Annex III

MICROZOOPLANKTON AND FEEDING OF ANCHOVY LARVAE

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During MAD-92 cruise samples of microzooplankton were taken simultaneously with ichthioplankton samples in order to detect favorable areas for the anchovy larval survival.

METHODS

Samples of microzooplankton were taken with a 15 cm diameter Bongo fitted with conical nets of 53 µm, attached at the same wire that the 40 cm diameter bongo used for sampling ichthyoplankton. So the area and stations sampled were the same as described for sampling of the eggs and anchovy larvae.

The samples were filtered and concentred in a 250 cc jar before preservation. The one used to analize biomass of microzooplankton was freezed at - 20 °C, the other used to analize composition of plankton were preserved with 5 % formol buffered with borax.

Laboratory procedures

1. Cuantitative analysis of microzooplankton.

We analized dry weight, organic matter and ashes of 193 samples of microzooplankton. Samples were defrosted and filtered with a mesh of 53 µm. Organisms bigger than 1 cm were eliminated of the analysis. Later the samples were dried in a stove at constant temperature of 70 °C during 24 hours in order to secure total dry. After 4 hours in a dessicator samples were weigthed, with a precision of 1 mg. Afterwards this samples were introduced in a owen at a temperature of 500 °C during 1 hour. Ashes were weighted with a precision of 1 mg.
Contents of organic matter was then obteined by the difference between dry weight and ashes weight.

2- Cualitative analysis of microzooplankton.

Composition of different groups of microzooplankton was analysed in samples of 39 stations, coinciding with those where larval condition was also analised, and also in two transects perpendicular to the coast south and middle Gulf of Lions.

Samples were diluted to 500 ml from which we taked a subsample of 10 ml. This subsample was diluted with destiled water in prpportions of 1:2 or 1:3, depending on the sample. From this final volume we taked 2 ml to be studied. We used a binocular microscope with a magnification of 40X to classificate the different groups of microplankton.

3.- Larval anchovy feeding

We studied the gut content of 228 anchovy larvae obteined by the 40 cm bongo net in selected stations along the catalan coast and gulf of Lions.

Anchovy larvae were measured with an eyepiece micrometer and afterwards the guts were removed and opened. The contents were identified, counted and copepod developmental stages measured (μm).

RESULTS

Microzooplankton distribution (Table I)

Maximum concentrations of organic matter were found at Gulf of Lions, with a maximum around 20 mg/m^3 at a coastal area near Cap d'Agde. Generaly the values over the Gulf were high and we can see two more high values in the central area (11 mg/m^3) and near the mouth of the Rhone river Going to the south the values were lower until the delta of the Ebro river with a maximum of 12 mg/m^3. At the Ligurian sea the values were generally lower, only a maximum of 11 mg/m^3 in front of Livorno.(Figs. 1 and 2). In fact, maximum values coincide with areas of lower salinities in the zones of outflow of rivers.

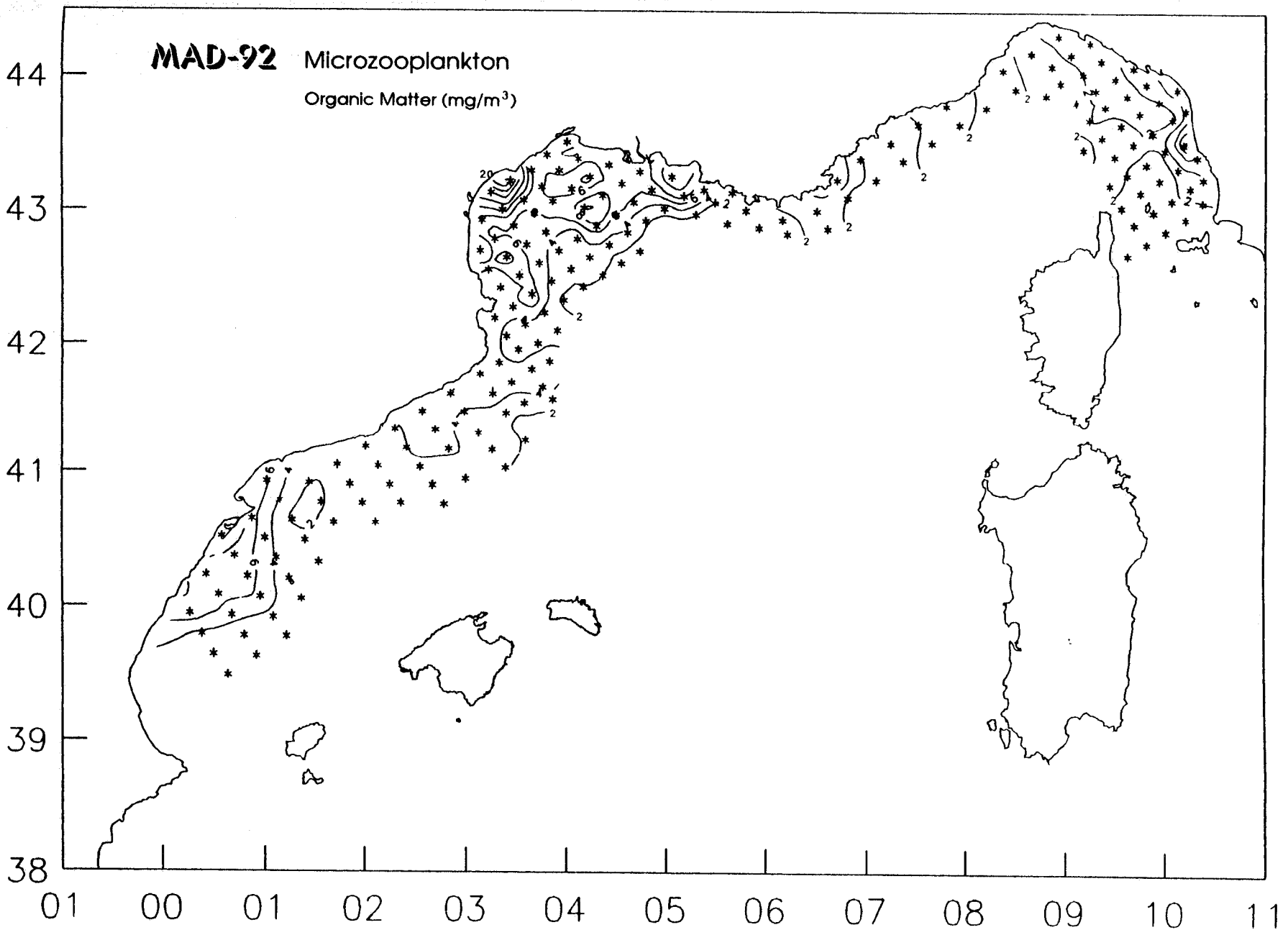
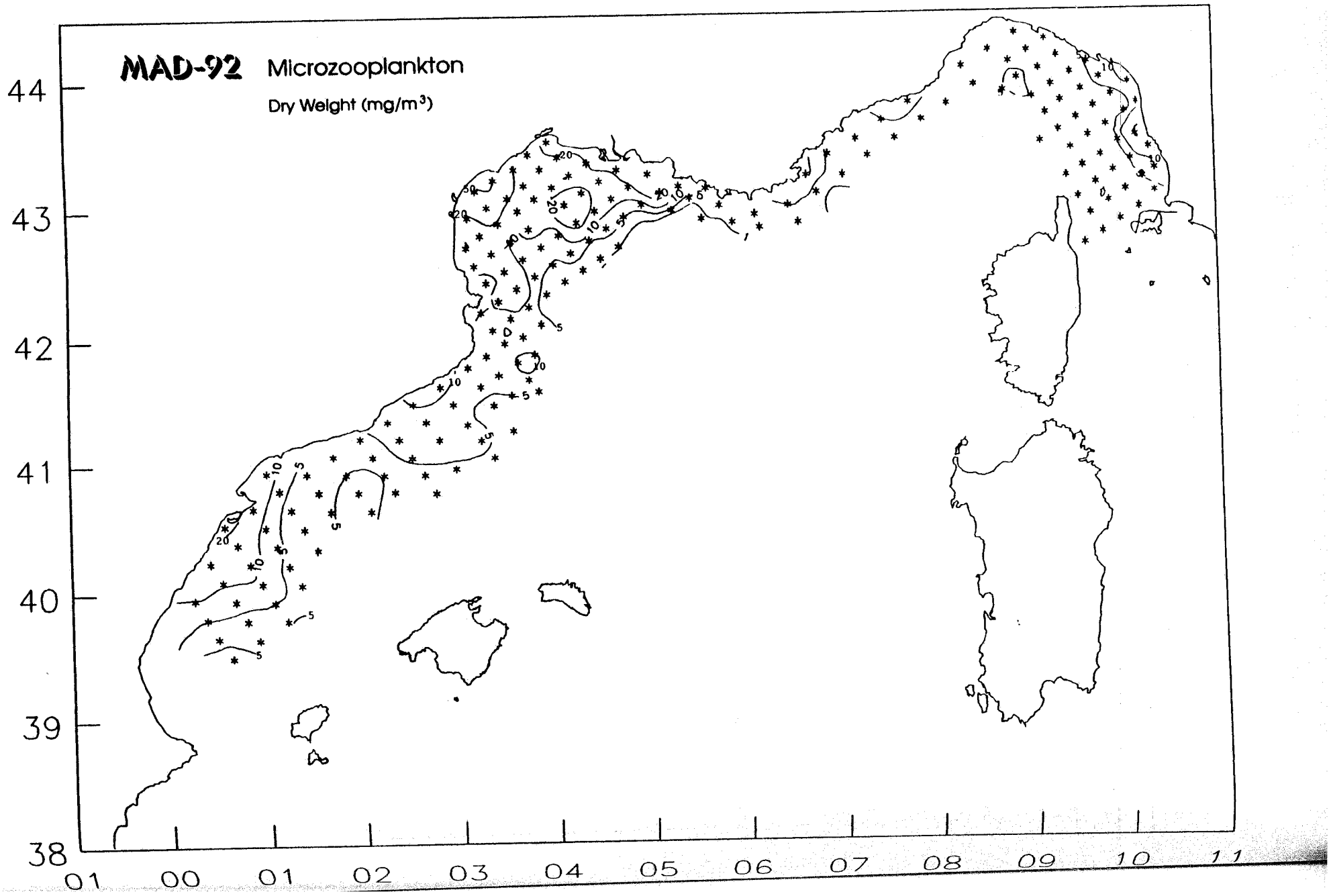


Fig. 1.- Organic matter spatial distribution.


MAD-92 Microzooplankton
Dry Weight (mg/m3)
44
43
42
41
40
39
38
01
00
01
02
03
04
05
06
07
08
09
10
11

Microzooplankton composition (Table II)

Nauplii and copepodites were the dominant components of microzooplankton, and were also important cladocers. Other potential preys for anchovy larvae were present but in less important numbers.

Distribution of abundances in the to transects analized (Fig. 3) showed that values of

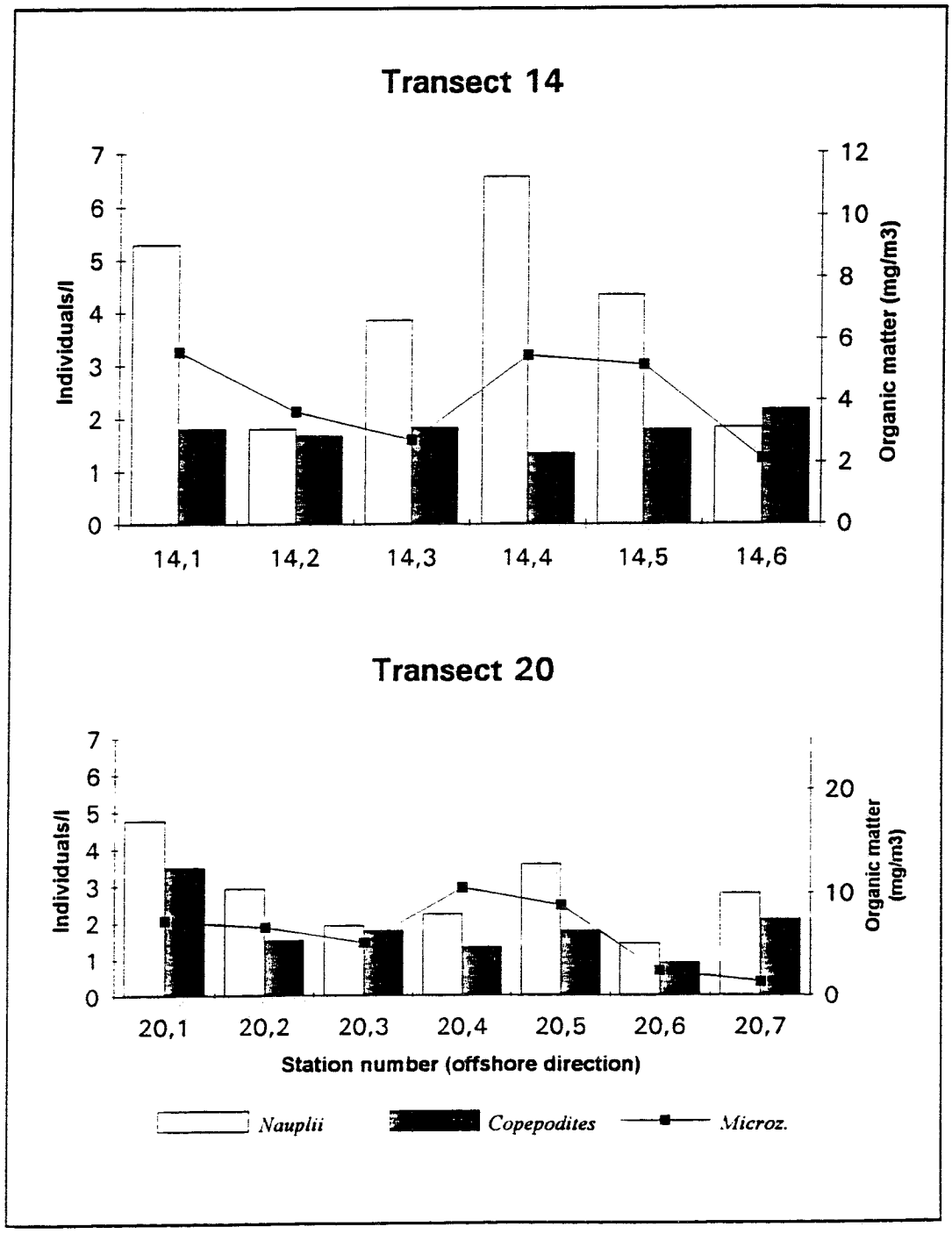


Fig. 3.- Microzooplankton composition and distribution in two transects along with biomass

microzooplankton are high at stations near the shelf break, and that the values of nauplii/l were closed to those of organic matter, while copepodites manteined similar values in all stations.

Anchovy larval feeding

The size range of larvae studied was 3.59 to 13.33 mm SL. Only de 10.52 % of the larvae examined had food in their gut. The size range of lavae with food in the gut was 5.33 to 11.59 mm SL. The mean number of particles per feeding larvae was 1.83 (Table III)

The main dietary components were eggs, naupliar and copepodite stages of copepods. Copepod eggs were the 29.5 % of the preys, nauplius the 27.2 % and copepodites de 31.8 %. Other items in the diet were cladocers, pollen of gymnosperms and other organic particles not identified. Cladocers were the bigger preys detected.

Measures of the maximum width of preys showed that maximum prey size increases with larvae size. Nevertheless the range of prey size also increases meaning that larger larvae feed on larger prey but continues feeding small preys (Fig. 4).

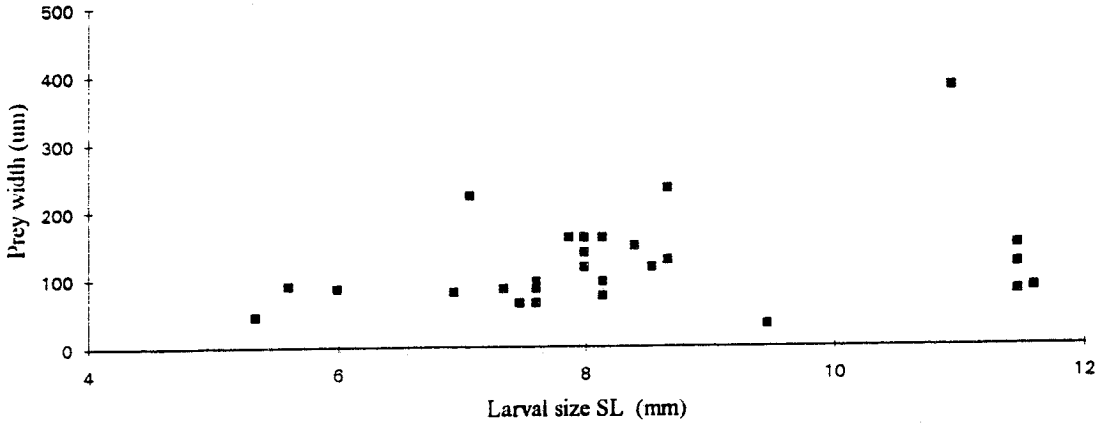


Fig. 4.- Prey size selection at different larval size.

From comparing the relative presence of copepod nauplii, copepodites and cladocers in larvae's guts with respect of microzooplankton composition in the same samples, sugests that anchovy do in fact select bigger preys (copepodits and cladocers) even if the presence of smaller size preys are abundant in the environment (Fig. 5).

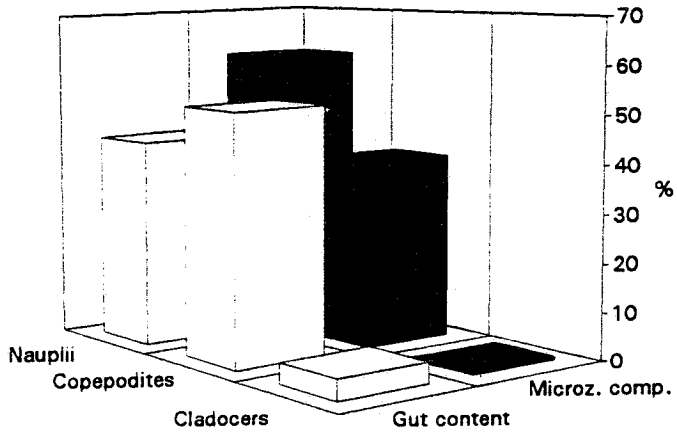


Fig. 5 Proportion of preys in larval guts and in the plankton.

Table I.- Biomass of microzooplankton samples taken on July 1992 in Northwestern Mediterranean sea

MAD-92 BIOMASS MICROZOOPLANKTON ESTIMATES

Sta.	Latitude (deg. dec.)	Longitude (deg. dec.)	Dry W. (mg/m3)	Org. Mat. (mg/m3)	Ashes (mg/m3)	Ash./D.W. %
11	39,945	0,120	10,51	8,01	2,50	23,82
12	39,793	0,175	4,74	3,28	1,47	30,89
13	39,645	0,226	3,60	2,30	1,30	36,16
14	39,488	0,289	7,14	3,91	3,23	45,26
21	40,228	0,194	12,25	6,35	5,90	48,18
22	40,082	0,250	10,46	6,57	3,89	37,22
23	39,930	0,308	6,87	5,08	1,79	26,06
24	39,780	0,362	3,03	2,08	0,95	31,45
25	39,630	0,415	3,81	2,37	1,44	37,87
31	40,513	0,263	24,77	11,67	13,10	52,89
32	40,368	0,322	13,79	6,85	6,94	50,31
33	40,218	0,379	12,48	6,94	5,54	44,39
34	40,067	0,433	9,40	5,93	3,48	36,97
35	39,917	1,041	4,36	2,86	1,51	34,50
36	39,778	1,099	4,93	3,18	1,74	35,36
41	40,645	0,397	14,46	6,60	7,87	54,40
42	40,498	1,004	7,79	4,84	2,95	37,85
43	40,353	1,055	5,94	3,77	2,17	36,56
44	40,202	1,112	2,37	1,65	0,71	30,18
45	40,053	1,167	4,31	2,92	1,39	32,34
51	40,928	1,012	13,14	6,41	6,73	51,19
52	40,785	1,071	7,45	3,97	3,47	46,65
53	40,635	1,125	2,55	1,67	0,89	34,77
54	40,483	1,183	3,29	2,36	0,93	28,35
55	40,323	1,245	4,42	3,20	1,22	27,66
61	41,067	1,146	--	--	--	--
62	40,915	1,200	2,89	1,97	0,92	31,80
63	40,768	1,256	2,10	1,56	0,54	25,63
64	40,617	1,312	4,87	3,23	1,63	33,56
71	41,053	1,328	3,68	2,42	1,26	34,34
72	40,905	1,385	4,99	3,03	1,96	39,34
73	40,763	1,442	7,39	3,86	3,53	47,72
74	40,617	2,050	5,23	3,33	1,90	36,26
81	41,193	2,004	4,51	3,00	1,50	33,33
82	41,047	2,061	4,24	2,61	1,63	38,50
83	40,900	2,004	5,06	2,79	2,27	44,81
84	40,767	2,163	3,90	2,65	1,26	32,18
91	41,330	2,134	6,35	3,70	2,65	41,71
92	41,185	2,187	6,20	4,16	2,04	32,88
93	41,038	2,247	5,35	3,66	1,69	31,52
94	40,900	2,304	3,75	2,01	1,74	46,33
95	40,757	2,355	2,98	2,28	0,70	23,48
101	41,470	2,256	10,17	5,46	4,71	46,33
102	41,327	2,314	8,32	4,36	3,96	47,61
103	41,178	2,375	7,55	4,32	3,24	42,87
104	40,948	3,001	3,99	2,56	1,43	35,91
111	41,607	2,383	11,79	6,18	5,62	47,62
112	41,467	2,443	7,14	3,63	3,51	49,14
113	41,300	3,058	5,61	3,40	2,21	39,42
114	41,173	3,119	6,70	3,79	2,91	43,44
115	41,035	3,180	3,05	2,09	0,96	31,48
121	41,757	3,063	8,26	4,35	3,90	47,27
122	41,607	3,122	6,60	6,27	0,34	5,14
123	41,458	3,182	3,51	2,12	1,39	39,66
124	41,247	3,267	2,93	1,89	1,04	35,52
131	41,847	3,149	9,03	4,90	4,14	45,80
132	41,695	3,206	6,95	3,88	3,08	44,28
133	41,537	3,264	4,97	2,94	2,03	40,87
141	42,193	3,130	10,77	5,59	5,19	48,21
142	42,055	3,182	7,28	3,64	3,64	50,00
143	41,950	3,235	5,23	2,73	2,50	47,78
144	41,797	3,295	11,17	5,47	5,70	51,03
145	41,660	3,345	9,50	5,16	4,63	48,79
146	41,567	3,390	3,41	2,13	1,28	37,54

Table I.- Cont.

Sta.	Latitude (deg. dec.)	Longitude (deg. dec.)	Dry W. (mg/m3)	Org. Mat. (mg/m3)	Ashes (mg/m3)	Ash./D.W. %
146	41,567	3,390	3,41	2,13	1,28	37,54
151	42,698	3,065	22,93	10,68	12,25	53,42
152	42,553	3,101	11,24	4,64	6,60	58,70
153	42,422	3,153	5,60	3,21	2,39	42,71
154	42,278	3,211	12,12	5,30	6,82	56,27
155	42,145	3,266	4,76	2,73	2,03	42,63
156	42,000	3,322	5,57	3,28	2,29	41,12
157	41,858	3,375	10,88	5,29	5,60	51,41
161	42,923	3,072	15,44	7,22	8,23	53,27
162	42,787	3,129	9,19	4,29	4,90	53,27
163	42,648	3,182	17,31	9,32	8,00	46,19
164	42,510	3,239	13,10	6,55	6,55	50,00
165	42,375	3,296	21,12	8,34	12,78	60,52
166	42,233	3,352	7,17	3,31	3,85	53,76
167	42,098	3,409	6,56	3,58	2,97	45,36
171	43,127	3,111	47,35	13,76	33,59	70,95
172	43,000	3,164	46,59	11,72	34,87	74,84
173	42,878	3,214	19,92	5,92	14,00	70,29
174	42,742	3,272	7,12	4,56	2,57	36,03
175	42,605	3,326	9,03	4,72	4,31	47,73
176	42,468	3,382	6,71	3,29	3,41	50,87
177	42,332	3,436	2,19	1,57	0,61	28,09
181	43,210	3,197	54,73	20,41	34,32	62,70
182	43,068	3,258	12,51	5,35	7,16	57,22
183	42,972	3,306	9,87	4,52	5,35	54,25
184	42,835	3,356	12,84	5,25	7,59	59,15
185	42,697	3,414	8,04	3,22	4,82	59,97
186	42,558	4,018	4,65	2,55	2,09	45,08
187	42,428	4,074	2,90	1,92	0,99	33,94
191	43,290	3,291	15,91	6,69	9,22	57,96
192	43,168	3,338	11,79	5,04	6,74	57,21
193	43,063	3,386	20,12	8,69	11,43	56,81
194	42,923	3,439	--	--	--	--
195	42,787	4,047	1,90	1,33	0,58	30,26
196	42,650	4,102	6,92	3,58	3,34	48,30
197	42,515	4,160	3,29	2,06	1,23	37,44
201	43,407	3,162	17,45	7,37	10,08	57,77
202	43,290	3,415	14,53	6,78	7,75	53,34
203	43,152	4,020	12,59	5,19	7,40	58,77
204	43,015	4,077	37,75	10,57	27,18	72,00
205	42,880	4,132	33,62	8,88	24,74	73,58
206	42,743	4,190	4,62	2,44	2,18	47,26
207	42,605	4,243	2,22	1,38	0,84	38,00
211	43,502	4,001	20,35	7,56	12,79	62,85
212	43,380	4,049	22,26	8,69	13,57	60,95
213	43,242	4,102	7,19	2,44	4,74	66,02
214	43,105	4,159	23,24	8,84	14,41	61,98
215	42,967	4,219	8,18	4,29	3,89	47,57
216	42,835	4,273	7,84	3,92	3,91	49,92
217	42,697	4,329	1,39	0,95	0,44	31,49
221	43,333	4,187	20,93	7,13	13,80	65,92
222	43,193	4,244	17,50	6,91	10,59	60,50
223	43,057	4,299	14,18	5,82	8,36	58,95
224	42,920	4,354	5,80	2,23	3,57	61,61
231	43,283	4,327	20,94	6,07	14,87	71,02
232	43,148	4,381	15,48	6,50	8,98	58,03
233	43,010	4,441	6,99	2,47	4,52	64,67
234	42,877	5,048	--	--	--	--
241	43,245	5,023	41,00	11,74	29,26	71,36
242	43,103	5,077	31,97	9,51	22,46	70,25
243	42,967	5,132	2,54	1,86	0,68	26,75
251	43,150	5,167	14,11	5,56	8,56	60,61
252	43,057	5,217	2,38	1,30	1,08	45,30
253	42,900	5,272	1,22	0,67	0,55	45,20
261	43,130	5,294	8,17	3,86	4,30	52,69
262	43,000	5,356	1,29	0,80	0,49	38,26
263	42,873	5,415	1,97	1,18	0,80	40,28
271	42,930	6,071	2,31	1,40	0,92	39,61
272	42,832	6,092	1,96	1,28	0,68	34,78
281	42,998	6,226	4,75	2,75	2,01	42,23

Table I.- Cont.

Sta.	Latitude (deg. dec.)	Longitude (deg. dec.)	Dry W. (mg/m3)	Org. Mat. (mg/m3)	Ashes (mg/m3)	Ash./D.W. %
282	42,868	6,274	4,05	2,93	1,12	27,63
291	43,227	6,316	11,67	5,80	5,87	50,30
292	43,095	6,363	1,17	0,81	0,36	30,59
301	43,382	6,420	2,85	1,52	1,33	46,65
302	43,227	7,040	2,43	1,55	0,88	36,20
311	43,500	7,106	1,64	0,96	0,68	41,46
312	43,370	7,161	2,27	1,70	0,57	25,22
321	43,642	7,230	4,94	1,92	3,02	61,14
322	43,503	7,292	4,03	2,56	1,46	36,32
331	43,782	7,357	6,59	3,11	3,48	52,80
332	43,643	7,418	3,13	2,16	0,97	31,02
341	43,767	8,088	2,41	1,69	0,72	29,73
351	44,058	8,162	2,56	1,45	1,11	43,46
352	43,912	8,219	1,59	1,18	0,41	25,90
361	44,320	8,414	3,49	1,45	2,04	58,35
362	44,187	8,290	4,30	2,60	1,71	39,65
371	44,270	9,105	1,79	1,11	0,68	37,95
372	44,178	9,021	2,06	1,44	0,62	30,11
373	44,092	8,385	4,47	3,07	1,40	31,30
381	44,133	9,158	2,43	1,54	0,89	36,69
382	44,033	9,075	3,73	2,07	1,66	44,50
383	43,962	8,423	5,74	3,00	2,75	47,84
384	43,863	8,357	5,32	3,35	1,98	37,12
391	44,082	9,301	5,72	2,64	3,08	53,83
392	44,000	9,221	2,41	1,58	0,82	34,27
393	43,905	9,132	1,75	1,16	0,60	33,99
394	43,812	9,044	5,35	3,58	1,77	33,08
401	43,957	9,358	6,98	2,80	4,18	59,93
402	43,863	9,272	2,60	1,20	1,40	53,87
403	43,778	9,173	3,19	1,90	1,29	40,46
404	43,683	9,103	2,49	1,84	0,65	26,04
411	43,915	10,047	11,88	5,51	6,37	53,60
412	43,822	9,414	3,21	1,82	1,38	43,14
413	43,730	9,328	2,17	1,35	0,81	37,55
414	43,642	9,245	3,81	2,60	1,21	31,75
415	43,548	9,159	3,41	2,38	1,03	30,18
416	43,462	9,076	1,65	1,24	0,41	25,09
421	43,755	10,084	6,91	4,04	2,88	41,60
422	43,688	10,024	2,15	1,31	0,84	39,10
423	43,583	9,386	2,79	1,89	0,90	32,29
424	43,502	9,300	4,21	2,62	1,59	37,70
425	43,410	9,216	4,10	2,78	1,33	32,34
431	43,500	10,076	25,12	11,08	14,04	55,90
432	43,457	9,440	2,30	1,67	0,63	27,33
433	43,350	9,357	3,80	2,37	1,43	37,69
434	43,272	9,271	1,83	1,12	0,71	38,78
435	43,197	9,193	3,60	2,68	0,92	25,59
441	43,407	10,137	14,14	5,05	9,10	64,32
442	43,317	10,050	5,42	2,58	2,84	52,36
443	43,232	9,415	1,33	0,80	0,53	39,82
444	43,142	9,330	1,89	1,21	0,68	35,86
445	43,033	9,246	2,55	1,55	1,00	39,22
451	43,243	10,163	8,39	3,95	4,44	52,94
452	43,178	10,104	5,48	2,78	2,70	49,26
453	43,087	10,022	3,14	1,95	1,19	37,91
454	43,000	9,389	3,53	2,01	1,52	42,96
455	42,907	9,302	2,29	1,29	1,01	43,95
461	43,070	10,161	3,94	1,84	2,10	53,26
462	42,950	10,085	1,23	0,64	0,59	47,76
463	42,858	9,444	3,36	2,02	1,34	39,90
464	42,767	9,359	2,00	1,36	0,64	31,93
465	42,682	9,274	1,46	0,80	0,66	45,00

Table II.- Microzooplankton composition of samples in which larval condition andfeeding was analized and from two transects off south and central Gulf of Lions

MAD-92 MICROZOOPLANKTON DATA								
Station	Dry weight mg/m3	Organic matter mg/m3	Ashes mg/m3	% Ash./D.w.	Nauplius/l	Copepodites/l	Total/l	Cladocers/l
6,1	—	—	—	—	3,167	4,882	8,049	0,000
7,2	4,994	3,030	1,965	39,34	2,961	1,790	4,751	0,000
7,3	7,392	3,865	3,527	47,72	2,064	0,938	3,096	0,094
8,2	4,245	2,610	1,634	38,50	3,325	1,627	4,952	0,000
8,3	5,056	2,791	2,266	44,81	0,049	0,583	0,632	0,000
9,1	6,346	3,699	2,647	41,71	2,589	1,110	3,863	0,164
9,2	6,202	4,163	2,039	32,88	4,344	3,137	7,602	0,121
9,3	5,347	3,662	1,685	31,52	1,819	1,940	3,880	0,121
9,4	3,749	2,012	1,737	46,33	1,411	1,683	3,094	0,000
10,1	10,175	5,461	4,714	46,33	1,601	1,779	3,380	0,000
10,2	8,319	4,359	3,961	47,61	4,417	1,767	6,184	0,000
10,3	7,554	4,315	3,239	42,87	3,596	2,578	6,242	0,068
11,2	7,145	3,634	3,511	49,14	4,125	1,404	5,530	0,000
11,3	5,614	3,401	2,213	39,42	4,328	3,995	8,389	0,067
11,4	6,700	3,789	2,911	43,44	3,203	2,380	5,675	0,092
12,1	8,259	4,355	3,904	47,27	4,612	2,253	7,187	0,322
12,2	6,605	6,265	0,340	5,14	6,710	3,799	10,590	0,081
13,1	9,035	4,897	4,138	45,80	2,900	2,900	5,912	0,112
13,3	4,972	2,940	2,032	40,87	7,014	2,630	9,644	0,000
14,1	10,766	5,589	5,190	48,21	5,300	1,805	7,104	0,000
14,2	7,285	3,642	3,642	50,00	1,805	1,679	3,483	0,000
14,3	5,225	2,729	2,496	47,78	3,855	1,835	3,086	0,000
14,4	11,173	5,471	5,702	51,03	6,568	1,351	3,753	0,150
14,5	9,499	5,163	4,634	48,79	4,345	1,800	5,400	0,000
14,6	3,408	2,129	1,279	37,54	1,831	2,174	6,978	0,000
15,2	11,240	4,642	6,598	58,70	2,808	0,828	4,599	0,000
15,3	5,595	3,205	2,390	42,71	3,677	2,096	4,717	0,000
19,5	1,902	1,326	0,576	30,26	1,251	1,682	4,686	0,000
20,1	17,454	7,371	10,083	57,77	4,766	3,495	8,261	0,000
20,2	14,534	6,781	7,752	53,34	2,939	1,533	4,473	0,000
20,3	12,591	5,191	7,400	58,77	1,933	1,795	3,866	0,138
20,4	37,752	10,569	27,183	72,00	2,252	1,351	3,753	0,150
20,5	33,618	8,881	24,737	73,58	3,600	1,800	5,400	0,000
20,6	4,620	2,436	2,183	47,26	1,437	0,924	2,361	0,000
20,7	2,223	1,378	0,845	38,00	2,810	2,096	4,906	0,000
21,5	8,176	4,286	3,889	47,57	4,805	2,295	7,099	0,000
21,6	7,837	3,925	3,913	49,92	3,772	3,537	7,309	0,000
22,3	14,185	5,823	8,362	58,95	2,620	6,517	9,265	0,128
25,1	14,115	5,559	8,555	60,61	3,004	1,391	4,395	0,000

Table III.- Data of incidence and prey size on gut contents of anchovy larvae at different sizes.

MAD-92 FEEDING LARVAE DATA

Station Number	Larvae Number	Min. Size (mm SL)	Max. Size (mm SL)	Preys (+/-)	Larva Size (mm SL)	Prey Numbers	Maximum Width Prey	
							Max. Size um	Min. Size um
1,3	5	5,46	8,39	-				
1,4	4	6,25	10,39	-				
2,3	3	5,33	6,79	-				
3,3	1	3,73	3,73	-				
3,5	3	6,66	11,46	-				
3,6	3	9,73	10,39	-				
4,2	2	3,59	4,66	-				
4,4	2	6,26	8,66	-				
5,2	1	7,33	7,33	-				
5,4	5	7,46	11,59	+	11,597	1	85	85
6,1	2	7,99	7,99	-				
6,3	3	5,06	7,73	-				
7,2	5	7,73	11,46	+	11,463	4	148	80
7,3	7	5,86	7,59	+	5,998	1	85	85
8,2	9	6,66	11,99	-				
8,3	5	7,06	11,06	-				
9,1	6	6,65	8,39	-				
9,2	5	5,46	8,66	-				
9,3	2	6,93	7,06	+	7,064	1	222	222
9,4	2	7,99	7,99	+	7,99	8	75	75
10,1	5	8,66	11,86	-				
10,2	5	8,26	10,66	-				
10,3	5	7,33	13,33	-				
11,2	5	6,66	9,33	+	6,931	2	80	80
11,3	5	7,19	8,93	+	8,397	1	148	148
11,4	5	7,19	10,93	+	8,131	4	160	75
12,1	5	7,06	10,13	-				
12,2	5	5,59	10,66	+	5,598	1	90	90
13,1	4	7,33	8,39	-				
13,2	5	4,93	6,93	-				
13,3	5	6,26	8,66	+	7,064	1	–	–
					7,864	1	160	160
14,1	5	7,99	9,73	-				
14,2	3	3,59	6,65	-				
14,3	5	5,19	7,86	-				
14,4	4	7,46	9,99	+	9,997	1	–	–
14,5	3	6,26	8,66	-				
15,2	6	4,66	9,19	+	5,332	1	45	45
15,3	5	6,53	8,66	+	6,531	1	–	–
					7,598	2	95	64
					8,531	1	116	116
					8,664	2	233	127
15,4	3	5,46	7,06	-				
15,5	5	6,65	7,73	+	7,331	3	–	85
15,7	8	6,13	9,33	-				
16,3	5	5,86	8,66	-				
16,4	3	4,26	7,73	-				
16,6	8	7,06	8,66	-				
16,7	2	8,93	8,93	-				
18,1	2	9,46	10,26	-				
19,5	5	8,66	11,06	+	9,464	1	32	32
20,4	2	6,13	8,26	-				
20,5	5	6,13	7,99	+	7,464	1	64	64
					7,998	1	116	116
				+	7,998	3	160	138
21,5	5	6,65	10,79	-				
21,6	5	6,66	8,66	-				
22,3	5	6,13	9,99	-				
25,1	5	5,99	7,33	-				