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Distribution of *Nephrops norvegicus* (Linnaeus, 1758) in Sea of Marmara

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Abstract: The distribution of the *Nephrops norvegicus* (Linnaeus, 1758) in Sea of Marmara has been studied. The data was collected between 01. December 2003 and 30. December 2003 from the SW part of Sea of Marmara. Totally, 274 *N. norvegicus* were sampled and mapped.
N. norvegicus, which is invariably associated with deep mud was found in that area. It has been found in these locations at depths of between 35 and 100m. The sediment in this area has been recorded as muddy-fine sand, which is worked and burrowed. The mud fraction in this area forms 85% or more than the sediment.
In addition deep mud habitats in the project area are currently not fished by beam trawling (for *Parapenaeus longirostris*) and are relatively undisturbed. However, beam trawling occurs over most of the deep mud habitats with *P. longirostris*. There are some limited areas which are generally minimally affected by anthropogenic disturbance. These include areas which are difficult to trawl because of the depth, bottom structure and abundance of the non fished species such as *Stichopus regalis*.
Areas with less trawling pressure can hold a range of more sensitive deep mud species such as *Funiculina* and because the strong food competition between *P. longirostris,* are the *Funiculina quadrangularis* dominant in that area.

Keywords: *Nephrops norvegicus, beam-trawl, Funiculina quadrangularis, salinity, conductivity, Sea of Marmara*

Materials and methods

A total of 274 pieces of *N. norvegicus* were caught in December from the ground of the Sea of Marmara, located between Karabiga harbour and Marmara Island and 35-100 meters deep (Fig. 1).
Fish samples (n = 244) were caught daily by working in relation with the fishermen in the Sea of Marmara between 01. December 2003 and 30. December 2003.
Additionally obtained samples (n = 30) from the diving stations in the same area at the same time.
The temperature, dissolved oxygen, conductivity measurements are taken from the stations (Fig. 3.) vertically from surface, to bottom as 1, 10, 15, 20, 25, 50, 75 and 85mts. in-situ.(WTW) And the salinity and density are calculated with processor computer programme (Hydro-Ql) (and other fractions as shown in tables 3-6)

Introduction

Stock identification surveys are an important tool in providing information on the locations of sea food populations, biological interactions with physical oceanography and larval survival generating variability in recruitment to sea food populations. Stock identification is an integral component of modern fisheries stock assessment studies and in turn of effective fisheries management. (Carvalho 1994)

The study was performed in the NW of Sea of Marmara where an important deep-sea beam trawl fishery for deep sea pink shrimp *P. longirostris* in traditionally carried out by the west Sea of Marmara fleets, on muddy bottoms from 80m. to 100m. deep.
Temperatures ranged from 11.16°C to 14.46°C, while salinity varied between 21.90‰. and 37.58 ‰.

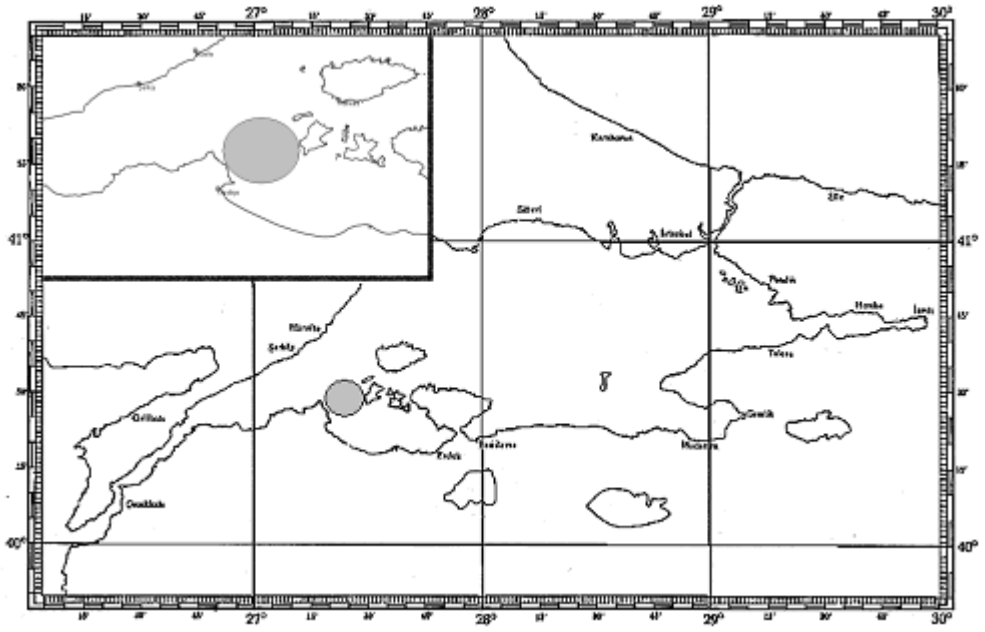


Fig.1. Indication of the project area.

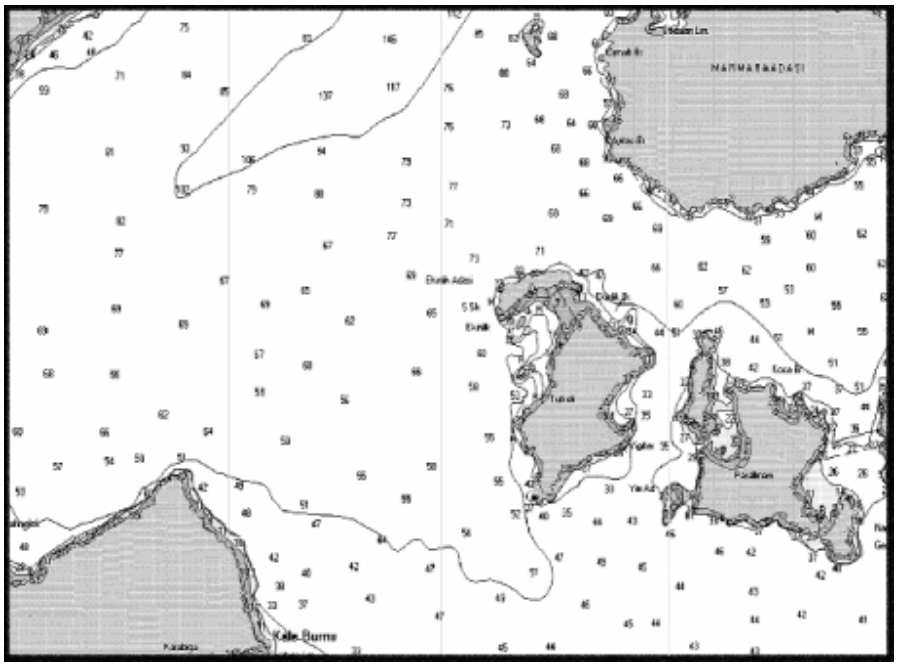


Fig.2. The depth profile of the project area.

27º 15' 34" E – 40º 34' 17" N
27º 28' 34" E – 40º 39' 17" N
27º 29' 14" E – 40º 28' 01" N
27º 24' 58" E – 40º 22' 05" N

Table.1. The frame co-ordinates of the project area.

Biology of *N. norvegicus*

Nephrops norvegicus is a small lobster, pale orange in colour. It grows to a maximum total length of 25cm., although individuals are normally between 18-20cm. The carapace has a non-segmented cover while the long abdomen is clearly segmented with terminal appendages that flattened and expanded, forming a tail-fan. The carapace is fused and covered with short spines at its anterior end. Rostrum is long and with 2 spins of each side. The segments of the long abdomen are grooved transversely.

The first 3 pairs of legs bear claws, the first pair being very long and slender with spiny ridges. The first pair of legs is very elongated with longitudinal, spiny ridges. There are 2 pairs of antennae, the second pair much longer and thinner than the first. The large kidney-shaped eyes are broader than the eyestalks, are black, and moveable.

Found sublittorally in soft sediment, commonly at depths of between 20-800m., although considerable populations exist at depths <200m. They live in shallow burrows and are common on grounds with fine cohesive mud which is stable enough to support their unlined burrows. Although *N. norvegicus* is capable of swimming, it is a crawler more than it is a swimmer.

N. norvegicus construct extensive shallow and branching burrows in soft sediments such as fine or silty mud at depths of 20-800m. Burrows may be up to 10cm. in diameter, over a metre long and penetrate the sediment to a depth of 20-30cm. (Rice & Chapman, 1981).

N. norvegicus usually remain within their burrows by day and emerge at sunset to forage during the night but in deeper water this activity is reversed and individuals are more active by day (Chapman & Rice, 1971).

In laboratory conditions, large males are less inclined to make burrows than females and small males, which may account for the higher proportion of large males that are caught in small catches (Andersen, 1962).

Rostrum of *N. norvegicus*

Pinched leg of *N. norvegicus*

Telson of *N. norvegicus*

Like other crustaceans, *N. norvegicus* must moult, shedding their hard exoskeleton, to grow. *N. norvegicus* contain no annually marked structures, such as the otoliths found in fish, so the estimation of growth rates, age and maximum age has proved to be particularly difficult in this species.

Growth (and fecundity) in *N. norvegicus* are known to vary geographically and have been shown to be negatively correlated with burrow density (Tuck *et al.*, 1997). Thus, growth rate appears to be density-dependent, and is also thought to be related to food availability. For example, Tuck *et al.* (1997) found growth was correlated with infaunal biomass. This suggests that nutritional stress occurs in populations with slower growing individuals. Growth of *Nephrops* may also be influenced at high densities through social behaviour changes (Cobb *et al.*, 1982).

Parslow-Williams *et al.* (2001) found evidence that nutritional limitation was occurring in *N. norvegicus* from a site in the Clyde Sea with a high population density, compared to another site with a low density of individuals.

Information on the growth rate of lobsters is very limited (Thomas, 1965). Despite being one of the most studied decapods, the area of age and growth estimation is still one for which there is no standard methodology (Castro, 1995).

N. norvegicus grows to a maximum total length of 25 cm (including telson, carapace and pinched legs), although is normally between 18-20 cm (Fish & Fish, 1996). The generally recognized standard measurement for *N. norvegicus* is carapace length (CL). The maximum recorded CL of *Nephrops norvegicus* was 80 mm (Mar.Ins., 2001). However, in recent years *N. norvegicus* with carapaces larger than 60 mm are rare (Mar.Ins., 2001).

Thus mature females about 23 mm CL and mature male *N. norvegicus* about 26mm. CL are around 2-3 years old.

Tuck *et al.* (2000) found that, in the Firth of Clyde, age at the onset of sexual maturity was relatively constant between different study sites but varied between sexes. In general, the age at onset of maturity was 4 - 4.5 years in males and 3 - 3.5 years in females. The size (carapace length) at sexual maturity was found to be positively correlated to asymptotic length and negatively correlated to adult density and ranged from 21 - 34mm. in females and 29 - 46mm. in males (Tuck *et al.*, 2000). The authors suggested that there may exist a minimum size threshold under which males may be too small to reproduce.

Most *N. norvegicus* stocks have an annual reproductive cycle Jorgensen (1925). Sexually mature *N. norvegicus* of both sexes moult towards the end of spring and into the summer. Mating takes place while the female is still 'soft' directly after the female has moulted and before the hardening of the new exoskeleton. Once fertilized the eggs are then carried on the females abdomen for 8-9 months, during which time the females tend to remain in their burrows. (Farmer, 1975)

It must also be noted that the number of eggs on the abdomen diminishes during incubation mainly due to predation (Morizur, 1979, Abelló & Sardá, 1982).

During incubation it is generally thought that ovigerous females tend to remain within their burrows (Farmer, 1975).

Females N. *norvegicus* come out of their burrows to allow their eggs to hatch and the larvae to escape from April -June (Farmer, 1974c).

Larval Development

Newly hatched larvae are incapable of swimming but moult within a few minutes of hatching to produce the first free swimming larval stage (Farmer, 1974c, Dickey-Collas *et al.*, 2000b). They are recognizable by their long dorsal spines on the abdomen and their large characteristic telson (Thorson, 1946). There are three larval stages in the development of *Nephrops norvegicus* together with a post larval stage (Jorgensen, 1925).

Stage I (zoea)

Of the zoea the first 13 pairs of appendages are fully developed. Towards the end of the stage the appendages of the second and fifth abdominal segments can be seen as small buds (Jorgensen, 1925). Orange chromatophores are present with yellow spots at the bases and joints of the pereiopods. These yellow spots are visible in the free swimming larval stages and disappear in the post larval stage (Farmer, 1974). The average larval length at this stage was reported to be about 6.5 mm (Jorgensen, 1925).

Stage II (Protozoea)

The appendages of the second and fifth abdominal segments are present as small structures but there is no sign of the appendages of the first segment. As the second moulting approaches, developing uropods become visible beneath the new cuticle in front of the caudal fork. The average length of a larva at this stage is around 8 mm (Jorgensen, 1925).

Stage III (zoea)

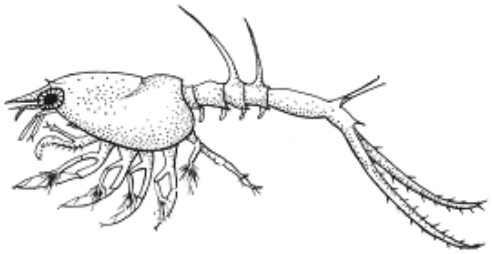
The pleopods of the second and fifth abdominal segments are fully developed as are the uropods but the first abdominal segment has no appendages. The caudal fork should now be segmented off from the last abdominal segment. Larvae at this stage average around 10 mm in length (Jorgensen, 1925).

Post larval stage (Mysis)

Once the third stage has been completed the larvae enters the 1st post larval stage. The juvenile no longer possesses long spines or a Claudia fork and the juvenile assumes the characteristics of an adult. (Jorgensen, 1925) suggested that during the moulting that changes the larva into a young adult, the juveniles appears to direct all of its energies towards the production of a new form, with little reserved for growth (Jorgensen, 1925). The average size of the post larvae is around 11 mm. (Jorgensen, 1925).

Garrod & Harding (1980) estimated that larval mortality was as high as 87% in the field.
The larval stages of *Nephrops norvegicus* spend around 50-60 days in the plankton before settlement (Farmer, 1975). Tuck *et al.* (1994) reported that juvenile *Nephrops norvegicus* appeared to preferentially take up residence in existing adult burrows. The juveniles constructed their own burrows as an extension of the adult burrows. However, as the juveniles grow and extend their own burrows, contact is lost with the adult *Nephrops* and the connection between juvenile and adult burrows is severed (Tuck *et al.*, 1994).

Nephrops norvegicus is widely distributed on muddy substrata throughout the North-East Atlantic from Iceland in the North to Morocco in the South. The species is found in the Mediterranean and is abundant in the Adriatic.



The 7mm. mysis stage of *N. norvegicus*

During several trials with the plankton net in the area, vertical from bottom to surface with 335 µ mesh size and 60cm.Ø, we couldn't find any eggs or larvae from N. Norvegicus during the project period.

Explanation

N. norvegicus, which is invariably associated with deep mud. In these locations it has been found at depths of between 35 and 100m. The sediment in this area has been recorded as muddy fine sand, which is worked and burrowed. The mud fraction in this area forms 95% or more of the sediment.
In addition deep mud habitats in the project area are currently not fished by beam trawling (for *Parapenaeus longirostris*) and are relatively undisturbed. However, beam trawling occurs over most of the deep mud habitats with *P. longirostris*. There are some limited areas which are generally minimally affected by anthropogenic disturbance. These include areas which are difficult to trawl because of the depth, bottom structure and abundance of the non fished species such as *Stichopus regalis*. Areas with less trawling pressure can hold a range of more sensitive deep mud species such as *Funiculina* and because the strong food competition between *P. longirostris* are the *Funiculina quadrangularis* dominant in that area. The total composition of beam-trawl catches as shown in (Table. 3.)
During the project period 4 numbers of *N. norvegicus* were from the beam trawl fisher from Şarköy and Mürefte is reported as by catch of *P. longirostris* beam trawling (1 from Şarköy, 3 from Mürefte). But after the discussions with the beam trawl fisher, we have seen that the reports are not regular and they are fishing max. 10-20 pcs. of *N. norvegicus.* every season
A small population of *N. norvegicus* is found in the project area. But when the beam trawl fishery go further including the mentioned area, the population of *N. norvegicus* is decreased.
In that case, we don't know the possible effects of cleaning out of funiculae, for the more reliable catch of deep sea pink shrimp in the mentioned area, to the *N. norvegicus* population.
Also we don't know the distribution of *N. norvegicus* in much deeper parts of Sea of Marmara. Near the project area Tekirdağ deep is located with ~1200m. May be on the upper parts of the Tekirdağ deep (100-800m.) is an intensive population of *N. norvegicus.*
We have also indicated during the diving surveys in the area, in some places *N. norvegicus* burrows in mud 20pcs. per m^2. But the average number of burrows was ~9-12 per m^2.

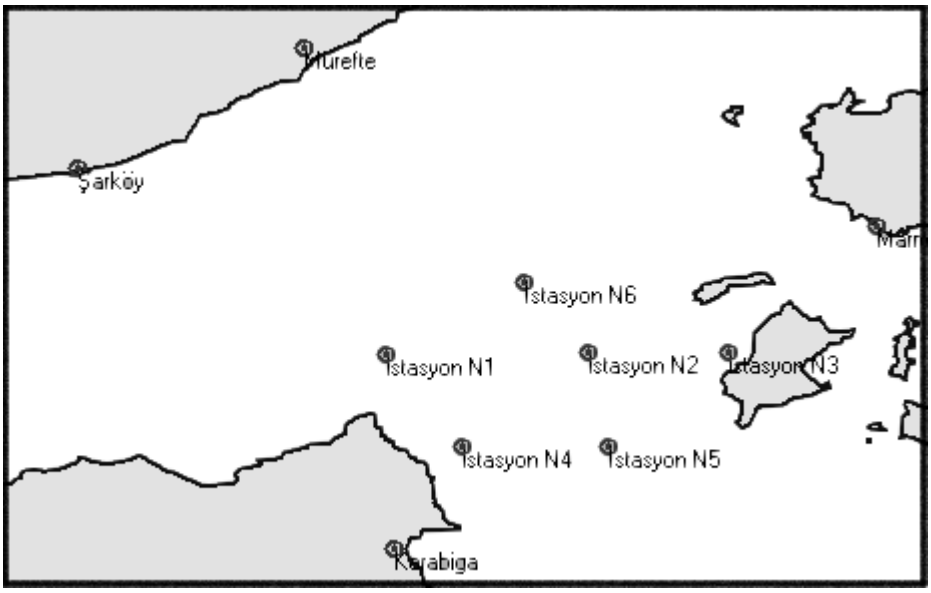


Fig. 3. Station positions of the survey, December 2003

istasyon N1	**27º 14' 34" E**	**40º 30' 33" N**
istasyon N2	**27º 24' 18" E**	**40º 30' 33" N**
istasyon N3	**27º 29' 02" E**	**40º 30' 33" N**
istasyon N4	**27º 20' 06" E**	**40º 27' 25" N**
istasyon N5	**27º 25' 58" E**	**40º 27' 25" N**
istasyon N6	**27º 24' 10" E**	**40º 32' 57" N**

Table. 2. The co-ordinates of sampling points

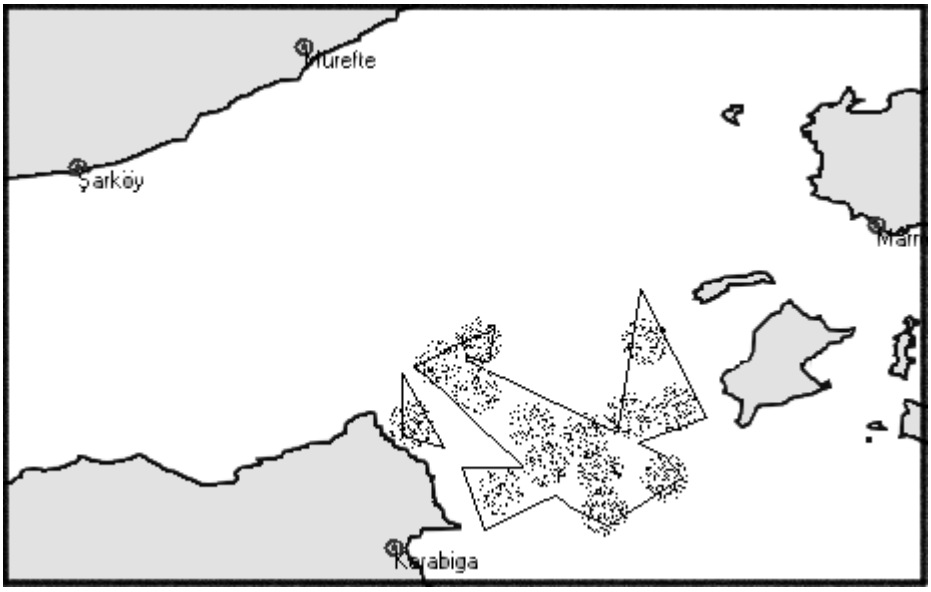


Fig. Diving routes in the project area

Table. 3.

Beg.: 01. December 2003 **Emin:** 27º14'34" **Nmin:** 40º27'25"
End.: 30. December 2003 **Emax:** 27º29'02" **Nmax:** 40º32'57"
Parameter: TºC

DEPTH (m)	MIN.	MAX.	DIF.	UNIT.	Opt.	Sdev.	Var.	Sem.	Opt. corr.	Vol. opt.	Vol. Sdev.
1	11.16	14.33	3.17	8	12.42	1.000	0.875	0.533	12.38	14.36	3.407
10	11.42	14..36	2.94	8	12.48	0.961	0.809	0.339	12.48	13.89	2.860
15	11.31	14.41	3.10	8	12.58	0.929	0.755	0.328	12.58	13.44	2.462
20	11.16	14.46	3.30	8	12.68	0.958	0.804	0.338	12.68	13.25	2.200
25	10.80	14.60	3.80	8	12.94	1.251	1.370	0.442	13.35	13.09	1.851
50	14.40	14.90	0.40	7	14.65	0.203	0.035	0.076	14.19	13.19	1.832
75	14.30	14.70	0.40	3	14.50	0.200	0.027	0.115	14.55	13.22	1.820
85	14.46	14.63	0.17	2	14.55	0.120	0.007	0.084	14.55	13.24	1.813

Table. 4.

Beg.: 01. December 2003 **Emin:** 27º14'34" **Nmin:** 40º27'25"
End.: 30. December 2003 **Emax:** 27º29'02" **Nmax:** 40º32'57"
Parameter: Salinity

DEPTH (m)	MIN.	MAX.	DIF.	UNIT.	Opt.	Sdev.	Var.	Sem.	Opt. corr.	Vol. opt.	Vol. Sdev.
1	21.90	30.30	8.40	8	24.69	2.728	6.513	0.964	24.14	22.03	3.381
10	22.28	30.44	8.16	8	25.24	2.663	6.207	0.941	25.24	22.83	3.475
15	23.04	30.73	7.69	8	26.34	2.590	5.870	0.915	26.34	23.91	3.519
20	23.80	31.01	7.21	8	27.45	2.589	5.864	0.915	27.45	24.73	3.573
25	25.70	33.50	7.80	8	30.21	2.908	7.398	1.028	31.74	26.41	3.896
50	36.60	37.30	0.70	7	36.89	0.219	0.041	0.082	35.34	27.07	4.557
75	37.00	37.60	0.6	3	37.37	0.321	0.069	0.185	37.31	27.34	4.791
85	37.58	37.60	0.02	2	37.59	0.014	0.000	0.009	37.59	27.52	4.935

Table. 5.

Beg.: 01. December 2003 **Emin:** 27º14'34" **Nmin:** 40º27'25"
End.: 30. December 2003 **Emax:** 27º29'02" **Nmax:** 40º32'57"
Parameter: Sigma-T

DEPTH (m)	MIN.	MAX.	DIF.	UNIT.	Opt.	Sdev.	Var.	Sem.	Opt. corr.	Vol. opt.	Vol. Sdev.
1	5.47	7.00	1.53	8	6.39	0.526	0.242	0.185	6.68	7.38	0.888
10	5.20	6.76	1.56	8	6.11	0.496	0.216	0.175	6.11	7.06	0.977
15	4.67	6.28	1.61	8	5.54	0.475	0.197	0.167	5.54	6.60	1.066
20	4.13	5.80	1.67	8	4.97	0.510	0.227	0.180	4.97	6.23	1.153
25	2.80	4.60	1.80	8	3.55	0.739	0.478	0.261	3.27	5.42	1.442
50	1.60	3.80	2.20	7	2.14	0.789	0.534	0.298	2.46	5.21	1.618
75	2.00	2.00	0.00	2	2.00	..	..	..	2.03	5.15	1.659
85	1.98	1.98	0.00	1	1.98	..	..	..	1.98	5.13	1.678

Table. 6.

Beg.: 01. December 2003 **Emin:** 27º14'34" **Nmin:** 40º27'25"
End.: 30. December 2003 **Emax:** 27º29'02" **Nmax:** 40º32'57"
Parameter: DO (mg/l)

DEPTH (m)	MIN.	MAX.	DIF.	UNIT.	Opt.	Sdev.	Var.	Sem.	Opt. corr.	Vol. opt.	Vol. Sdev.
1	5.47	7.00	1.53	8	6.39	0.256	0.242	0.185	6.68	7.38	0.888
10	5.20	6.76	1.56	8	6.11	0.496	0.216	0.175	6.11	7.06	0.977
15	4.67	6.28	1.61	8	5.54	0.475	0.197	0.167	5.54	6.60	1.066
20	4.13	5.80	1.67	8	4.97	0.510	0.227	0.180	4.97	6.23	1.153
25	2.80	4.60	1.80	8	3.55	0.739	0.478	0.261	3.27	5.42	1.442
50	1.60	3.80	2.20	7	2.14	0.789	0.534	0.298	2.46	5.21	1.618
75	2.00	2.00	0.00	2	2.00	..	..	..	2.03	5.15	1.659
85	1.98	1.98	0.00	1	1.98	..	..	..	1.98	5.13	1.678

Table 3-6. Hidrographical mesurement results

	N1	N2	N3	N4	N5	N6
Gerardia savaglia	1				1	
Caryophyllina smithii		1	2			
Funiculina quadrangularis	123	97	116	73	92	16
Turritella comunis	2		7	1	2	1
Gourmya vulgata	1	2	1	3		
Aporrhais pes-pelecani		1	3			
Tonna galea				1		
Murex trunculus	1		1		1	
Pecten jacobeus	8		11	9	6	1
Rudicardium tuberculatum	3		17			1
Sepiola rondeleti	7	1	2	3	5	2
Parapenaeus longirostris	1123	678	2134	1985	965	3125
Nephrops norvegicus	22	55	12	21	63	71
Macropipus arcuatus	8	16	54	22	4	11
Stichopus regalis	136	144	78	92	16	34
Echinocardium cordatum	8	16	11	6	9	7
Astropecten spinulosus		1		3	1	
Amphiura filiformis	21	16	8	19	6	3
Ophiura texturata	3	9	2	1	9	17
Raja mireletus	1			1		2
Torpedo torpedo			1			
Pomatoschistus microps	44	31	8	37	16	33
Lophius piscatorius		1		2	1	

Table.3. The catch results of beam trawls during the project. Indicated totally (pcs.)

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