A C T A A D R I A T I C A
INSTITUT ZA OCEANOGRAFIJU I RIBARSTVO - SPLIT
SFR JUGOSLAVIJA

Vol. XVII, No. 12

INVESTIGATIONS OF COPEPODS IN THE COASTAL AREAS OF SPLIT AND ŠIBENIK

ISTRAŽIVANJA KOPEPODA U SPLITSKOM I ŠIBENSKOM PRIOBALNOM PODRUČJU

DUBRAVKA REGNER

SPLIT, 1977.

INVESTIGATIONS OF COPEPODS IN THE COASTAL AREAS OF SPLIT AND ŠIBENIK

ISTRAŽIVANJA KOPEPODA U SPLITSKOM I ŠIBENSKOM PRIOBALNOM PODRUČJU

Dubravka Regner
Institute of Oceanography and Fisheries, Split

INTRODUCTION

Up to now, copepods (one of the zooplankton groups quantitatively best represented) have been investigated at only one coastal station, the Bay of Kaštela, in the central Adriatic (Gamulin, 1939, 1968; Regner D., 1970, 1973, 1974 a, b, c, 1975; Vučetić & Regner, 1973).

All the other qualitative and quantitative data on the central Adriatic copepods (Gamulin, 1939, 1948; Regner, D., 1973, 1974 b, c, 1975) have been collected from a rather large number of stations in the channels among the Dalmatian islands and from the open sea. We can almost say that even more attention has been paid to the influence of the open sea on the coastal waters of the central Adriatic.

This preliminary paper reports the most recent data on the Split and Šibenik coastal areas. These areas were investigated with respect to the fact that the urban agglomerations along the coast are fastly growing. These developed recreational and industrial centres may have an influence on the marine environment such as to disturb the natural balance.

Copepods investigations formed part of the research of the Institute of Oceanography and Fisheries in Split carried out in this Adriatic region during the years 1972, 1973 and 1974.

DESCRIPTION OF THE AREAS STUDIED

Investigations in the area of Split included 4 stations, from the estuary of the river Žrnovnica to the small town of Kaštel Sućurac (fig. 1).

Station 6 (43° 31' O" N, 16° 19' 2" E) is a permanent coastal station in the middle of the Bay of Kaštela. Depth is 38 m (Vučetić, 1965).

Station 9 (43° 32' 2" N, 16° 19' 2" E) is placed in the industrial basin, in front of the town of Kaštel Sućurac. Depth is 29 m.

Station 10 (43° 29' 7" N, 16° 26' 3" E) is in front of the Split harbour. Depth is 46 m.

Station 11 (43° 29' 4" N, 16° 31' 9" E) is in front of the Žrnovnica estuary. Depth is 32 m.

In the area of Šibenik the stations extended from the island Zlarin to the lake Prokljansko (Fig. 2).

Station S-1 is in the outer part of the Šibenik channel, southwest of the island Zlarin. Depth is 61 m.

Station S-2 is in front of the recreational complex »Solaris«, adjacent to the coast. Depth is 5 m.

The narroer area of Šibenik included 3 stations. They are: station P-1 29 m depth, station P-2 30 m deep and station P-3 36 m deep.

Station P-10 is in the lake Prokljansko. Depth is 17 m.

MATERIALS AND METHODS

Material was collected from the area of Split during September and November of 1972, then during March, July and October of 1973 and during January of 1974. Thus we obtained the data on the seasonal cycle of copepods.

Material was collected from the area of Šibenik during June, August and November of 1973 and during February and April of 1974. Thus we also collected the data from all four seasons.

It is to be pointed out that the number of species is much lower when material is collected seasonally than it is when material is collected from month to month. The data from both areas are comparable because the seasonal cycle of copepods was observed at both of them.

Collections were made by planktonic »Hensen« type net (silk No 3). Vertical botom-surface hauls were applied (V u č e t i ć, 1965).

RESULTS AND DISCUSSION

THE AREA OF SPLIT

Station 6 — in the middle of the Bay of Kaštela

A total of 24 species was identified (Table 1) as well as two genera which we didn't determine.

According to the frequency of occurrence the always present species are: *Centropages typicus* and *Acartia clausi*. Then follow *Clausocalanus jobei, Ctenocalanus vanus* and *Temora stylifera* which were found in four out of six samples. *Centropages kröyeri, Oithona plumifera* and *Corycaeus typicus* were found in four of the samples. Several other species were occasyonally observed.

The already existing data collected over a period of several years (R e g n e r, 1970) indicate that, with respect to the frequency of occurrence, three copepod groups can be distinguished in the Bay of Kaštela. First group comprises copepods that are always present, the second those present ocassionally in the course of the year, and the third those occuring particularly rarely. This has been confirmed by the data presented in this paper, as well. Neritic copepod species occurred permanently. They are eurythermal and eury-

haline species well adapted to changing envinronmental conditions. The occasionally present species occurred over a larger part of the year, particularly over the colder one. Rarely occurring species were found from time to time and always as isolated individuals.

Table I — The composition of copepods at station 6
Tabela I — Sastav kopepoda po vrstama na postaji 6

	IX. 1972	XI. 1972	III. 1973	VII. 1973	X. 1973	I. 1974
copepods						
Calanus helgolandicus	0	0	0	0	0	—
Calanus tenuicornis	—	80	60	0	0	0
Mecynocera clausi	40	0	0	0	0	—
Paracalanus parvus	0	0	0	100	40	20
Paracalanus nanus	0	0	20	40	0	0
Calocalanus pavo	0	60	60	0	20	0
Clausocalanus mastigophorus	0	0	40	0	0	0
Clausocalanus arcuicornis	60	0	20	20	0	0
Clausocalanus jobei	60	180	40	40	0	80
Clausocalanus furcatus	0	440	0	40	500	0
Ctenocalanus vanus	120	0	140	340	80	480
Diaixis pygmaea	—	40	20	0	0	0
Temora stylifera	820	460	0	600	400	—
Temora longicornis	0	0	60	0	0	0
Centropages typicus	460	980	220	840	560	40
Centropages kröyeri	120	0	0	560	120	240
Isias clavipes	0	0	0	0	0	—
Lucicutia flavicornis	0	0	0	0	—	—
Candacia armata	40	0	0	—	0	—
Acartia clausi	140	680	100	740	120	460
Oithona sp.	100	0	60	420	0	160
Oncaea sp.	0	0	—	0	0	0
Corycaeus typicus	60	0	20	80	0	—
Corycaeus latus	40	0	20	0	0	0
Corycaeus brehmi	0	0	0	20	40	0
Corycaeus furcifer	0	0	0	0	—	—
copepodits	140	0	360	260	220	180

During the year number of copepod species varied with seasons from 13 to 19 (Table 5) with peak in autumn. The most frequently occuring species were at the same time the dominant ones with respect to the number of individuals (Table 6). *Centropages typicus* appeared to have the largest number of individuals in spring, *Centropages typicus, Acartia clausi* and *Temora stylifera* in summer, *Temora stylifera* and *Centropages typicus* in autumn, and *Ctenocalanus vanus* and *Acartia clausi* in winter.

Station 9 — Kaštel Sućurac

A total of 23 copepod species was identified at this station (Table 2). No attempt was made at determination of two genera also found here. Five species were present in all the samples. These included: *Clausocalanus jobei, Diaixis pygmaea, Centropages kröyeri* and *Oithona plumifera. Temora stylifera* and *Centropages typicus* were found in five of the samples and *Ctenocalanus vanus* in four. Other species occurred more rarely.

Table II — The composition of copepods at station 9
Tabela II — Sastav kopepoda po vrstama na postaji 9

	IX. 1972	XI. 1972	III. 1973	VII. 1973	X. 1973	I. 1974
copepods						
Calanus tenuicornis	—	0	—	0	0	—
Mecynocera clausi	0	0	0	0	0	—
Paracalanus parvus	20	100	0	0	0	20
Calocalanus pavo	0	0	—	0	0	20
Clausocalanus arcuicornis	0	0	0	0	40	40
Clausocalanus jobei	60	40	—	20	20	60
Clausocalanus furcatus	60	0	0	0	20	0
Ctenocalanus vanus	20	0	440	0	80	200
Diaixis pygmaea	80	40	—	20	0	—
Temora stylifera	600	40	0	40	680	40
Temora longicornis	0	—	0	0	0	0
Centropages typicus	140	0	40	320	140	60
Centropages kröyeri	460	800	820	320	1020	60
Lucicutia flavicornis	0	0	—	20	0	0
Candacia armata	0	60	0	0	0	0
Acartia clausi	380	1800	660	220	60	1520
Euterpina acutifrons	—	0	—	20	0	0
Clytemnestra rostrata	20	0	20	0	0	0
Oithona sp.	20	—	—	20	—	—
Oncaea sp.	20	0	0	0	0	0
Corycaeus typicus	120	0	—	0	0	—
Corycaeus giesbrechti	0	0	0	0	20	0
Corycaeus latus	0	—	0	0	0	0
Corycaeus brehmi	0	0	20	0	20	0
Corycella rostrata	—	0	0	0	0	0
copepodits	40	120	220	40	60	160

The number of copepod species varied between 8 and 20. The largest number of copepods was recorded during autumn just like at the station previously described.

Some species were noted to occur occasionally at this station. Of these *Centropages kröyeri* and *Acartia clausi* were most numerous in spring, *Centropages typicus* and *Centropages kröyeri* in summer, *Acartia clausi, Centropages kröyeri* and *Temora stylifera* in autumn, and *Acartia clausi* in winter (Table 6).

Some species were not recorded from the other stations but only from this one. They were *Euterpina acutifrons, Clytemnestra rostrata* and *Corycaeus giesbrechti.* Their presence at this station is not surprising because they are neritic species.

Table III — The composition of copepods at station 10
Tabela III — Sastav kopepoda po vrstama na postaji 10

	IX. 1972	XI. 1972	III. 1973	VII. 1973	X. 1973	I. 1974
copepods						
Calanus helgolandicus	0	0	0	20	0	0
Calanus tenuicornis	0	20	40	0	0	—
Nannocalanus minor	0	40	20	0	—	0
Eucalanus elongatus	20	20	0	0	0	0
Mecynocera clausi	20	0	0	0	—	—
Paracalanus parvus	60	20	140	80	0	—
Paracalanus nanus	0	0	0	20	0	0
Calocalanus pavo	0	120	20	0	0	0
Calocalanus plumulosus	0	60	0	0	160	0
Clausocalanus mastigophorus	0	0	20	0	0	0
Clausocalanus lividus	0	20	20	0	0	0
Clausocalanus arcuicornis	60	20	40	0	100	0
Clausocalanus jobei	220	220	20	160	40	40
Clausocalanus furcatus	60	380	20	0	840	0
Ctenocalanus vanus	60	120	360	400	20	80
Diaixis pygmaea	0	0	60	40	0	0
Temora stylifera	780	40	0	80	1220	0
Temora longicornis	0	0	20	40	0	0
Centropages typicus	300	160	240	540	—	60
Centropages kröyeri	180	0	0	0	0	0
Centropages violaceus	0	0	0	0	—	0
Lucicutia flavicornis	0	0	0	0	0	—
Candacia armata	60	20	0	0	0	20
Candacia tenuimana	0	20	0	0	0	0
Labidocera wollastoni	0	0	0	0	—	0
Acartia clausi	380	20	240	420	20	120
Oithona sp.	340	40	60	140	100	100
Oncaea sp.	0	20	0	0	0	0
Sapphirina sp.	0	0	0	0	—	0
Copilia mediterranea	0	0	0	0	—	0
Corycaeus typicus	40	60	0	0	—	20
Corycaeus latus	0	0	0	60	40	0
Corycaeus brehmi	20	60	0	0	0	0
Corycella rostrata	0	80	0	0	—	0
copepodits	0	160	380	720	120	80

Station 10 — in front of the Split harbour

Material comprised 31 species and two genera. This number of species was the highest one compared to the other stations (Table 3). Study of the frequency of occurrence showed *Clausocalanus jobei, Ctenocalanus vanus, Centropages typicus* and *Acartia clausi* as permanently present species. *Paracalanus parvus* occured in five of six taken samples, and *Clausocalanus furcatus, Temora stylifera* and *Corycaeus typicus* in four of them.

The number of copepod species ranged from 10—26 during the year. The highest concentrations were also recorded in autumn (Table 5). *Ctenocalanus vanus, Centropages typicus* and *Acartia clausi* were the most numerous species in spring, *Centropages typicus, Acartia clausi* and *Ctenocalanus vanus* in summer, *Temora stylifera* and *Clausocalanus furcatus* in autumn, and *Acartia clausi* in winter.

Six copepod species identified at this station are otherwise normally classified as deep-sea species. They occur in the open sea, and in the course of a year, predominantly or at least occasionally, in deeper layers. These are *Eucalanus elongatus, Clausocalanus lividus, Centropages violaceus, Labidocera wollastoni* and *Copilia mediterranea.* The occurrence of these species can indicate the rate of open sea influence on this station.

Station 11 — estuary of the river Žrnovnica

A total of 28 copepod species and two genera were found (Table 4). No one of these species was found in all the samples. Five samples comprised the species *Clausocalanus jobei, Clausocalanus furcatus, Ctenocalanus vanus, Temora stylifera* and *Acartia clausi. Diaixis pygmaea* were found in four samples. The remaining species occurred rather rarely.

Species number varied from 12 to 17 during the year. It was considerably lower than the number of species at other stations (Table 5).

Table IV — The composition of copepods at station 11
Tabela IV — Sastav kopepoda po vrstama na postaji 11

	IX. 1972	XI. 1972	III. 1973	VII. 1973	X. 1973	I. 1974
copepods						
Calanus helgolandicus	0	0	0	20	0	0
Calanus tenuicornis	0	40	40	20	0	0
Nannocalanus minor	0	0	0	20	0	—
Mecynocera clausi	0	0	0	0	—	—
Paracalanus parvus	0	0	100	100	0	20
Calaoalanus pavo	0	100	0	0	0	0
Calocalanus plumulosus	0	0	0	0	0	20
Clausocalanus mastigophorus	0	40	0	40	0	0
Clausocalanus arcuicornis	0	0	—	0	—	20
Clausocalanus jobei	0	440	20	20	40	40
Clausocalanus parapergens	0	0	40	0	0	0
Clausocalanus furcatus	60	100	0	60	100	20
Ctenocalanus vanus	0	280	80	20	280	40
Diaixis pygmaea	0	—	—	0	—	40
Temora stylifera	380	40	0	60	220	—
Centropages typicus	0	0	60	260	60	0
Centropages kröyeri	60	0	0	0	20	0
Isias clavipes	0	0	0	0	0	20
Lucicutia flavicornis	0	0	0	0	0	20
Candacia armata	0	—	0	0	—	—
Pontella lo biancoi	0	0	0	—	0	0
Acartia clausi	220	0	320	120	20	140
Oithona sp.	20	40	40	180	40	80
Oncaea sp.	0	0	0	20	0	0
Sapphirina nigromaculata	0	0	0	20	0	0
Corycaeus typicus	0	40	—	0	0	20
Corycaeus flaccus	0	0	20	0	0	0
Carycaeus latus	0	0	0	20	—	0
Corycaeus brehmi	0	0	0	0	20	0
Corycella rostrata	0	0	—	20	0	—
copepodits	80	0	40	180	—	140

Acartia clausi was the dominant species in spring, *Centropages typicus* in summer, *Clausocalanus jobei* and *Temora stylifera* in autumn and *Acartia clausi* in winter (Table 6).

Three species recorded from this station were not recorded from the others. These were *Clausocalanus parapergens, Pontella lobiancoi* and *Corycaeus flaccus*. The first of these is typical open-sea species and two others occur more in the open sea than in nearshore waters, as well.

Table V — Seasonal variations in number of copepod species at stations of the Split area
Tabela V — Sezonske oscilacije broja vrsta kopepoda na postajama splitskog područja

Sezone:	Proljeće	Ljeto	Jesen	Zima
No. 6	13	13	*19*	14
No. 6	13	8	*20*	12
No. 9	14	11	*26*	10
No. 9	12	15	*17*	16

Table VI — Average values of dominat copepods/m^3 at stations of the Split area
Tabela VI — Srednje vrijednosti gustoće dominantnih vrsta kopepoda/m^3 na postajama splitskog područja

Kopepodi:	*Acartia clausi*	*Centropages typicus*	*Temora stylifera*	*Centropages kröyeri*
No. 10	37	*52*	38	17
No. 10	*96*	15	29	*72*
No. 11	17	19	*29*	2
No. 11	*17*	8	15	2

THE AREA OF ŠIBENIK

Station S-1 — northeast of Zlarin Island

A total of 29 species was recorded together with 2 genera whose species were not identified (Table 7).

According to the frequency of occurrence following species were present in all of the samples: *Nannocalanus minor, Paracalanus parvus, Clausocalanus arcuicornis, Clausocalanus jobei, Ctenocalanus vanus, Temora stylifera, Centropages typicus, Candacia armata* and *Acartia clausi*. All of these are neritic species, characteristic for the areas of the Adriatic similar to this one. The other species were present occasionally during the year. Some species were noted to occur particularly rarely (recorded from only one of the catches during the whole period of investigations). These are *Euterpina acutifrons, Sapphirina ovatolanceolata* and *Macrosetella gracilis*. Of these only first occurs in the coastal area, and two others in the open sea.

Table VII — The composition of copepods at station S-1
Tabela VII — Sastav kopepoda po vrstama na postaji S-1

	VI. 1973	VIII. 1973	XI. 1973	II. 1974	IV 1974.
copepods					
Calanus helgolandicus	20	20	0	—	20
Calanus tenuicornis	120	0	—	40	380
Nannocalanus minor	20	40	20	—	—
Mecynocera clausi	0	20	—	—	0
Paracalanus parvus	60	40	20	620	180
Calocalanus pavo	0	0	40	0	20
Calocalanus plumulosus	0	0	120	60	0
Clausocalanus mastigophorus	0	0	0	40	—
Clausocalanus lividus	20	0	0	—	0
Clausocalanus arcuicornis	40	40	80	320	80
Clausocalanus jobei	260	60	200	60	60
Clausocalanus furcatus	40	40	220	0	80
Ctenocalanus vanus	300	100	60	180	1700
Diaixis pygmaea	20	0	0	40	40
Temora stylifera	20	160	440	40	40
Temora longicornis	20	0	0	0	20
Centropages typicus	920	660	100	240	180
Isias clavipes	0	0	0	20	20
Lucicutia flavicornis	—	0	0	0	20
Candacia armata	20	20	—	20	—
Acartia clausi	160	640	200	820	580
Oithona sp.	180	600	340	40	80
Macrosetella gracilis	0	0	—	0	0
Euterpina acutifrons	0	0	0	0	—
Sappnirina ovatolanceolata	0	0	0	—	0
Oncaea sp.	60	0	60	—	0
Corycaeus typicus	60	0	60	60	40
Corycaeus flaccus	0	0	40	—	0
Corycaeus furcifer	20	0	0	0	0
Corycaeus brehmi	40	0	0	0	40
Corycella rostrata	0	0	—	20	0
copepodits	320	300	120	160	180

Tabela VIII — The composition of copepods at station S-10
Tabela VIII — Sastav kopepoda po vrstama na postaji S-10

	VI. 1973	XI. 1973	II. 1974
copepods			
Calanus tenuicornis	—	0	80
Mecynocera clausi	0	—	0
Paracalanus parvus	0	40	60
Calocalanus pavo	0	200	0
Calocalanus plumulosus	0	60	0
Clausocalanus arcuicornis	—	0	20
Clausocalanus jobei	—	20	0
Clausocalanus pergens	0	20	0
Clausocalanus furcatus	—	40	0
Ctenocalanus vanus	60	0	220
Diaixis pygmaea	20	0	0
Temora stylifera	0	240	20
Centropages typicus	20	40	60
Centropages kröyeri	20	0	0
Isias clavipes	0	0	—
Acartia clausi	440	80	3280
Acartia latisetosa	—	0	0

Oithona sp.	80	140	40
Oncaea sp.	—	—	0
Corycaeus typicus	—	20	60
Corycaeus flaccus	0	20	0
Corycaeus latus	0	20	20
Corycella rostrata	0	20	0
copepodits	60	80	1140

Table IX — The composition of copepods statation P-1
Tabela IX — Sastav kopepoda po vrstama na postaji P-1

	V. 1973	VIII. 1973	X. 1973	II. 1974
copepods				
Calanus helgolandicus	0	0	0	—
Calanus tenuicornis	—	0	0	—
Nannocalanus minor	0	0	0	—
Paracalanus parvus	60	60	20	80
Clausocalanus arcuicornis	0	0	40	0
Clausocalanus jobei	40	0	40	0
Clausocalanus furcatus	0	0	60	0
Ctenocalanus vanus	40	0	0	0
Diaixis pygmaea	0	0	0	—
Temora stylifera	0	0	40	0
Temora longicornis	20	0	0	0
Centropages typicus	60	40	20	360
Centropages kröyeri	80	0	120	160
Isias clavipes	0	0	0	60
Lucicutia flavicornis	0	0	0	—
Acartia clausi	120	100	0	920
Oithona sp.	20	0	60	0
Euterpina acutifrons	0	0	0	—
Corycaeus latus	0	0	20	0
copepodits	120	40	60	80

Table X — The composition of copepods at station P-2
Tabela X — Sastav kopepoda po vrstama na postaji P-2

	VI. 1973	VIII. 1973	XI. 1973	II. 1974	IV. 1974
copepods					
Calanus helgolandicus	0	0	0	0	80
Calanus tenuicornis	0	0	0	80	120
Paracalanus parvus	20	80	80	680	220
Clausocalanus arcuicornis	0	0	20	20	0
Clausocalanus jobei	20	—	20	60	0
Clausocalanus furcatus	0	0	20	0	20
Ctenocalanus vanus	20	60	20	260	440
Diaixis pygmaea	0	0	20	0	0
Temora stylifera	0	20	0	0	0
Temora longicornis	40	0	0	0	0
Centropages typicus	80	440	40	400	400
Centropages kröyeri	0	0	200	0	240
Isias clavipes	0	40	0	180	20
Candacia armata	0	0	20	0	0
Acartia clausi	740	2240	80	3900	620
Oithona sp.	0	100	140	0	20
Euterpina acutifrons	0	0	0	0	20
Oncaea sp.	0	0	20	0	0
Caligus rapax	0	—	0	0	0
copepodits	60	120	80	500	240

Number of copepod species ranged between 12 (found during summer, in august) — Table 14. The numerically dominant species at this station have already been mentioned as always present in the material. These are *Acartia clausi, Ctenocalanus vanus* and *Centropages typicus.*

Station S-10 — in front of the »Solaris«

Even though the depth at this station is small, 4.5—5 m, material contained 21 distinct copepod species and 2 genera (Table 8).

Of these only 3 were observed in all the samples, *Centropages typicus, Acartia clausi* and *Corycaeus typicus.* The other species occured occasionally and some open-sea species very rarely.

Number of species varied from 11 found in winter and summer to 14 found in spring (Table 13).

Acartia clausi dominated here in quantity. It was the only species occuring in a large number of samples.

Station P-1 — Šibenik harbour

A total of 18 species was identified (Table 9) together with a genus whose species were not determined. The species *Centropages typicus* and *Paracalanus parvus* were the only species always present in the material. Some other species were occasionally present in the course of a year, whereas 9 species out of 20 were characterized as rare. These included *Calanus helgolandicus, Clausocalanus arcuicornis, Diaixis pygmaea* and some others.

Number of species varied from only 3 in summer to 11 in winter (Table 13).

The species *Acartia clausi* dominated although we did not find it in all of the catches.

Station P-2 — Šibenik harbour

We identified a total of 17 species at this station (Table 10). No attempt was made at determination of species of two genera also found here.

Only four markedly neritic copepods were always present in the material, *Paracalanus parvus, Ctenocalanus vanus, Centropages typicus* and *Acartia clausi.* All the remaining species were present from time to time. The skin parasite of a large number of fish, *Caligus rapax,* was also identified here, Althouhg a parasite it sometimes occurs as freely swiming organism.

The number of species varied from 6 found in summer in June to 10 found in autumn (Table 13).

The species *Acartia clausi* was dominant here like it was at two preceeding stations.

Station P-3 — Šibenik harbour

A total of 22 copepod species (Table 14) was identified as well as 2 genera whose species were not determined.

Neritic species were also always present. These are *Paracalanus parvus, Ctenocalanus vanus, Centropages kröyeri* and *Acartia clausi.* Of a particular interest is that, although rarely, the open-sea species occured here. These were *Clausocalanus mastigophorus, Labidocera wollastoni* and some others.

The number of species varied considerably, from 7 in autumn to 18 in winter.

Table XI — The composition of copepods at station P-3
Tabela XI — Sastav kopepoda po vrstama na postaji P-3

	VIII. 1973	XI. 1973	II. 1974
copepods			
Calanus tenuicornis	0	0	20
Nannocalanus minor	20	0	0
Paracalanus parvus	120	40	120
Clausocalanus mastigophorus	0	0	—
Clausocalanus arcuicornis	0	0	40
Clausocalanus jobei	0	0	20
Clausocalanus furcatus	0	60	—
Ctenocalanus vanus	40	20	180
Diaixis pygmaea	20	0	20
Temora stylifera	0	20	0
Temora longicornis	20	0	20
Centropages typicus	140	0	220
Centropages kröyeri	80	120	120
Isias clavipes	0	0	40
Labidocera wollastoni	—	0	0
Lucicutia flavicornis	0	0	—
Acartia clausi	1000	420	2620
Oithona sp.	—	80	—
Euterpina acutifrons	0	0	—
Sapphirina ovatolanceolata	0	0	—
Oncaea sp.	—	0	0
Corycaeus typicus	—	80	0
Corycaeus brehmi	0	0	—
Caligus rapax	—	0	—
copepodits	20	80	20

Table XII — The composition of copepods at station P-10
Tabela XII — Sastav kopepoda po vrstama na postoji P-10

copepods				
Paracalanus parvus	20	20	0	0
Calocalanus pavo	0	0	0	+
Clausocalanus jobei	0	0	0	+
Clausocalanus furcatus	0	0	0	+
Ctenocalanus vanus	20	0	0	0
Temora stylifera	0	0	0	+
Temora longicornis	20	0	0	0
Centropages kröyeri	20	0	20	0
Acartia clausi	40	20	40	+
Acartia latisetosa	0	20	+	0
Oithona sp.	0	+	+	+
Corycaeus brehmi	0	0	0	+
brackish waters copepods	0	0	0	10
copepodits	0	60	+	0

Table XIII — Seasonal variations in number of copepod species at stations of the Šibenik area

Tabela XIII — Sezonske oscilacije broja vrsta kopepoda na postajama šibenskog područja

	II. 74 winter zima	IV. 74 spring proljeće	VI—VIII. 73 summer ljeto		XI. 73 autumn jesen	number of species kopepoda ukupno vrsta
S — 1	21	21	19	12	18	29
S — 10	10	/	10	/	14	20
P — 2	11	/	8	3	8	18
P — 2	8	10	6	8	10	17
P — 3	18	/	/	11	7	22
P — 10	6	/	5	3	3	11

Table XIV — Copepod species diversity index at stations of the Split and Šibenik areas

Tabela XIV — Indeks raznolikosti vrsta kopepoda na postajama splitskog i šibenskog područja

Područje Splita The area of Split			Područje Šibenika The area of Šibenik		
postaja:	6	4,2	postaja:	P-1	4,2
	9	4,1		P-2	3,0
	10	6,0		P-3	4,3
	11	5,7		P-1	6,0

Acartia clausi was also dominant species.

Station P-10 — the Lake Prokljansko

Only 11 marine copepod species were identified and 1 genus with very small number of individuals (Table 12). Meanwhile, some brackish species were recorded from here in February 1974. This is not surprising as salt and fresh water mix here.

With respect to the very low number of individuals found here we cannot draw any conclusion in the frequency of occurence of any of the species. Of the marine species *Acartia clausi* was found in all the samples. It was also the most numerous species.

*
* *

A total of 40 copepod species was recorded from the area of Split. The 3 genera also found there were not identified to the species level. The samples collected from the area of Šibenik contained 35 marine species and 2 genera (Tables 7—12). What we want to point out is that the number of recorded species was lower because sampling was seasonally carried out. But, at the same time, the data from both sites are comparable.

In the Split area the lowest number of species was identified at the station 9 (Table 5) in front of the town of Kaštel Sućurac. The number of species was somewhat at station 6, and still higher at station 11. The highest number of species was found at station 10 in front of the Split harbour.

In the Šibenik area the lowest number of species was found at the station P-10 what may be due to the mixing of fresh and brackish water at the site. With respect to the increase in the number of species the stations can be placed in order like this: stations P-2 and P-1 in the Šibenik harbour, station S-10 in front of the »Solaris«, P-3 also in the Šibenik harbour and S-1 in outer part of the Šibenik channel.

As it can be seen from the above, the highest number of species was recorded from the stations under the strongest influence of the open sea. This compares well with all the earlier studies. We have further tried to find some species common to all the stations. According to this criterion very similar to each other are stations 6 and 9 in the Bay of Kaštela. Following similar stations are 6 and 11, then 9 and 11. On the basis of 10-year investigations of copepods (Regner, 1970; Regner & Vučetić, in preparation) we can say for the station 6 that it is a typical coastal station with a definite species composition which was not altered for a rather long time interval (1960—1969). This may be indicative of the moderate eutrophication that has not negatively acted upon the planktonic copepods.

The station 10, in front of the town of Split harbour, showed the greatest species number and the highest number of individuals. Thus we can consider the eutrophication to have positively acted upon the copepod species there. The species composition at this station was the most similar to that at station 6. However, the occurence of some copepod species characteristic for the open-sea waters indicates the mixing of these waters with the open-sea ones.

The same species were recorded from the stations 9 and 11, but in somewhat lower quantity. This may result from the similarity in position between these two stations, namely from their closenest to the coast and rather small depth. The lowest number of species was identified at the station 9 placed in the shallow, coastal zone in the Bay of Kaštela. This indicates the pollution of this area.

The same cannot be said for the station 11 where the lowest number of specimens was found but with the very high diversity in number and composition of species. The open-sea copepod species were also recorded from here. This may result from the water exchange between this area and the area of the open Adriatic.

In the area of Šibenik the stations P-1 and P-2, as well as the stations P-2 and P-3 were observed to have the largest number of characteristics in common. This is not surprising because all of them are placed in the harbour of Šibenik. We can say that these stations form a distinctive group of stations

although some differences among them exist, as well. Thus, for example, the station P-3 is the most maritime station and the species recorded from it, as well as some other characteristics, are very similar to those at the station S-1 which is under the strongest influence of the open sea. The environmental conditions at the station P-10 in the lake Prokljansko differ from the conditions at any of the stations described in this paper. The area is under the strong influence of fresh water what was confirmed by the presence of species that ordinarily inhabit brackish waters.

Study of the diversity of species carried out by calculating the »global diversity index«, after M a r g a l e f (1951), enabled us to make still better comparison between the Split and Šibenik areas. The ratio number of species to number of individuals is obtained the »global diversity index«. In the equation

$$d = \frac{S - 1}{\log_n N}$$

S is the number of species and N number of individuals. The diversity index showed almost the same values for the coastal zones of both areas, as well as for the zones under the rather strong influence of the open sea (Table 14). These results are compatible with those obtained earlier for the index of copepod diversity (R e g n e r, 1974., in press) whose values increased going from the coast towards the open sea. Accordingly, the distribution of this index values, as well as the distribution of the number od species by stations are not far from what has normally been established for these areas. This may indicate that the state of copepod communities has not been seriously altered.

Table XV — Variations in copepod number/m^3 at the stations of the Split and Šibenik areas

Tabela XV — Kretanje broja kopepoda/m^3 na postajama splitskog i šibenskog područja

The area of Split		N/m^3	Područje Šibenika		N/m^3
The area of Split			The area of Šibenik		
postaja:	6	238	postaja:	P-1	56
	9	277		P-2	190
	10	166		P-3	128
	11	115		S-1	103

However, the study of the results obtained calculating the number of copepod individuals per m^3 (Table 15), indicate that some changes have already started. It is well known that number of individuals per m^3 decreases from the coast towards the open sea. This was proved also by our earlier investigations (R e g n e r, 1974, in press). This number, however, was considerably lower at the station P-1 in front of the town of Šibenik than it was at the stations placed farther in the open sea. This characteristic is not an ordinary one, and it may be accounted for by the negative influence of eutrophication.

CONCLUSIONS

1. Study of copepod *species distribution* in both areas showed that the highest number of species was identified at stations under the strongest influence of the open sea (station 10 in front of the Split harbour and S-1 in the outer part of the Šibenik channel). The number of species was lowest in the shalow coastal zones of the Bay of Kaštela (No 9) and in the Šibenik harbour (P-2).

2. Study of the *species composition* found stations 6 and 9 in the Split area to have the most of the characteristics in common. The same was obtained for the stations P-1, P-2 and P-3 in the Šibenik harbour.

3. Distribution of *diversity index values* varies within the range of ordinary values, i. e. it increases going from the coast towards the open sea.

4. *Number of copepod individuals* per m^3 indicated the first signs of negative effects of eutrophication on the copepod communities. The number of species identified at the station P-1 in front of Šibenik was considerably lower than expected for the coastal zone. This is, thus, the first record of the changes in the natural state of copepod communities.

LITERATURA

Gamulin, T., 1939. Kvalitativna i kvantitativna istraživanja planktonskih kopepoda u istočnim obalnim vodama srednjeg Jadrana 1936/37, Prir. istr. Jug. akad. znan. i umjetn., 22: 97-180, Zagreb.

Gamulin, T., 1948. Prilog poznavanju zooplanktona srednjedalmatinskog otočnog područja, Acta Adriatica, *3*, 7; 1—38, Split.

Margalef, R., 1951. Diversidad de especies en las comunidades naturales. Publ. Inst. Biol. apl. *9*,: 5—25, Bercelona.

Regner, D., 1970. Istraživanje fluktuacije planktonskih kopepoda srednjeg Jadrana, magistarski rad, 1—74, Zagreb.

Regner, D., 1971. Prilog poznavanju ekologije kopepoda *Centropages kröyeri* Giesbrecht iz Kaštelanskog zaljeva, Ekologija, *6*, 1: 113—121.

Regner, D., 1973. Sezonska raspodjela kopepoda u srednjem Jadranu u 1971, Ekologija, *8*, 1: 139—146.

Regner, D., 1974, a. Contribution to the knowledge of ecology of genus *Clausocalanus* from Kaštela Bary, Rapp. Comm. int. Mer Médit., *22*, 9, p. 83.

Regner, D., 1974, b. Some new data on the genus *Clausocalanus* in the Central Adriatic, Rapp. Com. int. Mer Médit., in press.

Regner, D., 1974, c. On the copepods diversity in the Central Adriatic in 1971, Rapp. Com. int. Mer Médit., in press.

Regner, D. & Vučetić, T., (u štampi) Dugoročne fluktuacije kopepoda u obalnom području srednjeg Jadrana — Kaštelanski zaljev.

Vučetić, T., 1965. Long term observations of zooplankton fluctuation in the Bay of Kaštela. Proc. tech. Pap. gen. Fish. Coun. Mediterr. 7, 47—56.

Vučetić, T. & Regner, D. 1973. Les fluctuations des Copépodes pélagiques dans la region de Split (Adriatique centrale), Rapp. Comm. int. Mer Médit., *21*, 8, : 485—487.

ISTRAŽIVANJA KOPEPODA U SPLITSKOM I ŠIBENSKOM PRIOBALNOM PODRUČJU

Dubravka Regner
Institut za oceanografiju i ribarstvo, Split

KRATAK SADRŽAJ

U ovom radu razmotreni su podaci o kopepodima iz splitskog (4 postaje) i Šibenskog priobalnog područja (6 postaja) (slike 1 i 2). Istraživanja su provedena tokom 1972, 1973. i 1974. godine, u okviru kompletnih oceanografskih istraživanja koje je Institut za oceanografiju i ribarstvo iz Splita vršio na ovom dijelu srednjeg Jadrana.

Na splitskom području registrirano je sezonskim uzimanjem materijala 40 vrsta i 3 roda, a na postajama šibenskog područja 35 vrsta i 2 roda. I na jednom i na drugom području, najveći broj vrsta nađen je na postajama koje su pod najjačim utjecajem otvorenog mora, što je prema dosadašnjim istraživanjima i uobičajeno.

Praćen je i uspoređen i sastav vrsta za oba područja i nađeno je da najveći broj zajedničkih karakteristika imaju postaje 6 i 9 u Kaštelanskom zaljevu i P-1, P-2 i P-3 u šibenskoj luci.

Proračunate su i vrijednosti indeksa raznolikosti za sve postaje istraživanih područja i nađeno je da su i one u granicama uobičajenih vrijednosti, tj. postupno se povišavaju prema otvorenom moru (Tablica 14).

Na prve znake negativnog djelovanja eutrofikacije na kopepode, ukazalo je praćenje broja primjeraka izračunato na m^3 mora (Tablica 15). Na postaji P-1 ispred Šibenika, nađene su naime mnogo niže vrijednosti od uobičajenih za priobalno područje, što bi mogao biti jedan od znakova promjene prirodnog stanja u zajednici kopepoda.