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Seasonal variations of the zooplankton community in a littoral marine ecosystem: Toulon Bay (Var, France)

Variations saisonnières de la communauté zooplanctonique dans un écosystème littoral marin : la baie de Toulon (Var, France)

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Mots clés : *communauté zooplanctonique, distribution spatiale et temporelle, écosystème littoral marin.*

ABSTRACT

Jamet J.-L., A.-S. Ferec-Corbel, 1996 - Seasonal variations of the zooplankton community in a littoral marine ecosystem: Toulon Bay (Var, France). Mar. Life, **6** (1-2) : 15-20.

The aim of this research was to study the seasonal variations of the zooplankton community in Toulon Bay (Var, France). Two stations (S1 et S2) were chosen within the little bay (petite rade) and two others (S3 et S4) outside (La Garonne and Niel Bays, respectively). Zooplankton hauls were carried out once a month (October 1995 to July 1996, plankton net 90 µm mesh size, flowmeter). Copepods were dominant in all stations (> 87 % of total zooplankton). Oithona nana *was always largely predominant in the little bay while* Microsetella norvegica *was a typical species outside. Zooplankton density was much higher (average 21443 ± 16303 ind . m^{-3}) in the little bay, than outside (average 2894 ± 2404 ind . m^{-3}). The polluted conditions prevailing in the little bay seem to be the explanation of the results recorded.*

RÉSUMÉ

Jamet J.-L., A.-S. Ferec-Corbel, 1996 - [Variations saisonnières de la communauté zooplanctonique dans un écosystème littoral marin : la baie de Toulon (Var, France)]. Mar. Life, **6** (1-2) : 15-20.

Le but de ce travail était d'étudier les variations saisonnières de la communauté zooplanctonique dans la baie de Toulon (Var, France). Deux stations d'échantillonnage (S1 et S2) ont été choisies dans la petite rade ; deux autres (S3 et S4) étaient situées à l'extérieur (baies de La Garonne et du Niel, respectivement). Le zooplancton était échantillonné une fois par mois, d'octobre 1995 à juillet 1996, avec un filet à plancton de 90 µm de vide de maille, équipé d'un volucompteur. Les Copépodes étaient toujours dominants (> 87 % de la communauté). Oithona nana *était toujours largement prédominante dans la petite rade, alors que* Microsetella norvegica *était typique des eaux externes. Dans la petite rade, la densité zooplanctonique était très élevée (en moyenne 21443 ± 16303 ind . m^{-3}) contrairement à l'extérieur (en moyenne 2894 ± 2404 ind . m^{-3}). Les conditions de pollution régnant dans la petite rade semblent être à l'origine de ces résultats.*

INTRODUCTION

Most of the world population lives close to the coast, within 100 kilometres of bays and estuaries (Norse, 1993). The perturbations caused by human activities destroy or severely alter these littoral ecosystems (Schubel, 1994). Toulon Bay (central point Lat. 43° 5' N and Long. 6° 0' E, Var, France) is seriously affected by urban discharges from Toulon and its conurbation (*ca.* 200 000 inhabitants) because of the lack of a sewage treatment. The bay is also characterised by intensive

shipping traffic due to naval and commercial activities and is strongly influenced by organic, metallic, chemical and biological (toxic phytoplanktonic species) pollution (Guillaud, Romanà, 1991). As part of of the study of zooplankton diversity as an indicator of a perturbed ecosystem (Jamet *et al.*, submitted), this paper provides quantitative information on the zooplankton community in a littoral shallow marine ecosystem.

MATERIAL AND METHODS

Four sampling stations were chosen (figure 1) according to a decreasing gradient of human impact. Station 1 (5 to 10 m depth) and station 2 (8 to 20 m depth) were located in the "petite rade" of Toulon (little bay in this study) where *Posidonia oceanica* meadows were absent. In Station 3 (3 to 13 m depth, La Garonne Bay) and Station 4 (4 to 14 m depth, Le Niel Bay), *P. oceanica* was abundant. The occurrence of *P. oceanica* may be considered as an indicator of a mildly or not perturbed environment (Paillard *et al.*, 1993). Vertical zooplankton hauls were carried out once a month from October 1995 to July 1996. Samples were taken with a plankton net (diameter 0.5 m, length 2.5 m, 90 µm mesh size). The volume of filtered water (between 5.0 and 21.4 m^3) was measured by a flowmeter. Samples were immediately stored in buffered ($CaCO_3$) 5 % formalin seawater. Subsamples were randomly drawn using a Hensen pipette from the sample adjusted to 250 ml. All zooplankters were identified to the nearest taxonomic group (species level and development stage if possible) and counted.

RESULTS

Three species of Cladocera were present: *Evadne nordmanni*, *Evadne spinifera* and *Podon polyphemoide* (table I). The latter was dominant and occurred essentially during Winter (February and March) in the little bay (max. in March, 1552 ind . m^{-3}, 4.3 % of total abundance, S2) but was less abundant outside. The other Cladocera were observed sporadically. Among the Copepoda, 16 species and 6 genera (with unidentified species) were determined. They were strongly dominant throughout this study and made up at least 87 % of the total zooplanktonic community, except in May at station 3 (72.6 %) and in January at station 4 (72.6 %). *Oithona nana* was strongly dominant all the year in the little bay and its occurrence was lower outside; *Microsetella norvegica* was present only outside the little bay, except for a single specimen found at station 2 in July. In addition, our results showed that zooplankton density was much higher in the inner bay (of all data 21443 ± 16303 ind . m^{-3}) than outside (of all data 2894 ± 2404 ind . m^{-3}) (figure 2). In autumn (October-December), in the little bay, *O. nana* (all development stages counted together) was the dominant species (max. 21241 ind . m^{-3} in December, S2) and *Euterpina acutifrons* (max. 1221 ind . m^{-3} in December) was maximum at station 1. Outside the bay, the density of *O. nana* was much lower than inside (max. 3644 ind . m^{-3}, November, S3); *Acartia* spp. and *M. norvegica* were also abundant during this season (max. 1340 and 159 ind . m^{-3}, December, S3 and S4, respectively). In winter (January-March), in the little bay, *O. nana* was still dominant (max. 32095 ind . m^{-3}, February, S1) and *Acartia* spp. reached the maximum in January (1048 ind . m^{-3}, S1). Outside, the density of *O. nana* was severely reduced (max. 754 ind . m^{-3}, January, S3). *O. similis* presented its maximum in March (1231 ind . m^{-3}, S4). During spring (April-May), *O. nana* was always dominant in the little bay (39360 and 55132 ind . m^{-3}, April, S1 and S2, respectively) decreasing at the end of spring (May). *Acartia italica* showed its maximum density in April (1053 ind . m^{-3}, S2).

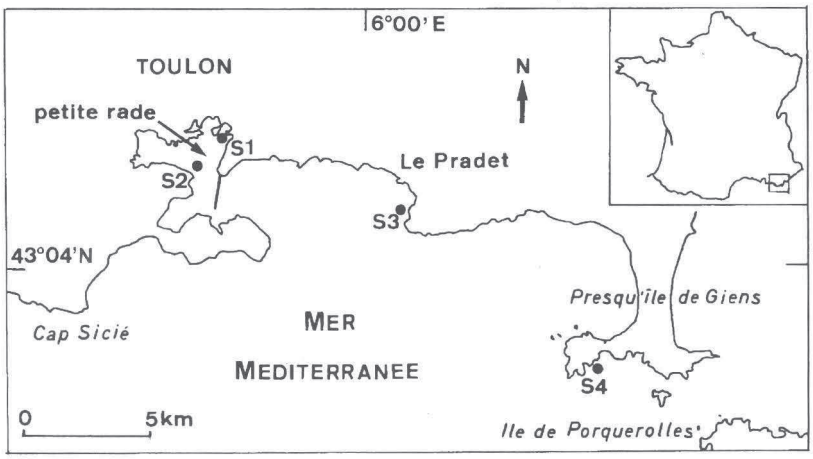

Figure 1 - Localisation of the four sampling stations (S1, S2, S3 and S4).
Localisation des stations d'échantillonnage (S1, S2, S3 et S4).

Table I - Monthly variations of the abundance (ind . m^{-3}) of the different taxonomic groups of the zooplankton community in Toulon Bay at the four stations (S1, S2, S3 and S4). / *Variations mensuelles de l'abondance (ind . m^{-3}) des différents groupes taxonomiques de la communauté zooplanctonique de la baie de Toulon aux quatre stations (S1, S2, S3 et S4).*

Taxonomic groups	Oct. 1995				Nov.				Dec.				Jan. 1996				Feb.			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
Evadne nordmanni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Evadne spinifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22 (2.3)	0
Podon polyphemoide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	331 (0.8)	205 (1.1)	0	0
Acartia clausi (adults)	0	0	0	0	0	0	0	28 (0.5)	51 (0.3)	0	0	0	0	0	0	0	0	0	0	0
Acartia clausi (copepodites)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acartia italica (adults)	0	125 (2.5)	29 (0.8)	29 (1.4)	0	0	241 (3.3)	112 (2.2)	356 (2.1)	377 (1.5)	0	0	48 (0.5)	307 (2.4)	0	0	110 (0.3)	68 (0.4)	0	0
Acartia spp. (copepodites)	0	376 (7.5)	606 (16.3)	230 (10.8)	241 (1.2)	656 (4.0)	934 (12.9)	1008 (19.8)	508 (3.0)	539 (2.1)	1340 (16.2)	95 (11.5)	1048 (11.0)	1009 (7.8)	636 (10.3)	192 (7.0)	662 (1.8)	342 (1.9)	43 (4.5)	43 (9.5)
Calocalanus spp. (adults + copepodites)	0	31 (0.6)	0	57 (2.7)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Candacia longimana (males)	0	0	0	0	0	0	0	28 (0.5)	0	0	0	0	0	0	0	0	0	0	0	0
Candacia longimana (copepodites)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clausocalanus furcatus (adults)	0	0	0	29 (1.4)	0	0	0	84 (1.7)	0	54 (0.2)	29 (0.3)	0	0	0	40 (0.6)	0	0	0	0	0
Clausocalanus spp. (adults)	0	0	0	0	0	0	0	0	51 (0.3)	0	0	0	0	0	0	0	0	0	0	0
Clausocalanus spp. (copepodites)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clytemnestra scutellata (adults)	0	0	0	0	0	0	0	0	51 (0.3)	0	0	32 (3.9)	0	0	0	0	0	0	0	0
Clytemnestra scutellata (copepodites)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Corycaeus spp. (adults + copepodites)	0	0	0	0	0	0	0	0	0	0	29 (0.3)	0	0	0	40 (0.6)	0	0	0	0	0
Euterpina acutifrons (adults)	122 (1.2)	94 (1.9)	202 (5.4)	86 (4.0)	604 (3.0)	0	301 (4.1)	56 (1.1)	814 (4.8)	270 (1.1)	87 (1.0)	0	48 (0.5)	132 (1.0)	40 (0.6)	0	110 (0.3)	0	43 (4.5)	0
Euterpina acutifrons (copepodites)	0	0	0	0	121 (0.6)	0	90 (1.2)	0	407 (2.4)	108 (0.4)	87 (1.0)	0	0	0	40 (0.6)	0	0	0	43 (4.5)	22 (4.8)
Microsetella norvegica (adults)	0	0	0	0	0	0	30 (0.4)	0	0	0	29 (0.3)	0	0	0	0	0	0	0	0	0
Microsetella norvegica (copepodites)	0	0	0	0	0	0	0	28 (0.5)	0	0	29 (0.3)	159 (19.2)	0	0	0	38 (1.4)	0	0	43 (4.5)	0
Oithona nana (females)	122 (1.2)	376 (7.5)	462 (12.4)	115 (5.4)	966 (4.7)	1604 (9.8)	1084 (14.9)	448 (8.8)	1068 (6.3)	8518 (33.5)	379 (4.7)	0	1429 (14.9)	1404 (11.0)	79 (1.3)	0	2868 (7.6)	1986 (10.6)	0	0
Oithona nana (males)	490 (4.9)	439 (8.8)	318 (8.5)	86 (4.0)	2414 (11.8)	510 (3.2)	271 (3.7)	0	2746 (16.3)	2588 (10.2)	233 (2.8)	0	0	746 (5.8)	79 (1.3)	0	551 (1.5)	205 (1.1)	0	0
Oithona nana (copepodites)	7531 (75.0)	2416 (48.1)	1386 (37.2)	230 (10.8)	8451 (41.4)	8748 (53.4)	2289 (31.4)	1316 (25.8)	7119 (42.4)	10135 (40.0)	1252 (15.1)	0	1857 (19.4)	2851 (22.2)	596 (9.7)	38 (1.4)	28676 (75.8)	12808 (68.1)	303 (31.8)	43 (9.5)
Oithona plumifera (males)	184 (1.9)	63 (1.2)	0	0	362 (1.8)	73 (0.4)	0	0	102 (0.6)	0	0	0	0	0	0	0	0	0	0	0
Oithona similis (adults)	0	0	0	0	0	73 (0.4)	30 (0.4)	84 (1.7)	0	54 (0.2)	233 (2.8)	0	0	44 (0.3)	40 (0.6)	0	0	68 (0.4)	22 (2.3)	0
Oithona similis (copepodites)	0	0	0	0	0	73 (0.4)	30 (0.4)	168 (3.3)	0	0	291 (3.5)	32 (3.9)	0	0	159 (2.3)	115 (4.2)	0	0	22 (2.3)	65 (14.3)
Oncaea media (adults)	0	0	0	0	0	0	0	28 (0.5)	51 (0.3)	0	0	0	0	0	0	0	0	0	0	0
Oncaea minuta (adults)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22 (4.8)
Oncaea spp. (copepodites)	122 (1.2)	157 (3.1)	0	0	483 (2.3)	437 (2.7)	0	0	51 (0.3)	108 (0.4)	553 (6.7)	159 (19.2)	95 (1.0)	263 (2.0)	80 (1.3)	577 (21.1)	331 (0.8)	68 (0.4)	86 (9.1)	65 (14.3)
Paracalanus parvus (adults)	0	0	0	115 (5.4)	0	0	90 (1.2)	112 (2.2)	0	54 (0.2)	58 (0.7)	0	0	0	0	0	0	0	0	0
Paracalanus parvus (copepodites)	0	0	0	0	0	0	0	0	51 (0.3)	0	0	0	0	44 (0.3)	0	0	110 (0.3)	0	0	0
Paracalanus spp. (copepodites)	0	0	0	115 (5.4)	0	73 (0.4)	0	140 (2.8)	0	54 (0.2)	117 (1.4)	32 (3.9)	0	0	40 (0.6)	38 (1.4)	0	0	0	22 (4.8)
Scolecithrix bradyi (adults)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temora stylifera (adults + copepodites)	0	0	0	29 (1.4)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cymbasoma tenuis (adults)	0	0	0	0	0	0	0	28 (0.5)	0	0	0	0	0	0	0	0	0	0	0	0
Nauplii *of Copepoda spp.*	1224 (12.2)	471 (9.4)	520 (14.0)	976 (45.9)	6519 (32.0)	3499 (21.3)	1867 (25.7)	1400 (27.6)	1220 (7.3)	1186 (4.7)	3437 (41.5)	286 (34.5)	4571 (47.7)	5044 (39.3)	3974 (64.7)	1731 (63.5)	3309 (8.8)	2260 (12.0)	259 (27.3)	86 (18.9)
Medusa larvae	0	0	0	0	0	0	30 (0.4)	0	0	54 (0.2)	0	0	0	0	0	0	0	137 (0.7)	0	0
Nematoda	61 (0.6)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polycheta larvae	122 (1.2)	0	87 (2.3)	29 (1.4)	0	73 (0.4)	0	28 (0.5)	102 (0.6)	0	58 (0.7)	32 (3.9)	190 (2.0)	175 (1.4)	199 (3.3)	0	221 (0.6)	137 (0.7)	0	65 (14.3)
Gasteropoda larvae	0	94 (1.9)	29 (0.8)	0	0	73 (0.4)	0	0	102 (0.6)	323 (1.3)	0	0	238 (2.5)	44 (0.3)	0	0	0	0	22 (2.3)	0
Bivalvia larvae	61 (0.6)	376 (7.5)	87 (2.3)	0	241 (1.2)	510 (3.2)	0	0	1983 (11.8)	916 (3.6)	0	0	0	439 (3.5)	79 (1.3)	0	331 (0.8)	342 (1.9)	22 (2.3)	0
Nauplii *of Cirripeda*	0	0	0	0	0	0	0	0	0	54 (0.2)	0	0	48 (0.5)	307 (2.4)	0	0	221 (0.6)	137 (0.7)	22 (2.3)	0
Amphipoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zoe larvae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Echinodermata larvae	0	0	0	0	0	0	0	0	0	0	58 (0.7)	0	0	44 (0.3)	40 (0.6)	0	0	0	0	22 (4.8)
Total of Cladocera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	331 (0.8)	205 (1.1)	22 (2.3)	0
Total of Copepoda	9795 (97.6)	4548 (90.6)	3523 (94.6)	2097 (98.6)	20161 (98.8)	15746 (96.0)	7257 (99.6)	5068 (99.5)	14646 (87.0)	24045 (94.7)	8183 (98.6)	795 (96.1)	9096 (95.0)	11844 (92.1)	5843 (94.8)	2729 (100.0)	36727 (97.2)	17805 (94.9)	864 (90.8)	368 (80.9)
Total other Invertebrates	244 (2.4)	470 (9.4)	203 (5.4)	29 (1.4)	241 (1.2)	656 (4.0)	30 (0.4)	28 (0.5)	2187 (13.0)	1347 (5.3)	116 (1.4)	32 (3.9)	476 (5.0)	1009 (7.9)	318 (5.2)	0	773 (2.0)	753 (4.0)	66 (6.9)	87 (19.1)
TOTAL	10039	5018	3726	2126	20402	16402	7287	5096	16833	25392	8299	827	9572	12853	6161	2729	37831	18763	952	455

Table I (continued) - Monthly variations of the abundance (ind . m^{-3}) of the different taxonomic groups of the zooplankton community in Toulon Bay at the four stations (S1, S2, S3 and S4). / *Variations mensuelles de l'abondance (ind . m^{-3}) des différents groupes taxonomiques de la communauté zooplanctonique de la baie de Toulon aux quatre stations (S1, S2, S3 et S4).*

Taxonomic groups	Mar.				Apr.				May				Jun.				Jul.			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
Evadne nordmanni	0	0	0	0	0	132 (0.2)	0	0	0	83 (2.2)	0	0	0	0	0	0	0	0	0	0
Evadne spinifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Podon polyphemoide	645 (3.1)	1552 (4.3)	0	0	0	0	0	0	0	0	0	34 (0.8)	0	120 (0.4)	0	0	0	0	0	0
Acartia clausi (adults)	0	0	0	0	0	0	0	0	158 (1.7)	0	24 (3.0)	0	41 (0.6)	0	0	0	0	0	0	25 (3.5)
Acartia clausi (copepodites)	0	0	0	0	0	0	0	0	53 (0.6)	991 (26.8)	0	0	123 (1.8)	120 (0.4)	0	0	0	0	0	0
Acartia italica (adults)	352 (1.7)	259 (0.7)	0	0	120 (0.3)	1053 (1.6)	0	0	263 (3.0)	413 (11.2)	0	68 (1.7)	123 (1.8)	240 (0.7)	0	0	130 (2.3)	363 (1.4)	27 (1.2)	0
Acartia spp. (copepodites)	2109 (10.1)	647 (1.8)	188 (10.8)	1077 (19.6)	720 (1.4)	2500 (3.7)	0	123 (7.6)	526 (5.8)	220 (5.9)	24 (3.0)	341 (8.6)	123 (1.8)	120 (0.4)	49 (5.7)	104 (4.7)	163 (2.9)	726 (2.9)	164 (7.6)	25 (3.5)
Calocalanus spp. (adults + copepodites)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Candacia longimana (males)	0	0	0	0	0	0	0	0	0	0	0	68 (1.7)	0	0	0	0	0	0	0	0
Candacia longimana (copepodites)	0	0	0	0	0	0	0	0	0	0	0	68 (1.7)	0	0	0	0	0	0	0	0
Clausocalanus furcatus (adults)	0	0	0	0	0	0	0	0	0	0	0	34 (0.8)	0	0	0	0	0	0	0	0
Clausocalanus spp. (adults)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clausocalanus spp. (copepodites)	59 (0.3)	0	0	0	0	0	0	0	105 (1.1)	0	0	34 (0.8)	0	0	0	0	0	0	0	0
Clytemnestra scutellata (adults)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	82 (3.8)	0
Clytemnestra scutellata (copepodites)	0	0	0	0	0	0	0	15 (1.0)	0	0	0	0	0	0	0	0	0	0	0	0
Corycaeus spp. (adults + copepodites)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49 (5.7)	35 (1.6)	130 (2.3)	0	82 (3.8)	25 (3.5)0
Euterpina acutifrons (adults)	176 (0.9)	0	188 (10.8)	128 (2.3)	120 (0.3)	263 (0.4)	0	0	0	0	24 (3.0)	102 (2.6)	0	0	24 (2.7)	35 (1.6)	0	0	0	0
Euterpina acutifrons (copepodites)	0	0	117 (6.8)	51 (0.9)	120 (0.3)	0	0	31 (1.8)	0	83 (2.3)	49 (6.1)	0	0	0	24 (2.7)	35 (1.6)	33 (0.6)	0	110 (5.1)	0
Microsetella norvegica (adults)	0	0	0	0	0	0	0	15 (1.0)	0	0	24 (3.0)	0	0	0	24 (2.7)	104 (4.7)	0	121 (0.5)	0	0
Microsetella norvegica (copepodites)	0	0	23 (1.3)	103 (1.9)	0	0	21 (3.6)	0	0	0	0	34 (0.8)	0	0	24 (2.7)	870 (39.0)	0	0	55 (2.5)	74 (10.3)
Oithona nana (females)	4395 (21.1)	5302 (14.6)	0	0	10800 (22.0)	6711 (10.1)	0	0	2947 (32.4)	193 (5.2)	0	0	1068 (15.5)	5160 (15.9)	24 (2.7)	35 (1.6)	911 (16.2)	2903 (11.4)	0	25 (3.5)
Oithona nana (males)	645 (3.1)	1940 (5.4)	0	0	3360 (6.8)	1053 (1.6)	21 (3.6)	0	789 (8.7)	0	0	0	492 (7.2)	2280 (7.0)	24 (2.7)	0	195 (3.5)	1935 (7.6)	0	0
Oithona nana (copepodites)	8145 (39.1)	22629 (62.5)	305 (17.6)	128 (2.3)	25200 (51.3)	47368 (71.0)	257 (44.6)	15 (1.0)	2526 (27.7)	716 (19.4)	98 (12.2)	0	2828 (41.4)	19320 (59.6)	98 (11.3)	0	2244 (39.8)	14516 (57.4)	164 (7.6)	50 (7.0)
Oithona plumifera (males)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oithona similis (adults)	0	0	0	77 (1.4)	0	0	0	0	0	0	0	68 (1.7)	41 (0.6)	0	0	0	0	121 (0.5)	0	0
Oithona similis (copepodites)	0	0	47 (2.8)	1154 (21.0)	0	0	0	62 (3.8)	53 (0.6)	275 (7.5)	24 (3.0)	580 (14.4)	0	0	24 (2.7)	0	33 (0.6)	0	0	0
Oncaea media (adults)	0	0	0	77 (1.4)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oncaea minuta (adults)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	121 (0.5)	0	0
Oncaea spp. (copepodites)	0	0	0	641 (11.7)	240 (0.4)	132 (0.2)	0	0	0	28 (0.7)	98 (12.2)	0	82 (1.2)	0	0	0	65 (1.1)	121 (0.5)	27 (1.2)	25 (3.5)
Paracalanus parvus (adults)	117 (0.6)	0	0	26 (0.5)	0	132 (0.2)	0	0	105 (1.1)	0	0	0	0	120 (0.4)	0	0	0	121 (0.5)	0	0
Paracalanus parvus (copepodites)	0	0	23 (1.3)	0	0	0	0	0	0	0	0	0	0	0	0	0	33 (0.6)	0	0	0
Paracalanus spp. (copepodites)	0	0	0	26 (0.5)	0	0	0	15 (1.0)	211 (2.3)	0	24 (3.0)	205 (5.1)	0	0	0	0	0	0	0	0
Scolecithrix bradyi (adults)	0	0	0	0	120 (0.3)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temora stylifera (adults + copepodites)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24 (2.7)	0	33 (0.6)	0	0	0
Cymbasoma tenuis (adults)	0	0	0	0	0	0	0	0	0	0	24 (3.0)	0	0	0	0	0	0	0	0	0
Nauplii *of Copepoda spp.*	3457 (16.6)	3362 (9.3)	797 (46.0)	1923 (35.0)	6480 (13.2)	4605 (6.9)	236 (41.0)	1231 (76.2)	1211 (13.3)	495 (13.5)	171 (21.1)	2011 (50.0)	0574 (8.3)	600 (1.9)	463 (53.0)	939 (42.1)	1106 (19.7)	2298 (9.1)	1288 (59.6)	344 (48.0)
Medusa larvae	234 (1.1)	0	0	0	0	0	0	0	0	28 (0.7)	0	34 (0.8)	287 (4.2)	1200 (3.7)	0	0	65 (1.1)	726 (2.9)	0	98 (13.7)
Nematoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polycheta larvae	117 (0.6)	0	23 (1.3)	26 (0.5)	600 (1.2)	132 (0.2)	21 (3.6)	0	0	28 (0.7)	0	0	164 (2.4)	480 (1.5)	0	0	163 (2.9)	121 (0.5)	0	0
Gasteropoda larvae	59 (0.3)	0	23 (1.3)	26 (0.5)	600 (1.2)	395 (0.6)	0	46 (2.8)	0	55 (1.8)	147 (18.3)	102 (2.6)	287 (4.2)	1560 (4.8)	0	70 (3.1)	98 (1.7)	605 (2.5)	110 (5.1)	25 (3.5)
Bivalvia larvae	293 (1.4)	0	0	0	480 (1.0)	1974 (2.9)	21 (3.6)	0	0	28 (0.7)	0	0	123 (1.8)	1080 (3.3)	0	0	0	242 (0.9)	55 (2.5)	0
Nauplii *of Cirripeda*	0	388 (1.1)	0	26 (0.5)	120 (0.3)	132 (0.2)	0	15 (1.0)	158 (1.7)	28 (0.7)	49 (6.1)	205 (5.1)	451 (6.6)	0	24 (2.7)	0	195 (3.5)	242 (0.9)	0	0
Amphipoda	0	0	0	0	0	0	0	0	0	0	24 (3.0)	0	0	0	0	0	0	0	0	0
Zoe larvae	0	0	0	0	0	0	0	46 (2.8)	0	0	0	0	0	0	0	0	0	0	0	0
Echinodermata larvae	0	129 (0.3)	0	0	0	132 (0.2)	0	0	0	28 (0.7)	0	34 (0.8)	41 (0.6)	0	0	0	0	0	0	0
Total of Cladocera	645 (3.1)	1552 (4.3)	0	0	0	132 (0.2)	0	0	0	83 (2.2)	0	34 (0.8)	0	120 (0.4)	0	0	0	0	165 (7.6)	0
Total of Copepoda	19455 (93.5)	34139 (94.3)	1688 (97.4)	5411 (98.5)	47280 (96.3)	63817 (95.7)	535 (92.8)	1507 (93.4)	8947 (98.3)	3414 (92.5)	584 (72.6)	3613 (89.9)	5493 (80.2)	27960 (86.3)	851 (97.3)	2157 (96.9)	5109 (90.8)	23346 (92.3)	1999 (92.4)	593 (82.8)
Total other Invertebrates	703 (3.4)	517 (1.4)	46 (2.6)	78 (0.5)	1800 (3.7)	2765 (4.1)	42 (7.2)	107 (6.6)	158 (1.7)	195 (5.3)	220 (27.4)	375 (9.3)	1353 (19.8)	4320 (13.3)	24 (2.7)	70 (3.1)	521 (9.2)	1936 (7.7)	0	123 (17.2)
TOTAL	20803	36208	1734	5489	49080	66714	577	1614	9105	3692	804	4022	6846	32400	875	2227	5630	25282	2164	716

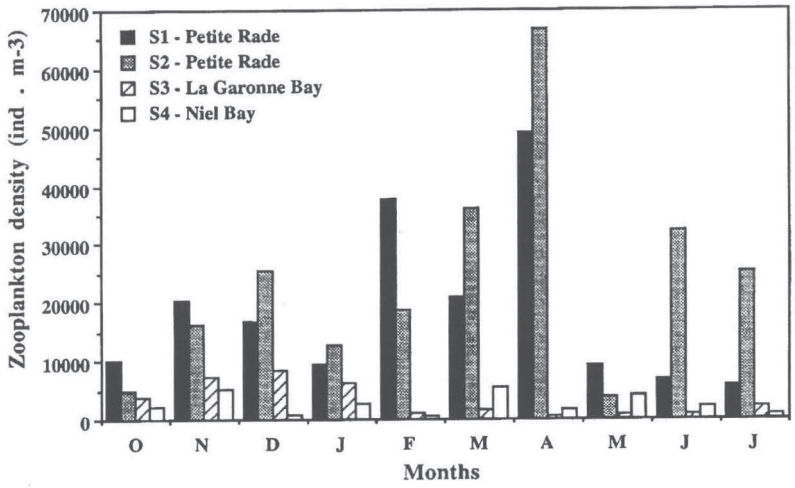

Figure 2 - Monthly variations of the total abundance of the zooplankton community in Toulon Bay (ind . m^{-3}) at the four stations (S1, S2, S3 and S4). / *Variations mensuelles de l'abondance totale de la communauté zooplanctonique de la baie de Toulon (ind . m^{-3}) aux quatre stations (S1, S2, S3 et S4).*

Outside, zooplankton density was very low during this season. *Acartia* spp. and *O. similis* were dominant (max. 341 and 648 ind. m^{-3}, May, S4, respectively). In summer (June-July), in the little bay, *O. nana* was the main species (max. 26760 ind. m^{-3}, June, S2). In June, the total zooplankton density was high with relatively high values (32400 ind. m^{-3}, S2) in the inner bay while in the Bays of La Garonne and the Niel, zooplankton density remained low (min. 716 and max. 2227 ind . m^{-3}, June and July, S4, respectively). *O. nana* was present at station 3 (max. 164 ind . m^{-3} in July) and *M. norvegica* was abundant (974 ind. m^{-3}, June, S4).

In this study, other Invertebrates were identified and we recorded 9 taxa, essentially at the stadium of larva; their abundance was low throughout this study (< 4 %), except in May when it reached 27.4 % of the total zooplankton community at station 3.

DISCUSSION

Copepods dominate the zooplankton community as classically recorded elsewhere in the world and particularly in the Mediterranean Sea (Ragosta *et al.*, 1995) and all the species listed in this study were inventoried by Razouls, Durand (1991), except for *Cymbasoma tenuis* (Monstrilloida) which has been rarely observed, at stations 3 and 4. This species was recently first recorded in the Mediterranean Sea by Suarez-Morales, Riccardi (in press). The quantitative analysis of the zooplankton community showed that the density was substantially higher inside the little bay than outside, particularly in the Niel Bay (S4) where density may be *e. g.* 83 times lower than the little bay (February). Contrary to Patriti (1984), who recorded a clear decrease in zooplankton numbers at heavely polluted stations, our results show that the highest zooplankton densities are found in the highly polluted little bay. In this system, *O. nana* strongly dominates throughout the year and we did not note marked seasonal preferences contrary to outside. According to other authors (Yamazi, 1964; Gaudy, 1971), *O. nana* develops well in brackish and polluted waters. Thus, subject to complementary studies, it is not excluded that this species may be used as an indicator of the polluted Toulon Bay. *A. italica* is also a characteristic species of the inner waters of the Toulon Bay in accordance with its distribution elsewhere in the Mediterranean bays or gulfs (Siokou-Frangou, 1996) but, to our knowledge, this species was mainly distributed at lower latitudes such as the North-West Mediterranean Sea, the South Adriatic Sea (Razouls, Durand, 1991) or the South Eastern Mediterranean Sea (Belmonte, 1996). In contrast, *M. norvegica* which was only found outside the bay, could be strongly sensitive to the anthropic perturbations characterizing the little bay.

Our results suggest that the qualitative and quantitative seasonal and geographical variations observed in Toulon Bay are linked to the anthropogenic pressure prevailing in this ecosystem such as naval and commercial harbour activities, urban and industrial discharges (heavy metals as mercury: Cossa (1994); hydrocarbons: Milano *et al.*, (1989). The presence of the large artificial breakwater reduces the water exchanges with the

off-shore water, thus adding to the semi-closed character of the inner bay. In conclusion, this study gives complementary information on the zooplankton compartment of a littoral polluted marine ecosystem structure, functioning and development are still whose relatively poorly known.

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