Management and sustainable utilization of costal-marine sediments.

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Abstract: Marine-coastal sediments are of increasing interest to stakeholders involved in the Blue Economy field. While they represent an essential resource for coastal areas facing erosion, they also pose challenges when removed from ports, lagoons, and river mouths. Effective and well-planned sediment management can often determine the feasibility of large-scale projects with significant economic, political, and social impacts.
The sediments to be handled raise ecological concerns and, given their potential to interfere with the conservation of marine ecosystems and the use of the sea as a resource, must be managed appropriately according to their overall quality. As defining this quality becomes a crucial aspect in management strategies, optimizing management approaches is crucial for addressing the diverse challenges associated with sediment use and recovery, and plays a key role in marine-related economic activities.

Keywords: Ecotoxicological risk assessment; Dredging; Erosion; Geochemical anomalies; Circular economy.

1. The importance of the marine sector for Italy

The marine-coastal zone has always been a natural catalyst for human activities. By the end of the 20th century, the number of people living along the Mediterranean coast was close to 136 million (Clark, 1997). In Italy this phenomenon is particularly significant, given that the country's coastline stretches nearly 8,000 km. Today, according to a report published by Teleborsa (2022), Italy derives a substantial contribution from activities related to coastal and port areas. Recent estimates indicate that the various economic, commercial, productive, tourism, and energy activities linked to the sea contribute approximately 25% of the national GDP.

In particular, the tourism sector alone, which is closely tied to the enjoyment of marine resources, accounts for over 60% of the total annual tourist flow (equivalent to 6% of the national GDP); with a population of 6.6 million Italian citizens, tourist arrivals by sea are estimated at 26 million. According to the same data, logistics connected to the so-called "motorways of the sea" handle around 64% of national imports and 50% of exports. In this context, port systems represent infrastructures of high strategic, economic, and social importance, and are expected to be further strengthened in the near future as a direct consequence of globalized trade (UN ESCAP, 2002). According to Teleborsa as well, Italy ranks third worldwide in aquaculture, with 800 production facilities distributed across the country, and it serves as a major hub for gas pipelines, power lines, and data transmission cables (Teleborsa, 2022).

2. Sediment management: a sustainability challenge

Within this broader framework, it is estimated that over the past fifty years, in parallel with the growing demand for coastal areas for tourism purposes, 35 million square meters of coastline have been lost, causing significant damage to local economies, as documented, for example, in the case of the erosion of the Plaja in Catania (Di Stefano, 2023).

In this context, sediments and their management represent a crucial factor that can substantially interfere with the economic activities described above. It is now well established that sediments act as a sink for macronutrients and environmental contaminants (Salomons et al., 1987). In particular, the coastal zone and port ecosystems, which are subject to the most significant anthropogenic impacts, are potentially at risk in this regard.

Among the substances that can accumulate in coastal sediments - especially in estuaries, lagoons (Specchiulli et al., 2011), and ports (Baumard, Budzinski, & Garrigues, 1998; Baumard, Budzinski, Michon, et al., 1998; Lipiatou et al., 1997; Rogers, 2002) - are metals and metalloids (e.g., As, Hg, Pb, Zn), xenobiotic compounds (e.g., PCBs, pesticides, PFOA/S, and PBDEs), and polycyclic aromatic hydrocarbons (PAHs), which in port environments can reach very high concentrations (Renzi et al., 2009), depending on the intended use of the area (tourism, commerce, industry, or mixed) (Renzi et al., 2011).

To assess the risks associated with sediment-related operations, specific regulations were introduced, beginning with the Ministerial Decree (M.D.) of January 24, 1996: “Directives concerning the procedures for issuing authorizations pursuant to Article 11 of Law No. 319 of May 10, 1976, and subsequent amendments, related to the discharge into marine waters or adjacent environments of materials from the dredging of marine or brackish environments, or from emerged coastal lands, as well as any other movement of marine sediments.” This was followed by Article 109 of Legislative Decree 152/06 (Environmental Regulations) and the implementing M.D. 173/2016, “Regulation setting out the methods and technical criteria for the authorization of the disposal at sea of dredged marine sediments,” which serves as its technical annex.

3. Geochemical anomalies and local tresholds

The regulatory evolution has been long and complex; the main challenges encountered throughout this process are detailed in a recent study (Renzi & Provenza, 2022). Briefly, as of today, while the 1996 decree remains in force only for laying cables and pipelines (Annex B2), M.D. 173/2016 governs sediment relocation activities for river mouth restoration, port dredging, and beach nourishment across the entire Italian territory, excluding national (SIN) and regional (SIR) remediation sites. Operations required to restore navigational depths and ensure port functionality must be carried out frequently (Bortone et al., 2004). In parallel, efforts to combat coastal erosion (Teleborsa, 2022) require sandy materials and thus involve the use of natural resources. In both cases, significant economic investments are needed—either for removal in the first case, or for placement in the second.

According to the principles of circular economy, resource enhancement, and recovery of natural materials, M.D. 173/2016 mandates that the potential use of sediments for beach nourishment must be assessed as a priority. This option should be considered the preferred solution for dredged sediment and may be excluded only if environmental risk classifications provide clear evidence that reuse is not feasible. Furthermore, the approach promoted by M.D. 173/2016 places primary importance on the assessment of ecotoxicological risk, while assigning a more marginal role to chemical hazard evaluation. In summary, conducting a toxicity test provides an integrated assessment of the potential environmental hazard associated with the handling of the tested sediment (APAT-ICRAM, 2007).

The innovation introduced by this decree lies in the shift from a tabular to a weighted assessment approach. Ecotoxicological results are weighted by considering the sensitivity of the tested species, the statistical significance of the results, the ecological relevance of the matrix, and the type of exposure. The chemical evaluation considers not only the type of contaminant that exceeded reference thresholds, but also the number of contaminants above limits and the extent of the exceedance (Pellegrini et al., 2016). The overall integration of these independently assessed hazard estimates determines the total risk associated with sediment relocation. The logic underlying the regulation is based on the Weight of Evidence (WoE) approach: if experimental evidence does not indicate harmful effects, the sediment is assigned a no-risk classification and can be used for beach nourishment (Regoli, 2023).

4. Future challenges

Italy's volcanic history has created natural geochemical anomalies, resulting in sediment enriched with metals and metalloids. Examples include the "Elba-Argentario" anomaly in Tuscany and the Aeolian Arc in Sicily (Bigongiari et al., 2015; Renzi et al., 2015). In these areas, the threshold levels of chemical contamination defined by Ministerial Decree 173/2016, which were developed on a national basis, are often too low. Fine-grained sediments (<63 μm) in these regions are naturally rich in feldspars and trace elements, which are often bound in crystalline structures and not biologically available - thus not ecotoxic (Herut & Sandler, 2006). In such contexts, site-specific chemical thresholds, combined with the Weight of Evidence approach, enable a risk classification appropriate to the specific environmental context. Particularly challenging is the management of sediments in geographical areas where the presence of a geochemical anomaly cannot be linked to natural geological conditions, but to a long-standing, anthropogenic industrial legacy that has become "naturalized" over historical times. In this context, the presence of minerals responsible for the anomaly in marine sediments is due to their historical extraction and is widespread over large areas. This is the case, for example, with background levels of Hg in the Friuli-Venezia Giulia region, where sediment concentrations range from <LOQ to 25 mg/kg dry weight (Rosset, 2023). Even in these historically altered areas, local background values should be defined based on actual environmental conditions.
It is desirable for the future to define locally derived reference values, available for all national territories affected by this type of anomaly. In this context, the inter-institutional cooperation agreement aimed at managing geochemical anomalies in the Tuscany Region is an example - applicable to other territorial contexts - of how virtuous synergies can be established to define regional-scale local baseline geochemical levels (Masi, 2023), representing an initiative that could be replicated nationwide.

4.1 Installation of cables and pipelines

A revision of the existing regulatory framework is recommended, as it is currently based on regulations from 1996. It would be necessary to reconsider the indicators used in sediments as contamination tracers, incorporating the integrated ecotoxicological approach, which is currently voluntarily included by many stakeholders during the characterization phase. Furthermore, it would be advisable to define a criterion for interpreting the results based on an objective risk assessment approach associated with

the handling activities for the specific project. TERNA is the largest independent operator of electricity transmission networks in Europe and the most involved entity in the national territory in terms of the design, scope, economic and social impacts of environmental characterization activities carried out in accordance with this regulation (Massara, 2023; Sandulli, 2023). It would be advisable to systematically and structurally organize the experiences gained over time by operators who have applied this regulation in its current form.

4.2 Dredging and beach nourishment

Several technical aspects still require attention, such as minimizing interferences in risk classification due to matrix characteristics or sampling delays. Solutions include selecting the most appropriate species battery for the specific context, evaluating the interference of ammonium levels for the selection of species of type III, minimizing the waiting time for complex matrices rich in organic matter between the sampling time and the execution of the analysis, and preparing the sediment elutriate according to a standardized and/or normalized method that ensures repeatability (Provenza & Anselmi, 2023).
Aspects related to the estimation of microbiological contamination should also be implemented. The reference to specific regulations for water quality regarding bathing is not easily transferable to sediments, which involve different methods and result expressions. The choice of methods and result expression is left open (MPN or CFU), implying limited comparability of results obtained when different methods and units of measurement are used. The interpretation of the contamination levels found is left to expert judgment, as no threshold limits or specific management strategies are defined based on the values found.

4.3 Specific case studies

Large-scale projects often present high execution complexity and many operations must be carried out under critical conditions. Notable examples include certain Commissioner-led projects, such as the construction of large maritime infrastructures like the “Piattaforma Europa” (D.P.C.M. April 16, 2021) and the dredging of the port of Casamicciola Terme (D.P.C.M. January 24, 2022).
In the first case, the project concerns the expansion of the Port of Livorno and includes the construction of a 4 km-long northern breakwater and confined disposal facilities covering an area of 130 hectares, making it one of the largest maritime works currently under development in Italy (Pribaz & Lotti, 2023).
In the second case, the dredging of the port of Casamicciola Terme represented an application of Ministerial Decree 173/2016 to recent alluvial deposits accumulated in the port basin, leading to significant challenges due to the complexity of the specific sediment matrix (Terlizzi, 2023).
Another particularly noteworthy case concerns the management of sediments within lagoon environments. Although lagoons are not covered by M.D. 173/2016 and are therefore subject to a different regulatory framework, certain marine communication channels in lagoon systems host small tourist and fishing harbors (e.g., the Orbetello Lagoon). These environments are inherently complex, and management interventions must be carefully tailored to the specific characteristics of the system under consideration.

The case of sediment management in the Venice Lagoon provides clear evidence that a context-specific, calibrated approach, such as the Weight of Evidence (WoE) framework, can be effectively applied to define sediment management strategies based on ecotoxicological effects and chemical contamination (Campostrini, 2023). This experience serves as a valuable reference that could be transferred to other lagoon environments across the national territory that require dedicated management plans.

4.4 Environmental monitoring: an ongoing need

The design of sediment-related interventions cannot disregard environmental monitoring, an activity explicitly required by the specific regulation Ministerial Decree 173/2016. Although not mandated by M.D. January 24, 1996, environmental monitoring is also widely implemented by various economic operators during the installation of cables and pipelines for the construction of major national energy interconnection infrastructure or fiber-optic networks.

The impacts associated with sediment handling can, in fact, be numerous and diverse. Documented physical effects include, for example, alteration of the intertidal profile (Jensen & Mogensen, 2000) or changes in population structure (Bonvicini Pagliai et al., 1985), as well as mechanical burial of ecologically valuable communities, such as Posidonia oceanica meadows (Duarte, 2002). There is also evidence of impacts caused by the release of chemical pollutants from disturbed sediments (Erftemeijer & Robin Lewis, 2006; Filho et al., 2004), particularly during oxidation processes that occur during sediment mobilization. These processes can lead to the release of organic matter-bound contaminants into the water column, potentially causing adverse effects on aquatic communities (Calevro et al., 1998; Gopalakrishnan et al., 2008).

Monitoring activities are also essential to rule out impacts on productive sectors such as aquaculture, on nursery areas of commercially important fish species, and on coastal zones designated for recreational use. Monitoring plans should include phased implementation and be carefully calibrated to the specific environmental context, with the aim of achieving a positive cost-benefit balance. Given the significant economic development of the sector (Teleborsa, 2022), it would be appropriate to optimize specific guidelines and protocols for monitoring aquaculture-related activities - both in terms of their own environmental impact and potential interference from nearby dredging operations in adjacent marine areas (Oliva, 2023).

It is particularly important to consider the objectives behind environmental monitoring, so that the intervention can be properly adjusted in terms of sampling stations, survey techniques, and target analytes, based on the specific protection goals. Currently, environmental monitoring plans are often developed based on general guidelines, relying heavily on expert judgment, and are typically focused on turbidity as a proxy indicator of environmental impact. However, this approach is limited, and there is a strong need to replace it with more context-sensitive methodologies, allowing for a more accurate assessment of the actual impact of sediment interventions (Tinti, 2023).

In many cases, the vast amount of data collected through environmental monitoring activities, including those conducted on a national scale and covering extensive areas, is not shared on public platforms. As a result, a significant body of acquired knowledge is at risk of being lost, despite its potential to serve as a key informational resource for the development of specific, standardized guidelines to be shared with regulatory bodies and ministerial research institutions. Within this context, the case of TERNA represents a notable added value that should be leveraged, given the availability of nationwide historical datasets derived from the past ten years of environmental monitoring. These data could contribute significantly to the development of targeted and effective

monitoring guidelines, in line with current needs for harmonization and transparency (Massara, 2023).
More broadly, in relation to both monitoring plans and their implementation under the existing regulatory frameworks, it would be highly desirable to establish a dialogue with the regional observatories and commissions operating at the national level. An example is the fisheries commission established under M.D. 173/2016, which has been adopted by many Italian regions. Such bodies could provide valuable insights into the conservation of fish stocks and the protection of nursery areas.

4.5 New technologies and the role of scientific research

Scientific research offers promising perspectives both in terms of optimizing methods, procedures, and processes (Anselmi, Cavallo, et al., 2023; Anselmi, Pastorino, et al., 2023), and in the selection of test species for assessing the ecotoxicological hazard classification of sediments (Broccoli et al., 2021; Pellegrini, 2023). Among the emerging areas of interest is a topic that remains underexplored in current regulatory frameworks and monitoring programs but holds significant potential impact: plankton seed banks in marine sediments.
During sediment handling operations, phytoplankton resting stages may be released into the water column and reactivated, potentially triggering microalgal blooms, including those involving toxic species, which can affect trophic networks and have consequences for human health and aquaculture activities (Boero, 2023). Dredging operations pose major technological challenges and operational complexities that must be addressed by companies operating in the sector, which are part of the broader marine economy supply chain. These enterprises require innovative solutions to optimize dredging processes, which must also be accepted by regulatory authorities (Cucco, 2023).
Among the potential innovative technologies, “bubble barrier” systems have been patented and are also included in M.D. 172/2016, which regulates dredging operations in nationally significant sites under Article 5-bis, paragraph 6, of Law No. 84 of January 28, 1994. Additionally, ejector-based pumping systems have been patented as effective tools for the routine management of sedimentation issues caused by the interaction between port infrastructure and natural marine current dynamics, particularly at port entrances and in basins (Saccani et al., 2023).

5. Fostering dialogue and discussion: recent experiences

In this context, it is hoped that widely recognized guidelines will be developed - also with the endorsement of regulatory bodies - to support the optimized and standardized selection of technical and technological solutions tailored to the specific characteristics of each intervention.
Among the most relevant stakeholders is the Expert Observatory established under M.D. 173/2016 by the Ministry for the Environment (now the Ministry of Enterprises and Made in Italy, MISE), which has been operational since November 2019 and coordinated by ISPRA during its first four-year term (2019–2023). The observatory includes representatives from national research institutions (ISPRA, CNR, ISS), five regional environmental protection agencies (ARPAs), and two regional representatives appointed by the State-Regions Conference. Its role is to evaluate the national application of M.D. 173/2016 in terms of authorization procedures and to collect feedback and implementation challenges from local stakeholders, identifying possible solutions (Pellegrini, 2023).
Among the key issues under debate are aspects related to intervention design, especially the representativeness of the sampling grid and coring relative to the total volume of sediment to be handled (Marconi & Doronzo, 2023; Pribaz & Lotti, 2023).
In this context, the National Technological Cluster BIG – Blue Italian Growth, as an institutional representative in the field of Blue Economy, could play a strategic role by promoting dialogue and interaction among stakeholders through the organization of workshops, conferences, and working groups focused on sediment management. The ultimate goal is to foster virtuous processes of economic valorization and circular economy approaches to marine resources, while ensuring environmental protection. An important step in this direction was the workshop organized by Cluster BIG in Naples on July 3, 2023, which marked the beginning of a collaborative process with participating stakeholders. The aim is to develop a summary document highlighting the needs and gaps related to sediment management that should be brought to the attention of the Ministry.
Given its nature and mission, Cluster BIG is well-positioned to serve as an interface between the business sector, stakeholders, and regional and/or ministerial regulatory bodies, bringing to the attention of legislators and technical institutions the critical issues and development roadmaps identified by all relevant actors. Accordingly, a dedicated internal working group has been established to draft a comprehensive and shared document summarizing the key outcomes, insights, and challenges that emerged during the workshop. This document will be circulated among all relevant stakeholders.

REFERENCES

ANSELMI, S., CAVALLO, A., DEL RIO, L., & RENZI, M. (2023). Impact of global change on environmental hazards of different clays: A case study on Aliivibrio fischeri. *Journal of Hazardous Materials*, *457*, 131806. https://doi.org/10.1016/j.jhazmat.2023.131806

ANSELMI, S., PASTORINO, P., PROVENZA, F., & RENZI, M. (2023). Ecotoxicity of marine sediments: Sampling and laboratory artifacts and their impacts on risk classification. *Journal of Environmental Management*, *334*, 117483. https://doi.org/10.1016/j.jenvman.2023.117483

APAT-ICRAM. (2007). *Manuale per la movimentazione di sedimenti marini*. Ministero dell'Ambiente e della Tutela del Territorio. Rome. https://www.isprambiente.gov.it/it/pubblicazioni/manuali-e-linee-guida/manuale-per-la-movimentazione-di-sedimenti-marini

BAUMARD, P., BUDZINSKI, H., & GARRIGUES, P. (1998). Polycyclic aromatic hydrocarbons in sediments and mussels of the western Mediterranean sea. *Environmental Toxicology and Chemistry*, *17*(5), 765–776. https://doi.org/10.1002/etc.5620170501

BAUMARD, P., BUDZINSKI, H., MICHON, Q., GARRIGUES, P., BURGEOT, T., & BELLOCQ, J. (1998). Origin and Bioavailability of PAHs in the Mediterranean Sea from Mussel and Sediment Records. *Estuarine, Coastal and Shelf Science*, *47*(1), 77–90. https://doi.org/10.1006/ecss.1998.0337

BIGONGIARI, N., CIPRIANI, L. E., PRANZINI, E., RENZI, M., & VITALE, G. (2015). Assessing shelf aggregate environmental compatibility and suitability for beach nourishment: A case study for Tuscany (Italy). Marine Pollution Bulletin, 93(1–2), 183–193. https://doi.org/10.1016/j.marpolbul.2015.01.021

BOERO, F. (2023). Banche di semi del plancton nei sedimenti marini. [Workshop tematico organizzato dal Cluster BIG-BsRC, Sedimenti marino-costieri. Gestione e valorizzazione della risorsa, Stazione zoologica A. Dohrn, Napoli, 03/07/2023]. https://clusterbig.it/workshop-sedimenti-marino-costieri/

BONVICINI PAGLIAI, A. M., COGNETTI VARRIALE, A. M., CREMA, R., CURINI GALLETTI, M., & VANDINI ZUNARELLI, R. (1985). Environmental impact of extensive dredging in a coastal marine area. Marine Pollution Bulletin, 16(12), 483–488. https://doi.org/10.1016/0025-326X(85)90381-9

BORTONE, G., AREVALO, E., DEIBEL, I., DETZNER, H.-D., DE PROPRIS, L., ELSKENS, F., GIORDANO, A., HAKSTEGE, P., HAMER, K., HARMSEN, J., HAUGE, A., PALUMBO, L., & VAN

VEEN, J. (2004). Synthesis of the sednet work package 4 outcomes. Journal of Soils and Sediments, 4(4), 225–232. https://doi.org/10.1007/BF02991117

BROCCOLI, A., MORRONI, L., VALENTINI, A., VITIELLO, V., RENZI, M., NUCCIO, C., & PELLEGRINI, D. (2021). Comparison of different ecotoxicological batteries with WOE approach for the environmental quality evaluation of harbour sediments. Aquatic Toxicology, 237, 105905. https://doi.org/10.1016/j.aquatox.2021.105905

CALEVRO, F., CAMPANI, S., RAGGHIANTI, M., BUCCI, S., & MANCINO, G. (1998). Tests of toxicity and teratogenicity in biphasic vertebrates treated with heavy metals (Cr3+, A13+, Cd2+). Chemosphere, 37(14–15), 3011–3017. https://doi.org/10.1016/S0045-6535(98)00342-7

CAMPOSTRINI, P. (2023). La gestione dei sedimenti nelle lagune: Il caso di Venezia. [Workshop tematico organizzato dal Cluster BIG-BsRC, Sedimenti marino-costieri. Gestione e valorizzazione della risorsa, Stazione zoologica A. Dohrn, Napoli, 03/07/2023]. https://clusterbig.it/workshop-sedimenti-marino-costieri/

CLARK, R. B. (1997). Marine pollution. Oxford University Press.

CUCCO, S. (2023). Sedimenti marino-costieri: Gestione e valorizzazione della risorsa Movimentazione dei sedimenti: Esperienze e criticità. [Workshop tematico organizzato dal Cluster BIG-BsRC, Sedimenti marino-costieri. Gestione e valorizzazione della risorsa, Stazione zoologica A. Dohrn, Napoli, 03/07/2023]. https://clusterbig.it/workshop-sedimenti-marino-costieri/

DI STEFANO, A. (2023). Analisi e previsione delle variazioni delle linee di riva come strumenti di base per la gestione delle aree costiere: Il caso studio della Plaja di Catania. [Workshop tematico organizzato dal Cluster BIG-BsRC, Sedimenti marino-costieri. Gestione e valorizzazione della risorsa, Stazione zoologica A. Dohrn, Napoli, 03/07/2023]. https://clusterbig.it/workshop-sedimenti-marino-costieri/

DUARTE, C. M. (2002). The future of seagrass meadows. Environmental Conservation, 29(2), 192–206. https://doi.org/10.1017/S0376892902000127

ERFTEMEIJER, P. L. A., & ROBIN LEWIS, R. R. (2006). Environmental impacts of dredging on seagrasses: A review. Marine Pollution Bulletin, 52(12), 1553–1572. https://doi.org/10.1016/j.marpolbul.2006.09.006

FILHO, G. M. A., CREED, J. C., ANDRADE, L. R., & PFEIFFER, W. C. (2004). Metal accumulation by Halodule wrightii populations. Aquatic Botany, 80(4), 241–251. https://doi.org/10.1016/j.aquabot.2004.07.011

GOPALAKRISHNAN, S., THILAGAM, H., & RAJA, P. V. (2008). Comparison of heavy metal toxicity in life stages (spermiotoxicity, egg toxicity, embryotoxicity and larval toxicity) of Hydroides elegans. Chemosphere, 71(3), 515–528. https://doi.org/10.1016/j.chemosphere.2007.09.062

HERUT, B., & SANDLER, A. (2006). IOLR Report H18/2006. Israel Oceanographic and Limnological Research (IOLR).

JENSEN, A., & MOGENSEN, B. (2000). Guide No. 6. International Association of Dredging Companies (IADC) and Central Dredging Association (CEDA). The Hague.

LIPIATOU, E., TOLOSA, I., SIMÓ, R., BOULOUBASSI, I., DACHS, J., MARTI, S., SICRE, M.-A., BAYONA, J. M., GRIMALT, J. O., SALIOTT, A., & ALBAIGES, J. (1997). Mass budget and dynamics of polycyclic aromatic hydrocarbons in the Mediterranean Sea. Deep Sea Research Part II: Topical Studies in Oceanography, 44(3), 881–905. https://doi.org/10.1016/S0967-0645(96)00093-8

MARCONI, A., & DORONZO, B. (2023). L'importanza del progetto della maglia di caratterizzazione dell'area di dragaggio. [Workshop tematico organizzato dal Cluster BIG-BsRC, Sedimenti marino-costieri. Gestione e

valorizzazione della risorsa, Stazione zoologica A. Dohrn, Napoli, 03/07/2023]. https://clusterbig.it/workshop-sedimenti-marino-costieri/

MASI, M. (2023). Accordo di collaborazione interistituzionale: La gestione delle anomalie geochimiche in Regione Toscana. [Workshop tematico organizzato dal Cluster BIG-BsRC, Sedimenti marino-costieri. Gestione e valorizzazione della risorsa, Stazione zoologica A. Dohrn, Napoli, 03/07/2023]. https://clusterbig.it/workshop-sedimenti-marino-costieri/

MASSARA, F. (2023). Progettazione e realizzazione di cavi marini: L'esperienza di Terna. [Workshop tematico organizzato dal Cluster BIG-BsRC, Sedimenti marino-costieri. Gestione e valorizzazione della risorsa, Stazione zoologica A. Dohrn, Napoli, 03/07/2023]. https://clusterbig.it/workshop-sedimenti-marino-costieri/

OLIVA, M. (2023). Impatto dell'acquacoltura sulla qualità dei sedimenti marini. [Workshop tematico organizzato dal Cluster BIG-BsRC, Sedimenti marino-costieri. Gestione e valorizzazione della risorsa, Stazione zoologica A. Dohrn, Napoli, 03/07/2023]. https://clusterbig.it/workshop-sedimenti-marino-costieri/

PELLEGRINI, D. (2023). L'applicazione del D.M. 173/16: Sintesi delle attività dell'osservatorio esperto. [Workshop tematico organizzato dal Cluster BIG-BsRC, Sedimenti marino-costieri. Gestione e valorizzazione della risorsa, Stazione zoologica A. Dohrn, Napoli, 03/07/2023]. https://clusterbig.it/workshop-sedimenti-marino-costieri/

PELLEGRINI, D., ONORATI, F., & MUGNAI, C. (2016). Giornate di studio – 7° Edizione. ISPRA Atti, Livorno 22-24 Novembre 2016. L'ecotossicologia come strumento di gestione. La ricerca, il controllo da parte delle Agenzie. Il mondo dei privati, Livorno. https://www.isprambiente.gov.it/it/pubblicazioni/atti/7a-edizione-delle-giornate-di-studio-201cricerca-e-applicazione-di-metodologie-ecotossicologiche201d

PRIBAZ, E., & LOTTI, I. (2023). Applicazione del D.M. 173/16 a grandi opere: Il caso della Piattaforma Europa. [Workshop tematico organizzato dal Cluster BIG-BsRC, Sedimenti marino-costieri. Gestione e valorizzazione della risorsa, Stazione zoologica A. Dohrn, Napoli, 03/07/2023]. https://clusterbig.it/workshop-sedimenti-marino-costieri/

PROVENZA, F., & ANSELMI, S. (2023). Classificazione di rischio dei sedimenti: Fattori interferenti, tecniche di controllo e vincoli dell'accreditamento. [Workshop tematico organizzato dal Cluster BIG-BsRC, Sedimenti marino-costieri. Gestione e valorizzazione della risorsa, Stazione zoologica A. Dohrn, Napoli, 03/07/2023]. https://clusterbig.it/workshop-sedimenti-marino-costieri/

REGOLI, F. (2023). Approccio Weight of Evidence nel monitoraggio ambientale e nella classificazione del rischio in ambiente marino. [Workshop tematico organizzato dal Cluster BIG-BsRC, Sedimenti marino-costieri. Gestione e valorizzazione della risorsa, Stazione zoologica A. Dohrn, Napoli, 03/07/2023]. https://clusterbig.it/workshop-sedimenti-marino-costieri/

RENZI, M., BIGONGIARI, N., & FOCARDI, S. E. (2015). Baseline levels of trace elements in coastal sediments from the central Mediterranean (Tuscany, Italy). Chemistry and Ecology, 31(1), 34–46. https://doi.org/10.1080/02757540.2014.943200

RENZI, M., PERRA, G., GUERRANTI, C., MARIOTTINI, M., BARONI, D., VOLTERRANI, M., GRAZIOSI, M., SPECCHIULLI, A., & FOCARDI, S. (2009). Assessment of environmental pollutants in ten southern Italy harbor sediments. Toxicology and Industrial Health, 25(4–5), 351–363. https://doi.org/10.1177/0748233709104868

RENZI, M., & PROVENZA, F. (2022). L'ecotossicologia nella movimentazione dei sedimenti portuali: Assetto normativo italiano e sua evoluzione. Journal of the Siena Academy of Sciences, 11–2022. https://www.fisiocritici.it/att-editoriale/atti/jsas/jsas-vol-11-2022#scienze-matematiche-fisiche-e-naturali

RENZI, M., TOZZI, A., BARONI, D., & FOCARDI, S. (2011). Factors affecting the distribution of trace elements in harbour sediments. Chemistry and Ecology, 27(3), 235–250. https://doi.org/10.1080/02757540.2010.547483

ROGERS, H. (2002). Assessment of PAH contamination in estuarine sediments using the equilibrium partitioning–toxic unit approach. The Science of The Total Environment, 290(1–3), 139–155. https://doi.org/10.1016/S0048-9697(01)01079-8

ROSSET, A. (2023). Problematiche applicative nella realizzazione delle opere. [Workshop tematico organizzato dal Cluster BIG-BsRC, Sedimenti marino-costieri. Gestione e valorizzazione della risorsa, Stazione zoologica A. Dohrn, Napoli, 03/07/2023]. https://clusterbig.it/workshop-sedimenti-marino-costieri/

SACCANI, C., PELLEGRINI, M., & MONDELLI, N. (2023). Gestione dei sedimenti in ambito portuale mediante l'utilizzo di eiettori. [Workshop tematico organizzato dal Cluster BIG-BsRC, Sedimenti marino-costieri. Gestione e valorizzazione della risorsa, Stazione zoologica A. Dohrn, Napoli, 03/07/2023]. https://clusterbig.it/workshop-sedimenti-marino-costieri/

SALOMONS, W., DE ROOIJ, N. M., KERDIJK, H., & BRIL, J. (1987). Sediments as a source for contaminants? Hydrobiologia, 149(1), 13–30. https://doi.org/10.1007/BF00048643

SANDULLI, R. (2023). Effetti delle opere di posa di cavi sottomarini sulle biocenosi di fondo. [Workshop tematico organizzato dal Cluster BIG-BsRC, Sedimenti marino-costieri. Gestione e valorizzazione della risorsa, Stazione zoologica A. Dohrn, Napoli, 03/07/2023]. https://clusterbig.it/workshop-sedimenti-marino-costieri/

SPECCHIULLI, A., RENZI ,M., PERRA ,G., CILENTI ,L., SCIROCCO ,T., FLORIO ,M., FOCARDI ,S., BREBER ,P., & FOCARDI, S. (2011). Distribution and sources of polycyclic aromatic hydrocarbons (PAHs) in surface sediments of some Italian lagoons exploited for aquaculture and fishing activities. International Journal of Environmental Analytical Chemistry, 91(4), 367–386. https://doi.org/10.1080/03067310903434758

TELEBORSA. (2022, JULY 20). PIL italiano, 25% dipende dal mare: Nomisma mare lancia sfida del futuro. https://finanza.lastampa.it/News/2022/07/20/pil-italiano-25percento-dipende-dal-mare/OTNfMjAyMi0wNy0yMF9UTEI

TERLIZZI, A. (2023). Situazioni complesse: Gestione dei detriti alluvionali di Casamicciola. [Workshop tematico organizzato dal Cluster BIG-BsRC, Sedimenti marino-costieri. Gestione e valorizzazione della risorsa, Stazione zoologica A. Dohrn, Napoli, 03/07/2023]. https://clusterbig.it/workshop-sedimenti-marino-costieri/

TINTI, I. (2023). Monitoraggi ambientali delle opere marittime: Normativa e applicazioni pratiche. [Workshop tematico organizzato dal Cluster BIG-BsRC, Sedimenti marino-costieri. Gestione e valorizzazione della risorsa, Stazione zoologica A. Dohrn, Napoli, 03/07/2023]. https://clusterbig.it/workshop-sedimenti-marino-costieri/

UN ESCAP. (2002). Commercial development of regional ports as logistics centres (No. ST/ESCAP/2194). https://hdl.handle.net/20.500.12870/2917