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A TOPOGRAPHICAL SURVEY OF HABITAT TYPES IN THE AREA CHARACTERIZED BY SEAGRASS MEADOW OF *POSIDONIA OCEANICA* IN THE SOUTHERN PART OF THE GULF OF TRIESTE (NORTHERN ADRIATIC)

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ABSTRACT

According to the national legislation and by considering international documents on nature conservation, the Mediterranean endemic seagrass Posidonia oceanica *was included in the latest edition of the Slovenian Red List of Rare and Endangered Species. Moreover, the only Slovenian site with* Posidonia oceanica, *which is also the only meadow along the West Istrian coast, was proposed to be declared a natural monument in 1994. However, besides some preliminary data on the topography and phenology of the meadow, very few data are available regarding its fauna and flora. Being an area of great conservation interest, a non-destructive underwater inspection has been carried out. The floristic and faunistic data, together with accurate habitat type cartography, are presented. A special emphasis was given to ichthyofauna.*

Key words: *Posidonia oceanica*, North Adriatic, topographical survey, nature conservation, non-destructive methods

RILIEVO TOPOGRAFICO DEI TIPI DI HABITAT NELL'AREA CARATTERIZZATA DA UNA PRATERIA DI *POSIDONIA OCEANICA* NELLA PARTE MERIDIONALE DEL GOLFO DI TRIESTE (NORD ADRIATICO)

SINTESI

Recentemente è stata inoltrata la proposta per dichiarare l'unico sito in cui ancora cresce una prateria di Posidonia oceanica *in acque slovene Monumento Naturale, vista la sua unicità e vulnerabilità. Fino ad oggi la fauna e la flora della zona non sono state studiate a sufficienza. Vista l'imminente dichiarazione ufficiale del sito ad area protetta, per il presente studio è stato usato un metodo di campionamento subacqueo non distruttivo. L'articolo riporta i dati faunistici e floristici, nonché un'accurata cartografia dei tipi di habitat della zona. L'ittiofauna ha occupato un posto di rilievo nella ricerca.*

Parole chiave: *Posidonia oceanica*, Alto Adriatico, rilievo topografico, tutela della natura, metodi non distruttivi

INTRODUCTION

Posidonia oceanica (L.) Delile is an endemic seagrass species in the Mediterranean. It forms seagrass meadows, which are nowadays considered to be amongst the most important habitat types in the infralittoral zone of the Mediterranean Sea. Seagrass beds are known to be key nursery areas for coastal fisheries. According to some authors, the presence of *P. oceanica* should be also regarded as a good biological indicator of water quality due to its sensitivity to human activities (*sensu* Piazzi *et al.*, 2000). The isolated *P. oceanica* meadow in Slovenian coastal waters, between the towns of Izola and Koper (referred hereafter as the Koper meadow), was described by Vukovič (1982). Besides the tiny patch of app. 2 m^2 close to Grado, it seems that the Koper meadow is the only remnant of this marine phanerogam in the Gulf of Trieste and along the Istrian coast. According to Benacchio (1938), *P. oceanica* was quite common on the silted bottom of the inner part of the Gulf of Trieste. However, a drastic reduction in its distribution was recorded just about 30 years later by Simonetti (1966) in his work dealing with distribution of the Zosteraceae in the Gulf.

Although no specific mapping programme for seagrass meadows has been made in Slovenia so far, some data are available on different aspects of the distribution (Vukovič & Turk, 1995) and phenology (Turk & Vukovič, 1998) of *P. oceanica* as well as on epiphytes and its colonisation (Orlando & Bressan, 1998). Some data are also at hand on the impacts of motorway pollution on the ecological conditions of the site (Faganeli *et al.*, 1997). One of the most interesting aspects of the Koper meadow – the possibility of being an ancient, post-glacial clone – is described in the work on genetic identity and homozygosity in Northern Adriatic populations of *P. oceanica* carried out by Ruggiero *et al.* (2002).

A decree for the protection of the meadow is being currently drafted by the government. The most important aspect of biodiversity is species composition, a checklist of a variety of species present in the area (Costello, 2000). To assess the marine biodiversity of a protected site, a non-destructive methodology is more suitable than any other classical sampling technique. Almost 50 years have passed from the inception of the non-destructive underwater visual census technique (Brock, 1954) for the study of coral reef fish assemblages. Numerous studies throughout the world confirmed the usefulness of this technique, which is nowadays accepted as a useful methodology to gain coastal fish density estimate (Harmelin, 1987; Francour, 1991, 1994; Harmelin-Vivien & Francour, 1992; Patzner & Serrao Santos, 1993; Harmelin *et al.*, 1995; Castellarin *et al.*, 2001). Today, visual census data are recognised as a valuable source of information for other aspects of fauna (Peharda *et al.*, 2000), flora, habitat types and in broader meaning for conservation purposes as well (Edgar *et al.*, 2000).

The present study aims to describe the habitat types occurring in the proposed protected area covered with *P. oceanica* seagrass meadows, and to assess the faunistic and floristic diversity of the area with non-destructive methods. Since this area is to be legally protected, such data can be very useful in the process of defining suitable conservation measures.

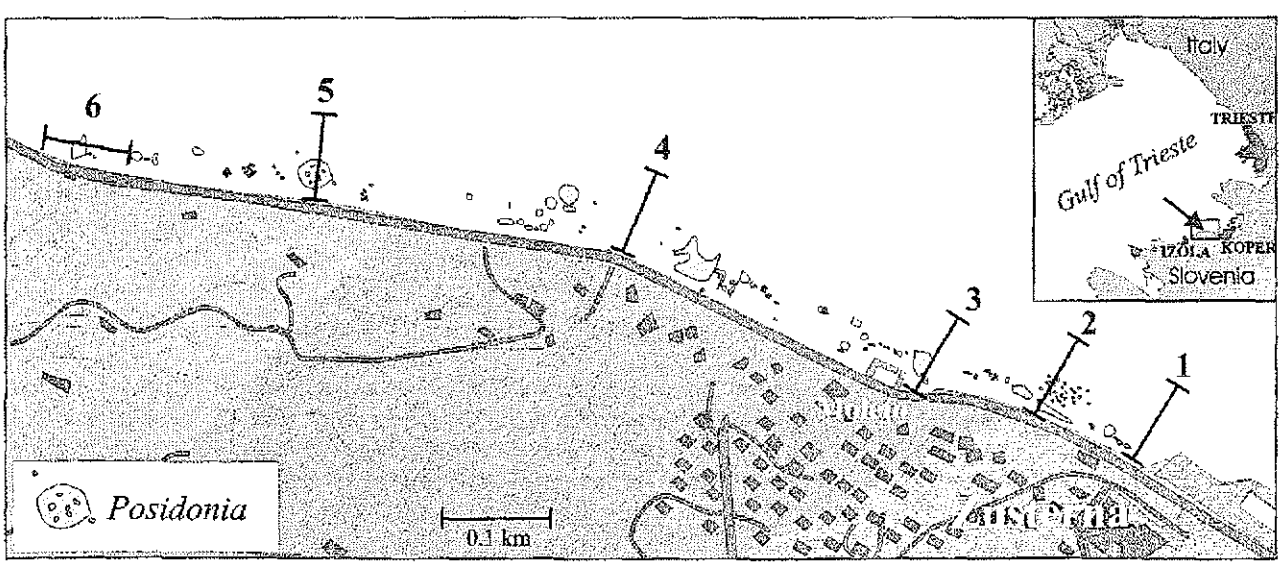


Fig. 1: Location of transects in the proposed natural monument area near Koper.
Sl. 1: Lokacije transektov na predlaganem naravnem spomeniku blizu Kopra.

MATERIAL AND METHODS

Study area

The study area is located between the towns of Izola and Koper, with the only site of *P. oceanica* seagrass meadow along the northern and western coasts of Istria. As a recent sediment of Koper Bay it consists of sandy silt with up to 40% of sand and less than 15% of clay (Ogorelec *et al.*, 1988).

The area surveyed is a known tourist resort with many recreational facilities. This is particularly true of the eastern part, which is close to the city of Koper and densely inhabited, whereas towards the city of Izola in the west the area is without any man-made structures but for the waterfront once used by the railway. On the other hand, the area has been subjected to a certain extent to organic pollution from the nearby city of Koper. Although recent studies have shown benthic organisms contaminated with PAH and heavy metals, this has not been reflected in the area's benthic community (Faganeli *et al.*, 1997).

Material and methods

Taking into account the vulnerability of the area, the underwater inspection of the area's flora, fauna and habitat types was carried out by SCUBA divers in the summer of 2000 and in the summer and autumn of 2001 along five vertical transect lines (station 1-5). The distances between different stations are shown in Fig. 1. During each survey we tried to get as much data as possible on the flora, fauna, habitat types and cryptobenthic fishes. A special emphasis was laid on the underwater mapping of different habitat types, occurring along the transect lines. Details about sighted animals and algae were written on a slate. Only the specimens, which were not determined during the sampling, were taken out in special bags and identified later in the laboratory and subsequently released. Only epifauna was taken into consideration.

For the assessment of coastal fish assemblage, a visual census technique was performed by two SCUBA divers along 60 m long transects. Coastal fish were counted up to 2 meter away from the transect rope by one or two divers. Two 30-m long measuring tapes were used. The average duration of a visual count transect was approximately 20 minutes. Additionally we used the data of one parallel census in *P. oceanica* habitat type at the station 6. In addition, a narcotiser quinaldin (MS222) was used to detect some cryptobenthic fish species, which could be otherwise overlooked.

Habitat type cartography was carried out by filming with underwater Sony camera (Handicam Hi-8). The diver with the camera followed the transect rope and filmed all habitat types. Afterwards, some shots of specific vegetation cover or peculiar habitat types in the neighbouring area were taken as well. Additionally, some specific habitat types were photographed with Subeye underwater camera. In the laboratory the transect films were carefully analysed and used for drawing habitat types. The coverage of each habitat type was estimated by calculating the area in habitat type distribution drawings.

RESULTS AND DISCUSSION

Floristic survey

At least 58 algal species and 2 other phanerogams (*Cymodocea nodosa* and *Zostera noltii*) were recorded in the investigated area (Tab. 1). Altogether 10 green macroalgae, 11 brown macroalgae and 37 red macroalgae were recorded. Twenty-four epibionts had been previously surveyed by Orlando & Bressan (1998).

The vegetation cover in the area is strongly connected with the ecological conditions, such as the water quality and the seabed substrata. In somehow deeper area, the seabed is covered by sandstone rocks and cobbles, which are not suitable for algae, and by some bigger boulders, to which *Alsidium corallinum* and *Anadyomene stellata* are attached.

Faunistic survey

Benthic invertebrate fauna

At least 88 taxa of benthic invertebrates were recorded in the studied area (Tab. 2). The majority of them, 38 species, were mollusks, followed by crustaceans (16), sponges (8), cnidarians (7), echinoderms (6), polychaets (6), tunicates (4) and bryozoans (3). At the station 1, at least 45 species were recorded, whereas at stations 2 and 3 at least 58 species were sighted. The invertebrates recorded were found mostly as fauna on rocks and boulders or as epibionts on *Posidonia*, *Cymodocea* and *Cystoseira*. The number of animals recorded is obviously far from complete, since only epifauna was taken into consideration. On the other hand, we used the technique of visual inspection mostly as it is a non-destructive method and at the same time very appropriate for protected areas. Many tiny and cryptic invertebrates could obviously not be recorded with such method.

Numerous studies demonstrated the importance of *Posidonia* seagrass meadows for a variety of animal groups. It is characterized as a complex biotic community with high richness, in which many animals spend all or part of their lives (*sensu* Garcia-Raso, 1990). According to Somaschini *et al.* (1993), the polychaete community of the *P. oceanica* bed is richer and more diversified than the neighbouring environment.

Tab. 1: Checklist of the flora associated with** Posidonia oceanica **seagrass meadow in the Žusterna-Moleto region (Legend: M = macroalgae, E = epiphyte, C = seagrass, Me = mediolitoral, Z Me = upper mediolitoral, S Me = lower mediolitoral, I = infralittoral, Z I = upper infralitoral, S I = lower infralitoral).

Tab. 1: Popis flore, povezane s travniki morske trave pozejdonke na območju med Moletom in Žusterno (Legenda: M = makroalge, E = epifit, C = morska trava, Me = mediolitoral, Z Me = zgornji mediolitoral, S Me = spodnji Mediolitoral, I = infralittoral, Z I = zgornji infralitoral, S I = spodnji infralitoral).

TAXON		Belt
Alsidium corallinum	M	I
Anadyomene stellata	M	I
Antithamnion tenuissimum	E	I
Ascocyclus orbicularis	E	I
Callithamnion corymbosum	E	I
Ceramium sp.	M + E	I
Ceramium cingulatum	E	I
Ceramium circinnatum	E	I
Ceramium tenerrimum	E	I
Chaetomorpha sp.	M + E	Me
Chylocladia sp.	E	I
Chylocladia verticillata	E	I
Chondria dasyphilla	M	I
Cladophora sp.	M	I
Cladophora echinus	E	I
Cladophora prolifera	M + E	S Me + I
Cladosiphon cylindricus	E	I
Cladostephus verticillatus	M	Me + I
Corallina granifera	M + E	Z I
Coratlina officinalis	M	Z I
Cymodocea nodosa	C	I
Cystoseira barbata	M	I
Cystoseira compressa	M	I
Dictyota dichotoma	M	Z I
Dictyopteris membranacea	M	S Me + Z I
Erithiotrichia carnea	E	I
Fucus virsoides	M	Z Me
Gelidiella nigrescens	M + E	I
Gelidium sp.	M + E	I
Gelidium spathulatum	M	I
Gigartina sp.	M	I
Gitaudya sphacelarioides	E	I
Halopithys incurvus	M	Z I
Heterosiphonia wurdemannii	E	I
Hydrolithon cruciatum	E	I
Hydrolithon farinosum	E	I
Laurencia obtusa	M	S Me +I
Laurencia papillosa	M	Z I
Lophosiphonia scopulorum	E	I
Nitophyllum punctatum	M	Z I
Padina pavonica	M	S Me + I
Peyssonnelia squamaria	M	S I
Pneophyllum fragile	E	I
Polysiphonia denudata	E	I
Polysiphonia furcellata	E	I
Polysiphonia nigrescens	E	I
Posidonia oceanica	C	I
Pseudolithophyllum expansum	M	S I
Pterocladia capillacea	M	S Me + I
Sphacelaria cirrhosa	M	I
Spyridia filamentosa	M + E	I
Stylonema alsidii	E	I
Titanoderma corallinae	E	I
Titanoderma pustulatum	E	I
Udotea petiolata	M	S I
Ulva sp.	M + E	S Me + I
Ulva rigida	M + E	S Me + I
Ulvella setchellii	E	I
Valonia utricularis	M + E	I
Wrangelia penicillata	M + E	I
Zostera noltii	C	I

Tab. 2: Checklist of benthic invertebrates recorded in the area during the study period.

Tab. 2: Seznam bentoških nevretenčarjev, opaženih na obravnavanem območju v obdobju vzorčevanja.

Porifera
- *Chondrosia reniformis*
- *Chondrilla nucula*
- *Clione celata*
- *Hippospongia communis*
- *Oscarella lobiformis*
- *Spirastrella cunctathrix*
- *Tethya aurantium*
- *Verongia aerophoba*

Cnidaria
- *Actinia equina*
- *Aiptasia mutabilis*
- *Anemonia sulcata*
- *Balanophyllia italica*
- *Cladocora caespitosa*
- *Eudendrium sp.*
- *Paranemonia cinerea*

Mollusca
- *Aplysia punctata*
- *Aporrhais pes pelecani*
- *Arca noae*
- *Astraea rugosa*
- *Bittium reticulatum*
- *Cerithium rupestris*
- *Cardium edule*
- *Chiton olivaceus*
- *Chlamys varius*
- *Dendrodoris limbatus*
- *Elysia timida*
- *Epitonium communis*
- *Gastrochaena dubia*
- *Gourmya vulgata*
- *Haliotis lamellosa*
- *Hinia costulata*
- *Hinia reticulata*
- *Hinia incrassata*
- *Lima hians*
- *Littorina neritoides*
- *Lithophaga lithophaga*
- *Loripes lacteus*
- *Monodonta articulata*
- *Murex brandaris*
- *Mytilus galloprovincialis*
- *Mytilaster minimus*
- *Ostrea edulis*
- *Patella caerulea*
- *Pholas dactylus*
- *Pinna nobilis*
- *Sepia officinalis*
- *Solecurtus strigillatus*
- *Thuridilla hopei*
- *Trunculariopsis trunculus*
- *Venerupis decussata*

Venus verrucosa
Vermetus triqueter
Polychaeta
Bispira sp.
Protula tubularia
Pomatoceros triqueter
Serpula vermiformis
Spirographis spallanzani
Spirorbis pagenstecheri
Crustacea
Alpheus sp.
Anilocra physodes
Balanus sp.
Carcinus aestuari
Callianasa stebbingi
Chthamalus stellatus
Eriphia spinifrons
Galathea sp.
Ligia italica
Maia verrucosa
Macropodia rostrata
Mysidae
Pinnotheres sp.
Porcellana platycheles
Upogebia littoralis
Bryozoa
Membranipora mebranacea
Electra posidoniae
Schizoporella sanguinea
Echinodermata
Amphipholis squamata
Cucumaria elongata
Holothuria tubulosa
Ophiothrix cf. *fragilis*
Paracentrotus lividus
Sphaerechinus granularis
Tunicata
Ascidia sp.
Diplosoma spongiforme
Microcosmos cf. *sulcatus*
Phallusia fumigata

Ichthyofauna

At least 33 coastal fish species were found to inhabit the studied area (Tab. 3). The number of species per transect varied from 9 to 22. Only 5 species were recorded at all transects. The majority of species (10) recorded were gobiids, followed by blennioids (8), sparids (6) and labrids (4). The dominant species were *Atherina* sp., *Symphodus roissali* and *S. cinereus*. In the patches of *Posidonia* meadow, only juvenile specimens of *Diplodus* spp. were abundant.

On the basis of a visual count, the highest density was recorded for *Symphodus roissali* with 9.8 specimens per 100 m^2, followed by *S. cinereus* with 3.08 per 100 m^2. However, it must be noted that the 60 m parallel census was carried out in the area, where almost 25% of the habitat type consisted of *Cystoseira* spp.

The dominant gobiid species were ascribed to the *Gobius xanthocephalus/fallax* group. Although the yellow markings on the head typical of the species *G. xanthocephalus* were quite distinct, we decided to use, for practical purposes, the group taxon, since the taxonomical differentiation during the inspection of the transect is almost impossible in the area, where this species is sympatric with other similar gobiids.

Small cryptobenthic fishes *Lepadogaster candollei*, *Zebrus zebrus* and *Millerigobius macrocephalus* were found in the *Posidonia* meadow (Tab. 3). As they were found under stones, they are not directly related to seagrass meadows. The goby *M. macrocephalus* has been till now recorded only at few sites in the Adriatic Sea (see Jardas, 1996).

In comparison with other areas in Slovenian coastal waters, the studied area is poor. Fifty-two fish species were recorded for Cape Madona Natural Monument, 49 for Strunjan Nature Reserve and 36 for Debeli rtič Natural Monument (Lipej & Orlando Bonaca, *in prep.*). The main reason for this lies in the fact that the data for other areas were obtained by the use of 90 m long vertical transects, due to which a broader variety of different habitats was obtained, which obviously affected the number of species. It is well known that the spatial heterogeneity is an important factor, which affects the species diversity of the area.

If we take into consideration only the seagrass meadow of *P. oceanica*, then only few species can be considered true residents of this area. Bussotti & Guidetti (1999) studied the fish communities associated with *P. oceanica* on the one hand and *Cymodocea nodosa* and *Zostera noltii* seagrass meadows on the other with the visual census technique monthly in August 1995 and August 1996 and never sighted more than 24 fish species. Bell & Harmelin-Vivien (1982) reported 49 fish species on *Posidonia* meadows with a trawl at a depth 16-18 m. However, only 30 species of them were considered to be residents. The depth obviously had an effect on the species number as well. According to the study of Guidetti (2000) on the visual census data in the southern Adriatic, only three species, *Spondyliosoma cantharus*, *Diplodus annularis* and to a minor extent *Symphodus ocellatus*, were associated with *P. oceanica*.

Since the number of samplings performed in the studied area is lower than in the other (above mentioned) three protected areas in Slovenian coastal waters, we can speculate that the number of species will increase with a further inspection of the area.

Tab 3: Coastal fish assemblage in the studied area. The abundance of different fish species are presented in ranges: - = no specimen recorded, 1 = single specimen, 2 = 2-3 specimens, 3 = 3-5 specimens, 4 = 5-10 specimens and 5 = more than 10 specimens. Cryptobenthic species, which were recorded with the use of narcotic, are marked with asterisk.

Tab. 3: Obrežna ribja združba na obravnavanem območju. Številko osebkov posameznih ribjih vrst je predstavljeno v rangih: - = noben osebek zabeležen, 1 = osebek, 2 = 2-3 osebki, 3 = 3-5 osebkov, 4 = 5-10 osebkov in 5 = več kot 10 osebkov. Kriptobentoške vrste vrste rib, ki smo jih potrdili z uporabo narkotičnega sredstva, so označene z zvezdico.

Št.	Species/ station (transects)	4	5	6	1	3
1	*Atherina sp.*	5	5	5	-	-
2	*Diplodus annularis*	-	1	3	-	2
3	*Diplodus puntazzo*	-	1	-	-	-
4	*Diplodus sargus*	-	1	-	-	1
5	*Diplodus vulgaris*	1	1	3	1	3
6	*Gobius cobitis*	1	1	-	-	-
7	*Gobius cruentatus*	1	1	1	1	1
8	*Gobius paganellus*	1	-	-	-	-
9	*Gobius fallax/xanthocephalus*	-	1	-	3	5
10	*Gobius niger*	-	1	-	1	3
11	*Gobius roulei*	-	1	-	-	-
12	*Lepadogaster candollei**	-	1	-	-	-
13	*Lipophrys adriaticus*	-	-	-	1	-
14	*Lipophrys dalmatinus*	4	4	-	-	-
15	*Millerigobius macrocephalus**	-	1	-	-	-
16	*Oblada melanura*	3	3	-	-	-
17	*Parablennius gattorugine*	1	-	-	-	1
18	*Parablennius incognitus*	2	-	-	-	1
19	*Parablennius rouxi*	-	1	-	-	-
20	*Parablennius sanguinolentus*	-	-	-	2	-
21	*Parablennius tentacularis*	1	1	-	-	-
22	*Pomatoschistus marmoratus*	-	-	-	-	5
23	*Sarpa salpa*	-	-	1	-	5
24	*Serranus hepatus*	1	-	-	-	3
25	*Serranus scriba*	2	2	2	2	-
26	*Symphodus cinereus*	2	3	5	3	5
27	*Symphodus ocellatus*	3	3	1	3	2
28	*Symphodus roissali*	5	5	5	3	2
29	*Symphodus tinca*	2	2	-	2	-
30	*Syngnathus acus*	1	-	-		
31	*Tripterygion tripteronotus*	2	-	-	-	-
32	*Zosterissesor ophiocephalus*	1	-	-	-	-
33	*Zebrus zebrus**	-	2	-	5	-
	Total number of species	19	22	9	12	14

Habitat types

The studied area is characterised by several different habitat types such as allochthonous limestone boulders, photophilic algal population on rocks and boulders, sandstone terraces, *C. nodosa* meadow, *P. oceanica* meadow, as well as muddy sands and mud (Fig. 2). The coverage of each habitat type at different transects is shown in Table 4. The comparison between five transects showed quite different habitat type distribution, although the distance between the 1st transect and the 5th transect was below 1 km. *Posidonia oceanica* was recorded as a patch or just with a few shoots. This again confirms the sporadic distribution of *Posidonia meadows sensu* leopard spot pattern. Station 1 was characterized by reduced water column transparency, which may have also an impact on the *Posidonia* distribution (Meinesz *et al.*, 1988).

Although the *C. nodosa* is present at all five vertical transects, its distribution is very diverse. Along transect 5

Tab. 4: Habitat type distribution (expressed as percentage of the entire surveyed transect area) along five transects. The term fine sand indicates the area not covered by vegetation.
Tab. 4: Razporeditev habitatnih tipov: apnenčasti balvani, terase peščenjaka, travnik cimodoceje, travnik pozejdonke, fini pesek, mulj, prodnjaki in infralitoralni kamni in skale (izraženih v odstotkih celotne površine pregledanega območja) na 5 transektih. Z izrazom fini pesek označujemo predele, ki niso bili poraščeni z vegetacijo.

Habitat type/stations (transects)	1	2	3	4	5
Allochthonous boulders	7.50	5.0	10.0	11.67	12.50
Sandstone terraces	0	0	21.67	7.50	0
Cymodocea meadows	33.33	13.33	18.33	8.33	26.67
Posidonia meadows	0	11.67	2.50	0.80	52.50
Fine sand*	0	22.50	28.33	45.83	4.20
Mud	22.50	15.00	0	0	0
Pebbles	10.83	5.83	13.33	12.50	4.20
Infralittoral stones and rocks	25.83	20.83	5.83	13.33	0.0

spreads a dense meadow, whereas in other transects the density is very low. It seems that the ecological conditions are not the same at the five studied transects.

Limestone boulders

Allochthonous limestone boulders were placed along the coastal trunk road to function as wavebreakers. Numerous niches are available on these boulders and between them, which has resulted in typical mediolittoral fauna and flora. A broad and large belt on the allochthonous limestone boulders is covered by the association *Fucetum virsoidis*, represented by *Fucus virsoides*. Characteristic of this belt are also some other common species, such as *Chaetomorpha linum*, *Padina pavonica*, *Cladophora prolifera*, *Cladostephus verticillatus*, *Dictyopteris membranacea*, and *Ulva rigida*. The last two also form the typical nitrophilic associations *Dyctiopteretum membranaceae* and *Pterocladio–Ulvetum*, which normally develop in areas influenced by organic pollution.

Pebbles

Pebbles of irregular shapes were found at all 5 studied transects. Due to the constant wave action, they are not overgrown with vegetation. However, at all transects benthopleustonic alga *Ulva rigida* was found as very abundant. This nitrophilous green alga is probably connected with outlets of sewage water from the nearby tourist resort Žusterna.

Most species inhabiting this area are hidden under pebbles. The typical fish species of this habitat type are *Gobius paganellus*, *G. cobitis* and *Parablennius sanguinolentus*.

Photophilous algae

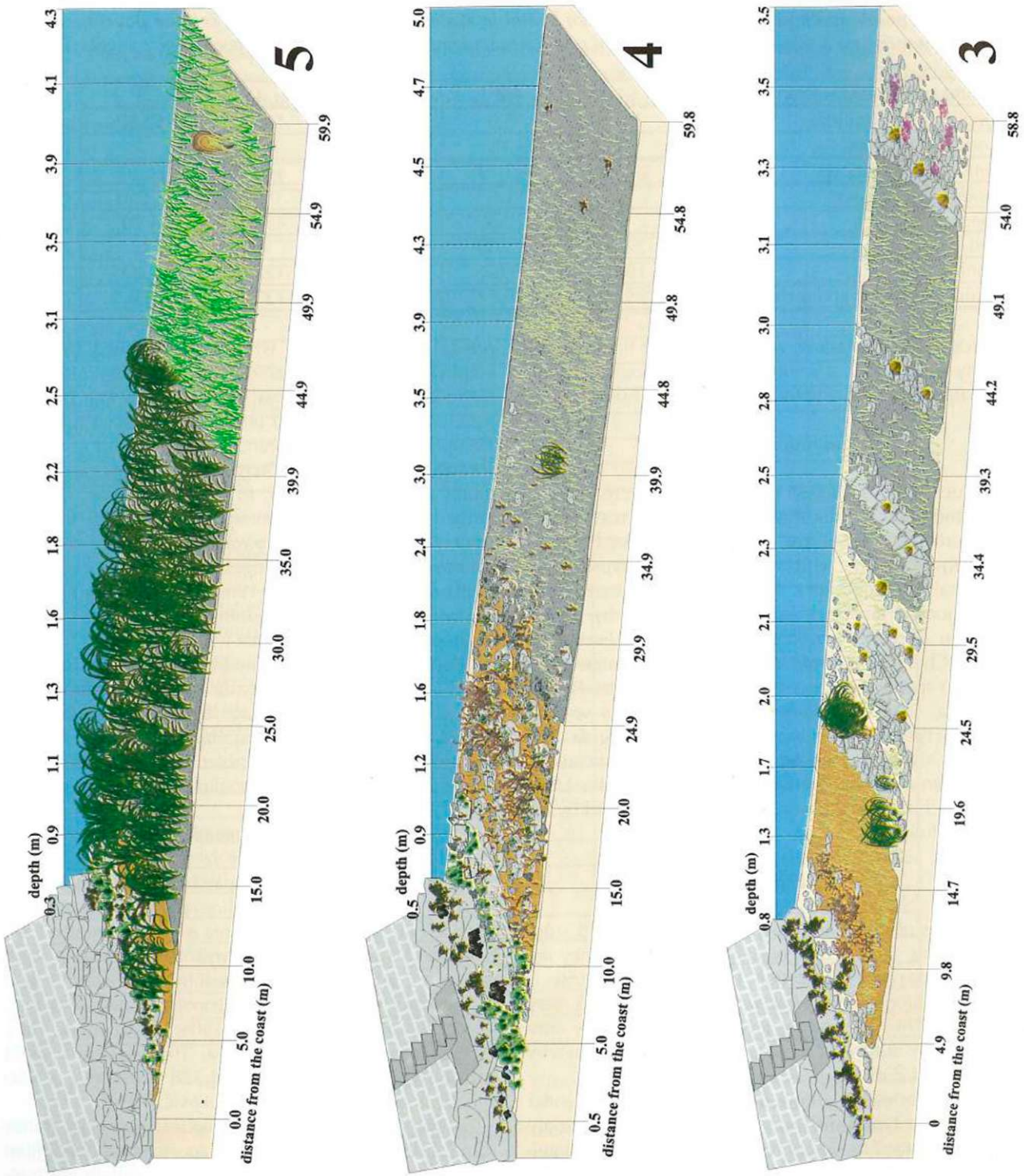
Other parts of the infralittoral belt are covered with dense algal phytal consisting mainly of *Cystoseira compressa* and *C. barbata*, which are inhabited by some epiphytes such as: *Corallina granifera*, *Ceramium* sp., *Gelidium* sp., *Polisiphonia furcellata*, *Spyridia filamentosa*, *Ulva rigida*, *Valonia utricularis*. On such substrata, *Halopithys incurvus*, *Laurencia papillosa* and *L. obtusa*, *Wrangelia penicillata*, *Dictyota dichotoma* are commonly distributed as well. In this habitat type, the majority of fishes occurred. Some boulders can be found at somewhat greater depth, forming substrata for dense algal cover and different sponges, sea anemones, vermetid snails and other molluscs. Wrasses such as *Symphodus roissali* and *S. cinereus* predominated in the fish assemblage of this particular habitat type.

Boulders are also inhabited by different fish species, which are using shelters made by endolithic bivalves such as *Lithophaga lithophaga* or live in the boulders' cracks and crevices. The majority of them are blennies *(Lipophrys dalmatinus, Parablennius incognitus)* and gobies *(Gobius cf. xanthocephalus, Zebrus zebrus)*.

Posidonia meadow

In the transition zone, the patches of *P. oceanica* are situated between stony coastline and mud at a depth interval of 0.5 m to 4 m. The area is approximately 1 km long and 50 m wide (Fig. 1), with the maximum depth between 2 and 4 m. It shows patchy distribution, e.g. it is restricted to small islets ("leopard spots") (Vukovič, 1982; Vukovič & Semroud, 1984; Vukovič & Turk, 1995), embraced by *C. nodosa*. The *Posidonia* shoot density varies between 360 and 588 shoots/m^2, or 460 shoots/m^2 on average (Turk & Vukovič, 1998).

In the shady parts of the *Posidonia* shoots or stones some rhodophycean algae such as *Pseudolithophyllum expansum* and *Peyssonnelia squamaria*, which are typical of coralligenous formations, were recorded. Only few fish species were sighted in this habitat type, but with the use of quinaldine we detected some interesting cryptobenthic species, such as *Millerigobius macrocephalus* and *Lepadogaster candollei*.


5
depth (m)
0.3 0.9 1.1 1.3 1.6 1.8 2.2 2.5 3.1 3.5 3.9 4.1 4.3
0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0 39.9 44.9 49.9 54.9 59.9
distance from the coast (m)
4
depth (m)
0.5 0.9 1.2 1.6 1.8 2.4 3.0 3.5 3.9 4.3 4.5 4.7 5.0
0.5 5.0 10.0 15.0 20.0 24.9 29.9 34.9 39.9 44.8 49.8 54.8 59.8
distance from the coast (m)
3
depth (m)
0.8 1.3 1.7 2.0 2.1 2.3 2.5 2.8 3.0 3.1 3.3 3.5 3.5
0 4.9 9.8 14.7 19.6 24.5 29.5 34.4 39.3 44.2 49.1 54.0 58.8
distance from the coast (m)

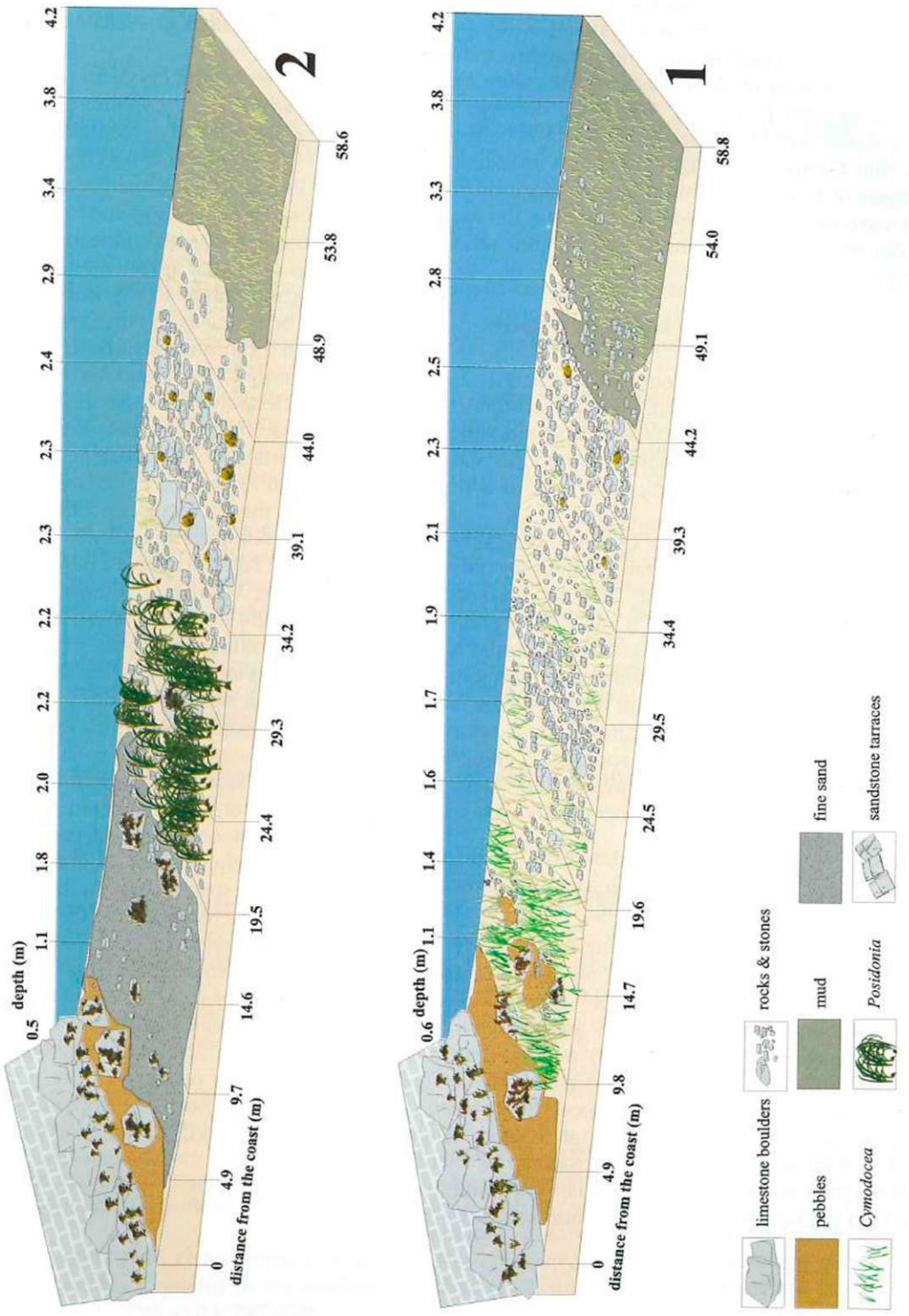


Fig. 2: Habitat type distribution at 5 linear transects in the study area (see Fig. 1).
Sl. 2: Razporeditev habitatnih tipov na 5 linearnih transektih na obravnavanem območju (glej tudi Sl. 1).

Cymodocea meadow

Close to the coast is also the *C. nodosa* seagrass meadow, occurring either in small patches in the sandy area or almost completely covering the entire transect area. A low number of *Zostera noltii* plants were found intermingling with *C. nodosa*. The mean density of *C. nodosa* shoots was 69 shoots/m^2 (Vukovič & Semroud, 1984). The *Cymodocea* seagrass meadow is extending to a depth of 6 to 8 m. Only few specimens of *Pinna nobilis* were found. In this seagrass meadow, the typical goby *Zosterissesor ophiocephalus* was sighted, although it was not abundant.

"Naked" boulders and sandstone terraces

These habitat types were found at transects 1, 2 and 3 between Moleto and Žusterna. Infra-littoral stones and boulders were poorly overgrown with vegetation (the so-called algal turf). The dominant invertebrate species were the sponge *Verongia aerophoba* and, to a minor extent, *Cladocora caespitosa*.

Sandstone terraces form a peculiar habitat type, which provides a number of suitable niches for different invertebrates and littoral fishes. They lie horizontally and thus give an impression of a man-made platform. The terraces are overgrown with corraligenous red algae *Pseudolithophyllum expansum*, from which the terraces obtained their colour. Dominant invertebrates were polychaets of the genera *Protula* and *Serpula*, vermetid gastropod *Vermetus triqueter* and sponges *V. aerophoba* and *Chondrilla nucula*. In little crevices and cracks between terraces, *Gobius* cf. *xanthocephalus* was established as the dominant littoral fish.

Sandy and muddy habitat types

Some species were sighted only in sandy patches or at the end of transects, where the stony bed is replaced by mud. In these peculiar habitat types, more specimens of *Pinna nobilis* were found than in the meadows, but the majority of them were dead. In our opinion, this should be attributed mainly to the high sedimentation rate in this area. The typical sand species *Pomatoschistus marmoratus* was found on sand at a depth range from 2 to 4 m between patches of *Posidonia* or *Cymodocea* seagrass meadows. *Gobius roulei*, a recently rediscovered gobiid species in the Adriatic sea (Kovačić, 1995), was more or less restricted to coarse sand, whereas *G. niger* preferred muddy areas.

NATURE CONSERVATION VALUE

The different aspects of the importance of *P. oceanica* meadows were confirmed in the last decades by numerous authors. The meadows are the base of the richness of the coastal waters of the Mediterranean (Molinier & Picard, 1952; Cinelli *et al.*, 1974; Boudouresque & Meinesz, 1982). This is due to the great surface of the sea bottom of the Mediterranean they cover, to the great quantities of organic material and oxygen they produce, to their contribution to the stability of the sea bottom and, last but not least, to the fact that the meadows host more than a thousand species of marine organisms. For all this reasons, the meadows of *P. oceanica* and the species themselves are legally protected in several countries around the Mediterranean. Besides, the contracting parties to the Barcelona convention included *P. oceanica* in Annex II – List of endangered or threatened species of the Protocol concerning specially protected areas and biological diversity in the Mediterranean (see Lipej *et al.*, 2000). Last but not least, the meadows of *P. oceanica* are listed as a priority habitat type in the EU Directive 92/43 on the conservation of natural habitats and on wild fauna and flora.

The importance of the tiny Koper meadow and consequently the need for a strict protection go even beyond the reasons listed in the previous paragraph. The total absence of genetic variability in the meadow, stated in the work by Ruggiero *et al.* (2002), is another strong cause of major concern for conservation of the species in this northernmost part of the Adriatic. Low levels of genetic variability and habitat fragmentation can influence species fragility by lowering populations resilience to increasing levels of ecosystem disturbance, either of anthropogenic origin or not (Meffe & Carroll, 1997). Legal protection of the Koper meadow as the only remnant of *P. oceanica* in the Gulf of Trieste and introduction of efficient conservation measures, together with a suitable long-term monitoring, should be regarded as issues of high priority. The regression of the meadow would not only jeopardise the survival of the species in the North Adriatic but would also add a hundred or more to the Slovene Red Lists of rare and endangered species.

TOPOGRAFSKI PREGLED HABITATNIH TIPOV NA OBMOČJU RASTIŠČA POZEJDONKE, *POSIDONIA OCEANICA*, V JUŽNEM DELU TRŽAŠKEGA ZALIVA (SEVERNI JADRAN)

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POVZETEK

Avtorji obravnavajo topografski pregled za zaščito predlaganega rastišča morske trave pozejdonke med Izolo in Koprom. Gre za edini travnik te vrste na zahodni in severni istrski obali in obenem ostanek nekdanjih obsežnih travnikov v Tržaškem zalivu. Za ugotovitev favnistične in floristične pestrosti ter za ovrednotenje habitatnih tipov so uporabili metode podvodnega nedestruktivnega popisa.

Za obrežno območje med Žusterno in Moletom je značilna pestra množica habitatnih tipov, med katerimi je z vidika zaščite najpomembnejši travnik morske trave pozejdonke (Posidonia oceanica). To je vrsta, ki je zaščitena tako v slovenskem kot tudi v evropskem merilu, njeni travniki pa so izjemno pomembni kot zavetišče ribjih mladic in kot ekološka niša za številne vrste bentoških alg in nevretenčarjev, ki na njej rastejo bodisi kot epibionti ali pa se skrivajo v koreninskih prepletih.

Znatno večje območje sicer pokriva druga vrsta trave, kolenčasta cimodoceja (Cymodocea nodosa), ki pa pozimi izgubi liste. Od zanimivejših habitatnih tipov je treba omeniti še terasaste kamnite sklade, ki jih najdemo na polovici poti med Moletom in Žusterno. Primerjava med posameznimi deli obravnavanega območja kaže, da je najmanj pestra favna bentoških nevretenčarjev na postaji ob kopališču Žusterna, medtem ko je na polovici poti do Moleta in ob samem Moletu favna neprimerno pestrejša. Podobno velja tudi za favno rib, ki je pestrejša ob Moletu. Pri tem poudarjamo, da bi z večjim številom vzorčevanj, predvsem pa z drugimi metodami, gotovo dopolnili ugotovljeni seznam flore in favne, medtem ko lahko za kartografski pregled habitatnih tipov trdimo, da gre za veren posnetek stanja na obravnavanem območju v času preiskav.

Ključne besede: *Posidonia oceanica*, severni Jadran, topografski pregled, varstvo narave, nedestruktivne metode

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