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THE MARANO AND GRADO LAGOON: A BRIEF SYNOPSIS ON THE AQUATIC FAUNA AND FISHERIES RESOURCES

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ABSTRACT

*The Marano and Grado Lagoon is one of the best preserved wetlands in the whole Mediterranean area. In spite of the presence of chemical pollutants, especially mercury, no clear criticism of the ecological status for macrozoobenthos and fish fauna was found. The distribution of macrozoobenthos species shows a clear relationship with the salinity gradient, due to both the renewal time of seawater and the freshwater inputs from the inland. The Lagoon constitutes an important habitat for fish fauna, particularly for the sensitive species, and a nursery ground for juveniles of marine migrants especially in the inner area of Marano basin. After 25 years from the introduction of Manila clam (*Venerupis philippinarum*), the pathway toward its sustainable aquaculture seems now possible.*

Key words: Marano and Grado Lagoon, northern Adriatic Sea, fish fauna, macrozoobenthos, fisheries resources

LAGUNA DI MARANO E GRADO: BREVE SINOSSI SULLA FAUNA ACQUATICA E LE RISORSE ITTICHE

SINTESI

*La Laguna di Marano e Grado è una delle zone umide meglio conservate di tutto il Mediterraneo. Nonostante la presenza di sostanze chimiche inquinanti, in particolare di mercurio, non sono state rilevate criticità evidenti in merito allo stato ecologico del macrozoobenthos e della fauna ittica. La distribuzione dei popolamenti macrozoobentonici dimostra una chiara relazione con il gradiente di salinità, dovuto ai tempi di ricambio con le acque marine e agli apporti di acque dolci di origine continentale. La laguna costituisce un importante habitat per la fauna ittica, in particolare per le specie considerate sensibili, nonché rappresenta un'area di nursery per il novellame delle specie marino migratorie, specialmente nella zona più interna del bacino di Marano. Dopo 25 anni dall'introduzione della vongola filippina (*Venerupis philippinarum*), il percorso verso la sua acquacoltura sostenibile sembra finalmente possibile.*

Parole chiave: Laguna di Marano e Grado, Alto Adriatico, fauna ittica, macrozoobenthos, risorse ittiche.

INTRODUCTION

The Marano and Grado Lagoon (hereafter referred as Lagoon) is one of the best preserved wetlands in the whole Mediterranean area. It is a shallow system, extending for approximately 32 km reaching up to 5 km of width for a total area of 160 km^2, located between the Tagliamento and Isonzo River deltas. The Lagoon is separated from the Adriatic Sea by six barrier islands (1.6 to 6 km long, for a total length of 20 km; 12 km wide) (Fontolan *et al.,* 2012). A central 8 m deep canal (Porto Buso), employed for navigation and commercial shipping separates the Marano basin (western part) from the Grado basin (eastern part). The whole basin is affected by semi-diurnal tidal fluxes (65 cm and 105 cm mean and spring tidal range, respectively) (Covelli *et al.,* 2008) and, on the basis of its salinity, by applying the Water Framework Directive (Directive 2000/60/EC), three main water types were identified (Fig. 1): mesohaline TME (salinity 5–20), polyhaline TPO (salinity 20–30) and euhaline TEU (salinity 30–40) (Bettoso *et al*., 2010).

The drainage basin of the Lagoon covers an area of about 1,880 km^2 and delivers important loads of both nutrients and pollutants. The main freshwater inputs are: the spring rivers (Stella, Turgnano, Zellina, Ausa-Corno, Natissa and Tiel) and the River Cormor, featuring a mountain watershed and the 30 drainage pumps of the low Friulian plain. In 2009 the Autorità di Bacino Regionale (ABR-FVG) calculated the mean discharge of the rivers alone as 81.5 m^3 s^{-1}, of which the main contributors are the Stella River (36.1 m^3 s^{-1}) and the Cormor River (10.7 m^3 s^{-1}). There are no data available regarding sediment load (Fontolan *et al.,* 2012). The Stella River is particularly important for its estuarine habitats. The main source of particulate matter comes from the sea, through the Tagliamento and Isonzo River deltas, and from the erosion of the barrier islands. The dispersion of sediments into the lagoon is mainly controlled by tidal fluxes through tidal inlets (Fontolan *et al.,* 2012).

The Lagoon is protected by the Ramsar Convention since 1971 (Convention on Wetlands of International Importance especially as Waterfowl Habitat, 1971). Following the implementation of the Habitats Directive (Council Directive 92/43/EEC), which concerns the protection of biodiversity, the Lagoon was included in the "Natura 2000" ecological network of protected are-

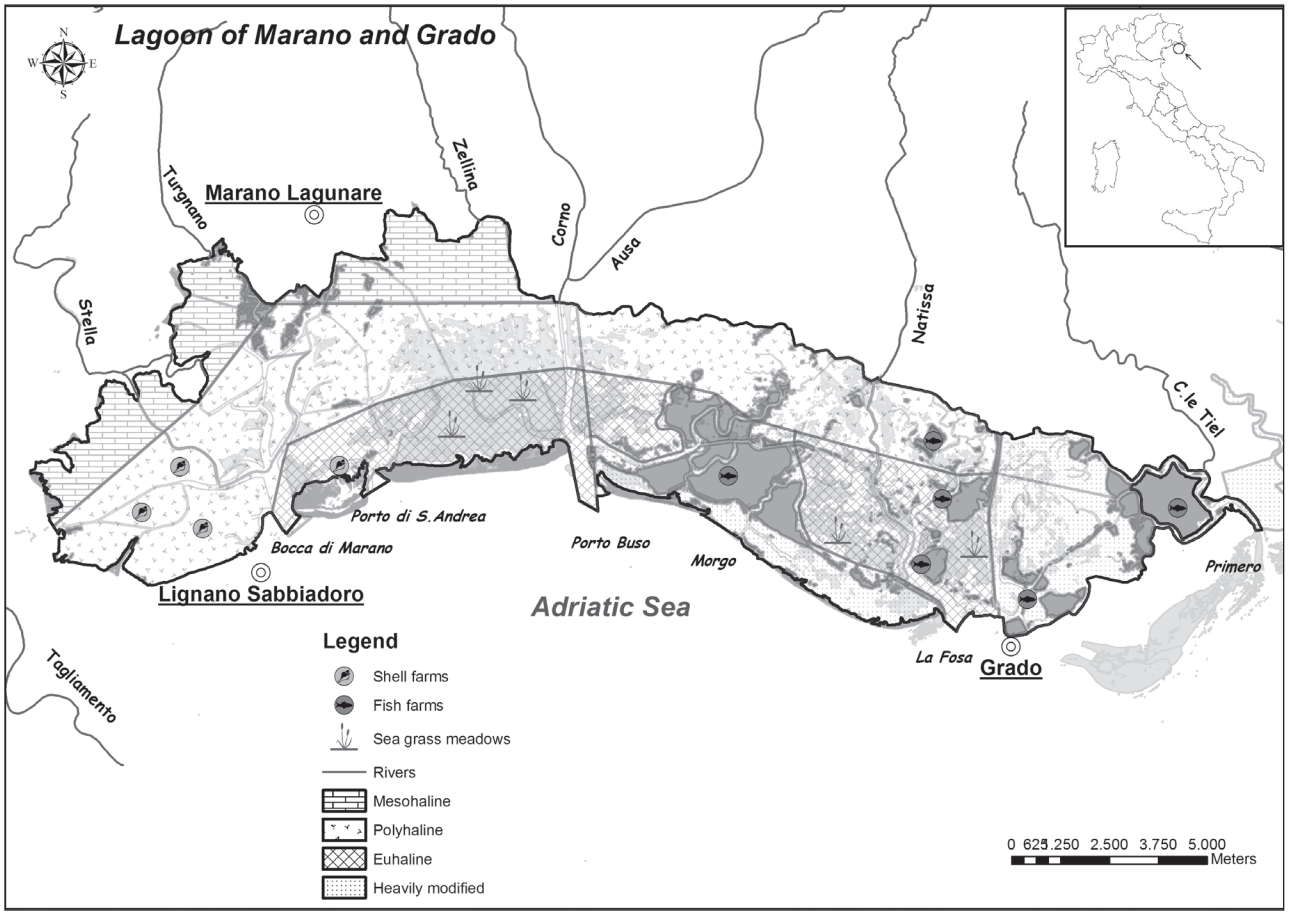

Fig. 1: The Marano and Grado Lagoon and water types according to the Directive 2000/60/EC.
Sl. 1: Maranska in Gradeška laguna in vodne tipologije v skladu z Direktivo 2000/60/ES

as (SCIs – IT3320037). The whole area hosts economic, tourism and industrial services, with fishing, clam harvesting (mainly *Venerupis philippinarum*) and fish-farming comprising the most important resources for today's local inhabitants (Fig. 1).

On the other hand, this system has a high degree of vulnerability due to the surrounding level of urbanisation and industry. In detail, the Lagoon experienced some remarkable environmental impacts which have affected the high natural value of the ecosystem and consequently influenced relevant socio-economic aspects (Covelli, 2012). At Porto Nogaro, located about 1 km north of the Ausa-Corno River mouth, several productive settlements are still present (*i.e.*, beer production, wood and plastics processing, magnesium, iron and steel production and wreckage). In addition, one of the main concern is related to the Torviscosa industrial site where processing of several chemical compounds, such as cellulose, chlor-alkali and textile artificial fibres were active since the 40-50's and are still in production (RAFVG, 1991; Caffaroindustrie, 2013). These factories, which are located inland, are responsible for contamination of soils and groundwaters especially with mercury (Hg), whereas the occurrence of other contaminants such as heavy metals (cadmium, zinc, arsenic, lead and copper), polychlorinated dibenzodioxins (PCDDs), furans (PCDFs) and polycyclic aromatic hydrocarbons (PAHs), is closely related to the location of the different chemical productions that took place in the industrial site (Menchini *et al*., 2009). Moreover, about 220,000 m^3 of wastes (fly ashes, pyrite ashes, toluene and benzoic pitch, barks, etc.) are located in the nearby areas. Due to this, in order to protect and manage, the Lagoon has been declared a "polluted site of national interest" because of its high level of sanitary and environmental risk (Ramieri *et al*., 2011).

Due to the presence of these chemical pollutants the aim of this paper is to show the main features of macrozoobenthos, fish fauna and fisheries resources in the Lagoon of Marano and Grado on the basis of basic literature and current monitoring programmes within the WFD 2000/60/CE application.

MATERIAL AND METHODS

The ecological status of the macrozoobenthic communities was assessed by Bettoso *et al*. (2010) according with the application of the Water Framework Directive (WFD 2000/60/CE). Benthic samples were collected by a 0.047 m^2 van Veen grab in May 2008 and the main features of the macrozoobenthos outlined by Bettoso *et al*. (2010) are reported.

A three years monitoring program (2010-2012) of fish fauna was carried out on 33 sampling stations with the aid of local fishermen by means of fyke nets. This represents a traditional and ancient fisheries method which is spread along the northern Adriatic lagoons. The fyke net consists of a barrier (about 60 m in length and 1.3 m in height) with a 0.7 cm mesh size, which leads the fish and the shrimps towards four cone shaped, unbaited traps, of the same mesh size. This kind of fishing gear takes advantage from the tidal dynamics in order to catch fish and shrimps, and the barriers are set sideways on the tide currents (Malavasi *et al*., 2004). All samples were collected after 24 hours from the setting of the fyke nets. The fish taxa were classified at a species level and the abundance was measured by counting the individuals caught in the trap end.

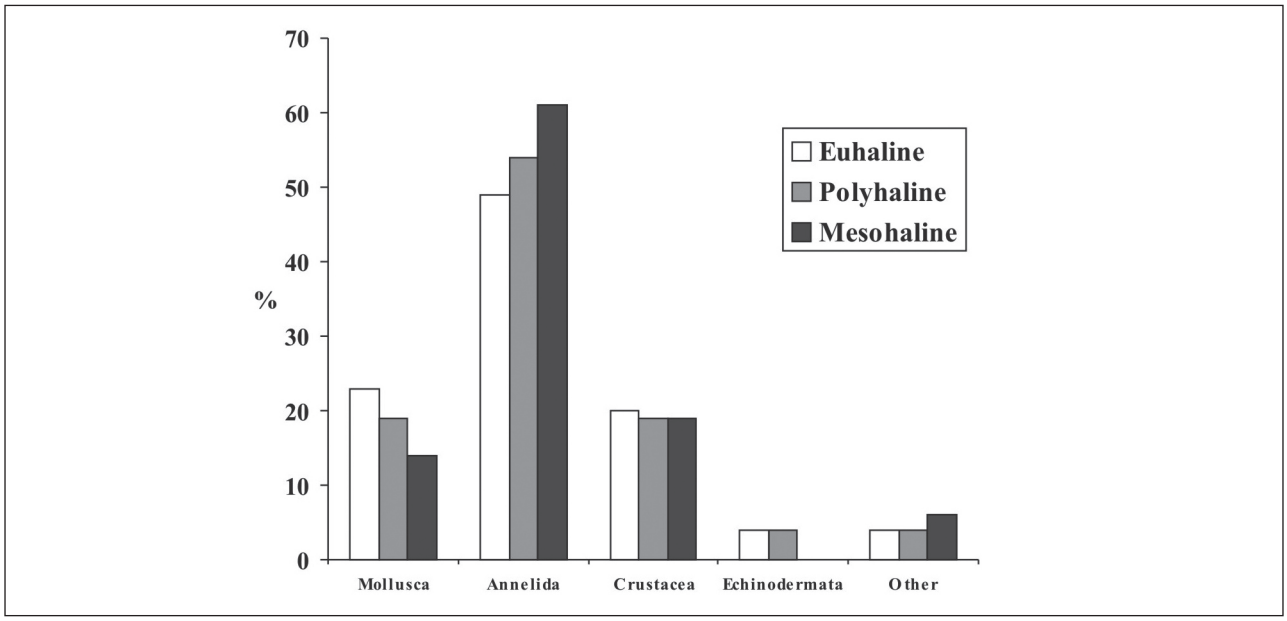

Fig. 2: Percentage subdivision of main taxa for euhaline, polyhaline and mesohaline water types.
Sl. 2: Porazdelitev glavnih taksonov (v odstotkih) za vodne tipologije: evhalina, polihalina in mezohalina

Tab. 1: Fish species recorded during the three years monitoring and related Estuarine Use Functional Group (EUFG) according to Franco** et al. **(2008): (ES) estuarine species, (MM) marine migrants, (MS) marine stragglers, (F) freshwater species, (A) anadromous species, (C) catadromous species. (*) indicates juvenile specimens
Tab. 1: Ribje vrste, zabeležene v treh letih programa spremljanja stanja, in z njimi povezane ekološke funkcionalne estuarijske skupine (EUFG) v skladu s Franco** et al. **(2008): (ES) stalne estuarijske vrste, (MM) morske selivke, (MS) občasne morske selivke, (F) sladkovodne vrste, (A) anadromne vrste, (C) katadromne vrste. (*) označuje juvenilne osebke

EUFG	Species
A	*Alosa fallax**
C	*Anguilla anguilla*
ES	*Aphanius fasciatus*
ES	*Atherina boyeri*
MM	*Belone belone*
MS	*Boops boops**
MS	*Conger conger**
F	*Cyprinus carpio**
ES	*Diplecogaster bimaculatus*
MM	*Diplodus annularis**
MM	*Engraulis encrasicholus**
ES	*Gambusia affinis*
F	*Gasterosteus aculeatus*
ES	*Gobius niger*
ES	*Gobius paganellus*
ES	*Hippocampus guttulatus*
ES	*Hippocampus hippocampus*
ES	*Knipowitschia panizzae*
MM	*Liza aurata**
C	*Liza ramada**
C, ES, MM	*Mugil cephalus**
MM, MS	*Mullus surmuletus**
MS	*Pagellus acarne**
MS	*Parablennius sanguinolentus*
MM	*Platichthys flesus**
MS	*Pomatomus saltatrix**
ES	*Pomatoschistus canestrinii*
ES	*Pomatoschistus marmoratus*
MM	*Pomatoschistus minutus*
F	*Pseudorasbora parva*
F	*Rutilus aula*
ES	*Salaria pavo*
MM	*Sardina pilchardus**
MM	*Solea solea**
MM	*Sparus aurata**
MS	*Sphyraena sphyraena**
MS	*Symphodus cinereus*
MM	*Syngnathus acus*
ES	*Syngnathus typhle*
MS	*Trachurus mediterraneus**
ES	*Zosterisessor ophiocephalus*

On regard of the fisheries resources in the Lagoon, a 10 years dataset of total catches (2000-2010) collected by fish market of Marano Lagunare and Grado cities was considered. Percentage abundance of the main resources were considered for each fisheries port, whereas in order to describe the aquaculture Lagoon status the basic literature from Sladonja *et al*. (2011) and Zentilin (2008) were considered.

RESULTS AND DISCUSSION

Macrozoobenthos

During 2008, on the basis of water types' surface and potential gradient of confinement from sea inlets to inner areas, 42 sampling sites were selected for the macrozoobenthos monitoring.

163 taxa were identified, of which 142 were determined to species level. Polychaetes were, by far, the dominant group in each water type, followed by molluscs, crustaceans, echinoderms and other taxa. The mesohaline Lagoon sites were characterized by the disappearance of echinoderms (Fig. 2). Taking into consideration the number of taxa, Shannon-Wiener and Margalef indexes, a clear decreasing gradient from euhaline to mesohaline basins was significant, whereas abundance did not show any gradient. Three characteristics species of paralic environments (*sensu* Guélorget & Perthuisot, 1992) and euryhaline and eurythermal biocenosis (LEE) (*sensu* Pérès & Picard, 1964) were found in most of the sampling sites: the bivalve *Abra segmentum*, the nereid polychaet *Hediste diversicolor* and the spionid polychaet *Streblospio shrubsolii*. These species represented at least 60% of the relative abundance in the inner zones, where typical marine species cannot survive, with the exception of those which are able to tolerate wide amplitude of chemical and physical parameters, such as polychaetes belonging to Capitellidae and Spionidae families (for further details see Bettoso *et al*., 2010).

Thus, it can be stated that salinity represents one of the main driving force influencing the distribution of benthic organisms in the Lagoon. By applying the cluster analysis, performed by Primer software package, three different areas as a function of closeness to inlets and freshwater inputs were defined (for further details see Bettoso *et al*., 2010). In more detail, the sites close to the inlets could represent a lagoon community with marine characteristics, whereas stations nearby the inner areas as a strictly paralic community and, finally, stations showing a combination of marine and paralic properties as a mixed community. These communities could correspond to the zones II, III and IV-V defined by Guélorget & Perthuisot's benthic zonation (Guélorget & Perthuisot, 1982, 1983, 1992). Marine group resembles the zone II, as a corresponding entrance into lagoon domain with the presence of most tolerant marine species belonging to fine well sorted sands (SFBC) biocenosis and fine superficial sands

(SFS) biocenosis. Mixed group was similar to zone III with a remarkable scarcity or even disappearance of echinoderms. Vatova (1963, 1965) noticed that the holothuroid *Trachythyone elongata* is the only one able to withstand sudden salinity changes. Finally, the paralic group resembled zone IV, because of the total disappearance of most tolerant marine species, such as echinoderms, and an absolute dominance of strictly paralic species such as *A. segmentum*, *Cerastoderma glaucum* and *H. diversicolor*. In some limited areas paralic group resembled also to zone V because of the presence of chironomids larvae (Bettoso *et al*., 2010).

Fish fauna

41 fish species were recorded (Tab. 1). The mesohaline Lagoon showed the highest number of species. This was due to the concomitant presence of the typical estuarine, freshwater and juveniles of marine migrant species, such as *Engraulis encrasicolus*, *Sardina pilchardus*, *Solea solea*, *Sparus aurata* and *Platichthys flesus*. Moreover, in this area were normally found some important protected species listed in the Habitats Directive, such as *Pomatoschistus canestrinii*, *Knipowitschia panizzae* and *Aphanius fasciatus* (Fig. 3). In particular, *P. canestrinii* was almost exclusive of the most confined area of Marano's basin, where salinity ranges between 5 to 20 and the sedimentary habitat is without vegetation, as observed by Gandolfi *et al*. (1982) and Franco *et al*. (2005). This endemic species of the Adriatic Sea (Miller, 1986) was recorded in both lagoon and estuarine basins from Monfalcone to the Po River mouth (Gandolfi *et al*., 1982). Moreover, it was found in the Jadro estuary (Kolombatović, 1891), at the mouth of Mirna and Raša Rivers in the Istria peninsula, but its presence was still not recorded in the transitional environments of Slovenia (Lipej *et al*., 2006).

K. panizzae was usually recorded in the mesohaline water types and in the polyhaline too. However, the identification of this species must be clarified because it is no longer possible to distinguish exactly *Knipowitschia caucasica* and *K. panizzae*; thus the taxonomic status of these species has to be still questioned (Kovačić, 2008).

A. fasciatus is a typical euryhaline fish species. It inhabits the brackish environment, lagoons, estuaries and salina, rarely it can be found in freshwater habitats (Li-

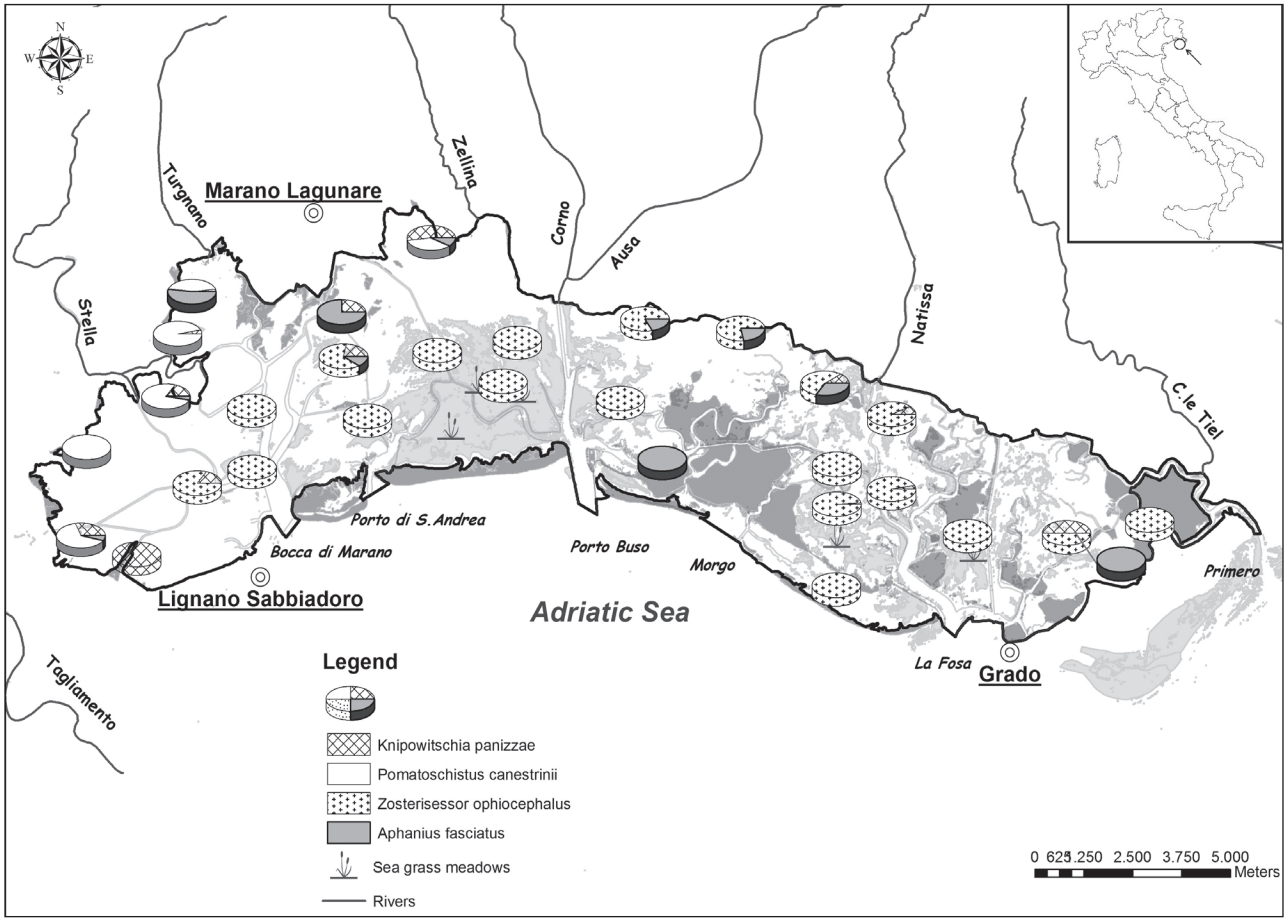

Fig. 3: Distribution of sensitive fish species in the Marano and Grado Lagoon.
Sl. 3: Porazdelitev občutljivih ribjih vrst v Gradeški in Maranski laguni

pej *et al*., 2006). Due to its euryhaline characteristics, this species was constantly recorded in each water type of the Lagoon and it is very abundant in the Val Cavanata, a dismissed fish farm located between the Lagoon of Grado and the Isonzo River mouth.

Finally, according to the Annex II of Habitat Directive the grass goby (*Zosterisessor ophiocephalus*) is not included in the list of endangered or threatened species, but it can be considered as a fundamental component of the typical lagoon resident fish species. Within the Lagoon *Z. ophiocephalus* was normally recorded in the euhaline and polyhaline water type, mainly where sea grass meadows prevail (Fig. 3).

Fishery and aquaculture

The Lagoon hosts the two most important fisheries ports of the Region Friuli Venezia Giulia: Marano Lagunare and Grado. Taking into consideration the number of vessels, they represent almost 80% of the fisheries fleet of the region (Sladonja *et al*., 2011). Fishermen operate at sea by trawling, seine, hydraulic dredge for bivalves (mainly *Chamelea gallina*, *Callista chione* and *Ensis minor*), trammel and gill nets, longlines, fish traps adapted to catch cuttlefish (*Sepia officinalis*) and mantis (*Squilla mantis*). Most of fishermen in Marano Lagunare work both at sea and lagoon and mainly employ the fyke nets (locally named "cogoli"), a fisheries method linked to the tidal regime (Sladonja *et al*., 2011).

The sand smelt *Atherina boyeri* represents the target species caught by fyke nets. In terms of abundance this species represents about 75% of the total catches in both Marano and Grado basins, followed by flounder (*Platichthys flesus*) and the Baltic prawn (*Palaemon adspersus*) (Fig. 4). The brown shrimp (*Crangon crangon*) is mainly caught in the inner areas of Marano basin during the early autumn season. In the last 25 years the fisheries catches data reported from the Marano Lagoon fish market showed a general decrease especially for the most important lagoon resources such as eel (*Anguilla anguilla*), flounder, sand smelt, grass goby and crustacean (*P. adspersus*, *C. crangon* and *Carcinus aestuarii*) (Zentilin, pers. comm.). This decrease was more noticeable from the end of 80′ and beginning of 90′, because of the Manila clam (*V. philippinarum*) appearance. This species was introduced in 1986 for aquaculture purposes in the Marano basin. Due to its spreading, massive abundance, the easiness of harvesting and overall the considerable market of this resource, it led to a consistent abandonment of traditional fishery. Nowadays, the fishermen employed in the Marano Lagoon are 25, whereas in the Grado basin they do not reach 5 units, although in the Grado Lagoon Manila clam showed a lower spread than in the Marano one. In this way an impulsive and uncontrolled exploitation of this resource occurred in the Marano Lagoon. In particular, during autumn-winter period, an improper use of the specific rake employed for the harvesting caused remobilization of finest sediments and potential contaminants. Due to this, the use of this rake was forbidden since 2007. During 2010, 74% of the production derived from aquaculture conducted in 130 ha of surface (772 tons). In this area a multifunctional vessel is employed for harvesting, seeding and removal of oyster shells. Moreover, in order to employ and educate fishermen toward a sustainable aquaculture in the Lagoon, a new area of about 600 ha is suitable for

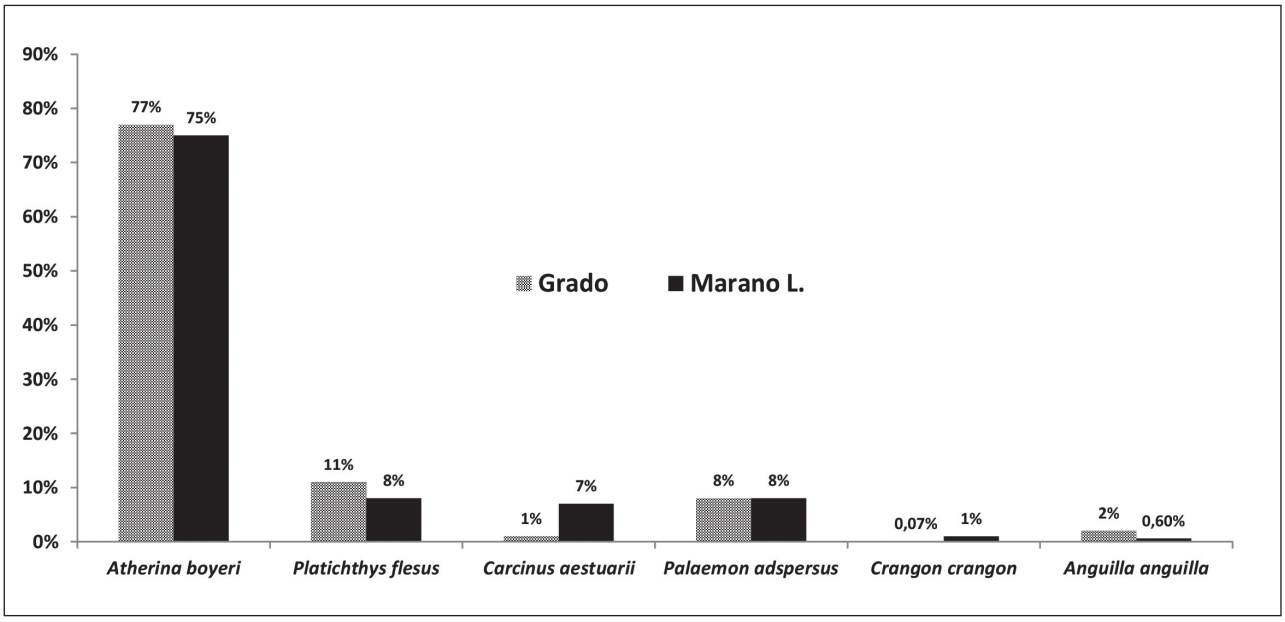

Fig. 4: Percentage catches of the main lagoon fisheries resources in Grado and Marano Lagunare (2010 data). Sl. 4: Ulovi večjih ribolovnih virov (v odstotkih) v Gradeški in Maranski laguni (podatki iz leta 2010)

the process of oyster removal and seeding. Nowadays, after 25 years from the introduction of Manila clam, the pathway toward its sustainable aquaculture seems now possible (Sladonja *et al*., 2011).

On regard fish farm activity, this is an ancient tradition arising to 16th century in the Grado Lagoon (Sladonja *et al*., 2011). Actually there are 40 fish farms with 514.4 ha of surface water bodies employed for the production. 15 fish farms are located in Marano Lagoon, whereas 25 fish farms are located in Grado basin. Target species are sea bream (*S. aurata*) and sea bass (*Dicentrarchus labrax*) with a limited production of mullet (*Mugil* spp.). In addition, elvers of *A. anguilla* are grown in fish farms and the production of other species like shi drum (*Umbrina cirrosa*) is actually under development. Unfortunately, it is very difficult to get data of production because of the disorganization of this economic sector (Zentilin, 2008).

GRADEŠKA IN MARANSKA LAGUNA: KRATEK POVZETEK O VODNI FAVNI IN RIBOLOVNIH VIRIH

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POVZETEK

*Gradeška in Maranska laguna sta eni izmed najbolje ohranjenih mokrišč v Sredozemlju. Kljub prisotnosti kemičnih onesnaževal, zlasti živega srebra, pri oceni ekološkega stanja makrozoobentosa in ribje favne ni bilo nikakršnih težav. Porazdelitev makrozoobentoških populacij kaže jasno povezavo z gradientom slanosti, ki se ustvarja zaradi časa izmenjave z morsko vodo in vnosov sladke vode celinskega izvora. Področje predstavlja pomemben habitat za ribjo favno, še posebej za občutljive vrste, kakor tudi pomembno območje za rast mladic morskih selitvenih vrst, ki se zadržujejo predvsem v notranjem delu Maranskega bazena. Po 25 letih od vnosa filipinskih ladink (*Venerupis philippinarum*) se tukaj pot do trajnostnega ribogojstva zdi končno mogoča.*

Ključne besede: Gradeška in Maranska laguna, severni Jadran, ribja favna, makrozoobentos, ribolovnimi viri

REFERENCES

Bettoso, N., I. F. Aleffi, L. Faresi, P. Rossin, G. Mattassi & P. Crivellaro (2010): Evaluation on the ecological status of the macrozoobenthic communities in the Marano and Grado Lagoon (northern Adriatic Sea). Annales, Ser. Hist. Nat., 20 (2), 193–206.

Caffaroindustrie (2013): The chemical world Caffaro industrie. http://www.caffaroindustrie.it/ita/azienda.html (18.11.2013).

Convention on Wetlands of International Importance especially as Waterfowl Habitat (1971): UN Treaty Series No. 14583. Ramsar (Iran), 2 February 1971.

Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. OJ L 206, 22.7.1992, p. 7–50.

Covelli, S. (2012): The MIRACLE Project: an integrated approach to understanding biogeochemical cycling of mercury and its relationship with lagoon clam farming. Est. Coast. Shelf Sci., 113, 1–6.

Covelli, S., J. Faganeli, C. De Vittor, S. Predonzani, A. Acquavita & M. Horvat (2008): Benthic fluxes of mercury species in a lagoon environment (Grado Lagoon, Northern Adriatic Sea, Italy). Appl. Geochem., 23, 529–546.

Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. OJ L 327, 22.12.2000, p. 1–73.

Fontolan, G., S. Pillon, A. Bezzi, R. Villalta, M. Lipizer, A. Triches & A. D'Aietti (2012): Human impact and historical transformations of saltmarshes in the Marano and Grado Lagoon, northern Adriatic Sea. Est. Coast. Shelf Sci., 113, 41–56.

Franco, A., P. Franzoi, S. Malavasi, F. Riccato, P. Torricelli & D. Mainardi (2005): Use of shallow water habitats by fish assemblages in a Mediterranean coastal lagoon. Est. Coast. Shelf Sci., 66, 67–83.

Franco, A., M. Elliott, P. Franzoi & P. Torricelli (2008): Life strategies of fishes in European estuaries: the functional guild approach. Mar. Ecol. Prog. Ser., 354, 219–228.

Gandolfi, G., P. Torricelli & A. Cau (1982): Observations on the biology of the black-spotted goby, *Pomatoschistus canestrinii* (Ninni). Nova Thalassia, 5, 97–123.

Guélorget, O. & J. P. Perthuisot (1982): Structure et évolution des peuplement benthiques en milieu paralique. Comparaison entre un modèle dessalé (l'Etang du Prévost, France) et un modèle sursalé (la Bahiret el Biban, Tunisie). Conséquences biologiques et géologiques. J. Rech. Oceanogr., 7, 2–11.

Guélorget, O. & J. P. Perthuisot (1983): Le domaine paralique. Expressions géologiques, biologiques et économiques du confinement. Trav. Lab. Geol. ENS., 16, 136 pp.

Guélorget, O. & J. P. Perthuisot (1992): Paralic ecosystem. Biological organization and functioning. Vie Milieu, 42 (2), 215–251.

Kolombatović, J. (1891): Glamoči (Gobii) Spljetskog Pomorskog okružja u Dalmaciji. God. Izvješće c. Kr. Vel. Realke u Splitu škol. god. 1890–1891., p. 3–29.

Kovačić, M. (2008): The key for identification of Gobiidae (Pisces: Perciformes) in the Adriatic Sea. Acta Adriat., 49 (3), 245–254.

Lipej, L., R. Turk & T. Makovec (2006): Endangered species and habitat types in the Slovenian sea. Zavod RS za varstvo narave, Ljubljana, 264 pp.

Malavasi, S., R. Fiorin, A. Franco, P. Franzoi, A. Granzotto, F. Riccato & D. Mainardi (2004): Fish assemblages of Venice Lagoon shallow waters: an analysis based on species, families and functional guilds. J. Mar. Syst., 51, 19–31.

Menchini, G., C. Amoroso, A. Barbanti, E. Ramieri, F. Melli, F. Lopez y Royo, L. Molinari, P. Simeoni & E. Bressan (2009): Il progetto di bonifica del sito industriale di Torviscosa. Rassegna Tecnica del Friuli Venezia Giulia, 6, p. 12–17.

Miller, P. J. (1986): Gobiidae. In: Whitehead, P. J. P., M. Bauchot, J. C. Hureau, J. Nielsen & E. Tortonese (eds.): Fishes of the North-eastern Atlantic and the Mediterranean. Unesco, Paris, p. 1019–1085.

Pérès, J. & J. Picard (1964): Nouveau Manuel de Bionomie Benthique de la Mer Méditerranée. Réc. Trav. Stat. Mar. Endoume, 31, 5–137.

RAFVG (1991): La qualità delle acque della Laguna di Marano. Regional Technical Report. Regione Autonoma Friuli Venezia Giulia, USL 8, Udine, 101 pp.

Ramieri, E., A. Barbanti, M. Picone, G. Menchini, E. Bressan & E. Dal Forno (2011): Integrated plan for the sustainable management of the Lagoon of Marano and Grado. Littoral 2010 – Adapting to Global Change at the Coast: Leadership, Innovation, and Investment 05008 (2011), DOI: 10.1051/litt/201105008.

Sladonja, B., N. Bettoso, A. Zentilin, F. Tamberlich & A. Acquavita (2011): Manila Clam (*Tapes philippinarum* Adams & Reeve, 1852) in the Lagoon of Marano and Grado (northern Adriatic Sea, Italy): socio economic and environmental pathway of a shell farm. In: Sladonja, B. (eds.): Aquaculture and the Environment - A Shared Destiny. INTECH open access publisher, p. 51–78.

Vatova, A. (1963): Ricerche quantitative sulla fauna bentonica delle lagune di Marano e di Grado. Boll. Pesca Piscic. Idrobiol., 18, 5–13.

Vatova, A. (1965): Nouvelles recherches sur la faune benthique de la lagune de Grado-Marano. Rapp. P.-v. CIESMM, 18 (3), 185–187.

Zentilin, A. (2008): Le valli: censimento, tipologie strutturali, produzioni, occupazione e ambiente. In: Le valli da pesca del Friuli Venezia Giulia. Regione Autonoma Friuli Venezia Giulia. Direzione centrale risorse agricole naturali forestali e montagna, p. 5–11.