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THE STOCK STATUS OF *CALLISTA CHIONE* (LINNAEUS, 1758) EXPLOITED IN THE GULF OF TRIESTE

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ABSTRACT

The study investigated smooth clam Callista chione *(Linnaeus, 1758), collected in July 2010 at 23 sample sites in the Gulf of Trieste. From the results it was found that in some groups, an inverse correlation exists between length--at-age (estimated from the number of the tiny slowing growth translucent bands with a LED pointer) and sampling depth. The results confirmed observation from 1992 and 1993 surveys and the environmental features at different depths are still largely unknown. Unfortunately in 2013 and 2014 the clam beds were affected by a mass mortality that could compromise this fishery in the maritime District of Monfalcone, so a rapid growth assessment could be helpful for fishermen activity and management decision.*

Key words: *Callista chione,* Gulf of Trieste, length-at-age, population structure

STATO DELLO STOCK DI *CALLISTA CHIONE* (LINNAEUS, 1758) NEL GOLFO DI TRIESTE

SINTESI

Nella ricerca, condotta nell'ambito dei rapporti di collaborazione con il CO.GE.MO. di Monfalcone è stata analizzata la popolazione di Callista chione *(Linnaeus, 1758) campionata a mezzo di un'imbarcazione professionale a fine luglio 2010 in 23 stazioni del Golfo di Trieste. Dai risultati, è emerso che organismi della stessa età stimata dall'enumerazione delle sottili bande chiare visibili per trasparenza, hanno lunghezza minore a profondità maggiore. Tale fenomeno potrebbe essere dovuto alle caratteristiche ambientali, tuttora in massima parte ignote, alle diverse profondità. Nel 2013 e nel 2014 le aree di pesca sono state interessate da episodi di mortalità che potrebbero mettere a rischio l'attività almeno nel C.M. di Monfalcone per cui un sistema rapido di censimento demografico può risultare di estrema utilità anche per gli operatori della pesca.*

Parole chiave: *Callista chione,* Golfo di Trieste, età - lunghezza, struttura di popolazione

INTRODUCTION

Callista chione (Linnaeus, 1758) is an infaunal species that lives in the Atlantic and in the Mediterranean, generally on sandy substrates at depths ranging from 10 to 130 m (Poppe & Goto, 1993; Moura *et al*., 2008) up to 180 m (Ezgeta-Balić *et al*., 2011).

The species is exploited in Portugal (Gaspar *et al*., 2001, 2002; Moura *et al*.,2009), Spain (Tirado *et al*., 2002; Baeta *et al*., 2014), France (Charles *et al*., 1999) Croatia (Ezgeta-Balić *et al*., 2011), Greece (Metaxatos, 2004; Leontarakis & Richardson, 2005), and in Italy mainly in the Gulf Trieste (Valli *et al*., 1983-1984; Del Piero, 1994, 1997-1998) and in the Gulf of Venice (Marano *et al*., 1998).

In the Gulf of Trieste the fishery is mainly carried out in an area 3-6 nm from the coast with hydraulic dredges. According to the Ministry of Agriculture, Food and Forestry (Ministero delle Risorse Agricole, Alimentari e Forestali, 1994) the smooth clams live burrowed in the sediment and are found on sandy beds with 200-300 m in extension and 50-100 cm in height. They are less frequent on the pelitic substrate. The Monfalcone Consortium for molluscs management (CO.GE.MO.) restricted the fishery in his own district and assayed the restocking of the bivalve beds in 2007 aiming at the recovery of the smooth clams populations in the area. With this purpose 20 metric tons of clams (with no size selection) were moved from an area 20-22 m in depth to a shallower one 14-16 m in depth. In addition the exploitation of the beds where the experiment took place was restricted. This decision was partly supported by previous data (Rebec, 1997-1998; Braida, 2001-2002). These authors, counted the macro-growth bands in the shell (dark and

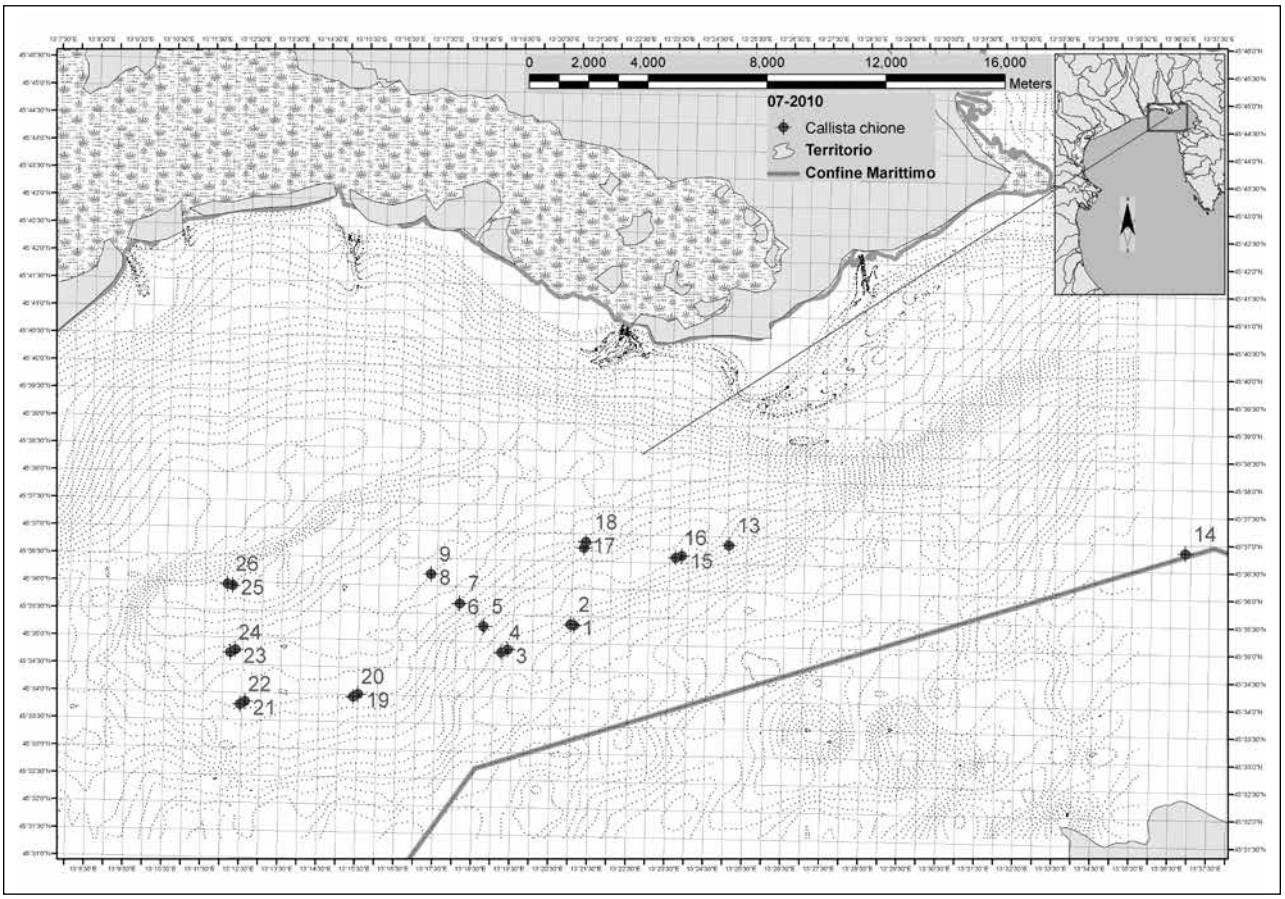

Fig. 1: Sampling stations, schematic outline (courtesy M. Burca, OGS). The detailed bathymetric map of the Gulf of Trieste was elaborated by the RIMA Dept. of the National Institute of Oceanography and Experimental Geophysics (OGS) (Dr. Diviacco and Dr. Burca) on the basis of a previous publication (Gordini** et al.**, 2003 with author's permission).

Sl. 1: Vzorčevalne postaje in shematski pregled (z dovoljenjem: M. Burca OGS). Natančni batimetrični zemljevid Tržaškega zaliva je bil izdelan v oddelku RIMA iz Nacionalnega inštituta za oceanografijo in eksperimentalno geofiziko (OGS) (dr. Diviacco in dr. Burca) na podlagi predhodne publikacije (z avtorjevim dovoljenjem Gordini** et al.**, 2003).

translucent, roughly one year), found a difference of three years among clams of the same length (45 mm) sampled at 16 and 22 m depth. Due to the results of Keller *et al*. (2002), showing that growth is faster till the clams reach the fourth year, it seemed a promising idea to transfer clams into a shallower area where the growth rate is supposed to be faster. All these results underlined the necessity of demography implementation in stock management of *C. chione*, being the minimum size only (25 mm, but fishermen select the clams from 40 mm onwards) an insufficient parameter for this long-living and still poorly known species. The objectives of the study are to underline the importance of demographic structure and growth rate as a support for the management strategies.

MATERIAL AND METHODS

The samples analysed in this study were collected in July 2010, onboard a commercial fishing boat equipped with a commercial dredge (bar space 25 mm). A total of 26 stations were sampled in the Monfalcone maritime District (Fig. 1). No clams were found on three stations (10, 11 and 12). Moreover, sample 25 was erroneously discarded after the first measurements and therefore no data is presented. The sampling sites were chosen in order to satisfy the management needs of the Consortium, by sampling both currently exploited areas and sites unfished for a long time. For each sample site the coordinates at the beginning and at the end of the haul were recorded by using the GPS receiver. Depth was obtained using the echo sounder on the vessel. The clams were weighed on board using a steelyard and were subsequently processed in the laboratory at the Department of Life Sciences, University of Trieste. Shell length was measured on a total of 1989 individuals with a digital calliper to the lowest mm. In addition, shell height and shell thickness of at least 30 randomly selected clams (786 individuals in total), were measured to the lowest mm with a digital calliper following Valli *et al*. (1983-1984, 1994).

The Kolmogorov-Smirnov D test was applied to the frequency distributions and 14 samples with significant difference in cumulative distribution distance are reported. On these 14 samples age-at-length estimates were done. The description of the shell structure can be found in Taylor *et al*. (1973). The estimated age was obtained counting the narrow bright bands on the left valve with a support of a LED pointer (Fig. 2). The tiny bright band is formed once a year (Rebec, 1997-1998; Braida 2001-2002) due to a lower growth rate, the latter being related to the local gonadal cycle (described by Valli *et al.*, 1983-1984) for the Gulf of Trieste area. For each subsample the individuals at 5th percentile, at the median value and at the 95th percentile were examined. In few dubious cases thin sections of the right valve (courtesy of Mr. L. Furlan, Prof. F. Princivalle and Prof. G. Fontolan, director of the Department of Mathematics and Geosciences of University of Trieste) were performed and then the growth rings were examined using a stereomicroscope. However not all dubious cases were resolved and therefore the individuals were excluded from the present analysis and stored for subsequent examination.

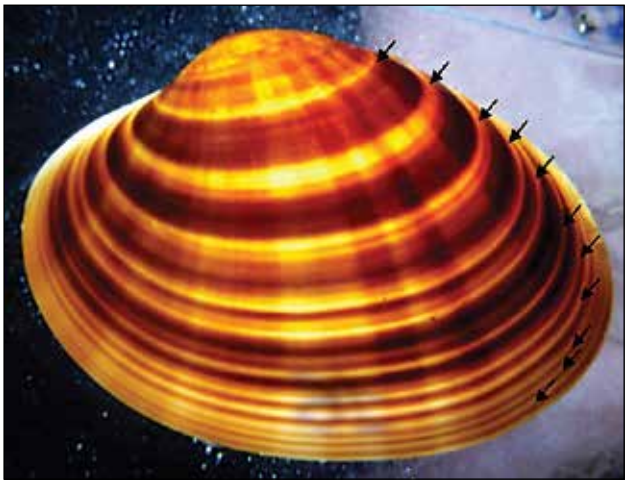

Fig. 2: Slow growth bright bands (marked by black arrows) and age estimate: length 6.4 cm, height 4.5 cm, thickness 2.7 cm. The clam is presumed to be 11 years old (credits C. Coglievina).
Sl. 2: Svetli trakovi, ki označujejo počasno rast (označeni s črnimi puščicami) in ocena starosti: dolžina 6,4 cm, višina 4,5 cm, debelina 2,7 cm. Starost školjke je ocenjena na 11 let (avtor C. Coglievina).

The Spearman's ρ test was performed to evaluate the relation between estimated length-at-age and station depth. The statistical analyses were performed using Statgraphics Centurion XVI.

RESULTS AND DISCUSSION

The results obtained from each station are summarized in Table 1. It can be observed that the lower density was found at station 13. In Table 3 are summarized the results for the 14 samples used for age analysis. The presence in the samples of specimen restocked in 2007 (st. 25 and 26) from a deeper to a shallower area showed a recovery in growth rate (Del Piero *et al*., 2010) suggesting to search for a rapid method for determining the age of the clams. The samples chosen were the ones showing significant differences in the Kolmogorov-Smirnov D test (Tab. 2) and were also different in the regression calculated between ln valve weight and ln dry weight (data not shown).

The data on distribution are important for management, as a proxy for testing the fishery area status and could help in management strategy and the differences in the regression slope among the variables reported

Tab.1: Survey results summary: only the sites where** C. chione **was found are reported.
***Tab. 1: Pregled dobljenih rezultatov z lokalitet, kjer je bila najdena školjka vrste** C. chione*

Station	Date	Depth (m)	Density (g/m²)	Abundance	Mean shell length ±SD (cm)	Median (cm)
1	26/07/10	18	28.4	99	5.56 ± 1.401	5.8
2		18/15	19.2	82	6.18 ± 0.93	6.25
3		18	9.3	68	6.28 ± 0.84	6.2
4		17	8	59	6.11 ± 0.663	6.2
5		17	18.5	108	6.28± 1.007	6.3
6		15	20.4	112	5.11 ± 1.489	5.2
7		15	4.2	72	5.07± 1.349	5.3
8		13	38.8	118	6.31 ± 0.804	6.3
9		13.5	49	120	5.43± 1.705	5.9
13	27/07/10	17.9	1.9	52	5.37± 1.383	5.7
14		17.5	2.5	19	5.58 ± 1.058	6
15		17	2.8	24	5.48±1.225	5.5
16		17.5	4.7	40	5.17± 1.468	5.65
17		15	16.6	117	5.45± 1.342	5.6
18		15.5	10.2	80	5.69±1.183	6.1
19	28/07/10	15.5	58.1	134	5.86±0.785	5.95
20		15	39.4	88	6.04± 0.746	6
21		15	164.2	94	6.20±0.756	6.2
22		15	127.5	102	5.87± 0.806	6
23		14	64.9	94	5.94±0.877	6
24		14.5	156.8	100	6.00±0.726	6.1
25*		12	68.8	104	5.84±1.042	5.9
26		11	157.1	103	5.83±0.866	5.9

* The sample 25 was erroneously discarded after the first measurements.

above, but not discussed here, may be also important for checking some population characteristics.

The age estimation was performed from the inner side of the left valve with a LED pointer from the umbo to the ventral margin: dark bands relatively large (fast-growing) and thin translucent (slow-growing; Taylor *et al*., 1973) become clearly visible. The periodicity of growth rate in this species and in this area was first reported in Hall *et al*. (1974). The observation was performed referring to past experiences, when massive growth ring counts and estimated age results were largely confirmed by isotopic analysis (Keller *et al*., 2002). In the umbo there are no particular problems discerning the two different bands, at the ventral margin it becomes more and more difficult. The ventral margin of the clams presented a tiny clear band. As the survey was done between 26 and 28 July, it can be assumed that the last translucent band represents the slowing or stopping of growth in 2010, probably due to reproduction cycle as observed by Rebec (1997-1998) and Braida (2001-2002). Similar pattern seems not to be uncommon since it was also found by Kelly & Cerrato (2007) in *Mercenaria mercenaria* in Narrangasett Bay (RI, USA).

In some special cases, bands of slow growth have been enumerated observing thin sections even if some patterns remain unresolved. Table 3 and Figure 3 show that similar lengths may correspond to different estimated age and in many cases less depth means higher length-at-year. The Spearman's ρ test was performed on clams assigned to the age-class 3 and 8 to explore if the supposed pattern was maintained among different cohorts in different years. The individuals younger than three and older than eight years were poor represented in the collected samples. The results showed the presence of an inverse correlation between length and depth. For the 3 years group (5 individuals) the ρ

Tab. 2: Results of the Kolmogorov-Smirnov D test. Dα - max difference obtained between two samples, D - max expected difference at p = 0.05.
Tab. 2: Rezultati Kolmogorov-Smirnovega D testa. Dα - maksimalna razlika med dvema vzorcema, D - maksimalna pričakovana razlika na nivoju p = 0,05

St	St	Dα	D
1	9	0.18439	0.17020
	13	0.23260	0.18434
	15	0.30900	0.22854
	24	0.19255	0.15263
5	16	0.25137	0.23981
6	9	0.17843	0.11726
	16	0.25016	0.24643
8	9	0.17607	0.11370
	18	0.19669	0.18665
13	19	0.22189	0.12859
	22	0.23141	0.17308
	23	0.23472	0.17676
	24	0.23219	0.23000
	25	0.23066	0.17308
14	16	0.37840	0.31711
	19	0.33293	0.21524
	22	0.33935	0.21465
	23	0.34161	0.25700
	24	0.33988	0.32211
16	19	0.30103	0.16791

was -1, n = 5, $p < 0.01$ and in the case of the group of 8 years (8 individuals) the ρ value was -0.729, n = 8, $p < 0.05$.

The hypothesis of difference in length-at-age due to the depth emerged previously (Del Piero, 1997-1998) as a result of the analysis of two surveys conducted in September 1992 and May 1993 when a rough relationship between exploitation strategies and the structure of the population studied was found. At the beginning of 90ies in order to increase the income, fishermen used to land smaller individuals because they were sold at a higher price. A warning was done about this practice that could drive, in the long run, to an imbalance in the age-classes structure with possible negative effect on recruitment due to a probable competition adults – recruits in the fishery areas at least, because at that time in unexploited clam beds (deeper than 20 m), no such effect was observed (Del Piero, 1997-1998).

The differences found in the distributions among samples could also be a consequence of a commercial strategy because often the fishermen are requested to land molluscs of size interval comprised between 4 cm and 6 cm regardless of the age. However, these results showed that difference might be primarily related to the depth, and this may be influenced by many causes all to be tested quite urgently. One of the reasons could be the exploitation carried out by fishermen usually on areas closer to the coast and at a shallower depth, causing a decrease in smooth clam density. Fishing closer to the coast is less expensive too, in terms of time and fuel spent and it could be the only chance to work in rough conditions at sea. It must be emphasized that there is a greater exploitation on the areas closer to the coast when sea conditions are unfavourable and it's possible to sell clams less valuable due to dark bands on the shell. These black bands are frequent on clams fished near rivers mouths and are due to presence of adsorbed FeS present in the upper layer of the shell as resulted through *elemental probe* X-ray microanalysis. The reddish colour of the shell is due to iron oxides in the external carbonate layer (Braida, 2001-2002; F. Princivalle, *pers. comm.*). The clams collected in those areas were in general larger (Del Piero, 1997-1998) probably due to the lower fishery pressure exerted.

Tab. 3 Samples from stations resulting significantly different in slope: three specimens randomly selected at 5th percentile (P 0.05), median and 95th percentile (P 0.95).
Tab. 3: Vzorci s postaj, ki so se značilno razlikovali v naklonu: trije naključno izbrani primerki na nivoju 5. percentila (P 0.05), mediane in 95. percentila (P 0.95)

Station	Depth (m)	Percentile	Length (cm)	Height (cm)	Thickness (cm)	Band no.
1	18	P 0.05	3.2	2.4	1.2	3
		median	5.8	4.6	2.8	8
		P 0.95	7.4	5.8	3.3	9
5	17	P 0.05	4.7	3.6	2.0	6
		median	6.4	4.5	2.7	11
		P 0.95	7.7	6.3	3.9	13
6	15	P 0.05	2.6	1.8	1.0	1
		median	5.1	3.8	2.2	5
		P 0.95	7.2	5.5	3.2	9
8	13	P 0.05	4.9	3.6	2.1	3
		median	6.4	4.8	2.9	8
		P 0.95	7.5	5.5	3.3	8
9	13.5	P 0.05	2	1.4	0.8	1
		median	5.9	4.4	2.5	6
		P 0.95	7.5	5.7	3.4	13
13	17.9	P 0.05	2.9	2.2	1.2	2
		median	5.7	4.4	2.6	8
		P 0.95	7.4	5.6	3.3	9
14	17.5	P 0.05	3.2	2.4	1.4	2
		median	6	4.6	2.8	7
		P 0.95	6.3	4.8	3.0	7
15	17	P 0.05	3.7	2.8	1.6	3
		median	5.4	3.9	2.4	7
		P 0.95	6.3	4.7	2.7	10
16	17.5	P 0.05	3.4	2.6	1.4	3
		median	5.7	4.2	2.7	6
		P 0.95	7	5.3	3.2	8
18	15.5	P 0.05	4	3	1.6	2
		median	6.1	4.6	2.9	7
		P 0.95	7.3	5.6	3.5	15
19	15.5	P 0.05	4.6	3.3	2.0	3
		median	6	4.5	2.7	8
		P 0.95	7	5.4	3.5	10
22	15	P 0.05	4.5	3.3	2.0	5
		median	6	4.5	2.8	6
		P 0.95	6.8	5.1	3.0	7
23	14	P 0.05	4.4	3.2	1.7	4
		median	6	4.5	2.7	7
		P 0.95	7.5	5.7	3.5	8
24	14.5	P 0.05	5	3.8	2.0	5
		median	6.1	4.4	2.6	7
		P 0.95	7.2	5.3	3.1	8

CONCLUSIONS

The survey carried out in 2010 depicts a quite complex situation of the population status of the smooth clam, with variable estimated density, distribution and length-at-age. The assessment of the latter was done using a rapid evaluation method.

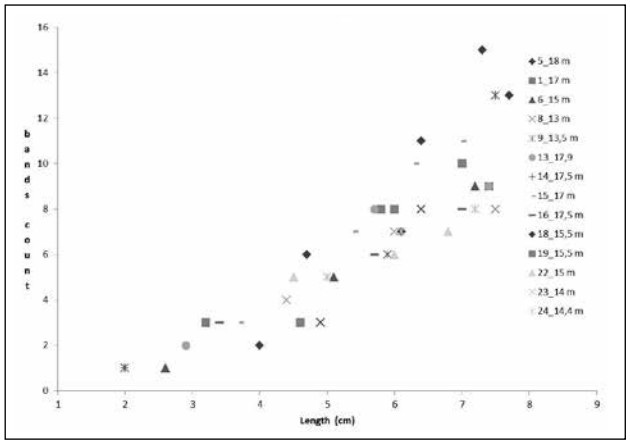

Fig. 3: Bands count and length (cm) in the 14 stations with significantly different regression slope for ln valve length and ln dry weight.
Sl. 3: Štetje trakov in dolžina (cm) na 14 postajah z značilnim različnim naklonom za ln dolžine lupine in ln suhe teže

Compared to more sophisticated techniques, *e.g.* fluorescence (Wanamaker *et al.*, 2009), acetate peel and isotopic analysis, the use of LED pointer for massive clear bands counts seems to be reliable, and compared with the thin sections obtained for this study, correct. This methodology has been verified in the past by Keller (1996-1997), Keller *et al.* (2002), Rebec (1997-1998) and Braida (2001-2002), which offered the possibility to obtain valuable information for the present work. It was confirmed that the restocking done by fishermen was successful (at least from the repeated analysis of the clams, Del Piero *et al.*, 2010). Unfortunately, parts of the shallower areas designed for repopulation were affected by mortality in late summer 2013 and early summer 2014 (*unpubl. data*). The causes are still unknown but at least in 2013 the molluscs didn't seem to suffer pathologies (G. Arcangeli, *pers. comm.*).

The differences in the length-at-age related to the depth were confirmed. Nevertheless, the ecological questions emerging from this study are at present far to be resolved. It seems urgent to modify the present fisheries regulation taking into account the demographic structure of *C. chione* population, a long-living species, with complex demography and still uncovered recruitment dynamics.

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The research was done as part of the agreement with the CO.GE.MO. of Monfalcone.

POPULACIJSKI STATUS ŠKOLJKE *CALLISTA CHIONE* (LINNAEUS, 1758) V TRŽAŠKEM ZALIVU

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POVZETEK

Julija 2010 smo v raziskavi analizirali školjke vrste Callista chione *(Linnaeus, 1758) na 23 lokalitetah. Dobljeni rezultati kažejo, da je za nekatere skupine značilna obratno sorazmerna korelacija med dolžino na določeni stopnji starosti (ocenjena na podlagi števila tankih, počasi rastočih prozornih trakov, ugotovljenih z uporabo LED kazalcev) in globino vzorčenja. Rezultati potrjujejo ugotovitve raziskav iz let 1992 in 1993, okoljske značilnosti na različnih globinah pa so še vedno pretežno neznane. Na žalost je v letih 2013 in 2014 nasade školjk prizadel množični pogin, ki bi lahko drastično vplival na ribištvo, povezano z ulovom školjk. S tega vidika bi bilo ugotavljanje hitrosti rasti za ribiško dejavnost in upravljavce zelo koristno.*

Ključne besede: *Callista chione,* Tržaški zaliv, dolžina ob določeni starosti, struktura populacije

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