Landscape Ecology Methods for the Placement of Artificial Reef Units in the Gulf of Venice (Italy)

Author(s): Alberto Rossi, Simonetta Boscolo, Andrea Falconi, Alberto Baroni and Gianumberto Caravello

Source: Journal of Coastal Research, Number 10061:211-216. 2011.
Published By: Coastal Education and Research Foundation
DOI: http://dx.doi.org/10.2112/SI61-001.16
URL: http://www.bioone.org/doi/full/10.2112/SI61-001.16

Journal of Coastal Research	SI	61	211-216	MCRR3-2010 Conference Proceedings	2011

Landscape Ecology Methods for the Placement of Artificial Reef Units in the Gulf of Venice (Italy)

Alberto Rossi[1], Simonetta Boscolo[2], Andrea Falconi[2], Alberto Baroni[1] and Gianumberto Caravello[1]

[1]Dip. di Medicina Ambientale e Sanità Pubblica,
Sede di Igiene, Università di Padova,
Via Loredan 18,
Padova 35133, Italy
Tel: + 39 049 8275395
Fax: + 39 049 8275395
alberto_rossi@live.it

[2]C.A.M. Idrografica SRL,
Viale S.M. Elisabetta 2,
30126 Lido di Venezia, Italy
Tel: + 39 041 5260930
Fax: + 39 041 5267696

www.cerf-jcr.org

ABSTRACT

ROSSI, A., BOSCOLO, S., FALCONI, A., BARONI, A and CARAVELLO, G., 2011. Landscape Ecology Methods for the Placement of Artificial Reef Units in the Gulf of Venice (Italy). *In:* Micallef, A. (ed.), *MCRR3-2010 Conference Proceedings,* Journal of Coastal Research, Special Issue, No. 61, pp. 211-216. Grosseto, Tuscany, Italy, ISSN 0749-0208.

The project is aimed to shielding and restoring some peculiar submerged areas, which need to be protected against damage caused by drag-net fishing in the Gulf of Venice. Many submarine outcrops are distributed along Venice's coast in the Northern Adriatic Sea. They are locally called "Tegnùe", relatively to resistance that they offered against trawlers nets. They are "beach rocks" or "reefs", depending on if they are of clastic or biologic origin. This area is a natural marine oasis where many species can reproduce and live. Our on-going research consists of the analysis of these peculiar parts of the Gulf of Venice sea bottom, with the employment of G.I.S. methodologies and Landscape Ecology principles.
Within the 64 km2 of the study area, there are seven distinct Tegnùe: information about conformation, surrounding layer type and granulometry, benthic colonization state were detected for each of them. Moreover in the whole area marine currents are being assessed, along with nautical routes that could have an influence and with seabed background condition.
In particular our work consisted of:

- realizing geo-referenced maps of the area;
- characterizing existing outcrops, in order to study their principal characteristics;
- census of the marine fauna in the areas of intervention, located in connection among the seven Tegnùe.

At the end we have processed collected data to detect optimal spots for placement of artificial habitat blocks. Furthermore the whole project will lead to a better understanding of the major role played by the sea outcrops as an ecological corridor for marine life and to enhance the ecological colonization by the benthic community. Last but not least, we'll be able to provide a better assessment about a possible ecotouristic resource for the littoral territory.

ADDITIONAL INDEX WORDS: *Gulf of Venice, Tegnùe, artificial substrates, G.I.S., landscape ecology methods.*

INTRODUCTION

The present research, started in March 2009, has been carried out within the plan "Protection and valorization of the Tegnùe's zones in the Gulf of Venice, project 2006 - 2009", and it applied the ecological methods to determine an appropriate Habitat® blocks placement (Fig. 1) in front of Venice's Lido.

The study counts the application of Landscape Ecology principles (Hinchey *et al*, 2008) through G.I.S. methodologies, and consists in the analysis of a seabed portion in the Gulf of Venice area (Italy) (Fig. 2), where peculiar submarine outcrops; the Tegnùe, are present. They could be "beach rocks" or "reefs", depending on if clastic or biologic origin.

Initial data derive from studies and analysis provided by nautical company C.A.M. Idrografica – Venezia and the Environmental Medicine and Public Health Department, University of Padova.

DOI: 10.2112/SI61-001.1 received XX; accepted XX

Figure1. A concrete Block Habitat®

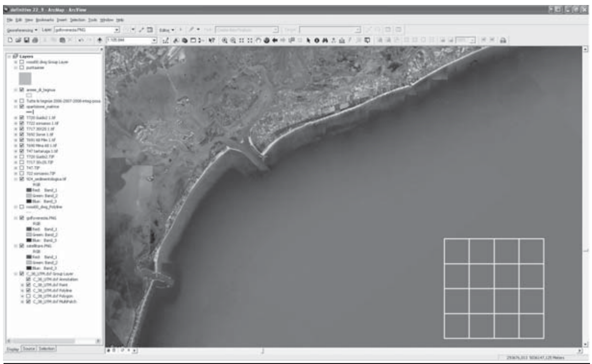

Figure2. The Gulf of Venice in G.I.S. and study area.

Tegnùe

These outcrops are locally called "Tegnùe" (Fig. 3), in relation to resistance that they offered against trawler nets characterize the Northern Adriatic sea from the Po outlet, to Grado city. There are a lot of rocks outcrops submerged of several dimensions, distributed at the bottom typically sandy that introduce peculiar ecological characteristics. It is possible to characterize one area in the Adriatic Sea where the Tegnùe are present in great number, at variable depth from 15 to 30 meters and with the maximum heights between 1 and 3m. (Stefanon and Mozzi, 1972).

- Slabs, formed after the last glacial period, throughout the cementation of beach sediments, when the sea level was lower than now, between approximately 10000 and 3000 years ago,
- Cemented sediment slabs and blocks of bottom throughout continuous gas methane leaking from the foundation,
- Biological rocks, similar to coralline reefs of the tropical seas, but in our case formed from various bioconstructors organisms, developed on the solid substrate offered from the previous two types.

The species richness of these areas is incredible, greater that in many other zones of the Mediterranean Sea. These areas, for the high number of living organisms present on the rocks and on the seabed, constitute a natural oasis for marine species; very much valuable because the juvenile stages like the presence of numerous gorges, where they find both shelter and food. (Mizzan, 1992; Ponti, 2001)

Artificial Reef

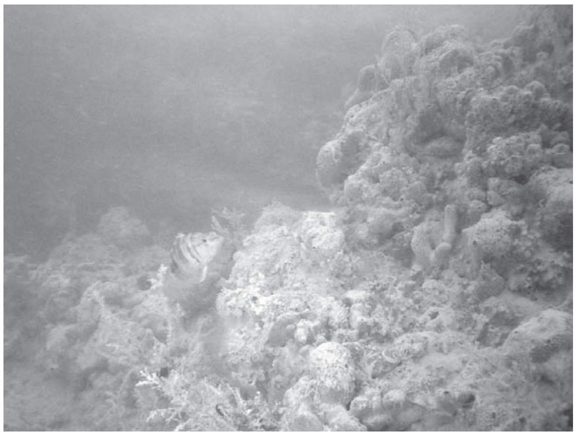

Figure3. Tegnùa environment.

OBJECTIVES

The natural outcrops have great importance for the Northern Adriatic sea but they often suffer severe damage caused by fishing pressure (De Juan *et al*, 2009), increased in these areas by the presence of numerous commercial interest organisms. One of the main objectives of the Plan is the protection of the Tegnùe, through the placement of manufactured Habitat® concrete blocks (figure 4). They provide shelter and substrate for settlement and they constitute a deterrent for the employment of fishing nets, because the fisherman prefer other nautical routes so as not to break their nets. It has been attempted to analyze the situation of the pilot area in order to estimate the possibility to create an "ecological network" on the seabed, to achieve an ecological continuity (Treml *et al*, 2008) for the active and passive shifts of floating organisms between Tegnùe (Zajac, 2008). The result is the creation of maps and standardized methods to identify the most ecologically appropriate positioning of Habitat® blocks.

Figure 4. Placement of Blocks.

MATERIALS AND METHODS

The choice of the location is derived from a preliminary assessment of the geomorphological characteristics and on the "matrix", that is the largest substrate in the study area. We analyzed the available information on the location of the 53 Tegnùe studied in the project, and a first georeferencing through G.I.S. has been carried out. In this way the best area for the pilot study was identified.

This area is characterized by: a similar depth of the outcrops, an appropriate distance from the main nautical routes and a substrate with suitable granulometry, which leads to sandy. Sand grain size contributes to better carrying capacity of the substrate, to avoid the sinking of the blocks that will be placed.

Following these selection criteria we have circumscribed a square area on the bottom for the correct application of ecological indicators. This area measures 64 km^2 and includes 7 Tegnùe: T47 (Tartaruga), T690 (Mina 68), T691 (Film68), T692 (Sorse), T717 (30x20), T720 (Guido 2), T722 (Sorsasso). In the Tegnùa T47 (Tartaruga) the Habitat® concrete blocks have already been placed. The remaining 6 Tegnùe (Mina 68, 68 Film, Sorse, 30x20, Guido2 e Sorsasso) have similar characteristics of depth and proximity. Therefore we can consider them as a model for the hypothesis "ecological network" in the future placement of the structures Habitat ®.

We georeferenced by ArcGIS 9.3 maps and images related to the chosen area, then a grid with side 8 * 8 km, and pixel of 10 meters, created by AutoCAD, was overlapped.

We digitalized the pixels affected by the presence of rocky areas and by difference were obtained sandy areas, this operation also useful for the application of Percolation Theory (Farina, 2001). The sediments samples were collected by Van Veen Grab in the nearness of all 7 Tegnùe for 4 replicates (in cardinal points).

Particle size analysis of sediments through method Buchanan (1984) was another important step for the characterization of the matrix.

The ecological analysis was carried out by the categorization of biotic communities in three levels (filter feeders, predators, top predators).

The preferential directions of movement of organisms between Tegnùe were identified according to the dominant current.

The Current, Theoretical and Experimental Connectivity:

$$\gamma = L/(3(N-2))$$

and Circulation:

$$\alpha = (L-N+1)/(2N-5)$$

were calculated to identify the more suitable blocks placement (Cantwell and Forman, 1993). (L= Link; N= Node)

RESULTS

Through the digitalization of the rockys areas, we have obtained a G.I.S. mapping of the zone with differential count of pixel for the rockys (Patch) and sandy (Matrix) zones (Fig. 5). At the end we have digitized 404 pixels from the corresponding area in the rocky substrate, on the whole area of 640000 pixels - 0.06% of the study area, and we took the difference like sandy matrix. The pixels are well distributed in Table. 1:

Table1: *Pixels distribution for each Tegnùa.*

Tegnùa	n° Pixels
T47 Tartaruga	259
T690 Mina 68	58
T691 Film68	12
T692 Sorse	34
T717 30x20	7
T720 Guido2	4
T722 Sorsasso	30

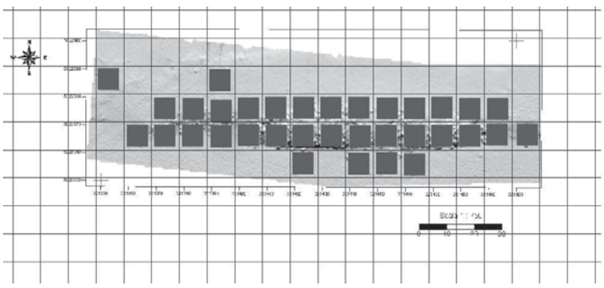

Figure5. An example of digitalization (Tegnùa T692). Dark squares: patches.

Since the rocky area is the 0.06% of the total zone by Percolation Theory, the theoretical minimal threshold of the 59.27% (Ziff, 1986) has not been reached. A value more than 59.27 % enables organisms to move freely within the system. In the marine seabed, unlike the ground surface, there is the absence of anthropic barriers for the organisms (Hanski, 1999): it makes the sandy matrix a percolating system, an indispensable medium for the movements of the plankton and nekton.

The granulometry analysis data agree with the "sedimentologic paper of the Northern Adriatic" (Brambati *et al*, 1988) but the Tegnùa Tartaruga and Tegnùa Mina68 are different from the others 5. Only in these 2 Tegnùe the fraction of < 63 µm size takes greater values (Fig. 6).

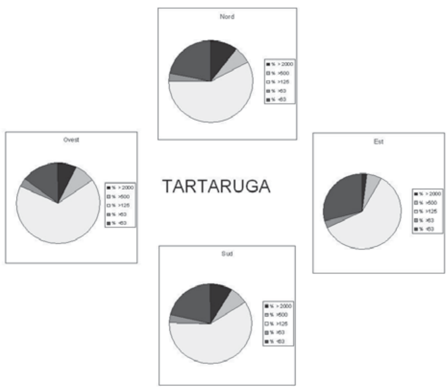

Figure6. Analysis of sediment grain size, Tegnùa Tartaruga.

We processed the photographic sampling data supplied by C.A.M. Idrografica (2009). Epifauna and fish species recorded in every Tegnùa, were reorganized into three classes (Fig. 7). Filter feeding organisms that feed on plankton and organic particles correspond to the level of primary consumers while Predators and Top Predators to the level of higher order consumers (Odum, 1973).

The number of identical species in all 7 Tegnùe is similar (Tab. 2), except in T47 Tarturga where the species richness is lower (23 total species), despite the larger extent of Teqùa area than the other. Perhaps this is due to the greater influence of human activity, increased for fishing pressure.

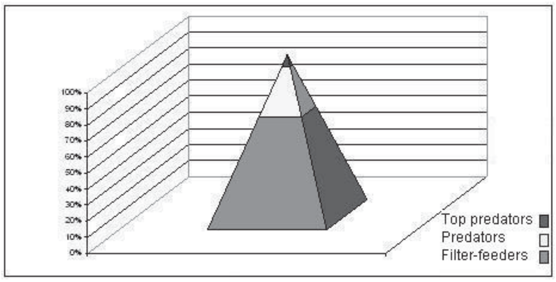

Figure7. Ecological pyramid, Tegnua Sorsasso.

Table 2: *Results of Biological tests.*

Tegnùa	Filter feeders	Predators	Top Predators	Total species
T47 Tartaruga	17	6	0	23
T690 Mina 68	31	17	2	50
T691 Film68	31	21	0	52
T692 Sorse	29	20	1	50
T720 Guido2	29	16	1	46
T722 Sorsasso	27	12	3	42
T717 30x20	25	13	2	40
Total species	56	36	4	96

Looking at the Atlas of surface currents of the Italian seas (1982), the main stream present in the Northern Adriatic Sea has got a direction of NE-SW. Probably the situation, in relation to Tegnùe analyzed in the study area, depends on the distance between the Tegnùe.

The Tegnùa T47 is isolated from the others by its location and distance, more than 2 km. The direction of the main stream is unfavourable for the switches and movements of plankton and nekton.

In a previous project the Habitat ® blocks were already immersed near T47, in a downstream location. The concrete blocks protect Tegnùe from fishing nets and provide larger substrates for colonization. So they may attract planktonic organisms carried by sea currents.

The results of the analysis of Connectivity and Circulation are shown in Tab. 3.

The Figure 8 shows the current situation of the area, depending on marine currents and distances between Tegnùe. In Figure 9 we see the theoretical situation, which does not consider the marine currents and shows the more numerous connections as possible. The experimental situation is shown in Figure 10; the addition of 4 new Nodes for the Ecological Network creates additional Links between Tegnùe.

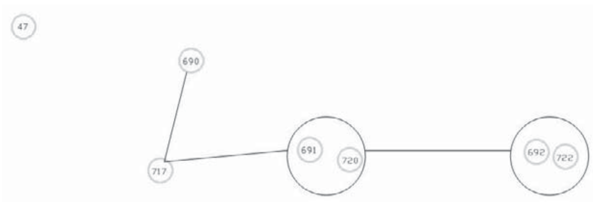

Figure8. Current situation for Connectivity and Circulation. The circles are the Nodes and the lines are the Links.

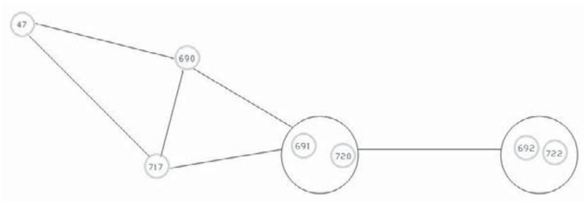

Figure9. Theoretical Situation.

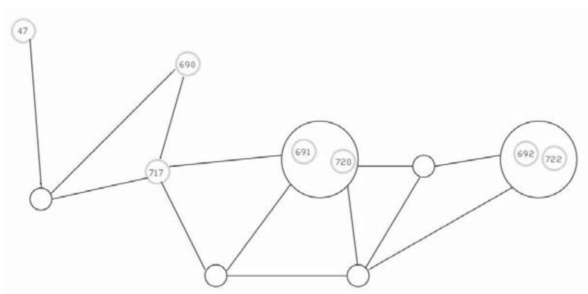

Figure10. Experimental Situation.

Table 3: *Connectivity and Circulation results.*

Setting	γ Connectivity	α Circulation
Current	0.33	-0.2
Theoretical	0.66	0.4
Experimental	0.38	0.62

After collecting and processing the information with G.I.S we have identified a method to highlight an optimal "buffer" area for the placement of blocks Habitat ® in Tegnùe. In the case of Tegnùe next to each other and with a favourable disposition to the mainstream, we have suggested placing blocks in the buffer area so as to have ecological continuity (Fig. 11).

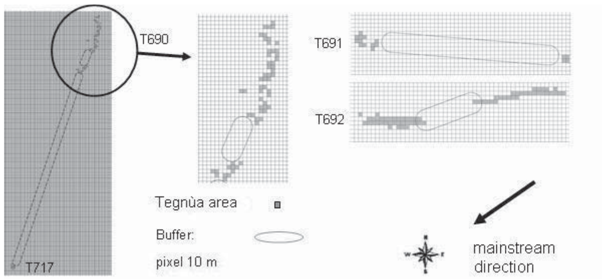

Figure11. Buffer zone to create ecological continuity between close Tegnùe.

The blocks optimal positioning should be carried out within an area of 50 meters width, with the aim to facilitate the Links between Tegnùe (Nodes), maintaining a functional alignment with dominant currents. Moreover, depending on the ecological situation and the distance between Tegnùe, the blocks will be placed within the buffer in row, for close Tegnùe.

For greater distances between the Tegnùe, the blocks will be placed in clusters according to the prevailing local currents. This will create new Nodes and Links of the network to increase the Connectivity of the system.

CONCLUSIONS

The habitats connection and populations linkages between Tegnùe are very low, because of their small number (7) within a wide area (64 km ²). The sea current dominant (NE-SW) can make the movements of organisms difficult, even sideways. The exchanges of living organisms are therefore possible in limited cases; between "node" and "node" and above all one-way.

The sandy matrix is 99.94% of the surface, it is considered percolating and its composition can be considered essential for the living organisms movements. The two elements of the landscape, Matrix and Patches, should be supported by the placement of Habitat ® blocks in areas where it is possible, to increase the "ecological network" effect.

In conclusion we can suggest for future studies about this, that other information is needed to develop more important aspects for preserving and promoting biodiversity and sustainability of "System Tegnùe":

- The dominant currents, which provide a good guideline for the long term research, are not accurate for small areas, such as those studied. In this case it would be useful to identify local currents and study the effects on organisms.
- A biocenotic complete analysis should be carried out on water and the matrix background, to identify and determine the presence of plankton and benthos. This allows getting complete trophic pyramids in order to better understand the ecological functionality of the "Tegnùe System".
- The sandy bottom is the most representative area of the seabed. More information of the seabed matrix (soft bottom biocenotic characterization) should be collected, especially in areas identified like buffer between Tegnùe.
- A study of fishing techniques and their effects on "Tegnùe System" in its planktonic, benthic and nektonic components should be carried out.

LITERATURE CITED

Baroni A., Falconi N., Falconi A. (2006) Research for the development and protection of three areas (Tegnùe) in the Gulf of Venice (Italy). *Proceedings of 2nd International conference on the management of coastal recreational resources - Beaches, yacht marinas and coastal ecotourism*, 25-27 th October 2006, Gozo, Malta. pp. 299-306.

Brambati A., Ciabatti M., Fanzutti G.P., Marabini F., Marocco R. (1988) *Carta sedimentologica dell'Adriatico settentrionale.* C.N.R.

Buchanan J.B. (1984) Sediment analysis. In: Holme N.A. & Mc Intyre A.D. (eds). *Methods for the study of marine benthos.* Blackwell, Oxford. London IBP Hand Book, 16: 41-65.

C.A.M. Idrografica – Venezia (2009) Comunicazione personale.

Cantwell M.D., Forman R.T.T., (1993). Landscape graphs: ecological modelling with graph theory to detect configurations common to diverse landscapes. *Landscape Ecology*, n°4, pp. 239-255.

De Juan S., Demestre M., Thrush S. (2009). Defining ecological indicators of trawling disturbance when everywhere that can be fished is fished: *A Mediterranean case study*. Marine Policy 33 472-478.

Farina A. (2001) *Ecologia del paesaggio, principi metodi e applicazioni.* UTET Libreria S.r.l. Torino.

Figley B. (2005*) Artificial reef management plan for New Jersey*. Department of Environmental Protection Division of Fish and Wildlife. State of New Jersey. 115 pp.

Hanski, I., 1999. *Habitat connectivity, habitat continuity, and metapopulations in dynamic landscapes.* Oikos 87, 209_/219.

Hinchey K., Nicholson M.C., Zajac R.N., Irlandi E.A. (2008). Preface: Marine and coastal applications in landscape ecology. *Landscape ecol* 23:1-5.

I.G.M. Istituto Geografico della Marina (1982) *Atlante delle correnti superficiali dei mari italiani.*

Mizzan L. (1992) *Malacocenosi e faune associate in due stazioni altoadriatiche a substrati solidi*. Boll. Mus. Civ. St. Nat. Venezia n.41.

Odum E. P. (1973) *Principi di Ecologia.* Piccin editore Padova. 584 pp.

Ponti M. (2001) Aspetti biologici ed ecologici delle tegnùe: biocostruzione, biodiversità e salvaguardia. Chioggia, *Rivista semestrale di studi e ricerche del Comune,* n.18, Chioggia. pp. 179-194.

Rousseau M.A. (2008) *Massachusetts Marine Artificial Reef Plan.* Division of Marine Fisheries, Department of Fish and Game, Executive Office of Energy and Environmental Affairs, Commonwealth of Massachusetts. 61 pp.

Stefanon A., Mozzi C. (1972) *Esistenza di rocce organogene nell'Alto Adriatico al largo di Chioggia*. Atti Ist. Ven. Sc. Let. Ed Arti 130: 495 - 499.

Treml E.A., Halpin P.N., Urban D.L., Pratson L.F. (2008). Modeling population connectivity by ocean currents, a graph-theoretic approach for marine conservation. *Landscape Ecol* 23:19-36.

Zajac R.N. (2008). Macrobenthic biodiversity and sea floor landscape structure. *Journal of Experimental Marine Biology and Ecology* 366 198-203.

Ziff, R. (1986) *Test of scaling exponents for percolation-cluster perimeters*., Phys. Rev. Lett., 56, pp. 545-548.