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Research Article

ENVIRONMENTAL STUDY OF THE SEASONAL SUCCESSION OF MESOZOOPLANKTON IN A BRACKISH WATER ODRA RIVER ESTUARY DURING 2003−2005

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ABSTRACT
The entire estuary water is dominated by the discharge of the River Odra into the Szczecin Lagoon. The water body is brackish and the salinity in the central part ranges 0.5 and 2 PSU. The Lagoon has a long eutrophication history; usually, two phytoplankton biomass peaks are observed: Diatoms in spring and blue-green algae in summer. The recent data on zooplankton is limited. Rotifers and Cladocerans supply the bulk of the zooplankton biomass. The ichtiofauna is composed of fresh and brackish water, migratory and marine species. Zooplankton and water samples were collected during 2003–2005. The results suggest that during 10 season's climate in Odra River estuary, Cladocera were the dominant group, large impact on the density of mesozooplankton were: *Daphnia cucullata* and *Daphnia longispina*, Copepoda played a lesser role in the Odra River estuary than Cladocera. Biomass of mesozooplankton from the Lagoon was significantly higher compared with the biomass of mesozooplankton from Odra River estuary, which could be related to a greater inflow of nutrients into the Lagoon and the increased growth of phytoplankton, which forms an excellent first stage food web for herbivorous and carnivorous zooplankton, and fish and consequently cormorants.

Keywords: Baltic Sea, II row Odra River estuary (Szczecin Lagoon), mesozooplankton, annual catch of fish, cormorants.

INTRODUCTION

The area under study is located in the southern part of the Baltic Sea, Szczecin Lagoon; a vast coastal water of the lake reservoir flow is part of the Odra River estuary. It has characteristic water flows associated with changes in river runoff and sea change inflows. The latter are dependent on the mounds and depressions of the Pomeranian Bay water levels, caused by strong and sustained winds or barometric pressure changes. The relatively small depth and large surface reservoir favor mixing of the waters, so there is no long-term phenomenon in the Lagoon of stratification. Temperature, oxygen and nutrients content in the surface waters and above the bottom vary slightly [Majewski 1980]. This favors the formation of specific structures of water biocenoses.

Zooplankton plays an active role in the ecological structures of reservoirs, especially in the transformation of mass and energy, so it is good bio-indicator for the existing physical conditions and chemical environment, it may also be an indicator of short-term and long-term water mass movements. At the same time plankton as a biological indicator allows you to track the evolution of the reservoir [Chojnacki 1986, 1987a]. The most important abiotic factors that significantly affect the abundance and species composition of not only zooplankton, but other hydrobionts are:

temperature and salinity, ocean currents, light, and biotic factors such as phytoplankton [Chojnacki 1987b, 1991, Chojnacki et al. 2007].

It was found that temperature regardless of salinity has a decisive influence on the ecological structure because it shapes the structure of the planktonic biota. The important role of this parameter due to the fact that decisively affects the physical and chemical properties of the water, combined with salinity shaping the biotic structure in the reservoir [Chojnacki 1984, 1987b]. There are two groups of organisms, which due to different thermal conditions behave differently; they are: eury- and stenothermic. Eurythermic organisms can tolerate a wide range of temperatures; they withstand any fluctuations in water temperature and are likely to be without any apparent harm to their body. However, stenothermic are more sensitive and depend on the species tolerance to changes in water temperature, and are not able to withstand wide changes. This seems the main cause of differences in geographical distribution of plankton [Schernewski, Schiewer 2002]. A characteristic feature of eurytheremic organisms is the ability of their simultaneous existence in the seas of hot water temperature and even cold, what makes them be most often ranked among the cosmopolitans of the sea. On the contrary, stenothermic that provided a narrow tolerance to water temperature fluctuations is limited in scope to the space of constant temperature with narrow amplitude [Huntley, Lopez 1992, Dzieżbicka-Głowacka 2004].

In addition to temperature, salinity is the second factor that plays an important role in the distribution of aquatic organisms. In Baltic Sea, salinity value decreases in both surface and bottom layers, from the west to the east and then towards the north. The result is a decrease in diversity of marine species in the same direction. This factor is also caused the zooplankton in Baltic Sea being poor in species, and each salty water group in Baltic Sea has single representative [Vuorinen et al. 1998]. Baltic waters characterized by differences in relation to the average salinity, this allow only life for euryhaline species, little sensitive and adapted to changes in saltiness, while stenohaline species, sensitive to changes in salinity is difficult to adapt in saline environment and therefore there are few in number or quickly die out [Schernewski, Schiewer 2002, Telesh et. al 2011]. Salinity, which was a factor in the history of Baltic Sea modeling plant and animal, causes impoverishment and sometimes abundant forms of marine or freshwater [Chojnacki et al. 1986, Grzeszczyk-Kowalska et. al 2012].

Following temperature and salinity, ocean currents play an important role in the horizontal distribution of organisms in the water column. Currents play an important role in plankton distribution which is a biological indicator of water masses in which the plankton exists, nutrition and reproduction. With the currents forced by winds from the northern direction, in the surface waters of the southern Baltic plankton appear typical of cold sea water and are mainly species of the order Copepoda: *Limnocalanus grimaldii* and *Calanus finmarchicus* [Radziejewska et al. 1973, Chojnacki 1976, Habashi et al. 2012].

Light is another environmental factor penetrating water column that causes quantitative and qualitative changes in the vertical direction and as such affect the ecological diversity of hydrobionts [Zielinski 2000]. Major changes in composition of the surface plankton during the day and night are caused vertical migrations which are largely dependent on the water transparency and the position of the sun at different times of the day, this creates specific exposure conditions, and in turn bring changes in the ecological factors, thermal, and other nutrients [Ohman et al. 1983, Habashi et al. 1993, Chojnacki et al. 2010]

Baltic Sea phytoplankton is very poor in species, due to its low salinity and water temperature in winter. Based on years of research 91 species of algae were found. Phytocoenoses planktonic species are not only permanent but also immigrants who enter Baltic Sea with infusions from the North Sea, which often are lost when the salinity drops below their tolerance [Mańkowski 1978, Chojnacki et al. 2007]. High concentrations of phytoplankton in the warm season are accompanied by relatively high production of zooplankton, an additional factor is flowing of water from the river with a large amount of impurities into the sea gets more and more nitrogen from human and land based activities - from fertilizer, which causes degradation of the coastal marine environment. Excess nitrogen increases blooms of phytoplankton and the distribution of the resulting excess organic matter reduces the oxygen content in water [Habashi et al. 1993, Duxbury et al. 2002].

OBJECTIVES

Szczecin Lagoon is a reservoir of variable conditions of habitat, caused by seasonal climatic conditions and the interaction between marine and inland waters. It is a II-row Odra River estuary characterized by a special structure of water with specific circulation. The main causes of the characteristic water circulation are primarily changes in water volume of river flow, changes caused by the "reverse" of marine water; besides, important role is played by other factors such as its topography, the direction, strength and frequency of winds and the shallow depth for easy mixing of waters. The aim of the study is:

- to determine the qualitative and quantitative structure of mesozooplankton in the II row of Odra River estuary,
- determination of mesozooplankton biomass,
- the influence of abiotic factors temperature and salinity on the density of mesozooplankton,
- determining the seasonal succession of mesozooplankton in the water of the II row Odra River estuary in 2003–2005.

STUDY AREA

Climatic conditions, the Lagoon shaped by the mid-latitude circulation and local circulation; Lagoon coincides with the breezes of the southern Baltic. The climate is very dynamic in terms of half cold weather lasting from October to March and the calmer, half warm from April to September. In the cold half-year strong fluctuations in atmospheric pressure were observed with annual average pressure of 1014 hPa [Cyberska 1980].

During the transitional period spring and summer are highlighted in the waters of the Baltic and the impact of the Lagoon on the air temperature. In spring it is a chilling effect and autumn is warmer than the sea in the hinterland [Cyberska 1980]. Due to the geographic location, the climate in the vicinity of the sea water area is characterized by high humidity in the range 75–90%.

Cloud is an element which is characterized by high volatility. During the year, most cloudy months are November and December, and the clearest-May and June [Cyberska 1980].

Szczecin Lagoon lies within humid and moderately warm climate (relatively warm summers and mild winters) [Bronk 1990]. It is the warmest region of Baltic Sea. Maximum air temperatures are recorded in July and reach to 36°C; the lowest occur in January and are -24°C. During the transitional periods spring and summer are highlighted the impact of the Baltic water and the Lagoon on air temperature. In the spring it is a chilling effect and autumn is warmer than the sea in the hinterland. Climate is characterized by high humidity in the range of 75–90%. Cloud is an element which is characterized by high volatility. During the year, most cloudy months are November and December, and the most cheerful-May and June [Cyberska 1980].

HYDROLOGICAL CONDITIONS

The Szczecin Lagoon is water powered mostly by the Odra River. Its share of the river flow is about 97%. Long-term average flow of the waters of the Odra in Gozdowice is 545 $m^3 \cdot s^{-1}$, which gives 17.2 $km^3 \cdot year^{-1}$ [Buchholz 1990].

Another important source of water inflow to the Lagoon is the Pomeranian Bay. Water circulation in the Szczecin Lagoon is controlled by the supply of river water and sea water inflow, caused by the difference between the sea and the Lagoon. Important role in water circulation is played by lagoon bottom morphology. The hollow trough between the two parts of the Lagoon water affects the EW direction, track shipping and promotes the penetration of marine waters to the south, up the mouth of the Odra [Robakiewicz 1993]. Water currents in the Lagoon are characterized by generally low speeds about 0.05 $m \cdot s^{-1}$ the strongest current are recorded at the entrance to the Canal Piast an average of 0.20 $m \cdot s^{-1}$. At the bottom it was measured at 0.30 $m \cdot s^{-1}$, and on the surface of 0.25 $m \cdot s^{-1}$ [Osadchuk 2004].

Salinity

Seasonal changes in water salinity during the year are closely related to the annual cycle of river water inflow to the Lagoon. After melting the ice, water salinity is rapidly decreased in the spring with an increase in the flow of river water, and then starting from June an increase in salinity till summer and reaching maximum during the November storms, causing marine waters flowed into the Lagoon. Considering the seasonal changes in salinity, three groups of data points with different characteristics can be distinguish: flood plain at the mouth of the straits to the Pomeranian Bay (average of 2.5–5.5 PSU), within the Bay (0–2 PSU) and in the estuary section a slight variation of salinity in a row a few tenths per thousands [Majewski 1980].

Oxygen level concentration

The oxygenation of flood water is also subject to seasonal variations. Winter is a time when in Szczecin Lagoon worst conditions of oxygen are recorded, which is caused by a large consumption of oxygen for life processes and contamination. The spring season is a sharp increase of oxygen concentration throughout the Lagoon. In summer the subsurface layers observed significant super saturation with oxygen. In autumn the oxygen concentration increases slightly, but the degree of saturation decreases [Młodzińska 1980].

Water color and transparency

Water color and transparency are equally important as hydrological factors. The color of water can vary from yellowish-green to brown. The estuary stretches Straits recorded the highest and lowest water transparency range of: 0.4 and 6.4 m. In the mouth of the Odra river the brown color with high turbidity and transparency, not exceeding 0.7 m dominates, but on the fairway, the water has a relatively high transparency [Nowak 1980].

Nutrients

Large amount of biogenic components, mainly phosphorus and nitrogen Flows into the Lagoon. According to data of the State Inspectorate for Environmental Protection [2004], taking account of domestic sewage and industrial agglomeration of Szczecin and Chemical Plant in "Police", the total load of phosphorus entering the lagoon is approximately 5730 T·year^{-1}, and the nitrogen of about 38 430 T·year^{-1}.

The studies have shown that the majority of that load flows through the reservoir and then into the Pomeranian Bay [Meyer et al. 1998, Lampe 1999]. The study also shows that retention of nutrients in the lagoon is very slow and reaches only 2–5% of the total annual load. Yearly accumulated in the sediments of the Lagoon is about 510 T nitrogen and 76 T phosphorous.

SAMPLING LOCATIONS

Complex hydrological conditions of the Szczecin Lagoon and the seasonal changes in the intensity of biological and hydrological processes were the basis for determining five sampling stations (Figure 1), located in the following geographical positions:

Fig. 1. Map showing sampling locations and its coordinates in the II row of Odra River estuary during 2003–2005 [Tyluś 2006]

Name of station	Latitude	Longitude
Z1	53°31'41" N	14°38 ,12" E
Z2	53°37'46" N	14°34 ,96" E
Z3	53°47'48" N	14°29 ,41" E
Z4	53°45'08" N	14°26 ,34" E
Z5	53°42'30" N	14°26 ,93" E

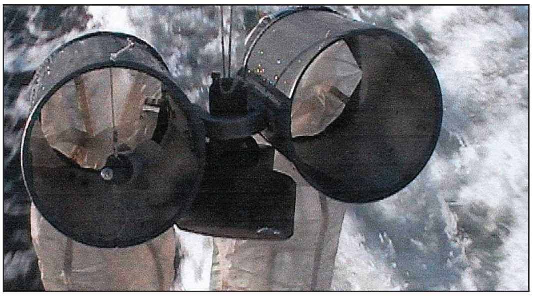


Fig. 2. Bongo net mounted with a flow meter of type General Oceanic and view of the sampling locations at the II-row of the Odra River estuary [Tyluś 2006]

MATERIAL AND METHODS

Fieldwork was conducted from June 2003 to July 2005 according to the method described in Standard Methods 2001, Accor. to Rise et al. [2012], and samples were collected on the following dates: 13.06.2003, 07.08.2003, 18.11.2003, 16.03.2004, 08.06.2004, 30.07.2004, 17.11.2004, 27.04.2005, 13.06.2005 and 20.07.2005. During the study the craft of Voluntary Water Rescue Service in Szczecin were used; the sampling locations were determined during each trip using Garmin GPS MAR76S. Water samples was collected with the use of Niskin sampler with 8L capacity form 1m below surface and 1 m above bottom, while the temperature was measured with accuracy of 0.01°C, and for pH used pH-meter WTW pH 325, and Secchi 20 cm black and white disk for water transparency.

Plankton samples were collected with the use of Bongo plankton net with Ø = 20 cm and mesh size of 80μm opening [Heral et al. 1976], it was equipped with a flow meter of type General Oceanic with velocity curves No. 2030 and 2031 (Fig. 2). Pelagic hauls were made for 10 minutes from bottom to surface at an average boat speed of about 3 knots. The Plankton samples were fixed with Lugol's iodine solution [Guziur et al. 2003] and then preserved with a solution of 70% ethanol.

Chemical analysis

Chemical laboratory analysis was conducted based on standard methods recommended by Standard Methods [2001], Accor. to Rise et al. [2012].

Biological analysis

Selected biological sample, depending on the density, divided in Folsom divider [McEvan et al, 1954] from 2 to 10 times to obtain a representative sub-sample containing at least 400 individuals. Then, for each subsample collected material in its entirety transferred to Bogorov chambers. A stereo microscope was used for qualitative and quantitative evaluation of the test material. The density of individuals in a 1m^3 was calculated according to formulas [Odum 1982, Chojnacki et al. 2007, Tyluś 2006, Habashi et al. 2012]:

$$L = l_n \times 2^n / V \text{ [ind. m}^{-3}\text{]}$$

where: L – taxon abundance in the water capacity unit [ind. m^{-3}], l_n – number of individuals in the sub-sample, n – number of dilutions of the original sample in Folsom's sample splitter, V – capacity of water filtered through the mesh [m^3].

$$V = M \times F \times r/2.66 = 0.000118 \times M$$

where: M – number of full log revolutions during the mesh operation under water, F – surface of mesh tube inlet 0.0314 [m^2], r – mesh tube radius 0.1 [m], 2.66 – constant for a log with speed curves 2030 and 2031 (General Oceanics).

SEASONAL SUCCESSION OF MESOZOOPLANKTON

Seasonal variability of environmental conditions in the temperate zone is the cause of periodicity in the growth of plankton. The occurrence of plankton in different seasons is dependent on the length of life cycles and development, and sensitivity to abiotic factors, especially the changes in water temperature and salinity. Thus, variation in species composition and density is highly expressed in aquatic ecosystems of climatic zones with clearly marked seasons [Chojnacki 1987b, Tarwid 1988, Habashi et al. 1993].

The study of the II-row of the Odra River estuary water in 2003–2005 confirm that the greatest impact on the structure of planktonic zoocenosis had temperature and salinity, which is also found in relation to estuarine waters [Różańska 1963, Chojnacki 1991, Szlauer 1994, Gasiūnaité, 2000, Mouny & Dauvin 2002, Telesh 2004]

After conducting a statistical analysis adopted by Stanisz [2001] the following Guo et al. [2003], demonstrated the existence of positive correlation between an increase in estuarine salinity and species richness. However, in the case of the II-row Odra River estuary in 2003–2005, this situation is not confirmed (Fig. 3, 4, 5 and 6).

RESULTS AND DISCUSSIONS

Diagram of seasonal succession of mesozooplankton in II-row Odra River estuary waters during 2003–2005 was as follows: spring was dominated by cladocerans *Daphnia cucullata* and its average density was 45 129 ind. m^{-3}, was also a subdominant *Diaphanosoma brahyurum* with 6636 ind. m^{-3}, while in summer season was still dominated by *Daphnia cucullata* with 48258 ind. m^{-3}, and so when the salinity was the lowest and amounted to about 0.3 PSU, and the highest water temperature that varies between 17–23 °C (Fig. 7, 8).

a)

b)

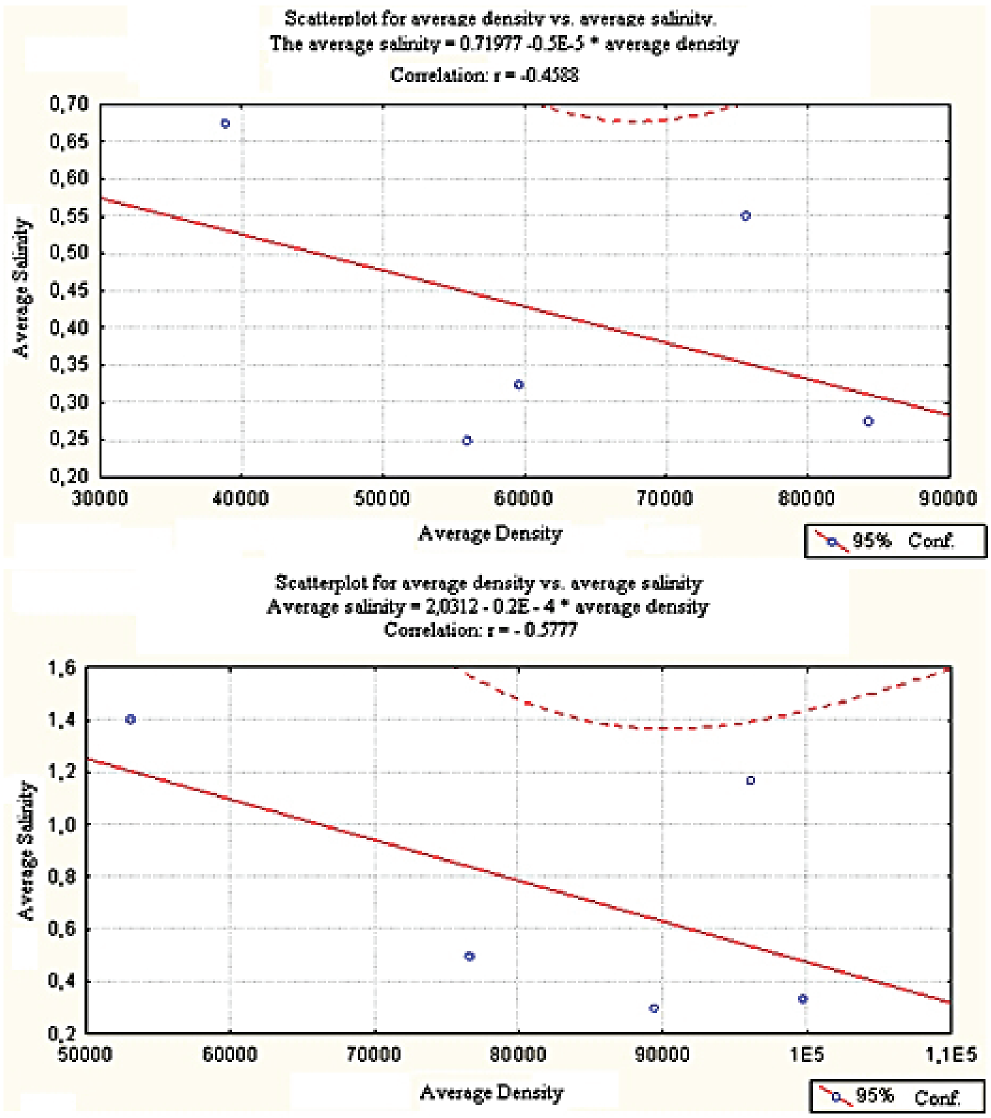
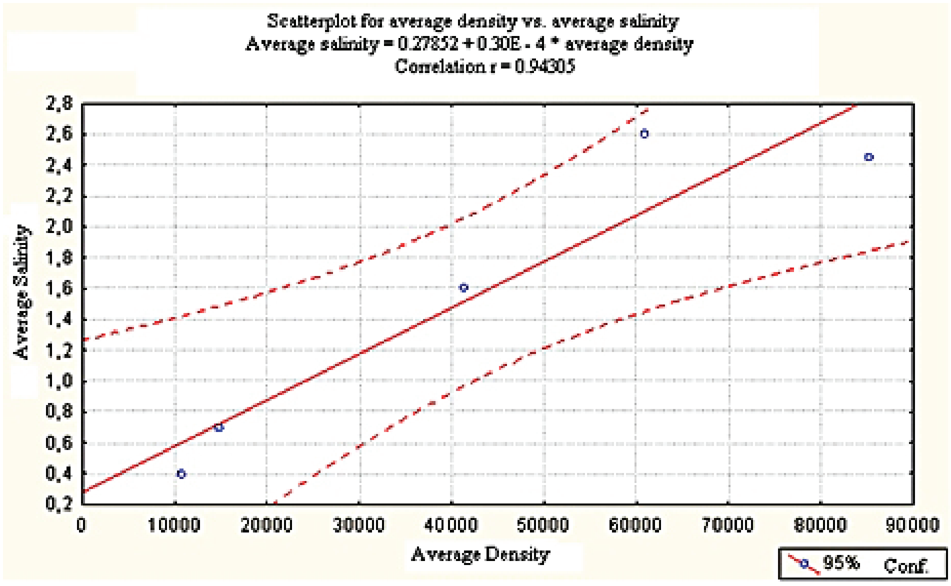


Fig. 3. Correlation between average mesozooplankton density and average salinity in the II row of the Odra River estuary in 2003–2005 (a – spring, b – summer) [Tyluś 2006]

a)



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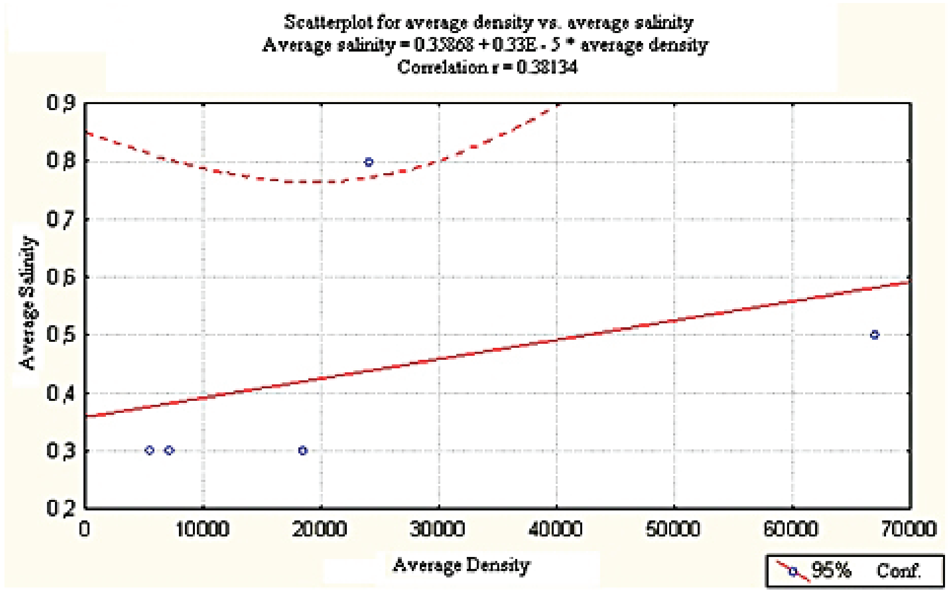


Fig. 4. Correlation between average mesozooplankton density and average salinity in the II row of the Odra River estuary in 2003–2005 (a – autumn and b – winter) [Tyluś 2006]

At that time there were also subdominant cladocerans *Diaphanosoma brahyurum* (28 747 ind. m^{-3}) and *Bosmina longirostris* (28 330 ind. m^{-3}). Taking over the dominance of autumn copepods *Eurytemora affinis* (4433 ind. m^{-3}) and the cladocerans *Daphnia cucullata* subdominant passed in position with a significantly lower density than in the previous seasons (3561 ind. m^{-3}).

In winter, there was another dominant rowing *Daphnia longispina* (1583 ind. m^{-3}) and subdominant classified copepods *Cyclops spp* (1476 ind. m^{-3}) (Fig. 7).

Meanwhile, the seasonal pattern of succession in the coming sea-waters of the southern Baltic arranged so that the Copepods were dominant during the cold seasons, while Cladocera in summer [Chojnacki 1984, 1991, Feike et al. 2007], a similar situation occurred in Szczecin Lagoon in autumn and winter when it was dominated by Copepods (Fig. 7, 8) [Chojnacki 1987a]. Dussart and Defaye [2001] and Telesh et al [2011] believe that Cladocera always dominate in freshwater while Copepods dominate in marine water. Such conditions existed in Szczecin Lagoon, which confirmed these authors' thesis, the more so, in these waters influx of saline water in autumn and winter was generally more noticeable with a distinct increase in salinity and temperature decreases, which created conditions for the seasonal dominance of Copepods in Szczecin Lagoon, but not in II-row Odra River estuary which is characterized by a strong majority of episodes of freshwater and

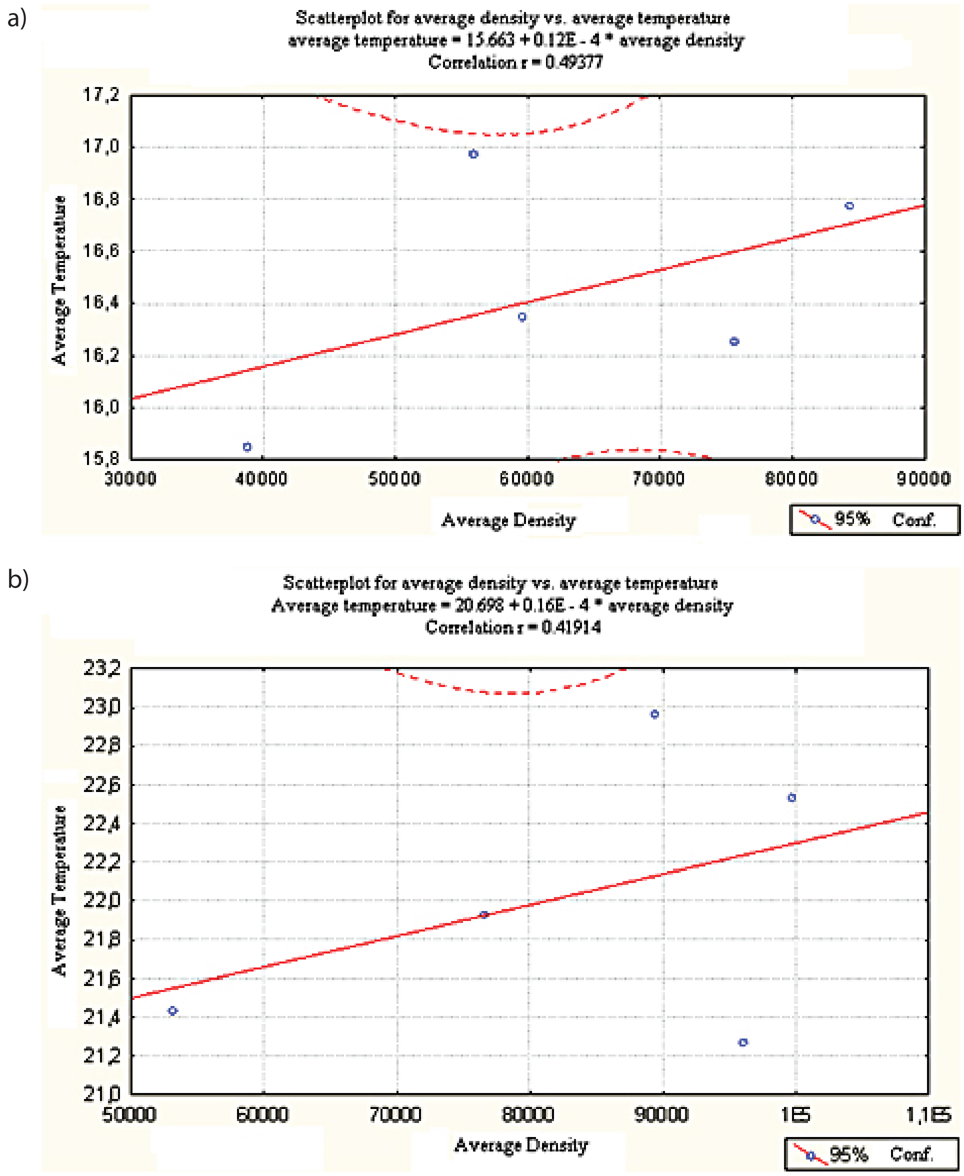


Fig. 5. Correlation between average mesozooplankton density and average water temperature in the II row of the Odra River estuary in 2003–2005 (a – spring, b – summer) [Tyluś 2006]

brackish water even during saline backwater from Baltic Sea (Fig. 8) [Chojnacki 1987a, Feike et al. 2007, Feike, Heerkloss 2008].

Figure 9 shows the simplified pyramid of potential productivity of hydrobionts at the II row of the Odra River estuary expressed in ton /year during 2003–2005, based on a 15% transfer efficiency of biomass to the trophic levels after Odum [1982] and Smith, Hollibaugh [1993]. Similar to remarks were made by Froneman [2001]. The overall results of this study suggest that the influence of the environmental factors examined in the study (i.e. temperature, salinity – Fig. 3–8) were relatively strong. However, these variables were assessed at a biomass level and community of bioseston level, where these variables are known to be important in structuring and conditioning the behaviour of organisms in estuaries [Chojnacki 1987a, 1991, Feike et al. 2007, Telesh et al. 2011].

Assuming that the efficiency of biomass and energy losses is moving to the next trophic level is 10–20% depending on trophic waters (these are eutrophic). Considering that mesozooplankton biomass consumers of the first order, as shown from the results of the years 2003–2005, which was evaluated respectively, phytocenosis plankton production and consumer manufacturing anticipated in II, III and IV row (predators) it was concluded that the transfer of biomass produced at different trophic levels from 2003 to 2005 decreased due to the harsh winters of 2003/2004 and 2004/2005 when water temperature in winter-spring season a)

b)

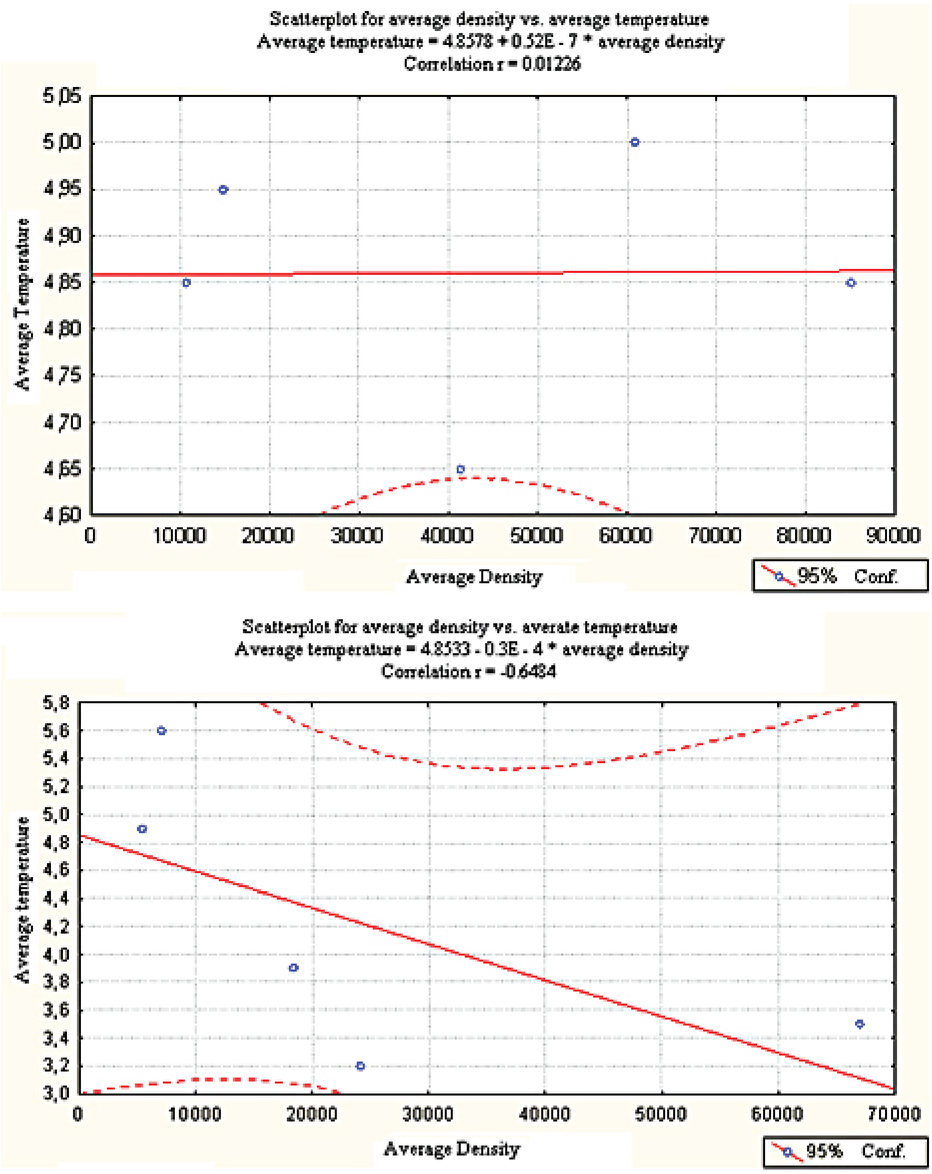


Fig. 6. Correlation between average mesozooplankton density and average water temperature in the II row of the Odra River estuary in 2003–2005 (a – autumn and b – winter) [Tyluś 2006]

was very low. Similar trends were also confirmed by independent results from commercial fishermen reflected fishing statistics on this area as shown in (Table 1) in the years 2004–2005.

The best results of fishermen catch in the II row Odra River estuary stem not only from lower productivity, but also due to:

1. Quantitative and qualitative data from the Regional Sea Fisheries Inspectorate in Szczecin,
2. Strict control during the periods of prohibited Fisheries for each season in this area,
3. Strong competition of predators and mainly great cormorants *Phalacrocorax carbo*, which in Poland and in EU Project Natura 2000 are on the red lists of protected animals [Głowaciński 1992, Chojnacki 1999].

The population of these birds great cormorants is estimated by ornithologists and ecologists for more than 10 000 individuals in whole area the II and III row of the Odra River estuary, they feed on expected 5400 tons of fish annually [Debout et al. 1995, Goostrey et al. 1998, Chojnacki 1999] – cormorant consume 672 g/day (predicted max. range 441–1095 g/day) per individual bird [Gremillet et al. 2003]. This is more than the total fish caught by commercial fishermen (Table 1), anglers and poachers. Despite these large “appetites” of predators, considerations provide a high productivity of this unique body of water [Newson et al. 2004]. The great cormorant is protected under Directive 79/409/EEC (the Birds Directive) and national jurisdictions.

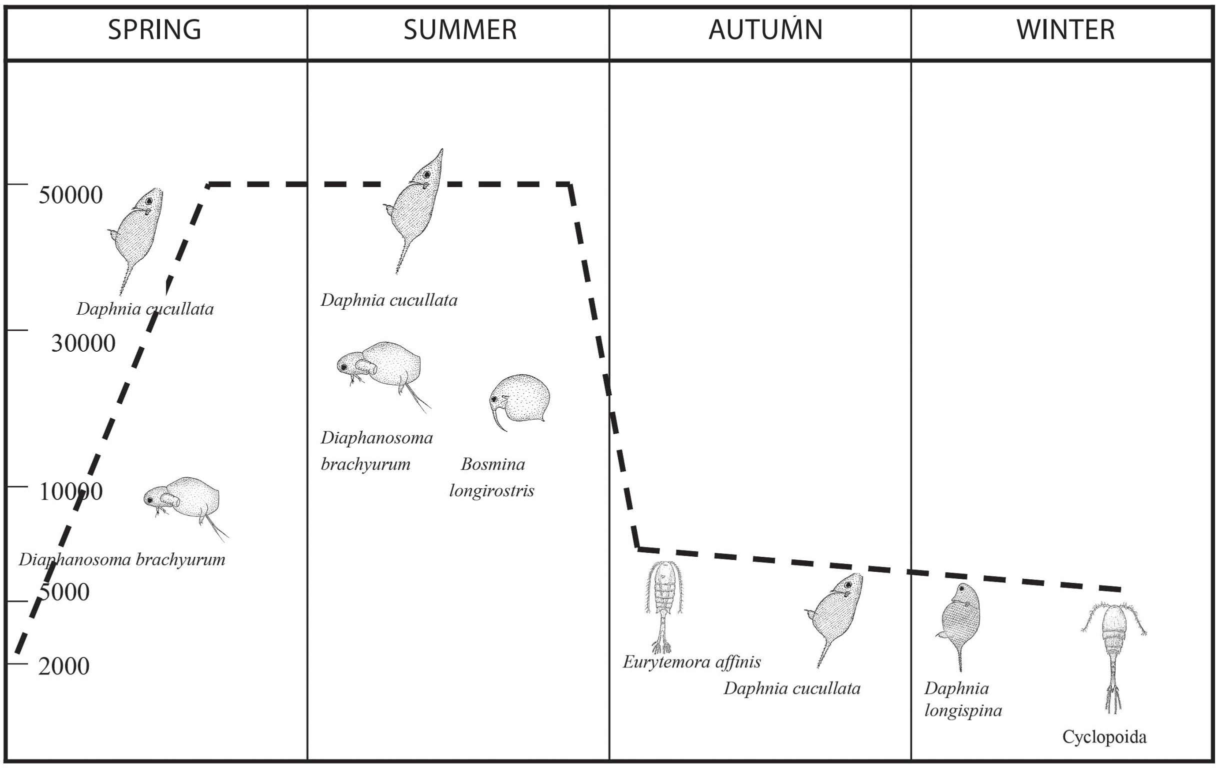


Fig. 7. Diagram of seasonal succession of Odra River ekotonos (II and III row of the Odra River estuary) during 2003–2005 based on its denisty (ind.$\cdot$m^3) [Tyluś 2006]

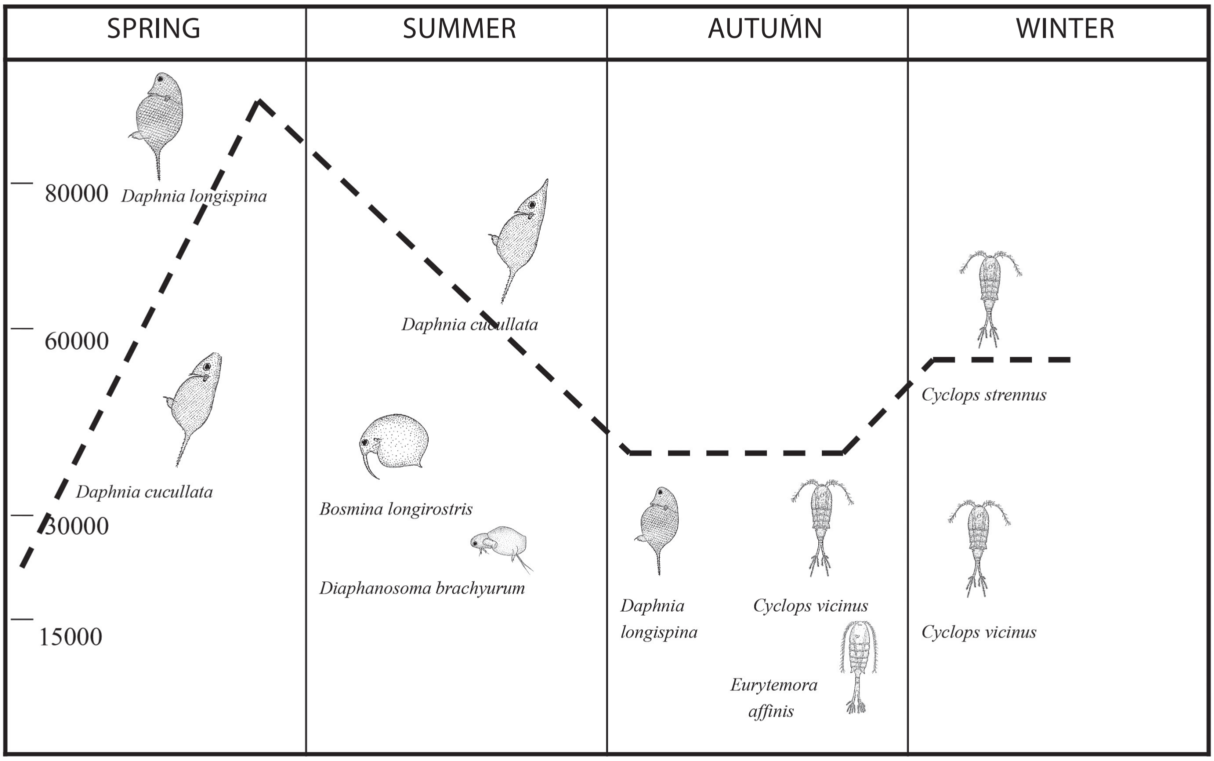
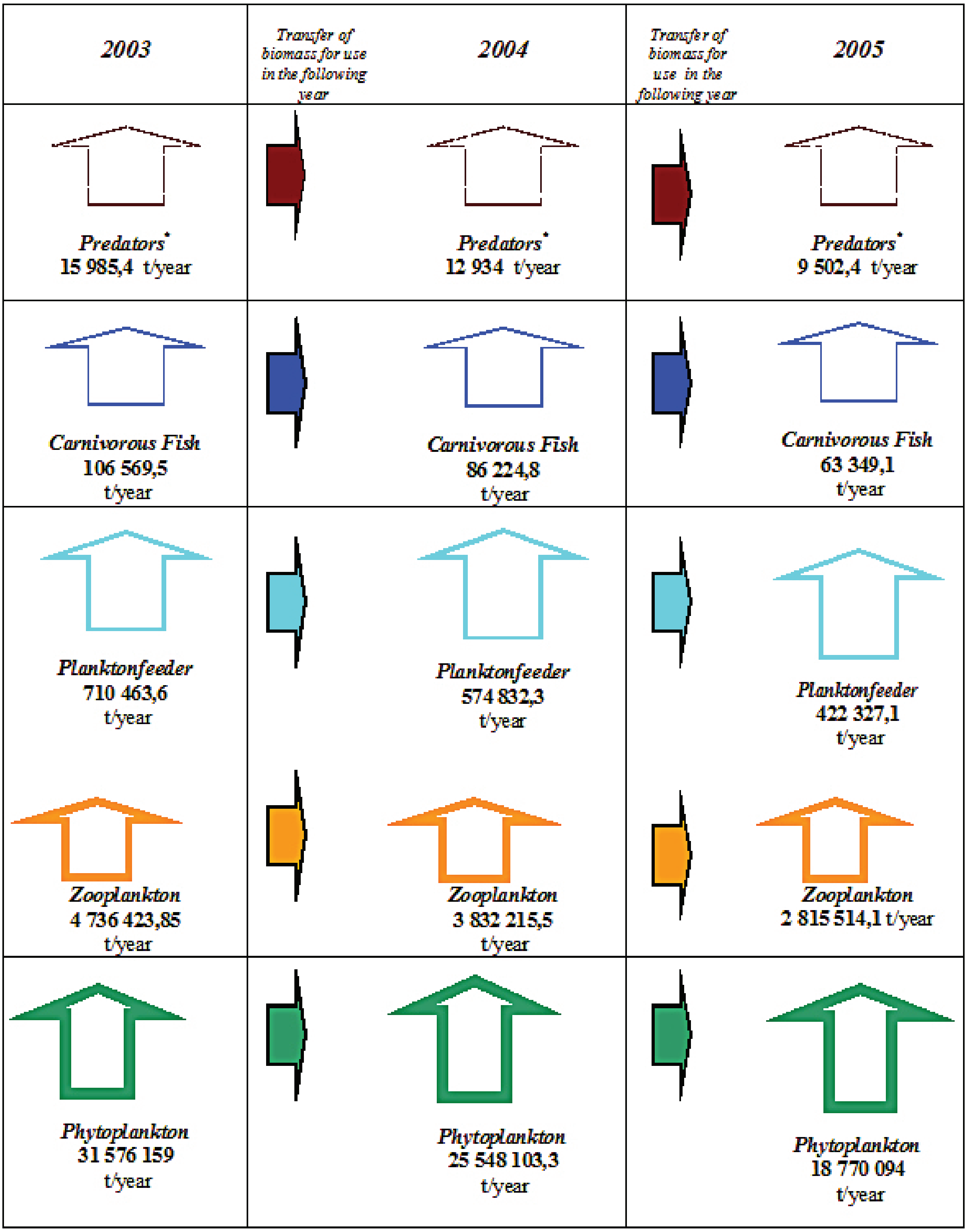


Fig. 8. Diagram of seasonal succession of mesozooplankton in Szczecin Lagoon during 2003–2005 based on its denisty (ind.$\cdot$m^3) [Tyluś 2006]



* Predators – birds "fish feeder" (including 10 thousand bird's population of black cormorants – *Phalacrocorax carbo* – in the season to consume 5400 tons of fish), poachers, anglers, professional fishermen.

Fig. 9. Simplified pyramid of potential productivity biomass of hydrobionts at the II row of the Odra River estuary in ton / year during 2003–2005, based on a 15% transfer efficiency of biomass to the trophic levels total area 479 km^2, mean depth 5 m [Smith, Hollibaugh 1993, Tyluś 2006, Habashi et al 2012]

Table 1. Summary of the annual catch in Szczecin Lagoon during the years 2004–2005 expressed as ton/year. Data collected as personal communication from the Regional Sea Fisheries Inspectorate in Szczecin and from the head of Sea Fisheries Department M.Sc. J. Doerman

List of species	2004	2005
Pikeperch - *Stizostedion lucioperca*	63.7	37.6
European neel - *Anguilla anguilla*	34.6	29.4
Perch - *Perca fluviatilis*	539.4	429.5
Bream - *Abramis brama*	840.4	615.6
Roach - *Rutilus rutilus*	1192.8	956.3
White bream - *Blicca bjoercna*	40.0	25.8
Zope - *Abramis ballerus*	15.0	21.5
Pike - *Esox lucius*	9.5	5.7
Whitefish - *Coregonus lavaretus*	12.9	11.7
Catfish - *Silurus glanis*	0.5	0.3
Burbot - *Lota lota*	7.8	5.9
Asp - *Aspius aspius*	5.2	2.5
Knife - *Pelectus cultratus*	0.0	0.0
Brown trout - *Salmo trutta trutta*	3.4	2.7
Salmon - *Salmo salar*	0.2	0.045
Tench – *Tinca tinca*	1.1	1.4
Herring - *Clupea harengus*	20.9	0.6
All other freshwater fish	18.4	7.9
Total in year	2805.8	2154.4

CONCLUSIONS

Based on the study of the Odra River estuary in 2003–2005 and after examining and discussing the collected data and from (Figures 3–9 and Table 1) the following conclusions have been made:

1. There was no clear stratification in the lagoon.
2. During the 10 seasons climate study in the II row Odra River estuary in the presence of biological material found 27 taxa of the group: Cladocera (10), Copepoda (12), Rotatoria (4), Ostracoda (1), and meroplankton organisms which temporarily remain in the water column during its development cycle.
3. Cladocera were the dominant group, which are found in high density and their maximum number was 129 476 ind.$\cdot$ m^{-3}. Large impact on the density of mesozooplankton dominated by: *Daphnia cucullata* and *Daphnia longispina,* with total maximum number of 116 969 ind.$\cdot$ m^{-3}.
4. The relationship between water temperature, salinity and mesozooplankton density reflected in the values of species richness index, whose value decreased with changes in water temperature and salinity.
5. The density of planktonic organisms and their taxonomic structure, decisively influenced by water temperature. As temperature increase caused an increase in density of mesozooplankton.
6. Comparing the biomass of zooplankton of the II row Odra River estuary, it was noticed significant difference, as to its size. Biomass of mesozooplankton Lagoon was significantly higher, comparing to the biomass of mesozooplankton of the II row Odra River estuary, which could be related to such greater inflow of nutrients into the Szczecin Lagoon and the increased growth of phytoplankton**.**
7. The transfer of biomass produced at different trophic levels from 2003 to 2005, decreased due to the harsh winters of 2003/2004 and 2004/2005 in which very low water temperature in winter-spring season was. Similar trends were also confirmed by fishing statistics on this area, this findings is not only due to lower productivity, but also due to: a – Strict control during the periods of prohibited Fisheries for each season and b – strong competition of predators and mainly Cormorants, which in Poland are on the red lists of protected animals, it was estimated that they consume 5400 tons annually of the fish stock which was almost 2-fold of the fish caught in 2005 (Table 1).

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