SEASONAL CHANGE OF THE ALIEN BIVALVE ARCUATULA SENHOUSIA (Benson in Cantor, 1842) POPULATION OF THE VARANO LAGOON (GARGANO, CENTRAL ADRIATIC SEA, ITALY)

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Introduction
Numerous non-indigenous species were recorded in the area of the Adriatic Sea in the last decades. One of these non-indigenous species in the Adriatic Sea is A. senhousia, from the southern Bay of Biscay. It is a mollusc, with this, small and elongate shell attaining a maximum length of about 32 mm, but the common size is from 10 to 20 mm in length and up to 12 mm in width. A. senhousia is a suspension feeder that inhabits both, hard and soft substrates, where it lives, attached with its bristles, in intertidal and sublittoral to 20 m deep. It is an opportunist, short-lived species (maximum life span is approximately 2 years), that grows quickly, suffers high mortality, but it could be very abundant within its native range of distribution or in the areas where it has been introduced. Its native range of distribution is Continental, from Siberian coast to Middle Pacific, and in the Red Sea, but it is now found in different parts of the world: western North America, Australia, New Zealand, the Atlantic coast of Europe and the Mediterranean Sea. In the Mediterranean Sea the species was first recorded in the eastern part, in Israel and Egypt, then in the southern France, in Italy in the area of Rovinj in the northern Adriatic Sea, and Slovenia. Additionally, in the Adriatic Sea the species was found in the Trieste Gulf, along the northern part of the western coast, in Venice, Suce di Grado, Comacchio Bay and other areas of the Po River Delta, in the breakwater-waves lakes in Gargano National Park, and in the coastal waters. A. senhousia was also recorded in the Tarento sea (north-western Ionian Sea), in the Tyrrenian Sea (Olbia Gulf - Sardinia) and Ligurian Sea (Lavaro port). In this paper the seasonal observations on the abundance, wet weight and frequency classes of non indigenous bivalve A. senhousia (Benson in 1842) were presented in the Varano lagoon, Gargano National Park, the biggest lagoon in southern Italy, during a survey carried within the framework of the Regional Project PEP Apulia 2007/2013.

Materials and methods
Study area
The Varano lagoon is a Mediterranean coastal lagoon located along the northern of the Gargano (Central Adriatic Sea) National Park (Fig. 1). The lagoon covers an area of 6.500 ha, with a perimeter of 53.50 km. The maximum depth is 12 m, with a mean depth of 5 m. The lagoon faces the sea is a bar of sand dunes. Two artificial channels (Arco and Varano) in the east and west extremes of the sand bar provide a connection with the Adriatic Sea. Salinity values are relatively stable for a lagoon, never dropping below 20 psu. Temperature extremes are 5°C and 30°C. The hydrological system consists of the lake itself, two channels to the sea, freshwater inputs from a small catchment basin drained. The main freshwater input (87 000 m$^{3}$/d) is from karst springs on the southern shore but the lagoon also receives the outflow of urban wastewater treatment plants and the runoff from agriculture and zootechnic activities. Due to low tide excursion and reduced exchange with the adjacent coastal area, water temperature is very long and it is estimated to about 1.5 years. The lagoon and the neighboring coastal marine area are exploited by mussel farming. Fish species are those typical of Mediterranean lagoon seas: seabream, seabass, eel, grey mullet, etc.

Sampling and data analysis
The samples were collected seasonally (May-July-October) during 2015, in 12 stations arranged along three transects perpendicular to the coastline (Fig. 2). The sampling was carried out by professional hydraulic dredge, with an opening of 55 cm and a lack of 7 mm per side on a sampling surface of approximately 5 m$^{2}$. The stations were placed on different bathymetries (1, 3, 4, 5 m), for each station it was assessed the abundance (ind/m$^{2}$) and wet biomass (g/m$^{2}$). Collected samples were screened in situ by sieve with mesh of 1 mm. For each transect, random specimen were collected by A. senhousia and on which the length (mm) and the wet weight (g) were measured and length-weight correlation by the ratio of the minimum squares regression and distribution of length classes were calculated. Spatial and temporal variability of abundance and size classes (length) were evaluated by the ANOSIM test. In addition to biological sampling, in two stations CTD profiles were detected.

Results
Environmental data (T°C, Salinity, O%) showed a typical seasonal pattern. The temperature varied from a minimum of 15.90°C (May) to a maximum of 30.05°C (July) detected in the SLK. Salinity ranged from a minimum of 19.46 (May -9 June) to a maximum of 24.85 psu (October). Dissolved oxygen (% saturation) showed average values close to saturation. In July, close to the base in SLK, low oxygen concentrations (22.46%) were found near hypoxic condition (Fig. 3). The average abundance and wet weight were measured as a mean of 1.446 ind/m$^{2}$ and 0.416 g/m$^{2}$ in October to a maximum of 20.14 ind/m$^{2}$ and 1.342 g/m$^{2}$ in July, respectively (Fig. 4). The highest abundance (May 18.45 ind/m$^{2}$) was found in July, instead the smallest average length (12.39±1.44) in October. There was a trend of decreasing abundance with time at all sites (Table 1). Significant differences (ANOSIM test) on abundance between sampling dates (R=0.290; p=0.001). Pooled length-frequency histograms for the population of A. senhousia showed two cohorts (bimodal) structure for most of samples (Fig. 5). In May and October, the population showed a bimodal distribution, characterized by two cohorts. In May the most frequent length was between 9.5 mm (63%) and a small number of between 27-30 mm (6%). In October the maximum was between 9-12 mm (20%) and 18-21 mm (20%). While in July the population showed a modal structure characterized by a single cohort, the most frequent length was between 18-24 mm (42%). The length showed significant differences (ANOSIM test) between transects (R=0.082; p=0.0101), stations (R=0.51; p=0.001) and sampling dates (R=0.261; p=0.001).

Discussion and conclusion
Environmental data (T°C, Salinity, O%) showed a typical seasonal pattern. The massive decrease in the abundance of the A. senhousia detected in October, it could be related to different factors like overheating of the water, during summer and the low oxygen concentrations (22.46%) near hypoxic condition (July). Intact the temperature and low oxygen concentrations has an important influence on the physiological and biochemical attributes of bivalves. The population growth in the Varano lagoon was extremely large, providing also a rich exploitable potential of crustacean mass populations in a Mediterranean lagoon. Abundance data and morphometric relationship confirm the presence of a stable and viable population of the A. senhousia in Varano lagoon. The average abundance of A. senhousia during this study in the Varano lagoon (Central Adriatic Sea) are comparable with the abundance data found for the same species in the north-eastern Adriatic Sea (Soca di Grado, Tyrrenian Gulf of Olbia and Isola, (Mar Pérez) coastal areas. At present, introduction way of the bivalve A. senhousia into Varano lagoon in not affected, but it could hypothesise their presence may be attributable to subsequent populations from near Adriatic Sea and introduced larvae and juveniles brought to lagoon with the seed of M. galloprovincialis. A. senhousia seems well adapted to Varano lagomonal habitat, and has all the necessary characteristics for an opportunistic invasive species. Information found may be useful for understanding the rapid spread that species has had in Adriatic Sea and, in particular, in transitional water ecosystems.