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CITIZEN EDUCATION BY INVOLVEMENT IN MARINE BIODIVERSITY MONITORING

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Abstract

Global monitoring of the biodiversity status is recognized as a priority necessity by the international scientific community. Projects that invite volunteers citizens to get involved in ecological research are able to obtain a considerable amount of data, decrease the costs for research institutes, and provide members of the community of every age valuable opportunities to improve their science literacy and environmental awareness and determine a more sustainable approach to the environment. For land environments it has been shown that citizens can be involved in research, by contributing significantly to the collection of data. Underwater research requires special operational skills and SCUBA certification, and it may be difficult to enroll large numbers of volunteers. Our experience shows that, in a short time, thousands of recreational divers can be recruited for monitoring the marine biodiversity status. On a specially formulated questionnaire, volunteers reported the presence of 61 marine taxa encountered during recreational dives. During the 4-year study, 3825 divers have completed 18,757 questionnaires, corresponding to 13,539 diving hours. The volunteer sightings-based index showed, in the monitored area, trends that have been corroborated by professional investigations. An environmental education program held in primary, junior and senior high schools was integrated in the project, focused on Mediterranean biodiversity and pollution threats. A new volunteer based biodiversity monitoring research project is now performed in the Egyptian Red Sea, involving divers, tourist citizens and tourism professional operators. A new survey questionnaire also contains information on the correct behaviour to adopt when approaching marine reefs, with the aims of tourist environmental education (www.STEproject.org). The above projects were realized by means of interdisciplinary collaboration nets, demonstrating that the creation of productive consortiums in the field of environmental monitoring, constituted by academy, ministerial, private institutions, enterprises and citizens is possible. In the same context of innovative actions in the fields of environmental monitoring and naturalistic education a third project fits in perfectly as a successor to the above previous ones: "2010-2012: EU-Ecotourism in Marine Conservation", an international research, where citizen tourist are directly involved in the marine biodiversity monitoring and in educational programs in the Western Mediterranean Sea, one of the world's region most visited by tourists. We believe that this EU project will be able to create positive economic impact for sustainable tourism enterprises, expand sustainable tourism market through ecological research monitoring and modern citizen science approach, quantify changing behaviour among both tourists and local tourism industry workers in approaching the marine environment, after the involvement in the monitoring activity and education. Involving Italian, French and Spanish universities and enterprises, this project will be proposed to the European Commission for evaluation.

Keywords

Ecotourism, environmental education, international collaboration, marine biodiversity, monitoring, natural resources management

1. INTRODUCTION

Preserving biodiversity and the benefits it provides is a basic need. The identification and quantification of threats will enable administrators to take effective conservation measures. While this requires the implementation of global monitoring programs, government agencies are relentlessly under funded, and cannot afford the necessary large-scale monitoring [1], [2]. In some cases, the economic impediments for data collection can be overcome by using the skills of volunteers: the "citizen scientists". Citizen involvement as ecological research operators improves scientific literacy and the naturalistic awareness amongst all age groups in the community [3], and determines a more sustainable approach to the environment [4]. The United Nations Environment Program emphasizes public involvement in environmental monitoring and management as an essential component of sustainability [2]. Citizens may be involved, by contributing to the collection of data, thus decreasing costs. For terrestrial environments, a range of ecological projects are actually based on the active involvement of the public [5]. Underwater research requires special operational skills and it may be difficult to involve large numbers of volunteers. In the 1990s there was a rapid increase in recreational diving [6], and research programs began to solicit recreational divers as volunteers, making use of their natural interest in marine diversity. Fish Survey Project, conducted in Florida and the Caribbean [7], and Reef Check, on a global scale [8] are two significant examples. The Fish Survey Project assesses volunteers on fish species identification skills and classifies recruits as "beginners" or "experts" according to the test results. Reef Check enrolls volunteers who pass a training course involving surveying techniques and diving skills. Participants perform successive surveys (fish, invertebrates, and substrate) at specific reef sites and transects at depths determined by a strict protocol, and collect biophysical and socioeconomic data on site under the guidance of professional scientists. These projects are able to involve few hundreds of recreational divers every year.

Asking volunteers to take tests and travel at their own expense to specific sites to perform surveys according to a strict protocol makes the research project less attractive reducing the number of volunteers willing to participate. Since 1999, in an effort to maximize recreational diver participation, we have been testing a method of volunteer involvement ensuring reliability nor diminishing the diver enjoyment [9]. Our goal has been therefore to unite research with recreation, putting citizens at the forefront of the conservation drive.

2. BACKGROUND PROJECTS

We first designed the "Mediterranean *Hippocampus* Mission" (1999-2001), focused on only one taxon: the seahorses [9]. Approximately 2500 recreational divers took part in the search for seahorses, and reported sightings on a user-friendly questionnaire. Volunteers enabled us to map the distribution of seahorses in the Italian Mediterranean Sea. Another equally important result was that the project highlighted the interest of the general public and recreational divers willing to take part in biological monitoring. This achievement prompted us to design more ambitious projects. The first, named "Divers for the Environment - Mediterranean Underwater Biodiversity Project", was aimed at (1) testing the effectiveness of non-professionals for simultaneously monitoring many marine coastal taxa to save time and money; (2) developing a volunteer sightings-based index model for evaluating the quality of the marine environment; (3) validating this citizen-volunteer based monitoring approach, comparing its results with those from professional investigations. From 2002 to 2005, we asked to recreational divers to complete a questionnaire recording the presence of animal and plant taxa and refuse (litter) (available on the project website: <http://www.progettosubambiente.org/sq.htm>). The questionnaire had two sections: one with photos to identify the surveyed organisms (<http://www.progettosubambiente.org/sq1.htm>), the other to record data (<http://www.progettosubambiente.org/sq2.htm>). Surveyed taxa had to be (1) benthic organisms easily recognizable by non-professionals; (2) historically expected to be found in the whole Mediterranean Sea (based on [10] and the databases Global Biodiversity Information Facility <http://www.gbif.org/>; Ocean Biogeographic Information System <http://iobis.marine.rutgers.edu/>, and MarineSpecies <http://www.marinespecies.org/>). These characteristics ensure that (1) the method is suitable for amateurs and that level of biodiversity can be correlated to local stress [11], [12]; (2) the variation detected among geographic areas in biodiversity composition do not reflect natural variations.

In four years, 3825 volunteer recreational divers spent 13 539 hours underwater and completed 18 757 survey questionnaires (Table 1). A percentage of 88.1 questionnaires involved rocky bottom, and only 8.6% sandy bottom. The low number of useful questionnaires from sandy bottoms has not enabled a space-time comparison of the results. Conversely, for rocky bottoms, most questionnaires

were useful (73.8-81.2% a year). The primary limiting factor in involving volunteers was the difficulty in obtaining data homogeneously distributed in space. Most surveys were made in the Northern Tyrrhenian and Ligurian Seas, accounting for 61.9% of the total number of questionnaires recorded for rocky bottoms (Fig. 1). The total number of survey stations on rocky bottoms was 209 (detailed results from each survey station are available from <http://www.progettosubambiente.org/stations.pdf>). The environmental quality index calculated did not change significantly on the time scale, but on the space scale it had a highly significant negative correlation with latitude ($r = -0.210$, $p < 0.01$), suggesting an improvement going from north to south (Fig. 2). Our findings regarding improvements of the environmental conditions in the coastal stations as latitude decreases are supported by data from the Italian Ministry of the Environment. At the same time as our study took place, the Ministry conducted sea water quality surveys, including parameters reflecting hygiene-health risks, based on basic oceanographic data [13]. For areas overlapping with those monitored by our study, data from the Italian Ministry also exhibits negative correlations between latitude and environmental quality: for the western region Pearson's $r = -0.244$, $p < 0.01$, 114 stations; for the eastern region Pearson's $r = -0.606$, $p < 0.001$, 46 stations. The main threats for the Mediterranean Sea can be summed up as eutrophication, production of mucilage, flourishing of toxic algae, domestic waste, release of hydrocarbons and oil, and contamination from heavy metals [14]. In the seas surrounding Italy these stressors are significantly more prominent in the northern areas than in southern ones with some northern locations extremely degraded [15]. In the northern parts of the Western Mediterranean, marked reduction in overall marine biodiversity has also resulted from both biological invasions of alien species and the largest mass mortality event of benthic invertebrates ever recorded in the Mediterranean basin [16], [17]. Finally, the Western Ligurian Sea coast and the bed of the North-Western Adriatic are among the Mediterranean sectors most affected by intensive fishing [18].

3. PRESENT AND FUTURE PROJECTS

In the same context of innovative actions in the fields of environmental monitoring and naturalistic education two new projects fit in perfectly as successors to the above previous project:

- 1) "2006-2010: Scuba Tourism for the Environment – Red Sea Biodiversity Monitoring Program", a 5-year volunteer based biodiversity monitoring research project whose main objectives are the involvement of dive tourists in the collection of data on the Red Sea marine biodiversity, and the promotion of environmental education of tourists. We set up a three-part questionnaire - the first part contained information on the correct behaviour to adapt in and around coral reefs, the second part was high resolution photographs of the organisms to be reported if sighted, and the third part was for reporting sightings - distributed in airports, aircrafts, diving center, inserted in popular magazines advertising the project and on the project website (<http://www.STEproject.org>). Currently we are analyzing the first year project data.
- 2) "2010-2012: EU-Ecotourism in Marine Conservation" (EMC), an international research, where citizen tourist are directly involved in the collection of data on marine biodiversity and in educational programs in the Mediterranean Sea. This project aims to develop a model of sustainable tourism based on the naturalistic education and awareness of both tourism professional operators and tourist citizens; involve dive tourists in the collection of data on the marine biodiversity in the Mediterranean Sea; develop an important database on marine biodiversity, which will enable the detection of trends in space and time in the status of single species or biodiversity in its complexity; furnish to environmental and conservation managers a biodiversity dataset, which will be used to define management, conservation, and restoration actions; export the EMC sustainable tourism and biodiversity monitoring model in all Europe and at global scale; increase the cooperation between European and international industry, policy, academic research and society in order to develop an interdisciplinary mentality focused on education, the sustainability of tourism activities, and the implementation of ecological monitoring research; quantify changing behaviour among both tourists and local tourism industry workers in approaching the marine environment, after the involvement in the EMC monitoring activity and education. This project will be proposed to the European Commission for evaluation.

3. THE ROLE OF TOURISM INDUSTRY AND MASS MEDIA IN THE PROJECTS DEVELOPMENT

Practical actions of sustainability must be integrated in all steps of tourism planning and coordination at community or regional level, and applied to all forms of tourism in all types of destinations. Among the means of sustainable tourism, the importance of raising environmental and socio-cultural awareness among tourism consumers and their education is emphasized [19]. For these reasons the Association of Italian Tour Operators, ASTOI, is one of a projects partners. ASTOI members develop and manage initiatives about responsible tourism (saving-energy guidelines, international campaigns against children's sexual exploitation, development of low impact products and customs). They contribute to these projects by

- involving its enterprise members and their resorts and employees in the project, in order to create a cascade effect able to involve hundreds of thousands of tourists in the project;
- organization and logistic support for meetings, conference, stages about research aims, methodology and results, Italy, or other European countries (for example during international tourism expositions as BIT- International Tourism Exchange; <http://www.bit.expocts.it>);
- distribution of awards and/or prizes as incentives to volunteers.

Special attention was given by the Egyptian Government (Egyptian Tourist Authority) to the second project, demonstrating that this novel approach of citizen volunteers involvement in marine conservation monitoring can be exported at an international government level, and also adopted as a model by non-EU country governments.

In these projects we also involved the main international diving agencies (IDEA - International Diving Educators Association, PADI - Professional Association of Diving Instructors, PSS - Professional Scuba Schools, SNSI - Scuba Nitrox Safety International, SSI - Scuba Schools International). The role of diving agencies is fundamental for involving recreational divers [9]. These agencies distributed the survey questionnaires at diving schools, swimming pools, diving centers, and specialized shops. They coordinated the organization of training courses for guides and diving instructors. We held training courses organized at diving centers and schools, hobby fairs, and at cultural events on marine environment. After the courses, the guides and instructors informed and involved recreational divers at diving sites by helping them with survey questionnaires. The training courses were effective because they reached and empowered a large number of diving professionals, who involved recreational divers (an example of cascading effect was the annual SSI scuba instructor meeting, during which 1-hour training, held by one scientist, was attended by more than thousands professional divers).

Underwater Life Project, Marine & Freshwater Science Group Association and Project Aware Foundation contributed by creating environmental education programs integrated in the project. These education programs were held in primary, junior and senior high schools, and were focused on Mediterranean biodiversity and pollution threats. Scholars were taken to the sea for field observations, and survey questionnaire completing.

The mass media also responded positively describing the problems, aims, and methods of studies and inviting divers to contact the research laboratory and diving centers affiliated with the projects. We set up an official partnership with the tourist magazine "Tuttoturismo" (Editoriale DOMUS) and the popular scientific magazine "Quark" (Hachette – Rusconi) and its related television program "SuperQuark", of the state television (RAI - Radiotelevisione Italiana); the press office of the university laboratory estimated the mass media circulation in more than 84 000 000 contacts (readers, radio and television audience, based on official audience ratings: <http://www.audipress.it/>, <http://www.audiradio.it/>, <http://www.auditel.it/>; press review on <http://www.progettosubambiente.org/media.htm>). Bachelor and master university students were involved in the project. They updated the internet sites <http://www.progettosubambiente.org/>, and <http://www.STEproject.org/> that informed volunteers in real time progress of the studies. The internet sites and correspondence were fundamental for the gratification and loyalty of the volunteers [20], [9], [2]. Divers were rewarded by acknowledgements and attendance certificates via email and mail.

At the end, a consortium will be constituted to develop EU-Ecotourism in Marine Conservation: it will include the top European associations of small and medium enterprises in the field of tourism, the top small and medium enterprises in the field of recreational dive tourism, important research institutes in the fields of Ecology and Biology (especially citizen and marine science), and Tourism Economy, and an important publishing house. The very high quality, experience, and capability of this consortium will implement a tangible research work plan at high quality level, and will produce strong project impacts, with diffusion at European and global scale.

4. CONCLUSION

Volunteer based monitoring models may contribute to the answering of key questions about ecological integrity. The monitoring of marine biodiversity or single threatened species may be performed for a long time at low cost, both inside and outside marine protected areas, contributing to the estimation of conservation action effectiveness, increasing scientific literacy in the community. Education, current "citizen science" approach, the development of an interdisciplinary mentality in researchers, and the realization of research projects taking into account the needs and behaviours of people are practical efforts necessary to complete the mission of modern conservation biology [21]. These projects will represent an example of how the industry, policy and academic university research can cooperate in developing an international scientific and educational project, contributing to a sustainable tourism activity and integration among local cultures.

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References

- [1] Balmford, A., Bennun, L., Ten Brink, B., Cooper, D., Côté, I.M., Crane, P., Dobson, A., Dudley, N., Dutton, I., Green, R.E., Gregory, R.D., Harrison, J., Kennedy, E.T., Kremen, C., Leader-Williams, N., Lovejoy, T.E., Mace, G., May, R., Mayaux, P., Morling, P., Phillips, J., Redford, K., Ricketts T.H., Rodríguez, J.P., Sanjayan, M., Schei P.J., Van Jaarsveld, A.S., Walther, B.A., 2005. The Convention on Biological Diversity's 2010 Target. *Science* 307, 212-213.
- [2] Sharpe, A., Conrad, C., 2006. Community based ecological monitoring in Nova Scotia: challenges and opportunities. *Environmental Monitoring and Assessment* 113, 395-409.
- [3] Evans, C., Abrams, E., Reitsma, R., Roux, K., Salmonsén, L., Marra, P.P., 2005. The Neighborhood Nestwatch Program: participant outcomes of a citizen-science ecological research project. *Conservation Biology* 19, 589-594.
- [4] Medio, D., Ormond, R.F.G., Pearson, M., 1997. Effects of briefings on rates of damage to corals by scuba divers. *Biological Conservation* 79, 91-95.
- [5] EPA (U. S. Environmental Protection Agency), 1997. What is volunteer monitoring? EPA, Washington, D.C., USA. Available from <http://epa.gov/owow/monitoring/volunteer/> (accessed May 2006).
- [6] RSTC (Recreational Scuba Training Council), 1997. Facts and figures. RSTC, Hettlingen, Switzerland.

- [7] Pattengill-Semmens, C.V., Semmens, B.X., 2003. Conservation and management applications of the reef volunteer fish monitoring program. *Environmental Monitoring and Assessment Journal* 81, 43-50.
- [8] Hodgson, G., 1999. A global coral reef assessment. *Marine Pollution Bulletin* 38, 345-355.
- [9] Goffredo, S., Piccinetti, C., Zaccanti, F., 2004. Volunteers in marine conservation monitoring: a study on the distribution of seahorses carried out in collaboration with recreational scuba divers. *Conservation Biology* 18, 1492-1503.
- [10] Riedl, R., 1991. *Flora e fauna del Mediterraneo*. Franco Muzzio Editore, Padova, Italy.
- [11] Therriault, T.W., Kolasa, J., 2000. Explicit links among physical stress, habitat heterogeneity and biodiversity. *Oikos* 89, 387-391.
- [12] Newman, C., Buesching, C.D., Macdonald, D.W., 2003. Validating mammal monitoring methods and assessing the performance of volunteers in wildlife conservation: "Sed quis custodiet ipsos custodiet?" *Biological Conservation* 113, 189-197.
- [13] Italian Ministry of the Environment and Land and Sea Protection, 2006. *Si.Di.Mar. Protection of the Sea: Monitoring Program of Coastal Marine Environment*. Si.Di.Mar., Rome, Italy. Available from <http://www.sidimar.ipzs.it> (accessed May 2006).
- [14] Danovaro, R., 2003. Pollution threats in the Mediterranean Sea: an overview. *Chemistry and Ecology* 19, 15-32.
- [15] Thibaut, T., Pinedo, S., Torras, X., Ballesteros, E., 2005. Long-term decline of the populations of *Fucales* (*Cystoseira* spp. and *Sargassum* spp.) in the Alberes coast (France, North-western Mediterranean). *Marine Pollution Bulletin* 50, 1472-89.
- [16] Boudouresque, C.F., Verlaque, M., 2005. Nature conservation, Marine Protected Areas, sustainable development and the flow of invasive species to the Mediterranean Sea. *Scientific reports Port-Cros National Park* 21, 29-54.
- [17] Linares, C., Coma, R., Díaz, D., Zabala, M., Hereu, B., Dantart, L., 2005. Immediate and delayed effects of a mass mortality event on gorgonian population dynamics and benthic community structure in the NW Mediterranean. *Marine Ecology Progress Series* 305, 127-137.
- [18] Caddy, J.F., 1998. Issues in Mediterranean fisheries management: geographical units and effort control. *Studies and Reviews of General Fisheries Council for the Mediterranean No.70*. FAO, Rome, Italy.
- [19] Lansing P., De Vries P. 2007: Sustainable tourism: ethical alternative or marketing ploy? *Journal of Business Ethics* 72: 77-85.
- [20] Brewer, C., 2001. Cultivating conservation literacy: "trickle-down" education is not enough. *Conservation Biology* 15, 1203-1205.
- [21] Meffe, G.K., Ehrenfeld, D., Noss, R.F., 2006. Conservation biology at twenty. *Conservation Biology* 20, 595-596.

Tables

Table 1. Distribution of survey effort. Distribution of survey effort performed by volunteer recreational divers in the four years of research; only useful questionnaires were elaborated. See section 2. for detail.

Year	Volunteer divers	Hours of diving	Total recorded questionnaires	Rocky bottom questionnaires		Sandy bottom questionnaires		Other habitat questionnaires	
				Recorded	% Useful	Recorded	% Useful	Recorded	% Useful
2002	936	2446	3342	2847	73.8	387	34.9	108	21.3
2003	1615	4459	6230	5544	79.3	428	19.2	258	46.5
2004	1214	3830	5313	4699	80.3	452	26.1	162	29.6
2005	803	2805	3872	3443	81.2	352	42.3	77	0.0
All years	3825	13539	18757	16533	79.0	1619	29.9	605	31.6

Figures

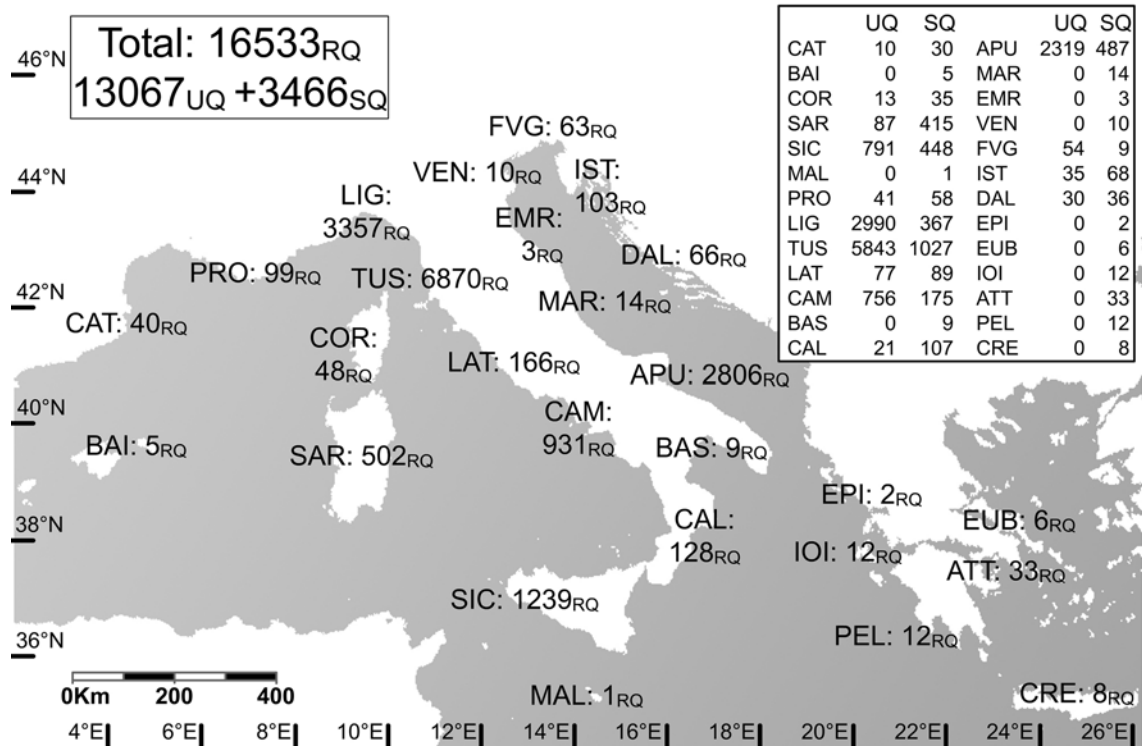


Fig. 1. Geographic distribution of the survey effort on rocky bottoms. Geographic distribution of the survey effort performed on rocky bottoms over the four years of research (2002-2005). The total number of questionnaires recorded (RQ) was divided into useful questionnaires (UQ), those coming from survey stations, and sparse questionnaires (SQ), those coming from diving sites that failed to reach the annual quorum of 10 recorded questionnaires. APU, Apulia; ATT, Attica; BAI, Balearic Islands; BAS, Basilicata; CAL, Calabria; CAM, Campania; CAT, Catalonia; COR, Corsica; CRE, Crete; DAL, Dalmatia; EMR, Emilia-Romagna; EPI, Epirus; EUB, Euboea; FVG, Friuli-Venezia Giulia; IOI, Ionian Islands; IST, Istria; LAT, Latium; LIG, Liguria; MAL, Malta; MAR, Marches; PEL, Peloponnesus; PRO, Provence; SAR, Sardinia; SIC, Sicily; TUS, Tuscany; VEN, Veneto.

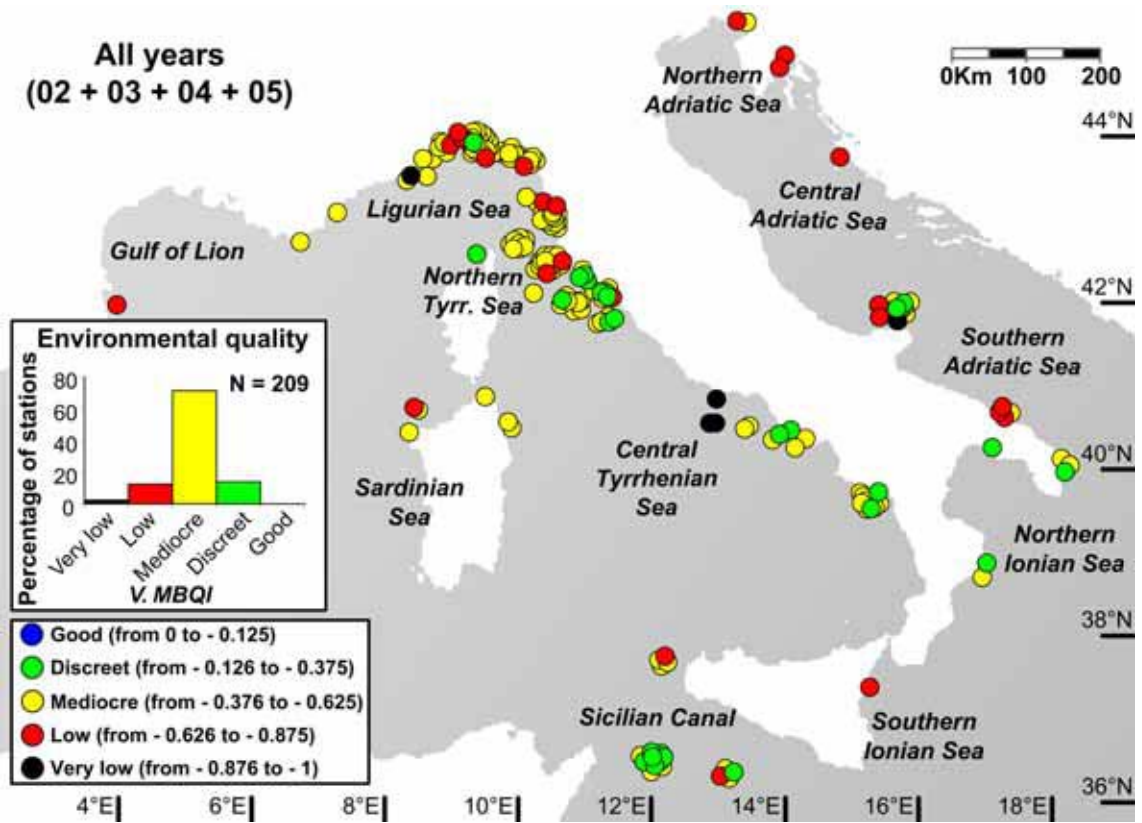


Fig. 2. Environmental quality index map. Environmental quality index (V.MBQI) in the 209 stations surveyed in the four years of research (2002-2005). Quality measured by the index in the 209 stations gave a Gaussian distribution, with most stations (71.3%) being of mediocre quality. The index did not show maximum quality class (good) in any of the stations.