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Science and Engineering of the Sea

POLYCHAETES SPECIES DIVERSITY

APPLYING MONITORING DATA FOR SPATIAL DISTRIBUTION, ECOLOGY UPDATE, ENVIRONMENTAL ASSESSMENT

Ph.D. Student	Tutor
Barbara La Porta	**Prof. Vincenzo Saggiomo**

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SUMMARY

Since research on soft-seabed macrozoobenthic community, including polychaetes, of Mediterranean and in particular Italian Saes still display a lack of data concerning taxonomic aspects and species distribution patterns, and the pre-existing information are frequently outdated, further studies and revisions of data are a primary necessity. These habitats are widely common in coastal areas all over the world and host most of sensitive and protected benthic habitats, species and typical biocoenoses as well as most of the human activities. At the same time, in a framework of an ecological sustainability of human activities, such as sand dredging extraction, upon the marine environment, it is important to understand the extent of their effects on marine ecosystem, to protect the environment itself and to develop management strategies. In Italy, the use of marine relict sands, to repair the effects of the increasing coastal erosion, has become more common in the last decades. The efficiency of biodiversity and environmental monitoring studies in marine environments is strongly influenced by the selection of the spatial and temporal scale. Investigations at regional as well as at adequate temporal scale allow to analyse the comprehensive variability of biological systems, strongly influenced by the interactions of numerous environmental factors (depth, geographic position and sediment types).

To display the variability of polychaetes diversity patterns in space and time, and to investigate how this variability is related to the habitat characteristics and human impacts, this research, is aimed to:1) identify diversity distribution patterns of polychaete assemblages and species at a regional (Latium Continental Shelf) related to depth, sediment grain size, latitude and longitude; 2) compare information, concerning the spatial distribution and ecology (related to sediment composition and depth range) of a number of selected soft-sediment polychaetes species, obtained at regional (Latium Continental Shelf) and national scale (Italian Continental Shelf); 3)–assess the effects of human activities (sand dredging) on marine ecosystems at a local scale through the analysis of biological diversity variation over time.

The amount of pre-existing studies, carried out in Mediterranean and in particular along the Italian Seas, concerning macrozoobenthos species, polychaetes, and their spatial distribution as well as the role of macrozoobenthic community for the environmental assessment, contributes to be the background of this research focused on the assessment of ISPRA multidisciplinary data-set, from environmental monitoring programmes, as a source of valuable scientific data.

Results from PERMANOVA, CCA, BIOENV and Spearman rank correlation analyses, have pointed out that the three main categories explaining the drivers of biodiversity patterns in the Tyrrhenian continental shelf are: bathymetric gradients, geographical features, responsible for the north-south gradient in environmental conditions, and environmental heterogeneity (i.e. grain size distribution, habitat complexity). ISA analysis showed that some species distribution is significantly associated to definite sediment grain sizes and depth ranges confirming or updating the ecological characteristics of the investigated species as emerged from the comparison of results of this study with pre-existing knowledge. Moreover, the species distribution patterns as well as the assemblages composition observed along the Latium continental shelf (tested with PERMDISP analysis), confirm results obtained in previous studies carried out in neighbouring areas along Tyrrhenian Sea. A continuum of species distribution along Tyrrhenian continental shelf can be expected and represented by means species diversity maps (by Universal Kriging interpolator) able to represent comprehensive species diversity distribution patterns at the regional scale; despite polychaetes have been demonstrated to be able to respond quickly to changes in their environment as a consequence of dredging activities, the assessment of the effects of these activities upon benthic organisms is quite complex to define.

Keywords: Polychaete assemblages, biocoenosis, soft-seabed

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1. INTRODUCTION

1.1 Context – The Era of Biodiversity

In Rio de Janeiro, Convention on Biological Diversity (1992) agreed that we are leading species to extinction and habitat destruction, and that some measures had to be taken. After the Rio Convention the exploration of biodiversity became more imperative than ever, since we cannot defend or manage something if we don't know it (Boero, 2010).

The accelerating loss of biological diversity poses serious concerns, and recent predictions explain that species loss might impair the functioning and the sustainability of ecosystems. The global scale of the biodiversity crisis has stimulated investigations that explore the relationships between biodiversity (expressed as the number, identity, and relative abundance of species), productivity, stability, and services in different ecosystems of the world (Danovaro *et al.*, 2008).

The Johannesburg World Summit on Sustainable Development (2002) called on countries to reduce their rates of biodiversity loss by 2010. The decade 2011-2020 has been declared as the United Nations Decade on Biodiversity with the strategic objectives of supporting framework for implementation of the Biodiversity Strategic Plan 2011-2020 and the Aichi Biodiversity Targets at national, regional and international levels, develop guidance to regional and international organizations and public awareness of biodiversity issues. Moreover, at Montreal on the 1st of August 2011, the Secretariat of the Convention on Biological Diversity has expressed support for continued action to control invasive species, one of a major cause of biodiversity loss. Since invasive species are a subtle threat to the natural balance of species and ecosystems, but can suddenly occur in explosive outbreaks, the global Strategic Plan for Biodiversity 2011-2020 has included a specific target on this issue.

The marine environment has received much less attention than its terrestrial counterpart in the area of biodiversity. This lack of attention probably results from the relatively limited accessibility of the ocean as well as its vast nature (i.e. covers approximately 70% of the earth's surface) (Snelgrove, 1999). As a consequence marine environment was described as an area of low biodiversity, and thus research focused on land. Thus most of the studies carried on during the last decade were focused or related to terrestrial system, while the knowledge of the processes that operate in marine ecosystems lags far behind (Snelgrove *et al.*, 1997; Gray,1997; 2000; Heip *et al.*, 1998) and therefore the need for more research in the marine environments is great. The wealth of biodiversity of marine environment is a consequence of millions of years of evolutionary history. This environment has a very high biodiversity because 32 out of the 33 described animal phyla are represented in there, and 15 phyla are exclusively marine (Norse, 1993). Consequently, marine organisms display a much larger phyletic diversity than those on land (Ray, 1988). Besides marine organisms contain a diversity of survival strategies not found on land and therefore, they may exhibit a higher functional diversity. Therefore, marine environment has not only a high phyletic diversity but also a great functional diversity.

Changes in marine biological diversity are now a primary result of direct and indirect human impacts as well as climatic influences (Ellingsen, 2001). The habitat degradation in marine ecosystems has actually reached alarming rates (Gray, 1997) thus, since marine environments also provide an irreplaceable resource to humankind, must be protected and managed into the future. Since changes of biological diversity have been described to be a good and synthetic descriptor of cumulative impacts due to human activities and climatic influences, changes of marine biodiversity are considered a key descriptor for the environmental assessment of marine waters. (Bilyard, 1987; Thomson *et al.*, 2003)

In Europe, according to the United Nations system-wide strategies and action plans, specific directives for a common protection and an harmonized and sustainable management and use of marine environments have been developed. To reduce the rates of biodiversity loss by 2010 the European Community has also launched a specific action plan (EU Action Plan, 2006). Marine Strategy Framework Directive 2008/56/EEC defines marine Good Environmental Status (GES) having regard to the structure, functions and processes of marine biodiversity. As well as the Water Framework Directive 2000/60/EEC defines the quality status of coastal marine environment on the basis of chemical and physical analysis of water and sediment and the characteristics of the biota, including benthic organisms. The Habitats Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora was adopted in 1992 as an European Union (EU) response to the Berne Convention. It aims to protect about 220 habitats and approximately 1,000 species listed in the directive's Annexes (species requiring designation of Special Areas of Conservation, species in need of strict protection, species whose taking from the wild can be restricted by European law). The directive led to the setting up of a network of Special Areas of Conservation, which together with the existing Special Protection Areas form a network of protected sites across the EU called Natura 2000. At regional basin level, some years before, in 1976, the Barcelona Convention 77/585/EEC, amended in 1995, and the Protocols drawn up in line with this Convention, aim to protect and improve the marine and coastal environment in the Mediterranean, whilst promoting regional and national plans contributing to sustainable development.

1.2 Biodiversity of Mediterranean Sea: soft-seabed macrozoobenthic community

The Mediterranean Sea is a marine biodiversity hot spot. Coll *et al.* (2010) listed approximately 17,000 marine species occurring in the Mediterranean Sea and Bianchi and Morri (2000) reported that 5.6% of the world's total described invertebrate species are present in the Mediterranean area. High percentages of Mediterranean marine species are endemic (Boudouresque, 2004; Tortonese, 1985) but estimates of marine diversity are still incomplete as yet—undescribed species will be added in the future. In addition, the invasion of alien species is a crucial factor that will continue to change the biodiversity of the Mediterranean, mainly in its eastern basin that can spread rapidly northwards and westwards due to the warming of the Mediterranean Sea. The study of Mediterranean marine diversity over many years has produced a significant amount of information (e.g. Pérès and Picard, 1964; Augier, 1982; Riedl, 1983; Margalef, 1985; Koukouras *et al.*, 2001; Costello *et al.*, 2001; Arvanitidis *et al.*, 2002; Relini, 2008). Yet this information remains incomplete with the discovery and description of new species, especially of small, less conspicuous and cryptic organisms. The biodiversity in the Mediterranean Sea may be in fact much higher than is currently known.

Among the various marine habitats soft-seabed, ranging from gravel to fine sediments, features a number of systems that are of interest on account of their widespread distribution and the importance and diversity of benthic infaunal communities (Gray, 1997; Snelgrove *et al.*, 1997).

Among marine species, soft-seabed macrozoobenthos, the community of organisms (broader than > 1mm) inhabiting on the surface, inside, or near the marine soft-seabed habitats is especially important from an ecological perspective because it plays an active and fundamental role in a large variety of ecological processes such as nutrient and pollutant cycling between sediments and water column (Gilek *et al.*, 1997; Pearson, 2001), in food webs (Oug *et al.*, 1998; Weisberg *et al.*, 1997), sediment transport (Aller and Yingst 1985) and bioturbation, which contributes to the oxygenation of sediments (Pearson, 2001; Giangrande *et al.*, 2001), and its (specific) composition influences ecosystem functions (Snelgrove *et al.* 1997) and can be used to assess the quality of benthic habitats (Pearson and Rosenberg 1978; Bilyard, 1987; Borja *et al.* 2000; Simboura and Zenetos 2002; Thomson *et al.*, 2003; Rosenberg *et al.* 2004; Dauvin and Ruellet 2007).

Even if the study of Mediterranean macrozoobenthos diversity has produced a significant amount of information (e.g. Pérès and Picard, 1964; Augier, 1982; Riedl, 1983; Margalef, 1985; Koukouras *et al.*, 2001; Arvanitidis *et al.*, 2002; Viéitez *et al.*, 2004; Relini, 2008), this information still remains incomplete because of the discovery and description of new species. Moreover those information, coming from outdated studies should, therefore be revised and updated on the base on newly collected information.

1.3 Soft-seabed macrozoobenthic community in the central Tyrrhenian sea (Italy)

Italian soft-seabed macrozoobenthic species (Minelli *et al.*, 1993-1995), has been revised within the overall updating process of the check list of Italian marine species, completed in 2005 and currently available for consultation on the Italian Society of Marine Biology (SIBM) website (www.sibm.it) (Relini, 2008 and the references therein). The updating of the species checklist of the Italian Seas (realized by a network of marine biologists from SIBM, public and private institutes, universities, managers of MPAs, freelance professional and ordinary citizens) takes into account the pre-existing literatures about macrozoobenthic community and species of the Italian seas and also species found outside Italian territorial waters and even along the coast of neighbouring regions such as Corsica, the Côte d’Azur, Istria, Malta.

Among these studies, a number of researches on macrozoobenthic communities of soft-seabeds were carried out along the Tyrrhenian continental shelf (west coast of Italy), from the northern portion of Tuscany coasts to the northern coasts of Sicily (southwest coast of Italy). Among detailed researches, aimed at defining soft substrata benthic communities structure and distribution, numerous studies were performed in wide areas of the Latium continental shelf. Among these: Della Seta *et al.*, (1977); Cognetti Varriale and Zunarelli Vandini (1979), Focardi *et al.*, (1982); Falciai *et al.*, (1983), Zurlini and Bedulli, (1983), Chimenz and Contessini (1986), Gambi and Giangrande (1986), Contessini *et al.* (1989), Ferretti *et al.*, (1989); Taramelli and Chimenz (1990), Taramelli and Venanzangeli (1990), Argenti *et al.* (1992), Chimenz (1993), Chimenz and Nicoletti (1994); Scipione and Lattanzi (1995), Nicoletti and Chimenz, (1995), Tomassetti and Chimenz Gusso (1998), Franceschini *et al.* (1996), Nicoletti *et al.* (2003), Scipione *et al.* (2005); La Porta *et al.* (2006), Targusi *et al.* (2007); Tomasseti *et al.* (2006), La Porta and Nicoletti (2009). Results, overall indicated that the species distribution mainly followed a bathymetric gradient as well as the distribution of sediment with depth. Moreover, the collected macrozoobenthic assemblages, affiliated to definite biocoenoses *sensu* Pérès and Picard (1964) (e.g. well sorted fine sand biocoenoses in the shallower areas, costal terrigenous mud in the deeper ones) according to their bathymetric and granulometric ranges and to their characteristic ecological boundaries, were accompanied by assemblages typical of mixed substrata (in terms of sediment texture), by species inhabiting transitional zones, between sandy and muddy substrata, or exclusive of smaller areas due to peculiar local environmental conditions (for instance the proximity of river mouths, *Posidonia oceanica* meadows, rocky shoals). In particular, Chimenz Gusso *et al.*, (1996) were involved in a multidisciplinary environmental study of wide areas of the Latium continental shelf. Soft-seabed communities were analyzed from 0 to 110 m of depth: up to about 7 m benthic assemblages were typical of superficial fine sand biocoenosis and, mainly in the southern portion, of well sorted fine sand biocoenosis. With the increase in depth the zoocoenoses found mirrored bathymetry as well as sediment gradient: sandy species occurred up to about 20 m of depth where organisms tolerant to finer fractions of the sediment co-occurred. An ecotone zone, between 20 and 30 m was inhabited by community typical of mixed sediment and in proximity of *Posidonia* *oceanica* meadows, above the lower limit, coastal detritic or muddy detritic biocoenoses were found. Offshore to the Tevere river mouth the biocoenosis of coastal terrigenous mud occurred already at 20 m of depth. Along Latium continental shelf this coenosis was mainly found approximately from 50 m, while in a number of areas, between 30 and 50 m of depth, assemblages typical of mixed or muddy detritic sediment were identified. This research, carried out at regional scale, confirmed or updated results of previous studies realized in smaller areas along the Latium coasts, and still represents the most recent widespread overview of biological and environmental features of the Latium continental shelf. A comparable zonation of soft-seabed benthic community was also found along other zones of Tyrrhenian continental shelf: for instance in wide areas of the Tuscany coasts (northern Tyrrhenian sea) (e.g. Gambi and Fresi, 1981; Castagnolo *et al.,* 1981; Castelli, 1982; Albertelli *et al.*, 1983; Castelli and Lardicci, 1985; Farina *et al.* 1985; Castelli *et al.*, 1986a, 1986b; Cognetti *et al.*, 1987; Zunarelli Vandini and Cognetti Varriale, 1981; Crema *et al.*, 1993; Fresi *et al.*, 1983, Castelli *et al.*, 1992; Bianchi *et al.,* 1993a,b,c; Fresi *et al.*, 1993; Targusi *et al.*, 2007), and in several areas of Campania coasts (southern Tyrrhenian sea) (e.g. Gambi *et al.*, 1983; Gambi and Giangrande, 1985; Gambi *et al.*, 1996).

1.4 Soft seabed macrozoobenthic assemblages in the environmental monitoring

Soft-seabed macrozoobenthos invertebrates represent an important tool for marine environmental monitoring. The ‘‘indicator species’’ is a qualitative approach based on the presence–absence of *taxa* sensitive to perturbations such as opportunistic *taxa*, or a quantitative method, based on numerical or *taxon*omic abundance (Giangrande *et al.*, 2005). Studies involving multispecies assemblages progressively replaced those related to the biology of single indicator species, because the effect of stress being easier to measure by means of the entire community, and examining changes in abundance of sets of species. In general, many studies indicate that the correlation between benthic communities diversity and some environmental variables, such as the nature of substrata, tidal regimes, salinity and oxygen concentration, water depth and temperature (Ellingsen, 2002; Josefson and Hansen 2004), makes them ideal candidates to be indicators of environmental conditions (Bilyard, 1987; Crema *et al.*, 1989; Warwick, 1993; Thomson *et al.*, 2003). Moreover, soft-seabed community structure and its species composition can be use both to assess the quality of benthic habitats and as "indicator" of marine environmental changes, resulting from human activities as well as climatic changes (Gray, 1981; Clarke and Ainsworth, 1993; Harkantra and Rodriguez, 2004; Kress *et al.*, 2004). Indeed, benthic species are generally sedentary or have a low motility and therefore most likely to respond to local environmental conditions, cover a wide range of feeding guilds, have relatively long and different life cycles (many benthic organisms have their larval stage as part of the pelagic compartment) and therefore give an integrated response over time to variation of water and sediment quality, exhibit different degrees of tolerance to stress conditions, (Dauer, 1993; Clarke and Warwick, 1994; Gray, 1990, 2000). Moreover, in marine environment the benthic fauna is considered as key groups in the understanding of the biological processes and community structure (Gambi *et al.*, 1982; Snelgrove *et al.* 1997; Gray, 2002).

Among the most important models, Species-Abundance-Biomass model (Pearson and Rosenberg, 1978) was developed to analyze and predict changes to the structure of community along gradient of different kinds of environmental disturbance. Over the years a number of methods and techniques have been developed such as Abundance/Biomass comparison curve technique (Warwick, 1986), or geometrical class distribution of species plot (Gray and Mirza, 1979), which also allows an objective selection of groups of indicator species (Gray and Pearson, 1982). More recently, Warwick and Clarke (1995) developed multivariate methods for the study of marine pollution through the analysis of the structure of soft-seabed communities, while a number of studies have taken into account higher *taxon*omic levels (e.g. Family or even Phylum), easier to detect, to analyze environmental changes (e.g. Warwick, 1993; Olsgard and Somerfield, 2000; Mistri and Rossi, 2000, 2001).

In Italy during the last decades numerous researches concerning marine environmental monitoring have been carried out taking into account soft-seabed macrobenthic communities. These communities have been used to assess the effects of urban sewage and pollution of marine sediments (Volpi Ghirardini *et al.*, 1999; De Pippo *et al.*, 2002) industrial or thermal waste (Crema and Bovincini Pagliai, 1980; Fresi *et al.* 1983; Lardicci *et al.*, 1999), the dumping of dredge matherials (Bovincini *et al.*, 1985; Nicoletti *et al.*,2004; Nicoletti *et al.*, 2006; Simonini *et al.* 2007, La Porta *et al.*, 2009;

Ponti *et al.*, 2009; Colosio *et al.*, 2007) offshore platform and drilling muds (Crema *et al.*, 1991, 2001;Trabucco *et al.*, 2006; Terlizzi *et al.*, 2008; Manoukian *et al.*, 2010), coastal defence structures (Nicoletti *et al.*, 2007; Bertasi *et al.*, 2007), aquaculture farming (Tomassetti *et al.*, 2009)

1.5 Annelida Polychaeta

Among the most frequent and abundant organisms characterizing marine benthic communities, Annelida Polychaeta account for up to more than a third of the total number of macrobenthic species in soft substrata (Day, 1967; Knox, 1977; Fauchald, 1977; Arvanitidis *et al.*, 2002).

Polychaetes have proven to be excellent indicators of environmental conditions due to their distribution over a broad range of environments and their ample display of ecological requirements (Bianchi e Morri, 1985; Dean, 2008). Because of their ecological variability, they are widely used in applied environmental research (Giangrande *et al.*, 2005; Dean, 2008 and the references therein), and, as surrogates for benthic biodiversity in marine sediments, can be extremely informative in assessing the condition or health of benthic environments (Reish, 1955; Pearson and Rosenberg, 1978; Bianchi e Morri, 1985; Gambi and Giangrande, 1986; Bellan *et al.*, 1988; Pocklington and Wells, 1992; Olsgard and Somerfield, 2000; Olsgard *et al.*, 2003; Belan, 2003; Dean, 2008; Mutlu *et al.*, 2010). Polychaetes have been extensively used in coastal studies for monitoring purposes especially in soft-bottom habitat (Crema *et al.*, 1991; Elias, 1992; Grall and Gle´marec, 1997; Solis-Weiss *et al.*, 2004). Polychaetes are one of the best indicators of environmental disturbance, since this *taxon* is composed by sensitive and tolerant species in a gradient from pristine to heavily disturbed habitats (Pocklington and Wells, 1992). Opportunistic polychaetes, such as species belonging to the Capitellidae, Cirratulidae, and Spionidae families, are selected in relation to their capability to proliferate after enrichment in organic matter (Pearson and Rosenberg, 1978) or other types of pollutants in the sediments (Bellan, 1984; Bellan *et al.*, 1988). Moreover, opportunistic species are pioneer organisms dominating the initial phases of succession processes after disturbance (Dauer and Simon, 1976; Zajac and Whitlatch, 1982) without suffering from intraspecific competition (Whitlatch and Zajac, 1985) and, in many cases, only one or two opportunistic species have been found to dominate at first. It is also well known that many opportunistic polychaetes are a complex of sibling species (Grassle and Grassle, 1974), rejecting the claim that many of such species are ‘‘cosmopolitan species’’.

Bianchi and Morri (2000) reported that 9.7% of the world's total described polychaetes species are present in the Mediterranean area; this percentage seems to be close to reality, since few Mediterranean polychaetes are being described these days, while there are many more species to be described around the world. There have been numerous studies investigating the systematics, *taxon*omy, morphology and ecology of Mediterranean polychaetes but a general account on the ecology of the Mediterranean species, carried out at a large scale, dates back to Bellan (1964). Further studies analysed the distribution of polychaetes at smaller scales (e.g. Gravina 1986; Castelli *et al.* 1992; Bianchi *et al.* 1993a,b,c; Crema *et al.* 1993; Simboura *et al.* 2000; Arvanitidis *et al.*, 2002; Viéitez *et al.*, 2004; Çinar 2005; Moreira *et al.* 2006; Cosentino and Giacobbe 2008; Zaâbi *et al.* 2009).

Concerning the Italian Seas Castelli *et al.* (1987) stated that the first check-lists of Italian polychaetes date back to Panceri (1874) and, exclusively for Adriatic Sea, to Pozar Domac (1978). A project aimed at a wide-ranging census of the Italian polychaete fauna (Gambi *et al.*, 1985; Castelli *et al.*, 1987) represented the main background for the edition of the Italian polychaetes check-list (Castelli *et al.*, 1995). Castelli *et al.*, (2008) published the last review of the polychaete species recorded in the Italian Seas based on the previous check-list and on the most recent scientific literature concerning researches carried out in Mediterranean and Italian Seas.

A number of studies investigated patterns of spatial distribution of soft-seabed polychaetes along different areas of Italian Seas, among them: Katzmann (1973) described polychaetes species collected in soft substrata of the central Adriatic Sea, Cognetti Varriale and Zunarelli Vandini (1979) analyzed polychaetes assemblages of littoral sandy substrata along the northern Latium coasts (central Tyrrhenian Sea), Gambi *et al.* (1983), proposed a general distribution pattern of soft-seabed polychaetes species, Castelli and Lardicci (1985) and Farina *et al.* (1985) investigated the Polychaeta fauna along Elba Island (northern Tyrrhenian sea), Gambi and Giangrande, (1985) analyzed the distribution and the trophic structure of polychaetes assemblages found in the Gulf of Salerno (southern Tyrrhenian Sea), Gambi and

Giangrande (1986) analyzed the influence of discharges of the rivers Ombrone and Tevere (northern and central Tyrrhenian sea) on polychaetes distribution, Gravina (1986) examined polychaete distribution patterns in relationships with environmental features of soft substrata in the Ligurian sea (north of Italy). More recently, Gambi *et al.* (1990) and Lardicci *et al.* (1990) published respectively an overview of the main aspects and problems of the geographic distributional pattern of Italian polychaetes focused on their biogeographical meaning, and a preliminary biogeographical analysis of polychaetes along Tuscany coasts (northern Tyrrhenian sea). Castelli *et al.*, (1992) characterized the infralittoral soft-seabed of Tuscany continental shelf on the base of polychaetes distribution, Cantone *et al.* (1993) worked on assemblages collected in the Ognina bay (eastern Sicily), Somaschini (1993) and Gambi *et al.* (1996) investigated the ecological role of some tubicolous species on polychaetes community structure respectively in a wide area along Tuscany and Latium coasts and in the Gulf of Policastro (southern Tyrrhenian sea). In the last decade a few number of studies have been carried out concerning distribution patterns of soft-seabed polychaete communities of the Italian Seas. Among them, Musco *et al.* (2004) analysed exclusively the family Syllidae along Apulia coasts (southern Adriatic Sea), La Porta *et al.* (2006) carried out a preliminary analysis of polychaete distribution in an area of Latium continental shelf, Mikac and Musco (2010) investigated syllids species from Rovinj (Croatia, north Adriatic Sea) from a biogeographic point of view and Mikac *et al.* (2011) followed the long-term changes of polychaete assemblages in the north Adriatic sea after a dystrophic crisis.

Several researches take into account polychaetes assemblages for the environmental monitoring of Italian seas. These organisms have been used to assess the effects of urban sewage (Musco *et al.*, 2009), pollution of marine sediments (Zunarelli Vandini and Cognetti Varriale, 1981) industrial or thermal waste (Crema and Bovincini Pagliai, 1980; Fresi *et al.* 1983; Lardicci *et al.*, 1999), the dumping of dredge materials (Marzialetti *et al.*, 2006; Loia *et al.*, 2009), offshore platform (Crema *et al.*, 1991, 2001), coastal defence structures (Marzialetti *et al.*, 2009), fish farm organic enrichment (Tomassetti and Porrello 2005).

1.6 Main issues

How many species live in defined area or habitat? Which is their spatial distribution? According to the Linnean (Brown and Lomolino 1998) and Wallacean (Lomolino, 2004) short fall, scientific research still display a lack of *taxon*omic and species distribution data. Therefore, overall studies of *taxon*omy, ecology and spatial distribution of marine benthic species are still incomplete (e.g. for Mediterranean Seas: Pérès and Picard, 1964; Augier, 1982; Riedl, 1983; Margalef, 1985; Bianchi *et al.*, 1993a,b,c; Crema *et al.*, 1993; Koukouras *et al.*, 2001; Costello *et al.*, 2001; Arvanitidis *et al.*, 2002; Relini, 2008 Cosentino and Giacobbe 2008). In particular, there is only a general account, dating back to Bellan (1964), on the ecology of Mediterranean polychaetes. Further studies only analysed the distribution of polychaetes at local scales (e.g. Gravina 1986; Castelli *et al.* 1992; Bianchi *et al.* 1993a,b,c; Crema *et al.* 1993; Simboura *et al.* 2000; Çinar 2005; Moreira *et al.* 2006; Cosentino and Giacobbe 2008; Zaâbi *et al.* 2009). Since, information on species distribution (concerning Polychaetes as well as other macrozoobenthic *taxa*) is still incomplete, many species are frequently recorded outside their known bathymetric and granulometric range and of their characteristic ecological boundaries, which define specific biocoenosis sensu Pérès and Picard (1964).

Soft sediment habitats are widely common in coastal areas all over the world and host most of sensitive and protected benthic habitats, species and typical biocoenoses as well as most of the human activities (Della Croce *et al.*, 1997; Snelgrove, 1999). The understanding of the relationships between pressures from human activities and their cumulative impacts on marine ecosystems, including biological diversity, are still partially understood. These relationships, which involve marine environment at several ecological level (species, habitat and ecosystems) are characterized by complex dynamics (Ghertsos *et al.*, 2000) that need to be better understood. Researches on species diversity are focused not only for the identification of species or priority sites for protection, but also for monitoring impacts of human activities, particularly in marine systems that underwent recurring harvest of natural resources, e.g. fishing and marine sand dredging (Leathwick *et al.*, 2006). In particular, the use of marine relict sands, to repair the effects of the increasing coastal erosion, has become more common in the last decades (Newell *et al.*, 1998). The impact of dredging activities on marine environment cause severe disturbances in macrozoobenthos assemblages in terms of the direct effect on sediment removal and the indirect effects associated with the deposition of suspended sediment caused by sand extraction (Desprez 2000; Sarda` *et al.* 2000; Boyd and Rees 2003; Newell *et al.*, 2004; Szymelfenig *et al.* 2006; Simonini *et al.* 2007; La Porta *et al.*, 2009).

Another important issue in diversity distribution studies is the selection of the investigation scale. Most studies on diversity have taken place either at small scales (e.g. bays or headlands) or large scales (e.g. whole ocean or large country) (Lancellotti and Vasquez, 1999) and there has been a paucity of investigations at regional scales (100–1000s of kilometres) (Zacharias and Roff, 2001). Furthermore, temporal scale has an important role in monitoring studies; usually these studies are carried out only over 1 or 2 years, so the conclusions do not take into account temporal variability of biological systems.

Among the main factors influencing the variability of marine benthic communities distribution, depth, latitude and longitude play a fundamental role (Nybakken, 1982). Several studies tested the existence of latitudinal or bathymetric gradients in the diversity of soft sediment biotas (Clarke, 1993; Kendall and Aschan, 1993; Dauvin *et al.*, 1994; Gage *et al.*, 2004; Renaud *et al.*, 2009) and most of them have identified an increase in diversity with water depth through the bathyal zone (Rex, 1981; Levin *et al.*, 2001). Depth, latitude and longitude represent a conjunction of environmental factors that often correspond to the main structuring forces of the marine communities. Among these factors sediment type, water temperature, pH, are closely related (and strongly correlated) with depth and geographic variables (e.g. Tenore, 1972; Guerra-Garcia and Garcia-Gomez, 2004; Van Hoey *et al.*, 2004).

Species diversity, in terms of both the number of species and their abundances, is a synthetic index which captures multi-dimensional information relative to the species composition of a benthic assemblage (Legendre and Legendre, 1998). Alpha diversity has been defined as the diversity of a set of sample or within habitat diversity (Gray, 2000), while beta diversity, originally conceived by Whittaker (1960) as a measure of the change in diversity between samples along transects or environmental gradients, can be broadly defined as the variability in species composition among sampling units for a given area at a given spatial scale (Anderson *et al.* 2006). Summarizing into a couple of indices values the diversity distribution of an entire area lead to a great loss of information. As diversity indices are spatially structured, showing autocorrelation (similar to most biological/ecological measures), geostatistics provide a valuable tool for a fully descriptive analysis over all the investigated area. A detailed map of diversity makes it possible to delimit and distinguish areas with greater diversity throughout the space (diversity hotspots) from areas with a low species diversity. Consequently, mapping using kriging interpolator allows to determine whether global trends are observed locally (Rufino *et al.*, 2008). As yet, geostatistical applications to diversity are scarce due to the heterogeneity or to the paucity of data as well the inconsistency between data and natural patterns (Maynou *et al.*,1996; Kienel *et al.*, 2002; Diniz-Filho *et al.*, 2003; Rufino *et al.*, 2008).

1.7 Study aims

Since research on soft-seabed macrozoobenthic community, including polychaetes, still display a lack of data concerning *taxon*omic aspects and species distribution patterns, and the pre-existing information are frequently outdated, further studies and revisions of data are a primary necessity, mainly for soft sediment habitats. These habitats are widely common in coastal areas all over the world and host most of sensitive and protected benthic habitats, species and typical biocoenoses as well as most of the human activities.

At the same time in a framework of an ecological sustainability of human activities, such as sand dredging extraction, upon the marine environment, it is important to understand the extent of their effects on marine ecosystem, to protect the environment itself and to develop strategies in order to support the ecosystems based management approach.

The efficiency of species diversity and environmental monitoring studies in marine environments is strongly influenced by the selection of the spatial and temporal scale. Investigations at regional scales as well as at adequate temporal scale allow to analyse the comprehensive variability of biological systems, strongly influenced by the interactions of numerous environmental factors such as depth, geographic position and sediment types.

To display the variability of polychaetes diversity patterns in space and time, and to investigate how this variability is related to the habitat characteristics and human impacts, this research, is aimed to:

1) identify diversity distribution patterns of polychaete assemblages and species at a regional (Latium Continental Shelf) related to depth, sediment grain size, latitude and longitude;
2) compare information, concerning the spatial distribution and ecology (related to sediment composition and depth range) of a number of selected soft-sediment polychaetes species, obtained at regional (Latium Continental Shelf) and national scale (Italian Continental Shelf);
3)–assess the effects of human activities (sand dredging) on marine ecosystems at a local scale through the analysis of biological diversity variation over time.

The amount of pre-existing studies, carried out at different scales in Mediterranean and in particular along the Italian Seas, concerning the analysis of macrozoobenthos species, especially polychaetes, and their spatial distribution as well as the role of macrozoobenthic community for the environmental assessment, contributes to be the background of this research, focused on the assessment of a multidisciplinary data-set, from environmental monitoring programmes, as a source of valuable scientific data for scientific research on marine biodiversity and for a sustainable use of marine environment resources. In particular, standard sampling methods, carried out in appropriate spatial and temporal scale, allow the collection of numerous and comparable data both to increase the scientific knowledge of benthic communities, in terms of species composition and spatial distribution and to assess marine environmental conditions and the effects of human activities, such as dredging activitie, on marine ecosystems through the analysis of biological diversity status and variation over time.

2. MATHERIALS AND METHODS

2.1 Study sites

Data collection was carried out in five areas of Latium continental shelf called "Macro-areas" (Fig. 2.1.1); the Region of Lazio local authority selected these areas because within them relict sand deposits, potentially exploitable for beaches nourishment, were found. An comprehensive research to identify and characterise relict sand deposits along Latium continental shelf was carried out by Chiocci and La Monica in 1999.

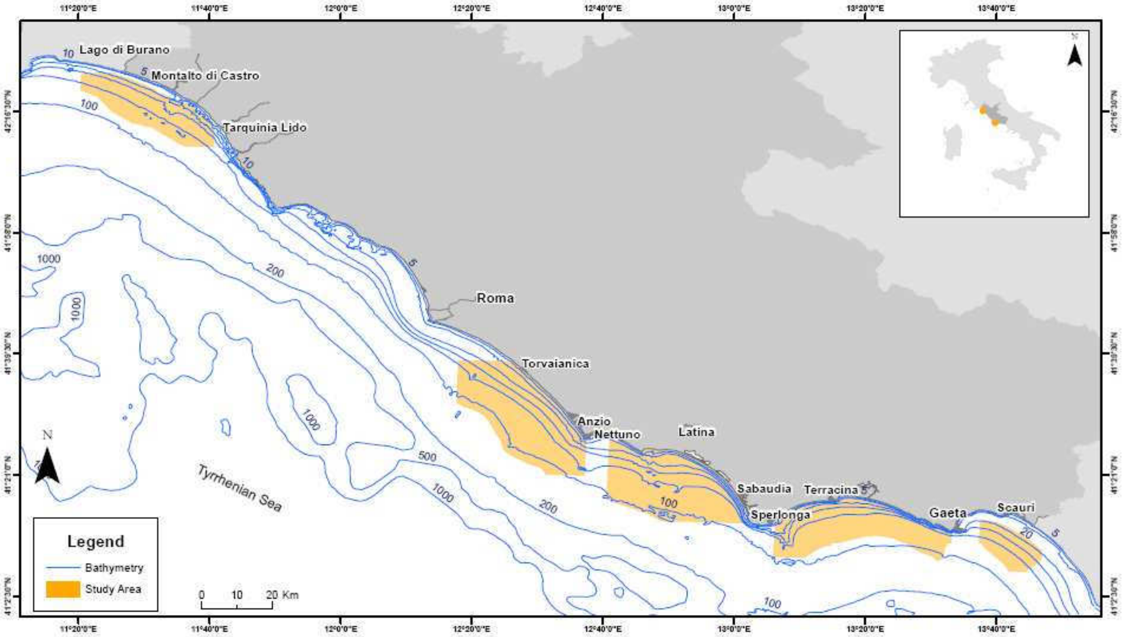


Figure 2.1.1 – Study areas along Latium continental shelf (Tyrrhenian Sea). From the northern to the southern area: Montalto di Castro, Torvaianica, Sabaudia, Terracina and Gaeta.

2.2 Dataset

From 1999 up to 2011 a series of sea water column and seabed samplings were conducted by Italian National Institute for Environmental Protection and Research (ISPRA) along the Latium continental shelf aimed at characterizing and monitoring relict sand deposits, potentially exploitable for beaches nourishment. Surveys were planned at macro-scale – environmental characterization - and local-scale – monitoring of dredging areas (Nicoletti *et al.* 2006). Data from the 5 macro-areas located along the Latium continental shelf were extracted from ISPRA's dataset on the bases of a common procedures of sampling and data collection according to methodologies proposed by Castelli *et al.* (2004). Data on the distribution of *Posidonia oceanica* seagrass along the coasts of Latium were extracted from the following works: Ardizzone and Belluscio (1996), Regione Lazio (2004) and Regione Lazio (2006). A map of surface sediment distribution in the five investigated areas was realized within a project carryed out by ISPRA and Regione Lazio local authority (ISPRA, 2010).

In the following paragraphs has been displayed methodologies used to collect the different data.

2.3 Sampling design and activities

Surveys and sampling activities were performed with the ISPRA R/V Astrea, from 2002 to 2004, as reported in Table 2.3.1. Samples had been taken in two replicates at 256 stations along transects perpendicular to the coast, spaced 2 nm each other, at depths ranging from 5 to 115 m, using a Van Veen grab (0.1 m^2 covering area) (Fig. 2.3.1) according to methodologies proposed by Castelli *et al.* (2004). The sediments sampled were sieved through a 1-mm mesh to retain invertebrate organisms classified as macrozoobenthos (body size ≥ 1 mm) and the collected material was preserved in seawater adding 4% $CaCO_3$-buffered formalin (Fig. 2.3.2).

Surface sediments samples were collected at each station with a box-corer (Figure vv). For each sampled station, depth and geographical position (UTM projection, datum WGS 84, 32N for data of Macro area of Montalto di Castro and 33N for the remaining macro-areas) were recorded.

Sampling design with number of stations, station code (area acronym, transect and depth) of each area were reported In Figures 2.3.3, 2.3.4, 2.3.5, 2.3.6, 2.3.7.

Figure 2.3.1 – ISPRA R/V Astrea and Van Veen grab during a sampling.

Figure 2.3.2 – Different phases of macrozoobenthos sampling: on board sediment sampled was sieved by 1-mm mesh and preserved in seawater adding 4% $CaCO_3$-buffered formalin.

Table 2.3.1 – Sampling design for each study area.

MACRO-AREAS investigated	**MACRO-AREAS acronym**	**Macrozoobenthic assemblages**	**Surface sediment**
Montalto di Castro	**MT**	December 2001, March 2002	December 2001, January and March 2002
Torvaianica	**TV**	March 2003	March 2003
Sabaudia	**SA**	February and March 2004	March and April 2004
Terracina	**TE**	May 2004	May 2004
Gaeta	**GT**	January 2002	February 2002

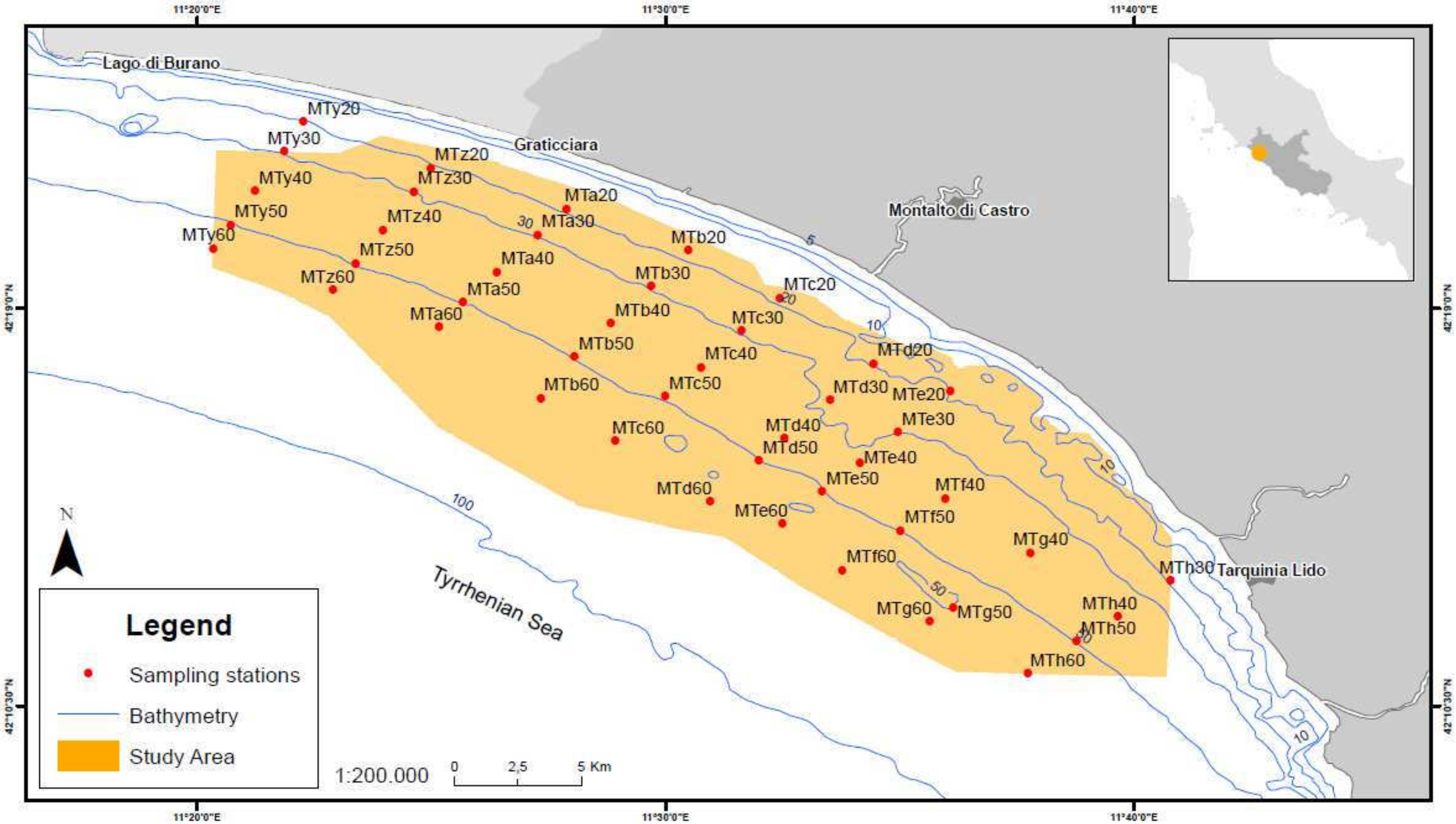


Figure 2.3.3 – Sampling plan of the study area of Montalto di Castro: 70 sampling stations.

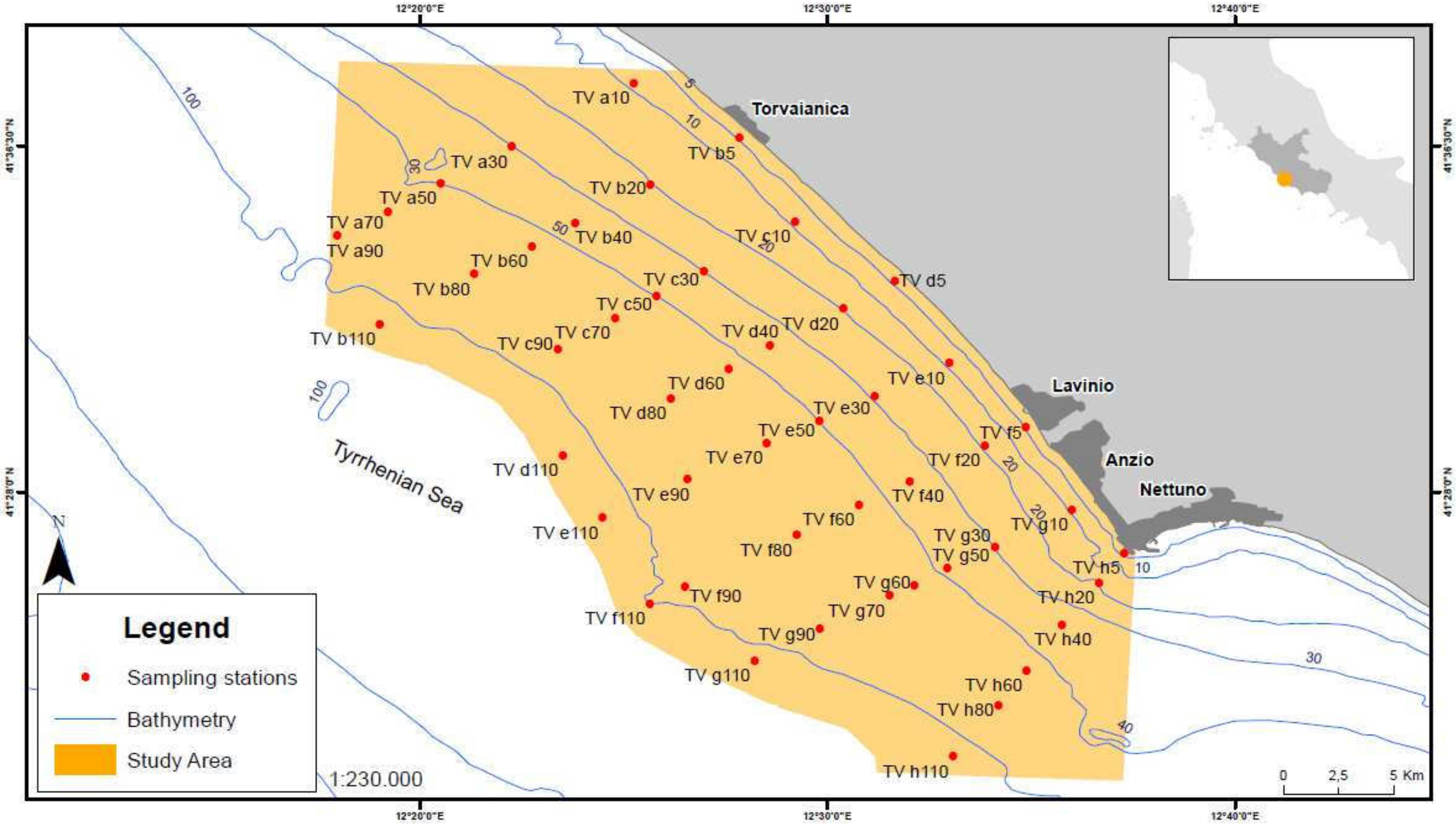


Figure 2.3.4 – Sampling plan of the study area of Torvaianica: 47 sampling stations.

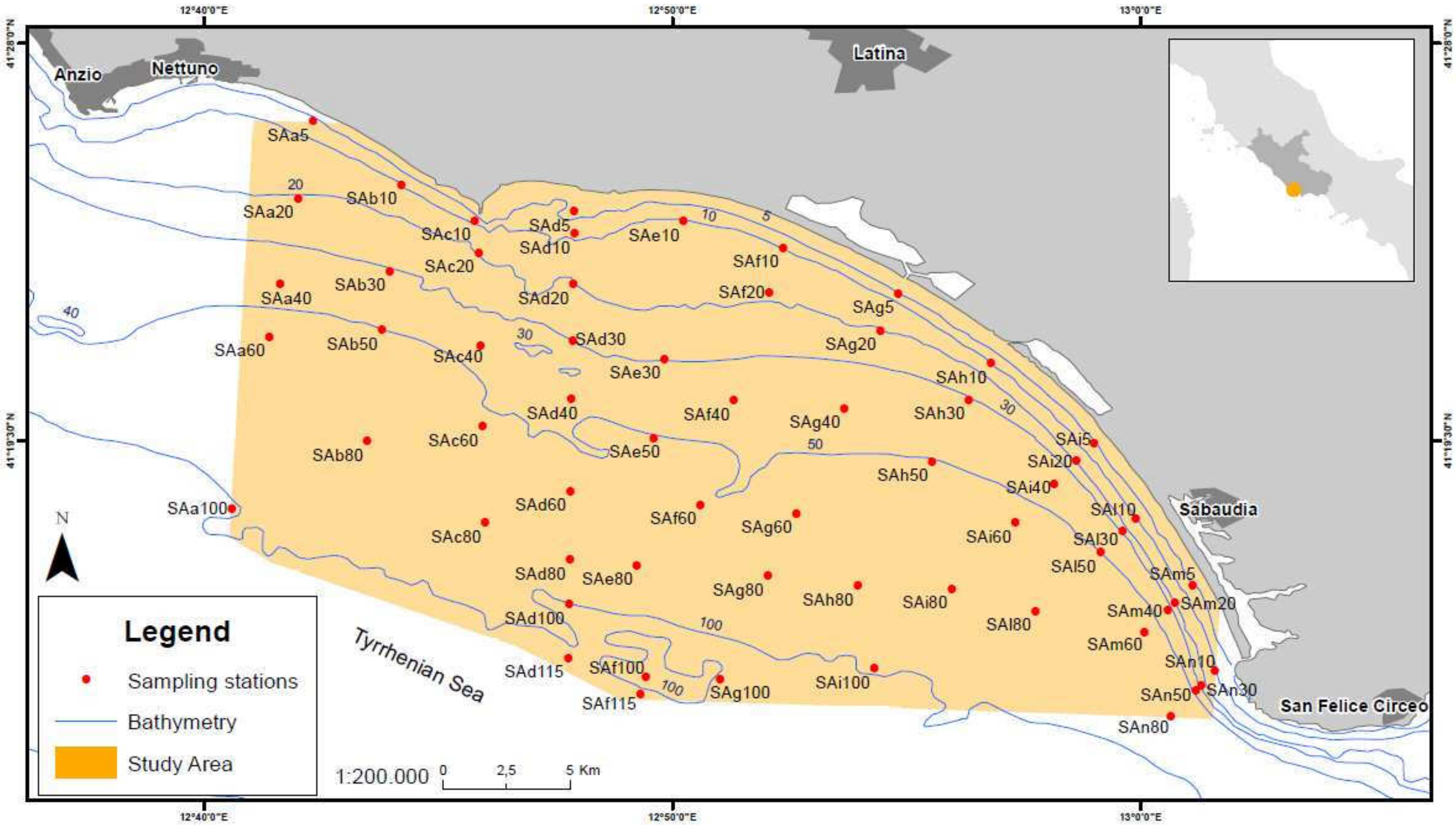


Figure 2.3.5– Sampling plan of the study area of Sabaudia: 56 sampling stations.

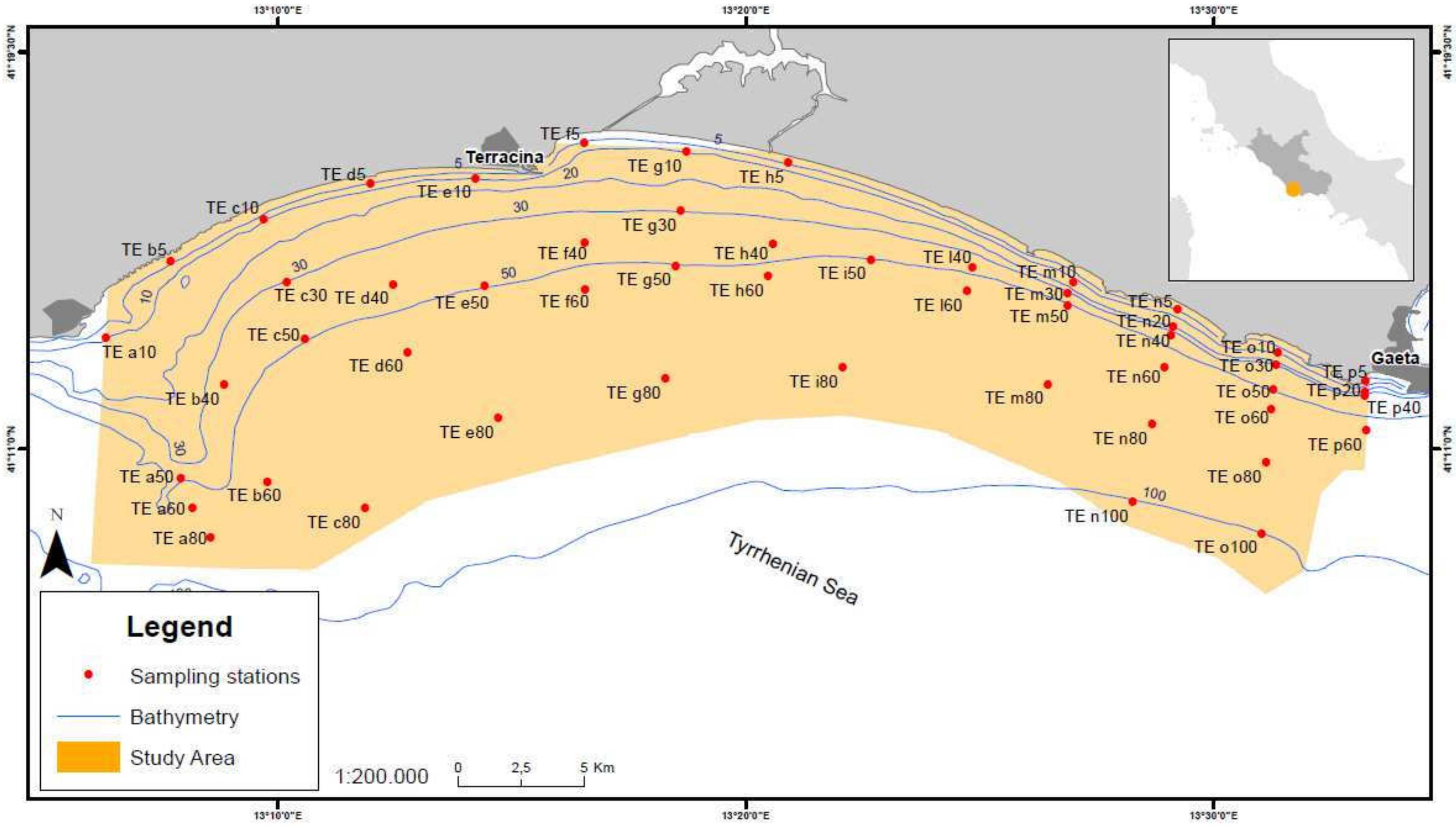


Figure 2.3.6 – Sampling plan of the study area of Terracina: 56 sampling stations.

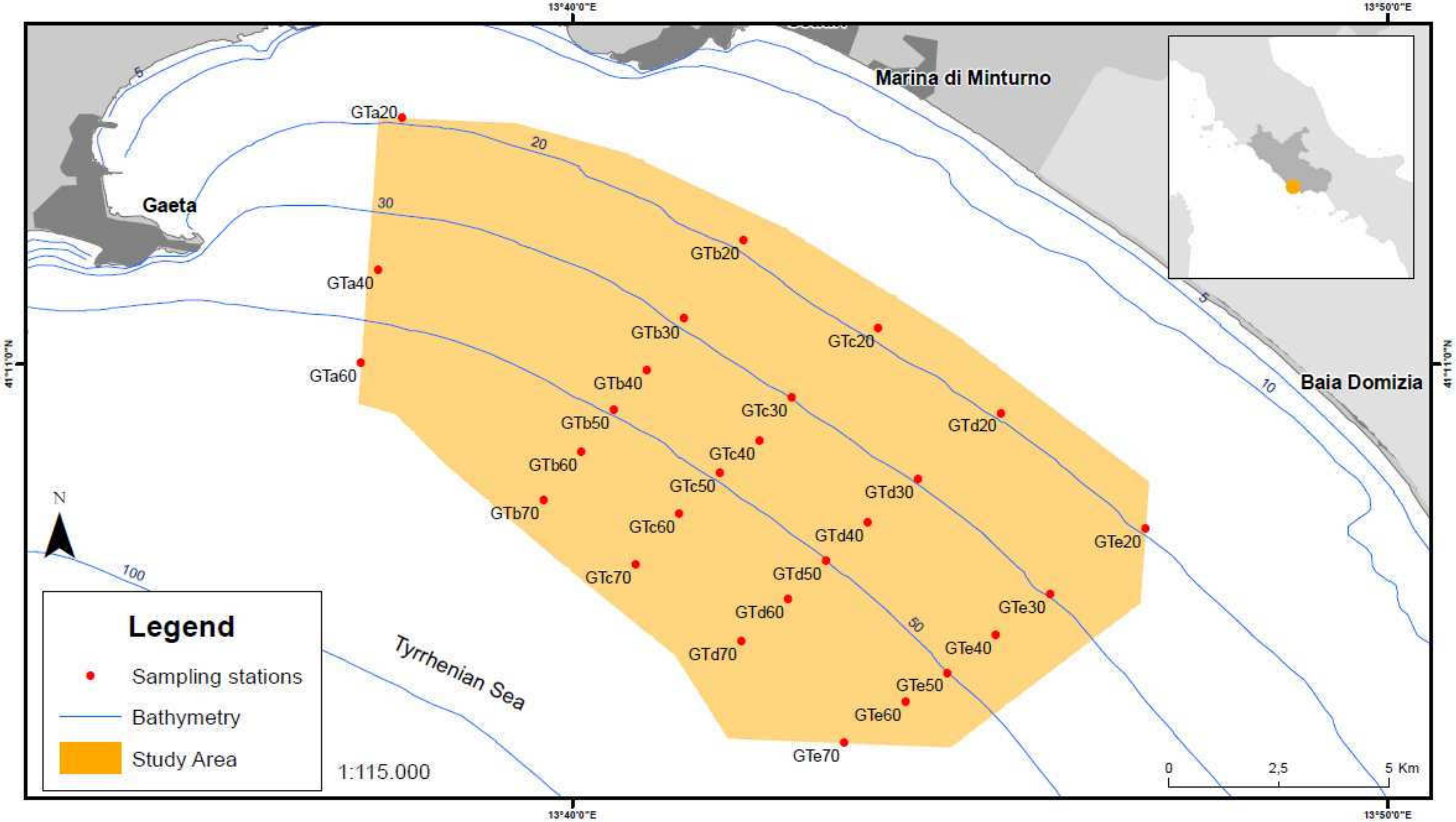


Figure 2.3.7 – Sampling plan of the study area of Gaeta: 27 sampling stations.

2.4 Laboratory analyses

Macrozoobenthic samples were sorted with a stereomicroscope into major *taxon*omical groups (Polychaeta, Mollusca, Crustacea and Echinodermata) and the collected polychaetes as well as the other *taxa* were counted and classified to the lowest possible *taxon*omic level; nomenclature followed the check list of Italian Seas (Relini, 2008).

Where available, information on the biocoenosis affiliation of the collected polychaete species (Bellan 1964; Pérès and Picard 1964; Picard 1965; Augier 1982), preferred sediment typologies and depth range distribution, was also extracted from existing literature (e.g. Pérès, 1982, Castelli *et al.*, 1992; Bianchi *et a.l*, 1993a,b,c).

Surface sediments samples were previously washed with a solution of H_2O_2 and distilled water and then dried to separate the fine fraction from the coarser. Analyses of the coarser fractions (> 63 µm) were performed with ASTM sieves in series with a range of 0.5 phi, while, the fine fractions (<63 µm) using an X-ray Sedigraf (Particle Size Measurement System) or a laser granulometer to obtain curves with detail of 0.5 phi. These analyses were performed by ISPRA's sediment laboratory.

2.5 Geo database

Data collected were used to build up a geo-referenced database (geodatabase), containing all the variables and their geographical position, by means the software ArcGis® ESRI (Arcinfo® 10.0). The geodatabase, designed for this study using UTM projection and datum WGS 84, was divided into feature datasets, 32N for data of Macro area Montalto di Castro and 33N for the remaining macro-areas. This geodatabase contains a series of tables related to different types of data for each sampled station i.e. sampling stations code, geographical position, depth, macro-areas (Montalto di Castro, Torvaianica, Sabaudia, Terracina, Gaeta), median grain size of surface sediment, macrozoobenthos assemblages (species composition and density) and some diversity indices.

2.6 Data analyses

Enviromental variables

Sediment relevant statistical parameters were calculated according to Folk and Ward (1957). Median is considered a good descriptor of environmental characteristics and it is an important parameter to explain the distribution of soft-seabeds benthic assemblages (Verfaillie *et al.*, 2006). Moreover, in each station surface sediments were analysed and classified according to sediment texture percentage, following Nota (1958): sand (S) (>95% content of sand), muddy sand (mS) (95–70%), very sandy mud (vsM) (70–30%), sandy mud (sM) (30–5%) and mud (M) (<5%). In order to manage with the amount of data and to facilitate the interpretation of results, the data were classified into six bathymetric groups. Thus the first group of station correspond to the upper infralittoral zone (I=5-10 m), the second with the lower infralittoral zone (II=20-30 m), the third with the upper circalittoral zone (III=40-50 m), the fourth, fifth and six with different levels of circalittoral zone (IV=60-70 m; V=80-90 m and VI=100-115 m).

Polychaete assemblages: univariate analyses

Abundance data were expressed as number of individual/m^2 (N), lumping the replicate samples at each station.

Gray (2000) stated that alpha diversity is the diversity of a set of sample or within habitat diversity. Hill's diversity numbers N_0, N1, N2, Ninf were calculated in each of the sampled stations as univariate measures of alpha diversity at each station. As each diversity number is of a different order and gives different weight to the less common species, their use can reveal different aspects of a community. N_0 weighs equally all species regardless of their abundance and therefore equals the number of species; N1,which gives less weight to rare species than N_0, is equivalent to the loge exponential form of the Shannon–Wiener index; N2 is the reciprocal of Simpson's index and places more weight on common species; and Ninf., the reciprocal of the proportional abundance of the commonest species (the reciprocal of the Berger–Parker index), is a measure of dominance, the “dominance index” (May, 1975). Pielou evenness index (J’), which describe the equitability of individual among the species found, was also performed. As sample size is known to influence diversity measures in different ways, species richness was also calculated for a standard sample size (Heip *et al.*, 1992) by using Hurlbert’s (1971) modification of Sanders (1968) rarefaction methodology (Dauvin *et al.*, 1994); rarefaction compensates for different sample sizes between stations (e.g. ES(100)=expected number of species in a hypothetical sample of 100 individuals) (Rees *et al.*, 2007). Rarefaction is based on drawing random samples from the distributional pattern of individuals among species in the total sample, to obtain an estimate of the total number of species in a smaller sample of individuals. This method has become the standard way to compare samples of different size (Gray, 2002). Species richness ES(n) is robust in the study of large-scale patterns and with sample size variations (Boucher and Lambshead, 1995).

Polychaete assemblages: multivariate analyses

Multivariate analysis was performed with abundance data to analyse the polychaetes assemblage variation patterns in terms of species composition and numerically abundance of species. Moreover, abundance data were transformed to presence/absence data in order to analyse differences among assemblages taking into account species shared or unshared. The output from the non-metric multidimensional scaling (nMDS) ordination model of the Bray–Curtis and Jaccard similarity matrices was obtained for the entire dataset. Canonical Correspondence Analysis (CCA) (Legendre and Legendre 1998) is correspondence analysis of a site/species matrix where each site has given values for one or more environmental variables (latitude, longitude, depth and median grain size). The ordination axes are linear combinations of the environmental variables. CCA is thus an example of direct gradient analysis, where the gradient in environmental variables is known *a priori* and the species abundances (or presence/absences) are considered to be a response to this gradient. CCA analyses was performed for the entire dataset.

Since assemblages distribution is presumably influenced by different environmental factors related to the areas characteristics and depth ranges, analysis of PERMANOVA (Anderson , 2001) (with 4999 permutations and Montecarlo validation test) was performed in order to identify which factors mainly influence the different assemblages distributions. Pair-wise test for each factor and for their possible interaction was carried out to display the most significant differences.

Beta diversity, a measure of between-habitat diversity, was originally conceived by Whittaker (1960) as a measure of the change in diversity between samples along transects or environmental gradients. Anderson *et al.* (2006) considered that beta diversity can be broadly defined as the variability in species composition among sampling units for a given area at a given spatial scale. PERMDISP on the basis of ecological measures of compositional dissimilarity can be used to test differences among groups in beta diversity. This analysis was performed on the basis of Jaccard measure which is directly interpretable as a percentage of unshared species; thus, species composition (presence/absence) information in conjunction with this resemblance measure test the homogeneity of multivariate dispersion as a measure of beta diversity (Anderson *et al.*, 2008).

The relationship between community structure and environmental variables was examined using the BIOENV routine using the Bray–Curtis similarity coefficient (Clarke and Ainsworth, 1993). BIOENV uses a Spearman's rank correlation to test for significant correlations between similarity matrices of polychaete abundance and of environmental variables. Latitude, longitude, depth and sediment composition (percentage silt–clay fraction < 0.063 mm) were the abiotic variables analysed. These analysis was undertaken for all five areas together.

Pairwise Spearman's rank correlation was performed between environmental variables (Latitude, longitude, depth and sediment composition) and biotic diversity for the whole studied areas. Univariate and multivariate analyses were performed using the software packages Primer v. 6.and PERMANOVA+ software (Anderson *et al.*, 2008) and PAleontological Statistics package – PAST v. 2.12.

Species ecology analysis

Indicator Species Analysis (ISA) (Dufréne and Legendre. 1997) has been performed in order to identify the species associated with or indicative of five groups of stations derived from Nota (1958) classification, and six groups of stations derived from depth range classification. This analysis combines the relative abundance of the species with their relative frequency of occurrence in the various groups and provides an indicator value subsequently tested by randomization.

Spatial diversity prediction maps

Prediction maps of some polychaete species density and community indices (ES, N1 and J') were realized by means geostatistic interpolator Universal kriging by means the software ArcGis® ESRI (Arcinfo® 10.0). The heterogeneity of the sampling grids, the lack of data spatial continuity between different macro-areas, and the results obtained from preliminary analysis conducted with the basic statistics highlighted the need to process the data separately for each macro-area. The statistical methods of spatial interpolation (geostatistics) are used to estimate variables distribution, even if they have not been measured, through the use of mathematical relationships.

3. RESULTS

3.1 Environmental variables: surface sediments

Surface sediments of each station were classified according to Nota (1958) and the distribution of sediment classes along the Latium continental shelf was described in Figure 3.1.1. A gradual trend of sediment grain size variation (from sand to mud) was observed with the increase in depth. Sandy stations (S=1) were found exclusively from 5 to 30 m of depth while whit the increase in fine fraction percentage a wider depth distribution of muddy sediment classes was described. Muddy-sand (mS=2) substrata characterized stations placed up to 60 m, very-sandy mud (vsM=3) started at 10 m and reached the bathymetry of 100 m even if it was not found at 70 m, sandy-mud from 20 to 110 m except at 70 and 90 m and muddy stations were identified exclusively from 40 to 115 m of depth.

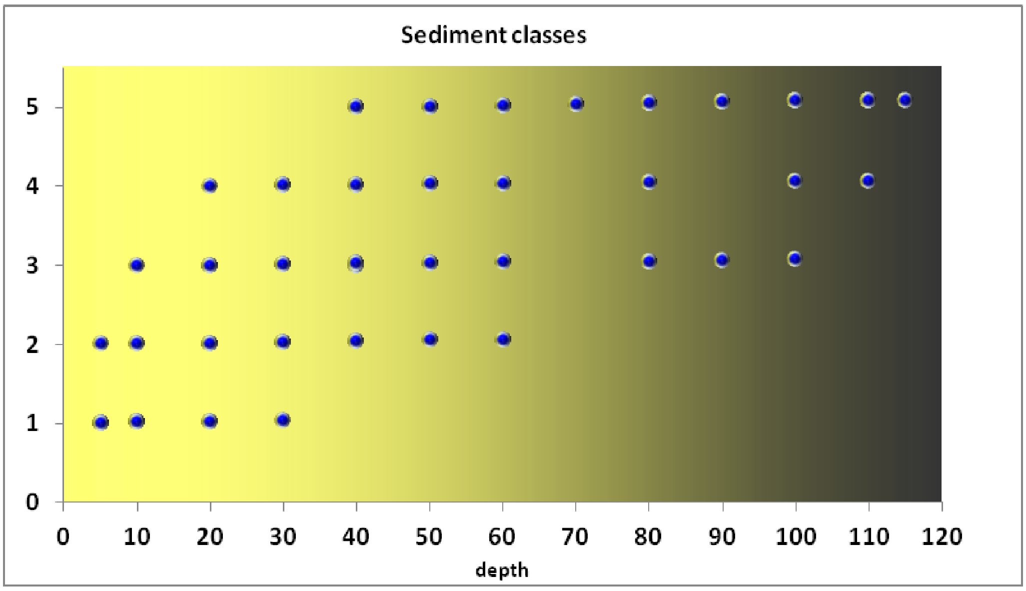


Figure 3.1.1 – Surface sediments distribution along Latium continental shelf. Sediment classification according to Nota (1958): sand (S=1) (>95% content of sand), muddy sand (mS=2) (95–70%), very sandy mud (vsM=3) (70–30%), sandy mud (sM=4) (30–5%) and mud (M=5) (<5%).

A prediction map of surface sediment distribution in the five investigated areas was realized within a project carryed out by ISPRA and Regione Lazio local authority (Fig. 3.1.2). To create the map universal kriging was performed interpolating data of surface sediment sampled in 221 stations, from north to south, distributed as follows: 36 stations at Montalto di Castro area (sampling survey of 2001 - 2002), 50 stations at Torvaianica (2003), 57 stations at Sabaudia (2004), 51 stations at Terracina (2004) and 27 stations at Gaeta (2002).

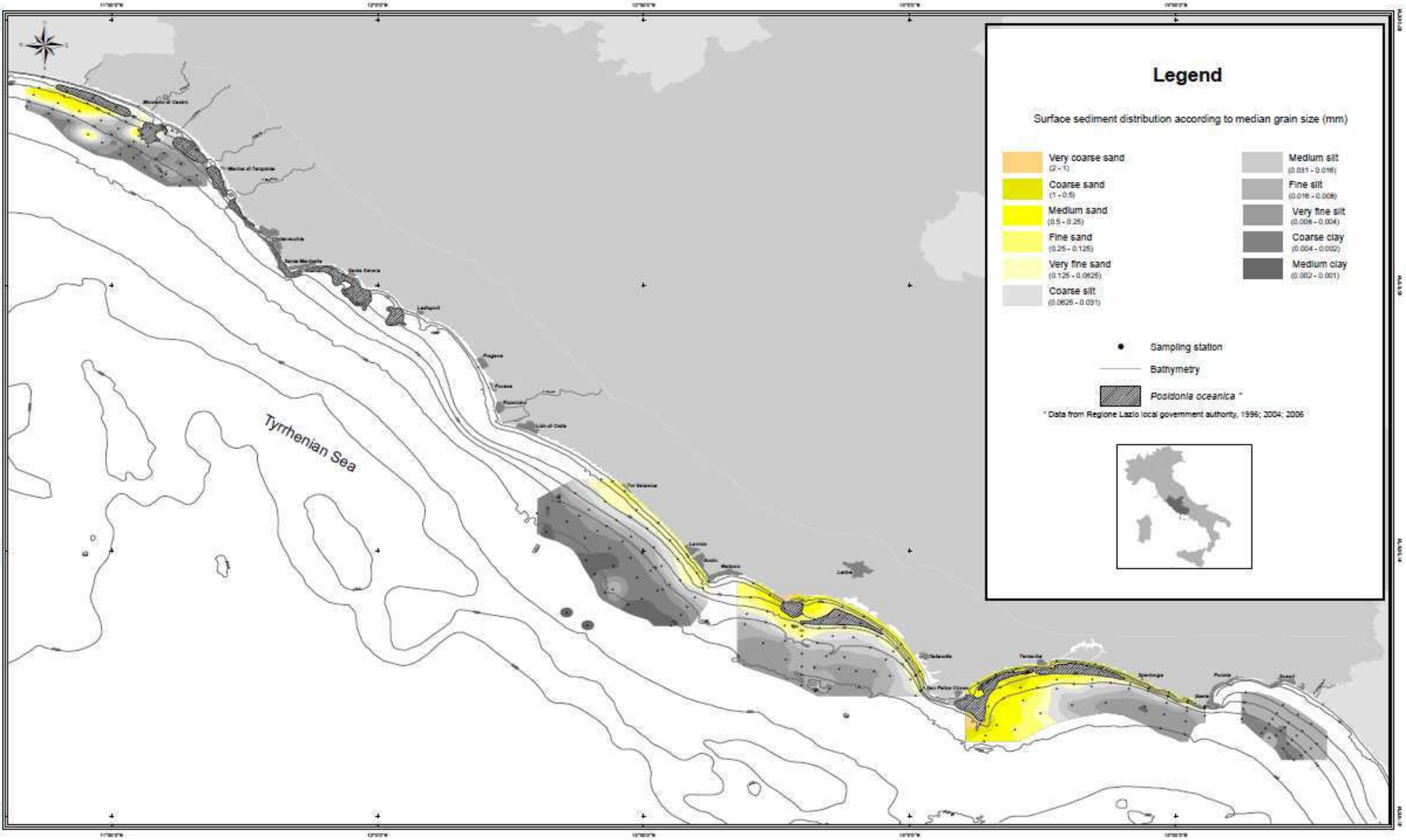


Figure 3.1.2 – Prediction map of surface sediments distribution in the five investigated areas along Latium continental shelf, realized within a project carried out by ISPRA and Regione Lazio local authority. Sediment distribution ranging from very fine sand (light yellow) to muddy clay (gray).

3.2 Polychaete assemblages: descriptive and multivariate analyses

The *taxon*omic analysis of the whole samples collected led to the identification of 48975 individuals. belonging to 42 families and 171 species (Tab.3.2.1).

The quantitative structure of polychaete assemblages of each area related to biocoenosis affiliation of species, preferred sediment typologies and depth range distribution has been described separately from the northern to the southern area.

According to Occhipinti *et al*. (2011) and Cantone *et al*. (2004), three alien species were found: *Mediomastus capensis*, *Notomastus aberans* and *Metasychis gotoi*.

The sampling stations where no polychaetes species were found were not considered within the presentation of results.

Table 3.2.1 – Polychaeta species found in the five study areas along the Latium continental shelf.

POLYCHAETA
Family Capitellidae
Capitella capitata (Fabricius, 1780)
Capitella giardi (Mesnil, 1897)
Capitomastus minimus (Langerhans, 1880)
Heteromastus filiformis (Claparède, 1864)
Leiocapitella glabra Hartman, 1947
Leiochrides sp.
Mediomastus capensis Day, 1961
Mediomastus fragilis Rasmussen, 1973
Notomastus aberans Day, 1963
Notomastus latericeus M. Sars, 1851
Notomastus lineatus Claparède, 1868
Pseudoleiocapitella fauveli Harmelin, 1964
Family Maldanidae
Axiothella constricta (Claparède, 1870)
Clymenura clypeata (Saint-Joseph, 1894)
Euclymene lumbricoides (Quatrefages, 1865)
Euclymene palermitana (Grube, 1840)
Praxillella affinis (M. Sars, 1872)
Praxillella gracilis (M. Sars, 1861)
Maldane glebifex Grube, 1860
Maldane sarsi Malmgren, 1865
Metasychis gotoi (Izuka, 1902)
Nicomache lumbricalis (Fabricius, 1780)
Petaloproctus terricolus Quatrefages, 1865
Family Cossuridae
Cossura soyeri Laubier, 1962
Family Opheliidae
Sub-Family Ophelininae
Armandia cirrhosa Filippi, 1861
Polyophthalmus pictus (Dujardin, 1839)
Family Scalibregmatidae
Scalibregma inflatum Rathke, 1843
Sclerocheilus minutus Grube, 1863
Family Orbiniidae
Sub-Family Orbiniinae
Orbinia cuvieri (Audouin & Milne-Edwards, 1833)
Phylo foetida (Claparède, 1870)
Phylo ligustica (Orlandi, 1896)
Phylo norvegica (M. Sars, 1872)
Scolaricia typica Eisig, 1914
Scoloplos (*Scoloplos*) *armiger* (O.F. Müller, 1776)
Family Paraonidae
Cirrophorus branchiatus Ehlers, 1908
Levinsenia gracilis (Tauber, 1879)
Family Paraonidae
Paraonis fulgens (Levinsen, 1883)
Family Cirratulidae
Aphelochaeta marioni (Saint-Joseph, 1894)
Caulleriella multibranchiis (Grube, 1863)
Chetozone cf *setosa*
Chetozone sp.
Chaetozone sp.1
Cirratulus cirratus (O.F. Müller, 1776)
Monticellina dorsobranchialis (Kirkegaard, 1959)
Family Acoetidae
Panthalis oerstedi Kinberg, 1855
Polyodontes maxillosus (Ranzani, 1817)
Family Aphroditidae
Laetmonice hystrix (Savigny, 1820)
Family Polynoidae
Harmothoë spinifera (Ehlers, 1864)
Malmgreniella ljungmani (Malmgren, 1867)
Malmgreniella lunulata (Delle Chiaje, 1841)
Family Sigalionidae
Pelogenia arenosa (Delle Chiaje, 1841)
Sigalion mathildae Audouin & Milne-Edwards, 1832
Sigalion squamosum (Delle Chiaje, 1830)
Sthenelais boa (Johnston, 1833)
Sthenelais limicola (Ehlers, 1864)
Family Chrysopetalidae
Chrysopetalum debile (Grube, 1855)
Family Hesionidae
Hesione splendida Savigny, 1818
Family Nereididae
Sub-Family Nereididinae
Eunereis longissima (Johnston, 1840)
Family Pilargidae
Ancistargis hamata (Hartman, 1969)
Ancystrosyllis groenlandica Mc Intosh, 1879
Pilargis verrucosa (Saint-Joseph, 1899)
Sigambra tentaculata (Treadwell, 1941)
Family Glyceridae
Glycera alba (O.F. Müller, 1776)
Glycera capitata Örsted, 1843
Glycera unicornis Savigny, 1818
Family Goniadidae
Glycinde nordmanni (Malmgren, 1866)
Goniada emerita Audouin & Milne-Edwards, 1833
Goniada maculata Örsted, 1843
Family Nephtyidae
Nephthys cirrosa Ehlers, 1868
Nephthys hombergi Savigny, 1818
Nephthys hystricis Mc Intosh, 1900
Nephthys incisa Malmgren, 1865
Nephthys sp.
Family Phyllodocidae
Sub-Family Eteoninae
Eteone longa (Fabricius, 1780)
Eteone picta Quatrefages, 1865
Family Paralacydoniidae
Paralacydonia cf *paradoxa*
Sub-Family Phyllodocinae
Phyllodoce laminosa Lamarck, 1818
Phyllodoce lineata (Claparède, 1870)
Phyllodoce macrophthalma Schmarda, 1861
Phyllodoce cf *maculata*
Family Euphrosinidae
Euphrosine armadillo M. Sars, 1851
Euphrosine foliosa Audouin & Milne-Edwards, 1833
Family Dorvilleidae
Dorvillea (*Dorvillea*) *rubrovittata* (Grube, 1855)
Protodorvillea kefersteini (Mc Intosh, 1869)
Dorvillea (*Schistomeringos*) *neglecta* (Fauvel, 1923)
Dorvillea (*Schistomeringos*) *rudolphii* (Delle Chiaje, 1828)

POLYCHAETA
Family Eunicidae
Eunice antennata (Savigny in Lamarck, 1818)
Eunice harassii Audouin & Milne-Edwards, 1834
Eunice oerstedi Stimpson, 1854
Eunice pennata (O.F. Müller, 1776)
Eunice vittata (Delle Chiaje, 1828)
Lysidice cf *ninetta*
Marphysa belli (Audouin & Milne-Edwards, 1833)
Marphysa fallax Marion & Bobretzky, 1875
Marphysa kinbergi Mc Intosh, 1910
Nematonereis unicornis (Grube, 1840)
Palola siciliensis (Grube, 1840)
Family Lumbrineridae
Lumbrineriopsis paradoxa (Saint-Joseph, 1888)
Lumbrineris coccinea (Renier, 1804)
Lumbrineris gracilis (Ehlers, 1868)
Lumbrineris latreilli Audouin & Milne-Edwards, 1834
Ninoe armoricana Glèmarec, 1968
Scoletoma emandibulata-mabiti (Ramos, 1976)
Scoletoma fragilis (O.F. Müller, 1776)
Scoletoma funchalensis (Kinberg, 1865)
Scoletoma tetraura (Schmarda, 1861)
Family Oenonidae
Arabella iricolor (Montagu, 1804)
Drilonereis filum (Claparède, 1868)
Family Onuphidae
Aponuphis bilineata (Baird, 1870)
Aponuphis brementi (Fauvel, 1916)
Aponuphis fauveli (Rioja, 1918)
Hyalinoecia tubicola Malmgren, 1867
Nothria conchilega (M. Sars, 1835)
Onuphis eremita Audouin & Milne-Edwards, 1833
Onuphis sp.
Onuphis sp.2
Family Serpulidae
Ditrupa arietina (O.F. Muller, 1776)
Hydroides pseudouncinatus Zibrowius, 1968
Pomatoceros lamarckii (Quatrefages, 1865)
Protula sp.
Serpula concharum Langerhans, 1880
Vermiliopsis infundibulum (Philippi, 1844)
Family Oweniidae
Myriochele oculata Zachs, 1923
Owenia fusiformis Delle Chiaje, 1841
Family Pectinariidae
Pectinaria auricoma (O.F. Müller, 1776)
Pectinaria koreni (Malmgren, 1866)
*Petta pusil*la Malmgren, 1866
Family Ampharetidae
Sub-Family Ampharetinae
Amage adspersa (Grube, 1863)
Ampharete acutifrons (Grube, 1860)
Amphicteis gunneri (M. Sars, 1835)
Anobothrus gracilis (Malmgren, 1866)
Sabellides octocirrata (M. Sars, 1835)
Family Ampharetidae
Sub-Family Melinninae
Melinna palmata Grube, 1870
Family Trichobranchiidae
Terebellides stroemi M. Sars, 1835
Family Terebellidae
Sub-Family Amphitritinae
Pista cristata (O.F. Müller, 1776)
Sub-Family Polycirrinae
Polycirrus aurantiacus Grube, 1860
Family Flabelligeridae
Brada villosa (Rathke, 1843)
Diplocirrus glaucus Haase, 1915
Flabelligera diplochaitus (Otto, 1821)
Pherusa monilifera (Delle Chiaje, 1841)
Pherusa plumosa (O.F. Müller, 1776)
Piromis eruca (Claparède, 1870)
Family Spionidae
Aonides oxycephala (M. Sars, 1862)
Aonides paucibranchiata Southern, 1914
Aquilaspio sexoculata Foster, 1971
Laonice cf *cirrata*
Malacoceros fuliginosus (Claparède, 1868)
Malacoceros tetraceros (Schmarda, 1861)
Minuspio cirrifera Wiren, 1883
Paraprionospio cf *pinnata*
Polydora ciliata (Johnston, 1838)
Prionospio caspersi Laubier, 1962
Prionospio ehlersi Fauvel, 1928
Prionospio fallax Soderstrom, 1920
Prionospio steenstrupi Malmgren, 1867
Scolelepis cantabra (Rjoia, 1918)
Scolelepis foliosa (Audouin & Milne-Edwards, 1833)
Scolelepis squamata (O.F. Müller, 1789)
Scolelepis tridentata (Southern, 1914)
Spio decoratus Bobretzky, 1870
Spio filicornis (O.F. Müller, 1766)
Spio multioculata (Rioja, 1918)
Spiophanes bombyx (Claparède, 1870)
Spiophanes kroyeri kroyeri Grube, 1860
Spiophanes sp.
Spionidae sp.
Family Poecilochaetidae
Poecilochaetus serpens Allen, 1904
Family Sternaspidae
Sternaspis scutata (Ranzani, 1817)
Family Chaetopteridae
Spiochaetopterus costarum (Claparède, 1868)
Family Magelonidae
Magelona alleni Wilson, 1958
Magelona sp2

3.2.1 MONTALTO DI CASTRO

Samplings in MTy20, MTz20, MTa20 and MTb20 stations confirmed the presence of *Posidonia oceanica* meadow while in MTd20, MTe20, MTf20, MTg20 and MTg30 stations were found hard substrata occasionally with *P. oceanica*. At 30 m of depth, samples collected in MTy30, MTz30, MTa30, MTb30, MTc30, MTd30, MTe30 and MTf30 stations indicated the occurrence of *P. oceanica* "dead matte". On the contrary, along transect h, positioned in front of Marta river, seafloor of station MTh30 was mainly composed by muddy sediment. Consequently the polychaete assemblages analysed coming from 34 of 70 stations planned.

A total of 5275 individuals belonging to 83 species were found at the investigated stations as reported in Appendix I

At 20 meters depth the most abundant species found were *Nephtys hombergi* (135 ind/m^2), typical species of sand and mixed sediment, *Notomastus aberans* (65), *Lumbrineris latreilli* (35), both associated to muddy sediments enriched of organic matter and *Eunice vittata* (30). Sandy species as *Owenia fusiformis, Nephtys hombergi*, *Scolaricia typica* (affiliated to well sorted fine sand biocoenosis) and *Pilargis verrucosa* together with species characteristic of sediment composed by organic detritus as *Aponuphis brementi, Euphrosine armadillo* and *Sigambra tentaculata* were also founded. In MTc20 station species as *Paralacydonia* cf *paradoxa, Glycera unicornis* and *Aphelochaeta marioni*, indicate the occurrence of muddy fractions in the sediment. At 30 meters *Notomastus aberans* (75) *Scoletoma emandibulata-mabiti* (65) and *Melinna palmata* (30), inhabiting in muddy sediments enriched of organic matter, were the most abundant species but were also quite numerous species as *Laonice* cf *cirrata, Pectinaria auricoma, Heteromastus latreilli, Notomastus latericeus, G. unicornis. Metasychis gotoi* (185), *Ampharete acutifrons* (115) (affiliated to Continental Terrigenous Mud biocoenosis), *G. unicornis* (105), *L. latreilli* (100) and *N. aberans* (90) (both associated to muddy sediments enriched of organic matter) were the dominant species of assemblages at 40 meters depth. The overall assemblage was typical of muddy seabeds but at MTa40, MTd40 and MTe40 also occurred species associated to gravel fractions of sediment (e.g. *Hylinoaciea tubicola*, *O. fusiformis*, *Myriochele oculata*, *Pectinaria auricoma*). The assemblages of stations at 50 m of depth were dominated by *L. latreilli* (115), *H. filiformis* (115), *T. stroemi* (110), *A. acutifrons* (110) and *Scoletoma emandibulata-mabiti* (105), species usually occurring in muddy seabeds as well as in the continental terrigenous mud biocoenosis even if they can tolerate coarse fractions of sediment. In some stations species as *Aponuphis fauveli, H. tubicola*, *Drilonereis filum*, *P. auricoma* suggested the presence of detritic habitats where these species are most common. At 60 m the most abundant species were *G. unicornis* (60), *S. emandibulata-mabiti* (60) and *A. marioni* (55), indicators of sediments enriched of organic matter. The assemblages occurred at this depth were typically of muddy seabeds except for those found in MTb60 station where some species affiliated to muddy detritic biocoenosis was recorded (*H. tubicola*, *Leiocapitella glabra)* .

Mean species richness values (N_0 which weights equally all species regardless their abundance) were relatively constant along the depth gradient but a quickly decreasing was observed at 60 m (trend confirmed by ES which estimate the expected number of species in an hypothetical sample of 100 individuals); the species abundance (N) gradually decreases with depth. Mean diversities (N_1 which gives less weight to the rare species, and N_2 which places more weight to the common species) show comparable trends, reaching the highest values at 50 m and the lowest at 60 m of depth. Pielou evenness (J') describe a high equitability among the species occurring at different bathymetries with the fewest number of dominant species at 50 m (N_{inf}: 6,53) (Fig. 3.2.1.1) (Fig. 3.2.1.2). The analysis of mean values of community indices according to sediment variation show species richness (N_0) and abundance (N) decrease with the increase of fine fractions in the sediment. As a consequence the deeper and muddy stations were characterized by poor polychaete assemblages in terms of diversity (N1 and N2) and species composition. On the contrary, in the stations placed where the percentage of sand is higher (i.e. very-sandy mud and sandy mud) (mainly from 20 to 50 m depth) (Fig. 3.2.1.3) species diversity increase. In each sediment type no dominant species was found as showed by J' and N_{inf} indices trend (Fig. 3.2.1.1).

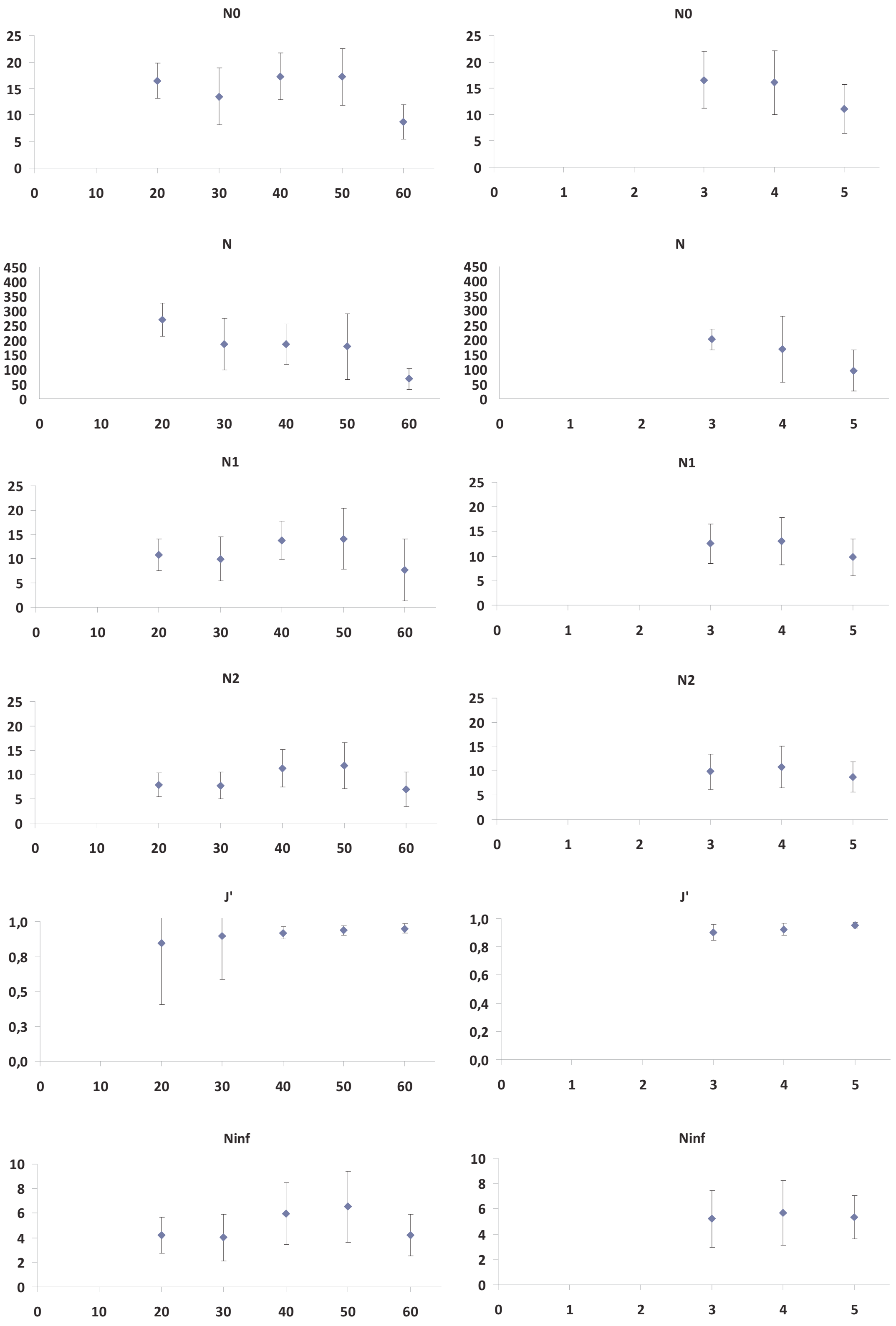


Figure 3.2.1.1 – Polychaete diversity according to depth (on the right) and sediment classes (on the left) along the continental shelf of Montalto di Castro: N species density (ind./m^2), J' Pielou evenness;, N0, N1, N2, Ninf Hill diversity number. Sediment classes according to Nota (1958): sand (S=1) (>95% content of sand), muddy sand (mS=2) (95–70%), very sandy mud (vsM=3) (70–30%), sandy mud (sM=4) (30–5%) and mud (M=5) (<5%).

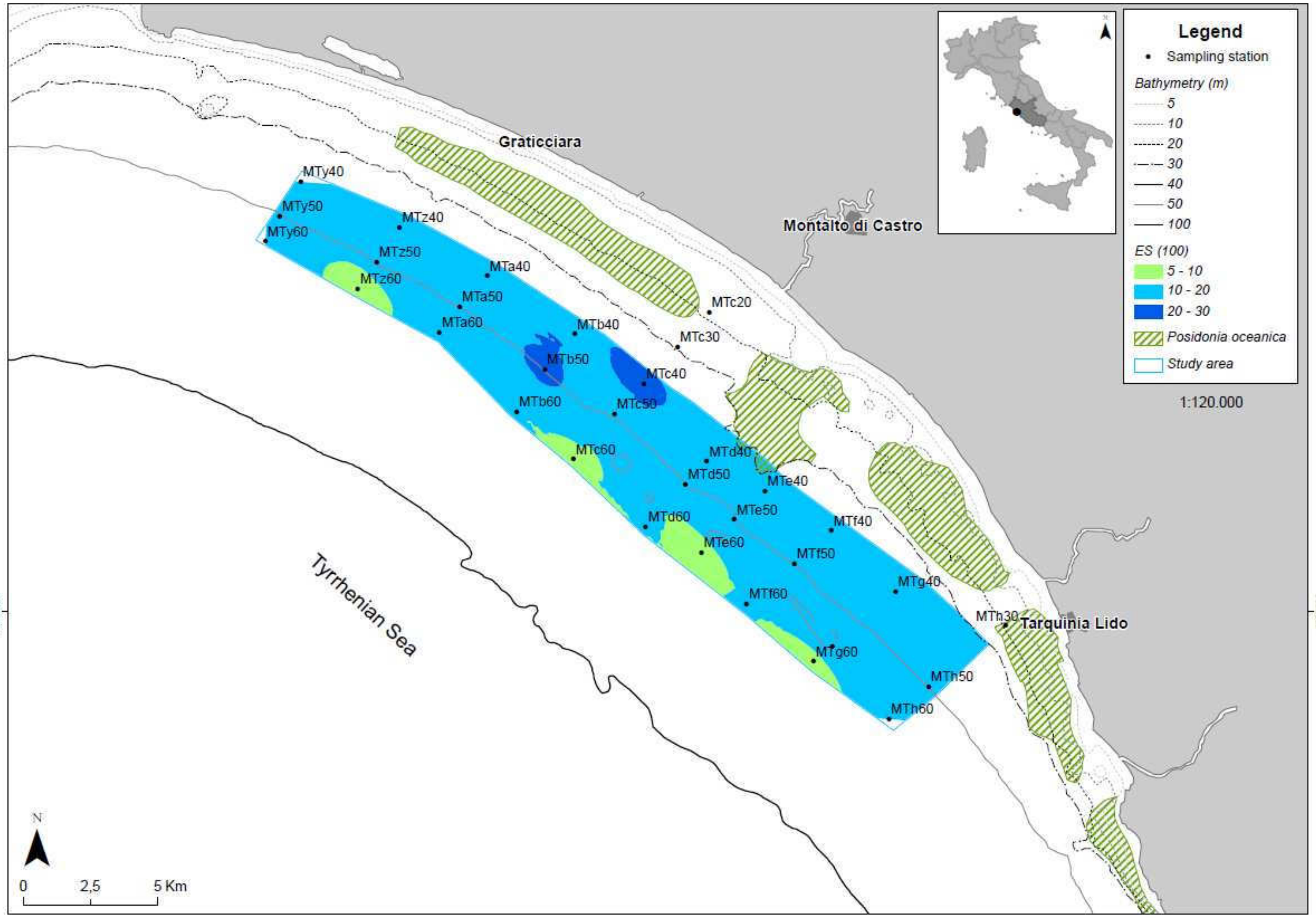


Figure 3.2.1.2 – Prediction map of ES, which estimate the expected number of species in an hypothetical sample of 100 individuals, in the area of Montalto di Castro.

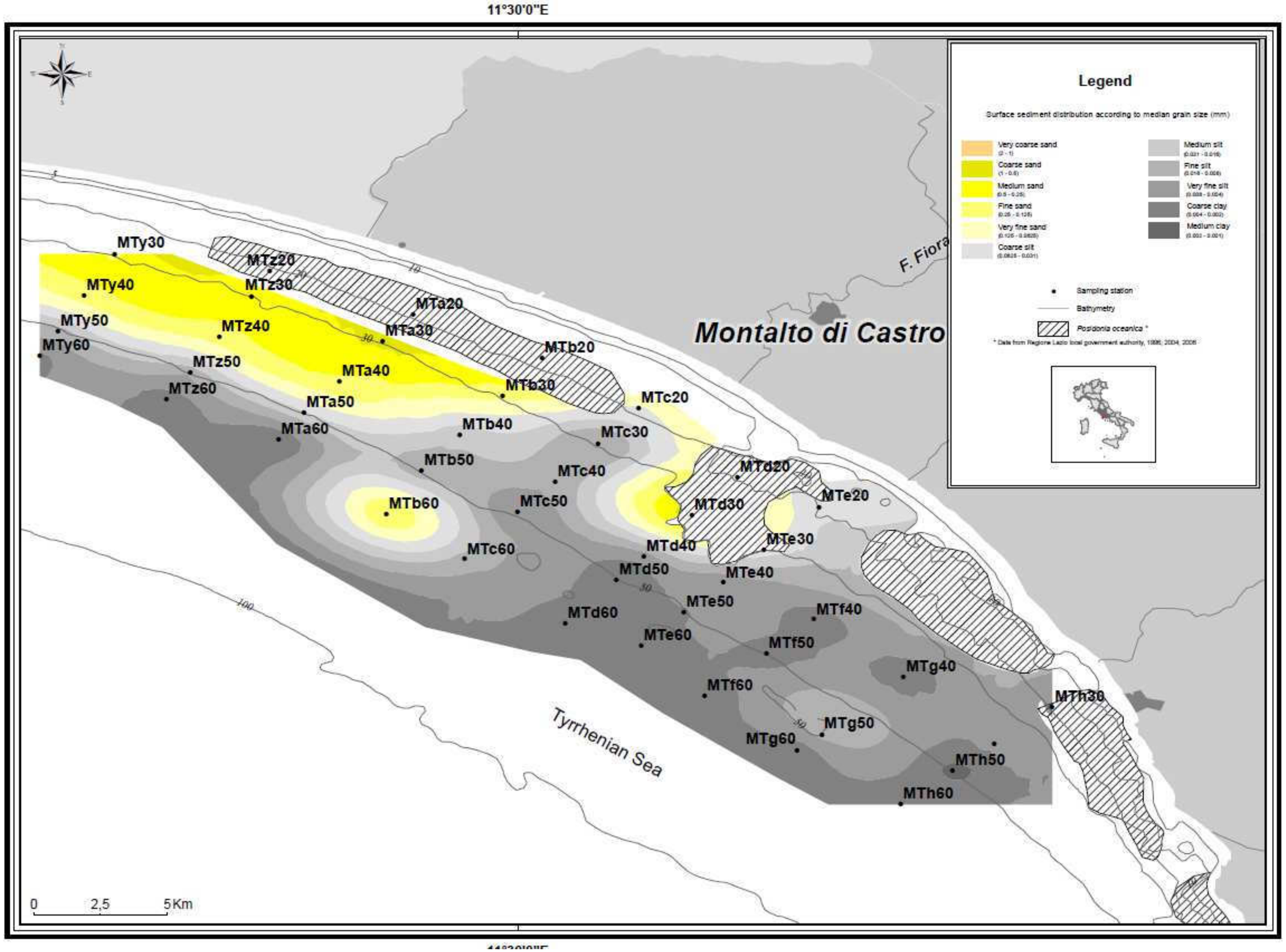


Figure 3.2.1.3 – Prediction map of surface sediments distribution along Montalto di Castro continental shelf.

3.2.2 TORVAIANICA

Over a total of 47 stations, 69 species and 11650 individuals were collected (Appendix II).
In the shallowest stations (5 m) the dominant species collected *Owenia fusifomis* (340 ind./m^2), *Onuphys eremita* (170), *Sigalion mathildae* (120) and *Mediomastus fragilis* (110) are typically found of sandy sediment and affiliated to the well sorted fine sands biocoenosis. The assemblage was composed exclusively by sabulicolus species as well as was observed at 10 m of depth where the most abundant species were *O. fusiformis* (2145), *Nothria concyilega* (300) (both exclusively found in TVe10 and TVg10), *S. mathildae* (65) and *Magelona* sp2. At 20 m, species that generally prefer coarse sediments (sand or organic detritus) such as *Aponuphis bilineata* (150), *Spio decoratus* (135), *O. fusiformis* (110) coexisted with species, usually inhabit mixed sediment and are tolerant to different amount of mud and organic matter, such as *Melinna palmata* (450), *Capitella capitata* (415 specimens exclusively in TVh20) and *Notomastus aberans* (325), the most abundant, and also *Clymenura leiopygos* (115), *Ampharete acutifrons* (100), *Glycera unicornis* (70) and *Heteromastus filiformis* (70). Increasing the depth (30 m) the number of species typical of muddy sediments increased, i.e. *Lumbrineris latreilli* (250), *Brada villosa* (90), *Scoletoma emandibulata-mabiti* (45), *G. unicornis* (40) *N. aberans* (30), *Melinna palmata* (25) and *Drilonereis filum* (20) even if a few species, for example *O. fusiformis* (15), *A. fauveli* (15), *S. decoratus* (5), typically associated to sandy seabeds, still occurred in some stations (e.g TVg30) with lower abundance than observed in the shallower ones. Between 20 and 30 m of depth a transition between assemblages normally affiliated to sands to those associated to mud was signaled. From 40 m to deeper bathymetries the species composition was exclusively typical of muddy sediments. Among the most frequent species, *L. latreilli* (whose abundance varied from 455 to 10 ind/m^2), *B. villosa* (155-5), *Paraprionospio* cf *pinnata* (160-5), *Sternaspis scutata* (105-5), *Praxillella gracilis* (65-5), *Terebellides stroemi* (70-45), *Notomastus latericeus* (100-5), *G. unicornis* (75-15), *Heteromastus filiformis* (65-15). The occurrence and abundance of some of these polychaetes varied following the depth gradient displaying different depth range preferences. For example *S.scutata* resulted mostly abundant from 40 m (105 ind/m^2) up to 60 m (about 50), *P. gracilis* from 40 up to 60 m (65-25), *T. stroemi* mainly recorded among 40-70 m (50-45) even if

it firstly occurred from 20 m of depth. Was interesting to signal that some specie normally found in shallower sandy seabeds were collected in some deep stations for instance *A. fauveli* at 80-90 m.

Species richness (N_0 and ES) reached the highest values at 20 and 40 m decreasing with depth; low values were also recorded in the shallowest station (5 and 10 m) where e few polychaetes occurred occasionally with a high number of specimens . Thus at 10 m the peak of species abundance (N) was mainly due to the dominance of *O. fusiformis* and *N. conchilega*. Comparable mean value of N was observed at 20 m where a smaller amount of dominant species was found. Below this depth, species abundance heavily decreased. Diversity indices (N_1 and N_2) show similar trends and the highest values were recorded at 20 and 40 m of depth. The overall assemblages of the area were characterized by a high equitability (J') except for some shallow stations at 5-10 m and for the deeper ones (N_{inf}: 1,9 at 110 m) (Fig. 3.2.2.1) (Fig. 3.2.2.2). The indices trends in relation to sediment classes show that species richness (N_0) and abundance (N) reached the highest vales in muddy-sand stations (mS) and decreased proportionally to the increase of percentages of both sand and mud in the sediment. The highest diversity (N1 and N2) was observed in sediments ranging from muddy-sand to very-sandy mud while the poorest assemblages mainly characterized by a few number of dominant species occurred in sandy stations (J': 0,72 and N_{inf}: 2,4) (Fig. 3.2.2.1) (Fig. 3.2.2.3).

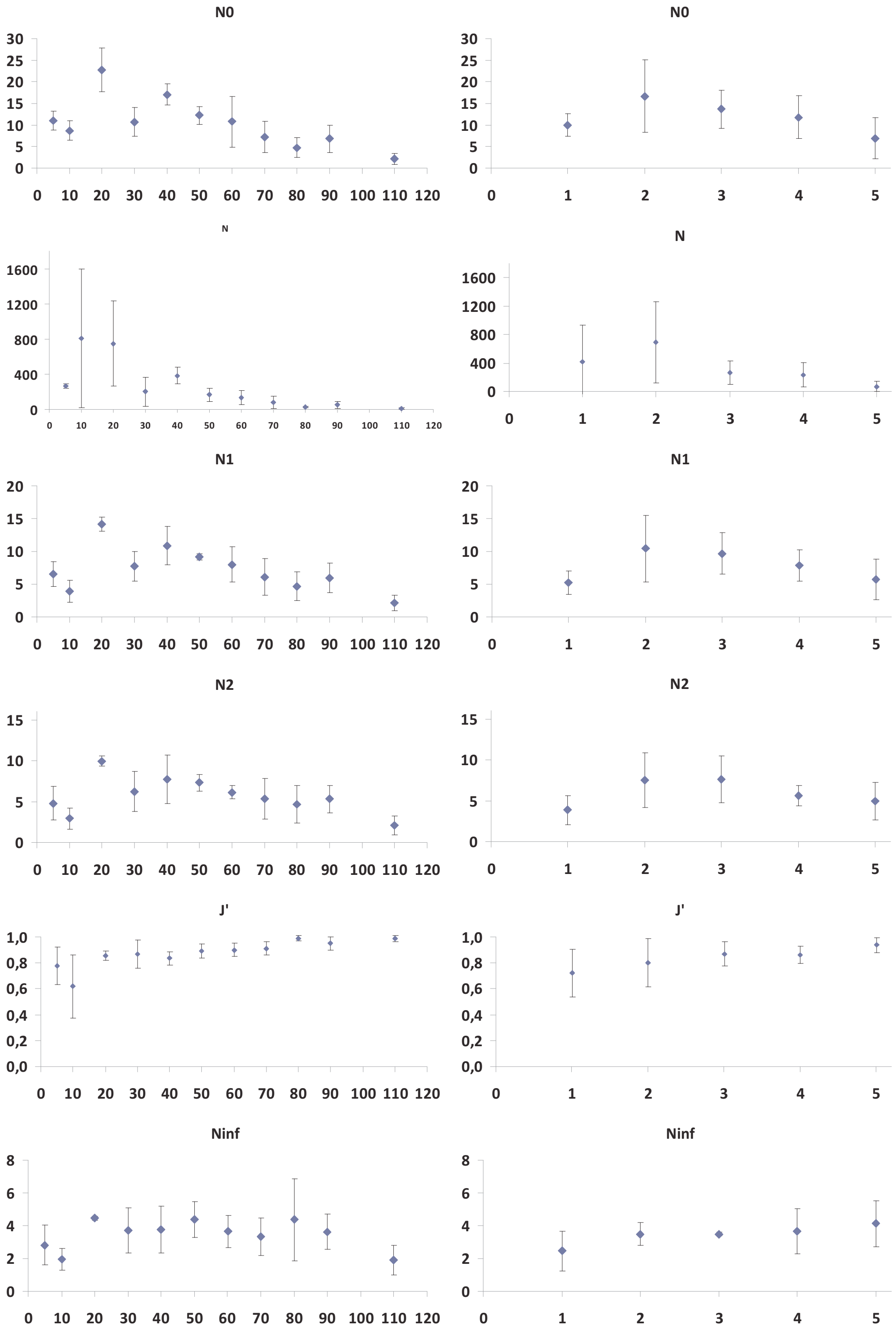


Figure 3.2.2.1 – Polychaete diversity according to depth (on the right) and sediment classes (on the left) along the continental shelf of Torvaianica: N species density (ind./m^2), J’ Pielou evenness;, N0, N1, N2, Ninf Hill diversity number. Sediment classes according to Nota (1958): sand (S=1) (>95% content of sand), muddy sand (mS=2) (95–70%), very sandy mud (vsM=3) (70–30%), sandy mud (sM=4) (30–5%) and mud (M=5) (<5%)

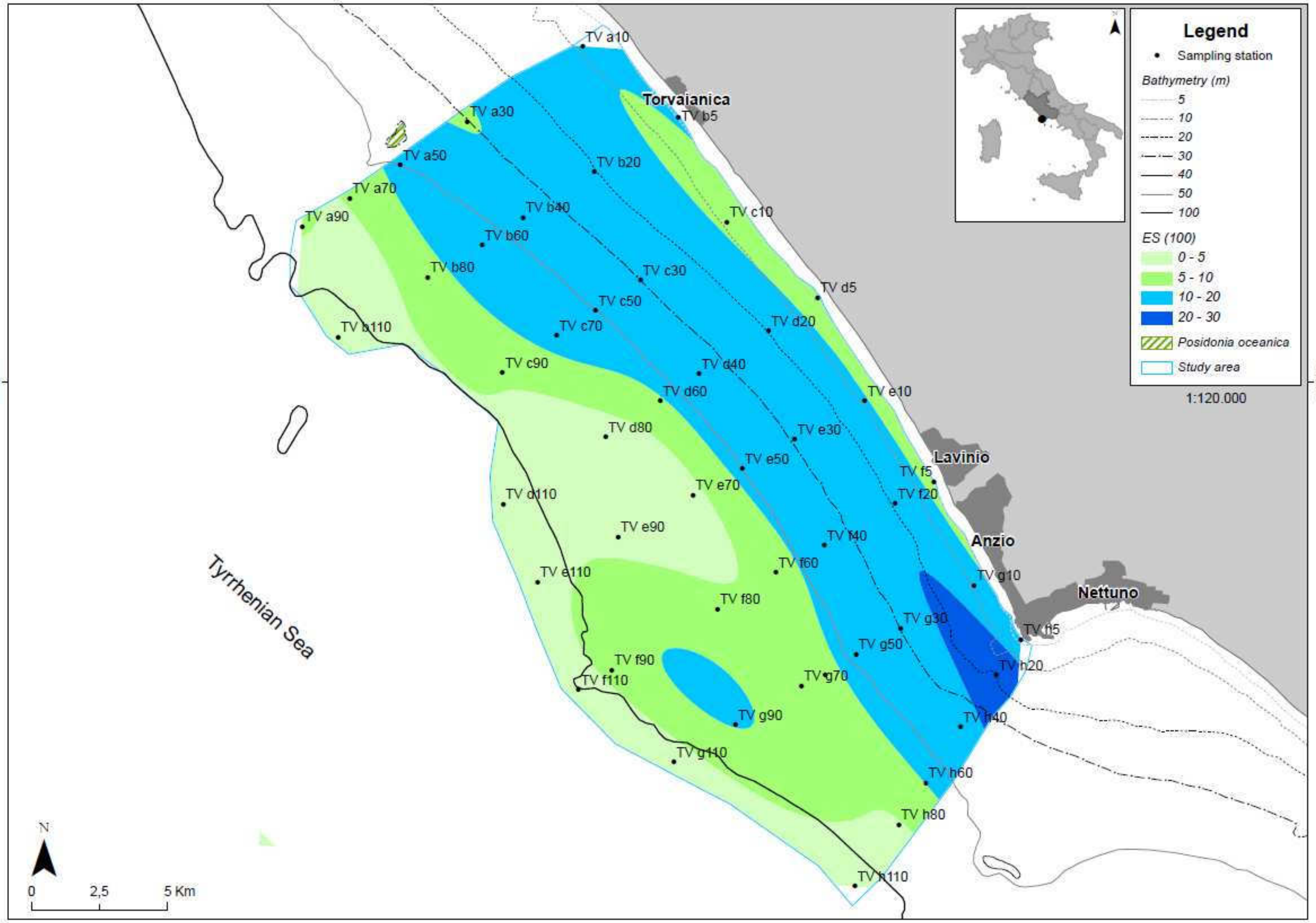


Figure 3.2.2.2 – Prediction map of ES, which estimate the expected number of species in an hypothetical sample of 100 individuals, in the area of Torvaianica.

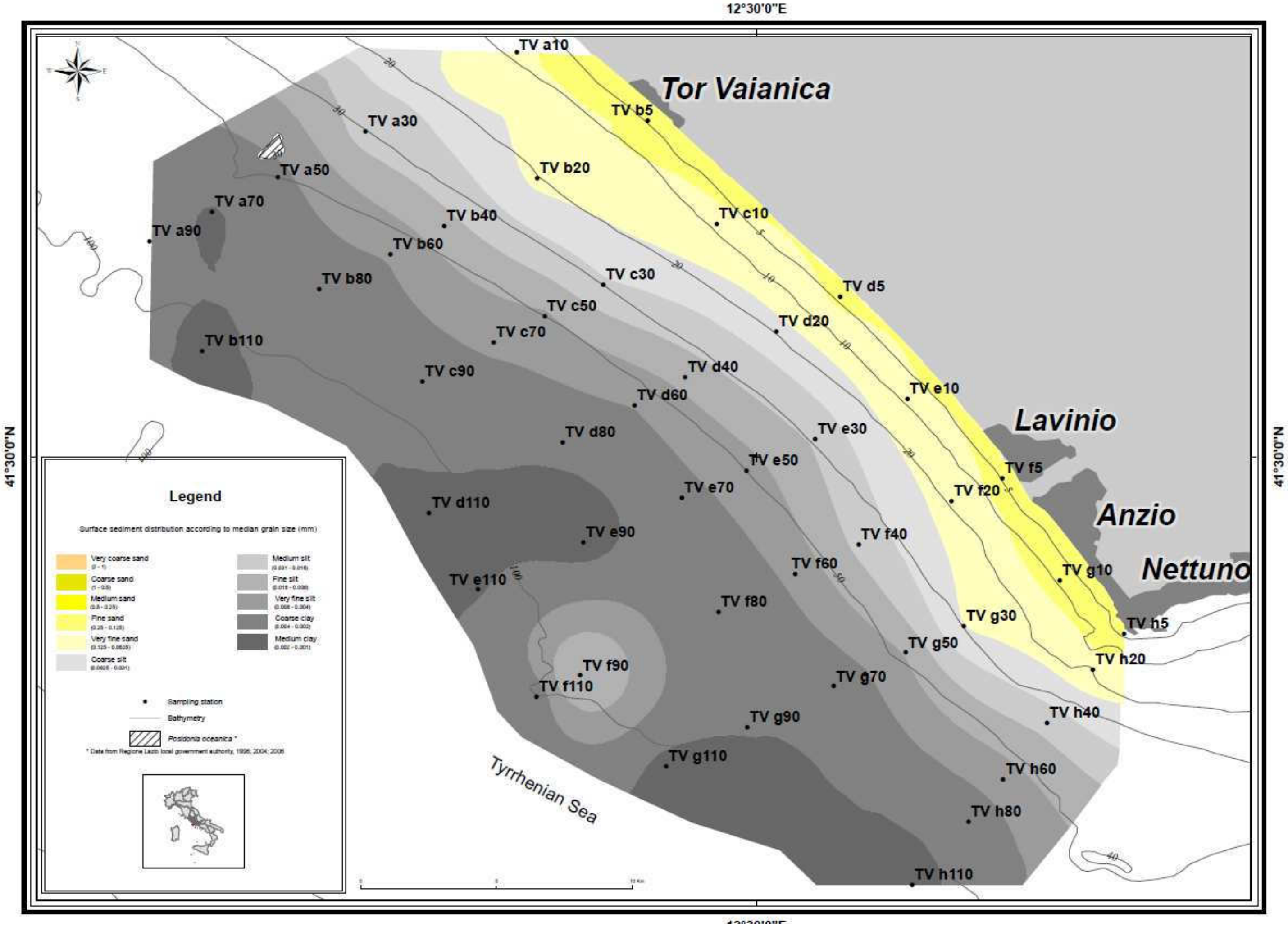


Figure 3.2.2.3 – Prediction map of surface sediments distribution along Torvaianica continental shelf.

3.2.3 SABAUDIA

Overall 106 species with a total of 13145 individuals were sampled in the 56 stations of Sabaudia (Appendix III). *Posidonia oceanica* meadows are present in front of Torre Astura promontory and the coastal lakes of southern Latium, ranging from about 10 (upper limit) to 30 m of depth. Transects from "c" to "h" across or were located in proximity of the meadows.

At 5 m depth the most abundant and wide distributed species were *Magelona* sp2 (225 ind/m2), *Scoloplos armiger* (145), *Lumbrineris tetraura* (140), *Sigalion mathildae* (75), typical species of well sorted fine sand biocoenosis, and *Spio decoratus* (40). These species became more abundant at 10 m where other sabulicolus species such as *Prionospio caspersi* (115), *Nephtys hombergi* (30) and *Owenia fusiformis* (25) were collected. At 20 m of depth assemblages were mainly composed by sandy species, e.g. *Aponuphis brementi* (210), *S. decoratus* (45), *Spiophanes bombyx* (45), *S. armiger* (20) and species of muddy seabeds as *Lumbrineris latreilli* (95), *Melinna palmata* (70), *Laonice* cf *cirrata* (65) (affiliated to continental terrigenous mud biocoenosis), *Notomastus aberans* (60), *Poecilochetus serpens* (55). Moreover, at SAd20 station, located in proximity of the *Posidonia oceanica*, meadow were signaled species associated to organic detritic seabeds as *Nephtys incisa* and M*yriochele oculata* and *Arabella iricolor,* frequent in algal biotopes. Some of the above species were also collected at 30 m where an increase of their abundances was observed, e.g. *L. latreilli* (760), *S. decoratus* (220), *S. armiger* (650), *P. serpens* (650), *A. brementi* (140). High densities were signaled as well for other species as *Nephtys hombergi* (420), *Spio multioculata* (285), *Paralacydonia* cf *paradoxa* (250) *Sternaspis scutata* (115) that occurred at the same depth. A transition zone between assemblages normally found in shallow waters, where the percentage of sand is high, and assemblages typical of mixed or muddy sediments was thus identified at the depth-range of 20-30 m as indicated by the species composition described. The bathymetry of 40m was characterized by the occurrence of a reduced amount of dominant species if compared with the previous assemblages, such as *L. latreilli* (565), *Notomastus latericeus* (265), *P. serpens* (245) e *Terebellides stroemi* (135), and *Paraprionospio* cf *pinnata* (130). Muddy species as well as typical species of continental terrigenous mud biocoenosis (e.g. *S. scutata* , *Laonice* cf *cirrata)* mainly composed the assemblages analysed ; in station

SAd40, on the contrary, a quite number of species inhabiting sandy or detritic seabeds such as *M. oculata*, *A. brementi*, *S. decoratus*, *Chaetozone* sp1 were collected. From 50 m to the deeper zones (115 m) the assemblages composition became more homogeneous, mostly composed by species living in sediment with high fractions of mud. *L. latreilli* (150-5), *Pseudoleiocapitella fauveli* (70), *P.* cf *pinnata* (55-10)*, S. scutata* (45-5), *T. stroemi* (50-5) were some of the most frequent and abundant species collected. *T. stroemi* occurred up to 60 m*, S. scutata* up to 80m, *Metasychis gotoi* was exclusively sampled between 60 and 80 m of depth. At one station placed at 60 m (SAd60) the assemblage was more heterogeneous than the others of the same depth due to the presence of species frequently associated to detritic habitats such as *Leiocapitella glabra, Hyalinoecia tubicola,* and species associated to sandy sediments as *O. fusiformis, P. auricoma* and *A. brementi*. A similar condition was signaled in one station at 100 m (SAd100) where muddy species coexisted with species that inhabits coarse sediments (affiliated to muddy detritic biocoenoses) such as *Laetmonice hystrix, H. tubicola*, and *L. glabra.*

Species richness (N_0 and ES) increased up to 30 m depth where reached the highest values; below this depth the number of species decreased and the stations placed between 80 and 110 m showed the lowest values. At 30 m was also recorded a peak of species abundance (N) due to high densities of a number of species sampled. The richest zones in terms of species diversity (N_1 and N_2) ranged from 20 to 30 m and 60 m depth, where station SAd60 contributed with a high number of species and individuals in contrast with the other stations at the same depth. In the assemblages analysed between 20 and 40 m the evenness with which individuals are distributed numerically among species (J') was the lowest of the area and in particular a few number of dominant species was signaled at 40 m (N_{inf}: 2,9) (Fig. 3.2.3.1) (Fig. 3.2.3.2). Species richness (N_0) and abundance (N) increased proportionally to the increase of percentage of mud in the sediments but where this fraction was > 95% a consequential severe decrease was observed. Very-sandy mud and sandy-mud sediments hosted the highest diversity (N1 and N2), and no dominant species (J' and N_{inf}) seemed to be associated to definite granulometric characteristics of sediment (Fig. 3.2.3.1) (Fig. 3.2.3.3).

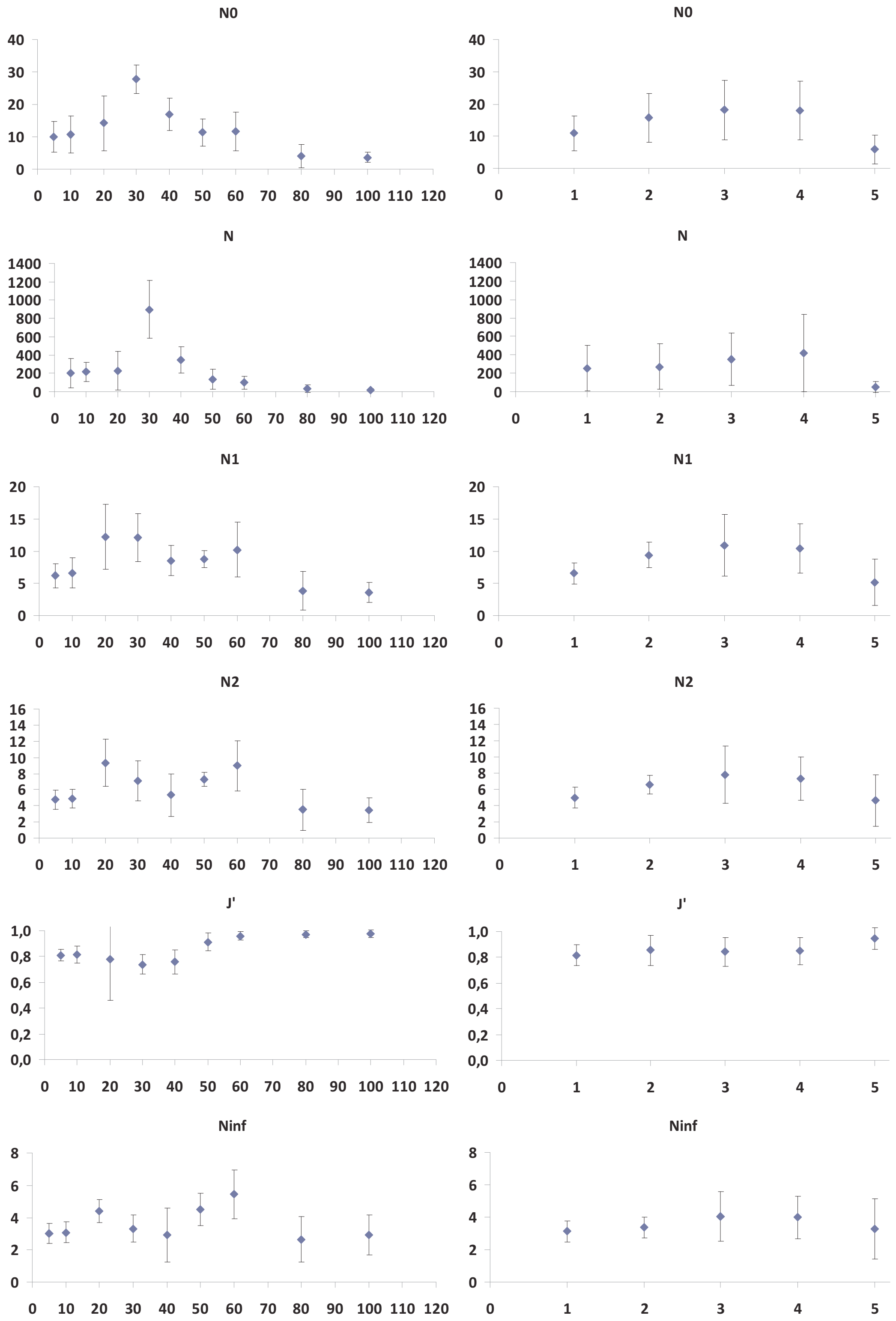


Figure 3.2.3.1 – Polychaete diversity according to depth (on the right) and sediment classes (on the left) along the continental shelf of Sabaudia: N species density (ind./m^2), J’ Pielou evenness;, N0, N1, N2, Ninf Hill diversity number. Sediment classes according to Nota (1958): sand (S=1) (>95% content of sand), muddy sand (mS=2) (95–70%), very sandy mud (vsM=3) (70–30%), sandy mud (sM=4) (30–5%) and mud (M=5) (<5%)

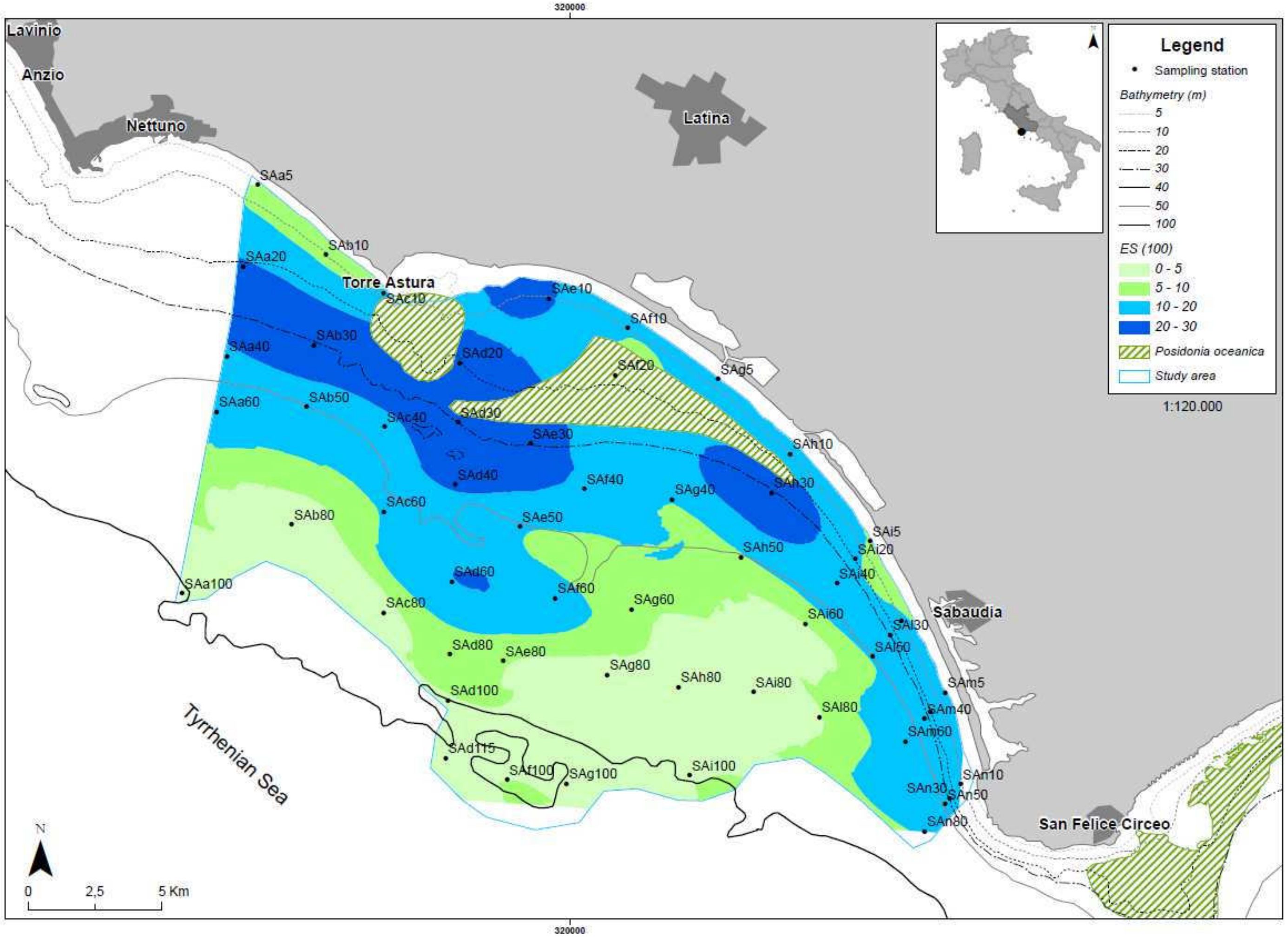


Figure 3.2.3.2 – Prediction map of ES, which estimate the expected number of species in an hypothetical sample of 100 individuals, in the area of Sabaudia.

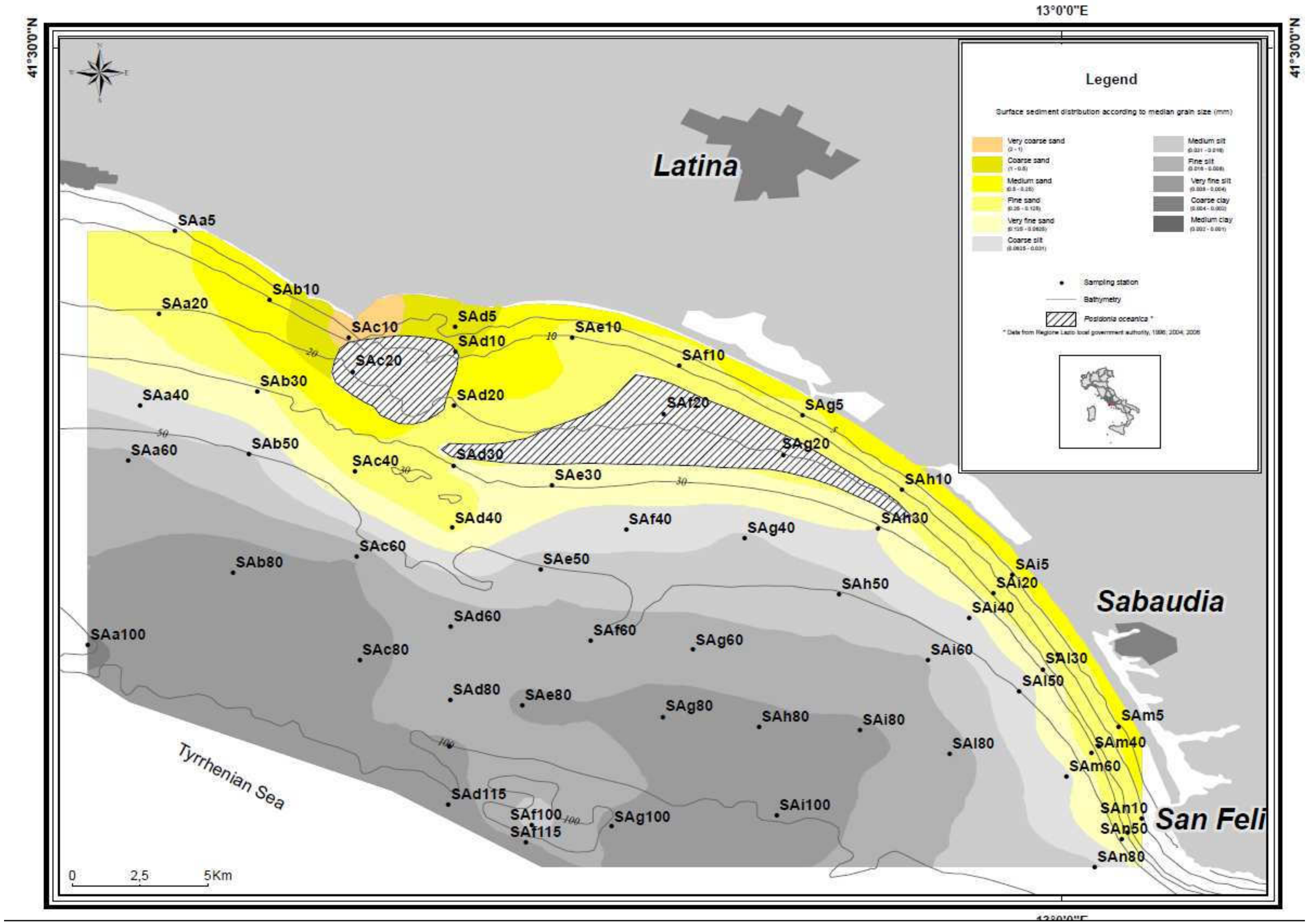


Figure 3.2.3.3 – Prediction map of surface sediments distribution along Sabaudia continental shelf.

3.2.4 TERRACINA

109 species and 15425 individual were identified over a total of 49 of the stations placed in Terraciana (Appendix IV). A wide *Posidonia oceanica* meadows have been signaled also in this area, from about 10 m offshore Cape Circeo to the proximity of Sperlonga village. The lower limits reach about 30 m of depth and follow the bathymetry trend.

The assemblages investigated at 5 m depth was dominated by *Magelona* sp2 (1375), *Prionospio caspersi* (1205), affiliated to the well sorted fine sand biocoenosis*,* *Lumbrineris funchalensis* (320), an hard seabed species that suggest the proximity of rocky shoals, *Owenia fusiformis* (320), *Mediomastus fragilis* (300). *Scoloplos armiger (130), Spio decoratus (95), Sigalion mathildae (50)*. Only some of the mentioned species were found at stations Ten5 and TEp5 where the assemblages were poor in terms of species number and abundance. A similar species composition was observed at 10 m where a reduction of the density of some of these species was observed in opposition with the increase recorded for some others, e.g. *P. caspersi* (620), *Magelona* sp2 (435), *Spio decoratus* (285) e *S. armiger* (255). Between 5 and 10 m depth the polychaete assemblages seemed to be typical of sandy seabed which usually host several species affiliated to well sorted fine sands biocoenoses (e.g. *P. caspersi, O. fusiformis, S. mathildae*). It was interest to signal that in the samples toke in TEb5 e TEf5 and TEg10 e TEm10 stations some species collected, which live in organic detritic sediments, (e.g. *Petta pusilla*, *Leiocapitella dollfusi* and *Miryochele oculata*) were probably related to the presence of *P. oceanica* and *Cymodocea nodosa* found in these zones in accordance with results of previous investigation carried out in this area (Ardizzone and Belluscio, 1996). The assemblages of 20 and 30 m of depth had several species in common with those analysed in the shallower depth (*S. decoratus*, *Aponuphis brementi*, *P. caspersi*) but at 30 m the species characteristic of muddy substrata became more frequent and abundant such as *Lumbrineris latreillii* (125)*,* *Notomastus aberans* (110)*, N. Latericeus* (110)*, Pista cristata* (15)*, Marphysa belli* (15). Exclusively in TEg30 station polychaetes composition was enriched of typical species of hard substrata (*Serpula concharum*, *Pomatoceros lamarckii*, *Hydroides pseudouncinatus, Hesione splendida*); the sediment sampled in this station was mainly composed by red algae. A comparable pattern of species distribution was observed at

40 m of depth where species that preferably live in the fine fractions of the sediment, e.g. *Poecilochaetus serpens* (100), *Paraprionospio* cf *pinnata* (95), *Laonice* cf *cirrata* (50), *Nematonereis unicornis* (105), *Paralacydonia* cf *paradoxa* (320), *N. aberans* (245), *N. latericeus* (115), *Metasychis gotoi* (65), coexisted with species normally found in coarse sediment (from sands to organic detritus) such as *Aponuphys fauveli* (600) (the dominant species), *A. brementi* (170), *Eunice vittata* (135), *M. oculata* (15). *A. fauveli* (230), *A. brementi* (105), *P. serpens* (140), and *P. paradoxa* (70) became the dominant species in TEe50 while the species wide distributed and abundant at 50m of depth were *L. latreillii* (85), *P.* cf *pinnata* (75), *M. gotoi* (55), *P. paradoxa* (75), *P. steenstrupi* (60). At 60 m of depth, as well as at 50 m, seabed was characterised by mixed sediment (from coarse to fine fractions) providing different habitats that can host species strictly associated to mud such as *P. serpens* (125), *Heteromastus filiformis* (95), *N. latericeus* (85), *P.* cf *pinnata* (75), *P. paradoxa* (70), *Sternapsis scutata* (10), species preferring mixed sediments as *A. brementi* (100) and species affiliated to the muddy detritic biocoenoses like *Hyalinoecia tubicola*, *Leiocapitella glabra, M. oculata*. The species composition found between 80 and 100 m was typically associated to muddy fractions; among the most abundant species *Prionospio ehlersi* (115), *P. serpens* (65), *Ampharete acutifrons* (20), *Prionospio steenstrupii* (15), *Heteromastus filiformis* (20).

The highest values of species richness (N_0 and ES) was reached at 40 m. Low values of N_0 and ES were also recorded at 5 and 10 m where e few species occurred with high abundance. In particular at 5 m the highest species abundance (N) was obtained mainly for the dominance of *P. caspersi* and *Magelona* sp2. Comparable mean value of N was observed from 10 to 40 m of depth and decreased below this range. The most diverse assemblages (N_1 and N_2 indices) were found from 30 to 50 m. At 30 m as well as at 10 and 20 m equitability (J') reached the lowest values and at 5 m

a number of dominant species was sampled (N_{inf}: 2,18) except for stations Ten5 and TEp5 (Fig. 3.2.4.1) (Fig. 3.2.4.2). The maximum number of species (N_0) was found in muddy-sand station and the highest abundance (N) in sand; density decreased proportionally to the increase of percentage of mud in the sediment. The assemblages characterized by a highest diversity (N1 and N2) were observed in sediments ranging from muddy-sand to very sandy-mud while the poorest assemblages mainly characterized by a few number of dominant species resulted in sandy stations (N_{inf}: 2,86). In each sediment type individuals were distributed numerically among species equitably (J') (Fig. 3.2.4.1) (Fig. 3.2.4.3).

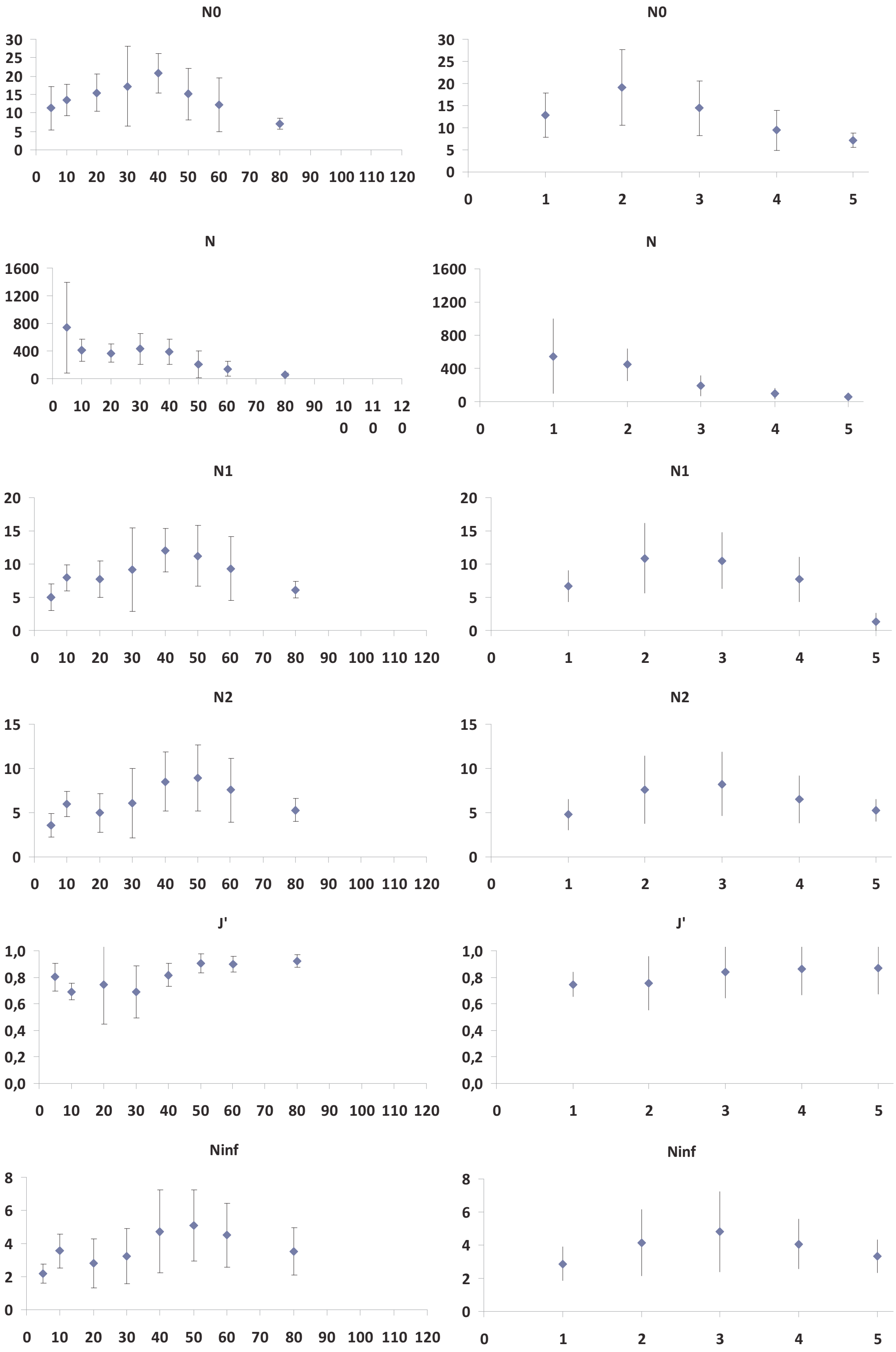


Figure 3.2.4.1 – Polychaete diversity according to depth (on the right) and sediment classes (on the left) along the continental shelf of Terracina: N species density (ind./m^2), J' Pielou evenness;, N0, N1, N2, Ninf Hill diversity number. Sediment classes according to Nota (1958): sand (S=1) (>95% content of sand), muddy sand (mS=2) (95–70%), very sandy mud (vsM=3) (70–30%), sandy mud (sM=4) (30–5%) and mud (M=5) (<5%)

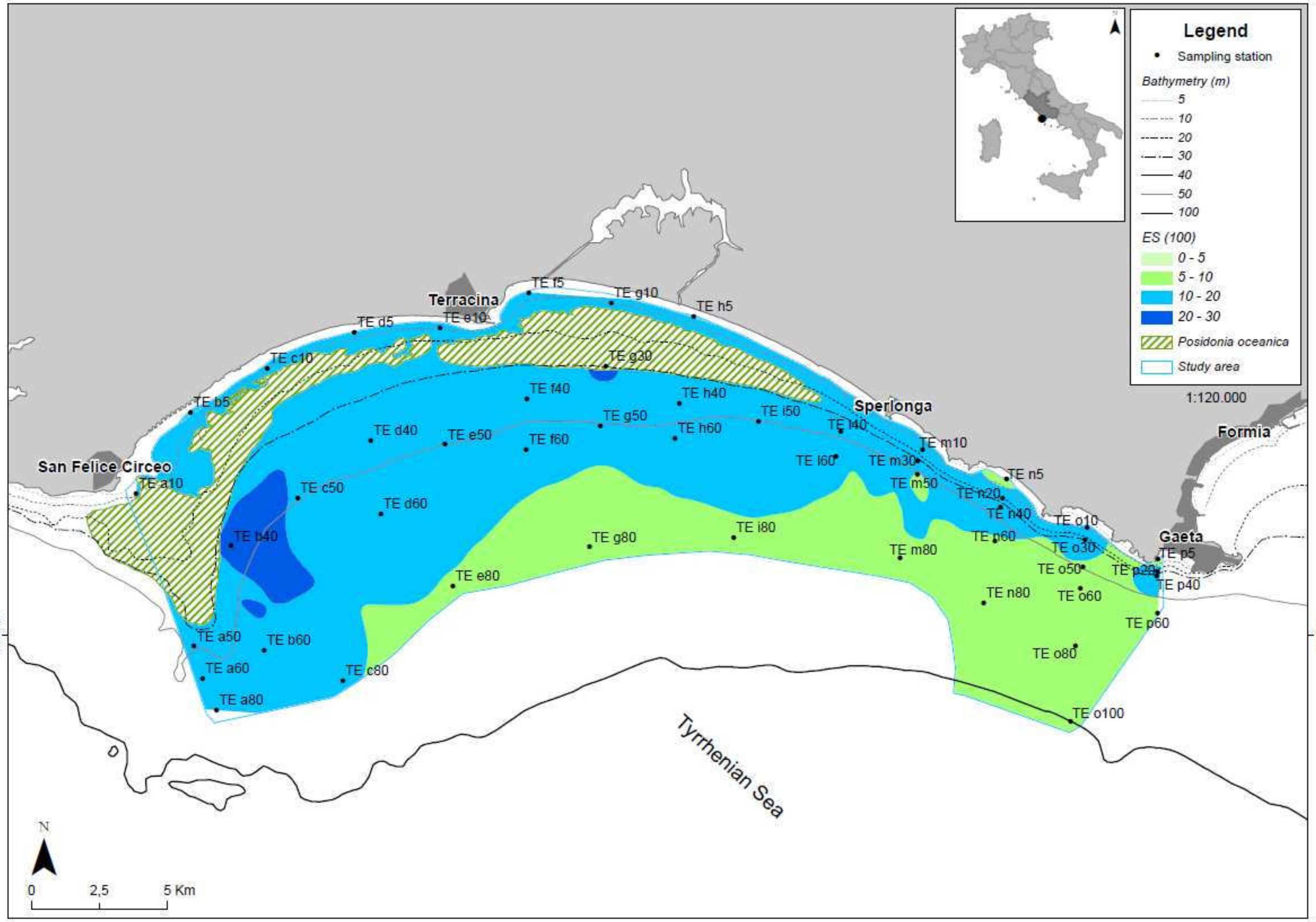


Figure 3.2.4.2 – Prediction map of ES, which estimate the expected number of species in an hypothetical sample of 100 individuals, in the area of Terracina.

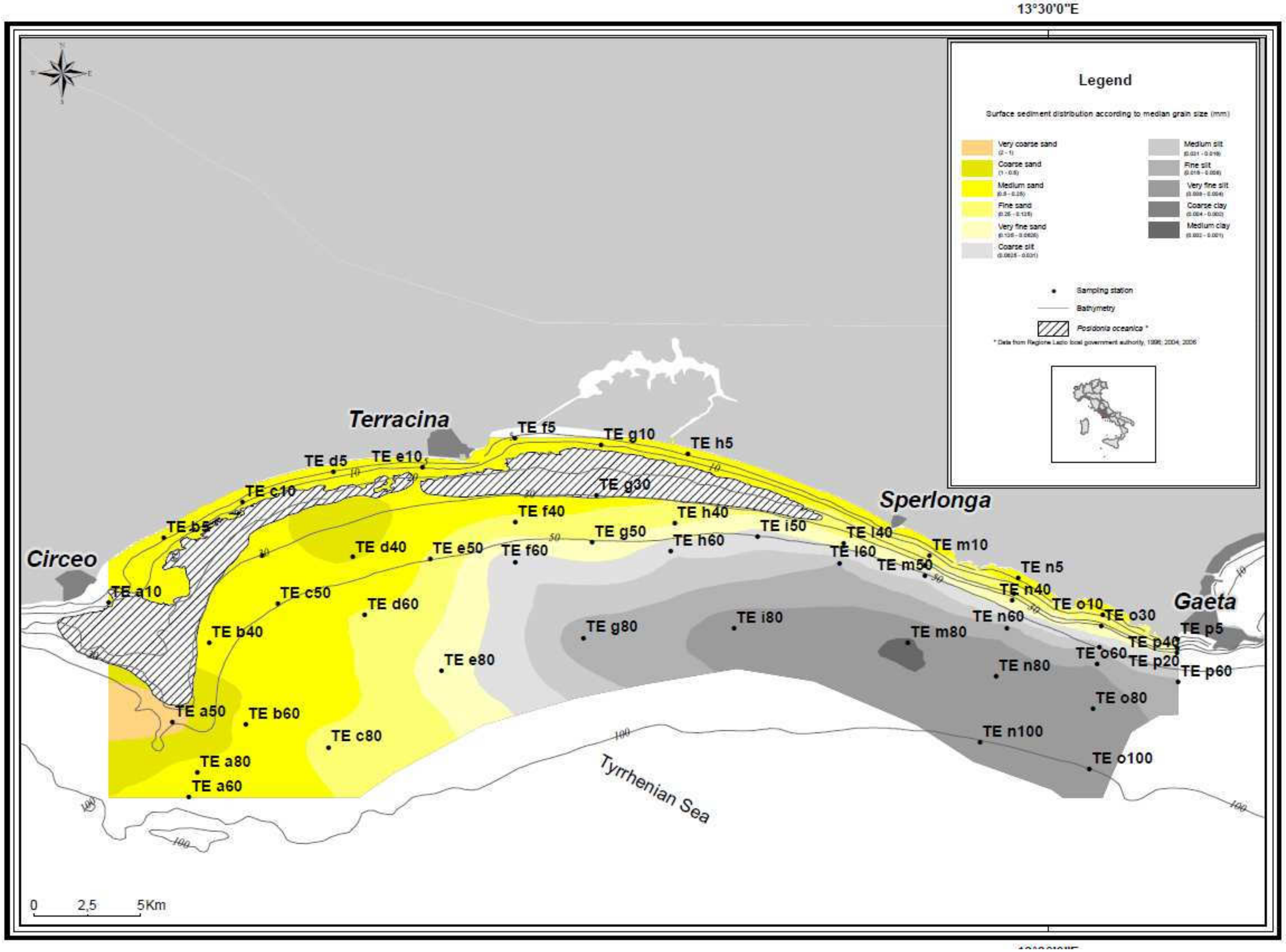


Figure 3.2.4.3 – Prediction map of surface sediments distribution along Terracina continental shelf.

3.2.5 GAETA

In 27 stations placed at Gaeta area 3465 individuals belonging to 49 species were collected (Appendix V).

At 20 m of depth the assemblages were composed by species normally found in coarse sediments (sand and organic detritus) as *Aponuphis bilineata* (95), *Nephtys hombergii* (220), *Owenia fusiformis* (10) as well species of muddy sediments *Notomastus aberans* (210), *Lumbrineris latreilli* (205), *Melinna palmata* (100). At 30 m the species composition was almost exclusively characteristic of muddy substrata as indicated by the high abundance of muddy species as *L. latreilli* (170), *Sternaspis scutata* (150), *Notomastus aberans* (120), *Laonice* cf *cirrata* (50). This pattern of species distribution was also observed at 40 m of depth. From 50 m of depth to the deeper zones were sampled exclusively species that prefer sediments with high percentage of mud and enriched of organic matter e.g. *Glycera unicornis* (35-25), *Heteromastus filiformis* (20-15), *Nephytys hystricis* (15-5), *Terebellides stroemi* (10-15), *N. aberans* (5-10), *Scoletoma emandibulata-mabiti* (55-15), *S. scutata* (25-5), *Aphelochaeta marioni* (20-5).

The highest species richness values (N_0 and ES) were reached between 20 and 30 m as well as for the species abundance (N). As a consequence, the assemblages with the highest species diversity (N_1 and N_2) were those analysed at this depths range. Pielou index (J') describe high equitability among the species occurring at the assemblages of 20, 40, and 60 m and minor values were, instead, recorded at 30, 50 and 70 m of depth. Nevertheless, no dominant species were individuated in all the investigated bathymetries as explained by N_{inf} index (Fig 3.2.5.1) (Fig 3.2.5.2). The richest assemblages in terms of number of species (N_0) were found in very-sandy mud sediments while the highest densities of individuals (N) was observed in muddy-sand sediments. Not great differences among species diversities were pointed out among the different sediment types (both for N1 and N2 index) as well as was recorded for the equitability and dominance indices (Fig 3.2.5.1) (Fig 3.2.5.3).

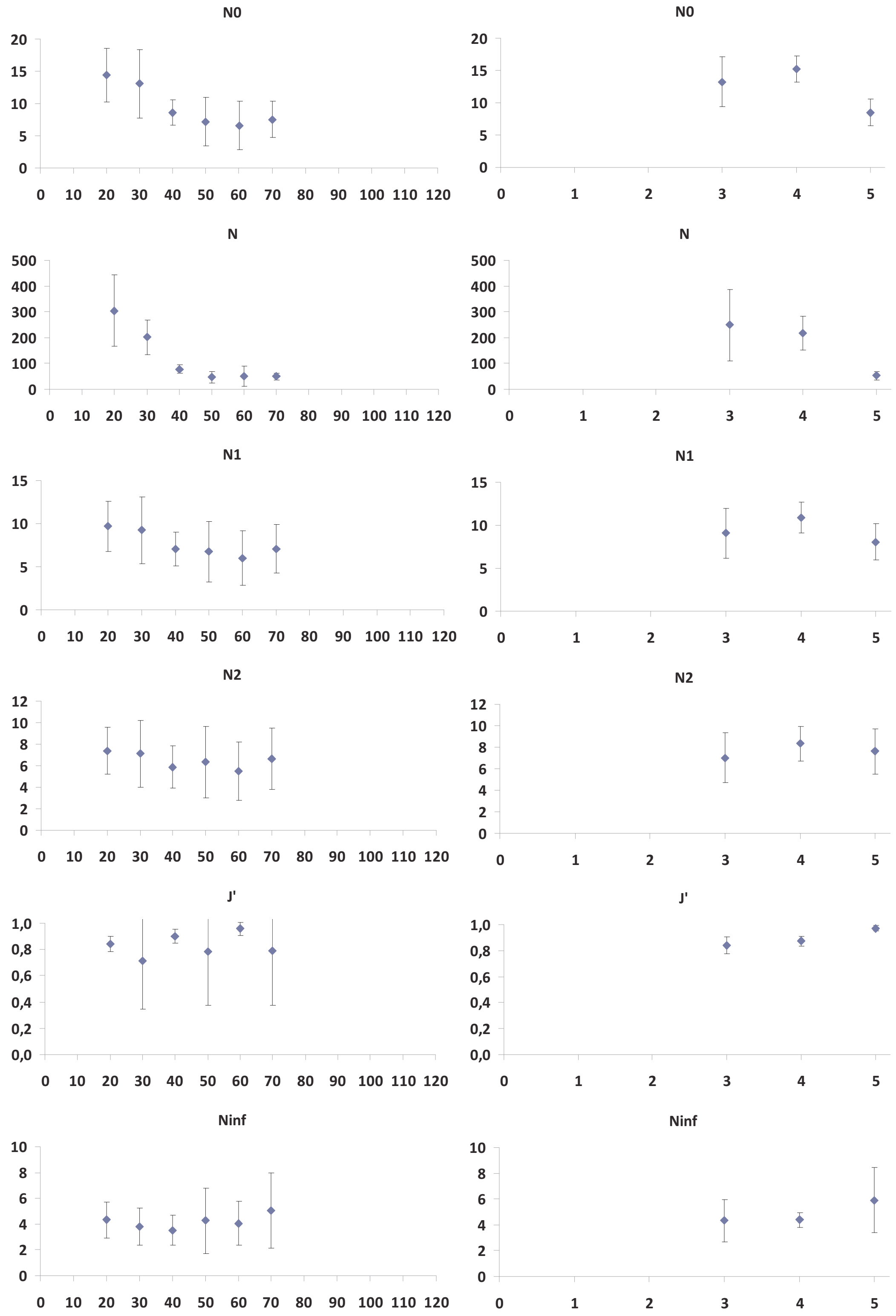


Figure 3.2.5.1 – Polychaete diversity according to depth (on the right) and sediment classes (on the left) along the continental shelf of Gaeta: N species density (ind./m^2), J' Pielou evenness;, N0, N1, N2, Ninf Hill diversity number. Sediment classes according to Nota (1958): sand (S=1) (>95% content of sand), muddy sand (mS=2) (95–70%), very sandy mud (vsM=3) (70–30%), sandy mud (sM=4) (30–5%) and mud (M=5) (<5%).

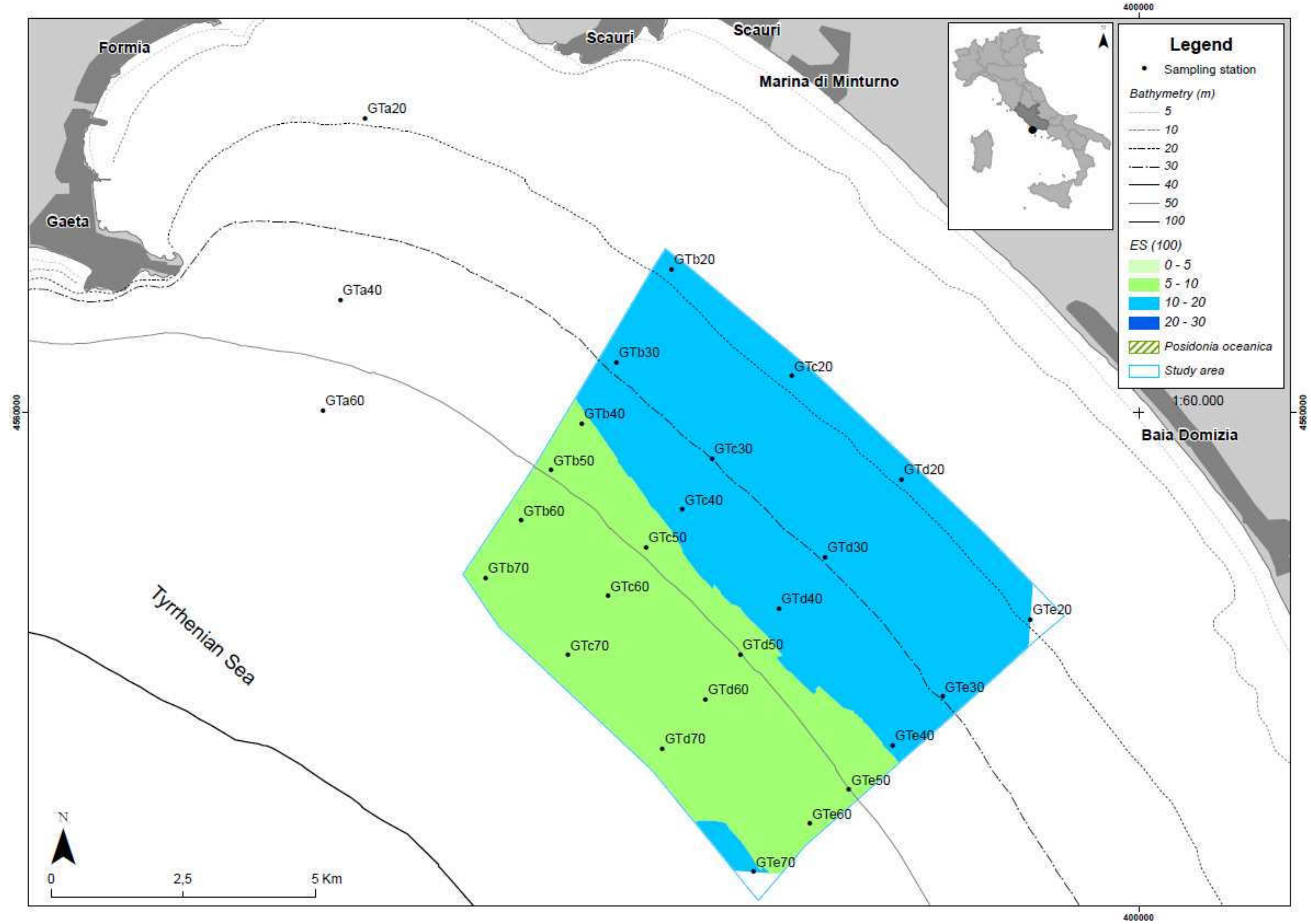


Figure 3.2.5.2 – Prediction map of ES, which estimate the expected number of species in an hypothetical sample of 100 individuals, in the area of Gaeta.

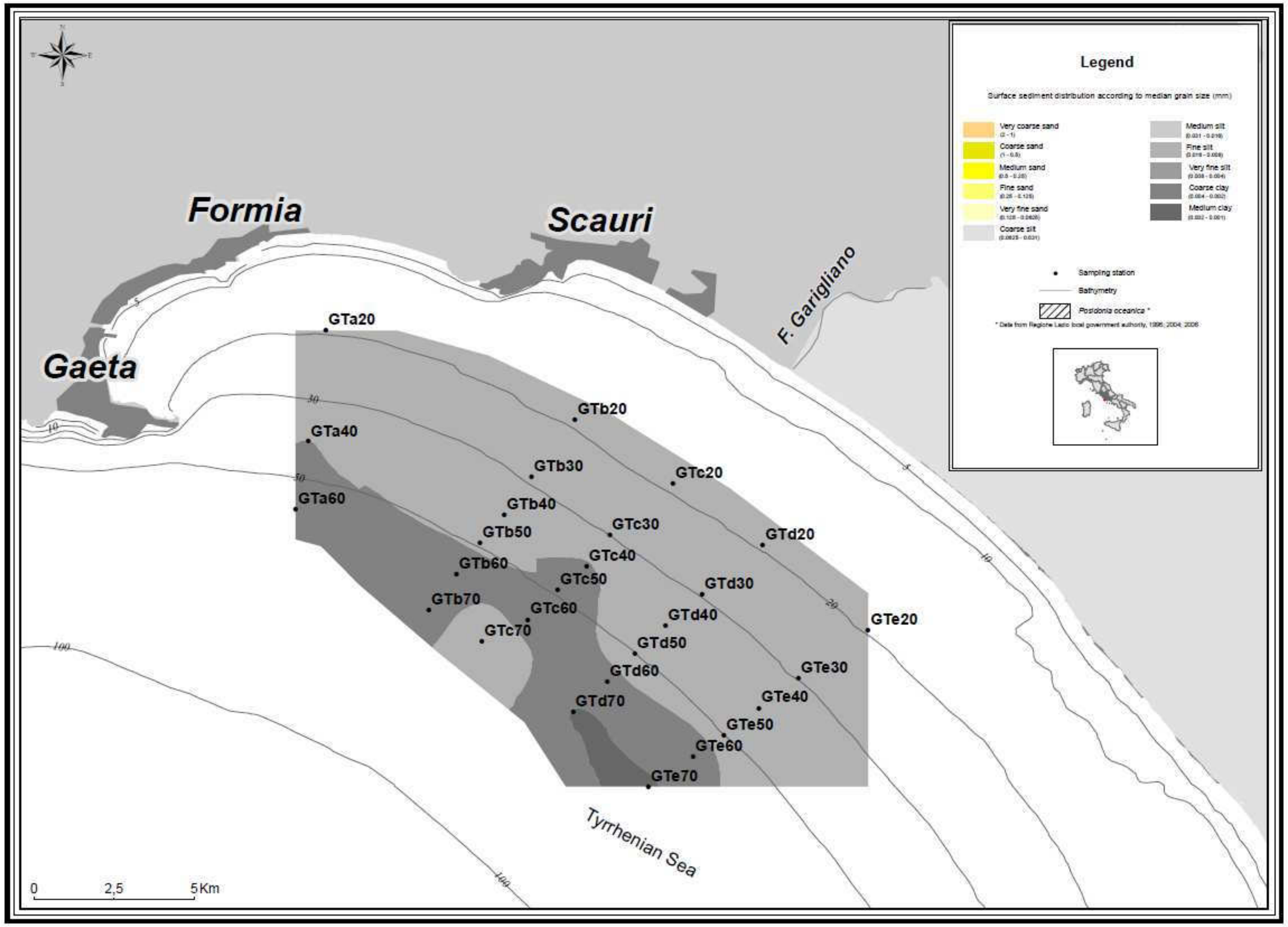


Figure 3.2.5.3 – Prediction map of surface sediments distribution along Gaeta continental shelf.

3.3 Statistical analysis

Polychaete assemblages: multivariate analyses

Multivariate analyses were performed to investigate distribution patterns of polychaete assemblages found in the five macro-areas. The nMDS ordination of polychaete data, concerning abundance of species, identifies patterns of distribution mainly related to the depth gradient (Fig. 3.3.1). Nevertheless differences in species distribution was also observed among the individual investigated areas (Fig. 3.3.2).

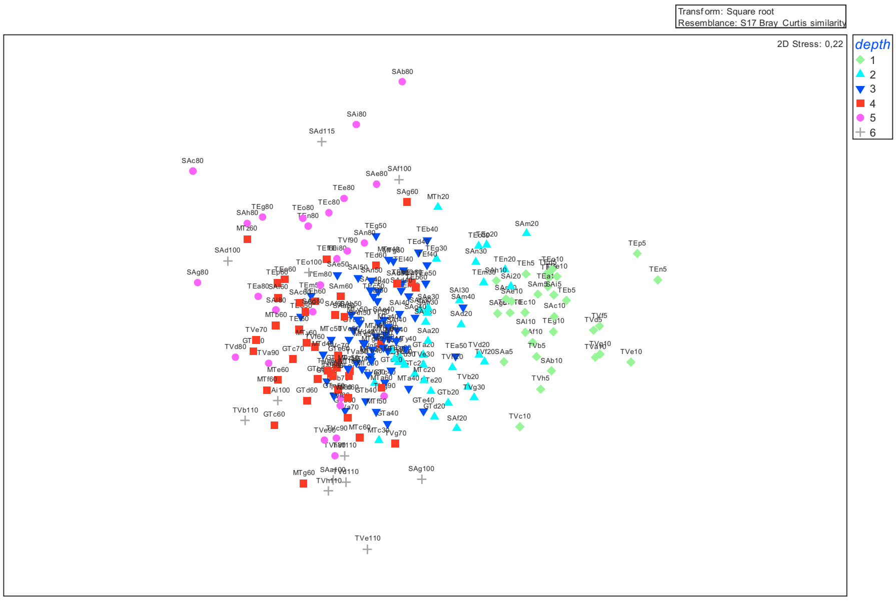


Figure 3.3.1 – nMDS ordination plot of polychaetes assemblages according to depth range: 1=5-10 m, 2=20-30 m, 3=40-50 m, 4=60-70 m, 5=80-90 m and 6=100-115. m of depth.

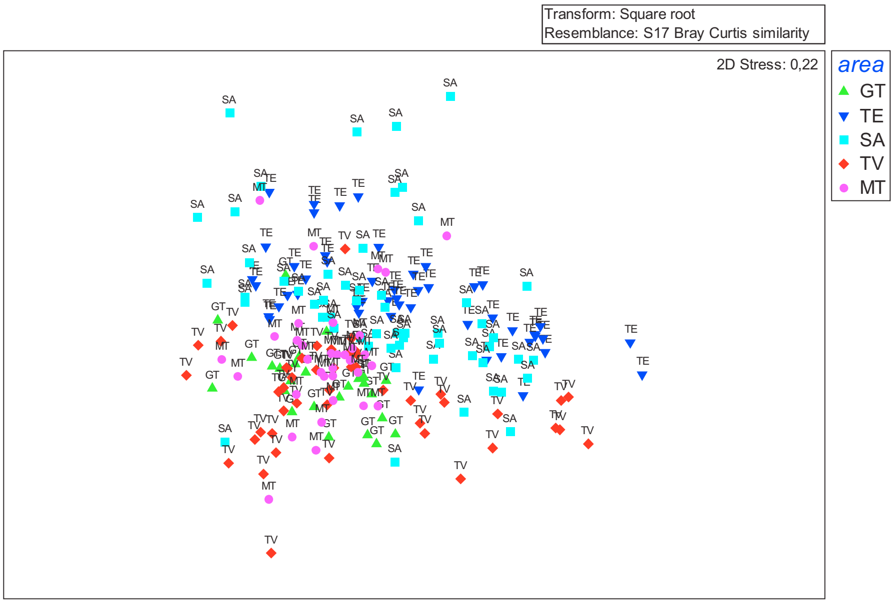


Figure 3.3.2 – nMDS ordination plot of polychaetes assemblages according to areas: MT, TV, SA, TE and GT.

PERMANOVA analysis performed on presence/absence (based on Jaccard similarity) and species abundance (Bray Cutis similarity) data proved that differences among assemblages distributions were significantly relate to the factor depth ranges, areas and to the relationships between these two factors (depthXarea) (Appendix VI). In detail, the test performed within each areas for depth ranges showed significantly differences between assemblages sampled at 40-50 m and at 60 m of depth at Montalto di Castro while at Torvaianica, assemblages found at all depth ranges differed to each others. Polychaete communities inhabiting Sabaudia seafloors from 40 m of depth to the deeper zones showed comparable characteristics as well as at Terracina, where similarities were mainly described among the assemblages collected in the deeper circalittoral zones (from 60 to 115 m) even if resemblances were also found between the deeper and the upper (40-50 m) circalittoral communities; the absence of differences between polychaete structure described at 20-30 and 90-115 m was probably due to the small number of species found in both ranges. At Gaeta the species structure resulted different all along the depth gradient. The analysis of polychaetes distribution patterns within depth ranges among the five areas highlights that the assemblages structure found at 5-10 m of depth was different among the areas of Torvaianica, Sabaudia and Terracina. A comparable result was obtained for the depth range of 20-30 m even if the assemblage of Montalto di Castro seem to be similar to those found at the same bathymetry at Torvaianica and Gaeta. With the increase of depth the similarities were found exclusively between assemblages occurred at Sabaudia and Terracina from 60 to 70 m and among those found at Torvaianica, Sabaudia and Terracina, between 110 and 115 m.

The nMDS plots on the basis of Jaccard measure and PERMDISP analysis show pattern of differences in assemblages composition (presence/absence) among the five areas (Fig. 3.3.3) (Fig. 3.3.4) (Appendix VII). The quite large spread of sample points correspond to the area of Sabaudia while the quite thin cluster of points correspond to Gaeta compared with the other areas (Appendix VII). The test for homogeneity reveals differences among the areas in terms of their variability in species composition except between Terracina *vs* Sabaudia and Torvaianica and Montalto *vs* Gaeta. The average Jaccard distance-to-centroid is about 54% for Gaeta (the lower percentage) and larger for Terracina (about 62%) and Sabaudia (about 63%) (Appendix VII). The pattern of heterogeneity of these last two areas was mirrored by similar pattern of variability in the environmental characteristics (e.g heterogeneity of sediment texture, presence of wide *Posidonia oceanica* meadows). PERMDISP analysis performed to measure diversity variability along the depth gradient shows common patterns of species composition between the infralittoral zones (from 5 to 30 m) and upper circalittoral zone (40-50 m), and among different levels of circalittoral zone. The lower average distance-to-centroid was estimated for upper infralittoral zone (5-10 m) (about 53%) while the larger for circalittoral zone ranging from 80 to 90 (about 63%) and 100-115 m (about 62%) of depth (Appendix VII).

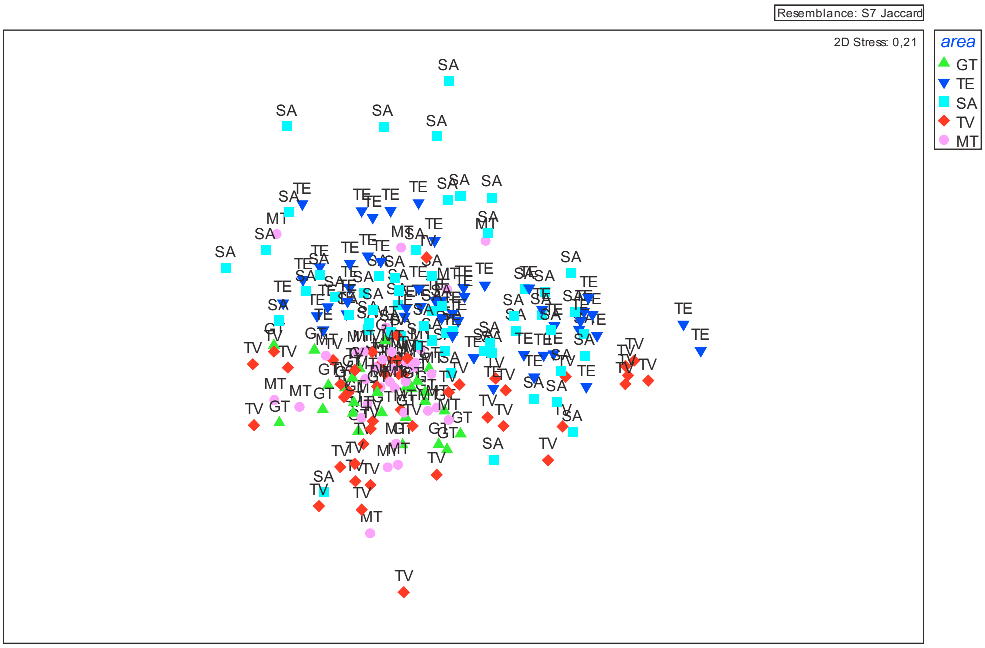


Figure 3.3.3 – nMDS ordination plot of polychaetes assemblages according to areas: MT, TV, SA, TE and GT.

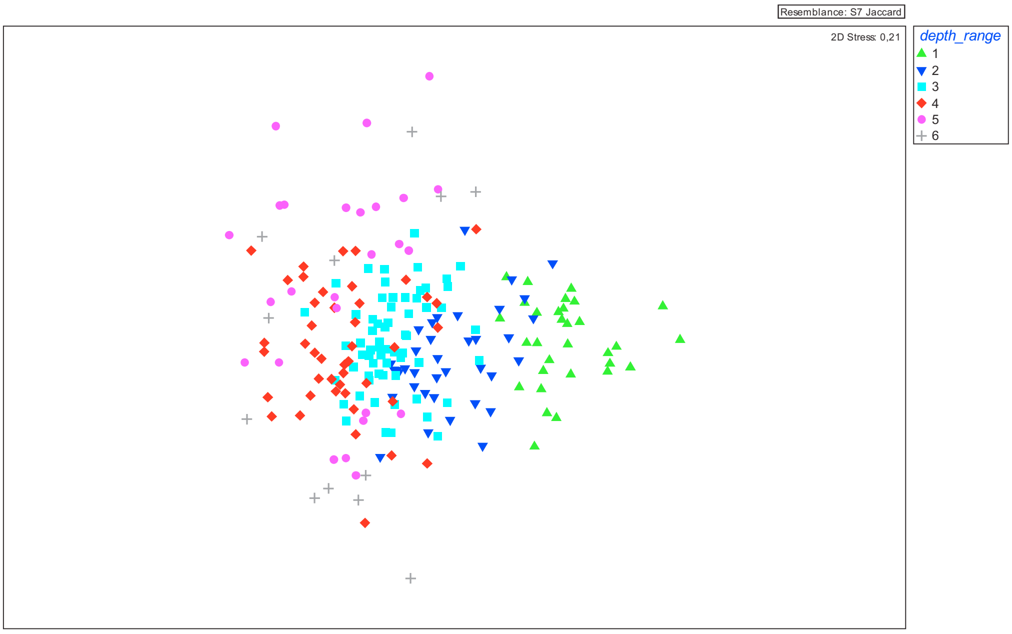


Figure 3.3.4 – nMDS ordination plot of polychaetes assemblages according to depth range: 1=5-10 m, 2=20-30 m, 3=40-50 m, 4=60-70 m, 5=80-90 m and 6=100-115. m of depth.

Results analyzed pointed out how biodiversity of Latium continental shelf varied with depth and latitude but the nMDS ordination, concerning species composition and polychaetes abundance identifies patterns of distribution also related to sediment texture (Fig. 3.3.5). It is evident the overlapping of polychaete assemblages ordination according to depth ranges and sediment classes regardless of areas (Fig. 3.3.1 and 3.3.5).

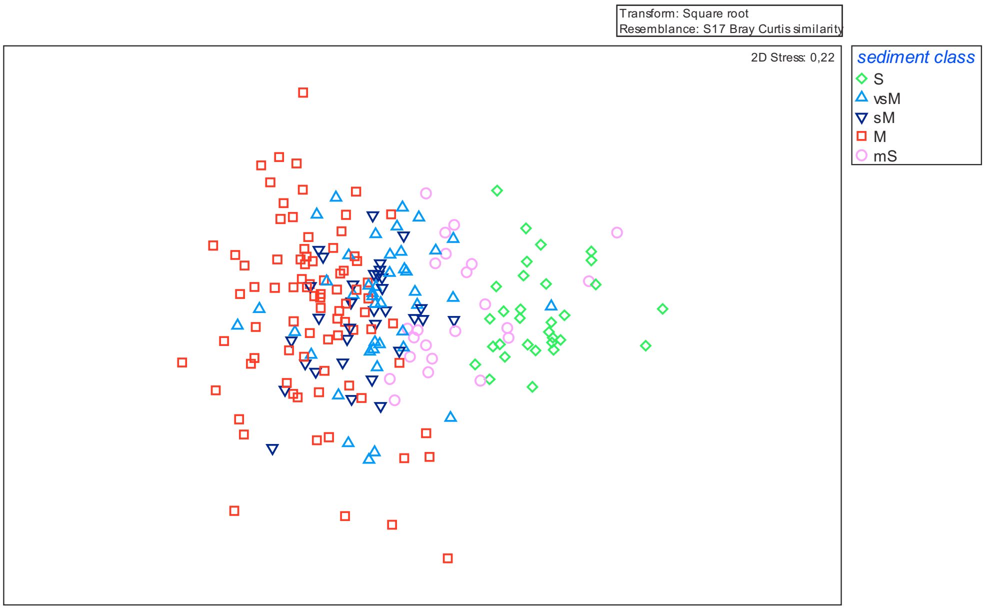


Figure 3.3.5 – nMDS ordination plot of polychaetes assemblages according to sediment classes (Nota, 1958): sand (S=1) (>95% content of sand), muddy sand (mS=2) (95–70%), very sandy mud (vsM=3) (70–30%), sandy mud (sM=4) (30–5%) and mud (M=5) (<5%)

To evaluate which gradients in environmental variables (latitude, longitude, depth and median grain size) mainly draw the assemblages and species distribution Canonical Correspondence Analysis (CCA) has been performed. Triplot based on CCA (Fig. 3.3.6; 3.3.7) displays about 83.94 % of the total variance in the first two axes. The eigenvalues of axis 1 (horizontally) and axis 2 (vertically) are 0.53 and 0.22, respectively; the eigenvalue of the axis 3 (not displayed) is 0.14. Among the four variable analyzed (quantitative environmental variables are indicated by arrows) depth gradient, positively correlated with axis 1, is considered to be the main abiotic factor conditioning the polychaetes assemblages distribution (Tab. 3.3.1). Patterns in faunal differentiation along the depth gradient also respond to median grain size of sediments which displays a low negative correlation with axis 1 (Tab. 3.3.1). Along axis 2, positively correlated with latitude and negatively with longitude, geographical distribution patterns of some species can be identified.

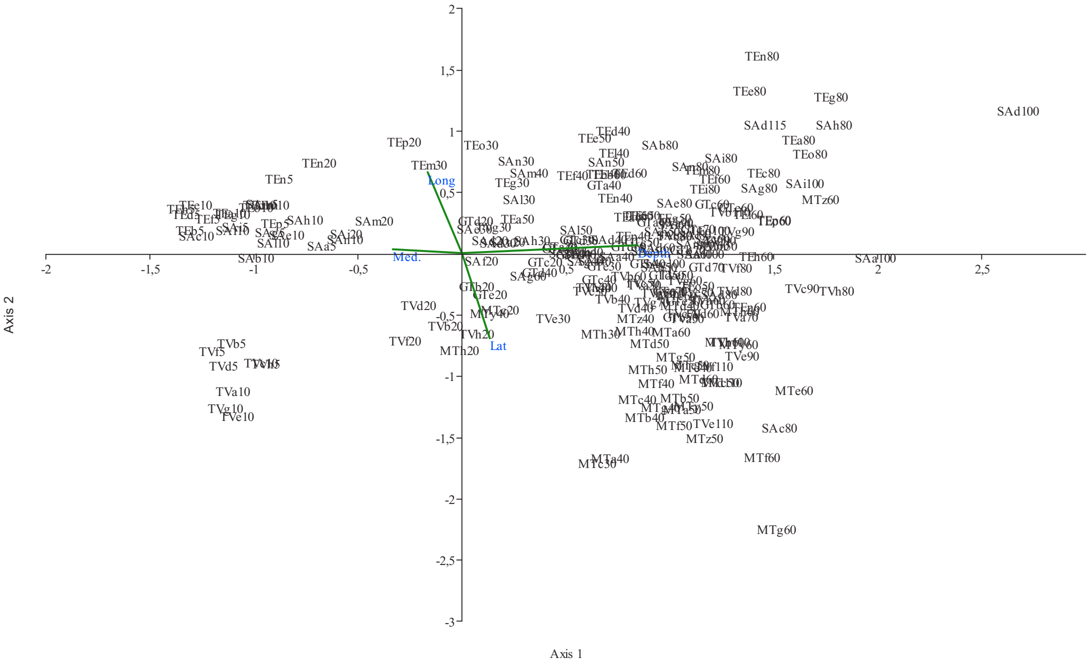


Figure 3.3.6 – CCA ordination plot of polychaetes assemblages found in each sampling station (station points). Green arrows represents the four environmental factors (latitude, longitude, depth and median grain size).

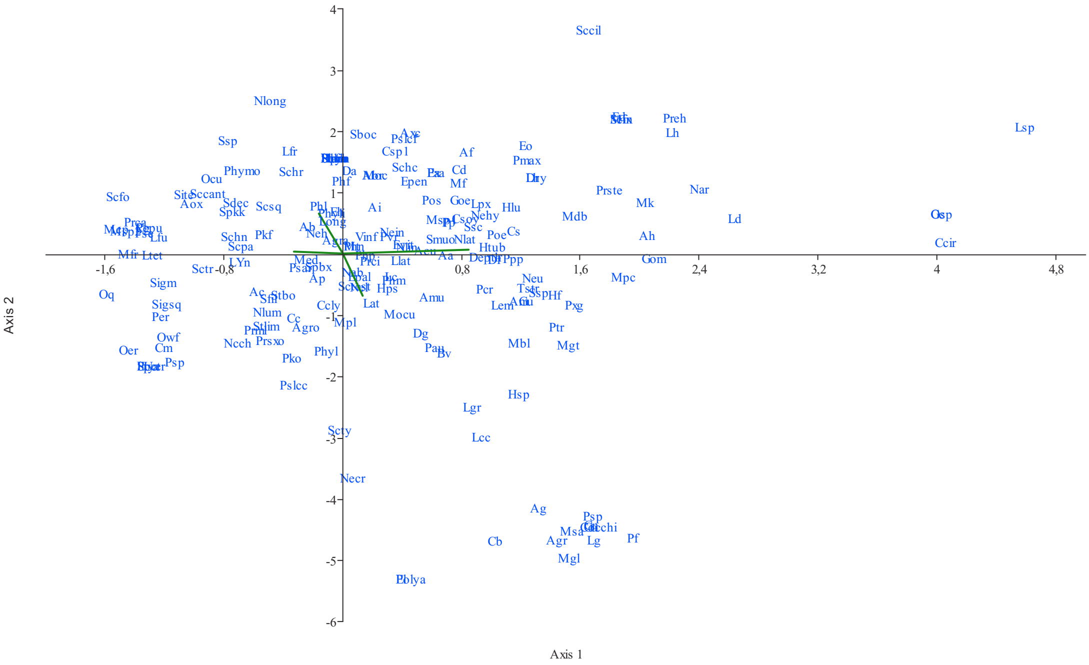


Figure 3.3.7 – CCA ordination plot of polychaetes species collected (species points). Green arrows represents the four environmental factors (latitude, longitude, depth and median grain size).

Table 3.3.1 – Correlations between environmental variables and site scores from CCA analysis

Correlations between env. variables and site scores			
	Envi. Axis 1	Envi. Axis 2	Envi. Axis 3
Depth	0,845	-0,088	-0,002
Med.	-0,333	-0,038	0,661
Lat	0,134	0,704	0,182
Long	-0,161	-0,670	-0,180

In details, assemblages sampled at 5 and 10 m of depth on sandy substrata (on the left in the plot) are separated into two groups highlighting main differences between the species composition found in Torvaianica and those found in Sabaudia and Terracina (Fig. 3.3.6). With the increase in depth and the decrease in median grain size similarities concerning the species compositions found at 20-30 m are confirmed among the areas of Montalto, Torvaianica and Gaeta; below this depth range the interaction between depth and sediment texture determined the complex variability of assemblages distribution. The analysis of species orientation in the CCA plot revealed a geographical distribution of some polychaetes, e.g. *Onuphis eremita*, *Owenia fusiformis*, *Nothria conchylega* mainly found in the upper infralittoral zone of Torvaianica, *Mediomastus fragilis*, *Prionospio caspersi*, *Magelona* sp2, *Mediomastus capensis*, *Sigalion squamata* more frequent in the lower infralittoral of Sabaudia and Terracina, *Maldane sarsi*, *Caulleriella caputesocis*, *Paraonis fulgens* mostly found at Montalto di Castro (Fig. 3.3.7).

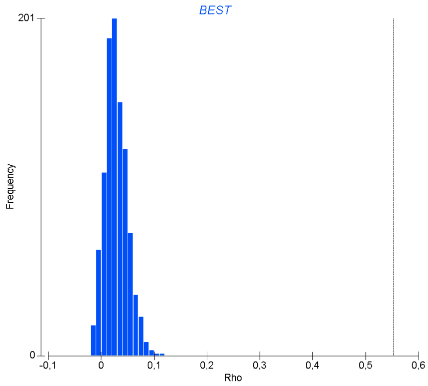
The Pairwise Spearman rank correlation between environmental variables and diversity indices was estimated for all data. Statistically significant correlations were mainly found among species richness, number of individuals, equitability index (N_0, ES, N and J') and depth and median grain size (Tab. 3.3.2).

Table 3.3.2 –Pairwise Spearman rank correlations between enviromental variables and biotic diversity for the whole study area. In bold are for statistically significant correlations.

	S	**ES100**	**N**	**J'**	**N1**	**Ninf**	**Depth**	**Med.**	**Lat**	**Long**
S										
ES100	0,98778									
N	0,8726	0,81225								
J'	-0,52523	-0,44921	-0,80069							
N1	0,86573	0,91419	0,57959	-0,11206						
Ninf	0,37465	0,44522	0,064207	0,44643	0,71815					
Depth	**-0,47959**	**-0,42723**	**-0,70032**	**0,69691**	-0,23319	0,10413				
Med.	**0,46202**	**0,41355**	**0,6504**	**-0,65908**	0,19848	-0,13721	-0,72882			
Lat	0,13831	0,15257	0,086461	0,027403	0,17239	0,086804	-0,082839	-0,029802		
Long	-0,063401	-0,089209	0,034802	-0,14373	-0,13565	-0,098812	-0,11065	0,12171	-0,9597	

All environmental variable were used in the BIO-ENV analysis; the resulting maximum Spearmen correlations (r_s) were found for depth and median grain size (Tab. 3.3.3) pointing out that these two variable were the abiotic factors better explain the species patterns of composition and distribution of the investigated areas.

Table 3.3.3 –Relationships between environmental variables and polychaetes data using BIOENV analysis. Two main variables (depth and median grai size) (in bold) best explain the faunal patterns. Resulting values are weighted by Spearman rank correlation coefficient (r_s).



	Variables	**r_s**	**Corr.Slection**
Variables	1	***0,553***	1
	2	***0,525***	1;2
1 Depth	2	0,362	1;4
2 Med.	3	0,349	1;2;4
3 Lat	2	0,341	1;3
4 Long	3	0,332	1-3
	1	0,321	2
	3	0,265	1;3;4
	4	0,258	All
	2	0,093	2;3

Spatial diversity prediction maps

Prediction maps of some community indices (ES, N and J'), realized by means geostatistic interpolator Universal Kriging, simplified the spatial distribution of polychaetes diversity along Latium continental shelf (Fig. 3.3.8; 3.3.9; 3.3.10). Diversity maps successfully identified the main patterns and tendencies of polychaete assemblages in detail, in accordance with the above results.

The trend observed along the depth gradient show low values of polychaete species richness (ES) and diversity (N1) in the upper infralittoral zone of . At this depth range diversity (N1) was low as well as equitability (J) due to the presence of a few number of dominant species. A wide area from 10-20 m to the upper circalittoral zone (and occasionally deeper bathymetries) was characterized by high species richness (ES) and diversity (N1) with a general increase in evenness (J'). Maps clearly pointed out zones with elevated richness and diversity in proximity of *Posidonia oceanica* meadows and shoals. In the deeper circalittoral zones a decrease in species richness and diversity, accompanied by an increase in evenness was observed. In some restricted areas of Torvaianica and Sabaudia, low values of equitability were mainly due to the relative dominance of a few species which occurred in the poor assemblages found.

On the whole all patterns of diversity distribution mirrored the environmental characteristics of each area (e.g. trend of bathymetry, sediment features, presence of *P. oceanica* beds and shoals) but can be also identified a latitudinal continuum of patterns.

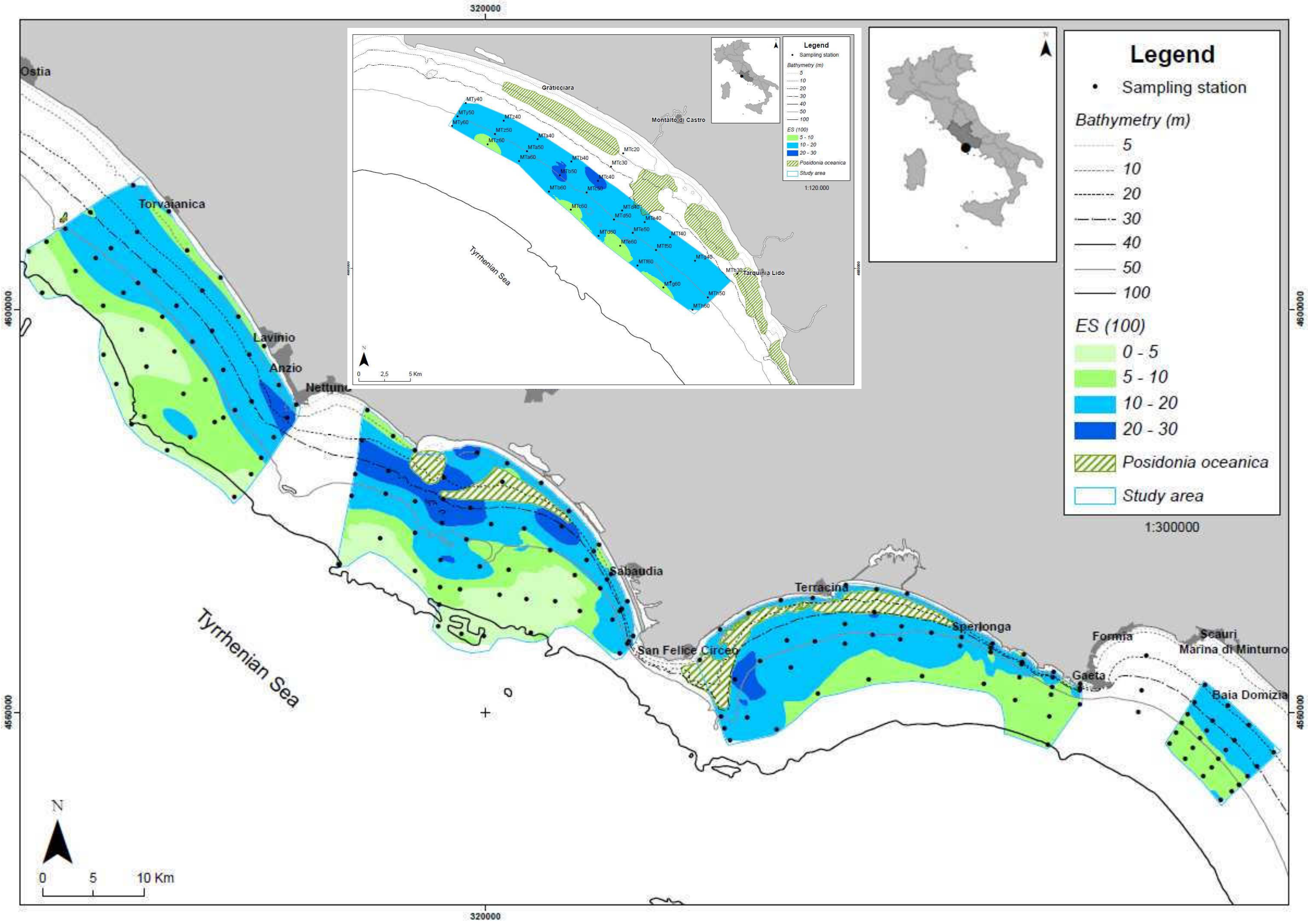


Figure 3.3.8 – Prediction map of species richness (ES100) in the five study areas: MT (in the smallest picture), TV, SA, TE and GT.

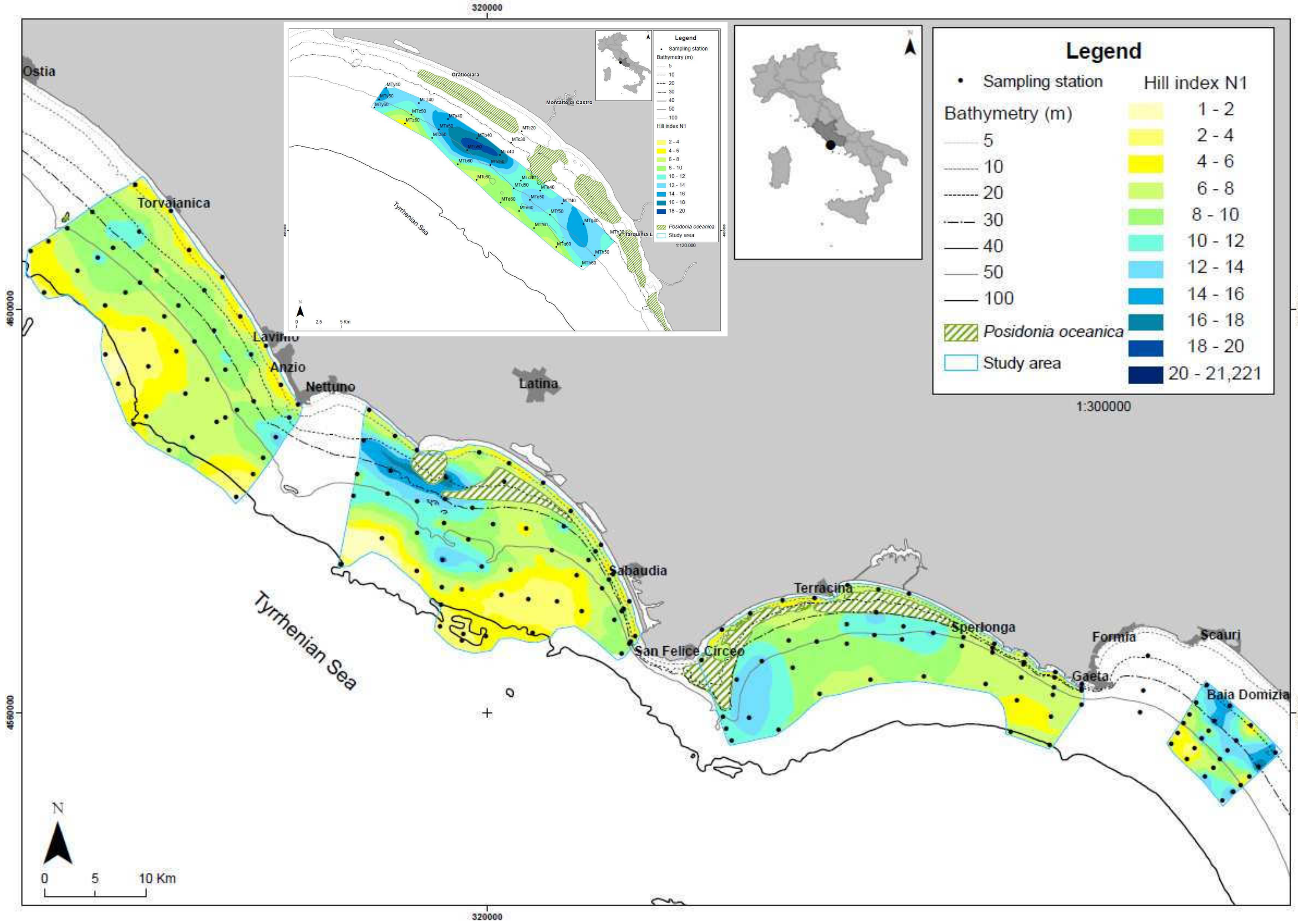


Figure 3.3.9 – Prediction map of diversity (N1) in the five study areas: MT (in the smallest picture), TV, SA, TE and GT.

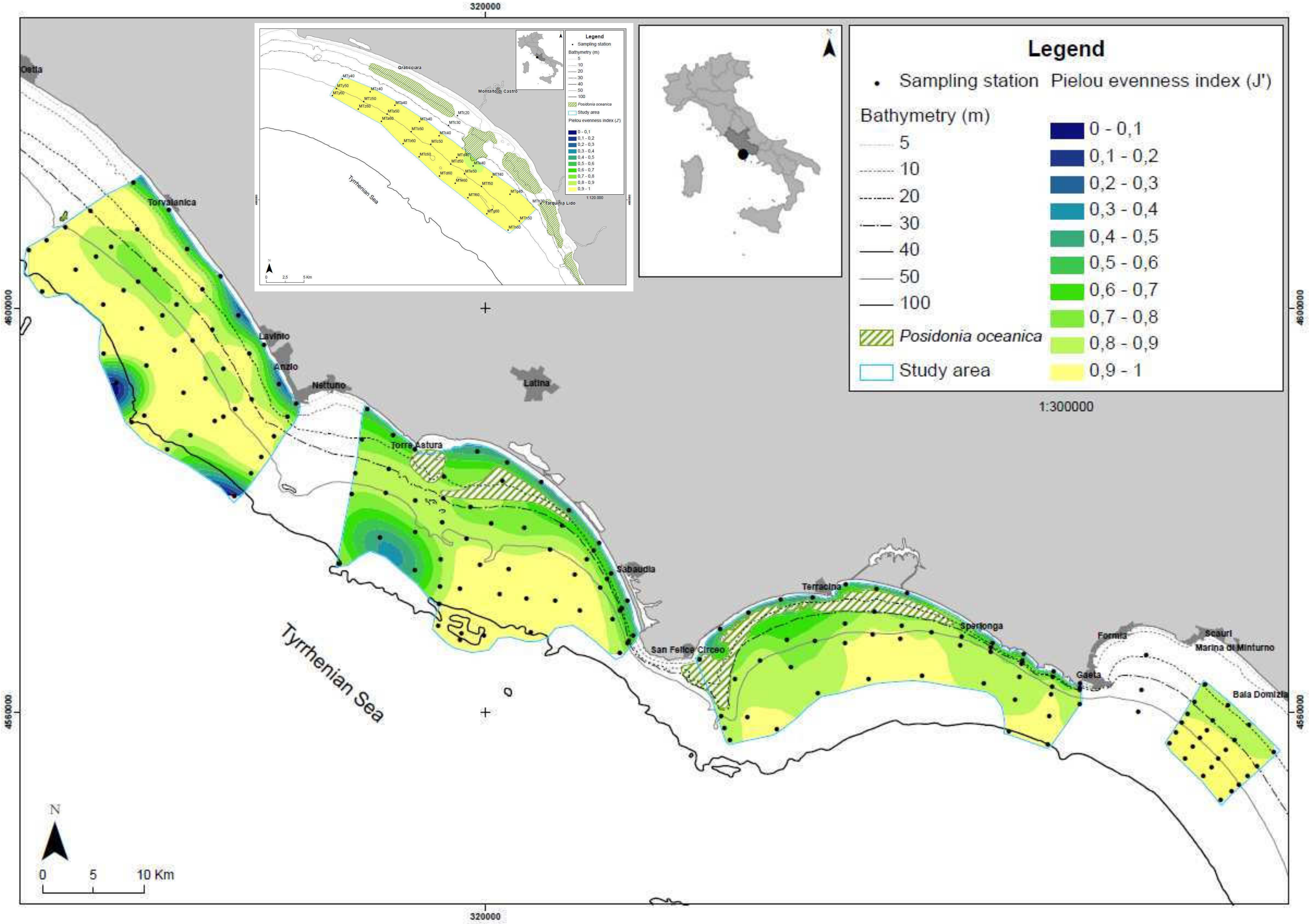


Figure 3.3.10 – Prediction map of Pielou evenness (J') in the five study areas: MT (in the smallest picture), TV, SA, TE and GT.

3.4 Species Ecological analysis

Results highlight that the polychaete assemblages structure and their distribution patterns along the Latium continental shelf mainly responded to two environmental factors, depth gradient and sediment texture, as well as the spatial variability was also influenced by latitude and longitude.

In order to identify the species associated with or indicative of groups of stations, five groups derived from Nota classification of sediments and six from depth ranges classification, Indicator Species Analysis (ISA) has been performed. Results demonstrate that some species distribution depends on definite granulometric characteristics of the sediment as well as definite depth ranges and the indicator values of ISA statistic specify the groups of stations that are associated with the species with different levels of significance (Appendix VIII)

74 polychaetes have statistically significant associations whit definite granulometric characteristics while 58 with depth ranges selected. Exclusively 34 species display an association both with sediment and depth range. The greatest number of the species found seem not to be strongly associated to specific environmental variables. In detail, 104 species seem not to have strong relationships with definite sediment texture and 120 with depth ranges.

In Figures 3.4.1-17 the distribution patterns of some species according to results obtained in this study were illustrated; it is interesting to pointed out the consistency between results of ISA analyses and the prediction distribution maps of some species.

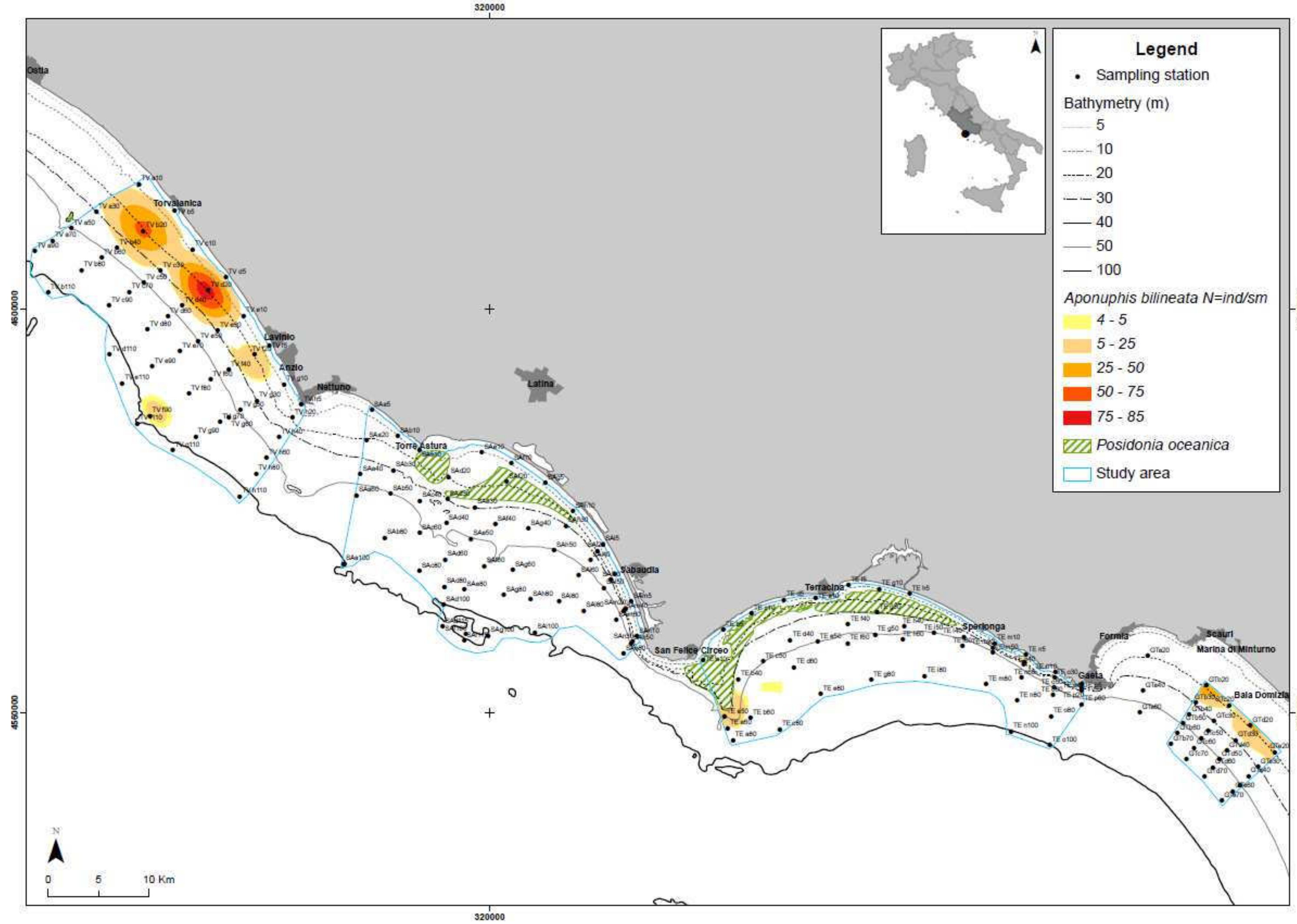


Figure 3.4.1 – Prediction map of *Aponuphis bilineata* distribution along the five study areas: TV, SA, TE and GT.

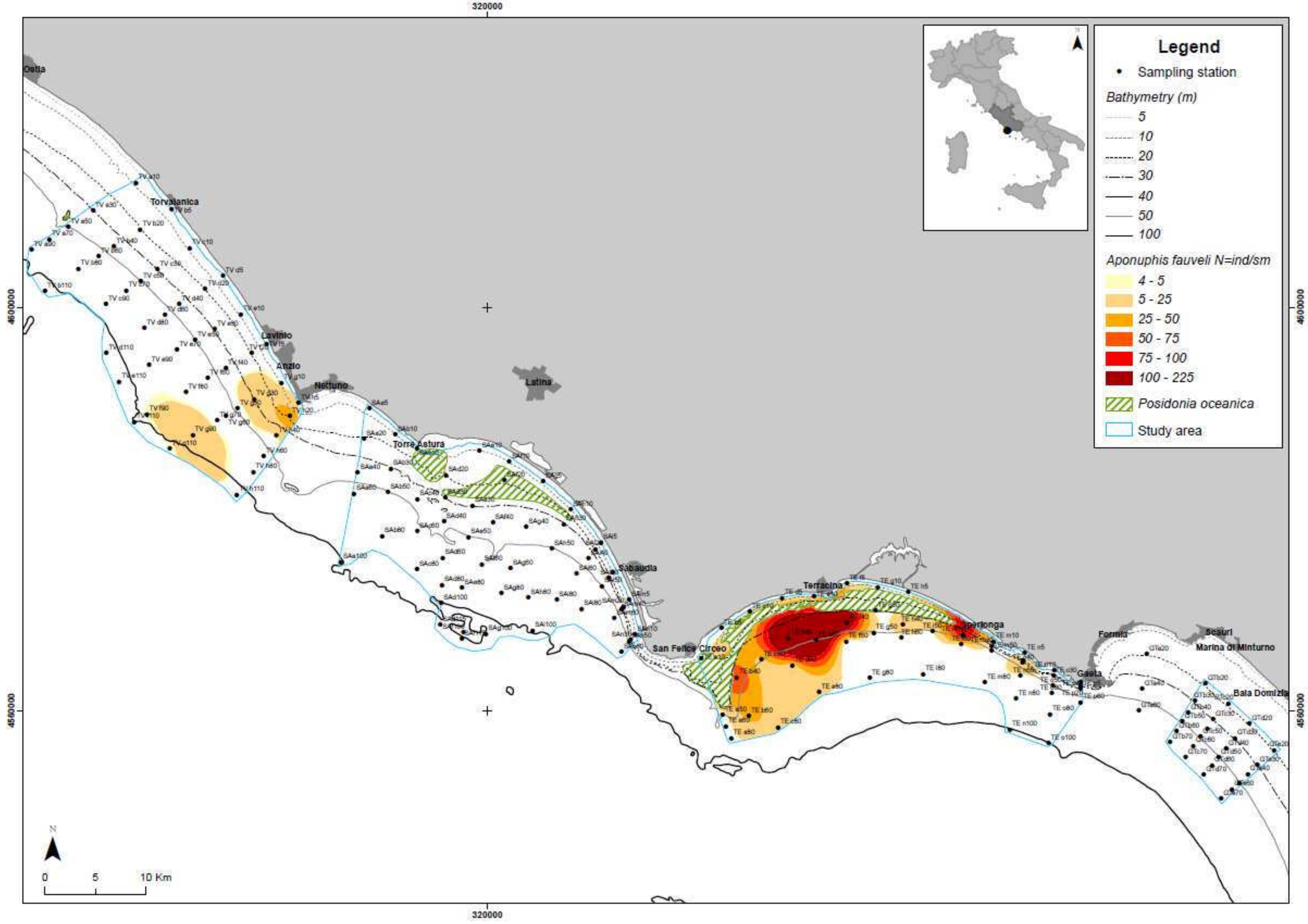


Figure 3.4.2 – Prediction map of *Aponuphis fauveli* distribution along the five study areas: TV, SA, TE and GT.

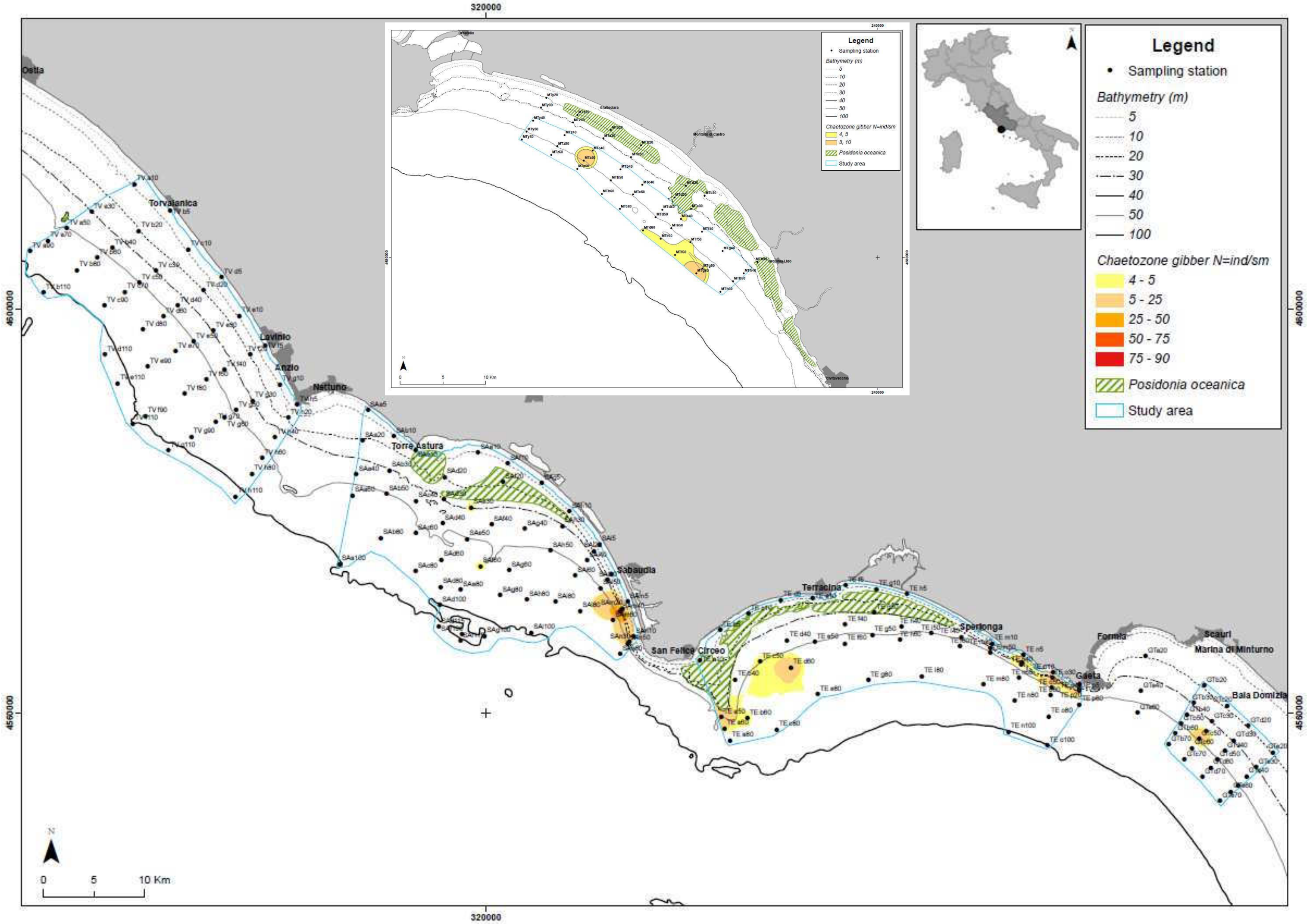


Figure 3.4.3 – Prediction map of *Chaetozone gibber* distribution along the five study areas: MT (in the smallest picture), TV, SA, TE and GT.

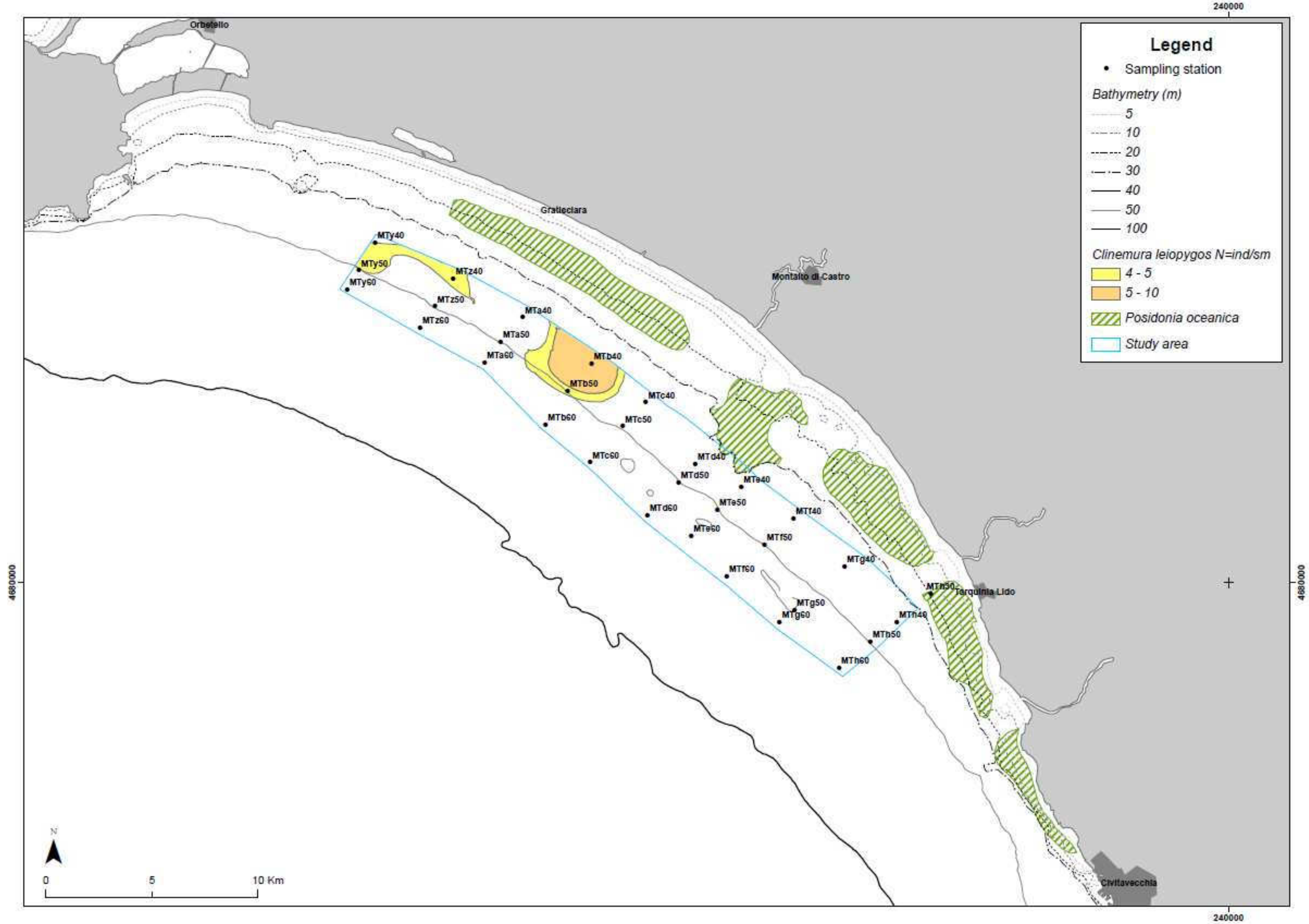


Figure 3.4.4 – Prediction map of *Clymenura leiopygos* distribution along the five study area MT.

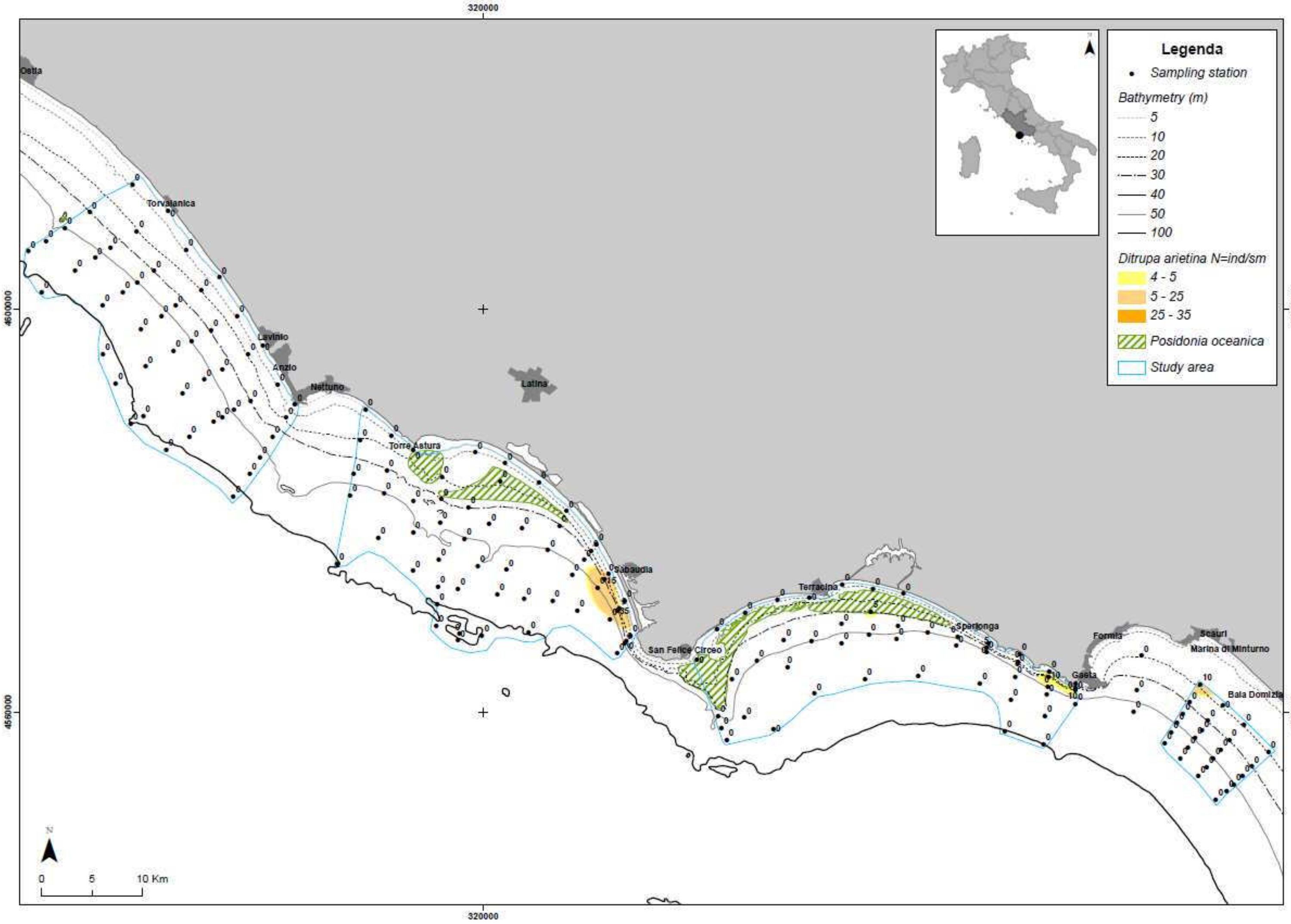


Figure 3.4.5 – Prediction map of *Ditrupa arietina* distribution along the five study areas: TV, SA, TE and GT.

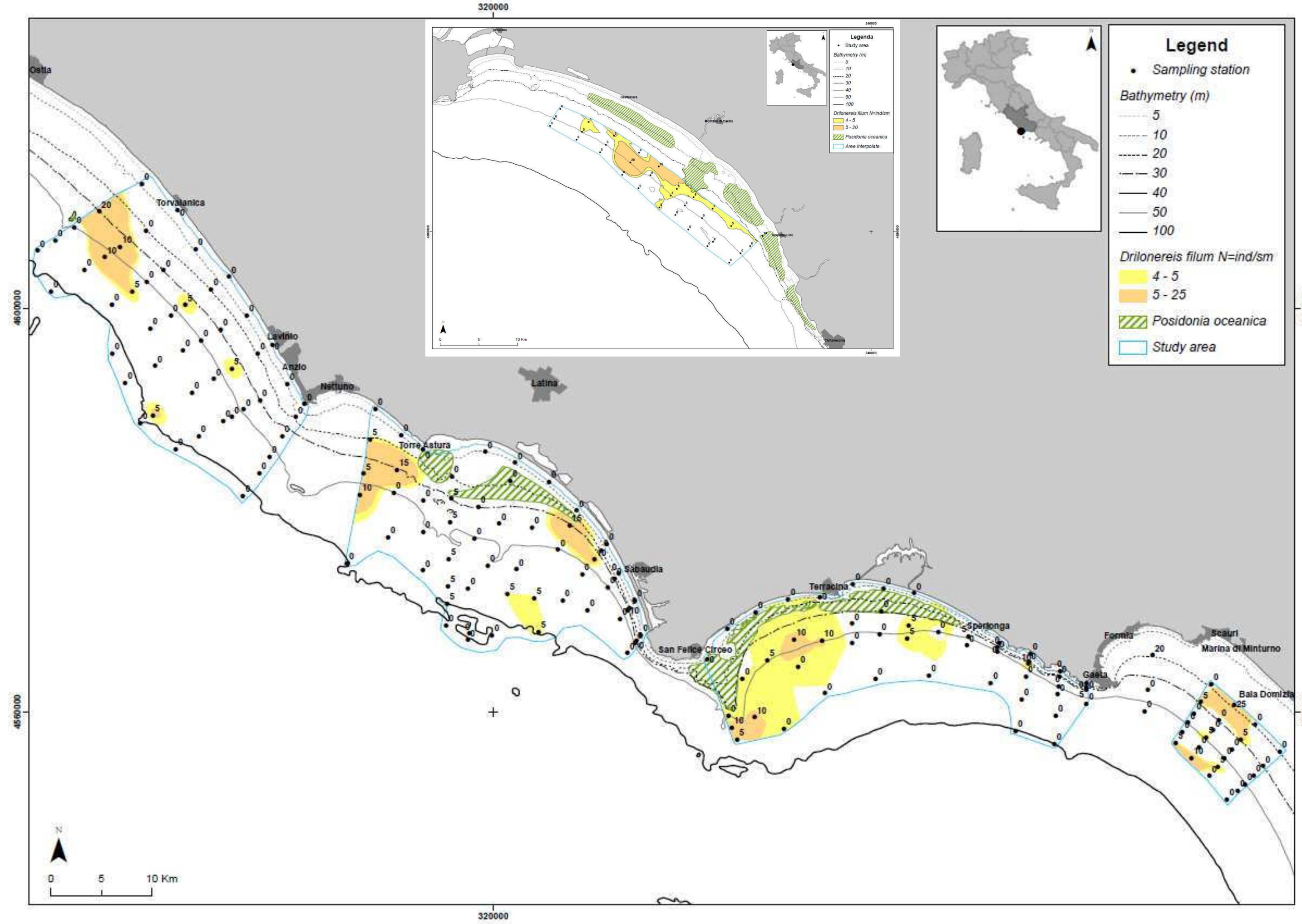


Figure 3.4.6 – Prediction map of *Drilonereis filum* distribution along the five study areas: MT (in the smallest picture), TV, SA, TE and GT.

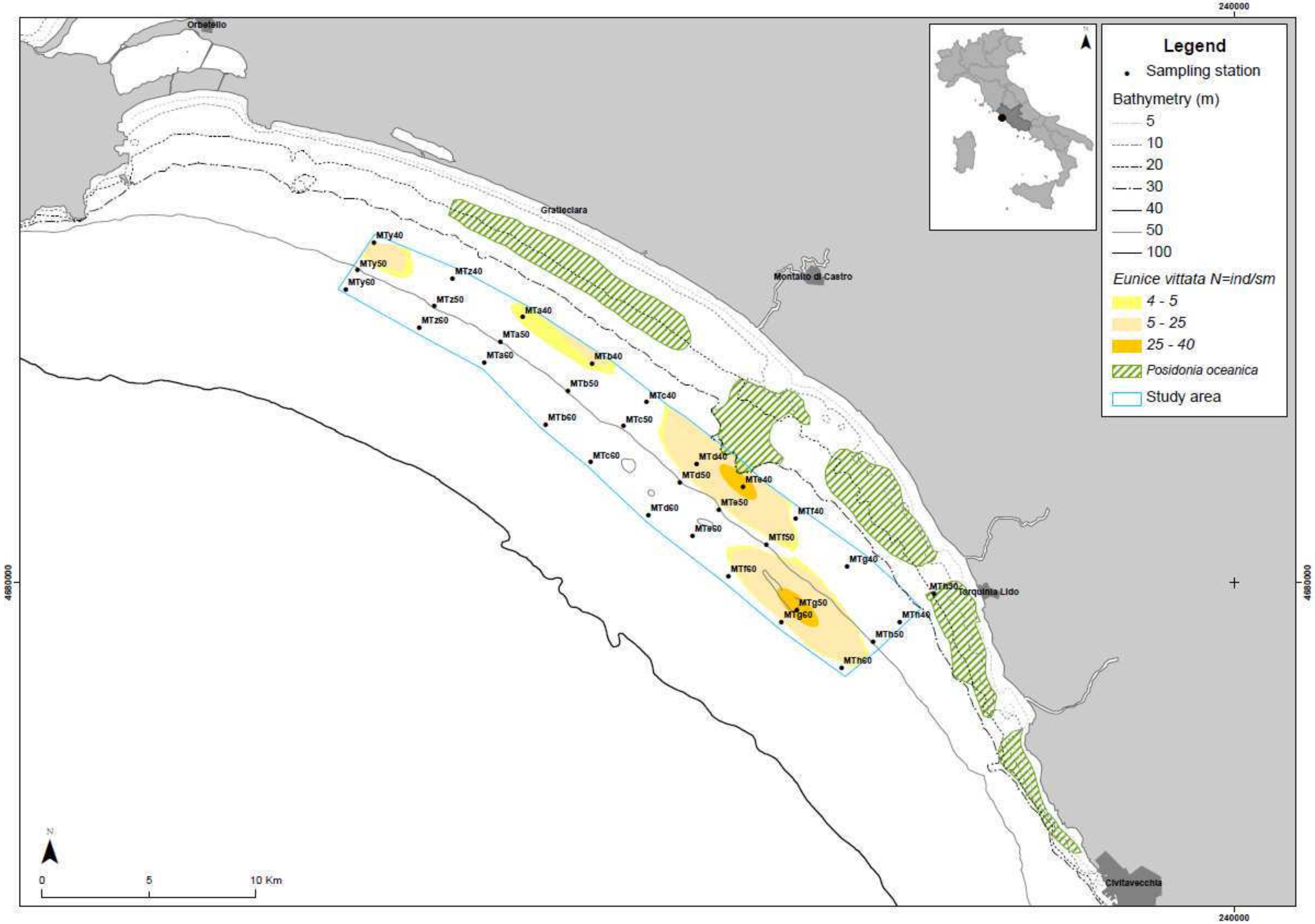


Figure 3.4.7 – Prediction map of *Eunice vittata* distribution along the five study area MT.

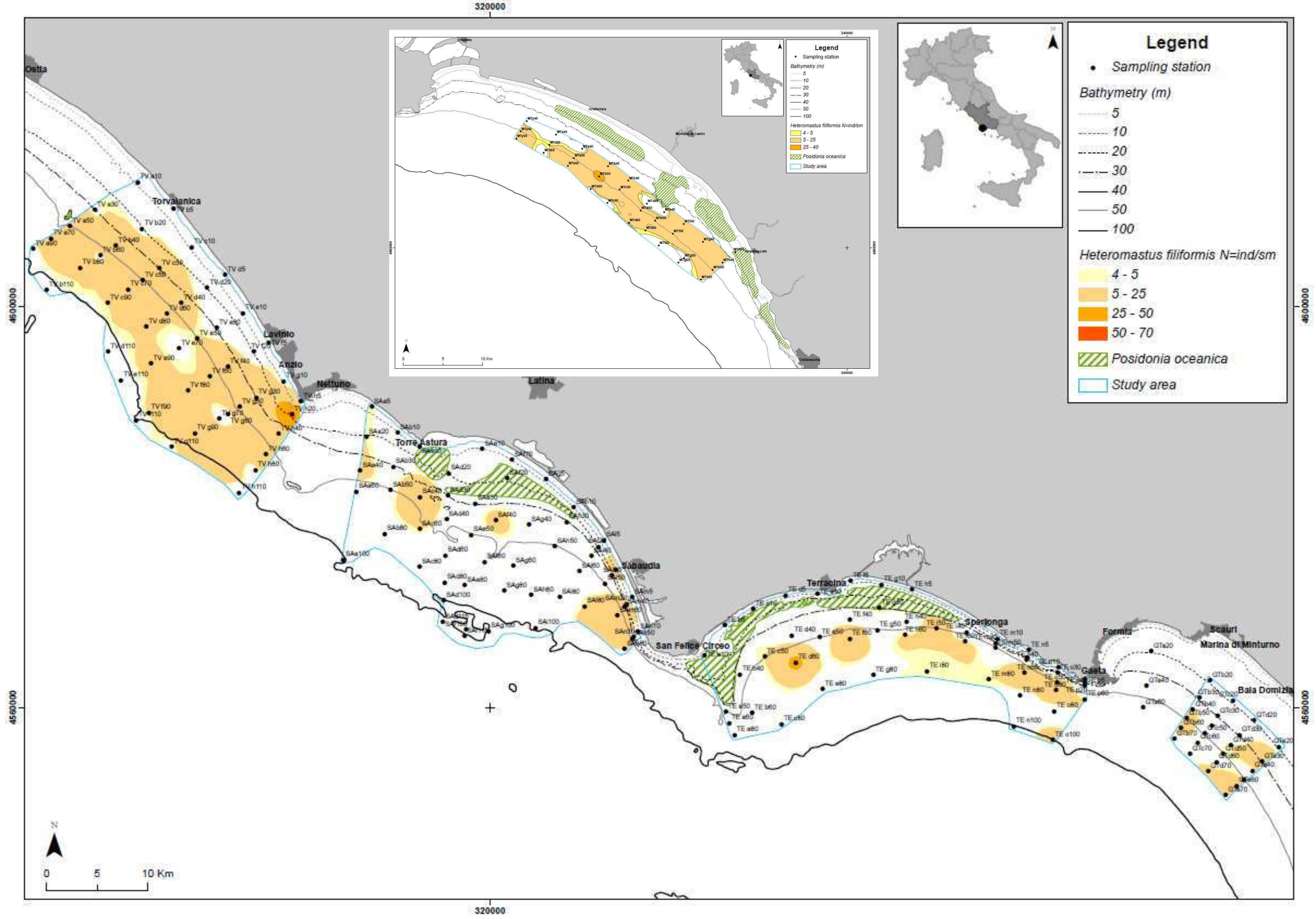


Figure 3.4.8 – Prediction map of *Heteromastus filiformis* distribution along the five study areas: MT (in the smallest picture), TV, SA, TE and GT.

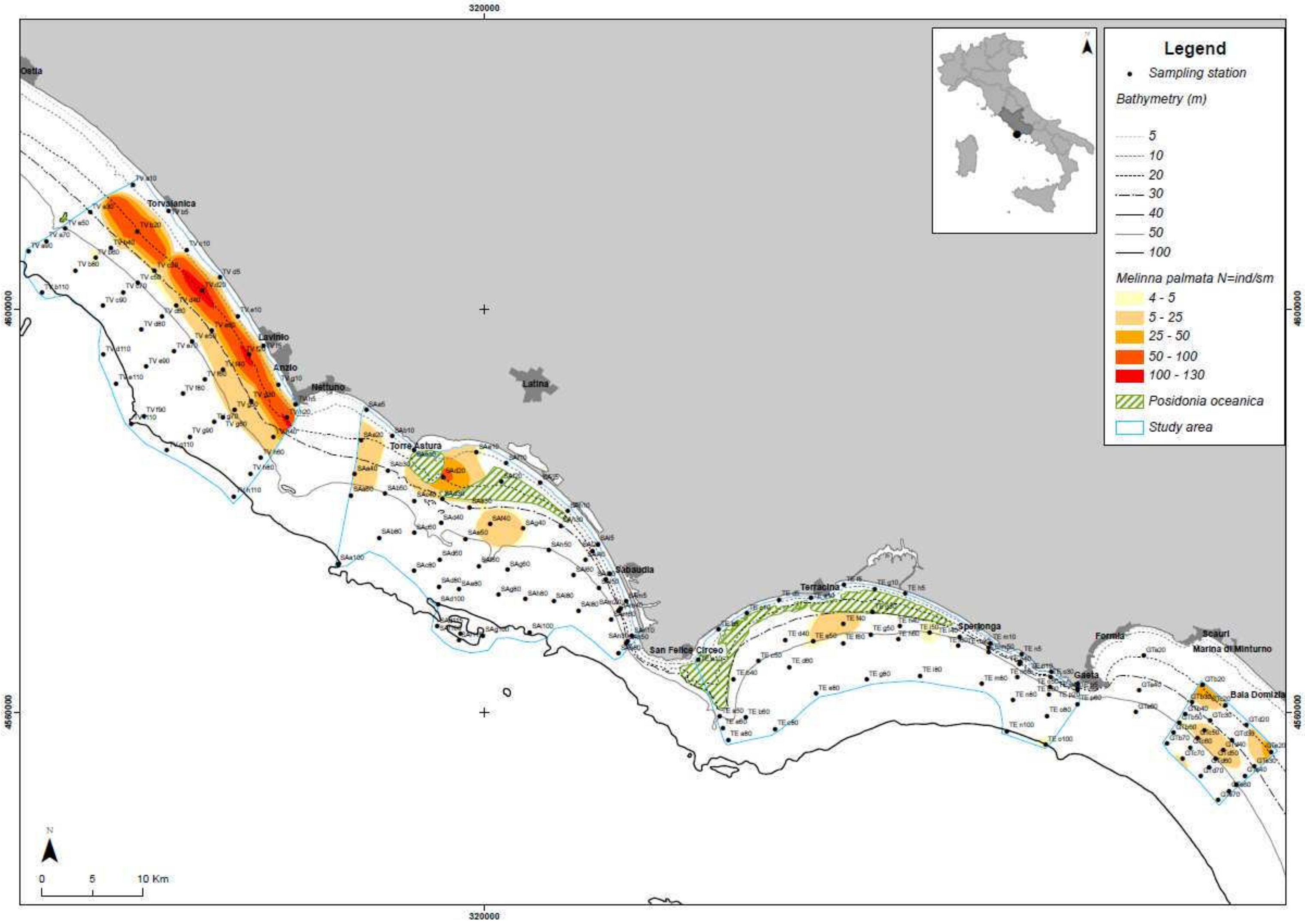


Figure 3.4.9 – Prediction map of *Melinna palmata* distribution along the five study areas: TV, SA, TE and GT.

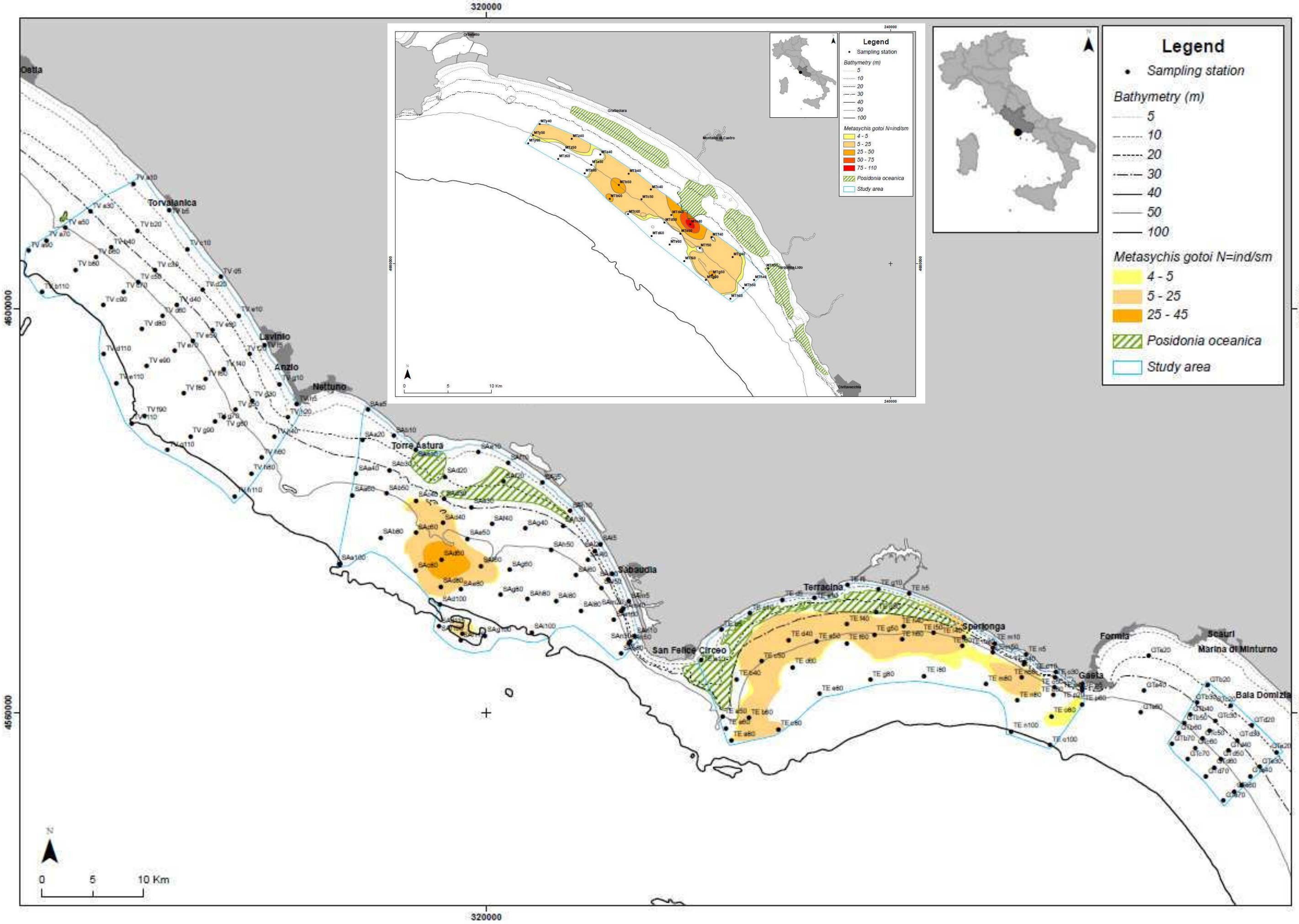


Figure 3.4.10 – Prediction map of *Metasychis gotoi* distribution along the five study areas: MT (in the smallest picture), TV, SA, TE and GT.

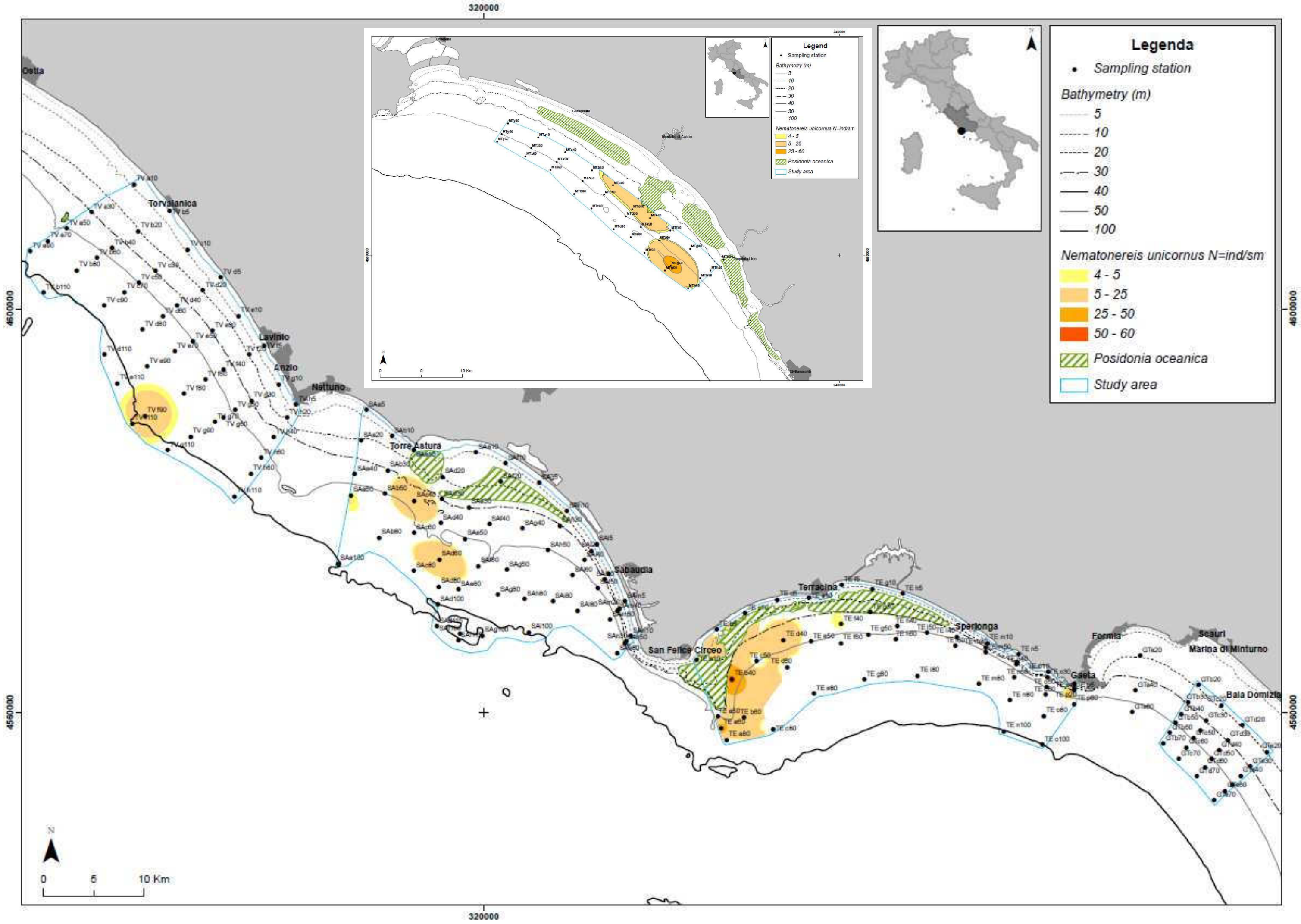


Figure 3.4.11 – Prediction map of *Nematonerei unicornis* distribution along the five study areas: MT (in the smallest picture), TV, SA, TE and GT.

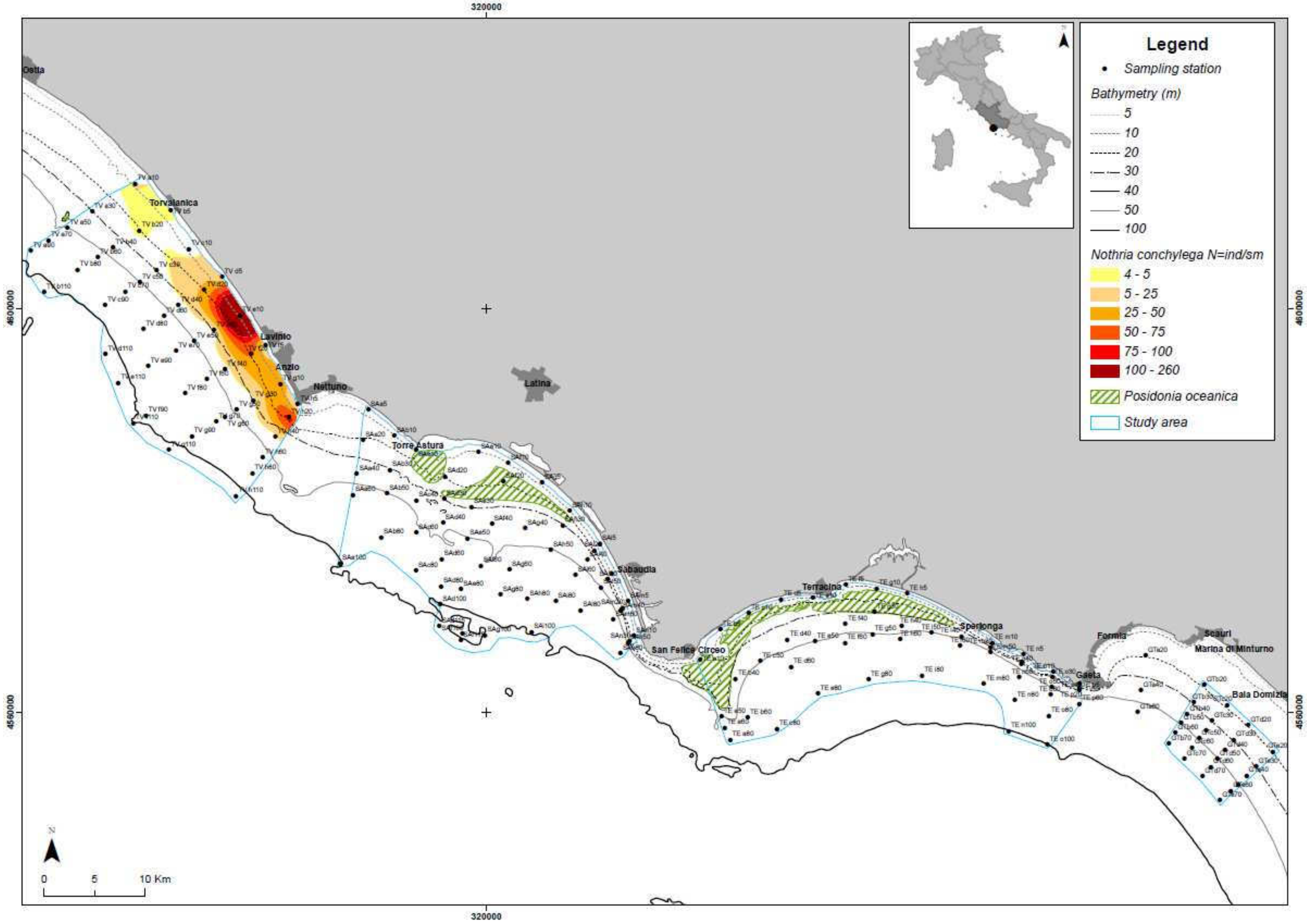


Figure 3.4.12 – Prediction map of *Nothria conchylega* distribution along the five study areas: TV, SA, TE and GT.

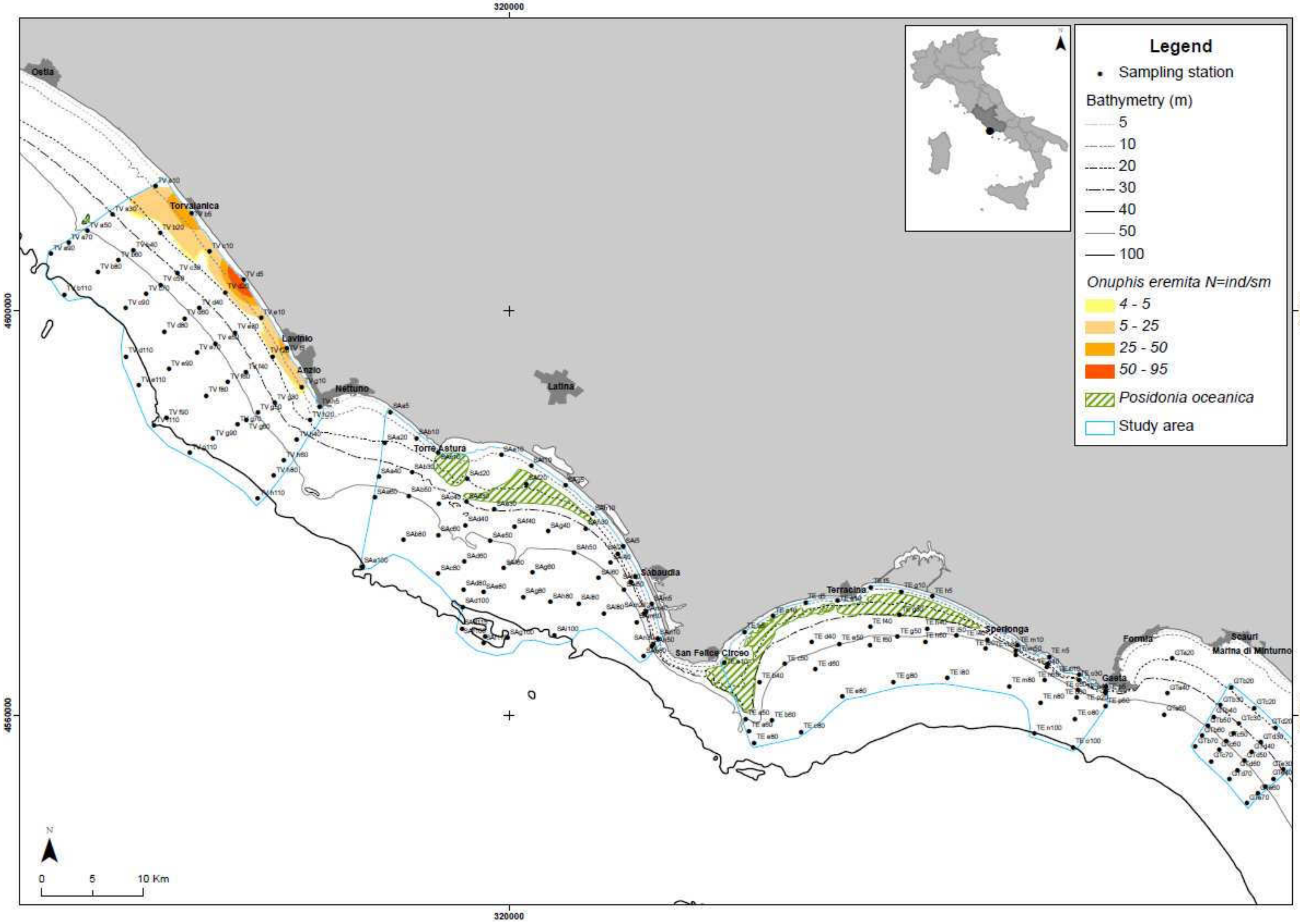


Figure 3.4.13 – Prediction map of *Onuphis eremita* distribution along the five study areas: TV, SA, TE and GT.

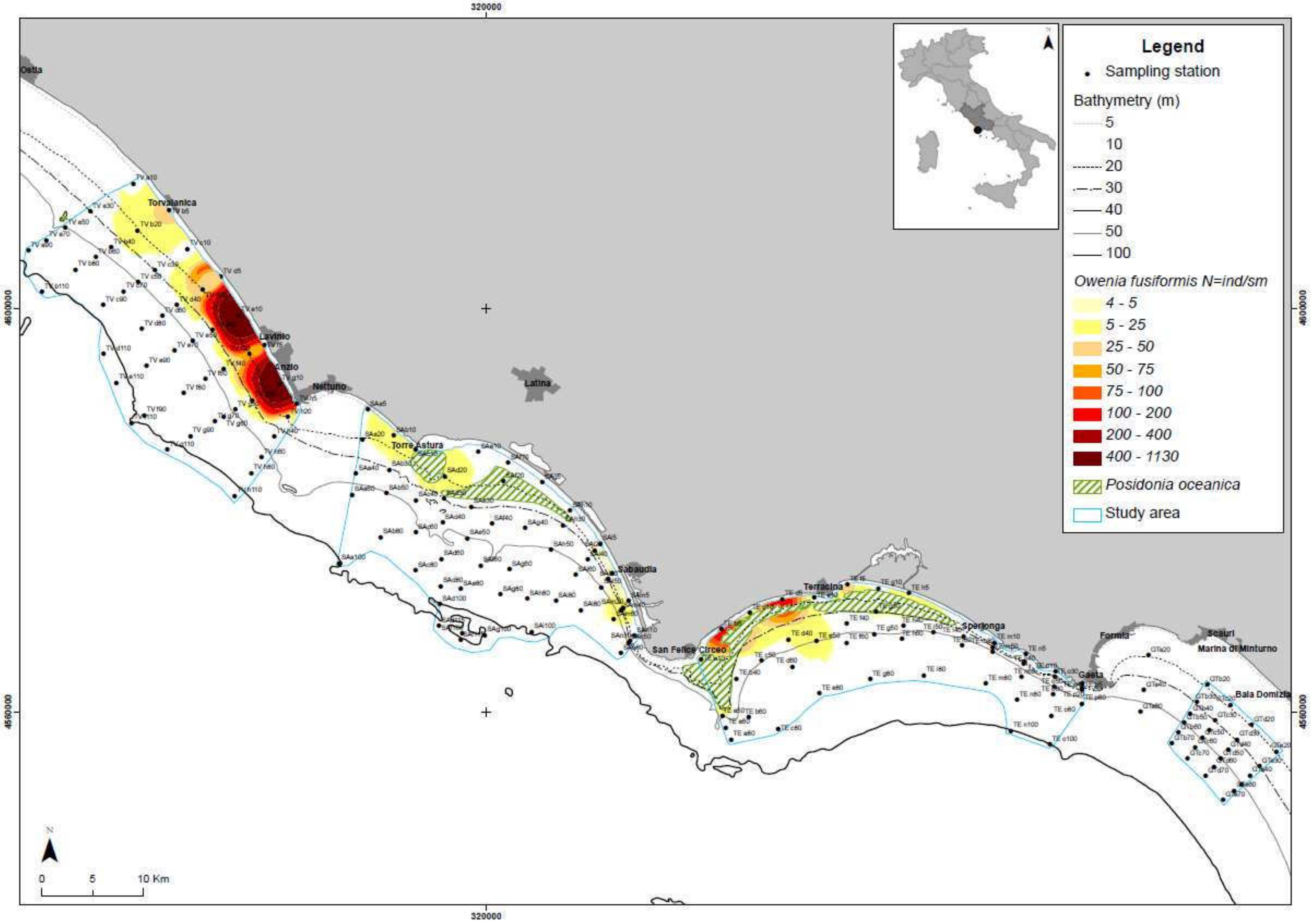


Figure 3.4.14 – Prediction map of *Owenia fusiformis* distribution along the five study areas: TV, SA, TE and GT.

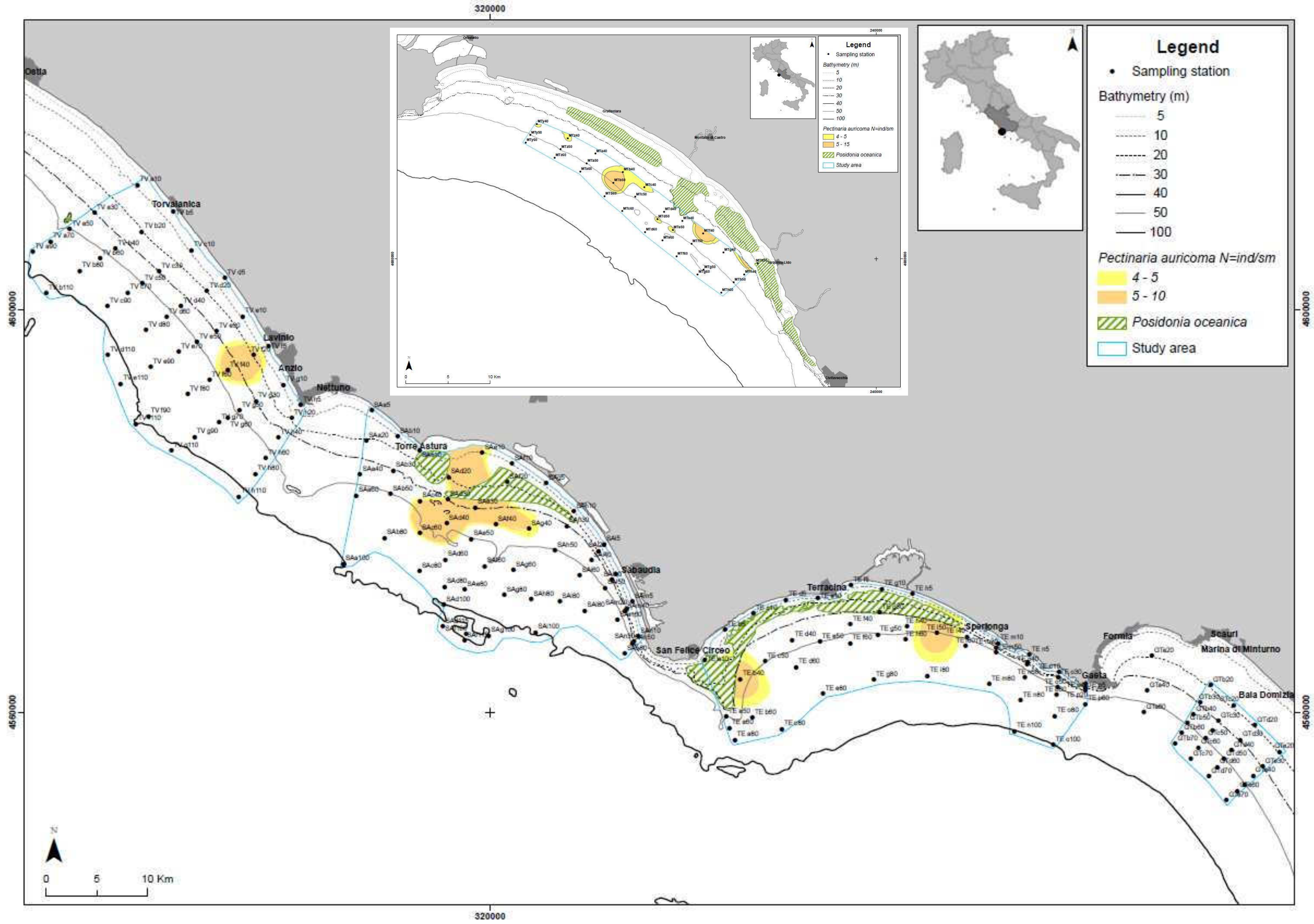


Figure 3.4.15 – Prediction map of *Pectinaria auricoma* distribution along the five study areas: MT (in the smallest picture), TV, SA, TE and GT.

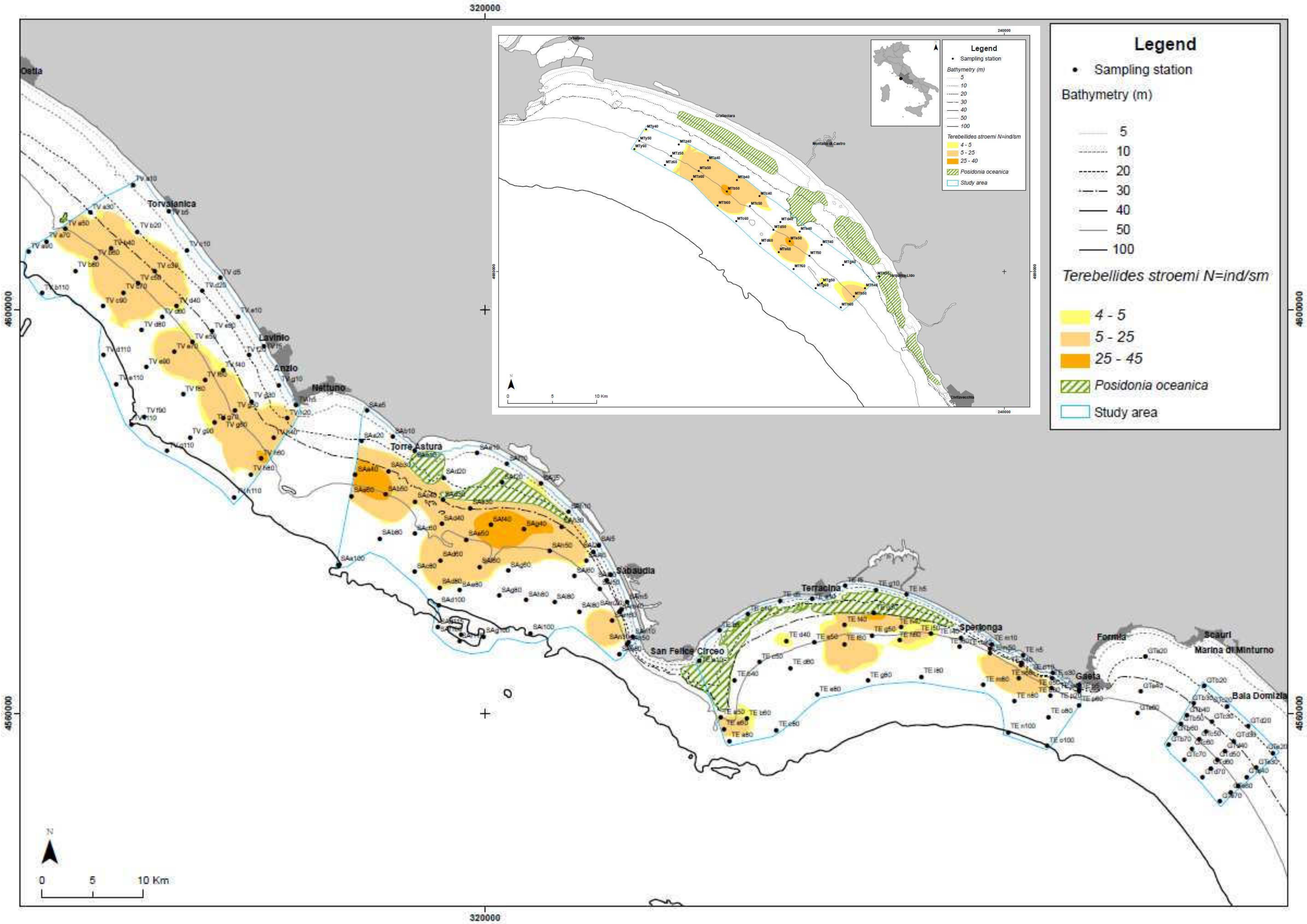


Figure 3.4.16 – Prediction map of *Terebllides stroemi* distribution along the five study areas: MT (in the smallest picture), TV, SA, TE and GT.

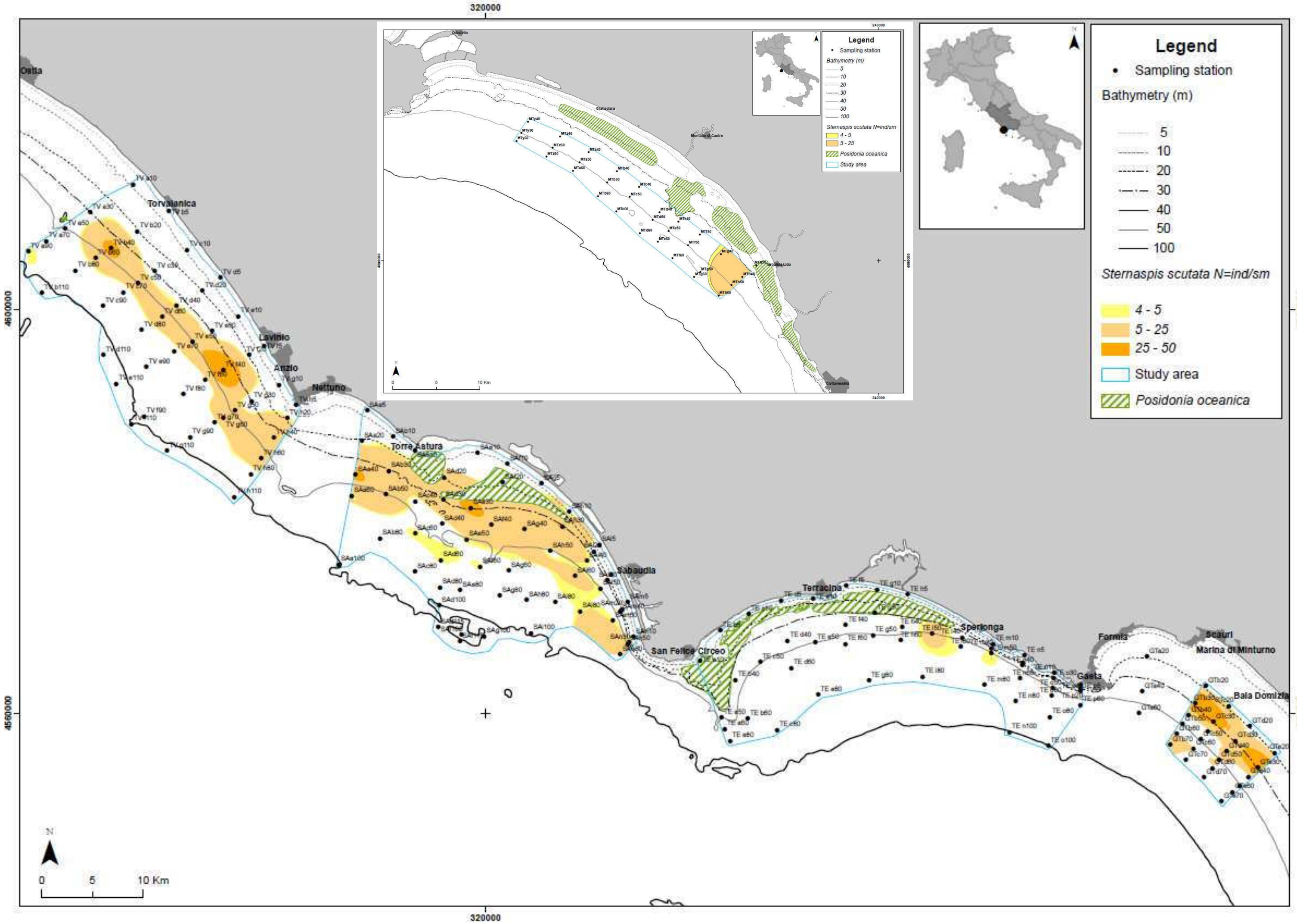


Figure 3.4.17 – Prediction map of *Sternaspis scutata* distribution along the five study areas: MT (in the smallest picture), TV, SA, TE and GT.

Data of soft-seabed species inhabiting the five investigate areas along the Latium continental shelf were functional to carry out a wider study aimed at analyze and update the spatial distribution and ecological characteristics, related to depth range and sediment composition, of 20 soft-sediments species found along Italian continental shelf. Data about the 20 selected polychaetes were extracted from a dataset collecting results of multidisciplinary environmental characterization and monitoring programmes for scientific research (e.g. sand dredging, offshore platforms developments, aquaculture, beach nourishments) carried out in Italy over the last 10 years by the Italian National Institute for Environmental Protection and Research (ISPRA). These 20 species were selected taking into account their spatial distribution and their ecological role in benthic assemblages. For each species, voucher specimens were available in ISPRA's reference collection, which is based on the material collected in numerous monitoring surveys.

Results of this study are available in the manuscript of La Porta *et al.* (2011), enclosed in the present thesis.

Comparing results from the present study and those illustrated in La Porta *et al.* (2011) have been pointed out differences between information about species ecology obtained at different scales of investigation, from regional to national scale (Tab. 3.4.3).

Table 3.4.3. Summary of results of Indicator Species Analysis (ISA) analyses from the present study and those illustrated in La Porta *et al.* (2011). Polychaetes species are associated with groups of stations, according to sediment classes and depth ranges, with different level of significance at two scales of investigation, from regional to national scale.

SPECIES	ISA-REGIONAL SCALE	ISA-NATIONAL SCALE
Aponuphis bilineata	mS = vsM (20-30m)	**mS** > vsM (**20-**50m)
Aponuphis brementi	mS (20-30m)	**mS** < vsM (20-**50**m)
Aponuphis fauveli	mS	mS < **vsM** (20-**50**m)
Caulleriella caputesocis	mS	vsM (30-50m)
Climenura leyopigos	(10-20m)	(20-30m)
Ditrupa arietina	sM (20-30m)	vsM (30-50m)
Eunice vittata	mS	**vsM**>sM (30-50m)
Hyalinoecia tubicola	-	vsM,sM(30,>50)
Melinna palmata	**mS**>vsM-sM (20-30m)	**vsM**<sM>M (10->50m)
Metasichis gotoi	(60-70 m)	**vsM**>sM (17-100m)
Nothria conchylega	**mS**>S (**5-10**;20-30m)	mS (1-10, 20-30m)
Onuphis eremita	S-mS (5-10m)	S (1-20m)
Owenia fusiformis	S-mS (5-10m)	**S**>mS (1-30m)
Pectinaria auricoma	**vsM**> sM	**mS**>vsM (**20-30**-50m)
Sternaspis scutata	**vsM**> sM, M	vsM,sM<**M** (**20-30**,<50)

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Results obtained from the analysis of diversity distribution patterns of polychaete assemblages and species at a regional (Latium Continental Shelf), related to some environmental factors (depth, sediment grain size, latitude and longitude) was used to assess the effects of human activities (sand dredging) on marine ecosystems at a local scale through the analysis of biological diversity variation over time.

The selected area where sand extraction activities had been performed was indeed included into the area of Montalto di Castro. Details and results of this research are available in La Porta *et al.*, (2009) enclosed in the present thesis.

Within the macrozoobenthic assemblages, polychaetes represented the most abundant *taxon* and variation over time in species diversity as well in community structure, as a consequence of dredging activities, could be mirrored by the polychaete assemblages (Fig. 3.4.18)

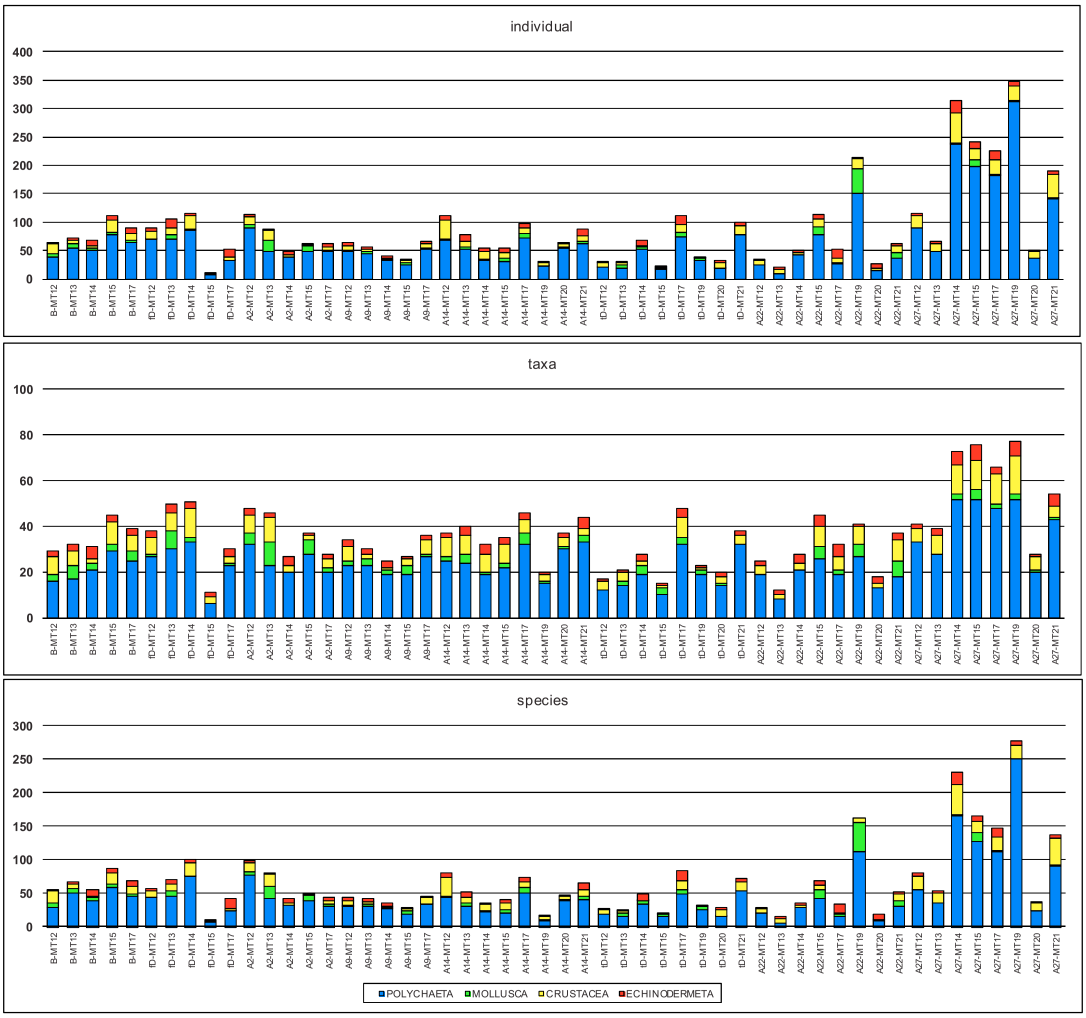

Figure 3.4.18 – Variation of Polychaeta (blue), Mollusca (green), Crustacea (yellow) and Echinodermata (red) *taxa* over time, in terms of number of individual, *taxa* and species in the stations located inside and outside a dredgingarea at Montalto di Castro, before, during and after dredging activities.

4. DISCUSSION

The analyzed polychaetes assemblages of Latium continental shelf were on the whole well represented in terms of number of species and individuals, although each investigated area was characterized by peculiarities in terms of species composition and community structure. Alpha diversity analyzed by Hill's numbers and community indices exhibited variability in spatial patterns of species distribution within areas. Species richness (N_0 and ES) indicated little differences between lower infralittoral and upper circalittoral zone; the transition depth-range between these two zones hosted the highest values of polychaetes richness but peaks of species number varied considering the environmental characteristics of each area. A relatively high percentage of finest fraction in the sediments, such as in muddy-sand and very-sandy mud substrata, seem to significantly display the coexistence of a great number of species while in sediments mainly composed by sand (>95%) or mud (>70%) species richness decreased in each area. Species density (N) was high between lower infralittoral and upper circalittoral zone as well in muddy-sand and very muddy sand sediments except for some sandy stations placed in the upper infralittoral of Torvaianica and Terracina areas where the highest number of individuals was mainly due to the present of a few dominant sandy species. Patterns of species diversity distribution (described by N_1 and N_2 indices) mirrored patterns described for species richness and individuals abundances in each area pointing out, in addition, some depths or sediment classes where the high percentage of relative presence of rare species contributed to increase diversity (e.g. 50 m at Montalto di Castro, 60 m at Sabaudia, very-sandy mud sediments at Torvaianica and Terracina, sandy-mud in Sabaudia). Rare species, in terms of restricted spatial range and/or low abundance, represent one of the few general ecological relationships applied to marine environment, contributing considerably to the total number of species and diversity of a given area (Sevastou *et al.*, 2011).

Beta diversity is a component of diversity, provides additional information to species richness and is a measure of between-habitat diversity as a measure of the change in diversity between samples along transects or environmental gradients (Whittaker, 1960). According to Anderson *et al.* (2006) beta diversity can be broadly defined as the variability in species composition among sampling units for a given area at a given spatial scale. Indeed beta diversity depend on the scale used to define local or habitat diversity (Loreau, 2000) and differ among benthic *taxon*omic groups (Ellingsen, 2001; Ellingsen and Gray, 2002). Most beta diversity studies concentrate on latitudinal clines (Quiroz-Martinez *et al.*, 2011; Kendall and Aschan, 1993; Dauvin *et al.*, 1994; Kendall, 1996; Ellingsen and Gray, 2002; Kindlmann *et al.*, 2007; Renaud *et al.*,2009). In the present study latitude and longitude have been displayed to be important environmental factors influencing the polychaetes diversity distribution at regional scale (100 – 1000s of kilometres) (CCA analysis). Nevertheless considering the limited geographical range (from 42° to 41°N and from 11° to 12°S) of this study, patterns of decline in diversity of polychaetes, as well as other macrobenthic *taxa*, with latitude documented by the mentioned Authors cannot be described.

Other environmental factors have been proved to be closely related (and strongly correlated) with beta diversity of polychaetes; depth and sediment texture were the main environmental factors influencing the polychaetes diversity distribution at a regional scale (as proved by CCA, BIOENV and Spearman rank correlations analyses). Polychaeta fauna of Latium continental shelf was clearly zoned showing differences among and within the depth ranges considered (PERMANOVA analysis). The infralittoral zones (lower and upper) displayed specific structure of polychaetes assemblages that reflect the various environmental conditions of each area e.g. the profile of the coast line, the bathymetrical gradient, light intensity, the variability of sediment texture according to depth and to the presence of river mouths as well as to the presence of *Posidonia oceanica* meadows, which may influence local hydrodynamics, entrap fine sediments among rhizomes, roots and *matte* and provide coarse fraction of organic detritus. These are among the main factors which control the distribution of benthic fauna (Pérès and Picard, 1964; Pérès, 1982). Different structures of assemblages inhabiting the upper circalittoral zones have been also pointed out among the areas (PERMANOVA and PERMDISP analyses). Perhaps, the environmental characteristics showed in the depth range 20-50 m of each area can influence polychaetes diversity patterns for a wider bathymetric range. As a consequence assemblages of deeper circalittoral zones showed similarities among areas as displayed exclusively for Sabaudia and Terracina from 60 to 70 m and for Torvaianica, Sabaudia and Terracina, between 110 and 115 m.

The trend observed along the depth gradient show low values of polychaete species richness and diversity in the upper infralittoral zone. This is a typical pattern observed in soft-seabeds where this zone, mainly characterized by sandy sediments, is normally dominated by other *taxa*, mostly Crustacea and Mollusca such as has been described by several Authors for Mediterranean seas (e.g. Fresi *et al.*, 1983; Castelli *et al.*, 1992; Bianchi *et al.*, 1993; Scipione *et al.*, 2005; Cosentino and Giacobbe, 2008). Probably the high hydrodynamic conditions and sediment instability in these zones are not favourable for many species of polychaetes such has been pointed out by several study along Tyrrhenian continental shelf (e.g. Crema *et al.*, 1993; Bianchi *et al.*, 1993a,b,c; Fresi *et al.*, 1983; Gambi *et al.*, 1983; Gambi and Giangrande, 1986; Gambi *et al.*, 1996). In this zone the low values of evenness found have been a consequence of the dominance of a few number of species which occurred in some shallow stations such as observed in Torvaianica were *Owenia fusifomis, Nothria conchylega* and *Onuphis eremita* dominated at 10 m of depth or at Sabaudia and Terracina where the most abundant species between 5 and 10 m were *Prionospio caspersi*, *Magelona* sp2, *Scoloplos armiger.* Most of the dominant species found in the three areas between 5 and 10 m of depth are affiliated to the well sorted fine sands biocoenoses and the majority number of the collected species are typically found in sandy sediments such as *Sigalion mathildae*, *Mediomastus fragilis*, *Nephtys hombergi*, *Spio decoratus*. The presence of most of these species was signalled in the shallowest depth ranges of different areas investigated along the Tyrrhenian continental shelf by several Authors (Gambi and Giangrande, 1986; Castelli *et al.*, 1992; Gambi *et al.*, 1996; Bianchi *et al.* 1993a,b,c; Crema *et al.* 1993; Somaschini, 1993; La Porta *et al.*, 2006) and in particular overlapped the species distribution described by Chimenz *et al.* (1996) along some shallow areas of the Latium coasts.

Rich assemblages in terms of number of species and diversity have been found both at the lower infralittoral zone and the upper circalittoral in accordance with literature (e.g. Simboura *et al.*, 2000; Gravina, 1986; Castelli *et al.*, 1992; Gravina and Somaschini, 1990). Gambi and Giangrande, (1986) analysing the polychaete assemblages of two areas influenced respectively by Ombrone and Tevere rivers described an “intensity effect” at about the same depth range. This effect was explained by the presence of mixed sediments which increase the spatial complexity of the substrata that result in a large number niche spaces and by the organic enrichment due to the rivers discharge which deposited in these zones. In the areas investigated in the present study at these depth ranges the heterogeneity of environmental factors (e.g. the presence of mixed sediment with high percentage of sand, organic detritic substrata, the lower limits of *P. oceanica* meadows, rocky shoals) provide different habitats that can host a number of species with different ecological habits. This wide depth range is therefore characterized by a high heterogeneity of polychaete assemblages which was on the bases of differences observed *intra* and *inter* areas at these depths. Nevertheless, the measure of diversity variability shows common patterns of species composition between the infralittoral zones and upper circalittoral zone. The complexity of the species distribution and composition patterns seems to indicate the presence of a transition zone, which represent an ecotone where the overlapping of different assemblages determines the high species richness and diversity signalled, in accordance with results of numerous study along the Tyrrhenian Sea (Castelli, 1982; Gambi *et al.*, 1983; Gambi and Giangrande, 1985; Castelli *et al.*, 1986a, 1986b; Crema *et al.*, 1993; Fresi *et al.*, 1983, Castelli *et al.*, 1992; Bianchi *et al.*, 1993a,b,c; Gambi and Giangrande, 1986; Gambi *et al.*, 1996; La Porta *et al.*, 2006) as well as in the Liguria Sea (Gravina, 1986). This pattern has been well described for Sabaudia and Terracina areas respectively at 20-30 m and in the neighbouring zones of 40 m of depth. Moreover the pattern of benthic heterogeneity described in these two areas was mirrored by similar pattern of variability in the environmental characteristics. Here sediment texture was composed of an amount of coarser fractions (from sand to organic detritus), more than the other areas, which usually present greater small-scale heterogeneity (Rees *et al.*, 2007). Indeed, coastal detritic as well as muddy detritic substrata are describe as hot-spot of biodiversity (Peres and Picard, 1964; Nicoletti *et al.*, 2003; De Domenico *et al.*, 2003; La Porta *et al.*, 2005). Furthermore, the presence of wide *Posidonia oceanica* meadows contributed to increase species diversity in the neighbouring zones because it allow the occurrence of species (e.g. *Myriochele oculata*, *Arabella iricolor*, *Petta pusilla*, *Leiocapitella dollfusi*) which superimpose to the more typical organisms of definite biocoenosis such as well sorted fine sands assemblage (Gambi *et al.*, 1983; Chimenz *et al.*, 2006; Scipione *et al.*, 2005). Also at Montalto di Castro *P. oceanica* beds contributed to increase species diversity in the neighbouring zones. Among the most abundant species found in the transition zone sandy species such as *O. fusifomis, Aponuphis bilineata, A. brementi, Spio decoratus, Scoloplos armiger* coexisted with muddy species as *Lumbrineri latreilli, Melinna palmata, Poecilochaetus serpens, Terebellides stroemi, Glycera unicornis.* Most of these species occurred in transition zones identified in other areas of Tyrrhenian Sea pointing out their tolerance to different fraction of sediments and to wide depth ranges (e.g. Gambi *et al.*, 1983; Bianchi *et al.*, 1993a,b,c; Somaschini, 1993; Crema *et al.*, 1993; Gambi and Giangrande, 1986).

A gradual impoverishment of assemblages with the increase in depth (circalittoral zone) both in terms of species richness and number of individual, accompanied by a decrease in diversity and an increase of evenness, has been described. This pattern could be related to an increase of fine fractions in the sediments and the consequent decreasing in habitats heterogeneity and confirms the general tendency of soft-seabed polychaetes to prefer low energy environments and sediment rich in fine fractions of sediment and organic matter (Knox, 1977). The low diversity found in the deeper circalittoral zones displayed similarities among Sabaudia and Terracina from 60 to 70 m and Torvaianica, Sabaudia and Terracina, between 110 and 115 m. Several Authors pointed out that it is difficult to clearly identify well-definite assemblages in Mediterranean circalittoral soft-seabeds (e.g. Pérès, 1982; Fresi *et al.*, 1983; Simboura *et al.*, 2000). Overall the assemblages found could been affiliated to muddy communities as well continental terrigenous mud biocoenosis but in some stations of Sabaudia and Terracina assemblages may be related to muddy detritic assemblages (e.g. *Hyalinoecia tubicola*, *Leiocapitella glabra, M. oculata)*. Species such as *Terebellides stroemi*, *Sternaspis scutata*, *Cirratulus cirratus*, *Paraprionospio* cf *pinnata* showed statistically significant associations with definite granulometric characteristics (i.e. percentage of mud < 70%) and depth ranges off the circalittoral zone. Also in this case results overall confirmed previous investigation along Tyrrhenian Sea both in terms of species composition and spatial distribution (Zurlini and Bedulli, 1983; Chimenz *et al.*, 2006; Gambi *et al.*, 1996; Fresi *et al.*, 1983).

As has been displayed this study in general confirmed the species distribution patterns as well as the assemblages composition observed over wide different areas of a Tyrrhenian Sea in previous studies. Thus a continuum of species distribution along Tyrrhenian continental shelf can be expected. Species diversity maps can represent comprehensive species diversity distribution patterns, including result obtained for the Latium continental shelf and those related to the neighbouring zones.

Results of this study also provide relevant information about the ecological characteristics of a number of soft-seabed species inhabiting the continental shelf environments in relation to depth range and sediment typologies (ISA analysis). As illustrated these information have been used to better describe the coenotic units which occurred at different depth ranges along Latium continental shelf. Moreover, results obtained at regional scale in addition with results at national scale can be useful to update some incomplete information about many species which are frequently recorded outside their known bathymetric and granulometric range and of their characteristic ecological boundaries, which define specific biocoenosis *sensu* Pérès and Picard (1964).

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Results obtained from the analysis of diversity distribution patterns of polychaete assemblages and species at regional scale (Latium continental shelf), and related to some environmental factors (depth, sediment grain size, latitude and longitude), gave essential information to assess the effects of human activities (sand dredging) on marine ecosystems at a local scale through the analysis of biological diversity variation over time.

The selected area where sand extraction activities had been performed was indeed included into the macro-area of Montalto di Castro.

Within the macrozoobenthic assemblages, polychaetes represented the most abundant *taxon* and variation over time in species diversity as well in community structure, as a consequence of dredging activities, could be mirrored by the polychaete assemblages. One important characteristic of the variation in diversity was the increase in species dominance most notably by polychaetes. *Terebellides stroemi*, described as an opportunistic species, and the sabulicolus specie, previously absent, *Streblosoma bairdi*, *Nephtys hombergi* and *Diplocirrus glaucus* colonised the dredged substrata in a short temporal range. This phenomenon is normally observed in dredged substrata where the defaunation allows the opportunistic species to form dense populations in the first phase of the recolonisation process, followed by an increase in the number of species and individuals with different ecological habits (Bonsdorff, 1980; Kenny and Rees ,1994, 1996; Newell *et al.*, 1998; Sarda` *et al.*, 2000; Van Dalfsen *et al.*, 2000; Newell *et al.*, 2004; Szymelfenig *et al.* 2006; Simonini *et al.* 2007; Marzialetti *et al.*, 2006). As a result polychaete species could been used as indicators of the general "health" of the overall community in relation to human activities impacts on marine environment. Even if results of several studies illustrate the ability of the polychaetes community to respond quickly to changes in their environment, it has been also demonstrate that even dominant species cannot be considered as stable indicators of variation in environmental conditions for the benthic community (Gambi *et al.*, 1982; Giangrande *et al.*, 2005; Dean, 2008 and the references therein). Dean (2008), moreover, pointed out that generalizations about particular species acting as indicators of stressed, or low diversity, communities in different geographic areas are tenuous. The use of polychaetes as indicators of community diversity and, therefore, overall health of the benthic community has value but it is apparent that there are no cosmopolitan positive or negative indicator species which will identify a community as healthy or unhealthy. Each region is inhabited by many species capable of a rapid response to an environment impacted by conditions negative to other species. Moreover, which of these species will respond to polluted conditions and become numerically dominant seems to vary with time.

Polychaete species can be used as positive or negative indicators of the effects of human activities on the benthic community but only within the confines of a definite sampling program, specific for the area studied and for the time period of the study. This aspect highlights the importance of environmental monitoring programs as a source of important scientific data such as relevant information on marine benthic communities ecology as well as on the ability of some species to respond to change in their environment. Such data providing information to analyse recolonisation processes which are difficult to predict because they are strongly influenced by different factors mainly specific of local conditions of the areas.

5. CONCLUSION AND OUTLOOKS

The present research, carried out in the Tyrrhenian Sea, along Latium continental shelf, has pointed out that:

- ✓ the three main categories explaining the drivers of biodiversity patterns in the Tyrrhenian continental shelf environments are: bathymetric gradients, geographical features, responsible for the north-south gradient in environmental conditions, and environmental heterogeneity (i.e. grain size distribution, habitat complexity);

- ✓ some species distribution is significantly associated to definite sediment grain sizes and depth ranges; these results contribute to confirm or update the ecological characteristics of the investigated species as emerged from the comparison of results of this study with pre-existing knowledge;

- ✓ the species distribution patterns as well as the assemblages composition observed along the Latium continental shelf, confirm results obtained in previous studies carried out in neighbouring areas along Tyrrhenian Sea. Thus a continuum of species distribution along Tyrrhenian continental shelf can be expected and represented by means species diversity maps which have been demonstrated to be a useful first attempt to represent comprehensive species diversity distribution patterns at the regional scale;

- ✓ despite polychaetes have been demonstrated to be able to respond quickly to changes in their environment as a consequence of dredging activities, the assessment of the effects of these activities upon benthic organisms is quite complex to define.

The knowledge of benthic invertebrates species is still incomplete and often outdated. Costello *et al.* (2010) have showed that there remain major gaps in basic knowledge of marine biodiversity, *taxon*omically and geographically.

This study has outlined the importance of the environmental monitoring programme as a source of valuable scientific data, such as relevant information on polychaete species composition of marine benthic communities, their ecology and diversity distribution.

Despite the Mediterranean Sea is a region of high biodiversity that ranks this basin among the best known marine areas of the world, much work remains to be done. At regional scale marine research in the Mediterranean is actually partial, reflecting sparse efforts along the different basins. Increased attempts are required in taxonomy and sampling of poorly known ecosystems as well as long-term monitoring programs aimed to analyse species and habitats ecology. At the same time, the invasion of alien species which constantly change the biodiversity of the Mediterranean Sea requires continuous monitoring.

It has also been demonstrate that the species richness and diversity of Polychaeta (as a surrogate of the entire macrozoobenthic assemblages), by sectors of the Tyrrhenian continental shelf, is a good indicator of the level of research effort to better represent the true biodiversity of this peculiar environment. The species diversity maps resulting from this study are a useful first attempt to represent comprehensive species diversity distribution patterns at the regional scale. Applying a comparable approach to results of neighbouring areas as well as to other benthic *taxa* (e.g Mollusca, Crustacea, Echinodermata) a more complete representation of species diversity distribution patterns can be obtained at a larger scale. Giangrande *et al.* (2005) stated that mapping the distribution of biodiversity constitutes an enormous challenge. However, some of the major patterns of diversity are becoming clearer, even if the mechanisms for generating them are still not fully understood. Much work is still required to establish the true spatial patterns and their underlying mechanisms to identify and to predict the impact of humankind on current patterns of diversity. Moreover maps can provide useful information for action plans aimed at protection and conservation of marine biodiversity.

Despite polychaetes as well as other benthic *taxa* have been widely used in the assessment of the ecological state of benthic communities, especially in response to human impacts (Dean, 2008), this study has demonstrate that the assessment of the effects of human activities (dredging activities in this case) upon benthic organisms is quite complex to define. At the same time, the present results have pointed out that a good monitoring project of human activities provide data useful to plan an adequate sustainable use of marine environment resources and to improve future monitoring actions. Protection, conservation and sustainable use of marine environment resources and its associated biodiversity need an integrated approach between scientific research and management. At regional scale most nations have jurisdiction over their resources and can, therefore, best produce efficient conservation measures (Connolly and Roughgarden, 1998). Indeed, by studying biodiversity patterns as well the influence of some environmental factors (e.g. depth and geographic variables) on diversity at regional scales, it is easier to establish natural frontiers to be used in management strategies (Le Pape *et al.*, 2007), establishing, for instance, depth intervals that are priorities for conservation.

Data from monitoring projects datasets can be a source of important information for the implementation of European directives by National Governments (e.g. Marine Strategy, Water Frame Directive, Habitat Directive) as well as Local Authorities (Biodiversity Strategies and Action Plans). In addition to further sampling and *taxon*omic efforts, much of what remains to be done requires free distribution of available data from national and regional research initiatives to the public. This will facilitate database updates and enable scientific discussion. As displayed by Coll *et al.* (2010) marine surveys are not always accessible at the regional level and, when available, data coverage is often incomplete. Individual research efforts in collaboration with institutions, (including museums, scientific institutes, government and intergovernmental agencies, universities) at the international, national, and regional levels must continue to advance our knowledge of marine biodiversity in the Mediterranean Sea and narrow down the unknowns.

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APPENDIX I: Species collected in the area of Montalto di Castro

SPECIES	ACRONYM	SAMPLING STATIONS																																		N tot
		MTy60	MTz60	MTa60	MTb60	MTc60	MTd60	MTe60	MTf60	MTg60	MTh60	MTy50	MTz50	MTa50	MTb50	MTc50	MTd50	MTe50	MTf50	MTg50	MTh50	MTy40	MTz40	MTa40	MTb40	MTc40	MTd40	MTe40	MTf40	MTg40	MTh40	MTc30	MTh30	MTc20	MTh20	
Amage adspersa	*Aa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Ampharete acutifrons	*Acu*	5	0	0	0	0	0	5	10	0	5	20	0	5	30	10	0	15	5	0	25	0	0	20	25	15	0	10	10	30	5	0	5	0	0	**255**
Amphicteis gunneri	*Ag*	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5	0	0	15	0	5	0	5	5	10	0	5	0	0	0	0	0	0	0	**55**
Ancystrosyllis groenlandica	*Agro*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Aphelochaeta marioni	*Am*	15	5	15	0	5	0	0	5	0	10	5	0	5	5	0	0	20	0	0	10	0	10	0	0	0	0	0	0	5	0	0	5	10	0	**130**
Caulleriella multibranchiis	*Amu*	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Aponuphis bilineata	*Ab*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	**25**
Aponuphis brementi	*Abr*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	**25**
Aponuphis fauveli	*Af*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Brada villosa	*Bv*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	10	0	0	0	10	5	0	0	5	25	0	0	0	5	0	**70**
Chetozone cf setosa	*Cs*	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Chetozone sp.	*Cocchi*	5	0	0	0	0	5	5	5	10	0	0	0	10	0	0	0	0	5	5	0	0	0	5	0	0	0	5	0	0	0	5	5	0	0	**70**
Cirrophorus branchiatus	*Cb*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	**5**
Clymenura clypeata	*Ccly*	0	0	0	0	0	0	0	0	0	0	5	0	5	5	0	0	0	0	0	0	5	5	0	10	0	5	0	0	0	0	0	5	0	0	**45**
Diplocirrus glaucus	*Dg*	0	0	15	0	0	0	0	0	0	0	0	0	5	5	0	0	5	10	0	15	0	5	0	0	25	0	0	0	5	20	0	0	10	0	**120**
Drilonereis filum	*Df*	0	0	0	0	0	5	0	5	0	0	0	5	0	20	0	5	0	0	0	0	0	5	5	0	10	5	5	5	5	0	0	10	0	5	**95**
Eteone longa	*El*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	**5**
Eunice vittata	*Evit*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0	10	0	5	5	0	15	35	0	0	0	0	0	0	30	**140**
Euphrosine armadillo	*EUa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	**10**
Glycera alba	*Ga*	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	**15**
Glycera unicornis	*Gu*	0	0	5	30	5	10	0	0	0	10	5	10	10	35	0	15	5	5	10	0	10	25	15	10	5	10	15	10	5	0	5	15	20	0	**300**
Glycinde nordmanni	*Gn*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Malmgreniella lunulata	*Hlu*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	**10**
Harmothoe spinifera	*Hsp*	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Heteromastus filiformis	*Hf*	5	0	25	0	0	5	5	0	0	5	15	5	5	40	10	10	10	10	0	10	0	0	0	10	5	0	0	15	20	15	0	20	10	0	**255**
Hyalinoecia tubicola	*Htub*	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	10	5	0	0	0	0	0	0	0	**35**
Hydroides pseudouncinatus	*Hps*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	**5**
Laonice cf cirrata	*Lc*	0	0	0	0	0	0	0	0	0	0	10	5	0	0	0	0	0	5	0	5	10	0	15	0	25	0	0	5	5	10	0	25	0	0	**120**
Leiocapitella glabra	*Ld*	0	0	0	5	5	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**20**
Levinsenia gracilis	*Lg*	0	0	0	0	0	0	0	0	0	0	0	5	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**
Lumbrineris coccinea	*Lcc*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	**10**
Scoletoma emandibulata-mabiti	*Lem*	10	0	5	0	0	25	0	15	5	0	0	10	5	30	5	15	15	5	10	10	5	0	5	5	5	5	0	5	0	5	20	45	5	0	**270**
Scoletoma funchalensis	*Lfu*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	**50**
Lumbrineris gracilis	*Lgr*	0	0	0	0	0	0	0	0	0	0	5	0	0	5	0	0	0	0	10	5	0	5	15	0	10	0	0	0	0	5	0	0	0	0	**60**
Lumbrineris latreilli	*Llat*	0	0	5	0	0	0	0	0	0	5	10	0	20	20	5	5	15	10	0	30	0	40	0	10	20	0	0	0	15	15	0	20	30	5	**280**
Lysidice cf ninetta	*LYn*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	**5**
Magellona sp1	*Msp1*	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	5	0	0	0	5	0	0	0	0	0	**20**
Maldane glebifex	*Mgl*	0	0	0	0	0	0	0	0	0	0	5	25	0	20	0	0	5	0	0	0	5	0	0	0	20	0	0	0	0	0	0	0	0	0	**80**
Maldane sarsi	*Msa*	0	0	0	0	0	0	0	5	0	0	0	0	15	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	**30**
Marphysa belli	*Mbl*	0	0	15	0	5	10	5	0	5	0	0	0	5	10	5	0	0	5	0	0	0	0	0	0	5	5	20	5	0	0	0	0	0	0	**100**
Marphysa kinbergi	*Mk*	10	10	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**30**
Melinna palmata	*Mpl*	0	0	0	0	0	5	0	0	0	5	0	5	10	5	0	10	20	0	0	0	15	0	0	5	20	0	0	15	10	0	15	15	5	0	**160**
Metasychis gotoi	*Mgt*	0	0	0	30	0	0	0	0	0	0	5	0	0	40	5	0	0	0	35	0	10	15	0	10	10	20	110	0	10	0	0	0	0	0	**300**
Monticellina dorsobranchialis	*Mdb*	5	5	0	0	0	0	0	5	0	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	5	0	0	**35**
Myriochele oculata	*Mocu*	0	0	0	5	0	0	0	0	0	0	0	0	0	5	5	0	0	0	10	0	0	0	20	10	5	0	0	0	0	0	0	0	0	5	**65**
Eteone picta	*Mpc*	0	0	0	0	0	0	0	5	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**
Nematonereis unicornis	*Neu*	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	0	0	0	0	0	10	5	20	0	0	0	0	0	0	15	**115**
Nephthys cirrosa	*Necr*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	5	0	20	**55**
Nephthys hombergi	*Neh*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	0	**65**
Nephthys hystricis	*Nehy*	0	0	0	0	0	0	0	5	0	0	5	0	5	0	0	0	0	0	0	0	5	0	0	0	0	10	10	5	10	0	0	5	0	0	**60**
Ninoe armoricana	*Nar*	0	0	0	0	0	0	10	5	0	0	0	0	0	0	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**25**
Nothria conchilega	*Ncch*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	**15**
Notomastus aberans	*Nab*	0	0	0	0	0	0	0	0	0	0	0	0	0	40	5	5	0	0	0	0	10	5	10	10	25	0	5	15	5	5	10	65	135	0	**350**
Notomastus latericeus	*Nlat*	0	0	15	0	0	10	5	0	0	0	0	0	0	5	0	0	5	0	0	5	5	10	10	0	0	5	20	0	0	0	0	20	0	0	**115**
Owenia fusiformis	*Owf*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	10	**20**
Paralacydonia paradoxa	*Pp*	5	0	0	15	0	0	0	0	0	0	10	0	0	0	0	5	5	0	20	0	5	5	10	5	0	0	15	5	0	0	0	0	5	0	**110**
Paraonis fulgens	*Pf*	0	0	0	5	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Paraprionospio cf pinnata	*Ppp*	0	0	0	0	5	0	0	0	0	0	5	5	5	15	5	0	15	0	0	5	15	5	0	5	0	0	0	5	0	0	0	0	0	0	**90**
Pectinaria auricoma	*Pau*	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	5	5	0	0	0	5	5	0	5	5	0	0	10	0	0	0	15	0	0	**65**
Pectinaria koreni	*Pko*	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	10	5	**25**
Petaloproctus terricolus	*Ptr*	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Phyllodoce laminosa	*Phyl*	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	**10**
Pilargis verrucosa	*Pvr*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	5	5	0	0	10	0	**25**
Piromis eruca	*Per*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	**15**
Pista cristata	*Pcr*	0	0	0	0	0	0	0	0	0	0	5	0	10	0	5	0	10	0	5	10	0	0	15	15	5	0	0	0	0	0	0	0	0	5	**85**
Poecilochaetus serpens	*Pos*	0	0	0	0	0	0	0	0	0	5	5	10	5	5	0	0	0	0	5	15	0	0	0	0	15	0	0	0	0	0	0	0	0	0	**65**
Polycirrus aurantiacus	*Polya*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	**5**
Polyophtalmus pictus	*Ppct*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	**5**
Praxillella gracilis	*Pxg*	10	0	0	0	0	0	0	0	0	5	5	0	15	5	15	0	15	0	0	0	0	10	0	0	0	5	0	20	10	5	0	0	0	0	**120**
Minuspio cirrifera	*Prci*	0	0	0	5	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**
Prionospio ehlersi	*Preh*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	**5**
Prionospio fallax	*Prml*	0	0	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Prionospio steenstrupi	*Prste*	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	10	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	**25**
Protula sp.	*Psp*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Scolaricia typica	*Scty*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	**20**
Sigambra tentaculata	*Site*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	**5**
Spio filicornis	*Sfil*	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Spio multioculata	*Smuo*	5	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**20**
Spiochaetopterus costarum	*Sctcst*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	10	0	0	0	0	0	0	0	0	5	0	0	15	0	0	**35**
Sternaspis scutata	*Ssc*	0	0	0	0	0	5	0	0	0	0	5	0	0	0	0	5	0	0	0	25	0	0	0	0	5	0	0	0	5	20	0	5	0	0	**75**
Terebellides stroemi	*Tstr*	5	0	10	5	0	0	5	0	0	0	0	0	20	35	0	0	40	0	5	10	5	0	10	15	10	0	0	0	0	5	0	0	0	0	**180**
Vermiliopsis infundibulum	*Vinf*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	**15**
N tot		**85**	**20**	**120**	**115**	**40**	**95**	**40**	**70**	**25**	**70**	**135**	**105**	**165**	**430**	**80**	**85**	**240**	**70**	**275**	**205**	**185**	**160**	**205**	**175**	**295**	**100**	**310**	**140**	**180**	**115**	**65**	**310**	**395**	**170**	**5275**

APPENDIX II: Species collected in the area of Torvaianica

SPECIES	ACRONYM	SAMPLING STATIONS																																																		
		TVb5	TVd5	TVf5	TVh5	TVa10	TVc10	TVe10	TVg10	TVb20	TVd20	TVf20	TVh20	TVa30	TVc30	TVe30	TVg30	TVb40	TVd40	TVf40	TVh40	TVa50	TVc50	TVe50	TVg50	TVb60	TVd60	TVf60	TVh60	TVg60	TVa70	TVc70	TVe70	TVg70	TVb80	TVd80	TVf80	TVh80	TVa90	TVc90	TVe90	TVf90	TVg90	TVb110	TVd110	TVe110	TVf110	TVg110	TVh110	TVf155	TVg155	Ntot
Amage adspersa	*Aa*	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Ampharete acutifrons	*Acu*	0	0	0	0	0	0	0	0	15	15	30	40	0	0	0	0	0	5	0	10	0	0	0	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**130**
Ancystrosyllis groenlandica	*Agro*	0	25	0	5	5	0	5	0	0	0	0	30	0	0	0	0	10	0	0	0	0	5	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**95**
Aonides oxycephala	*Aox*	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Aphelochaeta marioni	*Am*	0	0	0	5	0	0	0	0	0	10	10	0	0	0	0	0	5	0	0	5	0	0	0	0	15	0	0	0	0	0	45	5	0	0	0	0	5	0	0	0	5	0	0	0	0	0	0	0	0	0	**110**
Caulleriella multibranchiis	*Amu*	0	0	0	0	5	0	0	10	5	0	5	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	5	0	0	0	20	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**60**
Aponuphis bilineata	*Ab*	0	0	0	0	0	0	0	0	55	85	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	**155**
Aponuphis fauveli	*Af +Hfau*	0	0	0	0	0	0	0	0	0	0	0	55	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5	5	0	5	25	0	0	0	0	0	0	0	0	**115**
Brada villosa	*Bv*	0	0	0	0	0	0	0	0	0	0	30	10	5	45	45	0	70	25	50	10	5	15	0	10	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	**330**
Capitella capitata	*Cc*	0	0	0	0	0	0	0	0	0	0	0	335	0	0	0	0	0	0	0	5	0	5	0	0	0	0	0	5	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**360**
Capitomastus minimus	*Cm*	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Cirratulus cirratus	*Ccir*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	**5**
Clymenura clypeata	*Ccly*	0	0	0	0	0	0	0	0	25	45	5	40	5	0	5	0	0	0	0	15	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**145**
Diplocirrus glaucus	*Dg*	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Drilonereis filum	*Df*	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	10	5	5	0	0	0	0	0	10	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	**60**
Glycera capitata	*Gc*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	**5**
Glycera unicornis	*Gu*	0	0	0	0	0	0	0	0	10	0	10	50	10	15	10	5	10	5	5	5	5	0	0	10	15	15	0	30	15	20	20	0	10	5	0	5	5	0	10	5	0	0	0	5	0	5	0	5	0	0	**320**
Goniada maculata	*Gom*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Malmgreniella lunulata	*Hlu*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Heteromastus filiformis	*Hf*	0	0	0	0	0	0	0	0	0	0	0	70	0	15	0	0	25	10	20	10	20	20	5	15	0	5	5	25	0	20	10	0	0	5	5	5	0	0	5	10	5	30	0	0	0	0	0	0	0	0	**340**
Hyalinoecia tubicola	*Htub*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5	5	**15**
Laonice cf *cirrata*	*Lc*	0	0	0	0	0	0	0	0	0	0	0	0	5	20	20	0	0	0	55	40	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**145**
Leiocapitella glabra	*Ld*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	5	10	0	0	0	10	0	0	0	0	0	0	0	0	0	**30**
Lumbrineris coccinea	*Lcc*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Scoletoma emandibulata-mabiti	*Lem*	0	0	0	0	0	5	0	0	15	10	0	15	5	15	25	0	0	20	0	5	10	5	10	5	15	40	0	15	15	5	20	0	0	5	0	5	0	5	0	0	0	5	5	0	0	5	0	0	0	0	**285**
Scoletoma funchalensis	*Lfu*	0	0	0	5	0	0	0	0	0	0	0	5	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**25**
Lumbrineris latreilli	*Llat*	10	0	0	0	0	0	0	0	0	5	10	45	0	215	35	0	175	100	125	55	0	60	10	20	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0	**885**
Scoletoma tetraura	*Ltet*	0	0	0	10	5	0	0	30	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**85**
Magellona sp1	*Msp1*	0	0	0	5	0	0	0	0	5	0	0	0	0	0	0	0	0	5	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**25**
Magelona sp2	*Msp2*	5	25	30	5	5	5	0	50	0	0	15	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**145**
Marphysa belli	*Mbl*	0	0	0	0	0	0	0	0	25	0	0	45	0	0	0	0	0	5	10	5	5	0	0	0	0	5	5	5	0	0	0	0	5	0	0	0	5	0	5	5	0	5	0	5	5	10	0	0	0	0	**155**
Mediomastus fragilis	*Mfr*	65	10	35	0	15	0	0	0	0	15	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**155**
Melinna palmata	*Mpl*	0	0	0	0	0	0	0	0	95	130	115	110	0	5	15	5	0	5	10	15	0	0	0	10	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**520**
Metasychis gotoi	*Mgt*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Nematonereis unicornis	*Neu*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	5	0	0	0	0	**20**
Nephthys hystricis	*Nehy*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	**10**
Nothria conchilega	*Ncch*	5	10	10	0	5	0	260	35	5	30	55	85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**500**
Notomastus aberans	*Nab*	5	0	0	0	0	0	0	0	35	10	30	250	5	5	20	0	10	0	15	25	10	0	5	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**435**
Notomastus latericeus	*Nlat*	0	0	0	0	0	0	0	0	0	25	0	15	15	5	0	0	25	30	20	25	0	15	5	0	5	5	0	0	5	0	5	0	0	5	0	5	0	0	0	0	0	15	0	0	0	0	0	0	5	0	**230**
Onuphis eremita	*Oer*	40	95	35	0	20	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**205**
Onuphis sp.	Osp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	**5**
Owenia fusiformis	*Owf*	35	40	105	160	0	0	1130	1015	15	35	55	5	0	0	5	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2610**
Paralacydonia paradoxa	*Pp*	0	0	0	0	0	0	0	0	0	0	0	10	0	20	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	**40**
Paraonis spp.	Psp	20	10	0	0	85	15	100	265	30	15	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**545**
Paraprionospio cf *pinnata*	*Ppp*	0	0	0	0	0	0	0	0	0	0	0	0	15	30	25	0	55	20	40	30	15	65	15	65	80	15	15	40	10	0	10	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**555**
Pectinaria auricoma	*Pau*	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**20**
Pectinaria koreni	*Pko*	5	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**30**
Pilargis verrucosa	*Pvr*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5	10	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**25**
Pista cristata	*Pcr*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Poecilochaetus serpens	*Pos*	0	0	0	0	0	0	0	0	10	20	0	0	0	0	5	20	0	0	10	0	5	5	0	0	0	0	0	0	0	0	0	0	0	5	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	**90**
Praxillella gracilis	*Pxg*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	30	5	10	15	20	20	5	10	15	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	**155**
Prionospio ehlersi	*Preh*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Prionospio fallax	*Prml*	35	10	0	0	10	5	10	20	35	10	25	5	0	0	0	10	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**190**
Aquilaspio sexoculata	*Prsxo*	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Prionospio steenstrupi	*Prste*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	**5**
Protodorvillea kefersteini	*Pkf*	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Scolelepis cantabra	*Sccant*	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Scolelepis tridentata	*Sctr*	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Sigalion mathildae	*Sigm*	55	35	15	15	35	20	5	5	0	15	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**210**
Spio decoratus	*Sdec*	5	15	0	0	0	0	5	0	20	40	35	40	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**165**
Spio filicornis	*Sfil*	0	10	15	5	0	0	0	0	15	40	15	10	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**120**
Spio multioculata	*Smuo*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	5	0	5	5	5	0	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**45**
Spionidae sp.	Ssp	0	0	0	10	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5	0	0	5	0	0	0	0	0	0	0	0	**30**
Spiophanes bombyx	*Spbx*	0	0	10	5	0	0	0	0	10	0	25	40	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**100**
Sternaspis scutata	*Ssc*	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	30	5	50	20	0	10	20	10	10	10	0	15	15	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	**205**
Sthenelais boa	*Stbo*	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Sthenelais limicola	*Stlim*	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Terebellides stroemi	*Tstr*	0	0	0	0	0	0	0	0	0	0	0	10	0	20	0	0	25	5	5	15	15	25	5	25	5	0	5	30	10	0	25	15	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**245**
N tot		**285**	**285**	**255**	**240**	**190**	**55**	**1520**	**1455**	**435**	**560**	**525**	**1465**	**85**	**420**	**235**	**70**	**485**	**290**	**440**	**320**	**110**	**260**	**100**	**195**	**240**	**115**	**45**	**175**	**75**	**55**	**180**	**30**	**45**	**30**	**10**	**35**	**25**	**25**	**35**	**20**	**60**	**110**	**15**	**10**	**5**	**25**	**0**	**5**	**10**	**5**	**11665**

APPENDIX III: Species collected in the area of Sabaudia

SPECIES	ACRONYM	SAMPLING STATIONS																																																						
		SAa5	SAg5	SAi5	SAm5	SAb10	SAc10	SAe10	SAf10	SAh10	SAl10	SAn10	SAa20	SAd20	SAf20	SAi20	SAm20	SAb30	SAd30	SAe30	SAh30	SAl30	SAn30	SAa40	SAc40	SAd40	SAf40	SAg40	SAi40	SAm40	SAb50	SAe50	SAh50	SAl50	SAn50	SAa60	SAc60	SAd60	SAf60	SAg60	SAi60	SAm60	SAb80	SAc80	SAd80	SAe80	SAg80	SAh80	SAi80	SAl80	SAn80	SAa100	SAd100	SAf100	SAg100	SAi100	SAd115	Ntot
Ampharete acutifrons	*Acu*	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**
Ancistargis hamata	*Ah*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Ancystrosyllis groenlandica	*Agro*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**25**
Anobothrus gracilis	*Agra*	0	0	0	0	0	0	0	0	0	0	0	10	40	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**55**
Aonides paucibranchiata	*Ap*	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**
Aphelochaeta marioni	*Am*	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0	35	15	5	15	0	10	0	0	0	0	0	0	0	5	0	0	0	5	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**105**
Caulleriella multibranchiis	*Amu*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Aponuphis bilineata	*Ab*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	**15**
Aponuphis brementi	*Abr+Hbr*	0	0	10	0	0	0	0	0	5	0	0	70	125	5	5	5	5	50	10	0	75	0	0	0	5	0	0	0	15	0	0	0	0	0	0	0	30	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	**425**
Aponuphis fauveli	*Af +Hfau*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	**20**
Arabella iricolor	*Ai*	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0	15	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**40**
Armandia cirrhosa	*Ac*	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Brada villosa	*Bv*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**
Capitella capitata	*Cc*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Chaetozone sp.1	*Csp1*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	30	0	0	0	0	0	0	90	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**130**
Chetozone cf *setosa*	*Cs*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Chrysopetalum debile	*Cd*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Clymenura clypeata	*Ccly*	0	5	0	0	0	0	5	0	10	0	5	15	0	0	5	5	5	5	5	20	10	0	0	0	0	15	0	0	0	0	5	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**120**
Cossura soyeri	*Csoy*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	5	10	35	0	0	15	0	0	0	0	0	0	0	0	0	10	30	0	0	0	5	0	0	10	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	**145**
Diplocirrus glaucus	*Dg*	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**25**
Ditrupa arietina	*Da*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**50**
Dorvillea (Dorvillea) rubrovittata	*Dr*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Drilonereis filum	*Df*	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	15	5	0	15	0	0	5	0	5	0	0	10	10	0	0	0	0	5	10	0	5	0	0	0	0	0	0	5	0	5	5	0	0	0	0	5	0	0	5	0	**115**
Euclymene palermitana	*Epal*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Eunice harassii	*Eh*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**
Eunice pennata	*Epen*	0	0	0	0	0	0	0	0	0	0	0	0	10	5	0	0	0	0	0	0	0	10	0	0	15	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**50**
Glycera unicornis	*Gu*	0	5	0	0	0	0	0	5	0	0	0	0	15	5	0	0	15	5	10	5	5	0	0	0	25	15	0	0	0	5	0	5	0	0	0	5	5	10	0	0	0	0	0	5	0	0	0	0	0	0	5	0	0	0	5	0	**155**
Goniada emerita	*Goe*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**
Malmgreniella lunulata	*Hlu*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	5	0	0	0	5	0	0	0	0	5	0	0	15	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	**50**
Harmothoe spinifera	*Hsp*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Heteromastus filiformis	*Hf*	5	0	0	0	0	0	0	0	0	15	0	5	0	0	0	0	0	0	0	0	0	0	10	20	0	10	0	0	20	0	0	0	0	5	0	5	0	0	0	0	15	0	0	0	0	0	0	0	5	15	0	0	0	0	0	0	**130**
Hyalinoecia tubicola	*Htub*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	**50**
Hydroides pseudouncinatus	*Hps*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Laetmonice hystrix	*Lh*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	**5**
Laonice cf *cirrata*	*Lc*	0	0	0	0	0	0	0	0	0	0	0	45	20	0	0	0	0	15	0	40	0	0	5	10	5	0	15	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**165**
Leiocapitella glabra	*Ld*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	5	0	10	5	5	0	**35**
Leiochrides sp.	*Lsp*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	**10**
Lumbrineriopsis paradoxa	*Lpx*	0	5	0	0	0	0	0	0	15	0	0	0	20	0	0	5	5	10	30	10	5	0	0	0	5	20	0	0	0	0	10	10	5	20	0	5	0	0	5	0	10	5	0	0	10	0	0	5	5	15	0	0	0	0	5	0	**240**
Scoletoma emandibulata-mabiti	*Lem*	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	45	0	10	0	0	0	0	0	10	0	0	0	0	0	5	0	0	5	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**90**
Scoletoma fragilis	*Lfr*	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Lumbrineris gracilis	*Lgr*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**
Lumbrineris latreilli	*Llat*	0	10	0	0	0	5	20	0	25	0	30	45	35	10	5	0	125	130	75	420	0	10	165	15	20	160	115	80	10	30	5	20	15	80	20	0	10	0	0	0	15	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	**1710**
Scoletoma tetraura	*Ltet*	5	60	70	5	0	35	125	65	5	50	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**425**
Magellona sp1	*Msp1*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	5	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**20**
Magelona sp2	*Msp2*	25	110	50	40	25	95	55	40	110	40	30	0	5	0	0	0	5	0	0	0	0	20	0	0	0	0	5	5	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**675**
Malacoceros fuliginosus	*Mf*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**
Malacoceros tetraceros	*Mt*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**25**
Marphysa belli	*Mbl*	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	5	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**20**
Marphysa kinbergi	*Mk*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	5	0	0	0	0	10	0	0	0	0	5	10	5	15	0	0	5	0	0	0	10	0	5	0	0	0	0	5	0	0	0	10	**105**
Mediomastus fragilis	*Mfr*	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Melinna palmata	*Mpl*	0	0	0	0	0	0	5	0	0	0	0	15	55	0	0	0	0	5	0	0	5	0	15	0	0	10	5	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**120**
Metasychis gotoi	*Mgt*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	10	0	0	0	0	0	0	0	0	0	0	5	45	15	0	0	0	0	5	15	0	0	0	0	0	0	0	0	5	0	0	0	**105**
Monticellina dorsobranchialis	*Mdb*	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	10	5	0	0	5	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	25	0	0	0	0	0	0	**70**
Myriochele oculata	*Mocu*	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	20	0	20	5	10	0	5	0	0	0	0	0	5	45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**130**
Nematonereis unicornis	*Neu*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	5	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**40**
Nephthys hombergi	*Neh*	0	5	0	0	0	0	10	10	0	0	10	0	10	0	5	5	60	120	165	70	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**475**
Nephthys hystricis	*Nehy*	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	10	0	0	5	0	0	0	0	0	0	15	0	0	0	0	15	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	**70**
Nephthys incisa	*Nein*	0	0	0	0	0	0	0	0	0	0	0	0	35	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**45**
Nephthys sp.	*Nel*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Nichomache lumbricalis	*Nlum*	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Nothria conchilega	*Ncch*	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5	0	0	0	0	5	0	0	5	5	0	0	**35**
Notomastus aberans	*Nab*	0	0	5	0	5	0	0	0	0	0	0	30	30	0	0	0	5	10	20	15	50	0	0	0	10	0	0	20	15	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**220**
Notomastus latericeus	*Nlat*	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5	10	25	25	20	25	0	20	225	0	0	20	0	0	0	5	0	0	0	0	15	0	5	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	**415**
Notomastus lineatus	*Nlin*	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	20	0	0	0	15	0	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**65**
Onuphis eremita	*Oer*	0	0	0	5	0	15	0	0	0	0	5	0	0	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**40**
Onuphis sp2	*Oq*	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Owenia fusiformis	*Owf*	5	0	0	0	15	5	0	0	0	5	0	0	15	0	10	0	0	0	0	0	5	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**95**
Palola siciliensis	*Psc*	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**55**
Panthalis oerstedi	*Poe*	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Paralacydonia paradoxa	*Pp*	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	15	35	30	170	0	0	10	30	20	10	0	5	0	10	0	0	0	5	5	0	5	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	**365**
Paraprionospio cf *pinnata*	*Ppp*	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	40	40	10	45	10	0	70	15	0	15	0	25	5	30	0	10	5	10	5	0	0	0	0	5	20	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	**380**
Pectinaria auricoma	*Pau*	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	5	10	0	0	0	0	5	10	5	5	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**55**
Pherusa monilifera	*Phm*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**60**
Pherusa plumosa	*Php*	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	25	25	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**85**
Phyllodoce lineata	*Phyli*	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Phylo foetida	*Phf*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Phylo ligustica	*Phl*	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**20**
Phylo norvegica	*Phn*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Pilargis verrucosa	*Pvr*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	5	5	10	0	0	0	0	15	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**55**
Piromis eruca	*Per*	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Pista cristata	*Pcr*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**20**
Poecilochaetus serpens	*Pos*	10	0	0	5	0	0	0	0	0	0	5	20	25	0	10	0	0	5	5	0	105	465	5	20	0	5	0	0	215	0	0	5	0	5	0	0	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**920**
Polyodontes maxillosus	*Pmax*	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**20**
Praxillella gracilis	*Pxg*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	5	0	0	0	0	10	5	0	5	0	10	0	0	5	0	5	10	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	**70**
Prionospio caspersi	*Prca*	0	5	5	0	25	5	40	45	0	0	0	0	0	0	5	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	**165**
Minuspio cirrifera	*Prci*	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	225	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**240**
Prionospio ehlersi	*Preh*	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	5	5	0	0	0	5	0	5	0	0	10	0	0	0	0	0	0	0	0	0	5	0	0	25	0	0	0	0	0	0	**75**
Prionospio fallax	*Prml*	5	0	0	0	0	0	0	0	0	0	0	15	35	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**60**
Prionospio steenstrupi	*Prste*	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	10	0	0	0	0	5	0	0	0	5	0	0	0	0	0	0	**35**
Psammolyce arenosa	*Psar*	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Pseudoleiocapitella fauveli	*Pslcf*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	10	0	0	0	0	0	0	0	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**90**
Dorvillea (Schistomeringos) neglecta	*Schn*	0	35	0	0	0	0	0	5	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**70**
Scolaricia typica	*Scty*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Scolelepis squamata	*Scsq*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35	0	0	0	0	0	10	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**50**
Scolelepis tridentata	*Sctr*	0	0	0	5	0	0	0	0	0	0	10	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**25**
Scoloplos (Scoloplos) armiger	*Scpa*	0	85	50	10	0	0	20	45	80	30	45	0	0	0	5	15	0	230	245	160	10	5	0	0	0	10	0	0	5	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1055**
Sigalion mathildae	*Sigm*	0	60	10	5	0	0	0	30	30	0	0	0	10	0	10	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**160**
Sigalion squamosum	*Sigsq*	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**
Spio decoratus	*Sdec*	0	5	0	35	0	10	5	0	0	5	0	5	5	0	25	10	0	5	0	0	55	160	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**345**
Spio filicornis	*Sfil*	0	0	0	0	0	0	5	0	0	0	0	0	45	0	0	0	0	15	5	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**85**
Spio multioculata	*Smuo*	0	0	0	5	0	0	0	0	0	0	0	0	25	0	0	0	0	0	5	5	250	25	0	10	0	0	0	0	0	0	0	0	0	0	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	**350**
Spiophanes bombyx	*Spbx*	5	0	0	0	5	0	5	0	0	0	0	15	20	5	5	0	20	5	0	15	20	20	0	0	0	5	0	0	5	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**155**
Spiophanes kroyeri kroyeri	*Spkk*	0	10	0	0	0	0	5	5	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**40**
Sternaspis scutata	*Ssc*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	5	50	35	0	0	40	0	0	10	15	5	0	5	5	0	5	30	0	5	5	5	0	10	5	0	0	0	0	0	0	0	5	10	0	0	0	5	0	0	**280**
Sthenelais boa	*Stbo*	0	0	0	0	0	0	5	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**
Terebellides stroemi	*Tstr*	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	20	10	20	0	0	40	5	10	45	30	5	0	30	10	10	0	0	10	0	15	10	0	0	10	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	**310**
N tot		**60**	**430**	**200**	**115**	**95**	**180**	**380**	**250**	**325**	**145**	**140**	**360**	**650**	**40**	**95**	**135**	**540**	**910**	**790**	**1475**	**735**	**915**	**425**	**200**	**450**	**365**	**200**	**210**	**565**	**170**	**55**	**75**	**55**	**310**	**110**	**55**	**225**	**110**	**30**	**25**	**125**	**5**	**5**	**60**	**30**	**10**	**15**	**10**	**25**	**135**	**10**	**25**	**35**	**15**	**25**	**15**	**13145**

APPENDIX IV: Species collected in the area of Terracina

SPECIES	ACRONYM	SAMPLING STATIONS																																																		
		TEb5	TEd5	TEf5	TEh5	TEn5	TEp5	TEa10	TEc10	TEe10	TEg10	TEm10	TEo10	TEn20	TEp20	TEg30	TEm30	TEo30	TEb40	TEd40	TEf40	TEh40	TEl40	TEn40	TEp40	TEa50	TEc50	TEe50	TEg50	TEi50	TEm50	TEo50	TEa60	TEb60	TEd60	TEf60	TEh60	TEl60	TEn60	TEo60	TEp60	TEa80	TEc80	TEe80	TEg80	TEi80	TEm80	TEn80	TEo80	TEn100	TEo100	Ntot
Amage adspersa	Aa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Ampharete acutifrons	Acu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5	0	5	0	0	0	0	0	10	0	0	5	0	15	5	0	0	0	0	0	0	0	50
Amphicteis gunneri	Ag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Anobothrus gracilis	Agra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5	0	10	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30
Aonides oxycephala	Aox	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
Aphelochaeta marioni	Am	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
Caulleriella multibranchiis	Amu	0	10	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
Aponuphis bilineata	Ab	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	5	5	0	0	0	0	35	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5	0	0	0	0	70
Aponuphis brementi	Abr+Hbr	0	0	0	5	0	0	0	0	5	0	0	0	70	40	0	165	155	0	70	80	0	20	0	0	0	0	105	0	0	0	0	40	45	10	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	815
Aponuphis fauveli	Af +Hfau	0	0	10	0	0	0	0	5	5	0	0	0	5	0	0	0	0	75	225	155	20	100	25	0	0	20	200	5	5	0	0	0	30	15	0	0	0	0	0	0	0	15	10	0	0	0	0	0	0	0	925
Arabella iricolor	Ai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	5	0	5	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30
Axiothella constricta	Axc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Brada villosa	Bv	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Capitella capitata	Cc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Capitella giardi	Cg	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Chaetozone sp.1	Csp1	0	0	0	5	0	0	0	0	0	0	0	0	15	30	0	25	20	0	0	5	5	0	0	0	10	5	0	0	0	0	0	5	5	10	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	145
Chetozone cf setosa	Cs	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	20
Chrysopetalum debile	Cd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Clymenura clypeata	Ccly	0	0	0	0	0	0	5	0	5	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Cossura soyeri	Csoy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
Diplocirrus glaucus	Dg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Ditrupa arietina	Da	0	0	0	0	0	0	0	0	0	0	0	0	0	10	5	5	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30
Drilonereis filum	Df	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	10	0	5	5	10	0	0	5	10	0	0	0	0	10	10	0	0	5	0	0	0	0	5	0	0	0	0	0	0	0	0	0	80
Euclymene lumbricoides	Elum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Eunice antennata	Ea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Eunice oerstedi	Eo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Eunice pennata	Epen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25
Eunice vittata	Evit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	115	0	0	0	45	35	30	10	5	10	0	0	0	0	5	0	0	20	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	285
Euphrosine foliosa	Euf	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Flabelligera diplochaitus	Fd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Glycera unicornis	Gu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	10	10	0	0	0	0	0	0	30	5	0	0	0	5	0	0	0	5	0	0	0	0	5	0	0	0	0	75
Goniada emerita	Goe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Malmgreniella ljungmani	Hl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
Malmgreniella lunulata	Hlu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	5	5	0	0	10	0	0	5	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50
Hesione splendida	Hpan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	55
Heteromastus filiformis	Hf	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	5	0	0	10	0	10	0	0	30	20	5	5	15	15	5	0	0	0	0	5	5	0	0	0	10	145
Hyalinoecia tubicola	Htub	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	5	0	15	0	0	0	5	0	5	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	55
Hydroides pseudouncinatus	Hps	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Laetmonice hystrix	Lh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Laonice cf cirrata	Lc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5	0	0	20	5	5	15	0	5	15	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80
Leiocapitella glabra	Ld	5	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0	15	5	0	0	0	0	0	0	0	45
Lumbrineriopsis paradoxa	Lpx	0	0	5	0	0	0	10	0	0	0	0	0	0	0	5	0	0	0	0	5	5	0	5	5	0	5	0	0	5	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	70
Scoletoma emandibulata-mabiti	Lem	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Scoletoma fragilis	Lfr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Scoletoma funchalensis	Lfu	0	0	0	320	0	0	0	0	0	0	80	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	415
Lumbrineris gracilis	Lgr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Lumbrineris latreilli	Llat	0	0	0	10	0	0	0	0	0	0	35	0	15	0	120	5	0	10	15	5	55	10	20	5	15	20	10	15	20	5	0	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	400
Scoletoma tetraura	Ltet	75	45	25	0	10	0	10	25	45	0	0	60	0	0	0	0	0	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	310
Lysidice ninetta	LYn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Magellona sp1	Msp1	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Magelona sp2	Msp2	155	350	140	730	0	0	60	70	135	40	70	60	20	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	1840
Malacoceros fuliginosus	Mf	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5
Marphysa belli	Mbl	0	0	0	0	0	0	0	0	0	5	10	0	0	0	0	5	10	0	0	0	15	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50
Marphysa fallax	Mfx	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Marphysa kinbergi	Mk	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	10	5	0	0	0	0	0	0	0	0	5	0	0	5	0	0	0	10	0	0	0	0	0	0	0	10	0	10	0	0	0	0	60
Mediomastus capensis	Mcp	35	5	0	0	0	0	0	0	15	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60
Mediomastus fragilis	Mfr	120	40	45	90	0	5	30	45	40	20	35	15	0	5	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
Melinna palmata	Mpl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	25
Metasychis gotoi	Mgt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	20	15	5	0	5	0	15	10	15	10	5	0	0	10	0	0	10	5	15	0	5	5	15	0	0	0	0	0	5	0	0	190
Monticellina dorsobranchialis	Mdb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5	0	0	0	15	0	0	0	0	5	20	0	0	5	0	0	0	0	0	0	10	0	0	5	0	0	0	0	70
Myriochele oculata	Mocu	10	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	10	5	0	0	0	0	0	0	5	5	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65
Nematonereis unicornis	Neu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	60	20	5	0	0	5	15	0	0	0	0	0	0	0	40	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	165
Nephthys hombergi	Neh	10	15	10	5	0	0	10	5	0	5	0	0	0	0	0	0	0	0	5	30	0	0	0	0	0	0	25	0	0	0	0	15	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	160
Nephthys hystricis	Nehy	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	5	0	0	0	0	20	0	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5	0	0	0	0	5	55
Nephthys incisa	Nein	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	10
Ninoe armoricana	Nar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	5	0	5	5	10	0	5	0	5	15	0	0	10	0	0	65
Nothria conchilega	Ncch	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Notomastus aberans	Nab	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	105	0	0	5	115	65	15	45	0	0	5	5	0	5	0	10	0	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	395
Notomastus latericeus	Nlat	0	0	0	0	0	0	0	10	0	0	5	0	0	0	25	15	70	15	0	25	35	5	30	5	0	0	25	10	10	0	0	45	25	10	0	5	0	0	0	0	0	0	0	0	5	10	0	0	0	0	385
Orbinia cuvieri	Ocu	0	0	0	0	0	0	0	0	10	0	5	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
Owenia fusiformis	Owf	130	135	30	20	0	5	10	15	0	0	0	0	0	0	5	0	0	0	5	0	0	0	0	0	5	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	370
Palola siciliensis	Psc	0	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	265
Paralacydonia paradoxa	Pp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	90	5	45	40	40	85	15	5	0	40	0	25	0	0	15	45	0	5	0	0	5	0	0	0	0	0	0	0	0	5	5	0	0	490
Paraprionospio cf pinnata	Ppp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	15	45	10	15	0	10	15	0	25	10	15	0	0	5	0	5	15	10	5	35	0	0	0	0	0	0	0	0	0	0	245
Pectinaria auricoma	Pau	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
Petaloproctus terricolus	Ptr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Petta pusilla	Pepu	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Pherusa plumosa	Php	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5
Phyllodoce cf maculata	Phyb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
Phyllodoce laminosa	Phyl	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Phyllodoce lineata	Phyli	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Phyllodoce macrophthalma	Phymo	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Phylo ligustica	Phl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25
Pilargis verrucosa	Pvr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	5	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25
Pista cristata	Pcr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	5	10	25	5	0	0	0	10	15	15	5	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	110
Poecilochaetus serpens	Pos	0	5	0	5	0	0	0	0	0	0	0	0	5	10	0	35	55	0	10	70	5	0	10	5	0	10	70	15	45	0	0	10	15	75	25	0	0	0	0	0	0	5	5	0	10	30	5	5	0	5	545
Polyodontes maxillosus	Pmax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5	5	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	30
Pomatoceros lamarckii	Plam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Praxillella affinis	Pxa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Praxillella gracilis	Pxg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	30	0	0	0	0	0	5	10	5	5	0	0	0	5	5	5	0	0	0	5	80
Prionospio caspersi	Prca	380	615	85	125	0	0	175	130	200	25	85	5	105	0	0	55	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1995
Minuspio cirrifera	Prci	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Prionospio ehlersi	Preh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	5	0	0	5	5	0	0	0	0	15	0	15	0	5	10	20	15	35	10	0	10	20	5	0	0	190
Prionospio fallax	Prml	0	0	0	0	0	0	0	5	5	0	5	0	0	0	0	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35
Prionospio steenstrupi	Prste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	15	25	0	5	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	5	0	10	80
Protodorvillea kefersteini	Pkf	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Pseudoleiocapitella fauveli	Pslcf	5	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	10	5	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	40
Sabellides octocirrata	Sboc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Scalibregma inflatum	Scin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Dorvillea (Schistomeringos) neglecta	Schn	5	0	15	5	0	0	0	0	5	0	0	0	0	0	10	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60
Dorvillea (Schistomeringos) rudolphii	Schr	0	10	0	0	0	0	0	0	0	0	0	0	0	0	45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	55
Schlerocheilus minutus	Sclm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Scolelepis cantabra	Sccant	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Scolelepis foliosa	Scfo	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Scolelepis squamata	Scsq	0	5	0	0	0	0	0	0	0	0	0	5	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
Scolelepis tridentata	Sctr	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Scoloplos (Scoloplos) armiger	Scpa	20	35	25	20	0	30	40	20	40	20	35	100	5	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	400
Serpula concharum	Sech	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Sigalion mathildae	Sigm	5	5	10	20	10	0	50	40	10	5	15	0	25	10	5	5	0	0	0	5	5	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	230
Sigambra tentaculata	Site	0	15	5	5	0	0	0	10	0	0	10	25	5	0	10	5	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
Spio decoratus	Sdec	5	10	10	5	55	10	70	80	0	15	90	30	135	125	0	95	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	825
Spio multioculata	Smuo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	5	5	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	40
Spiophanes bombyx	Spbx	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	5	10	0	0	0	0	0	0	0	5	0	5	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45
Spiophanes kroyeri kroyeri	Spkk	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	15	0	0	0	0	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35
Spiophanes sp.	Ssp	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Sternaspis scutata	Ssc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	10	10	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0	5	0	0	0	45
Terebellides stroemi	Tstr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35	0	0	0	5	5	5	0	5	5	5	0	0	0	5	5	5	10	5	0	15	5	0	20	0	0	0	0	0	0	0	0	0	0	0	0	135
Vermiliopsis infundibulum	Vinf	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60
N tot		**960**	**1560**	**415**	**1385**	**75**	**55**	**495**	**510**	**520**	**135**	**490**	**315**	**470**	**270**	**755**	**590**	**470**	**420**	**500**	**715**	**370**	**265**	**305**	**145**	**130**	**180**	**620**	**90**	**280**	**45**	**95**	**305**	**340**	**185**	**110**	**60**	**65**	**85**	**40**	**75**	**45**	**100**	**90**	**40**	**50**	**85**	**40**	**35**	**0**	**45**	**15425**

APPENDIX V: Species collected in the area of Gaeta

SPECIES	ACRONYM	SAMPLING STATIONS																											
		GTa20	GTb20	GTc20	GTd20	GTe20	GTb30	GTc30	GTd30	GTe30	GTb40	GTa40	GTc40	GTd40	GTe40	GTb50	GTc50	GTd50	GTe50	GTa60	GTb60	GTd60	GTc60	GTe60	GTb70	GTc70	GTd70	GTe70	N tot
Ampharete acutifrons	*Acu*	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	5	0	**15**
Aphelochaeta marioni	*Am*	10	10	5	0	0	5	10	5	0	0	0	0	5	0	5	0	0	0	5	0	0	10	5	5	0	10	5	**95**
Aponuphis bilineata	*Ab*	0	55	5	25	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**95**
Brada villosa	*Bv*	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	**10**
Chaetozone sp.1	*Csp1*	15	0	0	0	0	0	0	0	0	0	0	5	0	0	0	10	0	0	5	0	0	0	0	0	0	0	0	**35**
Clymenura clypeata	*Ccly*	0	0	0	0	25	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**45**
Diplocirrus glaucus	*Dg*	25	0	20	0	0	0	10	10	10	5	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**95**
Ditrupa arietina	*Da*	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Drilonereis filum	*Df*	20	0	25	0	0	5	0	5	0	0	0	0	0	0	0	5	0	0	0	0	5	0	0	5	10	0	0	**80**
Eunice vittata	*Evit*	0	10	0	0	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**45**
Glycera unicornis	*Gu*	0	5	10	5	10	5	10	0	20	10	5	5	5	5	5	5	5	15	0	10	5	0	10	15	5	10	5	**185**
Heteromastus filiformis	*Hf*	0	0	0	0	0	0	5	0	20	5	0	0	5	0	10	0	5	5	0	10	0	0	10	0	0	10	5	**90**
Laonice cirrata	*Lc*	35	25	0	0	10	15	5	5	25	5	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	**135**
Scoletoma emandibulata-mabiti	*Lem*	40	10	15	5	10	5	20	10	10	0	15	5	0	0	0	0	10	5	0	30	0	5	20	5	0	5	5	**230**
Scoletoma funchalensis	*Lfu*	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Lumbrineris gracilis	*Lgr*	0	5	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**
Lumbrineris latreilli	*Llat*	120	0	80	5	0	50	60	35	25	5	5	20	20	15	0	10	0	0	0	0	0	0	0	0	0	0	0	**450**
Scoletoma tetraura	*Ltet*	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Magellona sp1	*Msp1*	0	0	0	0	0	0	5	0	5	0	10	0	10	10	0	5	10	0	0	0	0	0	0	0	0	0	0	**55**
Marphysa kinbergi	*Mk*	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	10	0	5	**25**
Melinna palmata	*Mpl*	5	55	5	0	35	0	0	0	0	0	0	10	15	0	5	5	5	0	0	0	0	0	0	0	5	0	5	**150**
Monticellina dorsobranchialis	*Mdb*	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5	0	**20**
Myriochele oculata	*Mocu*	0	15	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**20**
Eteone picta	*Mpc*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	10	0	0	0	0	**15**
Nephthys hombergi	*Neh*	25	60	35	75	25	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	**225**
Nephthys hystricis	*Nehy*	25	0	15	0	0	5	5	5	10	25	0	0	0	0	0	0	10	5	0	0	5	0	5	0	5	0	0	**120**
Nephthys incisa	*Nein*	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Eunereis longissima	*Nlong*	0	0	10	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**
Notomastus aberans	*Nab*	95	15	50	45	5	35	45	10	30	0	0	0	0	15	0	0	0	5	0	0	5	0	0	5	0	0	5	**365**
Notomastus latericeus	*Nlat*	0	0	0	0	0	0	5	0	0	0	0	5	0	0	0	5	0	0	0	0	0	0	5	0	0	0	0	**20**
Owenia fusiformis	*Owf*	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Paralacydonia paradoxa	*Pp*	0	0	0	0	0	0	0	5	10	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**20**
Paraprionospio pinnata	*Ppp*	0	0	0	0	5	0	0	0	0	0	0	15	5	0	0	10	0	5	0	10	0	0	5	0	0	5	0	**60**
Pectinaria auricoma	*Pau*	5	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**
Pectinaria koreni	*Pko*	5	5	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**
Phylo foetida	*Phf*	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Pilargis verrucosa	*Pvr*	10	0	5	10	0	0	20	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**55**
Pista cristata	*Pcr*	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5	0	0	0	0	0	0	0	0	0	0	0	**10**
Poecilochaetus serpens	*Pos*	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5	5	5	**25**
Praxillella gracilis	*Pxg*	0	0	0	0	0	5	0	0	0	0	5	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	**20**
Prionospio steenstrupi	*Prste*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	**10**
Pseudoleiocapitella fauveli	*Pslcf*	45	0	5	0	0	10	25	15	0	0	40	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	**145**
Scolaricia typica	*Scty*	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Polydora ciliata	*Sccil*	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	15	5	0	5	0	**35**
Scoloplos (Scoloplos) armiger	*Scpa*	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Spio filicornis	*Sfil*	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**30**
Spiochaetopterus costarum	*Sctcst*	10	0	15	0	10	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**40**
Sternaspis scutata	*Ssc*	25	0	5	0	0	50	35	15	50	5	0	0	10	0	0	0	5	0	5	5	5	5	5	10	0	0	0	**235**
Terebellides stroemi	*Tstr*	5	0	0	0	0	0	0	0	5	0	0	0	0	0	5	5	5	0	5	0	0	0	5	5	0	5	5	**50**
N tot		**530**	**295**	**310**	**175**	**215**	**210**	**280**	**130**	**250**	**65**	**90**	**70**	**100**	**65**	**40**	**75**	**60**	**40**	**20**	**70**	**30**	**25**	**110**	**55**	**40**	**70**	**45**	**3465**

APPENDIX VI: statistic outputs PERMANOVA tests

```
PERMANOVA
Permutational MANOVA

Resemblance worksheet
Name: Resem7
Data type: Similarity
Selection: All
Transform: Square root
Resemblance: S17 Bray Curtis similarity

Sums of squares type: Type III (partial)
Permutation method: Permutation of residuals under the full model
Number of permutations: 4999

FACTORS
Name    Type    Levels
depth   Fixed      6
area    Fixed      5

                                                                     Unique
Source            df        SS          MS    Pseudo-F   P(perm)     perms    P(MC)
depth              2     43968       21984      9,0321    0,0002      4974   0,0002
area               2     34014       17007      6,9873    0,0002      4973   0,0002
depthxarea**      14     87686      6263,3      2,5733    0,0002      4923   0,0002
Res              189  4,6002E5        2434
Total            212  8,0145E5

** Term has one or more empty cells

Details of the expected mean squares (EMS) for the model
Source          EMS
depth           1*Res + 42,949*depth
area            1*Res + 38,08*area
depthxarea      1*Res + 8,3223*depthxarea

Numerator terms
Source          Terms included in the numerator
depth           1*depth
area            1*area
depthxarea      1*depthxarea

Denominator terms
Source          Terms included in the denominator
depth           1*Res
area            1*Res
depthxarea      1*Res

COMPONENTS OF VARIATION
Source          Estimate     Sq.root
depth             455,19      21,335
area              382,69      19,563
depthxarea        460,13      21,451
```

```
PERMANOVA
Permutational MANOVA

Resemblance worksheet
Name: Resem7
Data type: Similarity
Selection: All
Transform: Square root
Resemblance: S17 Bray Curtis similarity

Sums of squares type: Type III (partial)
Permutation method: Permutation of residuals under the full model
Number of permutations: 4999

FACTORS
Name    Type    Levels
depth   Fixed        6
area    Fixed        5
```

depth group: 1=5-10 m, 2=20-30 m, 3=40-50 m, 4=60-70 m, 5=80-90 m and 6=100-115 m

```
PAIRWISE TESTS

Term 'depthxarea' for pairs of levels of factor 'depth'

Within level 'GT' of factor 'area'
                                            Unique
Groups            t              P(perm)     perms    P(MC)
2, 3         2,1029               0,0002      4467   0,0008
2, 4         2,4663               0,0002      4504   0,0002
3, 4         1,8059               0,0002      4497   0,0048
1, 5      No test, df = 0
1, 6      No test, df = 0
5, 6      No test, df = 0

Average Similarity between/within groups
       2        3        4     1   5   6
2  42,044
3  25,721   33,431
4  21,708   26,559   35,767
1      0        0        0     0
5      0        0        0     0   0
6      0        0        0     0   0   0

Within level 'TE' of factor 'area'
                                 Unique
Groups       t      P(perm)      perms     P(MC)
2, 3      2,1202    0,0002       4046     0,0002
2, 4      2,1318    0,0002       1843     0,0022
2, 1      2,3294    0,0002       3473     0,0004
2, 5      2,3357    0,0002       1261     0,0004
2, 6      1,5896    0,1664          6      0,116
3, 4      1,6502    0,0106       4966     0,0182
3, 1      4,0046    0,0002       4962     0,0002
3, 5      2,3636    0,0002       4936     0,0002
3, 6      1,4207     0,073         15      0,062
```

4, 1	3,6089	0,0002	4933	0,0002
4, 5	1,3855	0,0604	4543	0,0796
4, 6	1,1141	0,3954	10	0,2812
1, 5	3,6119	0,0002	4882	0,0002
1, 6	2,0869	0,0002	13	0,0022
5, 6	1,1915	0,2278	9	0,2418

Average Similarity between/within groups

	2	3	4	1	5	6
2	34,977					
3	16,109	31,355				
4	10,568	23,577	27,391			
1	21,401	4,8737	2,4194	43,819		
5	6,3085	14,217	22,755	1,9693	27,306	
6	5,2777	13,646	21,502	2,0094	19,59	0

Within level 'SA' of factor 'area'

Groups	t	P(perm)	Unique perms	P(MC)
2, 3	1,8568	0,0002	4972	0,0008
2, 4	1,8262	0,0002	4610	0,0024
2, 1	2,5794	0,0002	4942	0,0002
2, 5	2,1664	0,0002	4883	0,0002
2, 6	2,2247	0,0002	4109	0,0002
3, 4	1,1752	0,1182	4751	0,1904
3, 1	3,2047	0,0002	4964	0,0002
3, 5	1,9315	0,0002	4932	0,001
3, 6	2,2892	0,0002	4338	0,0002
4, 1	2,6972	0,0002	4613	0,0002
4, 5	1,1942	0,131	4025	0,1844
4, 6	1,447	0,0098	1632	0,0654
1, 5	2,6972	0,0002	4900	0,0002
1, 6	2,748	0,0002	4107	0,0002
5, 6	1,2913	0,0912	3152	0,1384

Average Similarity between/within groups

	2	3	4	1	5	6
2	27,671					
3	21,165	30,144				
4	13,8	24,039	20,815			
1	16,083	10,061	6,8295	38,375		
5	4,8744	10,816	13,894	2,6298	12,612	
6	3,5378	5,0837	11,29	1,4748	10,081	17,097

Within level 'TV' of factor 'area'

Groups	t	P(perm)	Unique perms	P(MC)
2, 3	2,3249	0,0002	3422	0,0004
2, 4	2,3521	0,0002	4519	0,0002
2, 1	2,5705	0,0002	3470	0,0002
2, 5	2,3291	0,0002	4526	0,0004
2, 6	2,2581	0,0002	1256	0,001
3, 4	2,0851	0,0002	4503	0,0014
3, 1	4,4249	0,0002	3460	0,0002
3, 5	2,7679	0,0002	4509	0,0002
3, 6	3,1796	0,0002	1264	0,0002
4, 1	3,617	0,0002	4530	0,0002

```
4, 5        2,0421     0,0002      4529     0,0036
4, 6        2,1709     0,0002      1846      0,003
1, 5        3,2825     0,0002      4483     0,0002
1, 6        2,8869     0,0002       942     0,0002
5, 6        1,6071     0,0202      1835      0,048

Average Similarity between/within groups
       2          3          4          1          5          6
2   31,794
3   28,983     56,875
4   17,542      35,97     37,206
1   15,525      3,856     2,4456      41,05
5   12,231     19,538     21,038     1,4256     29,554
6   6,8175     7,9822     13,738    0,87754     19,914     29,655

Within level 'MT' of factor 'area'
                                                    Unique
Groups            t                    P(perm)       perms      P(MC)
2, 3             1,2807                 0,0622        4020      0,1072
2, 4             1,2955                 0,0582         994      0,1322
3, 4             1,9987                 0,0002        4983      0,0002
1, 5        No test, df = 0
1, 6        No test, df = 0
5, 6        No test, df = 0

Average Similarity between/within groups
       2          3          4        1   5   6
2   19,398
3   25,683     35,578
4   15,715     21,031     21,265
1      0          0          0        0
5      0          0          0        0   0
6      0          0          0        0   0   0
```

```
PERMANOVA
Permutational MANOVA

Resemblance worksheet
Name: Resem7
Data type: Similarity
Selection: All
Transform: Square root
Resemblance: S17 Bray Curtis similarity

Sums of squares type: Type III (partial)
Permutation method: Permutation of residuals under the full model
Number of permutations: 4999

FACTORS
Name     Type     Levels
depth    Fixed         6
area     Fixed         5
```

depth group: 1=5-10 m, 2=20-30 m, 3=40-50 m, 4=60-70 m, 5=80-90 m and 6=100-115 m

```
PAIRWISE TESTS

Term 'depthxarea' for pairs of levels of factor 'area'

Within level '2' of factor 'depth'
                                        Unique
Groups        t       P(perm)      perms      P(MC)
GT, TE     2,7904      0,0002       1844     0,0002
GT, SA      2,241      0,0002       4896     0,0002
GT, TV     2,0593      0,0004       4509     0,0014
GT, MT     1,0256       0,389        713     0,3748
TE, SA     1,5755      0,0112       2977     0,0306
TE, TV     2,0172       0,001       1259      0,007
TE, MT     1,8054      0,0002        126     0,0208
SA, TV     1,7226      0,0032       4815     0,0086
SA, MT     1,5573      0,0054       1328     0,0252
TV, MT     1,1996       0,156        459     0,2072

Average Similarity between/within groups
        GT          TE          SA          TV          MT
GT   42,044
TE   9,5241     34,977
SA   20,781     21,811      27,671
TV   24,408     15,445       21,43      31,794
MT   31,202     8,2493      14,914      22,583      19,398

Within level '3' of factor 'depth'
                                        Unique
Groups        t       P(perm)      perms      P(MC)
GT, TE      2,531      0,0002       4971     0,0002
GT, SA     1,9611      0,0002       4935     0,0002
GT, TV     2,3339      0,0002       4521     0,0002
GT, MT     1,9586      0,0002       4976     0,0006
TE, SA      1,678      0,0002       4980     0,0032
TE, TV     2,5921      0,0002       4946     0,0002
TE, MT     2,5177      0,0002       4980     0,0002
SA, TV     1,7606      0,0004       4885     0,0038
```

```
SA, MT     2,2349     0,0002      4969     0,0002
TV, MT     2,2712     0,0002      4973     0,0002

Average Similarity between/within groups
          GT        TE        SA        TV        MT
GT   33,431
TE   16,386    31,355
SA   22,407    25,546    30,144
TV   29,993    25,534    34,687    56,875
MT     27,2    22,682    24,195    33,746    35,578

Within level '4' of factor 'depth'
                                    Unique
Groups         t     P(perm)       perms     P(MC)
GT, TE     2,1276     0,0002        4522    0,0012
GT, SA     1,5141     0,0068        4048     0,033
GT, TV      1,886     0,0002        4488    0,0046
GT, MT     1,6422     0,0006        4833    0,0116
TE, SA     1,1515     0,2024        4025    0,2324
TE, TV     1,8339     0,0014        4509    0,0082
TE, MT     1,7593     0,0002        4839     0,006
SA, TV     1,6525     0,0002        4035    0,0146
SA, MT     1,5005     0,0004        4372     0,026
TV, MT     1,6292     0,0008        4838    0,0152

Average Similarity between/within groups
          GT        TE        SA        TV        MT
GT   35,767
TE   17,517    27,391
SA   21,663    21,995    20,815
TV   27,541    22,086    20,831    37,206
MT   21,199    15,114      14,8    22,247    21,265

Within level '1' of factor 'depth'
                                              Unique
Groups               t             P(perm)     perms     P(MC)
GT, MT     No test, df = 0
TE, SA          1,9672              0,0002      4970    0,0012
TE, TV          2,9377              0,0002      4882    0,0002
SA, TV          2,7442              0,0002      4800    0,0002

Average Similarity between/within groups
       GT      TE         SA        TV      MT
GT     0
TE     0   43,819
SA     0   33,217     38,375
TV     0   20,998     19,558     41,05
MT     0        0          0         0       0

Within level '5' of factor 'depth'
                                              Unique
Groups               t             P(perm)     perms     P(MC)
GT, MT     No test, df = 0
TE, SA          1,6966               0,002      4502    0,0094
TE, TV          2,1879              0,0002      4489    0,0004
SA, TV          2,0027              0,0002      4510    0,0006
```

Average Similarity between/within groups

	GT	TE	SA	TV	MT
GT	0				
TE	0	27,306			
SA	0	10,455	12,612		
TV	0	12,796	6,8765	29,554	
MT	0	0	0	0	0

Within level '6' of factor 'depth'

Groups	t	P(perm)	Unique perms	P(MC)
GT, MT	No test, df = 0			
TE, SA	1,1958	0,279	7	0,257
TE, TV	1,3815	0,1684	5	0,2196
SA, TV	1,6758	0,014	462	0,0484

Average Similarity between/within groups

	GT	TE	SA	TV	MT
GT	0				
TE	0	0			
SA	0	5,3211	17,097		
TV	0	7,388	8,5991	29,655	
MT	0	0	0	0	0

```
PERMANOVA
Permutational MANOVA

Resemblance worksheet
Name: Resem4
Data type: Similarity
Selection: All
Resemblance: S7 Jaccard

Sums of squares type: Type III (partial)
Permutation method: Permutation of residuals under the full model
Number of permutations: 4999

FACTORS
Name          Type    Levels
depth_range   Fixed        6
area          Fixed        5

                                                                          Unique
Source                     df         SS         MS   Pseudo-F   P(perm)   perms    P(MC)
depth_range                 2      35065      17533     5,9428    0,0002    4945   0,0002
area                        2      30912      15456      5,239    0,0002    4948   0,0002
depth_rangexarea**         14      89115     6365,3     2,1576    0,0002    4888   0,0002
Res                       189   5,5759E5     2950,2
Total                     212   8,5777E5

** Term has one or more empty cells

Details of the expected mean squares (EMS) for the model
Source               EMS
depth_range          1*Res + 42,949*depth_range
area                 1*Res + 38,08*area
depth_rangexarea     1*Res + 8,3223*depth_rangexarea

Numerator terms
Source               Terms included in the numerator
depth_range          1*depth_range
area                 1*area
depth_rangexarea     1*depth_rangexarea

Denominator terms
Source               Terms included in the denominator
depth_range          1*Res
area                 1*Res
depth_rangexarea     1*Res

COMPONENTS OF VARIATION
Source               Estimate    Sq.root
depth_range            339,53     18,426
area                   328,42     18,122
depth_rangexarea       410,36     20,257
```

```
PERMANOVA
Permutational MANOVA

Resemblance worksheet
Name: Resem4
Data type: Similarity
Selection: All
Resemblance: S7 Jaccard

Sums of squares type: Type III (partial)
Permutation method: Permutation of residuals under the full model
Number of permutations: 4999

FACTORS
Name            Type    Levels
depth_range     Fixed        6
area            Fixed        5
```

depth group: 1=5-10 m, 2=20-30 m, 3=40-50 m, 4=60-70 m, 5=80-90 m and 6=100-115 m

```
PAIRWISE TESTS

Term 'depth_rangexarea' for pairs of levels of factor 'depth_range'

Within level '4' of factor 'area'
                                  Unique
Groups       t        P(perm)      perms     P(MC)
1, 2      1,9115      0,0002       3440     0,0002
1, 3      3,2212      0,0002       4963     0,0002
1, 4      2,9699      0,0002       4932     0,0002
1, 5      2,8226      0,0002       4874     0,0002
1, 6      1,7562      0,0002         13     0,0054
2, 3      1,8062      0,0002       4050     0,0008
2, 4      1,8467      0,0002       1840     0,0056
2, 5      1,8483      0,0002       1256     0,0022
2, 6      1,3879       0,158          6     0,1704
3, 4      1,4893      0,0116       4967     0,0228
3, 5      1,9182      0,0002       4937     0,0002
3, 6      1,2977       0,068         15     0,0904
4, 5      1,2659      0,0678       4488     0,1134
4, 6      1,1078      0,4084         10     0,2922
5, 6       1,078      0,5628          9      0,347

Average Similarity between/within groups
       1          2          3          4          5       6
1  33,952
2  17,403     24,999
3  4,6718     12,252     23,384
4  2,3083     7,7272      17,47     20,926
5    2,07     5,4081     10,276     15,638     17,444
6  2,0974     4,8901     9,8393     15,098     14,002       0

Within level '3' of factor 'area'
                                  Unique
Groups       t        P(perm)      perms     P(MC)
1, 2      2,0194      0,0002       4941     0,0002
1, 3      2,3709      0,0002       4960     0,0002
1, 4      2,0475      0,0002       4610     0,0004
```

1, 5	2,0969	0,0002	4892	0,0002
1, 6	2,0812	0,0002	4102	0,0002
2, 3	1,6998	0,0002	4972	0,0014
2, 4	1,6462	0,0002	4610	0,003
2, 5	1,968	0,0002	4903	0,0002
2, 6	2,0022	0,0002	4125	0,0004
3, 4	1,0675	0,2624	4734	0,3326
3, 5	1,6386	0,0002	4936	0,0034
3, 6	1,898	0,0002	4347	0,0006
4, 5	1,1735	0,1034	4051	0,193
4, 6	1,3384	0,01	1618	0,086
5, 6	1,2209	0,0868	3151	0,1602

Average Similarity between/within groups

	1	2	3	4	5	6
1	23,68					
2	13,344	24,27				
3	7,6617	16,377	21,274			
4	5,1136	11,571	17,558	14,719		
5	2,1895	4,323	8,197	9,3439	8,8381	
6	1,3908	3,0112	3,8082	7,4093	6,72	11,429

Within level '2' of factor 'area'

Groups	t	P(perm)	Unique perms	P(MC)
1, 2	2,5495	0,0002	3453	0,0002
1, 3	4,0209	0,0002	3458	0,0002
1, 4	3,208	0,0002	4526	0,0002
1, 5	2,9472	0,0002	4483	0,0002
1, 6	2,7037	0,0002	943	0,0002
2, 3	2,1996	0,0002	3489	0,0006
2, 4	2,1229	0,0002	4526	0,0002
2, 5	2,0346	0,0002	4502	0,0002
2, 6	2,0697	0,0002	1263	0,0008
3, 4	1,7318	0,0002	4466	0,0082
3, 5	2,2948	0,0002	4486	0,0002
3, 6	2,7028	0,0002	1219	0,0002
4, 5	1,6947	0,0002	4511	0,0074
4, 6	1,8378	0,0002	1826	0,0044
5, 6	1,4565	0,0192	1840	0,0646

Average Similarity between/within groups

	1	2	3	4	5	6
1	41,21					
2	14,104	29,166				
3	3,4303	24,442	48,072			
4	1,9932	14,053	29,861	27,813		
5	0,99287	10,796	16,554	16,052	21,151	
6	0,59028	6,0299	6,6953	10,623	13,94	21,667

Within level '5' of factor 'area'

Groups	t	P(perm)	Unique perms	P(MC)
1, 5	No test, df = 0			
1, 6	No test, df = 0			
2, 3	1,6794	0,0004	4487	0,006
2, 4	1,9354	0,0002	4530	0,0006

```
3, 4            1,6032          0,0002     4503    0,0098
5, 6        No test, df = 0

Average Similarity between/within groups
    1     2         3         4      5   6
1   0
2   0   32,691
3   0   20,772    23,865
4   0   18,219    18,336    25,77
5   0     0         0         0      0
6   0     0         0         0      0   0

Within level '1' of factor 'area'
                                          Unique
Groups            t            P(perm)     perms    P(MC)
1, 5        No test, df = 0
1, 6        No test, df = 0
2, 3            1,1849          0,0824     3947     0,154
2, 4            1,1541          0,1326      995     0,219
3, 4            1,7495          0,0002     4971    0,0006
5, 6        No test, df = 0

Average Similarity between/within groups
    1     2         3        4     5   6
1   0
2   0   14,616
3   0   19,585    26,659
4   0   12,117    14,853    14,4
5   0     0         0        0     0
6   0     0         0        0     0   0
```

```
PERMANOVA
Permutational MANOVA

Resemblance worksheet
Name: Resem4
Data type: Similarity
Selection: All
Resemblance: S7 Jaccard

Sums of squares type: Type III (partial)
Permutation method: Permutation of residuals under the full model
Number of permutations: 4999

FACTORS
Name            Type     Levels
depth_range     Fixed       6
area            Fixed       5

depth group: 1=5-10 m, 2=20-30 m, 3=40-50 m, 4=60-70 m, 5=80-90 m and 6=100-115 m


PAIRWISE TESTS

Term 'depth_rangexarea' for pairs of levels of factor 'area'

Within level '1' of factor 'depth_range'
                                                      Unique
Groups              t                   P(perm)       perms      P(MC)
4, 3             1,6522                 0,0002         4962      0,0028
4, 2             2,6395                 0,0002         4884      0,0002
3, 2              2,216                 0,0002         4826      0,0002
5, 1        No test, df = 0

Average Similarity between/within groups
        4          3          2       5   1
4   33,952
3   23,105     23,68
2   18,187     16,74      41,21
5       0          0          0       0
1       0          0          0       0   0

Within level '2' of factor 'depth_range'
                                        Unique
Groups          t        P(perm)        perms       P(MC)
4, 3         1,5266      0,0028          2979       0,0202
4, 2         1,8683      0,0002          1256       0,0028
4, 5         2,3122      0,0002          1828       0,0002
4, 1         1,5889      0,0002           126       0,0366
3, 2         1,7556      0,0002          4808       0,0034
3, 5         2,1372      0,0002          4915       0,0002
3, 1         1,5189      0,0048          1331       0,0244
2, 5         1,9642      0,0002          4523       0,0006
2, 1         1,2634      0,075            460       0,1574
5, 1         1,0946      0,25             713       0,3118

Average Similarity between/within groups
        4          3          2          5          1
4   24,999
```

```
3   16,723     24,27
2   12,647     17,961     29,166
5   7,4017     15,459     19,34      32,691
1   6,4282     11,514     18,178     23,255     14,616

Within level '3' of factor 'depth_range'
                                     Unique
Groups        t       P(perm)        perms     P(MC)
4, 3        1,4065    0,0006          4965     0,018
4, 2        2,3675    0,0002          4944     0,0002
4, 5        2,1452    0,0002          4952     0,0002
4, 1        2,1876    0,0002          4975     0,0002
3, 2         1,816    0,0002          4881     0,0006
3, 5        1,6302    0,0002          4928     0,0028
3, 1        1,8996    0,0002          4963     0,0002
2, 5        1,8903    0,0002          4507     0,0002
2, 1         1,999    0,0002          4971     0,0002
5, 1        1,7238    0,0002          4974     0,0008

Average Similarity between/within groups
       4          3          2          5          1
4   23,384
3   19,307     21,274
2   18,861     24,491     48,072
5   11,432     16,363     25,209     23,865
1   16,433      17,61     26,759     19,484     26,659

Within level '4' of factor 'depth_range'
                                     Unique
Groups        t       P(perm)        perms     P(MC)
4, 3        1,1393    0,1826          4034     0,2418
4, 2        1,6837    0,0012          4499     0,0082
4, 5        1,8454    0,0002          4506     0,0024
4, 1        1,5781    0,0004          4847     0,0082
3, 2        1,5048    0,0002          3996     0,0202
3, 5        1,4254    0,0008          4031     0,0412
3, 1        1,3828    0,0008          4395      0,04
2, 5        1,6227    0,0002          4490      0,01
2, 1        1,4702     0,001          4852     0,0218
5, 1        1,5419    0,0002          4810     0,011

Average Similarity between/within groups
       4          3          2          5        1
4   20,926
3    15,75     14,719
2   15,732     14,761     27,813
5    12,51     14,701     20,059     25,77
1    10,43     9,7147     15,738     13,75    14,4

Within level '5' of factor 'depth_range'
                                                       Unique
Groups              t                  P(perm)         perms     P(MC)
4, 3              1,4814                0,0022          4478     0,0254
4, 2              1,7911                0,0002          4503     0,0032
3, 2               1,755                0,0002          4516     0,001
5, 1        No test, df = 0
```

```
Average Similarity between/within groups
        4          3          2        5   1
4   17,444
3   6,6529     8,8381
2   8,6215     4,5351     21,151
5       0          0          0        0
1       0          0          0        0   0

Within level '6' of factor 'depth_range'
                                                  Unique
Groups            t                   P(perm)      perms      P(MC)
4, 3             1,1358               0,2796         7        0,293
4, 2             1,2839               0,1698         5        0,2388
3, 2             1,5054               0,013        462        0,0638
5, 1          No test, df = 0

Average Similarity between/within groups
       4          3          2        5   1
4      0
3   3,367      11,429
2      5        5,75      21,667
5      0          0          0        0
1      0          0          0        0   0
```

APPENDIX VII: statistic outputs of PERMDISP test

```
PERMDISP
Distance-based test for homogeneity of multivariate dispersions

Resemblance worksheet
Name: Resem6
Data type: Similarity
Selection: All
Resemblance: S7 Jaccard

Group factor: area
Number of groups: 5 station
Number of samples: 213

DEVIATIONS FROM CENTROID
F: 14,266
P(perm): 0,0001

PAIRWISE COMPARISONS
Groups        t          P(perm)
(4,3)      1,4105      0,1721
(4,2)      1,6631      0,1121
(4,5)      6,7885        1E-4
(4,1)      4,4572        2E-4
(3,2)      2,6014      1,6E-2
(3,5)      6,7813        1E-4
(3,1)       5,056        1E-4
(2,5)      3,3592      3,5E-3
(2,1)      2,2309      4,5E-2
(5,1)     0,96682      0,3661

MEANS AND STANDARD ERRORS
Group     Average       SE
4          61,835     0,52353
3          63,095      0,699
2          59,926     1,0373
5          54,546     1,0941
1          56,247     1,3047
```

```
PERMDISP
Distance-based test for homogeneity of multivariate dispersions

Resemblance worksheet
Name: Resem4
Data type: Similarity
Selection: All
Resemblance: S7 Jaccard

Group factor: depth_range
Number of groups: 6
Number of samples: 213

DEVIATIONS FROM CENTROID
F: 10,292
P(perm): 0,0001

PAIRWISE COMPARISONS
Groups        t        P(perm)
(1,2)      2,6801     1,15E-2
(1,3)      1,7734      0,1069
(1,4)      3,8495        6E-4
(1,5)      6,3757        1E-4
(1,6)      3,9509      1,3E-3
(2,3)      1,2777      0,2419
(2,4)      1,2843      0,2207
(2,5)      4,0713        8E-4
(2,6)      2,2804     9,29E-2
(3,4)      2,7544      9,8E-3
(3,5)      5,4543        1E-4
(3,6)      3,1853     2,52E-2
(4,5)       2,723     1,72E-2
(4,6)      1,3365      0,3396
(5,6)     0,63573      0,6099

MEANS AND STANDARD ERRORS
Group     Average       SE
1          53,418      1,1492
2          57,425     0,97262
3          55,829     0,76805
4          59,197     0,96557
5          63,158     0,94998
6          61,975      1,8167
```

Appendix VIII: The species-group contributions obtained from Indicator Species analysis (ISA). The indicator values of ISA specify the groups of stations that are associated with the species with different levels of significance (in bold). Sediment classes (Nota, 1958): sand (S=1) (>95% content of sand), muddy sand (mS=2) (95–70%), very sandy mud (vsM=3) (70–30%), sandy mud (sM=4) (30–5%) and mud (M=5) (<5%).

Species	**S**	**mS**	**vsM**	**sM**	**M**	**p-level**
Amage adspersa	**0.000**	**11.329**	**0.000**	**0.346**	**0.000**	**0.001**
Ampharete acutifrons	**0.000**	**14.276**	**1.631**	**3.138**	**0.180**	**0.006**
Amphicteis gunneri	0.000	0.622	4.474	2.733	0.051	0.245
Ancistargis hamata	0.000	0.000	0.000	0.000	1.250	0.637
Ancystrosyllis groenlandica	2.497	7.775	0.065	0.475	0.071	0.061
Anobothrus gracilis	**0.000**	**2.446**	**8.557**	**0.000**	**0.000**	**0.034**
Aonides oxycephala	3.398	2.058	0.000	0.000	0.000	0.214
Aonides paucibranchiata	1.263	0.000	0.688	0.841	0.000	0.902
Aphelochaeta marioni	0.215	2.339	8.740	10.212	6.598	0.328
Caulleriella multibranchiis	5.333	1.615	0.484	0.592	0.934	0.252
Aponuphis bilineata	**0.351**	**12.742**	**6.114**	**0.175**	**0.007**	**0.027**
Aponuphis brementi	**2.271**	**36.122**	**1.263**	**0.740**	**0.016**	**0.000**
Aponuphis fauveli	**0.441**	**41.529**	**1.757**	**0.000**	**0.061**	**0.000**
Arabella iricolor	0.000	3.774	7.640	0.000	0.039	0.060
Armandia cirrhosa	0.000	0.000	2.381	0.000	0.000	0.452
Axiothella constricta	**0.000**	**4.348**	**0.000**	**0.000**	**0.000**	**0.000**
Brada villosa	0.000	1.446	7.589	6.257	1.076	0.283
Capitella capitata	0.000	4.167	0.019	0.091	0.062	0.576
Capitella giardi	3.226	0.000	0.000	0.000	0.000	0.099
Capitomastus minimus	3.226	0.000	0.000	0.000	0.000	0.102
***Chaetozone* sp.1**	**3.034**	**22.735**	**0.465**	**0.032**	**0.214**	**0.001**
Chetozone cf *setosa*	0.552	1.003	1.203	1.470	0.083	0.923
Chetozone sp.	0.000	0.000	1.748	7.119	1.071	0.055
Chrysopetalum debile	**0.000**	**6.826**	**0.512**	**0.000**	**0.000**	**0.033**
Cirratulus cirratus	0.000	0.000	0.000	0.000	1.250	0.645
Cirrophorus branchiatus	0.000	0.000	0.000	0.000	1.250	0.628
Clymenura clypeata	2.482	12.079	3.043	8.496	0.060	0.083
Cossura soyeri	**0.000**	**0.000**	**3.770**	**12.309**	**0.019**	**0.004**
Diplocirrus glaucus	0.000	0.720	4.859	6.463	2.827	0.340
Ditrupa arietina	**0.311**	**12.426**	**0.169**	**0.310**	**0.000**	**0.006**
Dorvillea (Dorvillea) rubrovittata	0.000	0.000	2.381	0.000	0.000	0.415
Drilonereis filum	**0.049**	**7.455**	**16.689**	**9.559**	**2.091**	**0.018**
Eteone longa	0.000	0.000	2.381	0.000	0.000	0.437
Euclymene lumbricoides	**0.000**	**4.348**	**0.000**	**0.000**	**0.000**	**0.000**
Euclymene palermitana	**0.000**	**0.000**	**0.000**	**5.263**	**0.000**	**0.029**
Eunice antennata	0.000	0.000	2.381	0.000	0.000	0.434
Eunice harassii	3.226	0.000	0.000	0.000	0.000	0.100
Eunice oerstedi	0.000	2.809	0.842	0.000	0.000	0.169
Eunice pennata	0.475	3.884	3.106	0.316	0.000	0.324
Eunice vittata	**0.000**	**21.104**	**3.685**	**1.063**	**0.000**	**0.000**
Euphrosine armadillo	0.000	0.000	2.381	0.000	0.000	0.443
Euphrosine foliosa	**0.000**	**4.348**	**0.000**	**0.000**	**0.000**	**0.000**
Flabelligera diplochaitus	**0.000**	**4.348**	**0.000**	**0.000**	**0.000**	**0.000**
Glycera alba	0.000	0.000	0.742	3.624	0.000	0.228
Glycera capitata	0.000	0.000	0.000	0.000	1.250	0.610

Glycera unicornis	0.087	7.625	19.508	17.822	9.513	0.059
Glycinde nordmanni	0.000	0.000	0.000	1.784	0.403	0.580
Goniada emerita	0.606	2.200	0.000	1.612	0.000	0.577
Goniada maculata	0.000	0.000	0.000	2.632	0.000	0.261
Malmgreniella ljungmani	**0.000**	**4.348**	**0.000**	**0.000**	**0.000**	**0.000**
Malmgreniella lunulata	0.176	2.878	6.904	1.406	0.238	0.151
Harmothoe spinifera	0.000	0.000	1.131	1.382	0.000	0.925
Hesione splendida	**0.000**	**4.348**	**0.000**	**0.000**	**0.000**	**0.000**
Heteromastus filiformis	0.191	4.347	7.235	16.386	10.513	0.080
Hyalinoecia tubicola	2.129	3.223	4.059	1.889	0.000	0.562
Hydroides pseudouncinatus	0.000	3.338	0.000	0.611	0.000	0.144
Laetmonice hystrix	0.000	3.377	0.000	0.000	0.279	0.099
Laonice* cf *cirrata	**0.000**	**2.958**	**23.936**	**8.107**	**0.685**	**0.001**
Leiocapitella glabra	1.064	1.288	5.795	0.472	1.677	0.290
Leiochrides sp.	0.000	0.000	0.000	0.000	1.250	0.624
Levinsenia gracilis	0.000	0.000	3.772	0.000	0.260	0.142
Lumbrineriopsis paradoxa	2.764	1.130	6.099	7.358	1.349	0.421
Lumbrineris coccinea	**0.000**	**0.000**	**0.000**	**5.263**	**0.000**	**0.030**
Scoletoma emandibulata-mabiti	0.027	1.792	15.316	16.632	9.233	0.081
Scoletoma fragilis	0.000	0.000	4.762	0.000	0.000	0.070
Scoletoma funchalensis	**11.324**	**0.061**	**0.477**	**0.000**	**0.010**	**0.018**
Lumbrineris gracilis	0.000	0.407	8.544	4.473	0.135	0.054
Lumbrineris latreilli	**1.267**	**11.806**	**18.023**	**27.563**	**1.829**	**0.010**
Scoletoma tetraura	**40.881**	**4.263**	**0.165**	**0.013**	**0.028**	**0.000**
Lysidice cf *ninetta*	0.000	2.809	0.842	0.000	0.000	0.160
Magelona alleni	2.339	1.416	0.106	3.243	3.424	0.851
***Magelona* sp2**	**79.156**	**1.265**	**0.132**	**0.016**	**0.008**	**0.000**
Malacoceros fuliginosus	3.158	1.434	0.430	0.000	0.000	0.245
Malacoceros tetraceros	0.000	0.000	0.000	2.632	0.000	0.246
Maldane glebifex	0.000	0.000	4.295	3.148	0.000	0.220
Maldane sarsi	**0.000**	**0.000**	**0.365**	**6.685**	**0.000**	**0.042**
Marphysa belli	0.680	12.964	1.944	4.749	2.169	0.055
Marphysa fallax	**0.000**	**4.348**	**0.000**	**0.000**	**0.000**	**0.000**
Marphysa kinbergi	0.112	4.084	1.960	3.591	4.828	0.741
Mediomastus capensis	**12.903**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Mediomastus fragilis	**42.682**	**2.563**	**0.000**	**0.000**	**0.000**	**0.000**
Melinna palmata	**0.000**	**22.628**	**7.875**	**3.599**	**0.724**	**0.008**
Metasychis gotoi	0.000	7.822	13.263	9.265	0.321	0.064
Monticellina dorsobranchialis	0.000	6.511	3.797	5.566	0.957	0.366
Myriochele oculata	0.835	1.365	9.003	1.666	0.013	0.074
Eteone picta	0.000	0.000	0.566	0.692	1.873	0.685
Nematonereis unicornis	0.000	8.158	8.980	1.934	0.008	0.078
Nephthys cirrosa	0.000	0.000	4.288	0.262	0.000	0.147
Nephthys hombergi	4.592	5.891	5.991	3.431	0.003	0.638
Nephthys hystricis	**0.620**	**0.141**	**3.798**	**14.433**	**4.012**	**0.022**
Nephthys incisa	0.000	0.000	3.652	0.991	0.056	0.319
Nephthys sp.	0.000	0.000	0.000	2.632	0.000	0.257
Eunereis longissima	0.000	0.000	1.533	0.937	0.000	0.811
Nichomache lumbricalis	0.000	0.000	2.381	0.000	0.000	0.464
Ninoe armoricana	**0.000**	**0.000**	**0.588**	**12.566**	**0.972**	**0.011**
Nothria conchilega	**1.481**	**26.078**	**0.372**	**0.136**	**0.003**	**0.000**
Notomastus aberans	**0.152**	**29.570**	**15.751**	**7.405**	**0.389**	**0.001**
Notomastus latericeus	**0.375**	**24.361**	**13.027**	**6.262**	**1.408**	**0.008**
Notomastus lineatus	**0.000**	**0.534**	**0.320**	**7.819**	**0.000**	**0.025**
Onuphis eremita	**11.086**	**9.231**	**0.094**	**0.000**	**0.000**	**0.023**
Onuphis sp2	3.226	0.000	0.000	0.000	0.000	0.106

Onuphis sp.	0.000	0.000	0.000	0.000	1.250	0.610
Orbinia cuvieri	4.452	1.348	0.000	0.000	0.000	0.101
Owenia fusiformis	**21.393**	**26.689**	**0.208**	**0.012**	**0.000**	**0.003**
Palola siciliensis	2.702	0.094	0.085	0.277	0.000	0.532
Panthalis oerstedi	0.000	2.809	0.842	0.000	0.000	0.170
Paralacydonia paradoxa	0.018	14.933	14.727	8.276	0.380	0.089
Paraonis fulgens	0.000	0.000	1.131	1.382	0.000	0.931
Paraprionospio **cf** ***pinnata***	**0.000**	**3.511**	**12.191**	**26.558**	**4.898**	**0.000**
Pectinaria auricoma	**0.000**	**1.382**	**14.091**	**3.375**	**0.571**	**0.005**
Pectinaria koreni	0.235	2.135	5.379	0.156	0.000	0.185
Petaloproctus terricolus	0.000	5.417	0.000	0.992	0.000	0.066
Petta pusilla	3.226	0.000	0.000	0.000	0.000	0.099
Pherusa monilifera	**0.000**	**0.000**	**0.000**	**5.263**	**0.000**	**0.032**
Pherusa plumosa	0.000	0.399	2.515	2.926	0.000	0.438
Phyllodocecf maculata	**0.000**	**4.348**	**0.000**	**0.000**	**0.000**	**0.000**
Phyllodoce laminosa	1.303	0.000	2.839	0.000	0.000	0.297
Phyllodoce lineata	1.303	0.000	1.419	0.000	0.000	0.836
Phyllodoce macrophthalma	1.374	2.496	0.000	0.000	0.000	0.388
Phylo foetida	**0.000**	**0.000**	**0.000**	**5.263**	**0.000**	**0.032**
Phylo ligustica	**0.000**	**11.120**	**0.000**	**0.388**	**0.000**	**0.002**
Phylo norvegica	0.000	0.000	0.000	2.632	0.000	0.246
Pilargis verrucosa	**0.000**	**0.000**	**18.165**	**4.471**	**0.367**	**0.000**
Piromis eruca	3.226	0.000	0.000	0.000	0.000	0.097
Pista cristata	**0.000**	**15.415**	**5.613**	**2.420**	**0.228**	**0.005**
Poecilochaetus serpens	**7.716**	**32.725**	**3.766**	**2.077**	**0.579**	**0.004**
Polycirrus aurantiacus	0.000	0.000	2.381	0.000	0.000	0.437
Polyodontes maxillosus	0.000	3.754	4.691	0.917	0.000	0.186
Polyophtalmus pictus	0.000	0.000	2.381	0.000	0.000	0.443
Pomatoceros lamarckii	**0.000**	**4.348**	**0.000**	**0.000**	**0.000**	**0.000**
Praxillella affinis	0.000	0.000	2.381	0.000	0.000	0.434
Praxillella gracilis	**0.000**	**0.000**	**1.733**	**29.787**	**7.782**	**0.000**
Prionospio caspersi	**47.700**	**1.177**	**0.004**	**0.029**	**0.001**	**0.000**
Minuspio cirrifera	0.150	0.136	0.490	2.246	0.000	0.802
Prionospio ehlersi	0.000	0.304	9.860	6.245	1.472	0.093
Prionospio fallax	**7.319**	**20.776**	**0.914**	**0.271**	**0.008**	**0.000**
Aquilaspio sexoculata	**0.000**	**4.348**	**0.000**	**0.000**	**0.000**	**0.000**
Prionospio steenstrupi	0.260	2.835	1.701	3.030	0.937	0.864
Protodorvillea kefersteini	1.068	2.909	0.000	0.000	0.000	0.207
Protula sp.	0.000	0.000	2.381	0.000	0.000	0.421
Psammolyce arenosa	0.000	2.809	0.842	0.000	0.000	0.182
Pseudoleiocapitella fauveli	0.079	0.864	5.830	4.748	0.214	0.301
Sabellides octocirrata	**0.000**	**8.696**	**0.000**	**0.000**	**0.000**	**0.000**
Scalibregma inflatum	**0.000**	**4.348**	**0.000**	**0.000**	**0.000**	**0.000**
Dorvillea (Schistomeringos) neglecta	**14.686**	**0.476**	**1.143**	**0.000**	**0.000**	**0.000**
Dorvillea (Schistomeringos) rudolphii	0.457	3.732	0.000	0.000	0.000	0.173
Schlerocheilus minutus	**0.000**	**4.348**	**0.000**	**0.000**	**0.000**	**0.000**
Scolaricia typica	0.000	0.000	3.302	1.614	0.000	0.312
Scolelepis cantabra	**6.452**	**0.000**	**0.000**	**0.000**	**0.000**	**0.017**
Polydora ciliata	0.000	0.000	0.574	0.000	3.795	0.254
Scolelepis foliosa	**6.452**	**0.000**	**0.000**	**0.000**	**0.000**	**0.009**
Scolelepis squamata	**9.435**	**2.337**	**0.000**	**0.000**	**0.000**	**0.013**
Scolelepis tridentata	**13.170**	**0.798**	**0.000**	**0.000**	**0.000**	**0.003**
Scoloplos (Scoloplos) armiger	**40.884**	**0.397**	**0.304**	**3.476**	**0.002**	**0.000**
Serpula concharum	**0.000**	**4.348**	**0.000**	**0.000**	**0.000**	**0.000**
Sigalion mathildae	**60.300**	**7.964**	**0.084**	**0.000**	**0.000**	**0.000**

Sigalion squamosum	**0.000**	**4.348**	**0.000**	**0.000**	**0.000**	**0.000**
Sigambra tentaculata	**15.069**	**3.911**	**0.078**	**0.000**	**0.000**	**0.003**
Spio decoratus	**36.209**	**19.081**	**0.121**	**0.081**	**0.000**	**0.000**
Spio filicornis	**0.528**	**13.679**	**2.159**	**1.758**	**0.000**	**0.004**
Spio multioculata	0.546	0.331	2.380	10.358	0.683	0.268
Spiochaetopterus costarum	0.000	0.000	3.017	3.685	0.277	0.338
Spionidae sp.	1.430	1.299	0.000	0.000	0.967	0.853
Spiophanes bombyx	**3.938**	**27.875**	**1.393**	**2.213**	**0.008**	**0.000**
Spiophanes kroyeri kroyeri	**8.810**	**5.335**	**0.107**	**0.000**	**0.000**	**0.024**
Spiophanes sp.	3.226	0.000	0.000	0.000	0.000	0.113
Sternaspis scutata	**0.000**	**0.203**	**3.660**	**40.988**	**5.650**	**0.000**
Sthenelais boa	**0.000**	**11.030**	**0.368**	**0.000**	**0.000**	**0.002**
Sthenelais limicola	**0.000**	**4.348**	**0.000**	**0.000**	**0.000**	**0.000**
Terebellides stroemi	**0.025**	**4.691**	**10.717**	**21.210**	**5.997**	**0.006**
Vermiliopsis infundibulum	0.000	3.776	0.000	0.346	0.000	0.144

Appendix VIII: The species-group contributions obtained from Indicator Species analysis (ISA). The indicator values of ISA specify the groups of stations that are associated with the species with different levels of significance (in bold). Depth groups: 1=5-10 m, 2=20-30 m, 3=40-50 m, 4=60-70 m, 5=80-90 m and 6=100-115 m

Species	**5-10**	**20-30**	**40-50**	**60-70**	**80-90**	**100-115**	**p-level**
Amage adspersa	0.000	0.807	3.340	0.000	0.000	0.000	0.367
Ampharete acutifrons	0.097	9.352	0.982	2.013	1.098	0.000	0.097
Amphicteis gunneri	**0.000**	**0.000**	**11.236**	**0.262**	**0.000**	**0.000**	**0.016**
Ancistargis hamata	0.000	0.000	0.000	2.273	0.000	0.000	0.492
Ancystrosyllis groenlandica	5.065	2.444	0.766	0.079	0.000	0.000	0.216
Anobothrus gracilis	**0.000**	**8.685**	**0.936**	**0.000**	**0.000**	**0.000**	**0.045**
Aonides oxycephala	4.139	0.969	0.000	0.000	0.000	0.000	0.256
Aonides paucibranchiata	1.385	0.972	0.335	0.000	0.000	0.000	0.880
Aphelochaeta marioni	**0.194**	**17.461**	**3.294**	**16.495**	**0.276**	**0.000**	**0.015**
Caulleriella multibranchiis	5.188	1.366	0.471	3.005	0.000	0.000	0.306
Aponuphis bilineata	**0.000**	**22.082**	**0.525**	**0.000**	**0.694**	**0.308**	**0.001**
Aponuphis brementi	**0.347**	**24.671**	**1.485**	**1.394**	**0.000**	**0.099**	**0.003**
Aponuphis fauveli	0.311	1.235	11.511	0.231	4.415	0.000	0.089
Arabella iricolor	**0.000**	**9.977**	**0.918**	**0.157**	**0.000**	**0.000**	**0.018**
Armandia cirrhosa	0.000	2.703	0.000	0.000	0.000	0.000	0.340
Axiothella constricta	0.000	0.000	1.587	0.000	0.000	0.000	0.701
Brada villosa	**0.000**	**8.836**	**12.307**	**0.119**	**0.085**	**0.000**	**0.045**
Capitella capitata	0.000	2.511	0.116	0.318	0.000	0.000	0.846
Capitella giardi	3.226	0.000	0.000	0.000	0.000	0.000	0.179
Capitomastus minimus	3.226	0.000	0.000	0.000	0.000	0.000	0.181
Chaetozone sp.1	0.076	10.401	3.331	1.126	0.107	0.000	0.069
Chetozone cf *setosa*	0.595	0.418	0.576	1.181	0.846	0.000	0.986
Chetozone sp.	0.000	1.023	2.646	5.425	0.000	0.000	0.214
Chrysopetalum debile	0.000	1.113	0.384	0.787	0.000	0.000	0.934
Cirratulus cirratus	**0.000**	**0.000**	**0.000**	**0.000**	**3.846**	**0.000**	**0.062**
Cirrophorus branchiatus	0.000	0.000	1.587	0.000	0.000	0.000	0.704
Clymenura clypeata	**2.357**	**37.432**	**2.392**	**0.028**	**0.000**	**0.000**	**0.000**
Cossura soyeri	0.000	5.657	3.136	0.429	0.205	0.000	0.245
Diplocirrus glaucus	**0.000**	**13.168**	**9.372**	**0.148**	**0.000**	**0.000**	**0.017**
Ditrupa arietina	**0.000**	**11.804**	**0.432**	**0.000**	**0.000**	**0.000**	**0.012**
Dorvillea (Dorvillea) rubrovittata	0.000	0.000	1.587	0.000	0.000	0.000	0.694
Drilonereis filum	0.000	11.729	10.926	5.222	1.833	1.173	0.152
Eteone longa	0.000	2.703	0.000	0.000	0.000	0.000	0.303
Euclymene lumbricoides	0.000	2.703	0.000	0.000	0.000	0.000	0.294
Euclymene palermitana	0.000	5.405	0.000	0.000	0.000	0.000	0.128
Eunice antennata	0.000	0.000	1.587	0.000	0.000	0.000	0.719
Eunice harassii	0.000	2.703	0.000	0.000	0.000	0.000	0.335
Eunice oerstedi	0.000	0.000	0.653	1.338	0.000	0.000	0.885
Eunice pennata	0.000	3.562	2.621	0.336	0.000	0.000	0.355
Eunice vittata	0.000	5.673	8.368	0.317	0.000	0.000	0.119
Euphrosine armadillo	0.000	2.703	0.000	0.000	0.000	0.000	0.330
Euphrosine foliosa	0.000	2.703	0.000	0.000	0.000	0.000	0.294
Flabelligera diplochaitus	0.000	0.000	0.000	2.273	0.000	0.000	0.500
Glycera alba	0.000	0.000	1.850	0.948	0.000	0.000	0.516
Glycera capitata	0.000	0.000	0.000	0.000	3.846	0.000	0.057
Glycera unicornis	**0.085**	**21.000**	**14.549**	**16.175**	**2.187**	**3.038**	**0.023**
Glycinde nordmanni	0.000	0.000	3.175	0.000	0.000	0.000	0.213
Goniada emerita	0.000	5.195	0.000	0.816	0.000	0.000	0.106
Goniada maculata	0.000	0.000	0.000	2.273	0.000	0.000	0.484

Malmgreniella ljungmani	0.000	2.703	0.000	0.000	0.000	0.000	0.294
Malmgreniella lunulata	0.000	0.913	8.396	0.968	0.000	1.232	0.091
Harmothoe spinifera	0.000	0.000	3.175	0.000	0.000	0.000	0.228
Hesione splendida	0.000	2.703	0.000	0.000	0.000	0.000	0.294
Heteromastus filiformis	**0.191**	**4.025**	**17.210**	**14.184**	**7.098**	**0.272**	**0.049**
Hyalinoecia tubicola	0.000	4.442	2.089	1.071	0.818	0.818	0.480
Hydroides pseudouncinatus	0.000	2.089	0.360	0.000	0.000	0.000	0.527
Laetmonice hystrix	0.000	0.703	0.000	0.000	0.000	5.692	0.096
Laonice* cf *cirrata	**0.000**	**26.639**	**15.751**	**0.075**	**0.000**	**0.000**	**0.002**
Leiocapitella glabra	**0.605**	**0.000**	**0.000**	**3.603**	**6.450**	**1.466**	**0.024**
***Leiochrides* sp.**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**7.692**	**0.000**
Levinsenia gracilis	0.000	0.000	4.762	0.000	0.000	0.000	0.141
Lumbrineriopsis paradoxa	1.765	6.373	3.664	0.876	3.585	1.434	0.555
Lumbrineris coccinea	0.000	0.000	3.175	0.000	0.000	0.000	0.205
Scoletoma emandibulata-mabiti	**0.025**	**25.020**	**8.938**	**12.885**	**0.568**	**0.568**	**0.001**
Scoletoma fragilis	1.626	0.000	0.787	0.000	0.000	0.000	0.784
Scoletoma funchalensis	8.450	0.513	0.202	0.000	0.000	0.000	0.062
Lumbrineris gracilis	0.000	5.014	8.094	0.142	0.000	0.000	0.074
Lumbrineris latreilli	**1.477**	**41.879**	**27.600**	**0.427**	**0.081**	**0.000**	**0.000**
Scoletoma tetraura	**60.839**	**0.140**	**0.044**	**0.099**	**0.000**	**0.000**	**0.000**
Lysidice cf *ninetta*	0.000	5.405	0.000	0.000	0.000	0.000	0.123
Magelona alleni	**0.834**	**2.927**	**9.693**	**0.414**	**0.000**	**0.000**	**0.043**
Magelona sp2	87.659	0.280	0.052	0.000	0.009	0.000	0.000
Malacoceros fuliginosus	0.000	2.696	0.232	0.000	1.365	0.000	0.526
Malacoceros tetraceros	0.000	2.703	0.000	0.000	0.000	0.000	0.294
Maldane glebifex	**0.000**	**0.000**	**9.524**	**0.000**	**0.000**	**0.000**	**0.020**
Maldane sarsi	0.000	0.645	1.780	0.456	0.000	0.000	0.766
Marphysa belli	0.363	5.943	4.832	3.242	1.375	4.126	0.727
Marphysa fallax	0.000	0.000	0.000	2.273	0.000	0.000	0.510
Marphysa kinbergi	0.087	0.061	2.188	9.835	3.459	2.965	0.086
Mediomastus capensis	**12.903**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.010**
Mediomastus fragilis	**48.654**	**0.620**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Melinna palmata	**0.022**	**38.230**	**6.901**	**0.272**	**0.000**	**0.125**	**0.000**
Metasychis gotoi	**0.000**	**0.000**	**21.001**	**5.513**	**2.819**	**0.251**	**0.003**
Monticellina dorsobranchialis	0.000	3.952	2.019	4.554	5.335	0.000	0.558
Myriochele oculata	0.000	14.947	4.583	0.056	0.000	0.000	0.017
Eteone picta	0.000	0.000	0.822	5.053	0.000	0.000	0.101
Nematonereis unicornis	0.000	0.429	8.137	3.033	0.326	0.434	0.128
Nephthys cirrosa	0.000	3.171	0.656	0.000	0.000	0.000	0.305
Nephthys hombergi	**4.420**	**30.139**	**0.266**	**0.168**	**0.000**	**0.000**	**0.000**
Nephthys hystricis	0.546	6.131	6.938	3.353	0.097	3.492	0.467
Nephthys incisa	0.000	5.869	0.075	0.000	0.880	0.000	0.151
Nephthys sp.	0.000	2.703	0.000	0.000	0.000	0.000	0.346
Eunereis longissima	0.000	5.405	0.000	0.000	0.000	0.000	0.124
Nichomache lumbricalis	0.000	2.703	0.000	0.000	0.000	0.000	0.343
Ninoe armoricana	0.000	0.000	0.455	4.972	8.306	0.000	0.064
Nothria conchilega	**18.405**	**3.849**	**0.029**	**0.015**	**0.169**	**0.674**	**0.010**
Notomastus aberans	**0.113**	**59.697**	**11.014**	**0.224**	**0.000**	**0.000**	**0.000**
Notomastus latericeus	0.128	14.884	18.760	4.753	2.127	0.000	0.050
Notomastus lineatus	0.000	6.155	0.315	0.322	0.000	0.000	0.093
Onuphis eremita	**30.587**	**0.420**	**0.000**	**0.000**	**0.000**	**0.000**	**0.001**
Onuphis sp2	3.226	0.000	0.000	0.000	0.000	0.000	0.184
***Onuphis* sp.**	**0.000**	**0.000**	**0.000**	**0.000**	**3.846**	**0.000**	**0.057**
Orbinia cuvieri	5.543	0.000	0.224	0.000	0.000	0.000	0.107
Owenia fusiformis	**51.526**	**1.607**	**0.077**	**0.003**	**0.000**	**0.000**	**0.000**
Palola siciliensis	2.709	0.805	0.000	0.026	0.000	0.000	0.589
Panthalis oerstedi	1.471	0.000	0.000	0.000	2.092	0.000	0.541

Paralacydonia paradoxa	**0.025**	**11.064**	**19.033**	**2.689**	**0.560**	**0.000**	**0.020**
Paraonis fulgens	0.000	0.000	0.653	1.338	0.000	0.000	0.879
Paraprionospio* cf *pinnata	**0.000**	**6.436**	**31.617**	**12.069**	**0.170**	**0.000**	**0.001**
Pectinaria auricoma	**0.154**	**6.498**	**13.149**	**0.077**	**0.000**	**0.000**	**0.022**
Pectinaria koreni	**0.288**	**13.344**	**0.279**	**0.000**	**0.000**	**0.000**	**0.007**
Petaloproctus terricolus	0.000	0.000	1.305	1.338	0.000	0.000	0.854
Petta pusilla	3.226	0.000	0.000	0.000	0.000	0.000	0.179
Pherusa monilifera	0.000	2.419	0.167	0.000	0.000	0.000	0.531
Pherusa plumosa	**0.207**	**9.291**	**0.000**	**0.000**	**0.294**	**0.000**	**0.030**
*Phyllodoce*cf *maculata*	0.000	2.703	0.000	0.000	0.000	0.000	0.294
Phyllodoce laminosa	0.000	4.178	0.360	0.000	0.000	0.000	0.274
Phyllodoce lineata	1.626	0.000	0.787	0.000	0.000	0.000	0.755
Phyllodoce macrophthalma	1.755	1.232	0.000	0.000	0.000	0.000	0.662
Phylo foetida	0.000	5.405	0.000	0.000	0.000	0.000	0.137
Phylo ligustica	0.858	3.614	0.104	0.000	0.000	0.000	0.329
Phylo norvegica	0.000	2.703	0.000	0.000	0.000	0.000	0.294
Pilargis verrucosa	**0.000**	**19.664**	**4.933**	**0.063**	**0.000**	**0.000**	**0.001**
Piromis eruca	3.226	0.000	0.000	0.000	0.000	0.000	0.182
Pista cristata	**0.000**	**1.851**	**20.793**	**0.561**	**0.000**	**0.000**	**0.002**
Poecilochaetus serpens	**0.404**	**24.209**	**9.378**	**2.354**	**2.585**	**0.077**	**0.033**
Polycirrus aurantiacus	0.000	2.703	0.000	0.000	0.000	0.000	0.303
Polyodontes maxillosus	0.000	0.343	2.957	1.455	0.694	0.000	0.538
Polyophtalmus pictus	0.000	2.703	0.000	0.000	0.000	0.000	0.330
Pomatoceros lamarckii	0.000	2.703	0.000	0.000	0.000	0.000	0.294
Praxillella affinis	0.000	0.000	1.587	0.000	0.000	0.000	0.719
Praxillella gracilis	**0.000**	**0.166**	**23.553**	**6.684**	**2.519**	**0.336**	**0.001**
Prionospio caspersi	**47.316**	**1.011**	**0.002**	**0.004**	**0.022**	**0.000**	**0.000**
Minuspio cirrifera	0.151	2.393	0.110	0.150	0.000	0.000	0.822
Prionospio ehlersi	**0.125**	**0.175**	**1.210**	**2.233**	**3.183**	**0.000**	**0.002**
Prionospio fallax	**13.728**	**14.017**	**0.045**	**0.124**	**0.000**	**0.000**	**0.018**
Aquilaspio sexoculata	0.000	2.703	0.000	0.000	0.000	0.000	0.350
Prionospio steenstrupi	0.255	0.000	3.670	1.518	1.630	4.346	0.502
Protodorvillea kefersteini	1.429	1.505	0.000	0.000	0.000	0.000	0.816
Protula sp.	0.000	0.000	1.587	0.000	0.000	0.000	0.677
Psammolyce arenosa	2.162	0.000	0.523	0.000	0.000	0.000	0.481
Pseudoleiocapitella fauveli	0.090	8.331	5.399	0.000	0.128	0.000	0.119
Sabellides octocirrata	0.000	2.089	0.360	0.000	0.000	0.000	0.545
Scalibregma inflatum	0.000	0.000	0.000	2.273	0.000	0.000	0.510
Dorvillea (Schistomeringos) neglecta	**16.717**	**0.210**	**0.578**	**0.000**	**0.000**	**0.000**	**0.003**
Dorvillea (Schistomeringos) rudolphii	0.676	2.136	0.000	0.000	0.000	0.000	0.604
Schlerocheilus minutus	0.000	2.703	0.000	0.000	0.000	0.000	0.294
Scolaricia typica	**0.000**	**7.385**	**0.142**	**0.000**	**0.000**	**0.000**	**0.044**
Scolelepis cantabra	0.918	1.933	0.000	0.000	0.000	0.000	0.615
Polydora ciliata	**0.000**	**0.447**	**0.000**	**7.587**	**0.000**	**0.000**	**0.047**
Scolelepis foliosa	**6.452**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.023**
Scolelepis squamata	1.102	6.382	0.067	0.000	0.000	0.000	0.102
Scolelepis tridentata	5.943	3.129	0.000	0.000	0.000	0.000	0.115
Scoloplos (Scoloplos) armiger	**34.330**	**11.669**	**0.017**	**0.006**	**0.000**	**0.000**	**0.001**
Serpula concharum	0.000	2.703	0.000	0.000	0.000	0.000	0.294
Sigalion mathildae	**63.009**	**3.356**	**0.061**	**0.000**	**0.000**	**0.000**	**0.000**
Sigalion squamosum	3.226	0.000	0.000	0.000	0.000	0.000	0.191
Sigambra tentaculata	**13.641**	**3.990**	**0.000**	**0.000**	**0.000**	**0.000**	**0.008**
Spio decoratus	**24.010**	**25.944**	**0.013**	**0.000**	**0.000**	**0.000**	**0.001**
Spio filicornis	**2.210**	**21.607**	**0.019**	**0.039**	**0.000**	**0.000**	**0.002**
Spio multioculata	0.044	9.590	0.480	3.981	0.626	0.000	0.348
Spiochaetopterus costarum	**0.000**	**11.135**	**0.838**	**0.000**	**0.000**	**0.000**	**0.011**
Spionidae sp.	1.006	0.353	0.000	0.000	6.434	0.000	0.082

Spiophanes bombyx	**2.738**	**32.944**	**0.253**	**0.518**	**0.000**	**0.000**	**0.000**
Spiophanes kroyeri kroyeri	7.836	2.578	0.237	0.000	0.000	0.000	0.081
Spiophanes sp.	0.000	2.703	0.000	0.000	0.000	0.000	0.323
Sternaspis scutata	0.000	14.454	14.303	6.535	0.800	0.160	0.068
Sthenelais boa	1.018	2.859	0.247	0.000	0.000	0.000	0.512
Sthenelais limicola	0.000	2.703	0.000	0.000	0.000	0.000	0.317
Terebellides stroemi	**0.029**	**5.268**	**28.238**	**17.484**	**0.041**	**0.000**	**0.000**
Vermiliopsis infundibulum	0.000	2.357	0.203	0.000	0.000	0.000	0.498

Appendix IX:

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Ecology and spatial distribution of selected polychaete species from the Italian continental shelf

B. LA PORTA[1]*, P. TOMASSETTI[1], S. LOMIRI[1], S. MARZIALETTI[2], D. VANI[1], M. PENNA[1], P. LANERA[1], & L. NICOLETTI[1]

[1]*ISPRA – Institute for Environmental Protection and Research, Rome, Italy and* [2]*Marine Ecological Surveys Ltd, Bath, UK*

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Abstract
Data from several research and monitoring projects carried out between 1999 and 2009, for a total of 26 study areas located along the Italian continental shelf (Mediterranean Sea), were extracted from ISPRA's data set, to revise and update the existing information on the ecology and spatial distribution of 20 selected soft-sediment polychaete species. The species were selected taking into account their spatial distribution and ecological role in the benthic assemblages and the existence of voucher specimens deposited in ISPRA's reference collection. Samplings were taken at 872 stations on soft sediments, at depths ranging from 1 to 155 m. Surface sediment composition data were available at each site. The number of specimens from the selected species was extracted at each site, and relative abundance (%)calculated. The spatial distribution of each species was investigated according to the biogeographical zones identified in the Italian Seas. The distribution of five species (*Aponuphis bilineata*, *A. brementi*, *A. fauveli*, *Nothria conchylega*, and *Onuphis eremita*) was updated. Several species that were previously considered to be characteristic of a specific biocenosis, *sensu* Pérès & Picard (1964), e.g. *Diopatra neapolitana*, *Ditrupa arietina*, *Notria conchylega* and *Sternaspis scutata*, were found to be distributed over a wider bathymetric and granulometric range of surface sediments. Indicator Species Analysis highlights that the distribution of 17 selected species depends on definite granulometric characteristics of the sediment. This new relevant information outlines the important contribution of environmental monitoring programmes to scientific knowledge.

Keywords: *Polychaete assemblages*, *biocoenosis*, *soft bottoms*, *sediment texture*, *Mediterranean Sea*

Introduction

Polychaetes are amongst the most frequent and abundant organisms characterizing marine benthic communities, accounting for up to more than a third of the total number of macrobenthic species in soft substrata (Day 1967; Knox 1977). Polychaetes have proven to be excellent indicators of environmental conditions due to their distribution over a broad range of environments and their ample display of ecological requirements. Because of their ecological variability, they are widely used in applied environmental research (Giangrande et al. 2005). Although there have been numerous studies investigating the systematics, taxonomy, morphology and ecology of Mediterranean polychaetes, there are still significant gaps in the understanding of their ecology. Information on species distribution is incomplete, and many species are frequently recorded outside their known bathymetric and granulometric range and of their characteristic ecological boundaries, which define specific biocoenosis *sensu* Pérès & Picard (1964). There is only a general account, dating back to Bellan (1964), on the ecology of Mediterranean polychaetes. Further studies only analysed the distribution of polychaetes at local scales (e.g. Gravina 1986; Castelli et al. 1992; Bianchi et al. 1993a,b,c; Crema et al. 1993; Simboura et al. 2000; Çinar 2005; Moreira et al. 2006; Cosentino & Giacobbe 2008; Zaâbi et al. 2009). The information on the ecological and spatial distribution of species should therefore be revised and updated on the base on newly collected information.

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*Correspondence: B. La Porta, ISPRA, Institute for Environmental Protection and Research, Rome, Italy. Email: barbara.laporta@isprambiente.it

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Environmental monitoring programmes can be a source of valuable scientific data to increase the scientific knowledge of benthic communities and species, as these programmes allow the integration of multidisciplinary information. Moreover, frequent monitoring surveys and common sampling methodologies allow the collection of numerous and comparable data from different study areas.

This study proves the relevance of multidisciplinary environmental characterization and monitoring programmes for scientific research collating data extracted from a number of surveys (e.g. sand dredging, offshore platforms developments, aquaculture, beach nourishments) carried out in Italy over the last 10 years by the Italian National Institute for Environmental Protection and Research (ISPRA). These projects have provided data on sediment composition, associated benthic communities and depth range of a number of species in different areas of the Italian continental shelf.

In this study we present a first update on the spatial distribution and ecology (related to sediment composition and depth range) of 20 soft-sediment polychaete species along the Italian continental shelf. These species were selected taking into account their spatial distribution and their ecological role in benthic assemblages. For each species, voucher specimens were available in ISPRA's reference collection, which is based on the material collected in numerous monitoring surveys.

Material and methods

Data from 26 study areas located along the Italian continental shelf were extracted from ISPRA's data set (Figure 1). These locations were selected with base on the common procedures of data collection and analyses at each sampling period from 1999 to 2009. Samples had been taken in two replicates at 872 stations along transects perpendicular to the

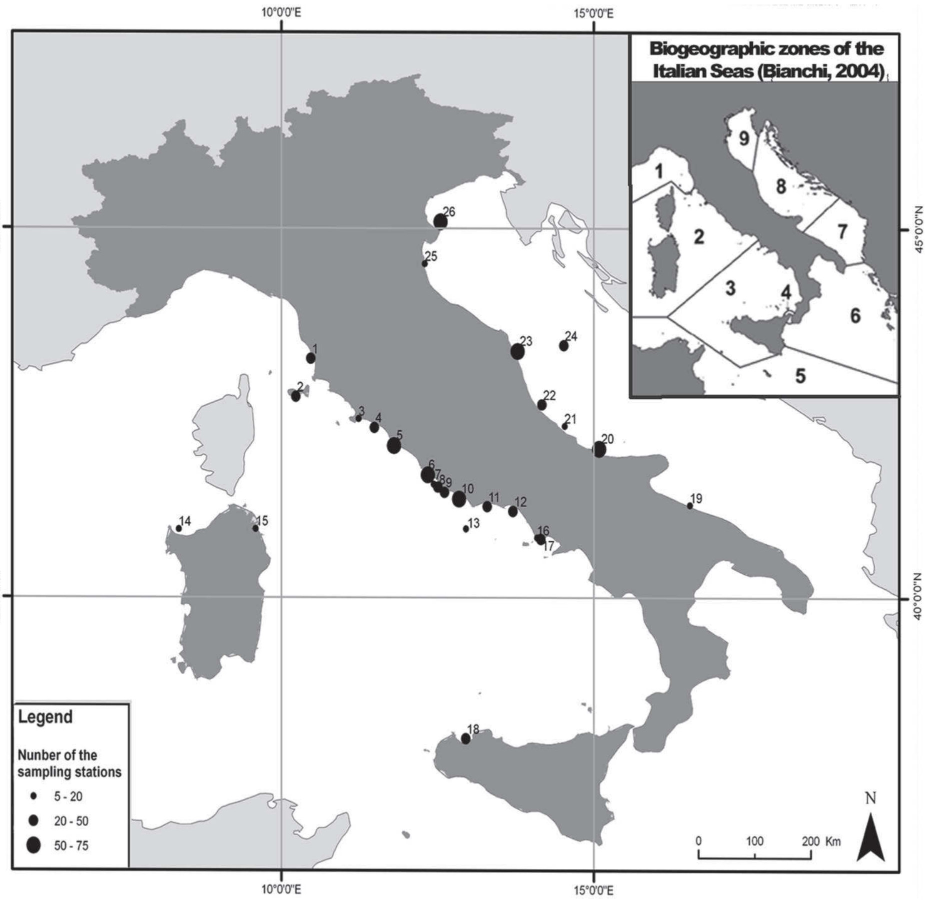


Figure 1. Location of the 26 study areas from which data was extracted. Stations are numbered from the Ligurian Sea to the northern Adriatic Sea. The dimension of the circle is proportional to the number of stations investigated in each area. 1, Rosignano; 2, Elba; 3, Porto Ercole; 4, Montalto; 5, Civitavecchia; 6, Ostia; 7, Torpaterno; 8, Torvaianica; 9, Anzio; 10, Sabaudia; 11, Terracina; 12, Gaeta; 13, Ponza; 14, Porto Torres; 15, Olbia; 16, Baia; 17, Bagnoli; 18, Castellammare; 19, Bisceglie; 20, Molise; 21, Ortona; 22, Giulianova; 23, Marche; 24, Civitanova Marche; 25, Ravenna; 26, Chioggia. The nine biogeographical zones described in the Italian Seas are as according to Bianchi (2004) and followed in the checklist of flora and fauna of the Italian Seas (Relini 2008)

Table I. The 26 study areas located in the nine biogeographical zones identified in the Italian Seas (Bianchi 2004), the number of sampling stations for each area, divided into depth ranges (C= Central; S= South; N=North).

Study Areas	Sea	Biogeographic Zone	Total number of Stations	Depth ranges (m)				
				0-10	10,1-20	20,1-30	30,1-50	>50
1. Rosignano	Ligurian Sea	1	35	7	15	7	4	2
2. Elba	N Tyrrhenian Sea	1–2	41		2	2	15	22
3. Porto Ercole	N Tyrrhenian Sea	2	11			11		
4. Montalto	C Tyrrhenian Sea	2	34			2	12	20
5. Civitavecchia	C Tyrrhenian Sea	2	70	1	5	21	43	
6. Ostia	C Tyrrhenian Sea	2	68	4	27	14	23	
7. Torpaterno	C Tyrrhenian Sea	2	26				18	8
8. Torvaianica	C Tyrrhenian Sea	2	50	4	4	4	12	26
9. Anzio	C Tyrrhenian Sea	2	31	4	7	4	16	
10. Sabaudia	C Tyrrhenian Sea	2	57	4	7	5	13	28
11. Terracina	C Tyrrhenian Sea	2	50	7	5	2	10	26
12. Gaeta	C Tyrrhenian Sea	2	27		5	4	9	9
13. Ponza	C Tyrrhenian Sea	2	19				3	16
14. Porto Torres	Sardinian Sea	2	17			5	12	
15. Olbia	C Tyrrhenian Sea	2	10	10				
16. Baia	C Tyrrhenian Sea	3	17	4	5	4	4	
17. Bagnoli	C Tyrrhenian Sea	3	33	33				
18. Castellammare	S Tyrrhenian Sea	3	21			3	17	1
19. Bisceglie	S Adriatic Sea	7	11		11			
20. Molise	C Adriatic Sea	8	52	20	11	11	7	3
21. Ortona	C Adriatic Sea	8	5		5			
22. Giulianova	C Adriatic Sea	8	28	10	7	4	5	2
23. Marche	C Adriatic Sea	8	75	75				
24. Civitanova Marche	C Adriatic Sea	8	23					23
25. Ravenna	N Adriatic Sea	9	9				9	
26. Chioggia	N Adriatic Sea	9	52	7	4	41		

coast, at depths ranging from 1 to 155 m (Table I), using a Van Veen grab (0.1 m^2 covering area). The sediments sampled were sieved through a 1-mm mesh and the retained material was preserved in seawater adding 4% $CaCO_3$-buffered formalin. Macrozoobenthic samples were further sorted into major taxonomical groups and the collected polychaetes counted and classified to the lowest possible taxonomic level. Surface sediments were collected at each station with a box-corer, analysed and classified according to sand percentage, following Nota (1958): sand (S) (>95% content of sand), muddy sand (mS) (95–70%), very sandy mud (vsM) (70–30%), sandy mud (sM) (30–5%) and mud (M) (<5%).

Twenty species, listed in Table II, were selected according to their spatial distribution, their ecological role and the existence of voucher specimens deposited in ISPRA's reference collection. For each species number of specimens and relative abundance (%) were calculated. Box-and-whisker plots (Tukey 1977) were performed to analyse the depth distribution of species. Depths were grouped in five ranges (1–10 m; 10.1–20 m; 20.1–30 m; 30.1–50 m; >50 m).

The spatial distribution of each species was further analysed according to the division of the Italian Seas into nine biogeographical zones, proposed by Bianchi (2004) (Figure 1) and applied in the Italian Checklist of marine flora and fauna (Relini 2008). No study areas were available for this study from biogeographical zones 4, 5 and 6.

Where available, information on the selected species on biocoenosis affiliation (Bellan 1964; Pérès & Picard 1964; Picard 1965; Augier 1982), preferred sediment typologies and depth range distribution was also extracted from existing literature.

Indicator Species Analysis (ISA) (Dufréne & Legendre 1997) has been performed in order to identify the species associated with or indicative of five groups of stations, derived from Nota (1958) classification. This analysis combines the relative abundance of the species with their relative frequency of occurrence in the various groups and provides an indicator value subsequently tested by randomization.

Table II. Distribution of the 20 selected species by the nine biogeographical zones of the Italian Seas. In white, the distribution of the selected species as reported in the Checklist of Flora and Fauna of the Italian Seas (Relini 2008); in grey, records confirming the species distribution; in black, new records distribution of five species (*Aponuphis bilineata*, *A. brementi*, *A. fauveli*, *Nothria conchylega*, and *Onuphis eremita*).

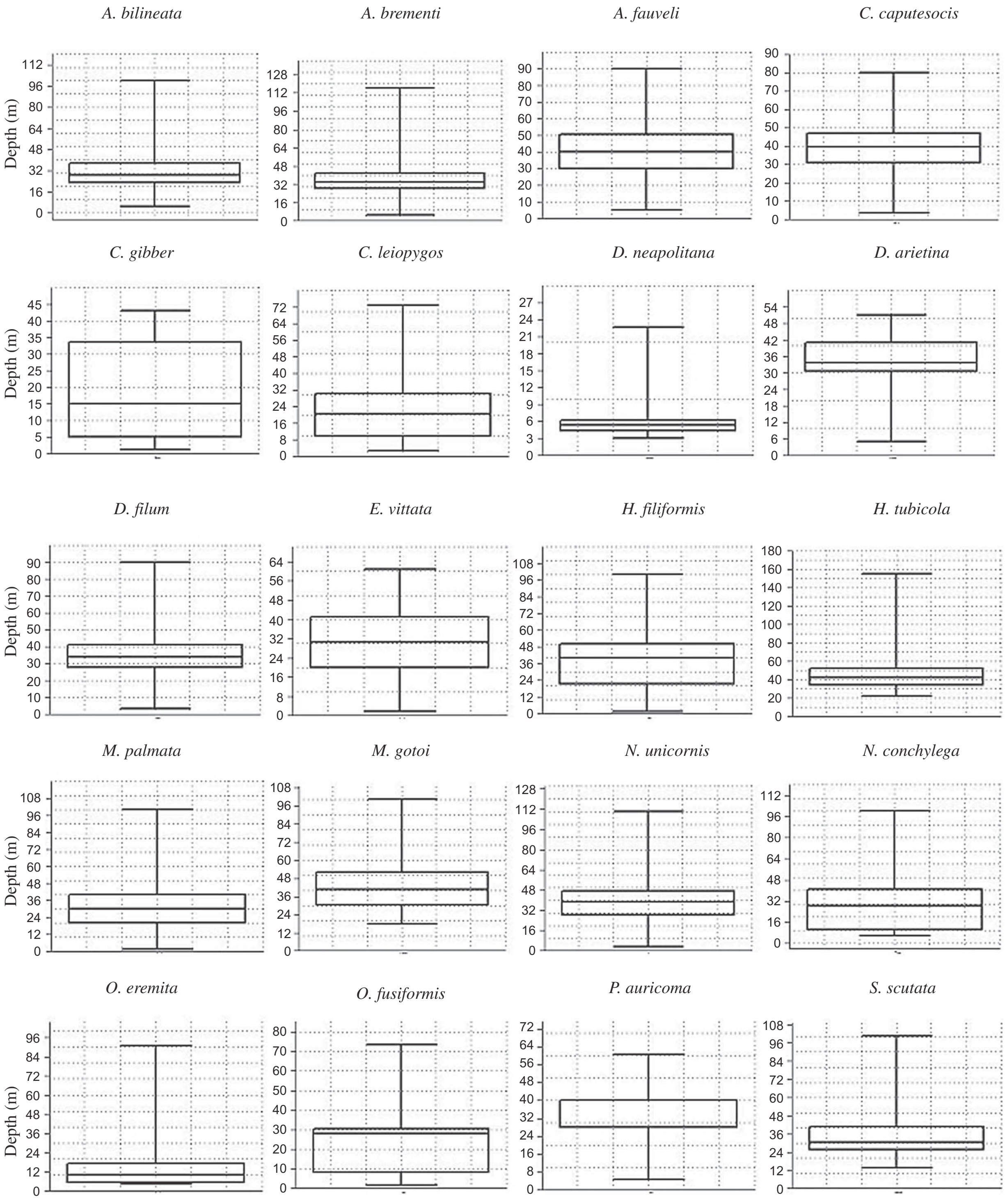
Species	Biogeographical Zones of Italian Seas								
	1	2	3	4	5	6	7	8	9
Aponuphis bilineata (Baird, 1870)	+	+	+	+	+	+	+	+	+
Aponuphis brementi (Fauvel, 1916)	+	+	+	+	+	+	+	+	+
Aponuphis fauveli (Rioja, 1918)	+	+	+	+	+	+	+	+	+
Chaetozone caputesocis (Saint-Joseph, 1894)	+	+	+	+	+	+	+	+	+
Chaetozone gibber Woodham & Chambers, 1994	+	+	+				+	+	+
Clymenura leiopygos (Grube, 1860)	+	+	+				+	+	+
Diopatra neapolitana Delle Chiaje, 1841	+	+	+	+		+	+	+	+
Ditrupa arietina (O.F. Muller, 1776)	+	+	+		+	+	+		+
Drilonereis filum (Claparède, 1868)	+	+	+	+	+	+	+	+	+
Eunice vittata (Delle Chiaje, 1828)	+	+	+	+	+	+	+	+	+
Heteromastus filiformis (Claparède, 1864)	+	+	+	+	+	+	+	+	+
Hyalinoecia tubicola (O.F. Müller, 1776)	+	+	+	+	+	+	+	+	+
Melinna palmata Grube, 1870	+	+	+		+	+	+	+	+
Metasychis gotoi (Izuka, 1902)	+	+	+		+		+	+	+
Nematonereis unicornis (Grube, 1840)	+	+	+	+	+	+	+	+	+
Nothria conchylega (M. Sars, 1835)		+	+	+	+	+	+	+	+
Onuphis eremita Audouin & Milne-Edwards, 1833		+	+			+	+	+	+
Owenia fusiformis Delle Chiaje, 1841	+	+	+		+	+	+	+	+
Pectinaria auricoma (O.F. Müller, 1776)	+	+	+	+	+		+	+	+
Sternaspis scutata (Ranzani, 1817)	+	+	+		+	+	+	+	+

Results and discussion

A total of 55,000 individuals from 200 species of polychaetes distributed across the Italian biogeographical zones 1, 2, 3, 7, 8, and 9 (Figure 1) were identified.

The allocation of the 20 selected species by biogeographical zones, as reported in the Checklist of flora and fauna of the Italian seas (Relini 2008), is presented in white in Table II. The results confirmed the presence of these species in some biogeographical zones (in grey) and updated the distribution of five of these species (in black). *Aponuphis bilineata*, *A. brementi* and *A. fauveli*, were recorded along the northern coast of the Island of Elba (Tuscan Archipelagos) in zone 1, which is considered to be a climate transitional area between zones 1 and 2 (Relini 2008). *Nothria conchylega* was found in zone 2, in the southern coast of the Island of Elba and along the coast of Latium (Central Tyrrhenian Sea) and *Onuphis eremita* was collected in zone 7, along the eastern coast of Apulia (Southern Adriatic Sea).

In Figure 2, box-and-whisker plots describe the depths distribution of the selected species. The analysis of the distribution revealed that most of the 20 species occurred at all depth ranges (Figure 3). Amongst the exceptions, *Chaetozone gibber* occurred exclusively from shallow waters to 50 m depth, *Diopatra neapolitana* was mostly distributed in shallow areas (1–10 m depth) and absent below 30 m, *Hyalinoecia tubicola* was sampled deeper than 20 m, *Metasychis gotoi* and *Sternaspis scutata* were only


A. bilineata *A. brementi* *A. fauveli* *C. caputesocis*

C. gibber *C. leiopygos* *D. neapolitana* *D. arietina*

D. filum *E. vittata* *H. filiformis* *H. tubicola*

M. palmata *M. gotoi* *N. unicornis* *N. conchylega*

O. eremita *O. fusiformis* *P. auricoma* *S. scutata*

Figure 2. Box-and-whisker plots describe the distribution of depths where species were found.

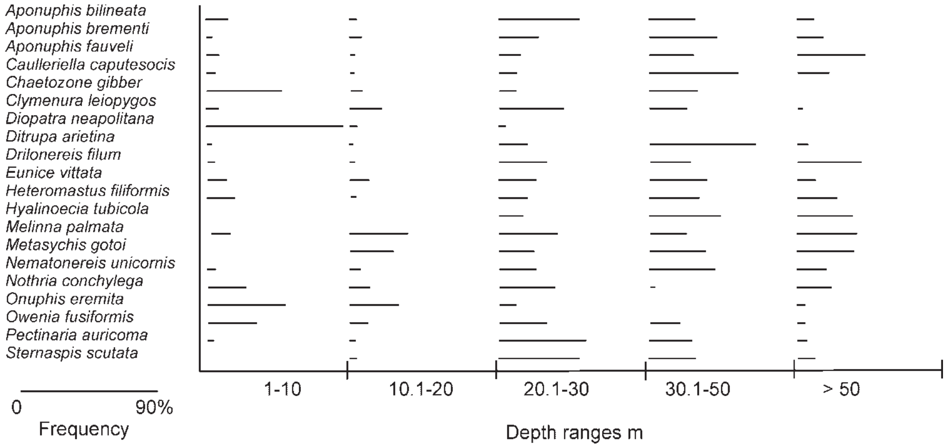


Figure 3. Distribution of the 20 selected species along the different depth ranges (in meters), taking into account the percentage of analysed stations, for each depth range, where the species were found. The maximum found percentage was 90%.

found deeper than 10 m, and *Onuphis eremita*, was absent in the 30–50 m depth range.

The species distributions show that all species were found in all sediment classes (Nota's sediment classification) except *Diopatra neapolitana*, which was not found in sandy-muds (sM) and *Metasychis gotoi* and *Pectinaria auricoma*, which were absent from sands (S) (Figure 4).

The species selected were present in the range of 0–20% relative abundance within the associated polychaete assemblages in all sediment typologies; higher values of relative abundance were recorded only for some species and in some classes of sediment (Table III).

The species-group contributions obtained from ISA are reported in Table IV. Results demonstrate that the species distribution depends on definite granulometric characteristics of the sediment and the indicator values of ISA statistic specify the groups of stations that are associated with the species with different levels of significance. It is interesting to highlight that 17 of the selected species are associated with specific groups with a high level of significance ($p \leq 0.01$ and $p \leq 0.001$) while *Hyalinoecia tubicola*, *Melinna palmata* and *Nothria conchylega* are associated with a low level of significance ($p \leq 0.05$). *Chaetozone gibber*, *Clymenura leiopygos* and *Diopatra neapolitana* have no significant relationship with the groups identified, suggesting a wide ecological tolerance against the sediment fractions. Moreover, *Drilonereis filum* and *Eunice vittata* have values of ISA that suggest a high tolerance to mixed sediment (vsM and sM) and *Sternaspis scutata* show a significant preference for muddy sediment (sM and M).

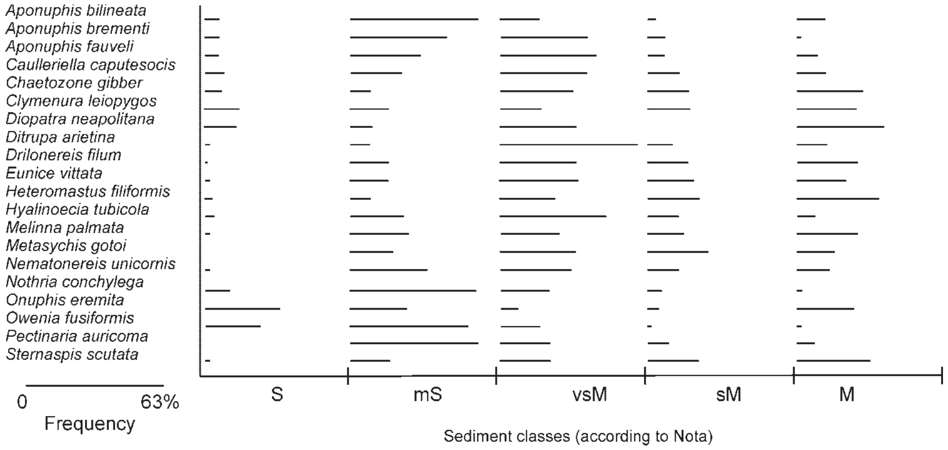


Figure 4. Distribution of the 20 selected species amongst different sediment classes according to Nota's classification (1958): sand (S) (>95% content of sand), muddy sand (mS) (70–95% content of sand), very sandy mud (vsM) (70–30% content of sand), sandy mud (sM) (30–5% content of sand) and mud (M) (<5% content of sand). The distributions take into account the percentage of analysed stations, for each sediment class, where the species were found. The maximum found percentage was 63%.

Table III. Frequency of station in each Nota's sediment class where each species was found. Species occurrence is also clustered into classes of relative abundances (%) of each species within the whole polychaete assemblages (S= sand; mS=muddy sand; vsM=very sandy mud; sM=sandy mud; M=mud).

	0-20 %					**21-40 %**					**41-60 %**					**61-80 %**				
	S	mS	vsM	sM	M	S	mS	vsM	sM	M	S	mS	vsM	sM	M	S	mS	vsM	sM	M
Aponuphis bilineata	15	123	41	9	31	1	16	2												
Aponuphis brementi	10	63	52	10	2		3	7	2											
Aponuphis fauveli	9	40	63	10	11		4	1		3		3							1	
Chaetozone caputesocis	6	16	27	10	7					1					1					
Chaetozone gibber	5	6	15	11	19				1											
Clymenura leiopygos	19	21	21	22	32			1					1							
Diopatra neapolitana	3	2	7		8															
Ditrupa arietina	1	4	24	5	6			2												
Drilonereis filum	1	28	58	29	46				2			1								
Eunice vittata	4	32	66	39	41															
Heteromastus filiformis	6	16	42	37	54				1	3										
Hyalinoecia tubicola	2	12	24	5	4															
Melinna palmata	5	70	76	44	73		7	1	4	5					1					
Metasychis gotoi		15	21	22	12			2	2											
Nematonereis unicornis	3	49	45	20	21															
Nothria conchylega	5	25	10	2	1		1		1											
Onuphis eremita	12	9	3	2	10	1	1													
Owenia fusiformis	56	161	57	5	3	17	10	1			4	2				3	1			
Pectinaria auricoma		71	28	12	10															
Sternaspis scutata	4	52	57	54	69			11	10	13				2	12				2	5

Table IV. The species-group contributions obtained from Indicator Species Analysis (ISA). The indicator values of ISA specify the groups of stations that are associated with the species with different levels of significance.

Species	S	mS	vsM	sM	M	*P-level*
Aponuphis bilineata	1.326	25.808	6.499	0.970	-	0.000
Aponuphis brementi	0.449	4.619	16.738	0.796	0.001	0.000
Aponuphis fauveli	0.242	3.816	17.674	0.531	0.231	0.000
Caulleriella caputesocis	1.112	0.998	6.531	1.195	0.131	0.001
Caulleriella gibber	0.645	0.069	1.276	2.794	3.381	0.167
Clymenura leiopygos	4.518	0.911	5.358	3.627	0.823	0.362
Diopatra neapolitana	0.322	0.014	2.411	-	0.983	0.074
Ditrupa arietina	0.008	0.024	8.932	0.349	0.059	0.000
Drilonereis filum	0.006	0.431	11.515	8.242	3.989	0.002
Eunice vittata	0.152	1.194	12.180	8.935	2.700	0.000
Heteromastus filiformis	0.320	0.747	6.284	1.223	0.050	0.000
Hyalinoecia tubicola	0.148	0.157	11.931	11.883	3.457	0.022
Melinna palmata	0.073	3.796	7.793	13.975	8.344	0.023
Metasychis gotoi	-	0.401	5.442	8.945	0.362	0.001
Nematonereis unicornis	0.143	2.719	11.495	4.522	0.954	0.000
Nothria conchylega	0.903	5.518	0.944	0.108	0.002	0.021
Onuphis eremita	8.653	0.53	0.101	0.068	0.308	0.000
Owenia fusiformis	64.494	8.374	0.803	0.004	0.001	0.000
Pectinaria auricoma	-	14.735	3.054	1.490	0.157	0.000
Sternaspis scutata	0.034	0.229	6.068	16.599	18.048	0.002

For each species, the information on biocoenoses affiliation, ecological significance, sediment typologies and depth ranges, as emerging from previous literature and from the results of this study, is summarized in Table V. These results are also listed below, in alphabetic order.

Aponuphis bilineata (Onuphidae) was found from 4 to 100 m depth (Figure 2) although it was mostly frequent between 20 and 30 m depth (Figure 3). The species mainly prefers muddy sand (mS) and very sandy mud (vsM) (Figure 4 and Table IV), where gravels are present, as along the Island of Elba and

Table V. For each species, information on biocoenoses affiliation, ecological significance, sediment typologies and depth ranges, as emerging from previous literature and from the results of this study. Results are listed in alphabetic order. Abbreviations: C = coralligenous biocoenoses, DC = biocoenoses of coastal detritic, DE = biocoenoses of muddy detritic, DL = biocoenoses of the shelf-edge detritic, SFBC = biocoenoses of well-sorted fine sand, SVMC = biocoenoses of surface muddy sands in sheltered waters, VTC = biocoenoses of coastal terrigenous mud, MI = Communities of unstable soft seabeds, excl. exclusive species, pref. = preferential species, sand tol. = species living on sands and tolerant to other fractions, mud tol. = species living on muds and tolerant to other fractions, Grav. = species living on gravely sediments, Lre = species with wide ecological distribution, Mixt. = species living on mixed sediments.

SPECIES	ECOLOGICAL CHARACTERISTICS ■ Biocoenoses - ecological significance ■ Sediment typology ■ Depth range (vertical zonation)	REFERENCES	ECOLOGICAL CHARACTERISTICS from ISPRA' dataset ■ Sediment typology ■ Depth range (m)
Aponuphis bilineata	■ DE, Lre, Grav. ■ very fine sand, sand, detritic sand, muddy sand, mixed sediments	Bellan 1964; Picard 1965; Giangrande & Gambi 1985; Gambi & Giangrande 1986; Bellan & Bellan-Santini 1991; Bianchi et al. 1993 b; Chimenz Gusso et al. 2001; Cosentino & Giacobbe 2008	■ sand (S), muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 4–100 m
Aponuphis brementi	■ Mixt.	Crema et al. 1993;	■ sand (S), muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 5–116 m
Aponuphis fauveli	■ DE, Mixt. ■ Circalittoral, Bathyal	Intès & Le Loeuff 1986; Bianchi et al. 1993a, b, c; Chimenz Gusso et al. 2001	■ sand (S), muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 5–90 m
Caulleriella caputesocis	■ mud-tol.	Bianchi et al. 1993 b	■ sand (S), muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 3,5–80 m
Chaetozone gibber	■ mud ■ Circalittoral	Cacabelos et al. 2008 ; Zaabi et al. 2009	■ sand (S), muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 1–43 m
Clymenura leiopygos	■ sand, muddy sand, ■ Infralittoral	Massé 1972; Giangrande & Gambi 1985; Crema et al. 1993	■ sand (S), muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 2,5–73 m
Diopatra neapolitana	■ SFBC excl ■ Sand, tolerant of small amount of mud, very sandy mud.	Bellan 1964; Picard 1965; Gambi & Giangrande 1986; Intès & Le Loeuff 1986; Bianchi et al. 1993a, b, c	■ sand (S), muddy sand (mS), very sandy mud (vsM), mud (M) ■ 3–22,7 m

Table V. (Continued)

SPECIES	ECOLOGICAL CHARACTERISTICS ■ Biocoenoses - ecological significance ■ Sediment typology ■ Depth range (vertical zonation)	REFERENCES	ECOLOGICAL CHARACTERISTICS from ISPRA' dataset ■ Sediment typology ■ Depth range (m)
Ditrupa arietina	■ DC excl., DC, MI ■ mixed sediments ■ Circalittoral, Infralittoral	Bellan 1961; Bellan 1964; Pérès & Picard 1964; Picard 1965; Augier 1982; Gambi & Giangrande 1986; Grémare et al. 1989; Crema et al. 1993	■ sand (S), muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 5–51 m
Drilonereis filum	■ Lre ■ sandy mud, mud, mixed sediments (with high fraction of sand), detritic sand, sediment with organic matter (Om) ■ Circalittoral, Bathyal	Bellan 1964; Picard 1965; Picard 1972; Gambi & Giangrande 1986; Intès & Le Loeuff 1986; Bellan & Bellan-Santini 1991; Bianchi et al. 1993a, b, c.	■ sand (S), muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 3–90 m
Eunice vittata	■ C, Lre, opportunist, colonizer Detritic sediment, sand, mixed sediments, median grain size sand, sediment with organic matter (Om)	Bellan 1961; Bellan 1964; Pérès & Picard 1964; Picard 1965; Picard. 1972; Diaz-Castañeda & Safran 1988; Bellan & Bellan-Santini 1991	■ sand (S), muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 1,5–60 m
Heteromastus filiformis	■ SVMC excl., companion species without specific ecological role, indicator of artificial or natural disturbance, euryhaline muddy enriched sediments ■ eurybathic	Pérès & Picard 1964; Bellan 1964; Picard 1965; De Gaillande 1968; Picard 1972; FAO/UNEP 1986; Gravina & Somaschini 1990; Dewarumez et al. 1992, Bianchi et al. 1993a; Carvalho et al. 2005	■ sand (S), muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 1,5–99 m
Hyalinoaecia tubicola	■ DC pref., Mixt. ■ muddy sand	Pérès & Picard 1964; Bellan 1964; Picard 1965; Bianchi et al. 1993a,b,c	■ sand (S), muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 22–155 m

Table V. (Continued)

SPECIES	ECOLOGICAL CHARACTERISTICS ■ Biocoenoses - ecological significance ■ Sediment typology ■ Depth range (vertical zonation)	REFERENCES	ECOLOGICAL CHARACTERISTICS from ISPRA' dataset ■ Sediment typology ■ Depth range (m)
Melinna palmata	■ DE ■ Mixed sediments, muddy fine sand, sediment with organic matter (Om) ■ Infralittoral, Circalittoral, Bathyal	Bellan 1963; Bellan 1964; Pérès 1982; Giangrande & Gambi 1985; Gambi & Giangrande 1986; Intès & Le Loeuff 1986; Hily 1987; Duineveld et al. 1991, Bianchi et al. 1993b; Dauvin 2000; Dos Santos Brasil & Gonçalves da Silva 2000	■ sand (S), muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 17,5–100 m
Methasychis gotoi	■ Mud	Picard 1965; Zavodnik et al. 1985, Cantone et al. 2004	■ muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 17,5–100 m
Nematonereis unicornis	■ DE, Mixt. MI ■ mud, sediment with organic matter (Om), *Posidonia oceanica* sheaths.	Bellan 1964; Picard 1965; Drago & Arbetelli 1978; Zavodnik et al. 1985; Bellan 1985; Intès & Le Loeuff 1986; Sardà 1986; Bianchi et al. 1993a, b, c	■ sand (S), muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 3–110 m
Nothria conchylega	■ DL, VTC, Mixt. ■ sandy mud ■ Circalittoral, Bathyal	Bellan 1964; Bellan 1963; Intès & Le Loeuff 1986 ; Bianchi et al. 1993c,b,c	■ sand (S), muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 5 –100 m
Onuphys eremita	■ SFBC excl.	Picard 1965; Bianchi et al. 1993a	■ sand (S), muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 4 –23 m and 90 m
Owenia fusiformis	■ DC, SFBC ■ Sand tol., fine sand, sandy mud, ecotonal zone enriched with organic matter ■ Infralittoral, Circalittoral	Pérès & Picard 1964; Bellan 1964; Picard 1965; Desbruyères et al. 1972-73; Intès & Le Loeuff 1986; Abbiati et al. 1987; Hily 1987; Bianchi et al. 1993a,b,c	■ sand (S), muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 1,5 –73 m
Pectinaria auricoma	■ DE pref., Mixt. ■ Mud. tol.	Picard 1965; Bellan 1964; Bianchi et al. 1993a	■ muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 4,5 – 60,5 m
Sternaspis scutata	■ VTC excl ■ sandy mud ■ Eurybathic, Circalittoral, Bathyal	Pérès & Picard 1964; Bellan 1964; Picard 1965; Picard 1972; Zavodnik et al. 1985; Gambi & Giangrande 1986;Crema et al. 1991; Bianchi et al. 1993a; Ben-Eliahu & Fiege 1995	■ sand (S), muddy sand (mS), very sandy mud (vsM), sandy mud (sM), mud (M) ■ 13,5 –100 m

western Sardinia coasts. Moreover, this species seems to tolerate a high percentage of mud occurring in both sandy mud and muddy stations (sM and M). Our results partially agree with the existing information that signalled *A. bilineata* in detritic and sandy substrata and in mixed sediment (Table V).

Aponuphis brementi and *Aponuphis fauveli* (Onuphidae) displayed similar sediment preferences to the congeneric species *A. bilineata* showing a significant association with very sandy mud (vsM) (Figure 4 and Table IV). *A. brementi* was more frequent below 20 m depth and up to 50 m while *A. fauveli* occurred below 30 m and up to 90 m depth (Figures 2 and 3). Our results add information to the existing literature where these species were described as 'misticolous' and *A. fauveli* in particular was affiliated to the muddy detritic biocoenoses (Table V).

Caulleriella caputesocis (Cirratulidae) was found from 3.5 to 80 m depth (Figure 2) and more frequently in deeper stations, below 30 m depth (Figure 3). It occurred in stations with high percentages of mud (vsM, sM and M) (Figure 4 and Table IV), in accordance with the existing information (Table V), but also in few stations where the sandy fraction was ≥95–70% of the sediment (S and mS).

Chaetozone gibber (Cirratulidae) was distributed in all sediment typologies, with higher frequency in muddy stations (vsM, sM and M) (Figure 4) as indicated in the literature (Table V). The species was mainly found in shallow water and never below 43 m depth (Figures 2 and 3).

Clymenura leiopygos (Maldanidae) was collected from 2.5 to 73 m (Figure 2) especially in stations located between 20 and 30 m depth (Figure 3). The presence of this species was signalled in sandy stations, as well as in all the other sediment typologies, with comparable frequencies (Figure 4). Our data show that *C. leiopygos* has a higher tolerance to different fractions of mud than what expressed in the existing literature (Table V).

Diopatra neapolitana (Onuphidae) was mostly found in shallow stations (above 10 m depth) but is present up to about 23 m depth (Figures 2 and 3). It was mainly collected in sediments with high percentages of mud (vsM and M) and only in a few sandy stations (S and mS) (Figure 4). These results suggest that this species has a good tolerance for mud, in partial agreement with previous literature that considered *D. neapolitana* a species typical of fine well-sorted sand assemblages (Picard 1965) and characteristic of sandy sediments, but tolerant to small amounts of mud (Table V).

Ditrupa arietina (Serpulidae) was mostly collected between 30 and 50 m depth, although its range spans from 5 to 51 m depth (Figures 2 and 3). According to our results, this species seems to tolerate different fractions of mud in the sediment, since it was mostly recorded on very sandy mud (vsM) and in other types of sediment, ranging from sand to mud (Figure 4 and Table IV). It is also interesting to underline that the gravel fraction was very scarce in all the stations where *D. arietina* was recorded, although this is a species normally affiliated to detritic coastal assemblages and it has been signalled on mixed sediments (Table V).

Drilonereis filum (Oenonidae) was found from 3 to 90 m depth, mostly below 20 m (Figures 2 and 3), in all sediment types even if it showed a high tolerance to mixed sediment (vsM and sM) (Figure 4 and Table IV); moreover, it was very rare in sandy (S) and shallow stations and up to 20 m depth. Our results, on the whole, confirm the information existing on this species (Table V).

Eunice vittata (Eunicidae) was found from 1.5 to 60 m depth (Figure 2). It is mostly frequent on muddy substrata, preferably in very sandy mud (vsM), sandy mud (sM) (Table IV) and mud (M) (depth range 30–50m), rather than on sandy sediments (S and mS) (Figures 3 and 4). The percentage of gravel (mainly composed of organic detritic matter) was more abundant in vsM sediments which characterized stations located around Island of Elba and few stations of Baia (Gulf of Naples). Our results partially agree with previous scientific literature (Table V).

Heteromastus filiformis (Capitellidae) was recorded between 1.5 and 99 m depth (Figures 2 and 3) in sediments characterized by a high percentages of mud (vsM, sM and M) and only in few sandy (S) and muddy sand (mS) stations (Figure 4 and Table IV). These results agree with the existing information, which defined the species as an exclusive species of upper muddy-sand assemblages living also in mud-rich sediments (Table V).

Hyalinoaecia tubicola (Onuphidae) was sampled exclusively below 20 m depth, frequently between 30 and 50 m (Figures 2 and 3). This species inhabited primarily very sandy mud (vsM), sandy mud (sM) and muddy sand (mS) sediments and was found in other sediment typologies in only a few stations (S and M) (Figure 4 and Table IV). In some of the stations where *H. tubicola* was recorded (mainly vsM and mS stations located in the Tyrrhenian Sea along the Island of Elba and the coast of Terracina and Sabaudia), the percentage of gravel suggested the presence of detritic habitats where, according to the scientific literature, this species is most common (Table V).

Melinna palmata (Ampharetidae) was collected from 1 to 99 m depth (Figures 2 and 3), and results show that the species is strongly linked to the muddy fraction of the sediment (Figure 4 and Table IV), in accordance with several authors (Table V). In fact, the stations where the species mostly occurred were characterized by an increasing percentages of mud (from mS to M classes).

Metasychis gotoi has been defined as an alien species for the Mediterranean Sea (Cantone et al. 2004; Occhipinti-Ambrogi et al. 2011). The species was sampled, in comparable frequencies, in sediments with a variable fraction of mud, with a significant preference for sandy mud (sM), and at depths ranging from about 17 to 100 m (Figures 2–4 and Table IV). This species was absent in shallow waters with sand percentages >95%. The data that we collected on this species integrate the information on the substrata inhabited by *M. gotoi* (Table V).

Nematonereis unicornis distribution (Eunicidae) highlights the wide bathymetric range of this species, recorded from 3 to 110 m depth with highest frequencies between 30 and 50 m depth (Figures 2 and 3). *N. unicornis* inhabits sediments with different percentages of mud (from mS to M) (Figure 4, Table IV) and – in some locations – with abundant fractions of gravel (Elba Island, Baia and Anzio, Tyrrhenian Sea). These results confirmed the information about this species, which normally has been affiliated to muddy-detritic assemblages (Table V) and classified as one of the few taxa able to burrow inside *Posidonia oceanica* sheaths (Gambi 2002).

Nothria conchylega (Onuphidae) was recorded from 5 to 100 m depth with variable frequencies at different depth ranges (Figures 2 and 3). It was mostly found in sediments with 70–95% sand (mS) and it was less frequent either at stations characterized exclusively by sand (S) or by lower percentages of sand (vsM, sM and M) (Figure 4 and Table IV). These results add information to previous literature, which described *N. conchylega* as a species typical of muddy sediment, often found in shelf terrigenous mud and in shelf edge detritic assemblages (Table V).

Onuphis eremita (Onuphidae) was collected up to 90 m depth and mostly between 4 and 10 m; no individuals were found between 30 and 50 m depth (Figures 2 and 3). *O. eremita* was frequent in sandy stations (S and mS) (Figure 4 and Table IV), in accordance with the literature that affiliated this species to the biocoenoses of well-sorted fine sand (Table V). Nevertheless, we signal that this species was also frequent in mud (M).

Owenia fusiformis (Oweniidae) was present in the depth range 1.5–73 m with variable frequencies (Figures 2 and 3). This species was mainly found in stations characterized by a high percentage of sand (S and mS) (Figure 4 and Table IV), in accordance with authors who described it as typical of fine well-sorted sand assemblages (Table V). Moreover, a significant percentage of gravel characterized some of the stations were the species was found at the Island of Elba, Porto Torres (Western Sardinia), Montalto (Central Tyrrhenian Sea) and Marche (Central Adriatic Sea) indicating that *O. fusiformis* inhabits also detritic substrata, as stated by Pérès & Picard (1964) (Table V).

Pectinaria auricoma (Pectinariidae) was mostly recorded between 20 and 30 m depth, although it was collected in the range of 4.5–60.5 m (Figures 2 and 3), on sandy substrata with low fractions of mud (mS) (Figure 4 and Table IV). We noticed that the increase of mud in the sediment led to the decrease of *P. auricoma*, and the species was absent in exclusively sandy sediment (S). Our results are partially in accordance with the common description of this species as affiliated to the muddy-detritic assemblages (Picard 1965) and as a mud tolerant species (Table V).

Sternaspis scutata (Sternaspidae) occurred exclusively below 13 m depth, mainly between 20 and 30 m (Figures 2 and 3). Our results indicate that this species inhabits primarily muddy sediments (sM and M), even if it was also found in several stations with very sandy mud (vsM) or muddy sand (mS) (Figure 4 and Table IV). These results partially confirm the previous information, which described this species as typical of the terrigenous mud-shelf assemblages and inhabiting sandy mud (Table V).

Conclusions

New relevant information emerged from the comparison of the results of this study with pre-existing knowledge. In fact, the data analysed allow us to update the distribution in the Italian Biogeographical Zones of five species (*Aponuphis bilineata*, *A. brementi* and *A. fauveli*, *Nothria conchylega*, and *Onuphis eremita*).

These results contribute to update the ecological characteristics of the investigated species in relation to depth range and sediment typologies, highlighting significant associations of a number of species with definite sediment classes. Moreover, this results outline that multidisciplinary data sets, as ISPRA's, are essential in increasing the scientific knowledge on the benthic communities and species that populates soft seabed substrata.

This study furthermore outlines the importance of environmental monitoring programmes as a source of important scientific data such as relevant information on marine invertebrate ecology. This work is meant to be a first contribution in the framework of a more extensive revision of our understanding of the ecological requirements and the distribution of polychaete species in soft sediments, improving our knowledge on the functioning and evolution of marine ecosystems.

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ORIGINAL ARTICLE

Relict sand dredging for beach nourishment in the central Tyrrhenian Sea (Italy): effects on benthic assemblages

Barbara La Porta, Monica Targusi, Loretta Lattanzi, Paola La Valle, Daniela Paganelli &
Luisa Nicoletti

ISPRA formerly ICRAM, Central Institute for Marine Research, Rome, Italy

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Correspondence
B. La Porta, ISPRA formerly ICRAM, Central Institute for Marine Research, via di Casolotti 300, 00166 Rome, Italy.
E-mail: barbara.laporta@isprambiente.it

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Abstract

The aim of this study is to analyse the effects in space and time of relict sand-dredging activities on macrobenthic assemblages, in an area situated offshore Montalto di Castro (central Tyrrhenian Sea, Italy), and to analyse the recolonisation processes of macrobenthos in the dredged areas. The area in question is characterised by relict sand deposits (Holocenic paleo-beaches), used for beach nourishment along the Latium coast. The effects of sand extraction on benthic assemblages were investigated before, during and after three dredging operations. The sites analysed are located within the dredged areas (inside stations) and in neighbouring, not dredged, areas (outside stations). The results showed that the impact of sand extraction was confined to the dredged stations and to the areas in proximity to the dredged areas. During dredging activities, the structure of benthic assemblages within the impacted stations was characterised by low species richness and diversity. Both the direct removal of sediment and the re-suspension and consequent deposition of fine sediment affected benthic assemblages of the impacted stations. A few months after the dredgings, a recolonisation process was still observed at all the impacted stations. A gradual recolonisation process was observed at those stations affected by only one dredging, whereas a different recolonisation was observed at those stations affected by two dredgings over time. This study suggests that differences of re-colonisation processes of benthic assemblages are related to the intensity of dredging operations in terms of dredging frequency.

To combat coastal erosion along the Italian coasts, the local governments and the environmental protection agencies of several regions have planned nourishment operations exploiting relict sand deposits, within the framework of the European project INTERREG IIIC BEACHMED-e (http://www.beachmed.eu).

Relict sands are non-diagnosed sedimentary deposits situated along the continental shelf in a state of disequilibrium with the present sedimentary dynamics. The removal of such sediments, occurring offshore at high depths, does not affect the wave motion regime and, therefore, coastal dynamics. The relict sand extraction is performed through the use of suction trailers or anchor dredges. A common consequence of trailer dredging is the development of shallow furrows 1–3 m in width and sometimes up to 5 m in depth (Desprez 2000). Anchor dredging leads to the formation of deep, cup-shaped depressions, typically up to 8–10 m deep (Boyd & Rees 2003). Both dredging methods can result in significant environmental alterations, which may take place on both physical and biological levels. The main physical effects involve variations in morphological and bathymetric features, modifications of superficial sediment characteristics, and an increase in water turbidity caused by the re-suspension of fine sediment in the water column during dredging activities. Concerning the biological effects, both dredging methods cause severe disturbances in macrozoobenthos assemblages in terms of the direct effect on sediment removal and the indirect effect associated with the deposition of suspended sediment caused by sand extraction (Desprez 2000; Sardà *et al.* 2000; Boyd & Rees 2003; Szymelfenig *et al.* 2006; Simonini *et al.* 2007). Nevertheless, the type of dredge employed, as well as the nature of the receiving environment, can potentially influence the spatial scale of impact on the benthic fauna, in terms of both direct and indirect effects caused by sand extraction (Boyd & Rees 2003). Boyd & Rees (2003), Newell *et al.* (2004), Robinson *et al.* (2005) and, more recently, Cooper *et al.* (2007) have shown that the impact on benthic assemblages is also related to the process of repeated dredgings within the dredged site. Robinson *et al.* (2005) and Cooper *et al.* (2007) also highlighted that benthic recolonisation processes in repeatedly dredged areas are particularly difficult to predict, because of both the different benthic responses to the intensity of dredging operations in terms of dredging frequency and the variations in environmental characteristics.

Between July 2004 and September 2005, three relict sand-dredging activities were performed in an area offshore Montalto di Castro (Lazio, Italy) in the central Tyrrhenian Sea, with the final aim of nourishing various beaches along the Lazio coasts. This area was characterised by the presence of relict sand deposits that were covered by a muddy layer of recent deposition, with a thickness that varies between a few centimetres and a few metres (Chiocci & La Monica 1999). For these operations, ISPRA, formerly ICRAM (Central Institute for Marine Research), carried out an environmental impact study related to marine relict sand extraction for beach nourishment, funded by the Regione Lazio local authority. This monitoring program has provided an opportunity to collect useful information for the evaluation of the consequences of sand extraction over a relatively short time period in an offshore area that until now has been poorly investigated. In particular, in this study we analysed: (i) the effects of relict sand-dredging activities on the macrobenthos assemblages; (ii) the recolonisation processes of macrobenthos in the dredged areas; (iii) the effects over time of repeated dredging activities on macrobenthos assemblages.

Material and Methods

The study area was located 3.5 nautical miles offshore from Montalto di Castro (Lazio, Italy) in the central Tyrrhenian Sea, on the continental shelf at 50 m of water depth.

The relict sand-dredging activities in this area took place in three different periods, July 2004 (first dredging), June 2005 (second dredging), and September 2005 (third dredging). Over this period, three changes in the boundaries of the extraction areas were reported (Fig. 1). For the first dredging, an anchor dredge was used, whereas for the second and third dredging a trailer dredge was used. The monitoring surveys were carried out from May 2004 to October 2006, before, during and after the dredging activities, as indicated in Nicoletti *et al.* (2006) (Table 1). The sampling plan provided five stations (named stations 1, 2, 3, 4 and 5), one of which was located inside the dredged area in order to monitor the first dredging. The second and the third dredging activities were carried out in proximity (N–NE) to the first area dredged. Three stations (6, 7 and 8) were added to the sampling plan to monitor these dredgings, as shown in Fig. 1. Macrobenthos sampling was carried out using a Van Veen grab with a surface of 0.1 m^2. Two replicates were collected at each station. Samples were sieved through a 1-mm mesh and the retained material was preserved in 4% $CaCO_3$ buffered formalin in seawater. For each station, samples of superficial sediments were collected through a box-corer to determine grain size distribution. Superficial sediments were classified according to Shepard (1954). The collected organisms were counted and classified to the lowest possible taxonomic level. In

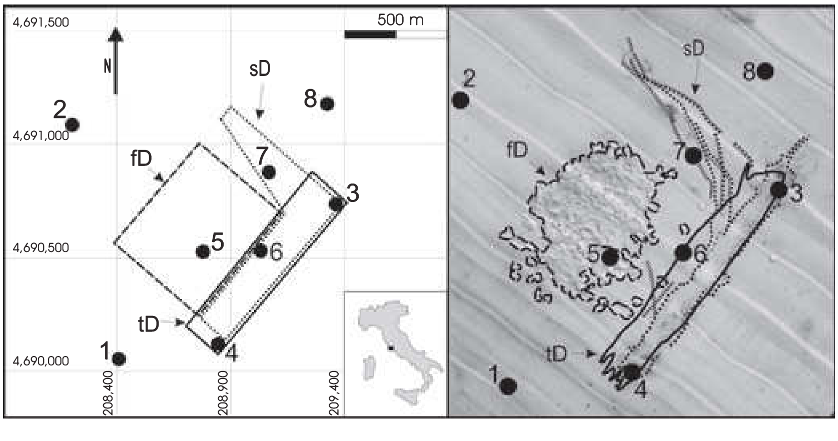

Fig. 1. On the left, the location of relict sand-extraction areas with a map of sampling stations (black point) is represented; on the right, side scan sonar reliefs of the dredged areas (fD = first dredged area; sD = second dredged area; tD = third dredged area) is reported.

Table 1. Sand-dredging characteristics and sampling plan of the three dredged areas.

	First dredged area	Second dredged area	Third dredged area
Volume sand extracted (m^3)	600,000	150,000	700,000
Water depth (m)	50	50	50
Type of dredge	Anchor dredge	Trailer dredge	Trailer dredge
Dredging period	July 2004	June 2005	September 2005
Sampling stations			
Inside the dredged area	5	6,7	3, 4, 6
Outside the dredged area	1, 2, 3, 4	1, 2, 3, 4, 5, 8	1, 2, 5, 7, 8
Surveys			
May 2004 – before dredging (B)	√	–	–
July 2004 – during first dredging (fD)	√	–	–
September 2004 – 2 months after dredging (A2)	√	–	–
April 2005 – 9 months after dredging (A9)	√	–	–
August 2005 – 14 months after dredging (A14)	√	√	√
September 2005 – during third dredging (tD)	√	√	√
May 2006 – 22 months after dredging (A22)	√	√	√
October 2006 – 27 months after dredging (A27)	√	√	√

particular, Polychaeta, Crustacea, Mollusca and Echinodermata were analysed. The main ecological indices (abundance, number of species, Margalef species richness and Shannon–Wiener diversity) were calculated. Multivariate analysis was performed with abundance data to analyse the benthic assemblage variation patterns in terms of species composition and numerically dominant species. The output from the non-metric multidimensional scaling (nMDS) ordination model of the Bray–Curtis similarity matrix was obtained for each station and sampling period. Univariate and multivariate analyses were performed using the software package PRIMER v. 6.1.5 (Clarke & Gorley 2001).

Results

During the study period, 4553 individuals belonging to 191 species were collected (Table 2). Polychaetes were the most abundant taxon (3371 individuals and 103 species), followed by crustaceans (626 individuals and 48 species), echinoderms (328 individuals and 10 species), and molluscs (228 individuals and 30 species). The most abundant species were the polychaetes *Paralacydonia paradoxa*, *Glycera unicornis*, *Paraprionospio pinnata*, *Metasychis gotoi*, the tanaid *Tuberapseudes echinatus*, and the ophiuroid *Amphiura chiajei*. In general, benthic assemblages were characteristic of muddy bottoms. The species composition did not show considerable variations over time. Only a few taxa showed variation over time; these were the opportunistic species *Corbula gibba* and *Terebellides stroemi*, and the sabulicolous polychaetes *Streblosoma bairdi*, *Nephtys hombergi* and *Diplocirrus glaucus*. These latter species were mainly found at the dredged stations.

The univariate analysis showed that the first dredging caused a drastic reduction of the ecological indices exclusively at station 5 located within the dredged area. Stations 1, 2, 3 and 4, located outside the first dredged area, seemed not to have been affected by dredging. Fourteen months after the end of the first dredging activity, impacted station 5 showed an increase in the ecological parameters. During the second dredging, no surveys for the macrobenthos monitorings were carried out. Nevertheless, the monitoring survey carried out 2 months after the second extraction, showed that only station 6 was characterised by extremely low indices values. During the third dredging, all stations except 1, 2 and 8, which were located outside the dredged area, showed a drastic decrease of the ecological indices (Fig. 2 and Table 3).

In general, data relating to the two monitoring surveys carried out after the end of the third dredging highlighted that all the impacted stations showed an increase in the ecological indices. Stations 5 and 6 were characterised by a particularly strong increase in these values (Fig. 2, Table 3), mainly due to the high abundance of a few opportunistic species (e.g. *C. gibba* and *T. stroemi*) and to the presence and abundance of previously absent species that colonised the impacted substrata (e.g. *S. bairdi, N. hombergi, D. glaucus*).

The nMDS ordination plot of data relating to each station and to each sampling period shows an overlapping of samples (Fig. 3). Station distribution confirms the homogeneity of the benthic assemblage observed over time. Station 5, which was affected during the first and the third dredging, segregated on the left side of the plot. Furthermore, on the right side we find stations 5 and 6 analysed during the last two monitoring surveys and

Table 2. Species collected during the study period.

- Mollusca
  - *Pseudotorinia architae* (O.G. Costa, 1839)
  - *Calliostoma (Ampullotrochus) gramtlatum* (Von Born, 1 778)
  - *Turritella communis* Risso, 1826
  - *Hyala vitrea* (Montagu, 1803)
  - *Calyptraea chinensis* (Linnaeus, 1758)
  - *Polinices macilenta* (Philippi, 1844)
  - *Polinices nitida* (Donovan, 1804)
  - *Eulima glabra* (Da Costa, 1778)
  - *Nassarius (Gussonea)* cfr. *comiculus* (Olivi, 1792)
  - *Nucula nucleus* (Linnaeus, 1758)
  - *Nucula sulcata* (Bronn, 1831)
  - *Saccella commutata* (Philippi, 1844)
  - *Thyasira biplicata* (Philippi, 1836)
  - *Glans aculeata* (Poli, 1795)
  - *Astarte sulcata* (Da Costa, 1778)
  - *Plagiocardium papillosum* (Poli, 1795)
  - *Lutraria* sp.
  - *Phaxas adriaticus* (Coen, 1933)
  - *Tellina donacina* Linnaeus 1758
  - *Tellina serrata* Brocchi, 1814
  - *Gari fervensis* (Gmelin, 1791)
  - *Abra alba* (Wood,1802)
  - *Abra prismatica* (Montagu, 1808)
  - *Abra renierii* (Bronn, 1831)
  - *Pitar rudis* (Poli 1795)
  - *Timoclea ovata* (Pennant, 1777)
  - *Corbula gibba* (Olivi,1792)
  - *Antalis inaequicostata* (Dautzenberg, 1891)
- Crustacea
  - *Iphinoe rhodaniensis* Ledoyer, 1965
  - *Iphinoe serrata* Norman, 1867
  - *Apseudes acutifrons* G O. Sars, 1882
  - *Apseudes elisae* Bacescu, 1961
  - *Apseudes latreilli* (Milne-Edwards, 1828)
  - *Tuberapseudes echinatus* (GO. Sars, 1882)
  - *Leptochelia savignyi* (Kroyer, 1842)
  - *Arcturella dilatata* (GO. Sars, 1883)
  - *Gnathia* sp.
  - *Anthura gracilis* (Montagu, 1808)
  - *Cirolana borealis* Lilljeborg, 1852
  - *Cirolana* sp.
  - *Ampelisca diadema* (A Costa, 1853)
  - *Ampelisca spinifer* Reid, 1951
  - *Ampelisca spinipes* Boeck, 1861
  - *Ampelisca typica* (Bate, 1856)
  - *Haploops dellavallei* Chevreux, 1900
  - *Haploops nirae* Kaim Malka, 1976
  - *Leptocheirus guttatus* (Grube, 1864)
  - *Leptocheirus mariae* G Karaman, 1973
  - *Medicorophium rotundirostre* (Stephensen, 1915)
  - *Photis longicaudata* (Bate & Westwood, 1862)
  - *Leucothoe incisa* Robertson, 1892
  - *Leucothoe lilljeborgi* Boeck, 1861
  - *Leucothoe oboa* G. Karaman, 1971
  - *Liljeborgia dellavallei* Stebbing, 1906
  - *Hippomedon massiliensis* Bellan-Santini, 1965
  - *Maera grossimana* (Montagu, 1808)

Table 2. (*Continued.*)

  - *Othomaera schmidtii* (Stephensen, 1915)
  - *Westwoodilla rectirostris* (Delia Valle, 1893)
  - *Harpinia agna* G Karaman, 1987
  - *Harpinia ala* G. Karaman, 1987
  - *Harpinia antennaria* Meinert, 1890
  - *Harpinia karamani* King, 2004
  - *Harpinia* sp.
  - *Metaphoxus fultoni* (Scott, 1890)
  - *Phtisica marina* Slabber, 1769
  - *Alpheus glaber* (Olivi, 1792)
  - *Athanas nitescens* (Leach, 1814)
  - *Processa canaliculata* Leach, 1815
  - *Callianassa subterranea* (Montagu, 1808)
  - *Goutretia denticulata* (Lutze, 1937)
  - *Jaxea nocturna* Nardo, 1847
  - *Paguristes eremita* (Linnaeus, 1767)
  - *Anapagurus laevis* (Bell, 1845)
  - *Anapagurus serripes* (Hope, 1851)
  - *Pagurus cuanensis* Bell, 1845
  - *Medorippe lanata* (Linnaeus, 1767)
  - *Ebalia deshayesi* Lucas, 1845
  - *Liocarcinus maculatus* (Risso, 1827)
  - *Goneplax rhomboides* (Linnaeus, 1758)
- Polychaeta
  - *Capitella capitata* (Fabricius, 1870)
  - *Heteromastus filiformis* (Claparede, 1864)
  - *Leiocapitella glabra* Hartman, 1947
  - *Notomastus aberans* Day, 1957
  - *Notomastus latericeus* Sars, 1850
  - *Notomastus lineatus* Claparede, 1870
  - *Pseudoleiocapitella fauveli* Harmelin, 1964
  - *Cossura soyeri* Laubier, 1964
  - *Clymenura clypeata* (Saint-Joseph, 1894)
  - *Praxillella affinis* (M. Sars, 1872)
  - *Praxillella gracilis* (M. Sars, 1872)
  - *Maldane glebifex* Grube, 1860
  - *Maldane sarsi* Malmgren, 1865
  - *Nematonereis unicornis* (Schmarda, 1861)
  - *Palola siciliensis* (Grube, 1840)
  - *Metasychis gotoi* (Izuka, 1902)
  - *Nicomache lumbricalis* (Fabricius, 1780)
  - Maldanidae gen.sp
  - *Polyophthalmus pictus* (Dujardin, 1839)
  - *Polyodontes maxillosus* (Ranzani, 1817)
  - *Harmothoe longisetis* (Grube, 1863)
  - *Lepidonotus clava* (Montagu, 1808)
  - *Lepidonotus squamatus* (Linnaeus, 1767)
  - *Malmgreniella lunulata* (Delle Chiaje, 1830)
  - *Sthenelais boa* (Johnston, 1833)
  - *Podarkeopsis arenicola* (La Greca, 1947)
  - *Pilargis verrucosa* (Saint-Joseph, 1899)
  - *Sigambra tentaculata* (Treadwell, 1941)
  - *Glycera alba* (O.F. Muller, 1776)
  - *Glycera tesselata* Grube, 1863
  - *Glycera unicornis* Savigny, 1818
  - *Glycinde nordmanni* (Malmgren, 1866)
  - *Goniada maculata* Oersted, 1843
  - *Nephtys hombergi* Savigny, 1818

Table 2. (*Continued.*)

Nepthys hystricis Mclntosh, 1900
Paralacydonia paradoxa Fauvel, 1913
Phyllodoce lineata (Claparede, 1870)
Dorvillea (Schistomeringos) neglecta (Fauvel, 1923)
Dorvillea (Schistomeringos) rudolphii (Delle Chiaje, 1828)
Aglaophamus rubellus (Michaelsen, 1897)
Eunice pennata (O.F. Muller, 1776)
Eunice vittata (Delle Chiaje, 1828)
Lysibranchia paucibranchiata Cantone, 1983
Marphysa belli (Audouin & Milne-Edwards, 1833)
Marphysa kinbergi Mclntosh, 1910
Lumbrineriopsis paradoxa (Saint-Joseph, 1888)
Lumbrineris gracilis (Fillers, 1868)
Lumbrineris latreilli Audouin & Milne Edwars, 1834
Scoletoma emandibulata-mabiti (Ramos, 1976)
Scoletoma fragilis (O.F. Muller, 1776)
Scotetoma tetrawa (Schmarda, 1861)
Arabella tricolor (Montagu, 1804)
Drilonereis filum (Claparede, 1870)
Apomtphis bilineata (Baird, 1870)
Apomtphys brementi (Fauvel, 1916)
Apomtphis fauveli (Rioja, 1918)
Hyalinoecia tubicola (O.F. Muller, 1776)
Myriochele oculata Zachs, 1923
Owenia fusiformis Delle Chiaje, 1841
Aphelochaeta marioni (Saint-Joseph, 1894)
Caulleriella mitltibranchiis (Grube, 1863)
Chaetozone caputesocis (Saint-Joseph, 1894)
Chaetozone setosa Malmgren, 1867
Monticellina dorsobranchialis (Kirkegaard, 1959)
Brada villosa (Rathke, 1843)
Diplocirrus glaucus (Malmgren, 1867)
Flabelligera affinis M. Sars, 1829
Sternaspis scutata (Ranzani, 1817)
Amage adspersa (Grube, 1863)
Amage gallasii Marion, 1875
Ampharete acutifrons (Grube, 1860)
Amphicteis gunneri (M. Sars, 1835)
Anobothrus gracilis (Malmgren, 1866)
Eclysippe vanelli (Fauvel, 1936)
Lysippe labiata Malmgren, 1866
Sabellides octocirrata (M. Sars, 1835)
Melinna palmata Grube, 1870
Pectinaria auricoma (O. F. Muller, 1776)
Pectinaria koreni (Malmgren, 1866)
Pista brevibranchia Caullery, 1915
Pista cnstata (O. F. Muller, 1776)
Streblosoma bairdi (Malmgren, 1866)
Terebellides stroemi M. Sars, 1835
Magellona spl
Magelona sp2
Spiochaetopteus costarum (Claparede, 1868)
Aonides paucibranchiata Southern, 1914
Laonice *cirrata* (M. Sars, 1851)
Minuspio cirri/era Wiren, 1883
Paraprionospio pinnata (Fillers, 1901)
Prionospio caspersi Laubier, 1962
Prionospio ehlersi Fauvel, 1928
Prionospio fallax Soderstrom, 1920
Prionospio steenstrupi Malmgren, 1867
Scolelepis bonnieri (Mesnil, 1896)
Scolelepis foliosa (Audouin & Milne-Edwards, 1833)
Spio decoratus Bobretzky, 1870
Spio filicornis (O. F. Muller, 1776)
Spio multioculata (Rioja, 1918)
Spiophanes bombyx (Claparede, 1870)
Spiophanes kroyeri Grube, 1860
Spiophanes kroyeri reyssi Laubier, 1961
Poecilochaetus serpens Alien, 1904
Echinodermata
Pseudotrachytyone sp.
Trachythyone elongata (Duben Koren, 1844)
Trachythyone tergestina (M. Sars, 1857)
Thyone fusus (O.F. Muller, 1776)
Phyllophorus urna Grube, 1840
Labidoplax digitata (Montagu, 1815)
Amphiura chiajei Forbes, 1843
Amphiura filiformis (O.F. Muller, 1776)
Ophiopsila aranea Forbes, 1843
Ophiura albida Forbes, 1839
Schizaster canaliferus (Lamarck, 1816)

characterised by high species richness and diversity. Concerning the grain size distribution of the sediments, some grain size variations were observed after the dredgings, both inside and outside the dredged areas. In particular, a significant increase in the sandy fraction (from 28% to 94.3%) was observed after the first dredging in station 5 (inside the dredged area) and another (from 47% to 88.7% of sand) was recorded after the third dredging in station 6 (inside the dredged area). No relevant grain size variations were reported in the other stations.

Discussion

The results obtained from this study, as expected and in accordance with some authors (Blake *et al.* 1996; Newell *et al.* 1998; Sardà *et al.* 2000; Van Dalfsen *et al.* 2000; Boyd & Rees 2003; Simonini *et al.* 2005), highlighted that the direct effects of relict sand dredgings on macrobenthos assemblages were limited to the dredged areas. In particular, all the stations located inside the dredged areas during the first (station 5) and the third dredging (stations 3, 4 and 6) showed a strong decrease in ecological indices as a consequence of the complete removal of superficial sediments. Despite the lack of data, both before and during the second dredging, it is important to highlight the case of station 6, where both the low values of the ecological indices recorded a few months after the second extraction and its position (inside the second dredged area) allowed us to hypothesise that this station was dredged during the second extraction.

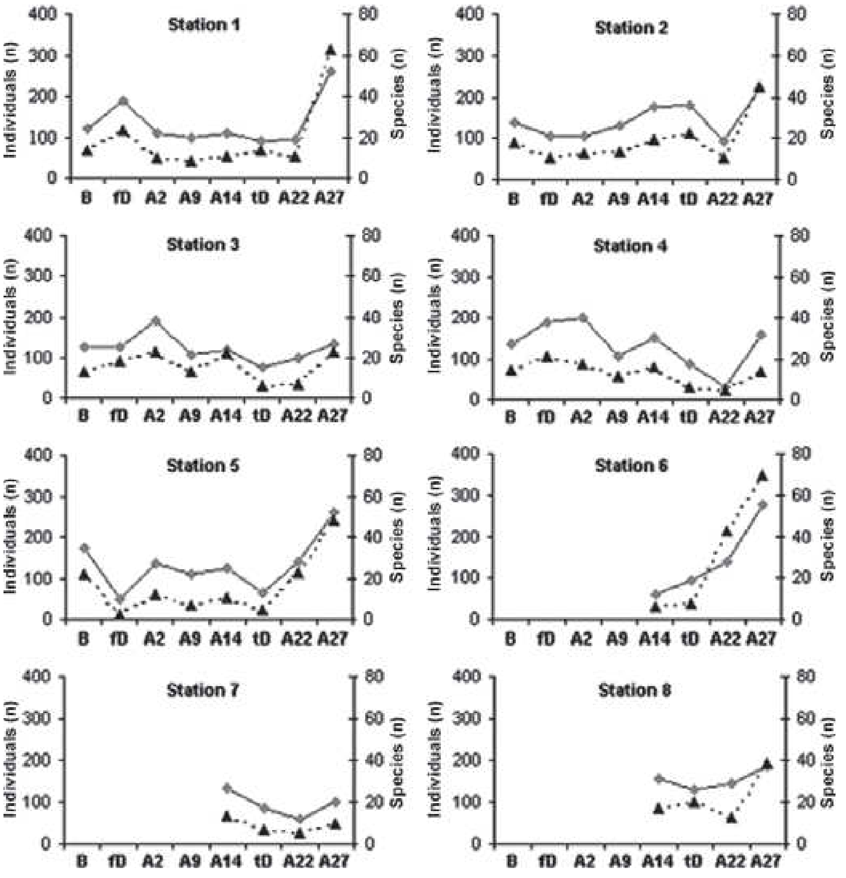

Fig. 2. Number of individuals (black line) and species (grey line) collected at each station over time.

Table 3. Species richness (d) and Shannon diversity (H′) values calculated for each station over time.

Stations		B	fD	A2	A9	A14	tD	A22	A27
1	d	5.74	8.03	5.62	5.34	5.86	4.37	5.06	9.37
	H′	4.21	4.86	4.10	3.97	4.14	3.30	3.95	4.67
2	d	6.40	5.35	5.29	6.53	7.92	7.90	5.15	8.62
	H′	4.05	4.02	3.99	4.50	4.77	4.87	3.77	4.96
3	d	5.96	5.94	8.05	5.32	5.23	4.25	5.64	5.93
	H′	4.24	4.36	4.71	3.97	3.88	3.51	4.11	4.07
4	d	6.18	8.68	8.93	5.35	7.34	5.03	1.85	7.77
	H′	3.95	4.93	5.00	4.11	4.64	3.91	2.15	4.64
5	d	7.61	3.75	6.87	6.07	6.51	3.96	6.40	9.99
	H′	4.54	3.28	4.50	4.25	4.47	3.36	4.38	5.11
6	d	–	–	–	–	3.97	5.19	5.31	9.60
	H′	–	–	–	–	3.45	4.09	3.34	4.07
7	d	–	–	–	–	6.75	4.75	3.74	5.30
	H′	–	–	–	–	4.47	3.71	3.22	4.03
8	d	–	–	–	–	7.19	5.85	7.09	7.31
	H′	–	–	–	–	4.63	4.28	4.53	4.35

This study highlighted that the impacts of relict sand dredgings on macrobenthos assemblages were observed in the zones in proximity to the dredged areas. These indirect impacts were due to the re-suspension and subsequent deposition of fine sediments caused by sand-extraction operations and was mainly evident at stations 5 and 7, which were located in proximity to the third dredged area. The increase in the fine fraction of superficial

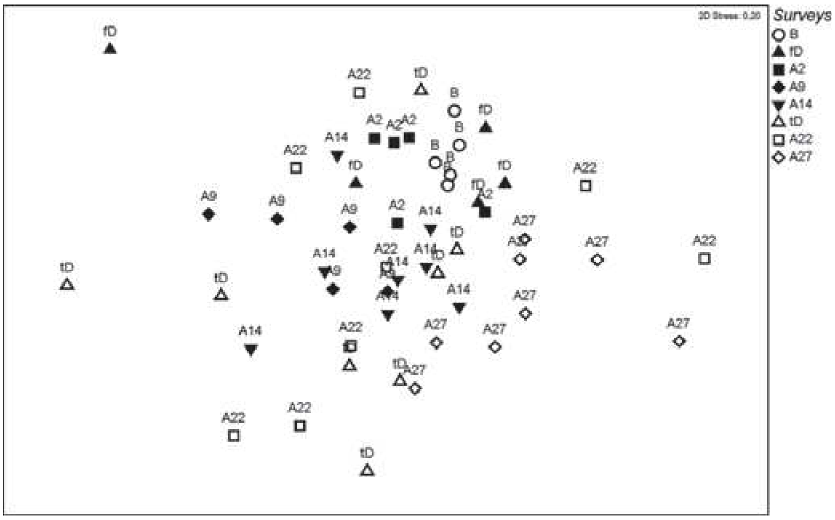

Fig. 3. 2D-nMDS ordination plot of abundance data of each station and each sampling period.

sediments observed in station 5 after dredging confirmed that fine sediment re-deposition had occurred.

These results also highlighted that a stronger sediment suspension was generated by the trailer dredge (used for the second and the third dredging), whose impact was greater than that of the anchor dredge (used for the first dredging).

Concerning the analysis of the recolonisation processes of macrobenthos assemblages, our results showed that a few months after the end of dredgings, the recolonisation processes could still be observed at all the impacted stations, in accordance with Green (2002), Boyd & Rees (2003), Simonini *et al.* (2005). In general, these processes are mainly due to the settlement of new recruits from the planktonic larvae and immigration of the adults from the neighbouring areas (Bonvicini Pagliai *et al.* 1985; Rees & Dare 1993; Newell *et al.* 1998; Van Dalfsen *et al.* 2000), but recolonisation processes are difficult to predict because they are strongly influenced by many different factors (*e.g.* biological cycles of different species, hydrodynamic regime, changes in sediment structure depth).

This study also revealed differences in the recolonisation processes of the impacted stations. The gradual recolonisation process was observed at stations 3, 4 and 7, whereas different processes (with an exponential trend) were observed at stations 5 and 6. These stations were initially characterised by the abundance of a few opportunistic species (*e.g. Corbula gibba* and *Terebellides stroemi*) and, subsequently (in the last monitoring), by an increase in abundance and in the number of sabulicolous species (e.g. *Streblosoma bairdi, Nephtys hombergi* and *Diplocirrus glaucus*) which had not been collected in the previous investigated periods. This phenomenon is normally observed in dredged substrata where the defaunation allows the opportunistic species to form dense populations in the first phase of the recolonisation process, followed by an increase in the number of species and individuals (Bonsdorff 1980; Kenny & Rees 1994, 1996; Newell *et al.* 1998; Sardà *et al.* 2000; Van Dalfsen *et al.* 2000; Nicoletti *et al.* 2004). The differences between two recolonisation processes at the impacted stations were probably related to the fact that the first group of stations (3, 4 and 7) was influenced exclusively by only one dredging (the third one), whereas the second group (5 and 6) was affected by two dredgings (respectively the first and the third one for station 5 and the second and the third one for station 6). Moreover, these differences could be related to the intensity of dredging operations in terms of dredging frequency, as also observed by Boyd & Rees (2003), Newell *et al.* (2004), Robinson *et al.* (2005) and Cooper *et al.* (2007).

This study has confirmed the observations of some authors (Robinson *et al.* 2005; Smith *et al.* 2006) concerning the difficulties in evaluating the effects over time of relict sand dredgings on benthic assemblages, due to the high number of factors involved. In our specific case, the analysis of the impact on the assemblages was further complicated by the use of two different types of dredge, and by the fact that dredging activities were repeated within a relatively short period of time, as well as in areas that are very close to one another. Further, medium-term monitoring surveys will provide a more detailed description of how the recolonisation process of macrobenthos assemblages affected by sand dredging will occur, as well as how long this will take.

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