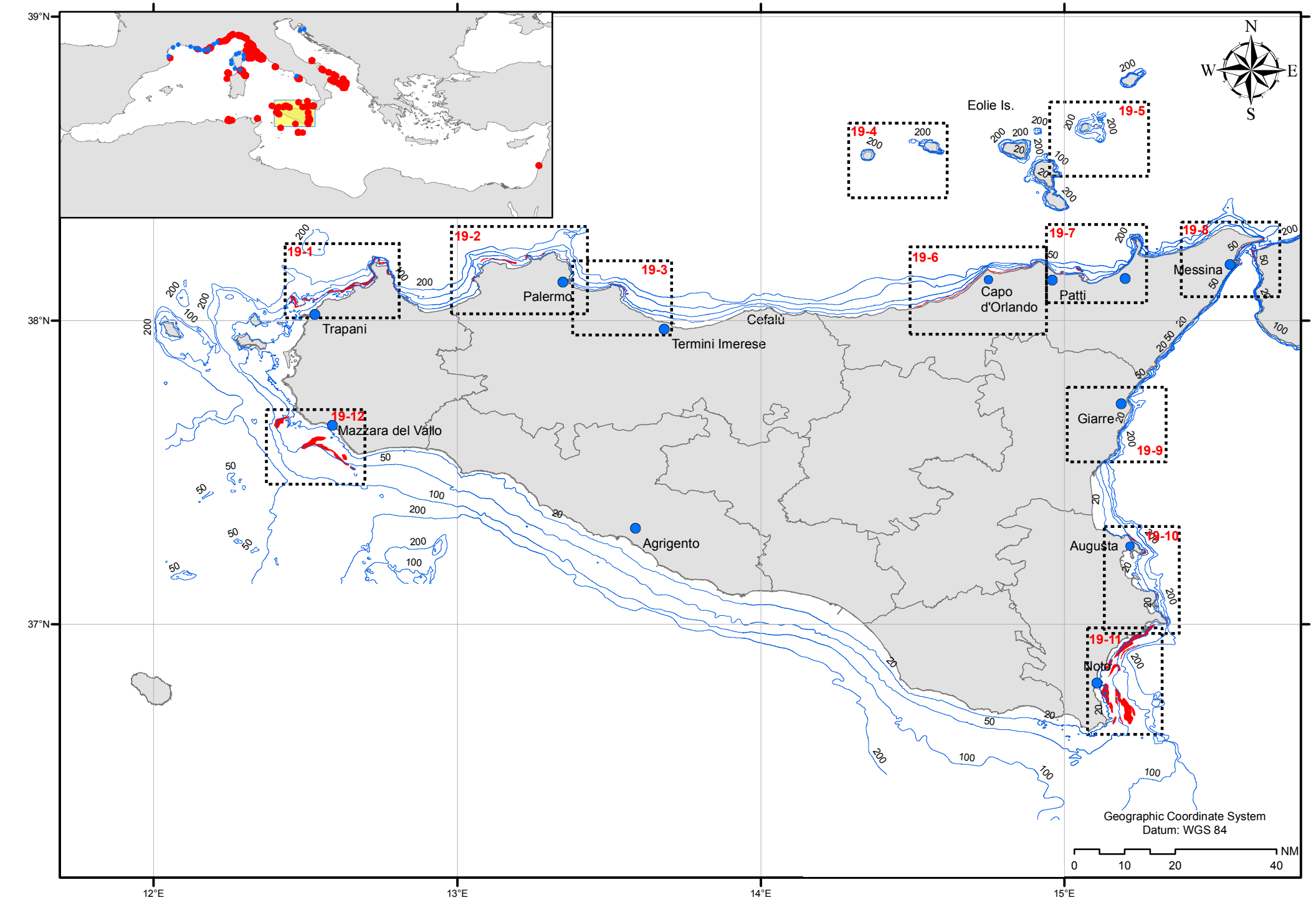
Original scale

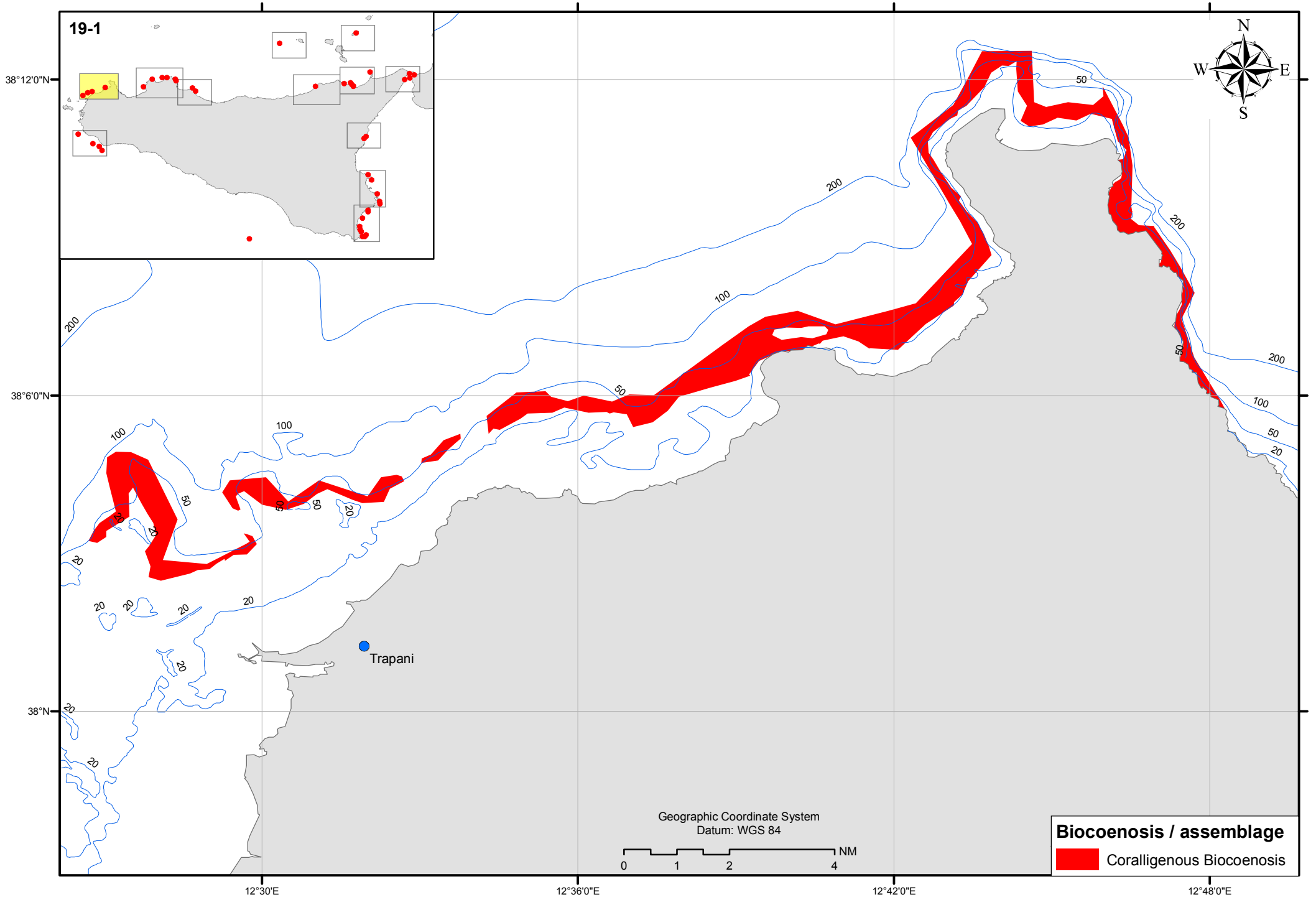
Layout

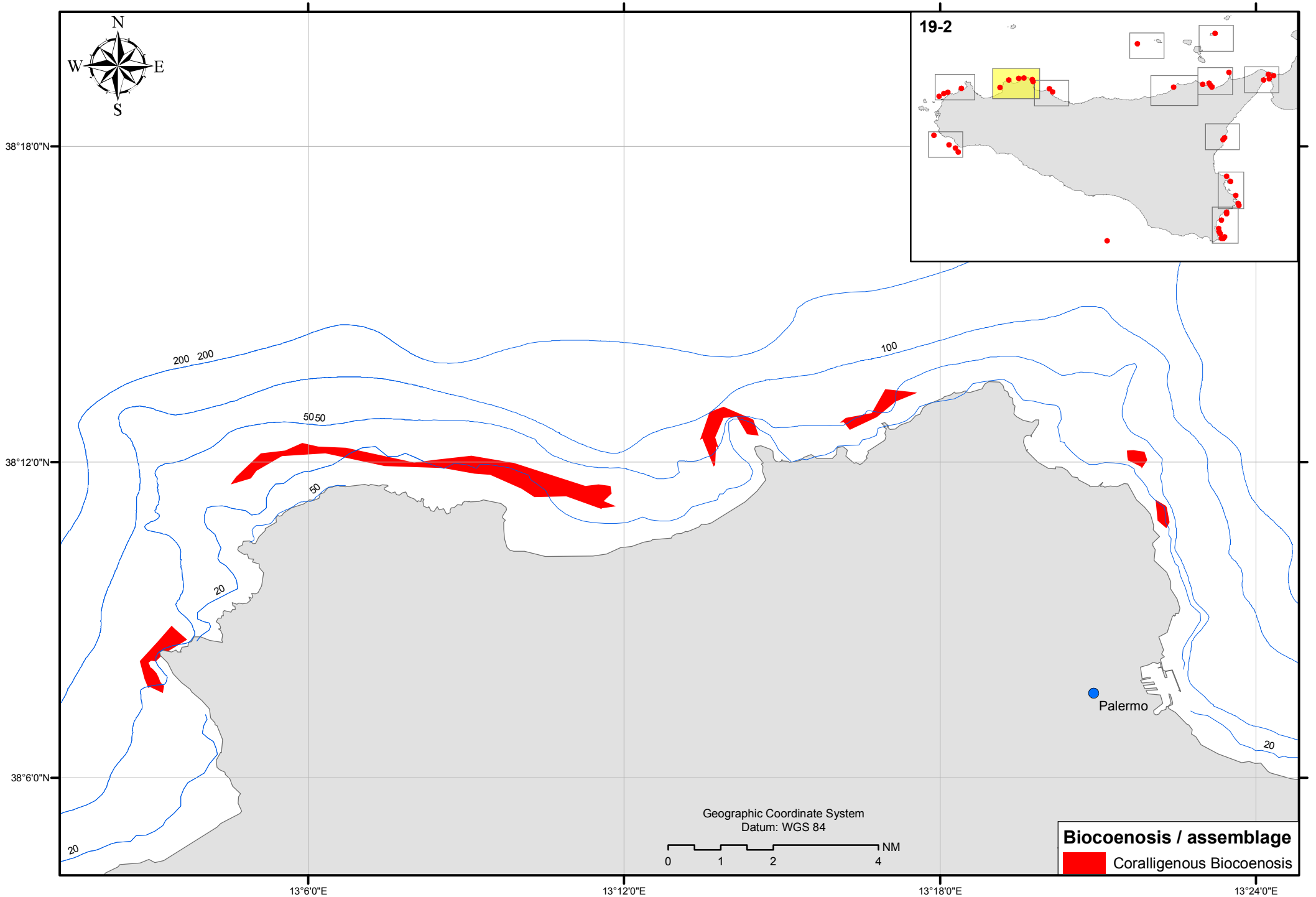
Number of layouts: 13

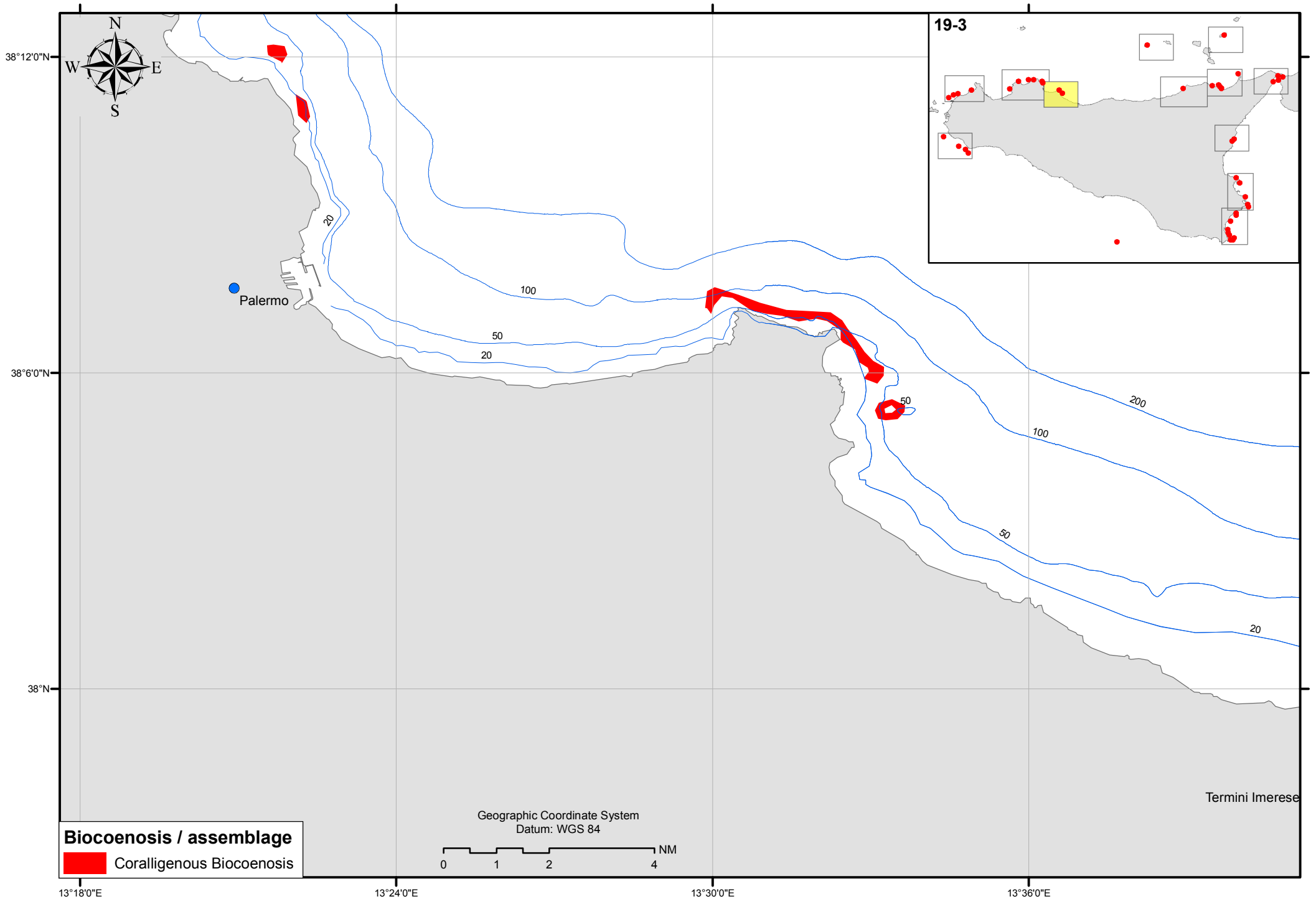
Database ID

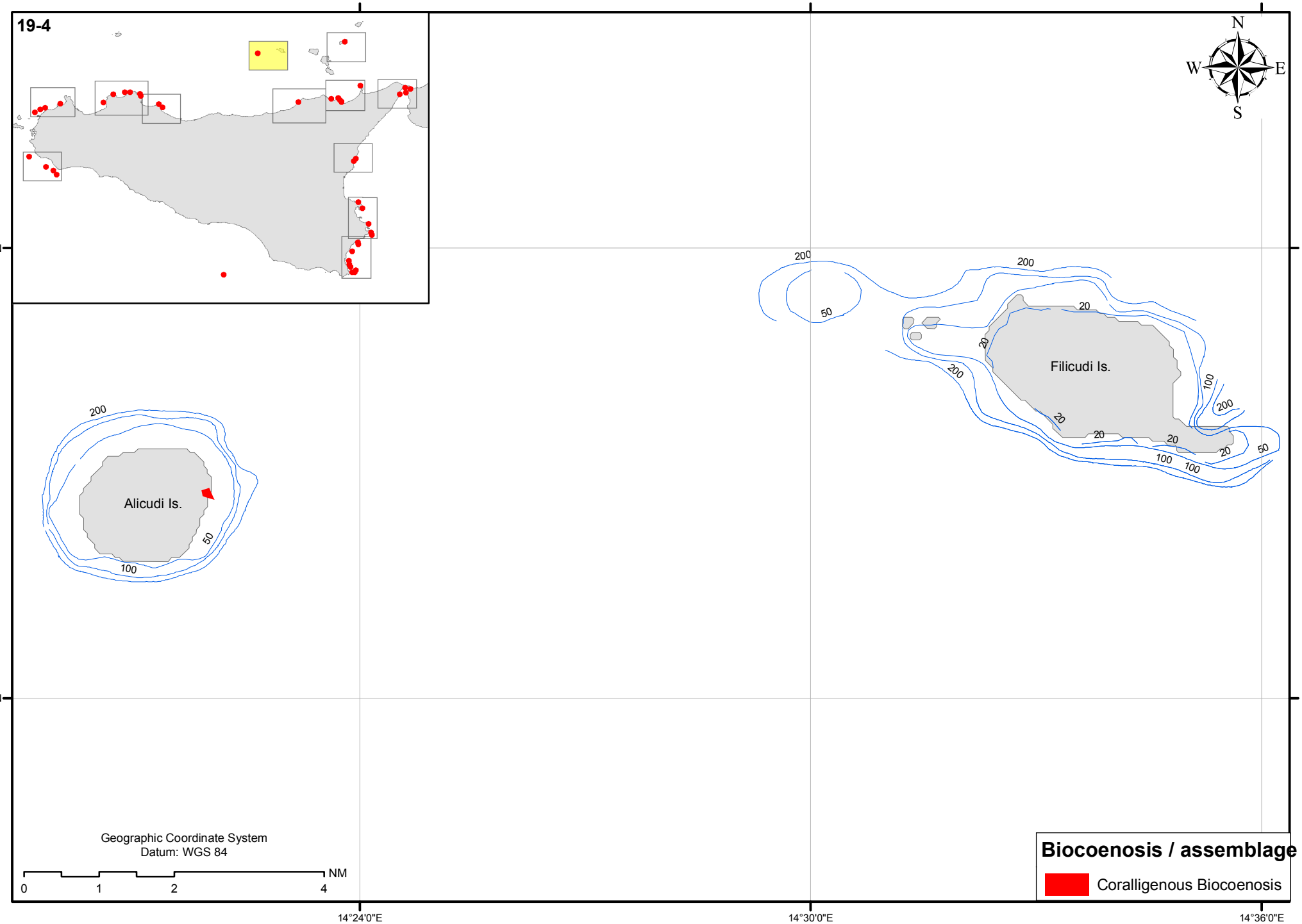
23

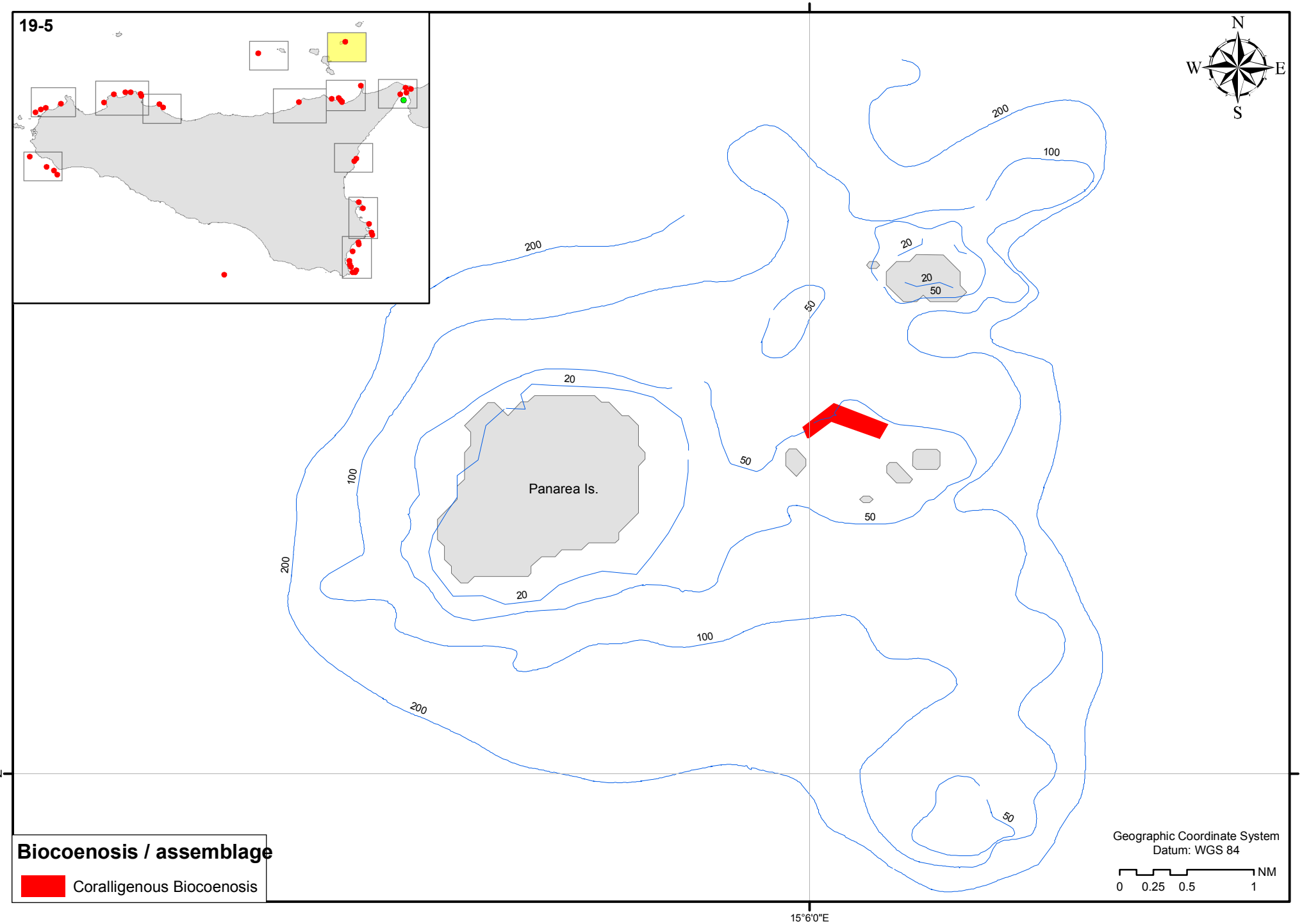

39°N
38°N
37°N
12°E
13°E
14°E
15°E
N
S
W
E
Eolie Is.
19-1
19-2
19-3
19-4
19-5
19-6
19-7
19-8
19-9
19-10
19-11
19-12
Trapani
Palermo
Cefalù
Termini Imerese
Capo d'Orlando
Patti
Messina
Giarre
Augusta
Agrigento
Mazzara del Vallo
Noto
Geographic Coordinate System
Datum: WGS 84
0 10 20 40
NM

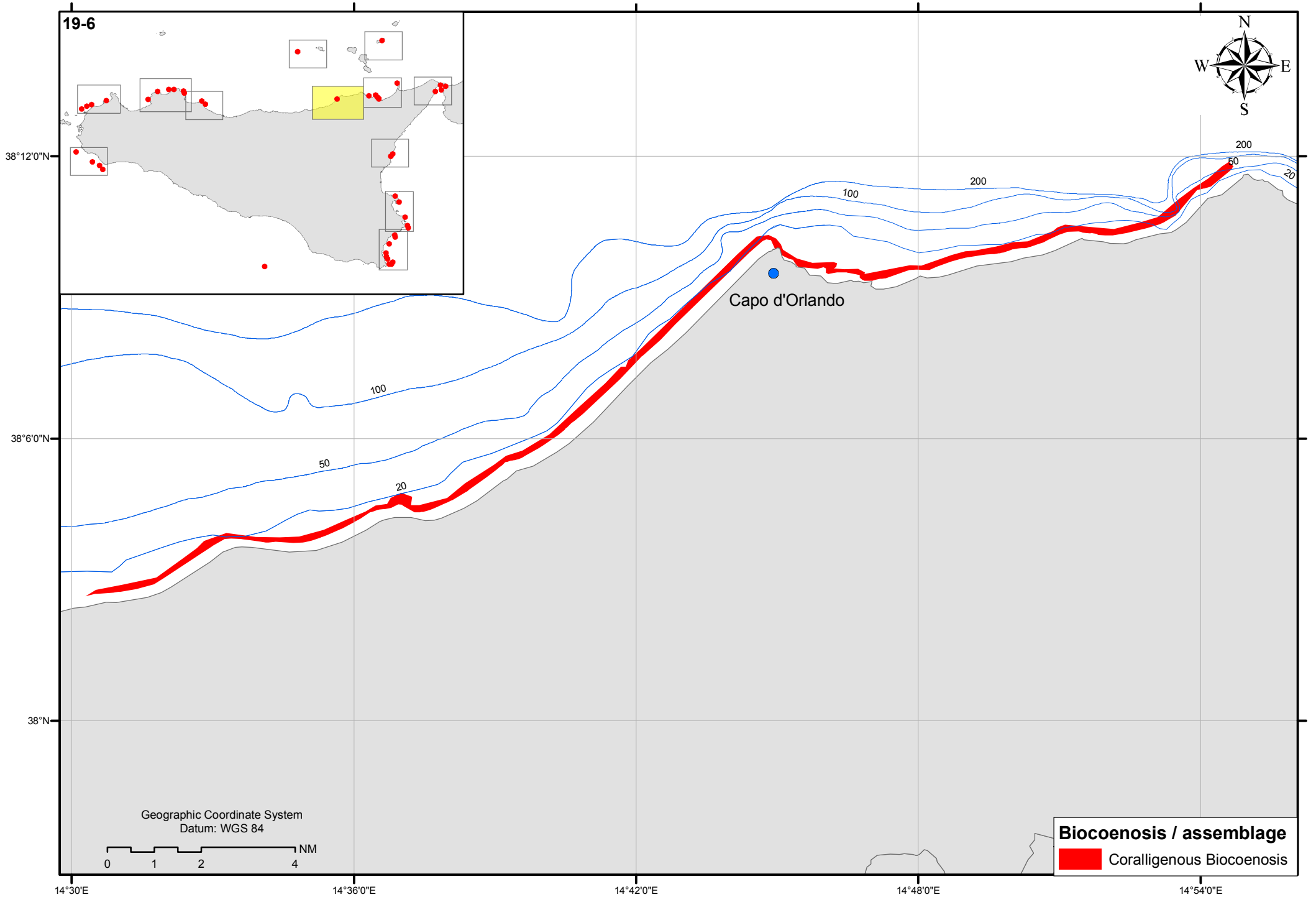

19-1
38°12'0"N
38°6'0"N
38°N
12°30'E
12°36'0"E
12°42'0"E
12°48'0"E
N
W
E
S
Trapani
Geographic Coordinate System
Datum: WGS 84
0
1
2
4
NM
Biocoenosis / assemblage
Coralligenous Biocoenosis

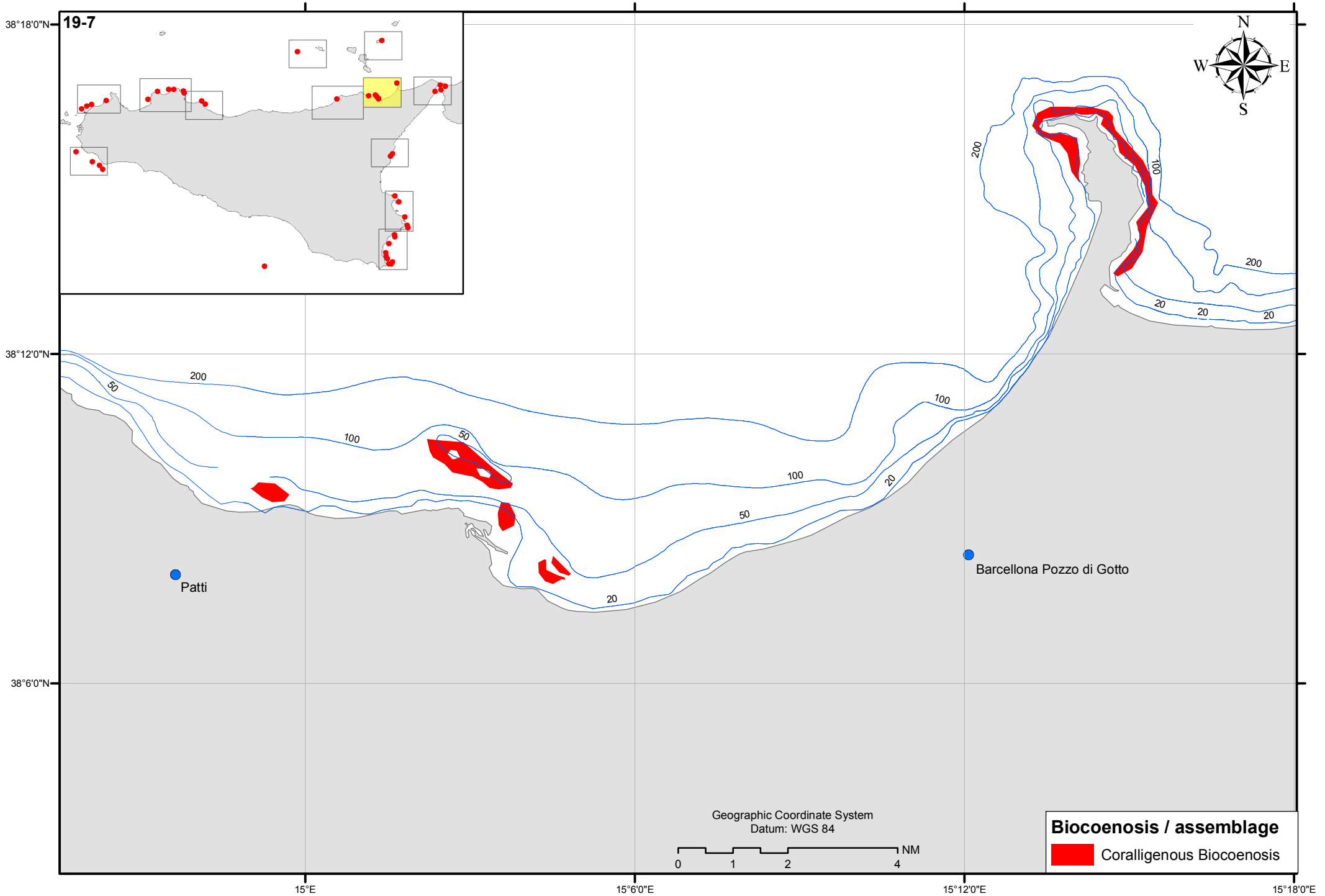

N
W
E
S
19-2
38°18'0"N
38°12'0"N
38°6'0"N
13°6'0"E
13°12'0"E
13°18'0"E
13°24'0"E
200
200
100
50
50
50
20
20
20
Palermo
Geographic Coordinate System
Datum: WGS 84
0
1
2
4
NM
Biocoenosis / assemblage
Coralligenous Biocoenosis

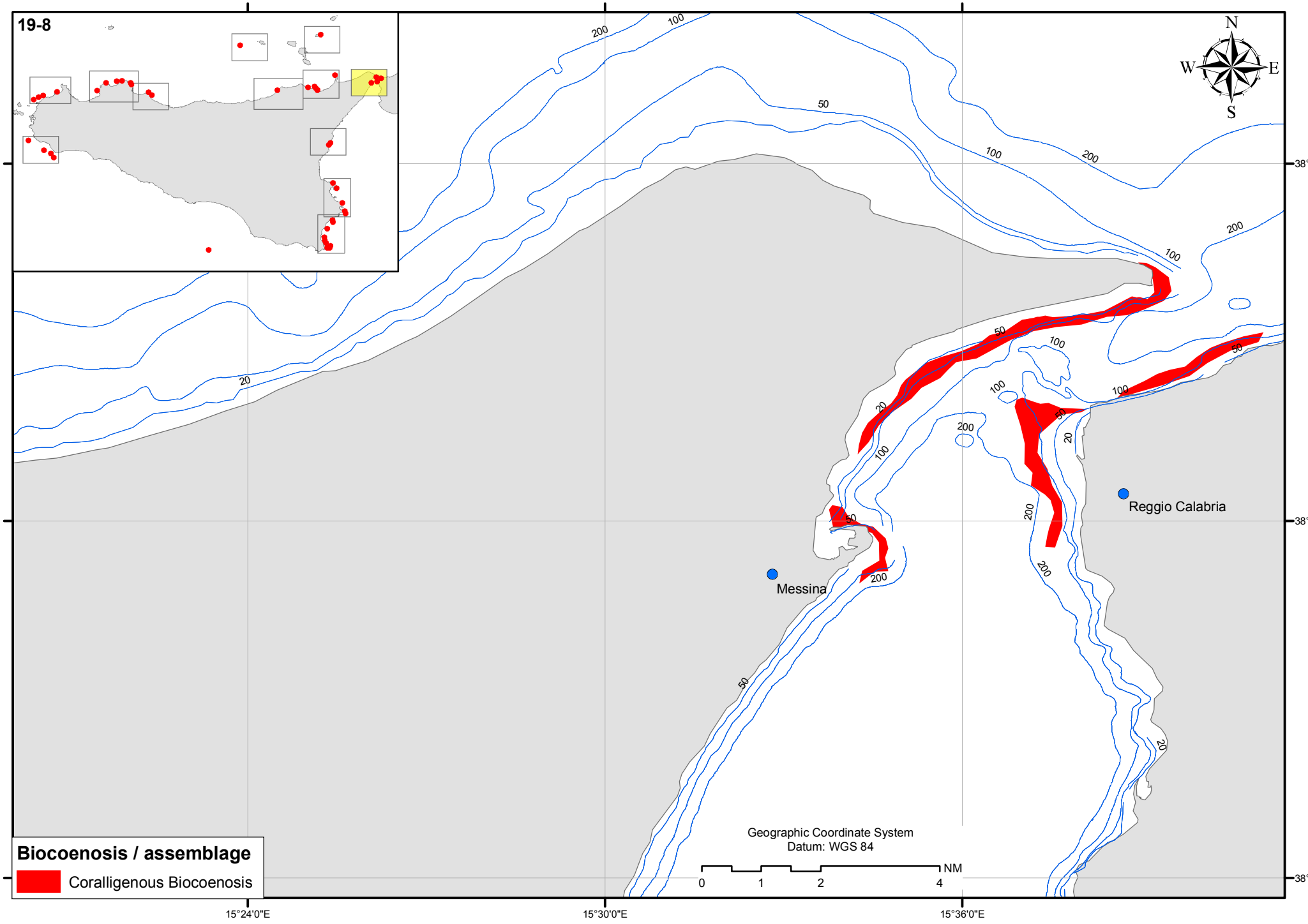

19-3
N
W
E
S
38°12'0"N
38°6'0"N
38°N
13°18'0"E
13°24'0"E
13°30'0"E
13°36'0"E
Palermo
Termini Imerese
20
100
50
20
50
200
100
50
20
Biocoenosis / assemblage
Coralligenous Biocoenosis
Geographic Coordinate System
Datum: WGS 84
0
1
2
4
NM

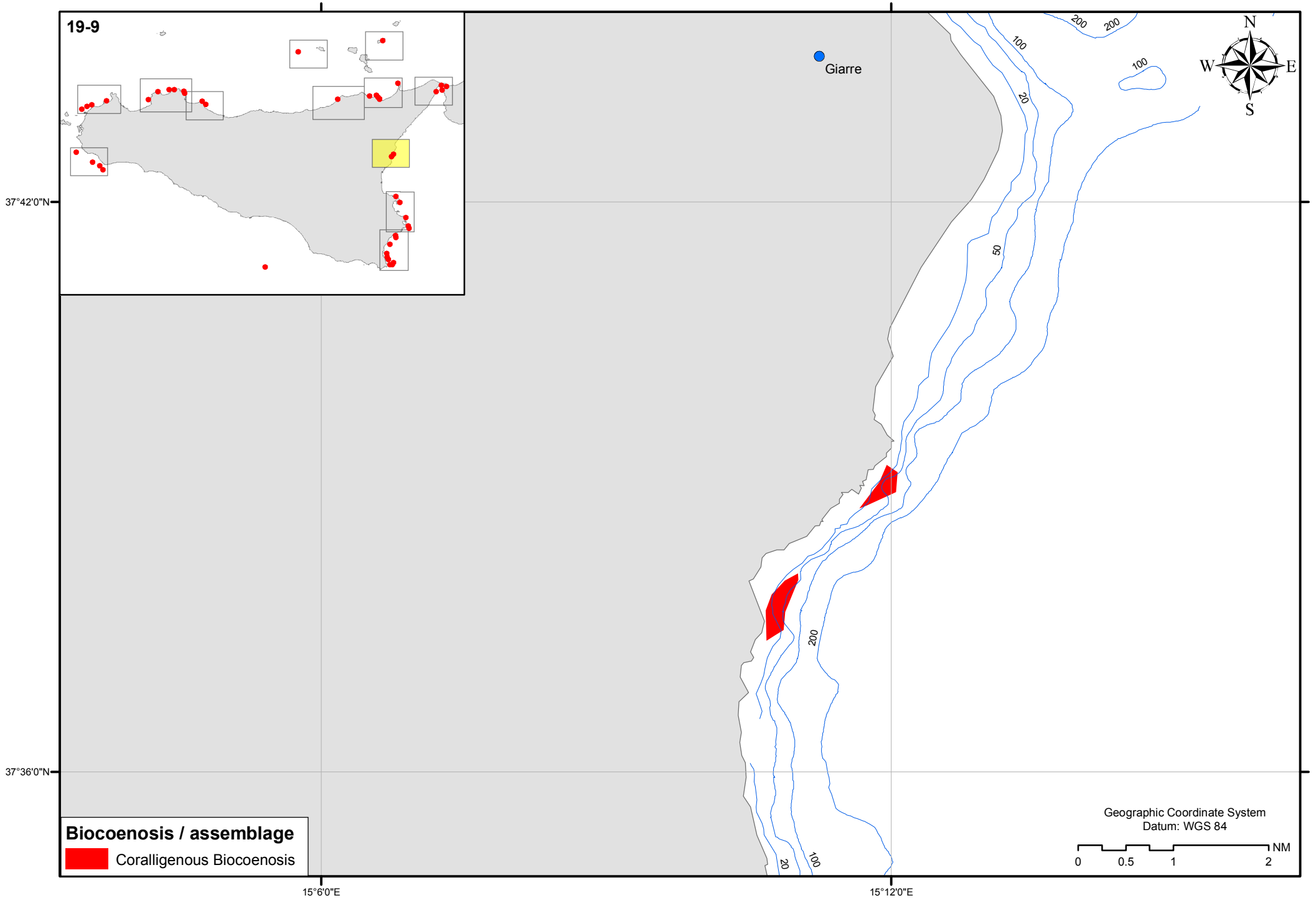

19-4
N
W
E
S
38°36'0"N
38°30'N
14°24'0"E
14°30'0"E
14°36'0"E
Alicudi Is.
Filicudi Is.
200
100
50
20
Geographic Coordinate System
Datum: WGS 84
0
1
2
4
NM
Biocoenosis / assemblage
Coralligenous Biocoenosis

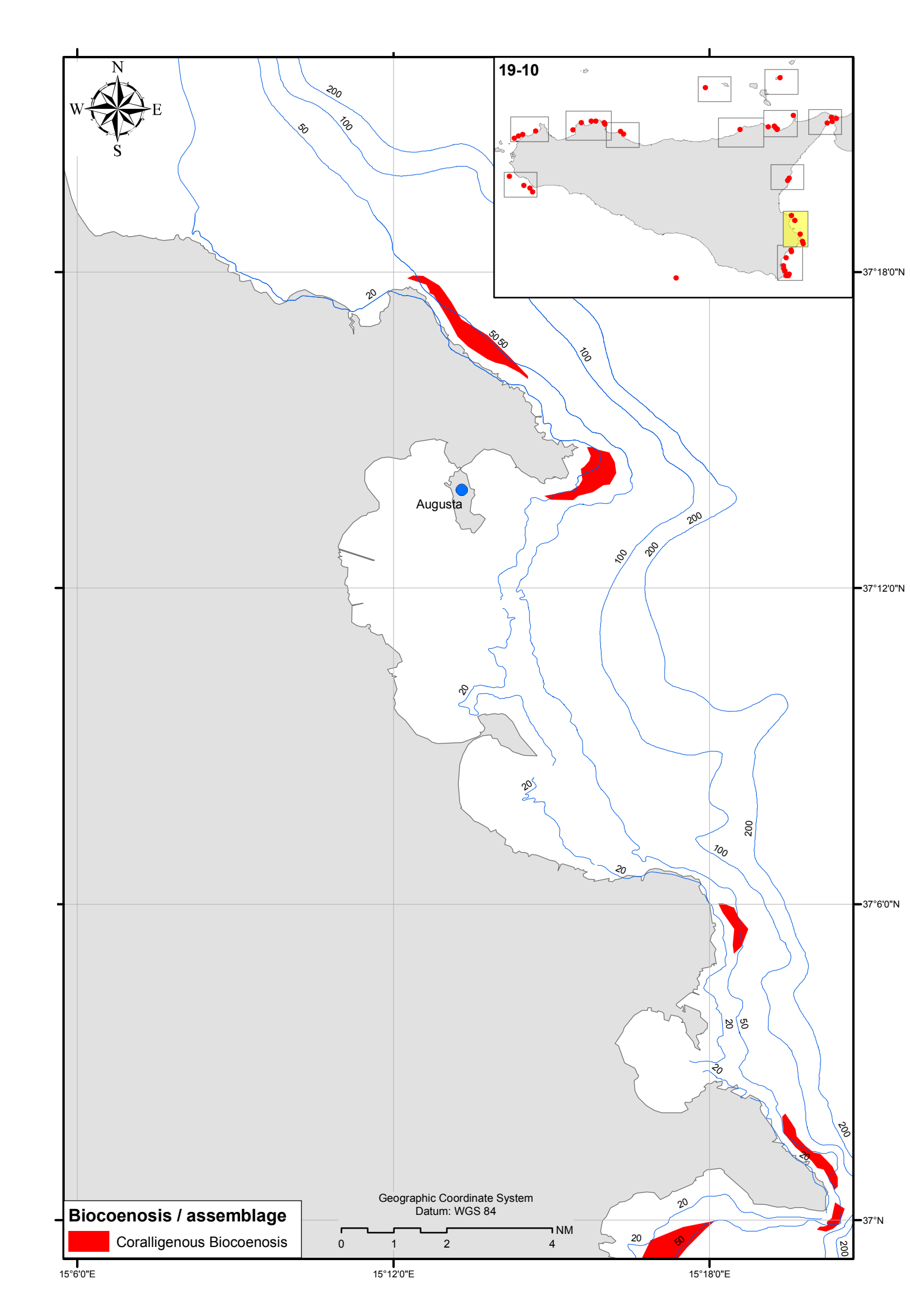

19-5
N
W
E
S
200
100
20
50
Panarea Is.
38°36'0"N
15°6'0"E
Biocoenosis / assemblage
Coralligenous Biocoenosis
Geographic Coordinate System
Datum: WGS 84
0 0.25 0.5 1
NM

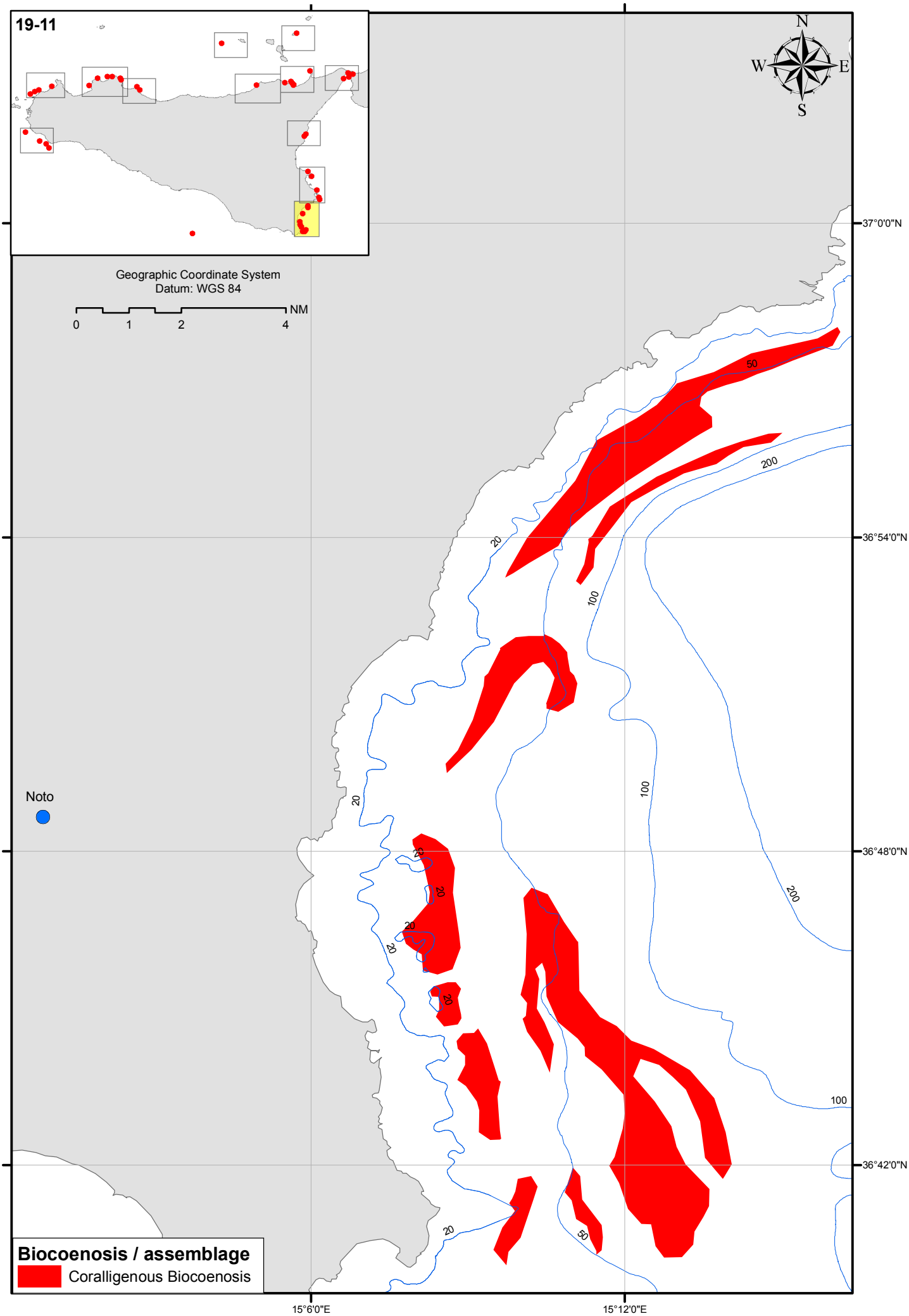

19-6
N
W
E
S
38°12'0"N
38°6'0"N
38°N
14°30'E
14°36'0"E
14°42'0"E
14°48'0"E
14°54'0"E
200
100
50
20
Capo d'Orlando
Geographic Coordinate System
Datum: WGS 84
0
1
2
4
NM
Biocoenosis / assemblage
Coralligenous Biocoenosis

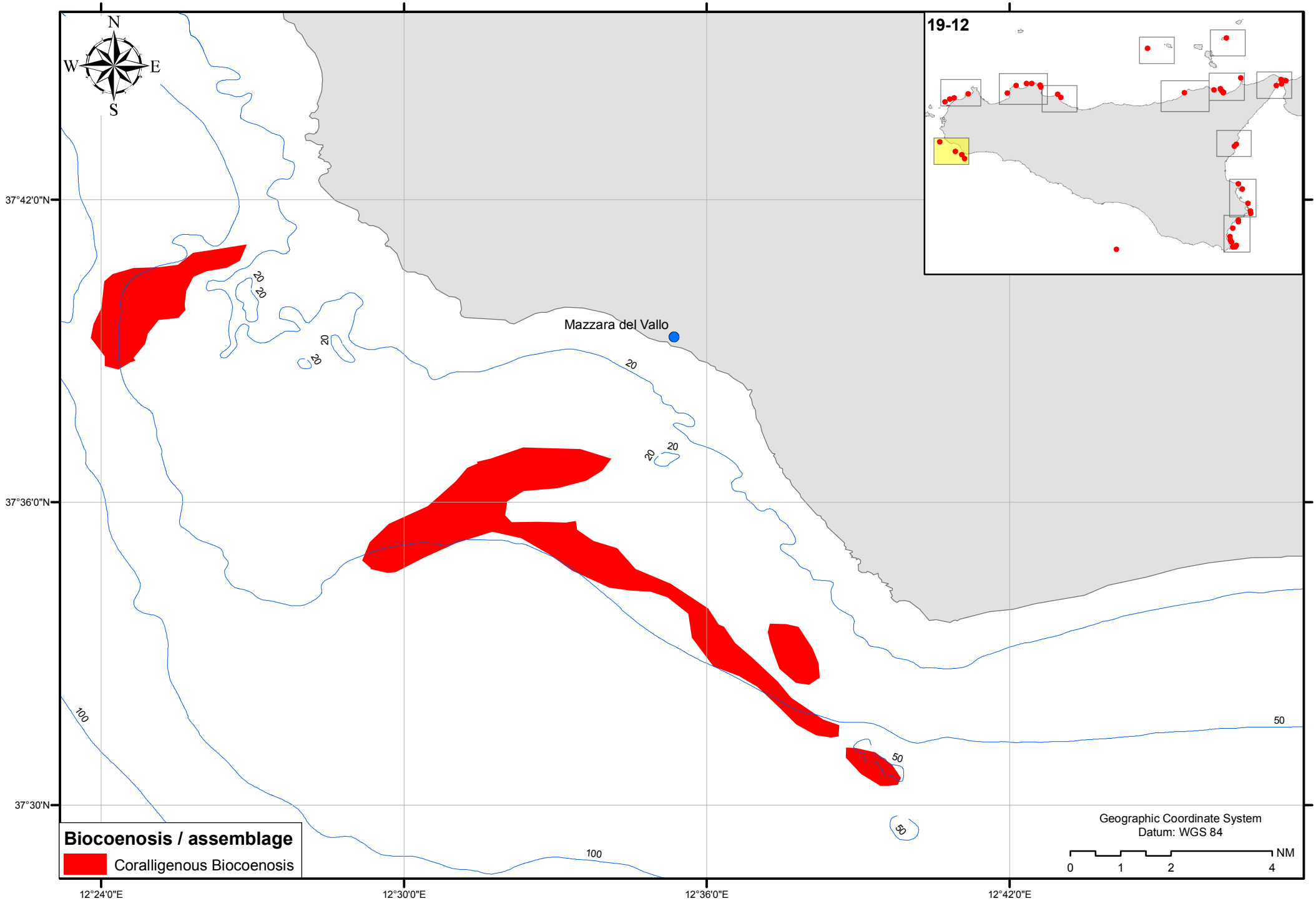

19-7
38°18'0"N
38°12'0"N
38°6'0"N
15°E
15°6'0"E
15°12'0"E
15°18'0"E
N
W
E
S
200
100
50
20
Patti
Barcellona Pozzo di Gotto
Geographic Coordinate System
Datum: WGS 84
0
1
2
4
NM
Biocoenosis / assemblage
Coralligenous Biocoenosis


19-8
N
W
E
S
Messina
Reggio Calabria
38°18'0"N
38°12'0"N
38°6'0"N
15°24'0"E
15°30'0"E
15°36'0"E
Geographic Coordinate System
Datum: WGS 84
0
1
2
4
NM
Biocoenosis / assemblage
Coralligenous Biocoenosis


19-9
Giarre
200
200
100
100
20
50
200
100
20
N
W
E
S
37°42'0"N
37°36'0"N
15°6'0"E
15°12'0"E
Biocoenosis / assemblage
Coralligenous Biocoenosis
Geographic Coordinate System
Datum: WGS 84
0
0.5
1
2
NM


19-10
N
W
E
S
Augusta
200
100
50
20
37°18'0"N
37°12'0"N
37°6'0"N
37°N
15°6'0"E
15°12'0"E
15°18'0"E
Biocoenosis / assemblage
Coralligenous Biocoenosis
Geographic Coordinate System
Datum: WGS 84
0
1
2
4
NM


19-11
N
W
E
S
Geographic Coordinate System
Datum: WGS 84
0
1
2
4
NM
Noto
37°0'0"N
36°54'0"N
36°48'0"N
36°42'0"N
15°6'0"E
15°12'0"E
50
200
100
20
Biocoenosis / assemblage
Coralligenous Biocoenosis


N
W
E
S
19-12
Mazzara del Vallo
20
20
20
20
20
20
100
100
50
50
50
37°42'0"N
37°36'0"N
37°30'N
12°24'0"E
12°30'0"E
12°36'0"E
12°42'0"E
Biocoenosis / assemblage
Coralligenous Biocoenosis
Geographic Coordinate System
Datum: WGS 84
0
1
2
4
NM

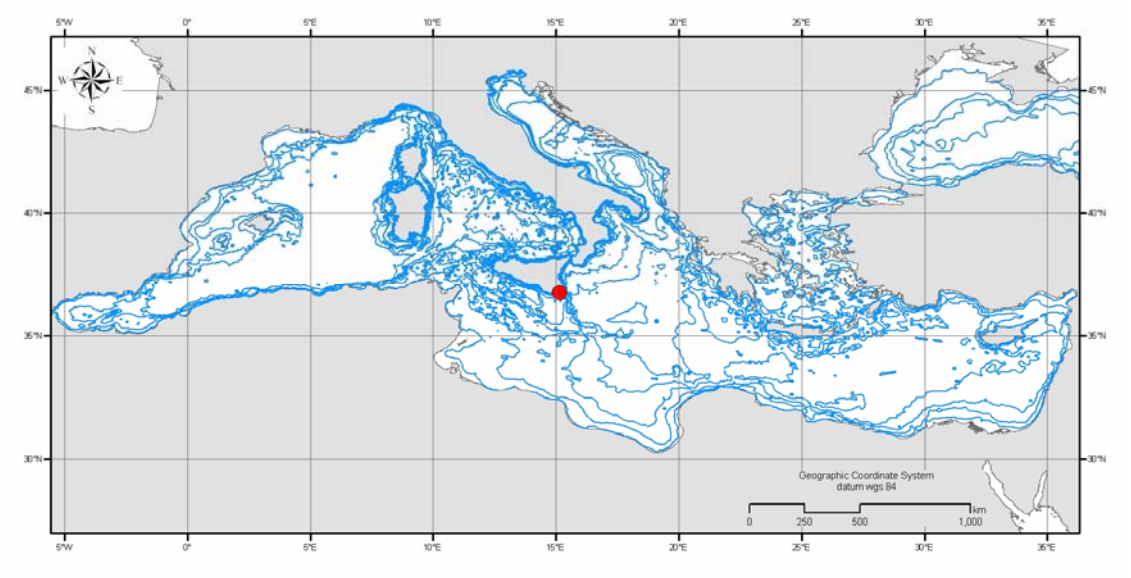
Data sheet 20

Reference document source

CANTONE G., MOLLICA E., FASSARI G., DI PIETRO N., CATALANO D. (1999). Biocoenotic map of the continental shelf in Noto Gulf (eastern Sicily). *Biol. Mar. Medit.* **6** (1): 347-350

Location

Ionian Sea, Italy, Noto.



Sampling Date

Sampling method

Scuba diving (scrabbing), dredge

Original scale

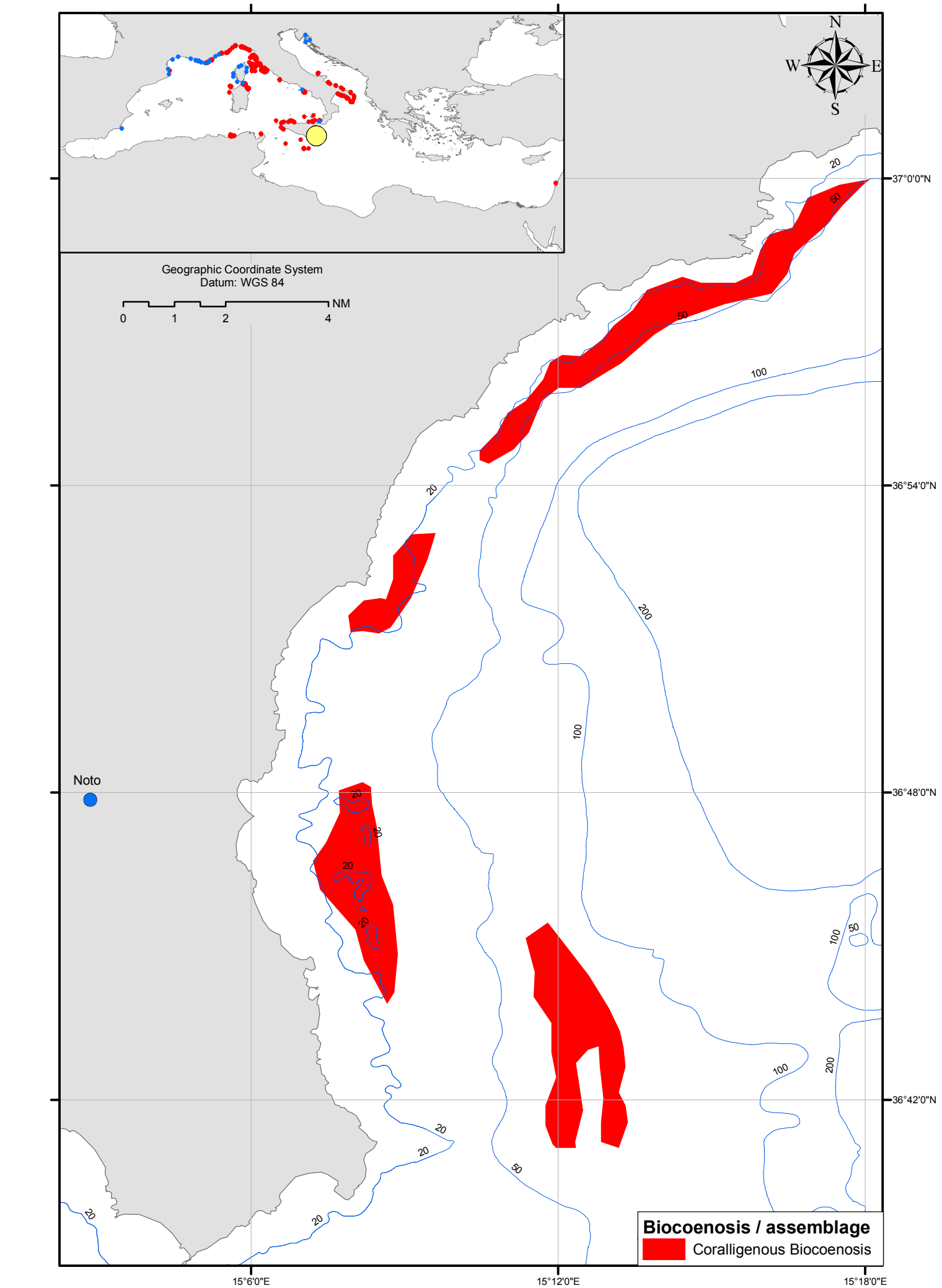
Scale: 1:50.000

Layout

Number of layouts: 1

Database ID

4


N
W
E
S
Geographic Coordinate System
Datum: WGS 84
0
1
2
4
NM
Noto
37°0'0"N
36°54'0"N
36°48'0"N
36°42'0"N
15°6'0"E
15°12'0"E
15°18'0"E
20
50
100
200
Biocoenosis / assemblage
Coralligenous Biocoenosis

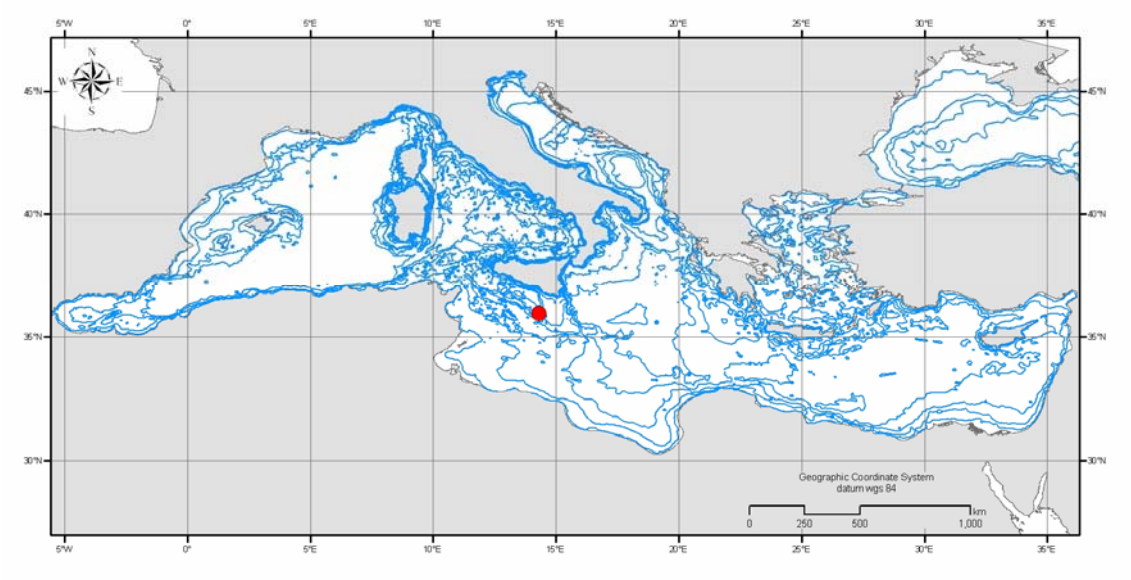
Data sheet 21

Reference document source

DIMECH M., CAMILLERI M., BORG J.A., SMITH I.P., SCIBERRAS M., SCHEMBRI P.J. (2007) – The potential of fisheries reserves as a tool for biodiversity conservation. The case of the 25 Nautical Mile Fisheries Management Zone around Malta. In: *European Symposium on marine protected areas as a tool for fisheries management and ecosystem conservation. Emerging science and interdisciplinary approaches (Murcia, 25-28 September 2007). Perez-Ruzafa A., Hoffmann E., Boncoeur J., Garcia-Charton J.A., Marcos C., Salas F., Sorensen T.K., Vestegaard O. (eds.).Abstracts Book*. 79 pp.

Location

Ionian Sea, Malta.



Sampling Date

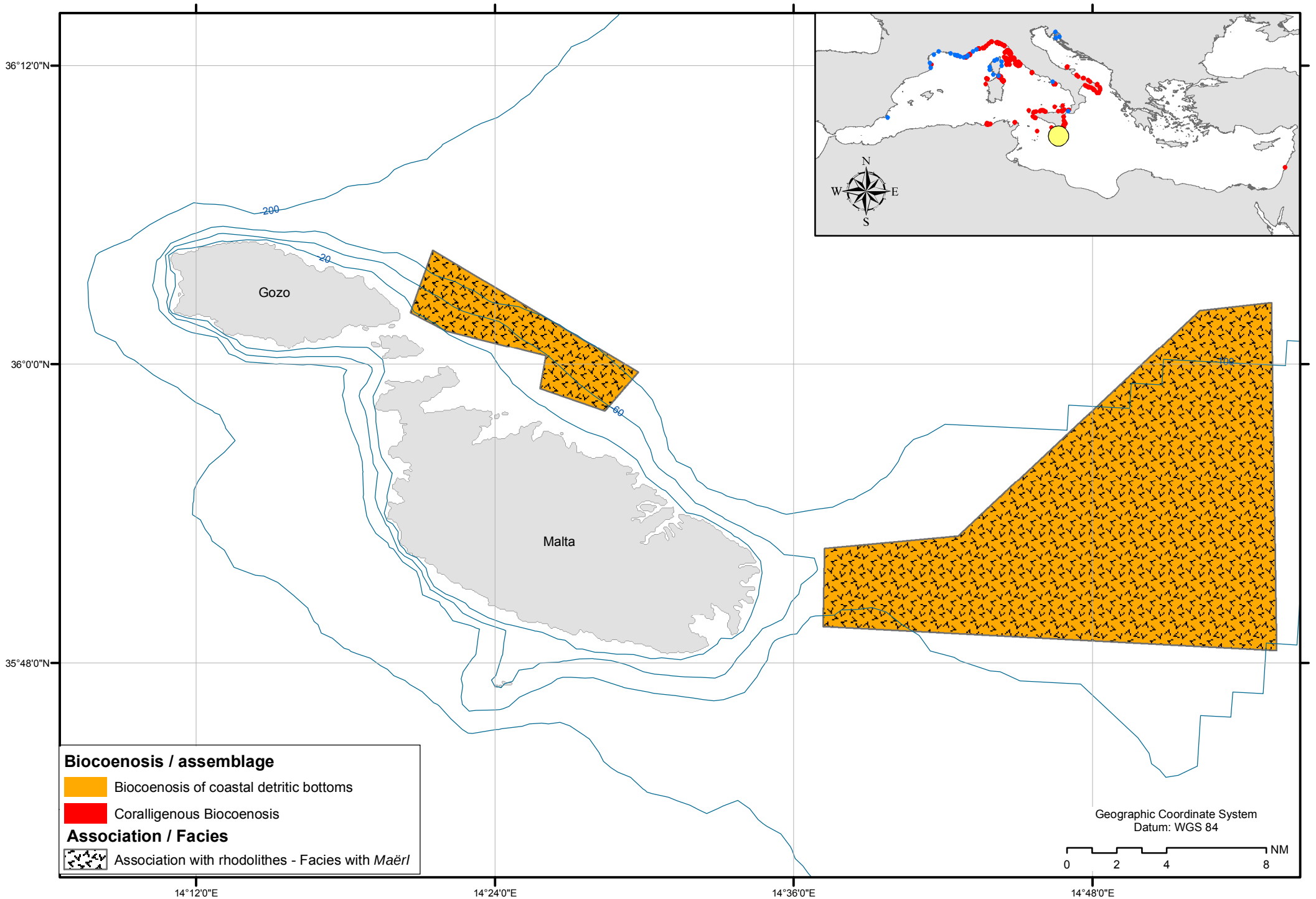
Sampling method

Original scale

Layout

Number of layouts: 1

Database ID


36°12'0"N
36°0'0"N
35°48'0"N
14°12'0"E
14°24'0"E
14°36'0"E
14°48'0"E
200
20
60
Gozo
Malta
N
W
E
S
Biocoenosis / assemblage
Biocoenosis of coastal detritic bottoms
Coralligenous Biocoenosis
Association / Facies
Association with rhodolithes - Facies with Maërl
Geographic Coordinate System
Datum: WGS 84
0
2
4
8
NM

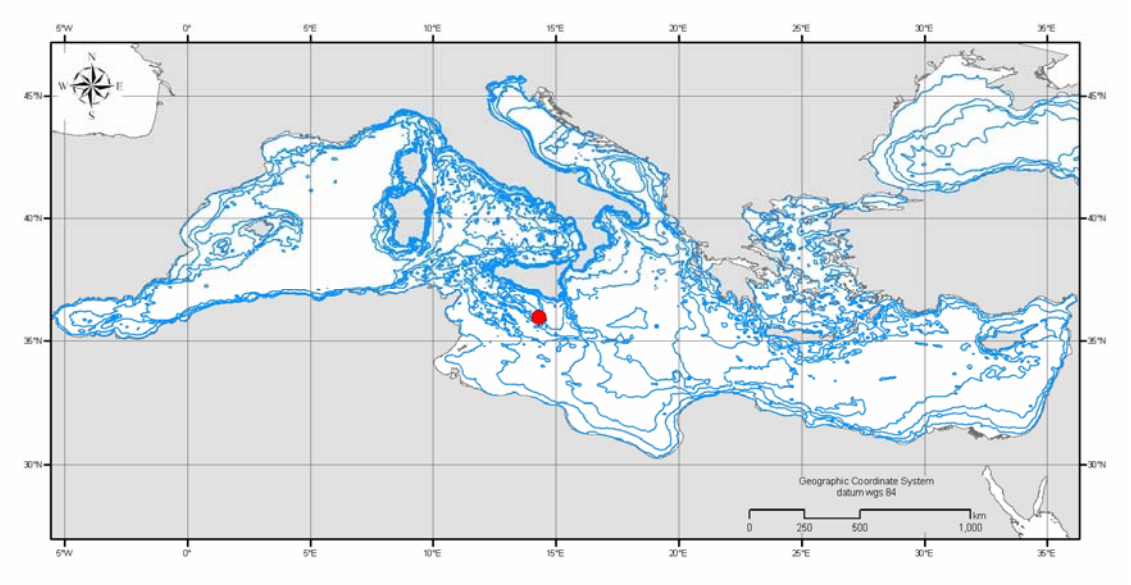
Data sheet 22

Reference document source

UNEP/MAP. (2003) - MAP CAMP Project "Malta": final integrated project document and selected thematic documents. *MAP technical Reports Series.* 138 pp.

Location

Ionian Sea, Malta.



Sampling Date

2000

Sampling method

Scuba diving

Original scale

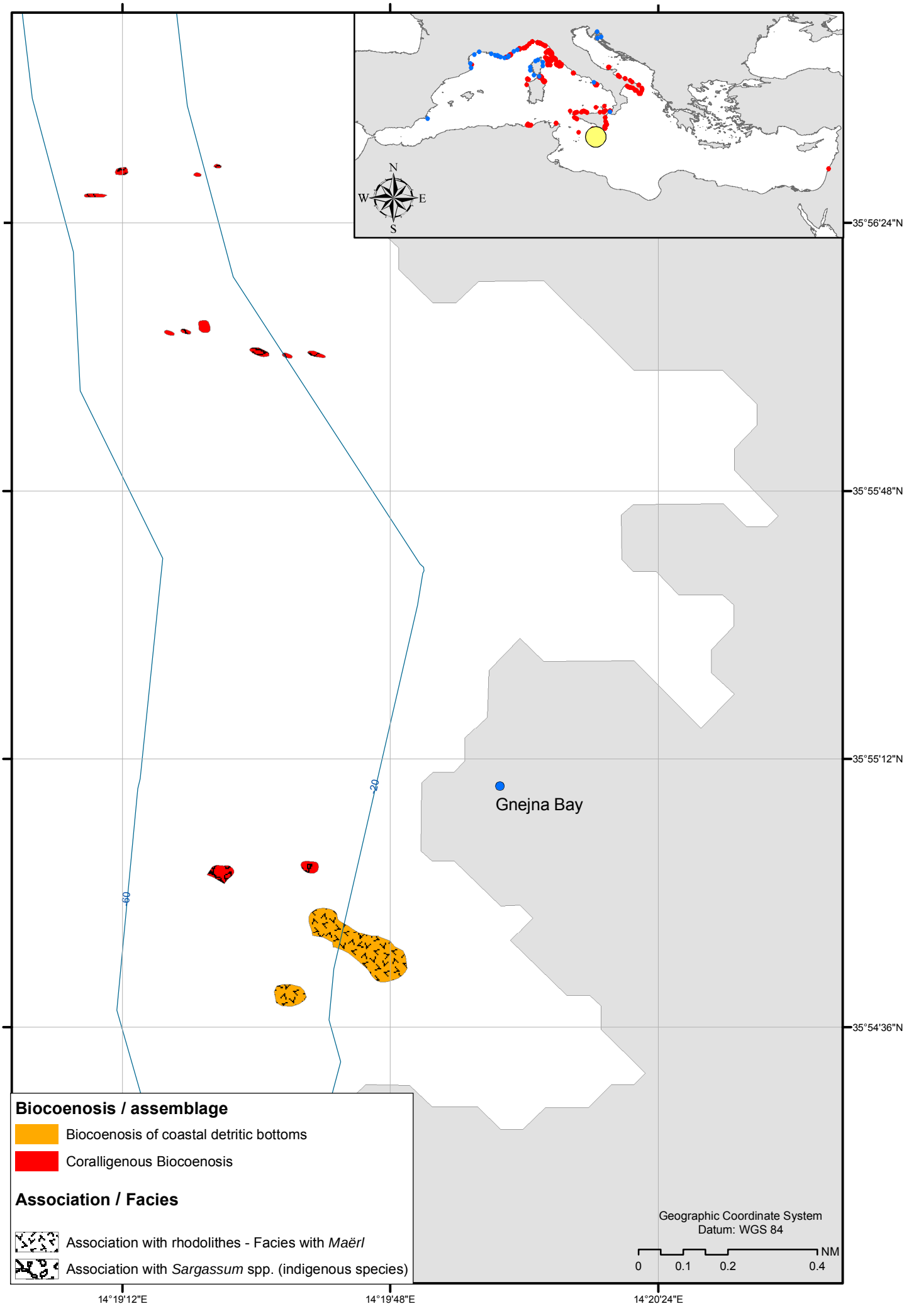
Scale: 1:2.500

Layout

Number of layouts: 1

Database ID

17


N
W
E
S
35°56'24"N
35°55'48"N
35°55'12"N
35°54'36"N
Gnejna Bay
20
60
Biocoenosis / assemblage
Biocoenosis of coastal detritic bottoms
Coralligenous Biocoenosis
Association / Facies
Association with rhodolithes - Facies with Maërl
Association with Sargassum spp. (indigenous species)
Geographic Coordinate System
Datum: WGS 84
0
0.1
0.2
0.4
NM
14°19'12"E
14°19'48"E
14°20'24"E

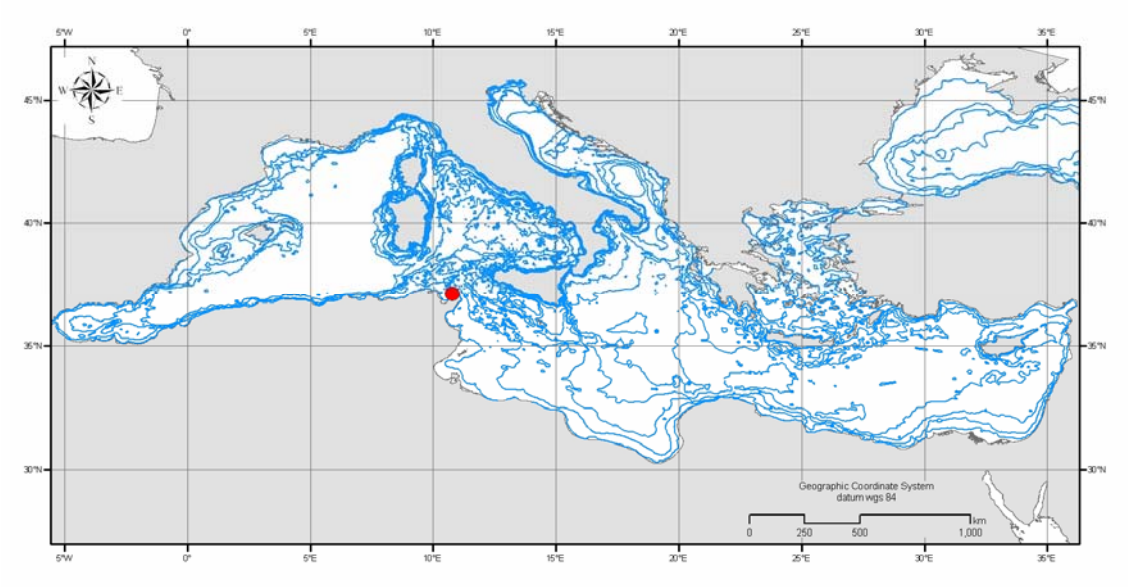
Data sheet 23

Reference document source

ORUETA J.F., LIMAM A. (2004) - Plan de gestion de la partie marine du Parc National de Zembra et Zembretta. Regional Project for the Development of Marine and Coastal Protected Areas in the Mediterranean Region (Document APAL - project MedMPA). 126 pp.

Location

Western Mediterranean, Tunisia, Zembra e Zembretta.



Sampling Date

2002 - 2003

Sampling method

Scuba diving, dredge

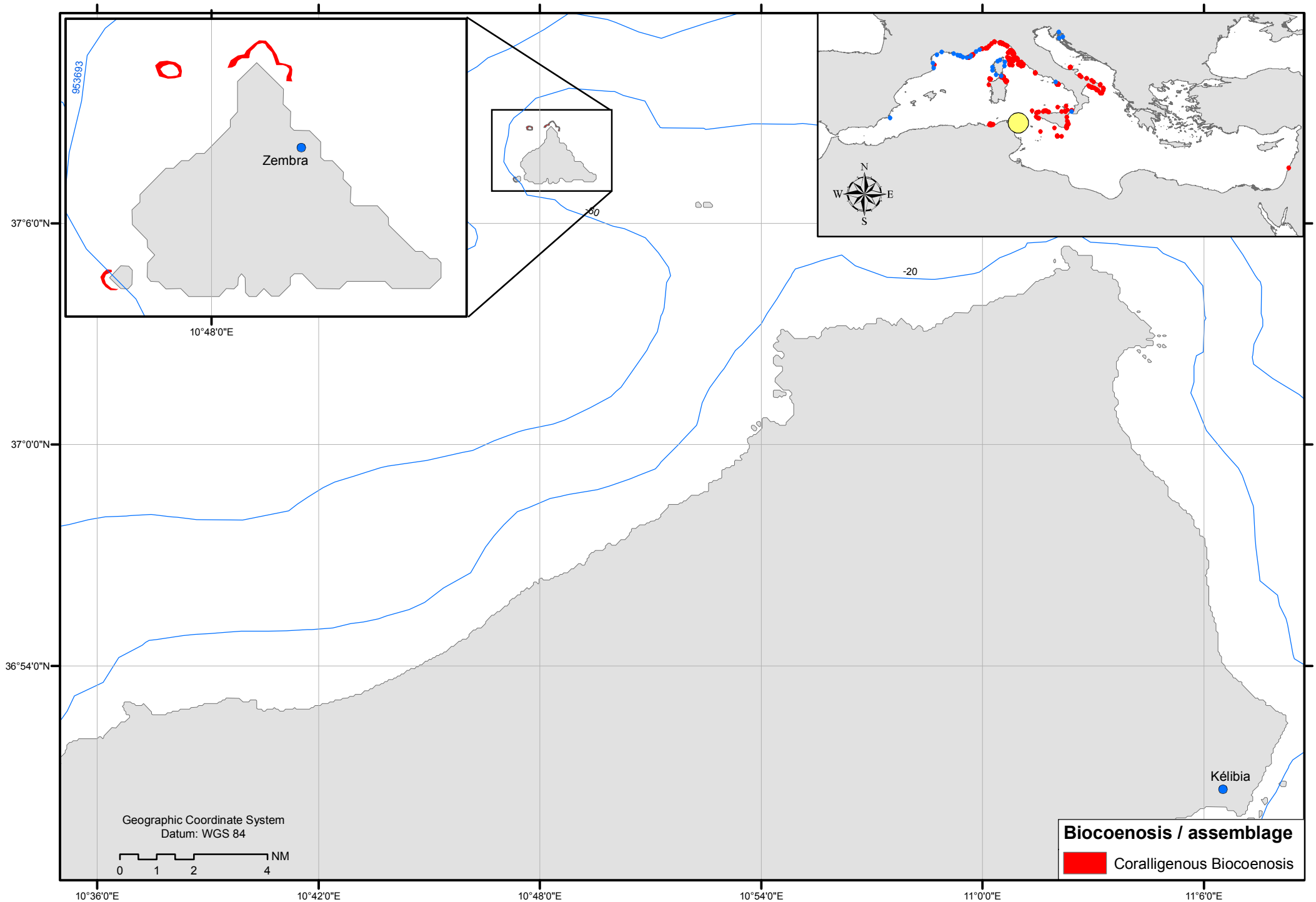
Original scale

Layout

Number of layouts: 1

Database ID

9


953693
Zembra
-50
-20
37°6'0"N
37°0'0"N
36°54'0"N
10°48'0"E
N
W
E
S
Kélibia
Geographic Coordinate System
Datum: WGS 84
NM
0 1 2 4
10°36'0"E
10°42'0"E
10°48'0"E
10°54'0"E
11°0'0"E
11°6'0"E
Biocoenosis / assemblage
Coralligenous Biocoenosis

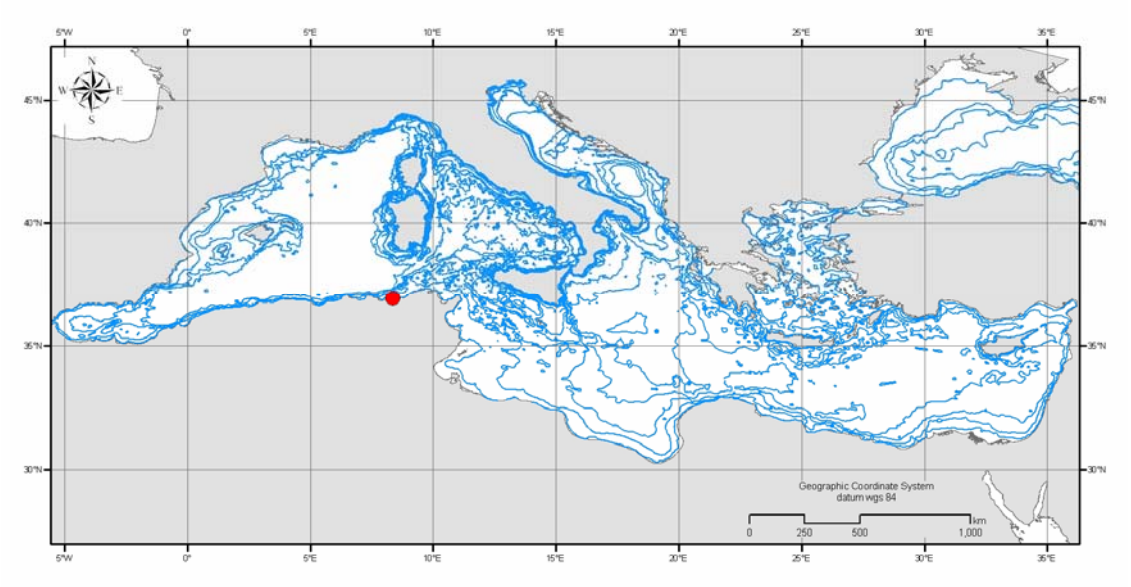
Data sheet 24

Reference document source

GRIMES S. (2005) - Plan de gestion de l'aire marine du Parc National d'El-Kala (Wilaya d'El-Turf). *Regional Project for the development of marine and coastal protected areas in the Mediterranean region (MedMPA)*. 148 pp.

Location

Western Mediterranean, Algeria, El-Kala.



Sampling Date

2004

Sampling method

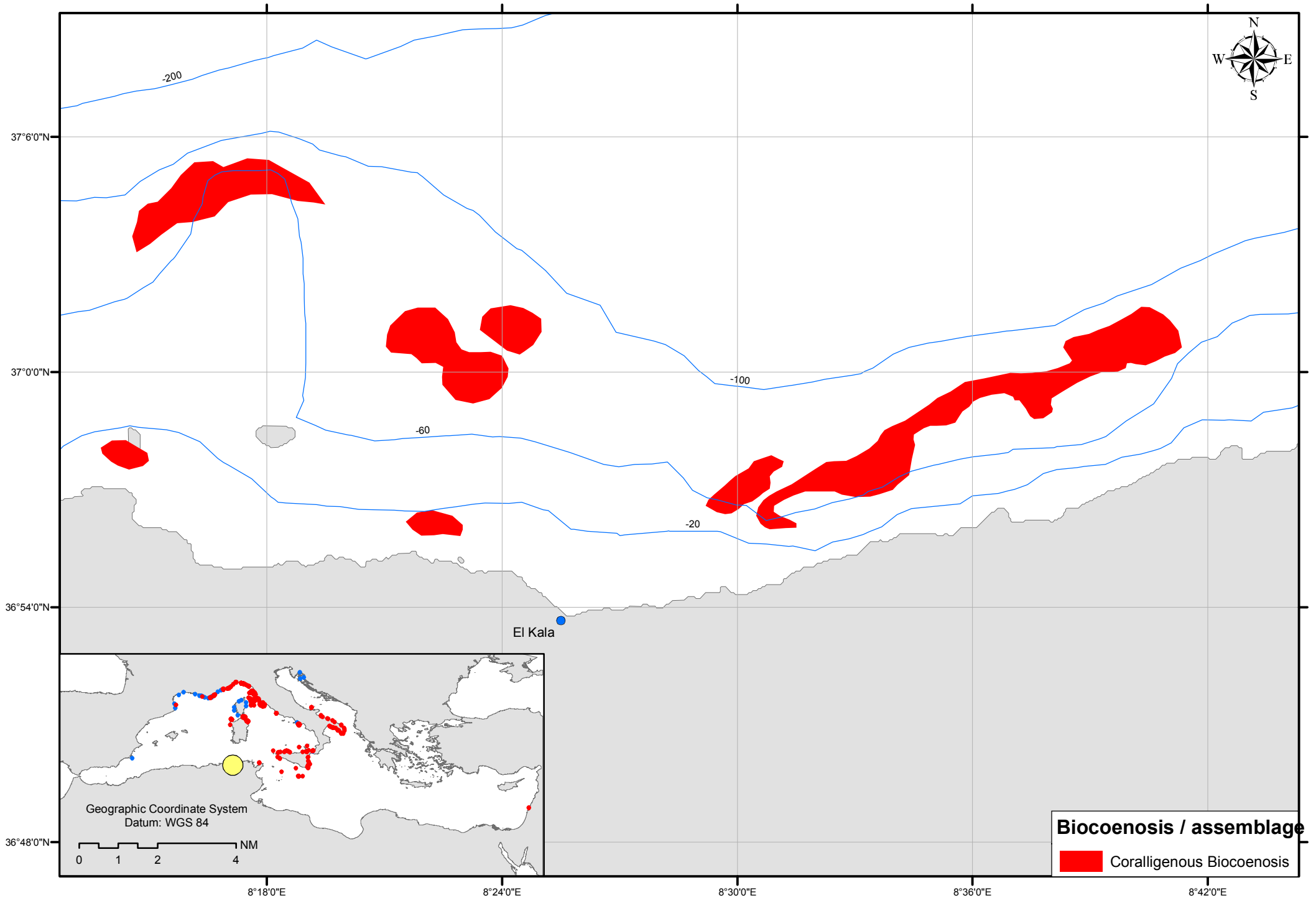
Original scale

Layout

Number of layouts: 1

Database ID

19


N
W
E
S
-200
-100
-60
-20
37°6'0"N
37°0'0"N
36°54'0"N
36°48'0"N
El Kala
8°18'0"E
8°24'0"E
8°30'0"E
8°36'0"E
8°42'0"E
Geographic Coordinate System
Datum: WGS 84
0 1 2 4
NM
Biocoenosis / assemblage
Coralligenous Biocoenosis

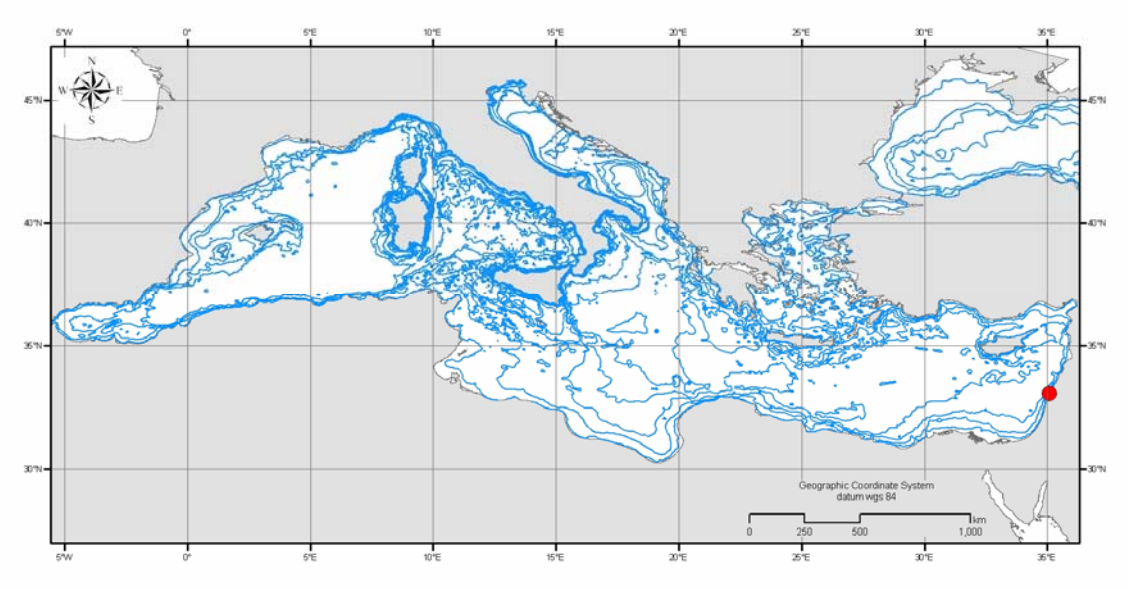
Data sheet 25

Reference document source

RAMOS ESPLÁ A., VALLE PÉREZ C. (2004) - Final report (Activity MP4): marine biodiversity study of the Rosh Haniqra-Akhziv Nature Reserves (Israel) to the establishment of a management plan. *Regional Project for the Development of Marine and Coastal Protected Areas in the Mediterranean Region (MedMPA).* 126 pp.

Location

Aegean Sea, Israel, Rosh Haniqra-Akhziv.



Sampling Date

2004

Sampling method

Scuba diving

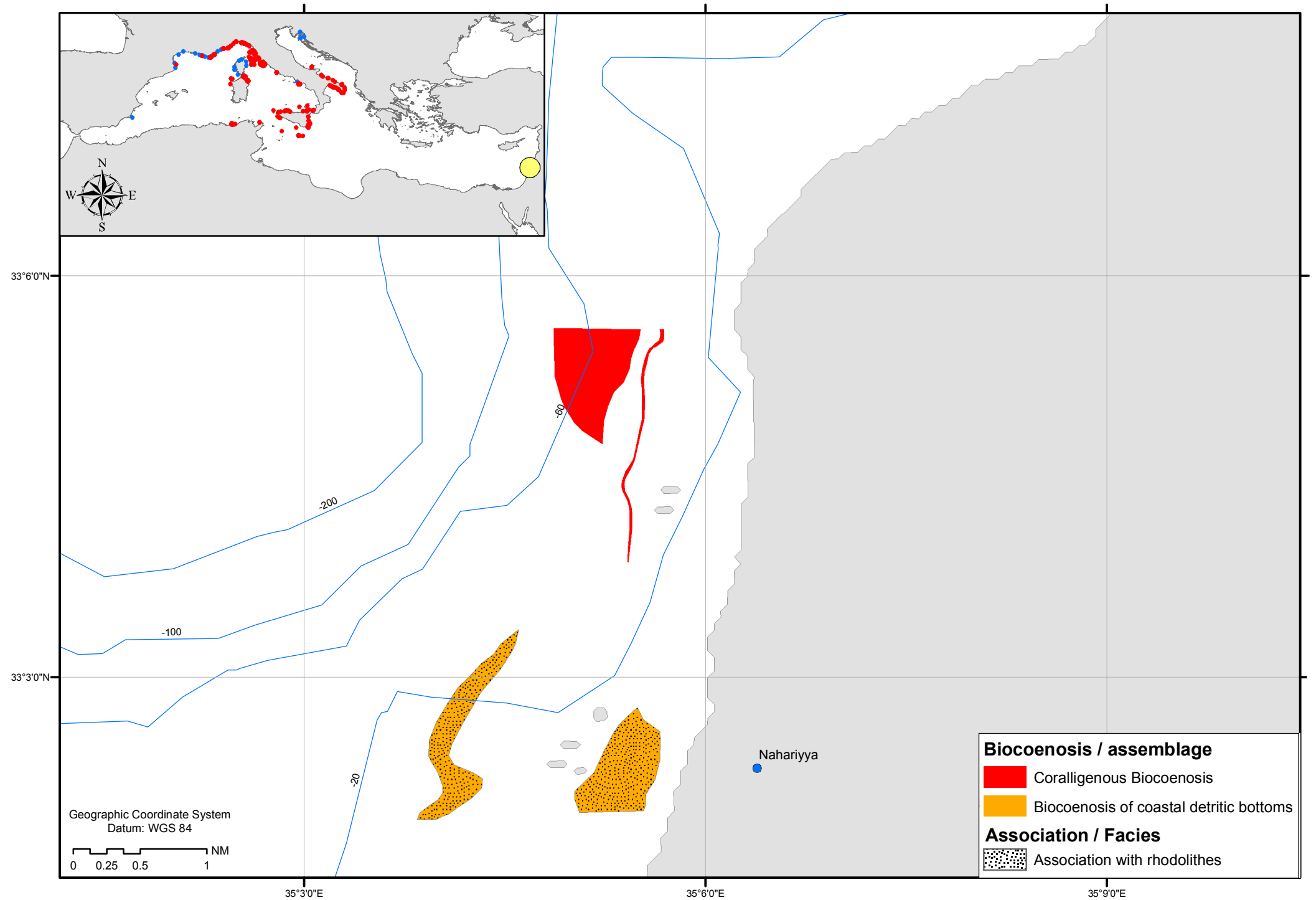
Original scale

Layout

Number of layouts: 1

Database ID

10


N
W
E
S
33°6'0"N
33°3'0"N
35°3'0"E
35°6'0"E
35°9'0"E
-60
-200
-100
-20
Nahariyya
Geographic Coordinate System
Datum: WGS 84
0 0.25 0.5 1 NM
Biocoenosis / assemblage
Coralligenous Biocoenosis
Biocoenosis of coastal detritic bottoms
Association / Facies
Association with rhodolithes