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The state of Ionian-Adriatic coastal habitats: the database of "Carta della Natura" System of Italy

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Abstract
Aim of this work is to provide a national scale synthesis of useful data for conservation status assessment of Italian Adriatic - Ionian coastal habitats. Basing on the data provided by the Carta della Natura information system it has been possible to consider about 70% of the Ionian and Adriatic coastlines. Initially all the patches included in a buffer of 500 meters from the coastline has been extracted from regional habitat maps and for each habitat type has been calculated: total and mean surface area, number of biotopes. After that the study focus on threatened coastal habitats, considering the classification used by the Carta della Natura system.
Taking into account the Ecological Value index, about 90% of Natural habitat biotopes fall into "high" and "very high" classes. Comparing these data with "Environmental Fragility" classes distribution it is possible to highlight a set of habitat types at higher risk of degradation. Representative coastal habitats are included in this set. Risky conditions are due to high Ecological Value and Environmental Fragility indexes, involving factors such as fragmentation, rarity, suitability to host threatened species, and to important anthropogenic pressures. Many biotopes at risky conditions are already included in protected areas. For this reason particularly attention should be given to the success of management tools.

Key words: Anthropogenic Pressure, Directive 92/43/EEC, Ecological Sensitivity, Ecological Value, Environmental Fragility, Habitat, Map of Habitats

Introduction

Carta della Natura is an informative system following the Italian Law on Protected Natural Areas (no. 394/1991), aiming at assessing quality and fragility status of natural environment in Italy. It has, therefore, two main objectives: the knowledge (by mapping environmental homogeneous units) and the assessment (by the use of indicators and indexes to estimate quality and fragility values) of the Italian landscapes and habitats.

Basic information layers (Maps of Habitats) are produced according to the European criteria for habitats classification and the assessment layers are realized through the use of widely shared indexes and indicators. Outputs of information system are different thematic maps of Ecological Value, Ecological Sensitivity and Anthropogenic Pressure, and Environmental Fragility.

Data from Carta della Natura information system are particularly useful in case of environmental evaluations, landscape planning at regional scale, designation of ecological network or green infrastructures planning, and whenever a shared base of quantitative and qualitative data are required.

Materials and methods

The basis of the work is represented by the Carta della Natura information system, consisting of a set of map layers (ISPRA, 2009a). Map of Habitats identified units as described in the CORINE Biotopes System (C.E.C., 1991; ISPRA, 2009b).

Spatial scale at 1:50,000 imposes accuracy limits (mapped only patches > of 1 hectare) and may produce loss of biotopes of limited extent, but allows the necessary synthesis to represent habitats of entire regions and to highlight the most significant ones at national scale.

The assessment process aims to create assessment maps that determine, for each environmental unit, the following indexes: Ecological Value, Ecological Sensitivity, Anthropogenic Pressure and Environmental Fragility. The last one is a result of a combination of Ecological Sensitivity and Anthropogenic Pressure Indexes (ISPRA, 2009a) . The maps are related to administrative regional boundary and are the results of application of specific algorithms on selected indicators. Ecological Value means the measure of a biotope quality from the environmental point of view, defined by law as "natural value". It is calculated using specific indicators.

Environmental Fragility measures the state of vulnerability of the environmental unit from the natural and environmental point of view. It is proportional both to the predisposition of suffering damage and to the disturbance due to human activities.

Considering a biotope Ecological Sensitivity as its

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intrinsic predisposition to the degradation risk and Anthropogenic Pressure as disturbance caused by human activities, the amount of the Environmental Fragility of a biotope is the result of the combination of these two indexes.

ISPRA created a specific application for the indicators and indexes calculation, able to ensure consistency in file management and algorithms application (ISPRA, 2009a).

Calculating process is structured in subsequent phases:

1) Normalization of indicator values: this phase is necessary because indicators that contribute to the calculation of each synthetic index value are extremely heterogeneous. Through normalization they may be compared and processed in the same algorithm.

2) Calculating the value of three indexes: Ecological Value, Ecological Sensitivity and Anthropogenic Pressure, processing jointly standardized indicators through the application of the TOPSIS method, known as the "Ideal Point" (Hwang&Yoon1981). The choice of the TOPSIS method, based on experimental texts, allows a more articulated distribution of the resulting values and therefore a better defined class rank value.

3) Subdivision of indices values into five classes: 'very low', 'low', 'medium', 'high' and 'very high'.

4) Identification of Environmental Fragility: implemented using a double entry matrix (with ecological sensitivity and anthropogenic pressure).

The calculation of each indicator requires a sets of data: some indicators use existing valid data recognized at national and/or European level, while others refer the polygon geometry, such as perimeter or area. Suitable databases are from official publication sources.

Since the assessment objective phase is to highlight the natural aspect, no indicators and indexes for biotopes of completely artificial environments, such as urban areas, industrial areas and quarries are calculated. Study area is identified within a buffer of 500 meters from the coastline, including all types of habitats: natural, semi-natural and anthropogenic. This buffer extends for about 2000 km along Friuli Venezia Giulia, Veneto, Abruzzo, Molise, Puglia, Basilicata and Sicily coastline, and it is interrupted in correspondence of the Regions Emilia Romagna, Marche and Calabria, due to the progress of the Carta della Natura (Fig.1). It represents approximately 70% of the entire Adriatic-Ionic Italian coast.

Studied area extends over 190,430 hectares and represents a selection of coastal habitats maps realized at Regional level. The study particular highlights the context of coastal ecosystems, by analyzing interactions with other natural habitats, but also giving a special attention to the effect of semi-natural and artificial habitats about them.

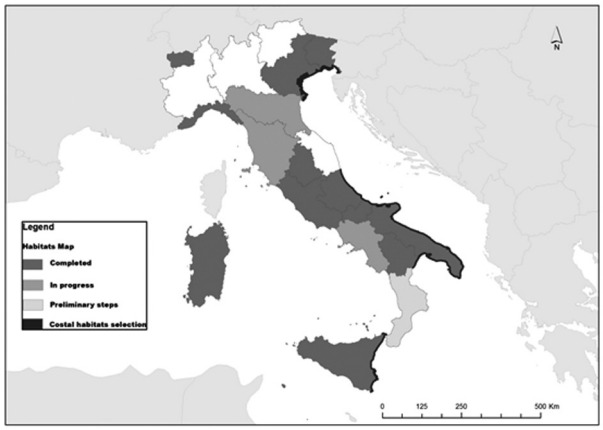

Fig. 1 - Progress on regional Carta della Natura Information System and study area.

Biotopes analysis allowed to highlight: habitat types, differentiating semi-natural and anthropogenic habitats from the natural ones and which are typical of coastal environment; size, number of biotopes and their coverage percentage, analyzing all habitats types, and separately coastal and other natural habitat; the risk of degradation of natural habitats of each biotope considering Ecological Values and Environmental Fragility indexes.

Results

Distribution analysis show the presence of 82 different Habitats types along Ionian-Adriatic coast, including 65 natural types and 17 among man-made and semi-natural types .

Man-made and semi-natural habitats, account for a significant portion of the study area, of about 35%, despite of the numerical inferiority compared to the natural habitat types. Natural habitats are distributed on 65% of the studied area (about 124,000 hectares), about 56% belong to 18 different types of coastal ecosystems (CEC,1991; ISPRA, 2009b).

Figure 2 shows for each habitat, average and total surface area and number of biotopes.

It indicates also correspondence with Annex 1 of the Habitats Directive (European Commission, 2013) highlighting the priority ones. Surface area provides a measure of each habitat representativeness (Figs. 2 and 3). This is an important data for assessment of conservation status of habitat types, as recommended in guidelines for assessment and reporting under Article 17 of the Habitats Directive (Evans & Arvela, 2011).

Combining total surface area with the number of biotopes of an habitat type, it is possible to obtain indication about its fragmentation, that is the inverse of average surface (Figs. 2 and 4): the lower the ratio of surface area and number of biotopes of each habitat,

CODE	HABITAT	TOTAL SURFACE (Ha)	N° biotopes	SURFACE AVERAGE (Ha)	DIRECTIVE 92/43/CEE (annex 1)	Priority interest (*)
21	Lagoons	73.994	93	796	X	*
14	Mud flats and sand flats	8.637	76	114	X	
15.1	Salt pioneer swards	4.662	311	15	X	
16.1	Sand beaches	4.193	210	20		
16.29	Wooded dunes	4.168	52	80	X	*
53.1	Reed beds	3.842	216	18		
15.5	Mediterranean salt meadows	1.802	137	13	X	
34.81	Mediterranean subnitrophilous grass communities	1.770	294	6		
34.6	Mediterranean tall-grass steppes	1.632	135	12	X	*
34.5	Mediterranean xeric grasslands	1.619	93	17	X	*
23	Standing brackish and salt water	1.603	24	67		
16.28	Dune sclerophyllous scrubs	1.595	54	30	X	
42.84	Aleppo pine (Pinus halepensis) forests	1.573	24	66	X	
18.22	Mediterranean sea cliff communities	1.555	138	11	X	
32.4	Western meso-Mediterranean calcicolous garrigues	1.432	144	10		
16.21	Shifting dunes	1.395	131	11	X	
24.1	River course	1.345	40	34	X	
42.83	Stone pine (Pinus pinea) forests	805	30	27	X	
15.6	Saltmarsh scrubs	795	70	11	X	
16.27	Dune juniper thickets and woods	724	67	11	X	*
16.3	Humid dune-slacks	490	25	20	X	
32.211	Oleo-lentisc (Olea, Pistacia) brush	433	35	12		
15.21	Flat-leaved cordgrass swards	400	47	9	X	
15.81	Sea-lavender (Limonium) salt steppes	392	55	7	X	*
44.61	Mediterranean riparian poplar (Populus alba) forests	359	84	4	X	
31.8A	Tyrrhenian sub-Mediterranean deciduous thickets	322	41	8		
41.731	Northern Italian Quercus pubescens woods	294	33	9		
41.732	Southern Italian and Sicilian Quercus pubescens woods	267	90	3		
45.1	Olive-carob forests	236	2	118	X	
42.1B	Fir reforestation	232	31	7		
45.31A	Southern Italian holm-oak forests	175	34	5	X	
31.81	Medio-European rich-soil thickets	132	21	6		
45.318	Northern and central Italian holm-oak forests	121	7	17	X	
17.1	Unvegetated shingle beaches	99	27	4		
62.11	Western eu-Mediterranean and oro-Iberian calcareous cliffs	89	16	6	X	
45.319	Illyrian holm-oak woodland	78	2	39	X	
16.22	Grey dunes	71	13	5	X	
34.75	Eastern sub-Mediterranean dry grasslands	68	20	3	X	
32.22	Tree-spurge (Euphorbia dendroides) formations	63	9	7	X	
44.81	Oleander, chaste tree and tamarix galleries	62	11	6	X	
44.44	Po oak-ash-alder forests	57	6	9	X	
22.1	Fresh waters	50	9	6		
32.219	Wood clubrush (Scirpus sylvaticus) meadows	50	2	25		
24.225	Mediterranean gravel beds	39	19	2	X	
32.3	Meso-Mediterranean silicicolous maquis	38	3	13		
53.2	Large sedge communities	38	5	8		
32.23	Diss (Ampelodesmos mauritanica)-dominated garrigues	36	7	5	X	
24.53	Mediterranean river mud communities	35	11	3	X	
19	Islets and rock stacks	34	10	3	X	
32.11	Evergreen oak matorral	24	7	3		
37.31	Purple moorgrass (Molinia caerulea) meadows and related communities	16	3	5	X	
37.4	Mediterranean tall humid grasslands	14	3	5	X	
44.12	Lowland, collinar and Mediterraneo-montane willow brush	12	8	2	X	
33.6	Italian Sarcopoterium spinosum phryganas	12	4	3	X	
44.63	Mediterranean riparian ash (Fraxinus angustifolia) woods	12	1	12	X	
34.323	Middle European Brachypodium-dominated semi-dry grasslands	9	2	5	X	
38.2	Lowland hay meadows	7	2	4	X	
44.62	Mediterranean riparian elm (Ulmus minor) forests	6	1	6	X	
44.513	Western Mediterranean alder galleries	5	1	5	X	*
32.212	Thermo-Mediterranean heath-garrigues	3	3	1		
44.713	Sicilian plane tree canyons	3	1	3	X	
31.844	Tyrrhenian broom (Cytisus) fields	3	1	3		
32.217	Coastal Helichrysum garrigues	3	2	1	X	
44.13	White willow (Salix alba) gallery forests	2	2	1	X	
32.215	Calicotome brush	1	2	1		

Fig. 2 - Summary of some characteristic parameters of natural habitat (coastal habitat types in gray) in study area. Data from: Carta della Natura information system

the higher the habitat fragmentation.

Analysing natural habitats, we can notice that “Lagoons” (Corine Biotopes code 21), the most widespread habitat (74,000 hectares), have a low level of fragmentation, since it is divided in a number of patches relatively low (93). Similarly, habitats with minor extensions, as "Wooded dunes" (Corine Biotopes code 16.29) are relatively fragmented.

On the contrary other typical coastal habitats, such as "Mediterranean cliff communities" (Corine Biotopes code 18.22), "Shifting dunes" (Corine Biotopes code 16.21) "Grey dunes" (Corine Biotopes code 16.22) and “Dune juniper thickets and woods” (Corine Biotopes code 16.27), are characterized by high fragmentation, with small total surface area and several patches.

It is important to notice the rarity of some habitat types, which have few polygons and very small extensions: “Coastal *Helicrysum* garrigues" (Corine Biotopes code 32.217), "Italian *Sarcopoterium Spinosum phrygana*" (Corine Biotopes code 33.6), "Sea lavender salt steppes” (Corine Biotopes code 15.81), “Illyrian holm oak forests” (Corine Biotopes code 45.319) and “Northern and central holm oak forests” (Corine Biotopes code 45. 318), or some riparian habitat types that are locate in small flaps at the mouths of rivers. All this data are scale-dependent and results depend on the spatial definition of habitats mapping. For this reason it is important to focalize attention on the results on a large scale more than on specific ecological consideration.

Using data extracted from regional Carta della Natura databases and relating to Ecological Value classes,

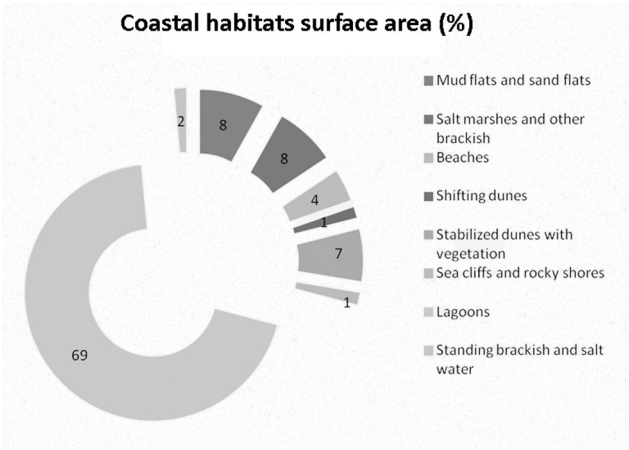

Fig. 3 - Percent of surface area of coastal habitat types.

natural habitats and coastal habitats classes of values have been compared, also as percentage values of surface area occupied by classes (Fig.5).

Higher Ecological Values classes most represented in the coastal habitats group are due to their peculiarities: some of them are included in Annex I of Directive 92/43 CEE and are suitable for many different species of flora and fauna, many of which are threatened; they are mostly rare habitat types particularly in the coastal area.

Their value is also already recognized since 67% of the area examined in this paper is subjected to various levels of security and protection (protected areas, Natura 2000 network sites, Ramsar areas).

In addition to the Ecological Value, the Environmental Fragility has been considered, which provides a measure of the actual state of the risk acting on environmental unit (Fig. 6).

In order to highlight the most threatened biotopes the combination of Value and Fragility has been studied. This analysis is extremely useful to perform actions on environmental conservation and planning, and allows to identify habitats containing high value natural resources exposed to greater risk of deterioration or loss.

The diagram in Fig.7 shows the distribution of habitats types in relation to Ecological Value (x-axis) and Environmental Fragility (y-axis). Position of each habitat type in the graph is the average of the values of the classes of Environmental Fragility and Ecological Value calculated on the total of biotopes belonging to the habitat, assigning numerical values from 1 to 5 classes, from "very low" to "very high". Habitat types on which a 'maximum attention' is required are those that fall in the upper right section, because they are at “very high” Ecological Value and “very high” Fragility.

All coastal habitats (highlighted codes Fig. 7) are assigned in "very high" sections for Ecological Value. The only exception are for beaches (16.1 and 17.1) and for "non-marine brackish and salt water" (23) habitats type.

It should also be noted that coastal habitats in higher Fragility classes are all included in Annex 1 of the Di-

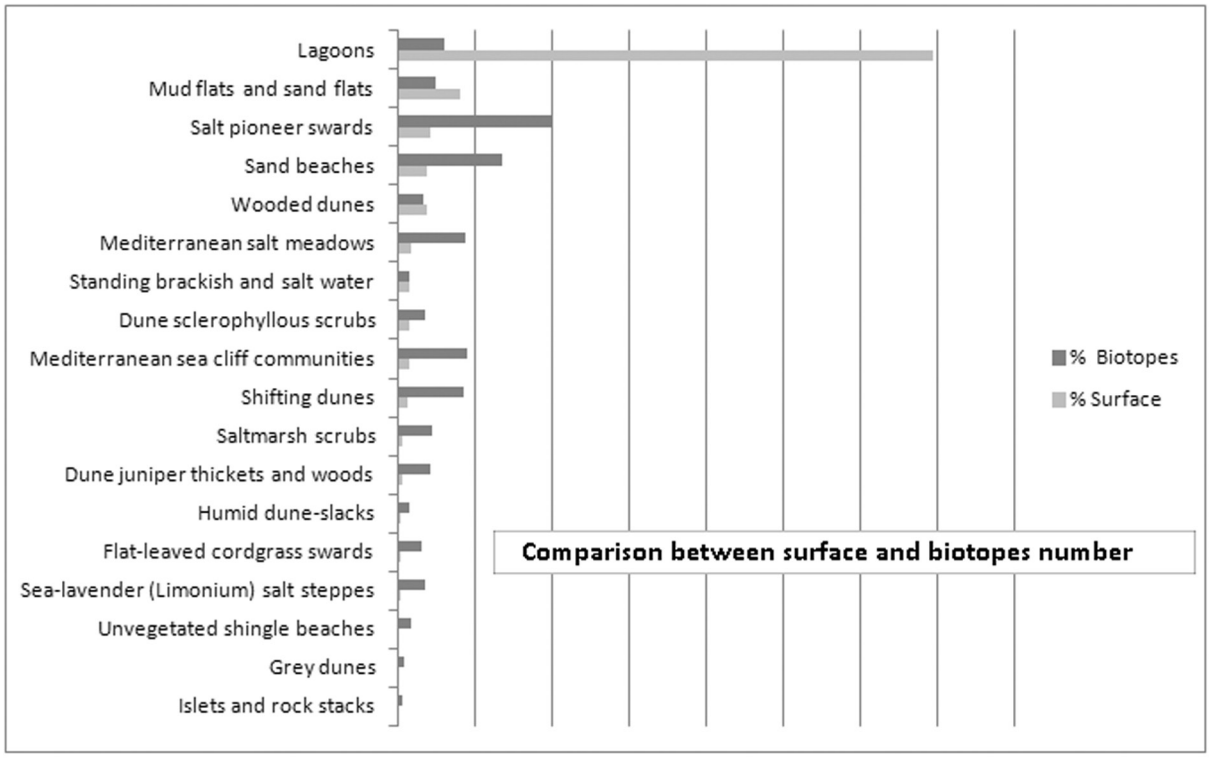

Fig. 4 - Percent of surface area and biotopes number of each coastal habitat type.

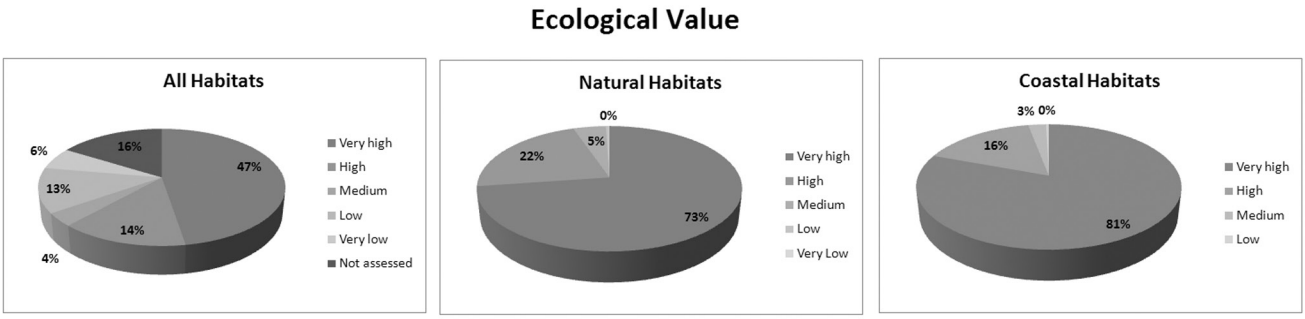

Fig. 5 - Ecological Values classes distribution considering all habitats, natural habitats and coastal habitats. Percent values refer to surface area.

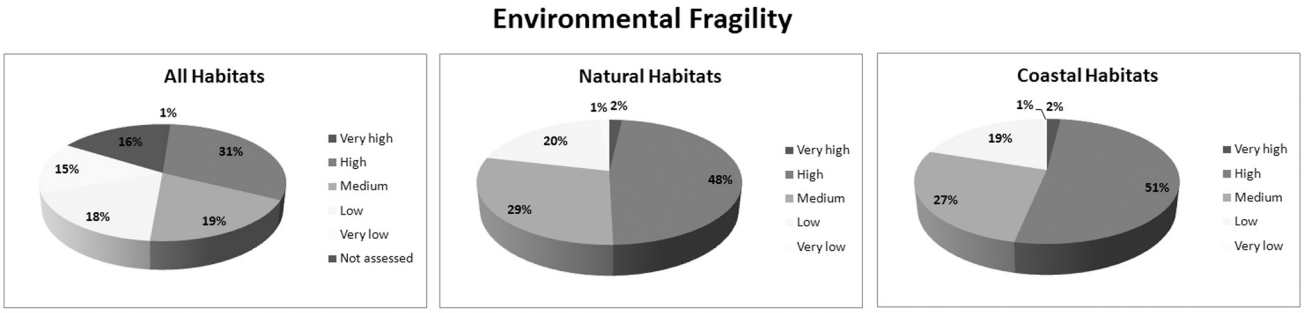

Fig. 6 - Environmental Fragility classes distribution considering habitats, natural habitats and coastal habitats. Percent values refer to surface area.

rective 92/43 CEE as habitats of priority interest.

Habitat types "Dune juniper thickets and woods" (Corine Biotopes code 16.27) and "Sea lavender salt steppes" (Corine Biotopes code 15.81) are at maximum risk because Ecological Value and Environmental Fragility are both "very high".

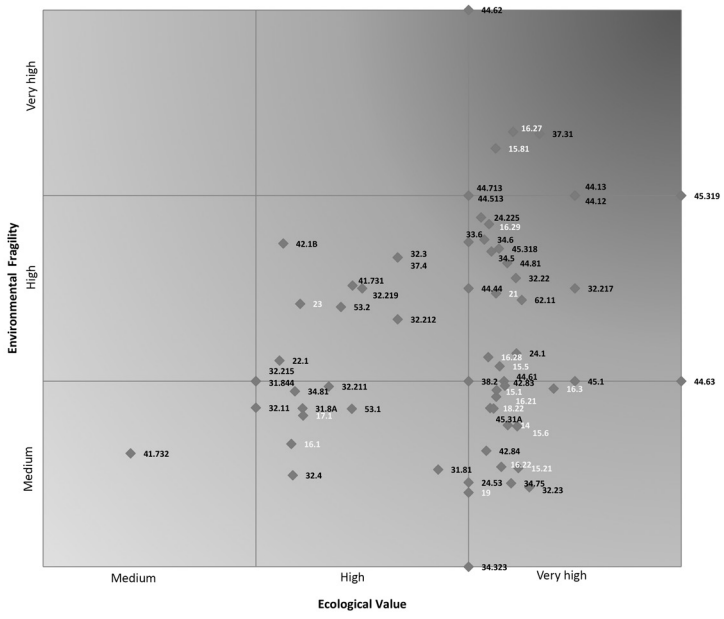

Fig. 7 - Relationship between Ecological Value and Environmental Fragility classes of habitat types (Corine Biotopes codes).

Environmental Fragility play a very important role because almost all coastal habitat types are at "very high" Ecological Value. It depend on the indicators that consider: DH priority interest, small average size of biotopes, high level of fragmentation.

As an example we can observe that the coastal habitats which falling within the less vulnerable class, "Wooded dunes" (Corine Biotopes code 16.29) and "Lagoons" (Corine Biotopes code 21), have a lower fragility because they have significantly greater average size and equally low fragmentation level (Fig. 3).

Conclusion

This work shows the potential of the Carta della Natura information system wich is a tool, shared at national level, that allows territorial and ecological large-scale analysis.This study confirm critical condition of coastal environment, which status needs to enhance conservation measures. Great presence of anthropogenic habitats reduce connectivity of natural ones and in particular on the coasts, and fragmentation is an important threat who can lead to complete loss of natural heritage that they represent.

Event thought high extent of surface area investigated is located within protected areas, assessment shows that fragility of coastal habitats

stands at high classes value: for the purposes of conservation attention should be given to the effective of management tools.

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