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An Analysis of the Coastal Fish Assemblage of the Ustica Island Marine Reserve (Mediterranean Sea)

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With 2 figures and 11 tables

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Abstract. A study of the coastal fish assemblages in the marine park of Ustica Island (Southern Tyrrhenian Sea, Mediterranean) was conducted from June 1994 to September 1995 and from June 1996 to September 1997. The principal aims of the research were to: (1) define the faunistic features of local fish communities; (2) assess the effectiveness of the protection regime of the marine park on the fish assemblages ('reserve effect'); (3) provide information on the distribution of some *Epinephelus* and *Diplodus* species in the shallowest depth zone of the island. During seasonal surveys, underwater visual censuses were carried out at several sites located in three zones of the island, each with a different level of protection. Observations were made along 250 m^2 transects at 3–5, 10–15 and 25–30 m depth ranges. Additional surveys were made by SCUBA diving and snorkelling. A statistically significant effect of depth on the fish community parameters was observed, whereas differences linked to protection level, zones, sites and seasons were not significant. The abundance and frequency of occurrence of some species, particularly dusky grouper *Epinephelus marginatus*, were positively correlated with the degree of protection of the different zones of the marine park. Certain sites of the island are important as nursery areas for three species of the genus *Diplodus* (*i.e.*, *D. puntazzo*, *D. sargus* and *D. vulgaris*).

Problem

The study of fish assemblages in marine protected areas must by definition be based on nondisruptive sampling methods which do not alter the environmental integrity ensured by the protection regime.

Visual census methods meet this requirement, since they permit a community assessment without removal of the organisms, conversely to other traditional techniques (*i.e.*, sampling by trawls and dredges, poisons) (Bortone & Kimmel,

1991). Moreover, they can be used on heterogeneous rocky bottoms, such as coral and artificial reefs, where the usual sampling devices are limited or impossible to apply (Buxton & Smale, 1984; Bohnsack & Bannerot, 1986; Bortone *et al*., 1989; Bortone *et al*., 1991; Samoilys, 1992).

Several studies of coastal fish assemblages have been made in marine reserves of the Mediterranean using visual censuses. In the French national park of Port Cros, investigations have focused either on the whole fish community (Harmelin-Vivien & Harmelin, 1975; Harmelin, 1984, 1987) or on species of high interest, such as the dusky grouper (*Epinephelus marginatus*) (Robert *et al*., 1987; Chauvet & Francour, 1989) and the brown meagre (*Sciaena umbra*) (Harmelin & Marinopoulos, 1993). Other studies conducted in the marine reserves of Banyuls-Cerbère (French Mediterranean coast), of Las Islas Medas (Spain) and of Scandola (Corsica) indicated the effects of protection on fish assemblages (Bell, 1983; Garcia-Rubies & Zabala, 1990; Francour, 1991; Dufour *et al*., 1995).

Along the Italian coast, visual assessment of the coastal fish assemblages has been performed in some areas of high naturalistic interest, such as Gorgona Island (Vacchi *et al*., 1997a), Torre Guaceto (Marconato *et al*., 1996), Portofino (Tunesi & Vacchi, 1993; Vacchi & Tunesi, 1993) and the Aeolian Islands (Vacchi *et al*., 1997b), which are under environmental protection.

The literature on the fish of the Ustica Island marine reserve is scarce, despite its importance as the only extensive Italian marine reserve. De Cristofaro (1970) reported a list of fish species obtained from fishing captures and underwater sightings. A preliminary survey on the fish assemblage of the island was conducted by Vacchi *et al*. (1999).

The objectives of the present monitoring study were to: (a) define the faunistic traits of the coastal fish assemblage of Ustica Island, (b) estimate the benefits of protection measures on certain target species, and (c) obtain data on the distribution of some *Epinephelus* and *Diplodus* species in the shallowest depth zone of the island.

Material and Methods

1. Study area

Ustica is a small volcanic island (8 km^2) located in the Southern Tyrrhenian Sea (Mediterranean Sea), 67 km north of the Sicilian coast.

Established in 1986, the marine protected area of Ustica, which includes the entire island coastline and extends seaward for 5.6 km, was divided into three zones of incremental levels of protection (Fig. 1). Zone A (integral reserve – in which all fishing activities and navigation are forbidden) comprises a small area (60 hectares) located along the north-western coast and 350 m offshore. Zone B (general reserve – in which local artisanal fishing, diving activities and angling are permitted) extends 5.6 km offshore between Punta Gavazzi and Punta Omo Morto. Finally, Zone C (partial reserve – in which local artisanal fishing and all types of recreational fishing, including spearfishing, are allowed) includes the southern coastal area (5.6 km offshore) between Punta Omo Morto and Punta Gavazzi.

2. Sampling sites

The Cala Sidoti and La Caletta (Zone A) were characterized by a rocky plateau with gentle slope, with an abrupt drop at its most offshore point. Photophilic algae covered the entire area. Patches of *Posidonia*

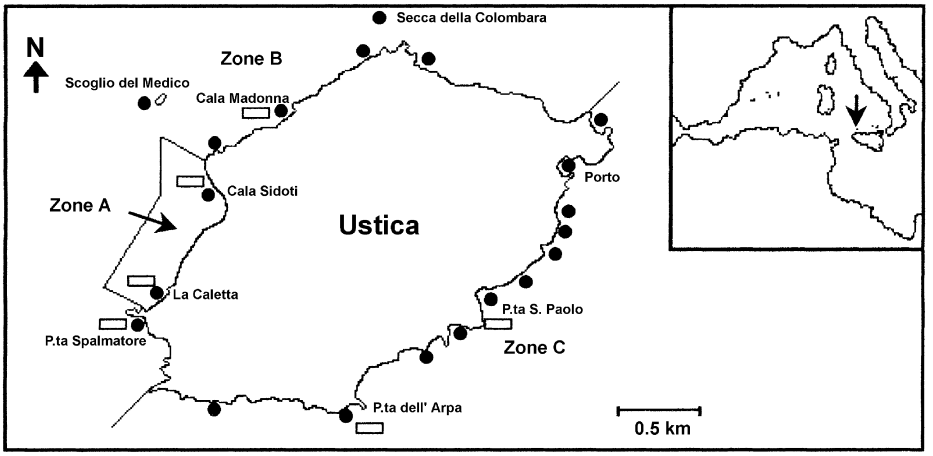

Fig. 1. Location of sampling sites in the marine reserve of Ustica Island (Southern Tyrrhenian Sea). Zone A: integral reserve; Zone B: general reserve; Zone C: partial reserve. ▭ transect; ● tract.

oceanica were also present in the intermediate and deep transects. Zone B (Cala Madonna) had bottom features similar to those in Zone A. The other site, Punta dello Spalmatore, was characterized by a rocky bottom covered by photophilic algae and having a steep slope and numerous crevices. In Zone C (*i.e.*, Punta S. Paolo and Punta dell'Arpa), the deeper stands were characterized by rocky bottom and large patches of *P. oceanica* which had settled on coarse sand.

3. Censusing method

Ten seasonal surveys involving fish visual censuses were conducted from June 1994 to September 1997. Qualitative and quantitative data on the fish assemblage of Ustica were collected by means of the strip transects method (Harmelin-Vivien *et al.*, 1985). In order to obtain additional information about the composition of the fish fauna we used the tracts method, again according to Harmelin-Vivien *et al.* (1985). Following the latter method, we also studied the distribution of certain *Epinephelus* and *Diplodus* species in the shallowest depth zone (0–3 m).

Strip Transects. Visual counts were conducted by SCUBA diving along 50 m × 5 m (250 m^2) transects as follows: the observer, swimming slowly (3–4 $m \cdot min^{-1}$) along the transect line, recorded the number and size of fishes on a PVC slate. Any fishes grouped in schools larger than 10 individuals were assigned to six abundance classes (11–30, 31–50, 51–100, 101–200, 201–500, > 500 individuals). The size (total length) of individual fish was assigned to one of four size classes (small, medium, large and very large), each corresponding to one quarter of the recorded maximum total length of the species (Fischer *et al.*, 1987). In addition, small individuals of some species were recorded as juveniles on the basis of morphological features (*e.g.*, the colour pattern). During each census, sea-weather conditions and selected environmental parameters such as water transparency, type of substrate and macrobenthic coverage were noted.

During the first series of seasonal surveys (from June 1994 to September 1995), censuses were performed at four sampling sites: Cala Sidoti (Zone A), Cala Madonna and Punta Spalmatore (Zone B), Punta S. Paolo (Zone C) (see Fig. 1). The censuses were conducted at two depth ranges (3–5 m = shallow transect; 10–15 m = intermediate transect) and replicated twice except for Cala Madonna (February 1995) and Punta Spalmatore (September 1995), due to the unfavourable sea-weather conditions.

During the second series of seasonal surveys (from June 1996 to September 1997), an additional

transect depth range (25–30 m = deep transect) as well as two additional sampling sites, namely La Caletta (Zone A) and Punta dell'Arpa (Zone C), were also studied (Fig. 1).

The total number of transects performed in the Zones A, B and C were 87, 94 and 78, respectively.

Tracts. The tracts were performed by SCUBA diving and snorkelling at several sites within zones A, B and C (Fig. 1). The duration in case of SCUBA diving was 30–60 min, depending on depth (maximum depth: 55 m). The snorkelling method took 15 min and was generally conducted at 0–10 m depth.

From September 1995 to September 1997, some snorkelling tracts were conducted in the three zones of the island at 0–3 m depth in order to assess the distribution of groupers (*Epinephelus marginatus* and *Epinephelus costae*) and sargo breams (*Diplodus puntazzo*, *Diplodus sargus* and *Diplodus vulgaris*) in such a shallow area. The distance covered during each tract ranged between 30 and 45 m. The size (total length) of all individuals of groupers and sargo breams was estimated by 5-cm size classes.

4. Data analysis

Qualitative aspects of the fish assemblage. A comparison of species composition among the three zones was performed using a Dice (= Sorensen) similarity index (Blanc *et al*., 1976).

Species richness was expressed by considering the number of species (S), the species diversity and homogeneity using the Shannon–Weaver diversity index (H′) and the evenness index (J′) (Pielou, 1966). These parameters were calculated for each survey, site and depth by pooling data from the sample replicates. Owing to the differences in the site number and the transect depth investigated, data collected during 1994–95 and 1996–97 were examined separately, using a discriminant analysis.

Assessment of reserve effect. In order to evaluate the reserve effect on certain target species, their abundance (expressed as the mean number of individuals per transect), frequency of occurrence and size distribution (expressed as frequency of each size class) within zones A, B and C were examined. Data collected during 1994–95 and 1996–97 were examined separately due to the differences in the site number and the transect depth investigated. A statistical analysis was applied to these data: abundance was compared among the three zones (between transects performed at the same depth) using the Mann–Whitney U-test, whereas frequency of occurrence was compared using the 'difference between two percentages test' (Statistica, Statsoft). In order to assess the relationship between protection level and size distribution, the percentages of larger individuals (individuals of large and very large size classes) within zones A, B and C were compared using the 'difference between two percentages test'.

Distribution of groupers and sargo breams. From data collected by snorkelling at 0–3 m depth, the frequency of occurrence and size distribution of groupers and sargo breams within the three zones were calculated.

Results

1. Qualitative aspects of the fish assemblage

A total of 83 species, representing 27 families, were observed (Table 1). The actual species richness of our sample was higher, as individuals belonging to the genus *Atherina* and the family Mugilidae were not identified to species.

The most speciose families were Labridae (12 species), Gobiidae (10 species), Sparidae (10 species) and Blenniidae (9 species). The total number of censused species was higher in Zone C (72 species) than in Zones A (63 species) and B (62 species). Nevertheless, the species composition observed in the three zones was nearly homogeneous. The Dice similarity index was high between Zones A and B (0.86) and Zones B and C (0.85), and slightly lower between Zones A and C (0.80).

Table 1. Species censused visually (by means of strip transects and tracts methods) from June 1994 to September 1997 within the three zones of Ustica Island.

family	species	Zone
Apogonidae	*Apogon imberbis* (Linnaeus 1758)	A,B,C
Atherinidae	*Atherina* sp. Linnaeus 1758	A,B,C
Balistidae	*Balistes carolinensis* Gmelin 1788	A
Belonidae	*Belone belone* (Linnaeus 1761)	C
Blenniidae	*Aidablennius sphinx* (Valenciennes 1836)	A,B,C
	Coryphoblennius galerita (Linnaeus 1758)	B,C
	Lipophrys canevai (Vinciguerra 1880)	A,B,C
	Lipophrys pavo (Risso 1810)	A,B
	Lipophrys trigloides (Valenciennes 1836)	B,C
	Parablennius gattorugine (Brünnich 1768)	A,B,C
	Parablennius rouxi (Cocco 1833)	A,B,C
	Parablennius sanguinolentus (Pallas 1811)	A,B,C
	Parablennius zvonimiri (Kolombatovic 1892)	A,B,C
Bothidae	*Bothus podas* (Delaroche 1809)	C
Carangidae	*Caranx crysos* (Mitchill 1815)	A
	Lichia amia (Linnaeus 1758)	A
	Naucrates ductor (Linnaeus 1758)	A
	Seriola dumerilii (Risso 1810)	A,B,C
	Trachinotus ovatus (Linnaeus 1758)	A
	Trachurus sp. Rafinesque 1810	A,B,C
	Trachurus mediterraneus (Steindachner 1868)	A,B,C
	Trachurus trachurus (Linnaeus 1758)	C
Centracanthidae	*Centracanthus cirrus* Rafinesque 1810	A,C
	Spicara maena (Linnaeus 1758)	A,B,C
	Spicara smaris (Linnaeus 1758)	A,B,C
Dactylopteridae	*Dactylopterus volitans* (Linnaeus 1758)	C
Dasyatidae	*Dasyatis pastinaca* (Linnaeus 1758)	A
Engraulidae	*Engraulis encrasicholus* (Linnaeus 1758)	C
Gadidae	*Phycis phycis* (Linnaeus 1766)	B,C
Gobiidae	*Gobius* sp. Linnaeus 1758	A,B,C
	Gobius bucchichi Steindachner 1870	A,B,C
	Gobius cobitis Pallas 1811	B,C
	Gobius cruentatus Gmelin 1789	C
	Gobius geniporus Valenciennes 1837	A,B,C
	Gobius auratus Risso 1810	A,B,C
	Gobius niger Linnaeus 1758	A,C
	Gobius paganellus Linnaeus 1758	A,B,C
	Gobius vittatus Vinciguerra 1883	C
	Pomatoschistus sp. Gill 1864	B
	Thorogobius ephippiatus (Lowe 1839)	C
Labridae	*Coris julis* (Linnaeus 1758)	A,B,C
	Labrus merula Linnaeus 1758	A,B,C
	Labrus viridis Linnaeus 1758	A,B,C
	Symphodus cinereus (Bonnaterre 1788)	A,B,C
	Symphodus doderleini Jordan 1891	A,B,C
	Symphodus mediterraneus (Linnaeus 1758)	A,B,C
	Symphodus melanocercus (Risso 1810)	A,B,C
	Symphodus ocellatus Forsskål 1775	A,B,C
	Symphodus roissali (Risso 1810)	A,B,C
	Symphodus rostratus (Bloch 1797)	A,B,C
	Symphodus tinca (Linnaeus 1758)	A,B,C
	Thalassoma pavo Linnaeus 1758	A,B,C

continued on next page

Table 1. Continued.

family	species	Zone
Moronidae	*Dicentrarchus labrax* (Linnaeus 1758)	C
Mugilidae	*Mugilidae indet.*	A,B,C
	Chelon labrosus (Risso 1826)	A,B,C
	Liza aurata (Risso 1810)	A,C
Mullidae	*Mullus barbatus* Linnaeus 1758	C
	Mullus surmuletus Linnaeus 1758	A,B,C
Muraenidae	*Muraena helena* Linnaeus 1758	B,C
Pomacentridae	*Chromis chromis* (Linnaeus 1758)	A,B,C
Pomatomidae	*Pomatomus saltator* (Linnaeus 1766)	B
Scaridae	*Sparisoma cretense* (Linnaeus 1758)	A,B,C
Sciaenidae	*Sciaena umbra* Linnaeus 1758	A,B
Scorpaenidae	*Scorpaena maderensis* Valenciennes 1833	A,B,C
	Scorpaena notata Rafinesque 1810	B,C
	Scorpaena porcus Linnaeus 1758	A,B,C
	Scorpaena scrofa Linnaeus 1758	A,B,C
Serranidae	*Anthias anthias* (Linnaeus 1758)	A,B,C
	Epinephelus costae (Steindachner 1878)	A,B,C
	Epinephelus marginatus (Lowe 1834)	A,B,C
	Serranus cabrilla (Linnaeus 1758)	A,B,C
	Serranus scriba (Linnaeus 1758)	A,B,C
Sparidae	*Boops boops* (Linnaeus 1758)	A,B,C
	Diplodus annularis (Linnaeus 1758)	A,B,C
	Diplodus puntazzo (Cetti 1777)	A,B,C
	Diplodus sargus (Linnaeus 1758)	A,B,C
	Diplodus vulgaris (E. Geoffroy St.-Hilaire 1817)	A,B,C
	Oblada melanura (Linnaeus 1758)	A,B,C
	Pagellus acarne (Risso 1826)	C
	Sarpa salpa (Linnaeus 1758)	A,B,C
	Sparus aurata Linnaeus 1758	C
	Spondyliosoma cantharus (Linnaeus 1758)	A,B,C
Sphyraenidae	*Sphyraena viridensis* (Cuvier 1829)	A,B
Tripterygiidae	*Tripterygion* sp. Risso 1826	A,B,C
	Tripterygion delaisi (Cadenat & Blache 1971)	A,B,C
	Tripterygion melanurus Guichenot 1845	A,B,C
	Tripterygion tripteronotus Risso 1826	A,B,C

Community parameters calculated for the two series of surveys (1994–95 and 1996–97) are shown in Table 2. During the 1994–95 surveys, the mean species number decreased progressively in the Zones A, B and C for the intermediate transect; for the shallow transect it was the highest in Zone C and the lowest in Zone B. A comparison of the mean diversity indices (H′) among the three zones indicated that Zone B had the highest species diversity (except for Punta Spalmatore along the shallow transect). A similar trend was indicated by the mean evenness indices (J′). The community parameters, calculated for each survey, were not significantly associated with zone, site, depth or season.

During 1996–97, the mean species number for each zone was comparable along the same transect depth. However, this parameter increased with transect depth.

Table 2. Community parameters calculated for the two series of surveys. The values (mean ± standard deviation) refer to transects at different depths within the three zones of Ustica Island. S, number of species; H′, Shannon–Weaver diversity index; J′, evenness index; n, number of transects.

survey series	Zone	site	transect	S	H′	J′	n
1994–95	A	Cala Sidoti	shallow	10.8 ± 1.3	1.26 ± 0.25	0.54 ± 0.13	12
			intermediate	13.2 ± 2.3	1.46 ± 0.07	0.57 ± 0.05	15
	B	Cala Madonna	shallow	11.3 ± 2.2	1.50 ± 0.27	0.63 ± 0.15	9
			intermediate	11.0 ± 2.9	1.48 ± 0.43	0.62 ± 0.15	8
		Punta Spalmatore	shallow	9.5 ± 1.3	1.02 ± 0.20	0.45 ± 0.07	9
			intermediate	12.5 ± 1.7	1.57 ± 0.23	0.63 ± 0.11	8
	C	Punta S. Paolo	shallow	13.2 ± 5.4	1.43 ± 0.18	0.57 ± 0.06	13
			intermediate	9.8 ± 1.9	0.82 ± 0.29	0.37 ± 0.16	13
1996–97	A	La Caletta	shallow	13.4 ± 2.3	0.99 ± 0.11	0.39 ± 0.06	10
			intermediate	13.2 ± 1.8	0.85 ± 0.43	0.32 ± 0.15	10
			deep	15.8 ± 2.7	1.39 ± 0.38	0.51 ± 0.15	10
		Cala Sidoti	shallow	11.4 ± 3.5	0.91 ± 0.22	0.38 ± 0.10	10
			intermediate	13.6 ± 3.0	0.93 ± 0.46	0.36 ± 0.17	10
			deep	16.2 ± 2.4	1.55 ± 0.21	0.56 ± 0.08	10
	B	Cala Madonna	shallow	13.0 ± 3.2	1.26 ± 0.30	0.51 ± 0.15	10
			intermediate	13.8 ± 1.9	1.15 ± 0.37	0.44 ± 0.13	10
			deep	14.6 ± 2.3	1.24 ± 0.22	0.46 ± 0.08	10
		Punta Spalmatore	shallow	11.4 ± 1.1	0.98 ± 0.25	0.40 ± 0.09	10
			intermediate	15.4 ± 2.1	1.07 ± 0.43	0.39 ± 0.16	10
			deep	17.0 ± 1.9	1.20 ± 0.28	0.42 ± 0.09	10
	C	Punta S. Paolo	shallow	14.2 ± 2.7	1.31 ± 0.14	0.50 ± 0.04	11
			intermediate	14.2 ± 1.8	0.94 ± 0.27	0.36 ± 0.11	12
			deep	15.8 ± 2.0	1.62 ± 0.13	0.59 ± 0.05	10
		Punta dell'Arpa	shallow	12.3 ± 3.5	1.00 ± 0.04	0.40 ± 0.05	6
			intermediate	15.7 ± 3.2	1.35 ± 0.46	0.49 ± 0.13	6
			deep	17.3 ± 1.5	1.32 ± 0.33	0.46 ± 0.10	6

Differences in H′ among sites had no association with a specific factor. The intermediate transect of each site (except for Punta dell'Arpa) showed the lowest J′ value. The application of discriminant analysis on the community parameters of this survey series provided a highly significant model ($P < 0.0001$), when depth was tested as dependent variable. In contrast, the community parameters were not significantly associated with the other variables (zone, site and season).

Gregarious species such as *Chromis chromis* and some labrids (*i.e.*, *Coris julis*, *Thalassoma pavo*, *Symphodus tinca* and *Symphodus ocellatus*) were the most frequent and abundant in both series of surveys.

Overall we observed juveniles of 10 species and many of these were labrids. During 1994–95, juveniles of six species (*Mullus surmuletus*, *C. julis*, *S. ocellatus*, *S. tinca*, *T. pavo*, *C. chromis*) occurred only in spring and summer; two of these species were censused in Zone A, the remaining species were observed in Zone B.

During the successive surveys (1996–97), juveniles of eight species (*Sarpa salpa*, *Spondyliosoma cantharus*, *Tripterygion delaisi*, *Symphodus rostratus*, *S. ocellatus*,

C. julis, *T. pavo*, *C. chromis*) were observed only in summer; seven of these species were censused in Zone C and only four species each in Zones A and B.

2. Assessment of reserve effect

The abundance of target species within Zones A, B and C during the two survey series are reported in Tables 3 and 4. *Serranus cabrilla*, *Serranus scriba*, *Spondyliosoma cantharus* and *Sarpa salpa* were generally the most abundant species. The dusky grouper (*Epinephelus marginatus*), although recorded in each sample site, was often only represented by a few individuals, particularly in Zones B and C. On the other hand, *S. salpa* in the 1996–97 survey series was more abundant in Zones B and C than in Zone A. Less abundant species were some sparids (*Diplodus puntazzo*, *D. sargus* and *D. vulgaris*) and labrids (*Labrus merula and Labrus viridis*). These labrids were almost exclusively observed in Zones A and B.

The results of the Mann–Whitney U-test, applied on the abundance data, are presented in Table 5. Significant differences among the zones were obtained only for three species (*Mullus surmuletus*, *S. scriba* and *E. marginatus*). In particular, *E. marginatus* and *S. scriba* were always more abundant in the zones with the highest protection.

The frequency of occurrence of target species within the three zones during the two series of surveys are presented in Table 6. The species censused most frequently were *S. cabrilla* and *S. scriba*. Conversely, the three *Diplodus* species occurred in the three zones in a low percentage of censuses.

The statistical comparison indicates that, for both series, the frequencies of occurrence of target species, except for *S. cabrilla*, were higher in the zone with the highest protection (Table 7).

As for the demographic structure of target species (Tables 8 and 9), in 1994–95 very large individuals occurred in Zones A (*L. viridis*, *L. merula* and *S. scriba*) and B (*L. merula*, *S. cabrilla* and *Scorpaena scrofa*). In 1996–97, very large individuals were observed in Zone A (seven species), B (four species) and C (two species). It is noteworthy that for some species of high commercial value (*i.e.*, *L. merula*, *L. viridis*, *D. sargus* and *Oblada melanura*) very large individuals were censused only in Zone A.

In Table 10, the results of the statistical comparison indicate that, for *S. cabrilla*, *S. scriba*, *O. melanura* and *S. cantharus*, the percentage of larger individuals in Zone A was higher than in Zones B and C. Conversely, larger individuals of *S. salpa* and *M. surmuletus* were most frequent in Zones C and B, respectively.

3. Distribution of groupers and sargo breams

Data collected by snorkelling in the shallowest coastal area (0–3 m deep) are reported in Table 11. The dusky grouper (*E. marginatus*) was the most frequent species, mostly in Zones A and B. Conversely, the sightings of the golden grouper (*Epinephelus costae*) were rather sporadic, especially in Zones B and C. The highest total number of individuals was censused, for both grouper species, in Zone A, the

Table 3. Mean abundance (number of individuals per transect ± standard deviation) of target species censused during the 1994–95 surveys within the three zones of Ustica Island. s, shallow transect; i, intermediate transect. Number of transects in parentheses.

	Zone A		Zone B		Zone C	
species	s (12)	i (15)	s (18)	i (16)	s (13)	i (13)
Seriola dumerilii	–	–	–	0.19 ± 0.75	–	–
Labrus merula	–	0.13 ± 0.35	–	0.06 ± 0.25	–	–
Labrus viridis	0.08 ± 0.29	0.27 ± 0.59	0.06 ± 0.24	–	–	–
Mullus surmuletus	0.46 ± 1.12	0.77 ± 1.29	0.17 ± 0.38	0.31 ± 0.60	1.15 ± 1.26	–
Scorpena scrofa	0.08 ± 0.29	–	0.06 ± 0.24	–	–	–
Epinephelus marginatus	0.33 ± 0.65	0.13 ± 0.35	0.06 ± 0.24	0.06 ± 0.25	0.08 ± 0.28	–
Serranus cabrilla	0.08 ± 0.29	0.60 ± 0.83	0.69 ± 0.99	0.44 ± 0.81	0.38 ± 0.65	0.62 ± 0.87
Serranus scriba	1.58 ± 1.31	2.47 ± 1.3	1.22 ± 1.11	3.38 ± 1.90	0.54 ± 0.66	1.77 ± 1.09
Diplodus vulgaris	–	–	–	–	0.08 ± 0.28	–
Oblada melanura	4.08 ± 8.85	0.97 ± 1.75	2.31 ± 4.06	0.72 ± 2.13	0.62 ± 1.52	–
Sarpa salpa	–	1.70 ± 5.16	–	0.50 ± 2.00	0.08 ± 0.28	0.08 ± 0.28
Spondyliosoma cantharus	–	0.13 ± 0.35	0.11 ± 0.47	0.13 ± 0.50	0.31 ± 0.63	0.38 ± 0.96

Table 4. Mean abundance (number of individuals per transect ± standard deviation) of target species censused during the 1996–97 surveys within the three zones of Ustica Island. s, shallow transect; i, intermediate transect; d, deep transect. Number of transects in parentheses

	Zone A			Zone B			Zone C		
species	s (20)	i (20)	d (20)	s (20)	i (20)	d (20)	s (17)	i (18)	d (16)
Seriola dumerilii	0.25 ± 1.12	0.15 ± 0.67	–	–	0.28 ± 0.88	–	–	–	–
Labrus merula	0.05 ± 0.22	0.30 ± 0.66	0.25 ± 0.44	0.10 ± 0.31	0.10 ± 0.31	0.05 ± 0.22	0.06 ± 0.24	–	–
Labrus viridis	0.15 ± 0.37	0.15 ± 0.37	0.10 ± 0.31	0.10 ± 0.31	0.05 ± 0.22	–	0.12 ± 0.33	–	–
Mullus surmuletus	0.15 ± 0.49	0.05 ± 0.22	0.60 ± 0.75	0.20 ± 0.70	0.45 ± 0.60	0.45 ± 0.60	0.41 ± 0.94	0.56 ± 1.10	0.63 ± 0.81
Scorpaena scrofa	–	–	–	–	–	–	0.06 ± 0.24	–	–
Epinephelus costae	–	–	0.05 ± 0.22	0.05 ± 0.22	–	0.05 ± 0.22	–	–	–
Epinephelus marginatus	0.90 ± 1.02	0.80 ± 1.01	0.30 ± 0.66	0.30 ± 0.47	0.25 ± 0.44	0.35 ± 0.93	0.06 ± 0.24	–	0.06 ± 0.25
Serranus cabrilla	0.70 ± 1.03	1.00 ± 1.26	4.15 ± 2.68	0.65 ± 0.93	0.50 ± 0.83	3.20 ± 1.74	1.41 ± 1.28	1.67 ± 1.94	3.19 ± 1.97
Serranus scriba	2.10 ± 1.65	4.98 ± 4.13	0.95 ± 1.05	1.73 ± 1.46	3.35 ± 1.60	1.45 ± 1.32	1.18 ± 1.29	3.11 ± 1.67	0.81 ± 0.75
Diplodus puntazzo	–	–	0.10 ± 0.45	–	–	–	–	–	–
Diplodus sargus	0.40 ± 1.08	–	0.05 ± 0.22	–	–	–	0.06 ± 0.24	–	–
Diplodus vulgaris	0.05 ± 0.22	–	–	0.10 ± 0.31	–	–	0.12 ± 0.49	0.06 ± 0.24	–
Oblada melanura	4.05 ± 8.53	0.90 ± 2.77	0.05 ± 0.22	5.00 ± 10.85	4.38 ± 10.50	–	2.09 ± 6.19	5.50 ± 18.20	2.50 ± 10.00
Sarpa salpa	5.73 ± 11.00	0.75 ± 2.31	0.10 ± 0.31	8.18 ± 18.87	0.80 ± 3.14	17.75 ± 67.44	3.18 ± 5.99	16.56 ± 59.09	12.38 ± 31.50
Spondyliosoma cantharus	0.35 ± 0.75	1.03 ± 1.78	0.75 ± 2.02	0.35 ± 0.81	0.35 ± 0.67	1.70 ± 2.81	0.35 ± 1.06	2.03 ± 3.12	2.66±4.78

Table 5. Results of the Mann–Whitney U-test for the difference in the abundance of target species among the three zones of Ustica Island during the two series of surveys.

surveys	species	transect	Zones	difference
1994–95	*Mullus surmuletus*	shallow	C > B	*
	Serranus scriba	shallow	A > C	*
	Serranus scriba	intermediate	B > C	*
1996–97	*Epinephelus marginatus*	shallow	A > C	**
	Epinephelus marginatus	intermediate	A > C	**

*P < 0.05; **P < 0.01.

Table 6. Frequency of occurrence of target species censused during the two series of surveys within the three zones of Ustica Island. Number of transects in parentheses.

	1994–95			1996–97		
species	Zone A (27)	Zone B (34)	Zone C (26)	Zone A (60)	Zone B (60)	Zone C (51)
Seriola dumerilii	–	2.94	–	3.33	3.33	–
Labrus merula	7.41	2.94	–	16.67	8.33	1.96
Labrus viridis	14.81	2.94	–	13.33	5.00	3.92
Mullus surmuletus	29.63	20.59	30.77	20.00	30.00	31.37
Scorpena scrofa	3.70	2.94	–	–	–	1.96
Epinephelus costae	–	–	–	1.67	3.33	–
Epinephelus marginatus	18.52	5.88	3.85	41.67	25.00	3.92
Serranus cabrilla	25.93	35.29	34.62	63.33	56.67	76.47
Serranus scriba	88.89	82.35	65.38	80.00	80.00	76.47
Diplodus puntazzo	–	–	–	1.67	–	–
Diplodus sargus	–	–	–	6.67	–	1.96
Diplodus vulgaris	–	–	3.85	1.67	3.33	3.92
Oblada melanura	33.33	26.47	7.69	16.67	21.67	21.57
Sarpa salpa	11.11	2.94	7.69	18.33	20.00	29.41
Spondyliosoma cantharus	7.41	5.88	19.23	30.00	33.33	35.29

Table 7. Results of the 'difference between two percentages test' for the difference in the frequency of occurrence of target species among the three zones of Ustica Island during the two series of surveys.

surveys	species	Zones	difference
1994–95	*Labrus viridis*	A > C	*
	Serranus scriba	A > C	*
	Oblada melanura	A > C	*
1996–97	*Labrus merula*	A > C	**
	Epinephelus marginatus	A > C	***
	Epinephelus marginatus	B > C	**
	Serranus cabrilla	C > B	*
	Diplodus sargus	A > B	*

*P < 0.05; **P < 0.01; ***P < 0.001

Table 8. Size class distribution (expressed as percentage) of target species censused during the 1994–95 surveys within the three zones of Ustica Island. Size classes: j, juvenile; s, small; m, medium; l, large; vl, very large. Number of transects in parentheses.

	Zone A (27)					Zone B (34)					Zone C (26)				
species	j	s	m	l	vl	j	s	m	l	vl	j	s	m	l	vl
Seriola dumerilii	–	–	–	–	–	–	–	100.0	–	–	–	–	–	–	–
Labrus merula	–	–	–	50.0	50.0	–	–	–	–	100.0	–	–	–	–	–
Labrus viridis	–	–	40.0	–	60.0	–	–	100.0	–	–	–	–	–	–	–
Mullus surmuletus	–	11.8	76.4	11.8	–	12.5	–	25.0	62.5	–	–	31.2	46.9	21.9	–
Scorpaena scrofa	–	–	100.0	–	–	–	–	–	–	100.0	–	–	–	–	–
Epinephelus marginatus	–	50.0	33.3	16.6	–	–	100.0	–	–	–	–	100.0	–	–	–
Serranus cabrilla	–	–	60.0	40.0	–	–	5.1	53.9	35.9	5.1	–	20.0	40.0	40.0	–
Serranus scriba	–	1.8	33.9	53.6	10.7	–	1.3	42.8	55.9	–	–	16.1	48.4	35.5	–
Diplodus vulgaris	–	–	–	–	–	–	–	–	–	–	–	–	100.0	–	–
Oblada melanura	–	86.6	13.4	–	–	–	78.3	21.7	–	–	–	100.0	–	–	–
Sarpa salpa	–	92.2	7.8	–	–	–	–	100.0	–	–	–	–	100.0	–	–
Spondyliosoma cantharus	–	50.0	50.0	–	–	–	25.0	75.0	–	–	–	44.4	55.6	–	–

Table 9. Size class distribution (expressed as percentage) of target species censused during the 1996–97 surveys within the three zones of Ustica Island. Size classes: j, juvenile; s, small; m, medium; l, large; vl, very large. Number of transects in parentheses.

	Zone A (60)					Zone B (60)					Zone C (51)				
species	j	s	m	l	vl	j	s	m	l	vl	j	s	m	l	vl
Seriola dumerilii	–	100.0	–	–	–	–	36.4	63.6	–	–	–	–	–	–	–
Labrus merula	–	–	–	16.7	83.3	–	–	20.0	80.0	–	–	100.0	–	–	–
Labrus viridis	–	37.5	37.5	12.5	12.5	–	33.4	33.3	33.3	–	–	100.0	–	–	–
Mullus surmuletus	–	–	62.5	37.5	–	–	4.6	72.7	9.1	13.6	–	22.2	51.9	25.9	–
Scorpaena scrofa	–	–	–	–	–	–	–	–	–	–	–	–	100.0	–	–
Epinephelus costae	–	–	100.0	–	–	–	50.0	50.0	–	–	–	–	–	–	–
Epinephelus marginatus	–	37.5	50.0	12.5	–	–	50.0	38.9	11.1	–	–	50.0	50.0	–	–
Serranus cabrilla	–	9.4	29.5	46.6	14.5	–	12.6	59.8	24.1	3.5	–	19.0	56.2	24.8	–
Serranus scriba	–	–	25.9	66.0	8.1	–	0.8	46.7	44.8	7.7	–	5.6	41.0	45.5	7.9
Diplodus puntazzo	–	–	100.0	–	–	–	–	–	–	–	–	–	–	–	–
Diplodus sargus	–	–	–	22.2	77.8	–	–	–	–	–	–	–	100.0	–	–
Diplodus vulgaris	–	100.0	–	–	–	–	50.0	50.0	–	–	–	33.3	66.7	–	–
Oblada melanura	–	10.5	58.5	3.0	28.0	–	39.5	55.2	5.3	–	–	–	71.6	28.4	–
Sarpa salpa	–	–	51.7	36.1	12.2	–	–	43.0	41.3	15.7	1.1	0.2	17.6	77.5	3.6
Spondyliosoma cantharus	–	42.3	35.5	21.2	–	–	68.7	29.2	2.1	–	2.3	47.1	44.1	6.5	–

Table 10. Results of the 'difference between two percentages test' for the difference in the percentage of larger individuals (large and very large size classes) of target species among the three zones of Ustica Island during the two series of surveys.

surveys	species	Zones	difference
1994–95	*Mullus surmuletus*	B > A	**
	Serranus scriba	A > C	*
1996–97	*Serranus cabrilla*	A > B	***
	Serranus cabrilla	A > C	***
	Serranus scriba	A > B	***
	Serranus scriba	A > C	***
	Oblada melanura	A > B	***
	Oblada melanura	A > C	***
	Oblada melanura	B > C	***
	Sarpa salpa	C > A	***
	Sarpa salpa	C > B	***
	Spondyliosoma cantharus	A > B	**
	Spondyliosoma cantharus	A > C	*

*P < 0.05; **P < 0.005; ***P < 0.001

Table 11. Overall data on groupers and sargo breams collected in the tracts performed by snorkelling (0–3 m depth) within the three zones of Ustica Island from September 1995 to September 1997.

species	Zone	tracts n	individuals total n	frequency of occurrence	individuals mean n ± SD
Epinephelus costae	A	52	12	15.4	0.23 ± 0.58
	B	72	2	2.8	0.03 ± 0.16
	C	56	5	8.9	0.09 ± 0.29
Epinephelus marginatus	A	52	129	73.1	2.48 ± 2.57
	B	72	111	69.4	1.54 ± 1.61
	C	56	49	51.8	0.87 ± 1.06
Diplodus puntazzo	A	52	6	11.5	0.11 ± 0.32
	B	72	1	1.4	0.01 ± 0.12
	C	56	14	3.6	0.25 ± 1.74
Diplodus sargus	A	52	29	26.9	0.56 ± 1.14
	B	72	32	25.0	0.44 ± 0.87
	C	56	105	12.5	1.87 ± 6.31
Diplodus vulgaris	A	52	3	5.8	0.06 ± 0.23
	B	72	17	20.8	0.24 ± 0.49
	C	56	502	30.4	8.964 ± 48.31

lowest in Zone B (*E. costae*) or C (*E. marginatus*). This trend was also observed for frequency of occurrence and mean number of individuals.

Regarding the three *Diplodus* species, the highest (total or mean) number of

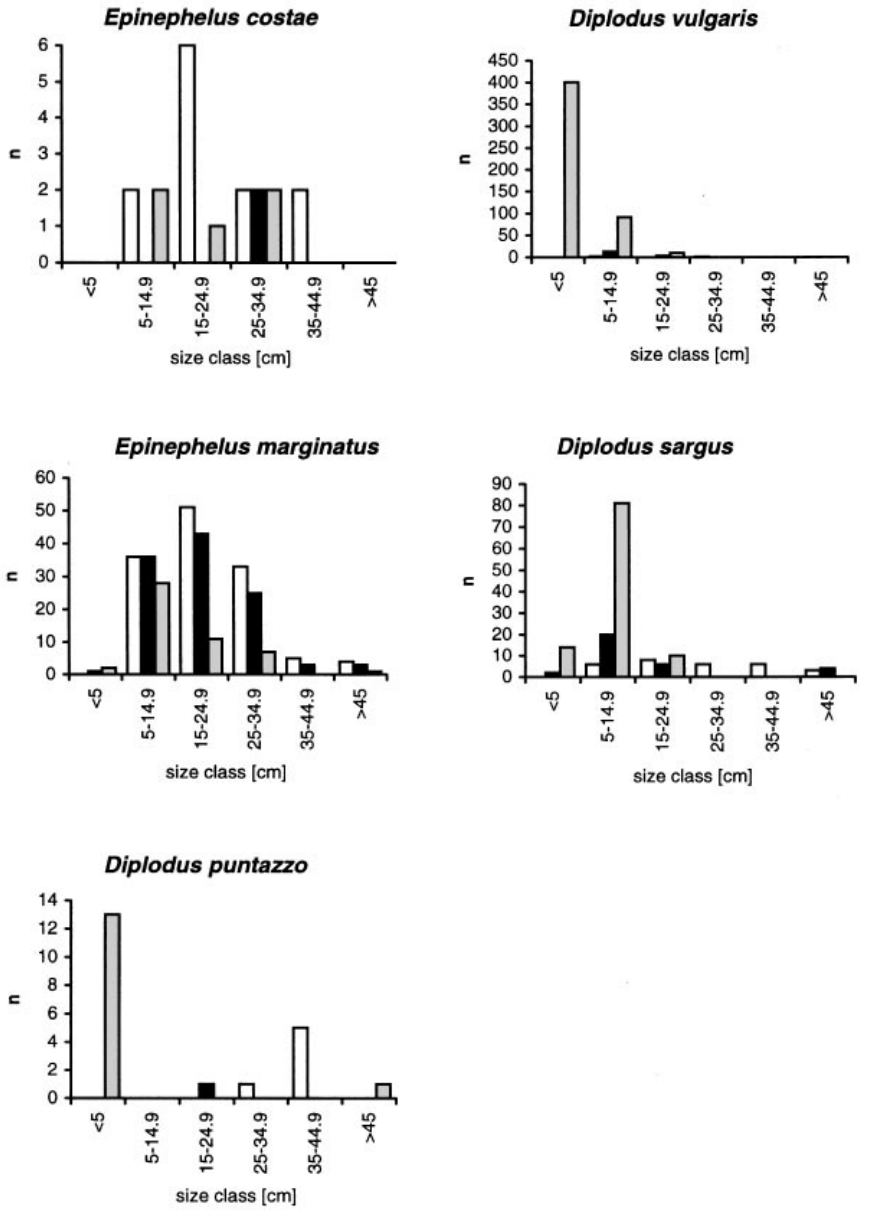

Fig. 2. Size class distributions (expressed as number of individuals) of groupers and sargo breams censused in the tracts performed by snorkelling (0–3 m depth) within the three zones of Ustica Island from September 1995 to September 1997. □ Zone A; ■ Zone B; ▩ Zone C.

individuals occurred in Zone C, followed by Zone B (*D. sargus* and *D. vulgaris*) or A (*D. puntazzo*). *Diplodus vulgaris* was sampled most frequently in Zone C, *D. puntazzo* and *D. sargus* in Zone A.

Note that the high number of individuals of the three *Diplodus* spp. in Zone C

is mostly due to the many juveniles or small individuals censused in this zone during the 1996–97 surveys.

The size distribution of groupers and sargo bream within the three zones is reported in Fig. 2. At each zone, *E. marginatus* showed the broadest size composition. In addition, the number of the largest individuals (> 15 cm SL) increased with higher levels of protection. The size distribution of *D. puntazzo*, *D. sargus* and *D. vulgaris* was narrower and, in Zone C, limited to the smallest size classes. The largest individuals (> 25 cm SL) occurred almost exclusively in Zone A.

Finally, it is interesting to mention the presence, during the survey of June 1994, of some juveniles (from 1.5 cm to 2.5 cm TL) of *D. sargus* within a tide pool at Cala Sidoti.

Discussion

The present study provided extensive information on the coastal fish assemblage of Ustica Island, at least within the bathymetric range examined.

In general, some features of the fish community of Ustica Island's Marine Reserve, such as the taxonomic composition, the presence both of numerically dominant species (*e.g.*, *C. julis*, *T. pavo*, *S. tinca*) and vulnerable species (*e.g.*, *D. puntazzo*, *D. sargus*, *D. vulgaris*, *L. merula*, *L. viridis*), are also found in other protected areas in the NW Mediterranean Sea (Bell, 1983; Harmelin, 1987; Garcia-Rubies & Zabala, 1990; Harmelin *et al.*, 1995).

The fish assemblage of Ustica Island does, however, have some peculiarities. The presence of certain thermophilic species such as *Balistes carolinensis*, *Caranx crysos*, *Centracanthus cirrus*, *E. costae*, *Sparisoma cretense* and *Scorpaena maderensis* is biogeographically relevant (Riera *et al.*, 1995). The sighting of *Gobius vittatus* is also noteworthy due to its rarity in the Mediterranean Sea (Tortonese, 1975; Escoubet & Murgia, 1981).

As previously reported in the Aeolian Islands (Vacchi *et al.*, 1997), *C. julis* and *T. pavo* showed a different bathymetric distribution, the latter being more abundant in shallow water.

Our censuses also revealed a high abundance of the dusky grouper (*E. marginatus*) in the coastal area and, conversely, a low frequency of the three sargo bream species (*D. puntazzo*, *D. sargus* and *D. vulgaris*). The paucity of sargo breams can be related to the scarcity of hydrodynamically sheltered areas suitable for recruitment along the Ustica coast (Harmelin-Vivien *et al.*, 1995). The harbour inlet is the only such site; indeed, many juvenile *D. sargus* and *D. vulgaris* were observed here during 1996–97. Moreover, the observation of juvenile *D. sargus* within a tide pool deserves further investigation in order to test the effectiveness of this environment as a recruitment site.

The fish assemblage within zones of different protection levels is consistent with regard to species composition and community parameters. The highest total number of species in Zone C (versus Zones A and B) is probably because a larger variety of habitats (*e.g.*, with respect to depth range) was investigated in the explored tracts of this zone. In fact, the mean number of species sampled in the three zones showed no substantial differences if only transect data were considered.

As suggested by discriminant analysis, the community patterns are indeed influenced by the habitat features, such as depth, rather than the protection level.

In the marine protected areas, the chief benefits of protection involve vulnerable species subjected to heavy fishing. For these target species, the reserve effect influences both quantitative (*e.g.*, increase of abundance and of average and maximum individual size) and behavioural aspects (*e.g.*, changes of spatial distribution) (Harmelin *et al.*, 1995). In our study, this situation has been observed for some target species when their abundance, frequency of occurrence and size distribution within the three zones of Ustica Island were compared.

In the integral and general reserve zones (Zones A and B), the above-mentioned benefits become even more evident for the target species affected by spearfishing, such as *L. merula*, *L. viridis* and *E. marginatus*.

Censuses performed by snorkelling in the shallowest coastal area of Ustica confirm that the frequency of occurrence and individual size of dusky groupers are positively correlated with protection level. The individual sizes were also larger of *D. puntazzo* and *D. sargus* within the most protected zones.

The conspicuous frequency of *E. marginatus* in the very shallow bottoms of zone A emphasises a behavioural change in terms of spatial distribution; this pertains to the recovery of original habitats in the absence of anthropogenic disturbance.

Summary

Seasonal surveys, carried out between 1994 and 1997 in the marine reserve of Ustica, improved our knowledge of fish assemblages of this island. Qualitative and quantitative data on fish populations in the three Zones (A, B and C) with different levels of protection were collected using the visual census method.

On the whole, 82 teleosts and one elasmobranch, belonging to 27 fish families, were censused. Labridae and Sparidae, with 12 and 10 species, respectively, are the dominant families. The presence of uncommon species (such as *Gobius vittatus*), as well as of biogeographically relevant species (*i.e.*, *Balistes carolinensis*, *Caranx crysos*, *Centracanthus cirrus* and *Sparisoma cretense*), is among the faunistic peculiarities of Ustica Island.

For some vulnerable species, abundance and frequency of occurrence are positively correlated with protection level. The reserve effect is also evident in the increase of average and maximum individual size with the degree of protection.

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