

(

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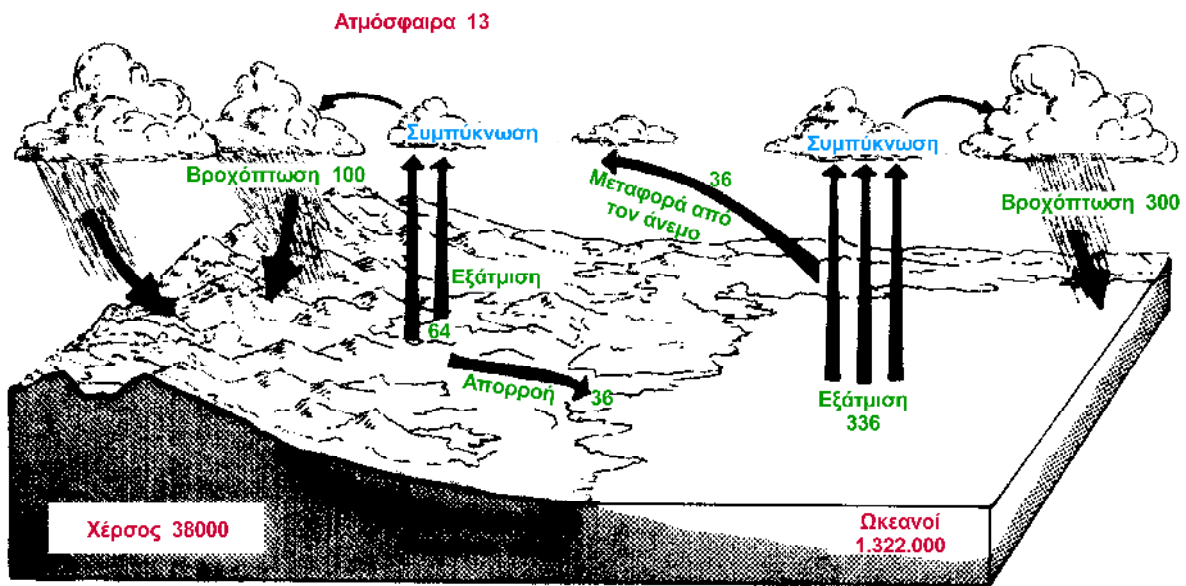
.

2011

1.3.

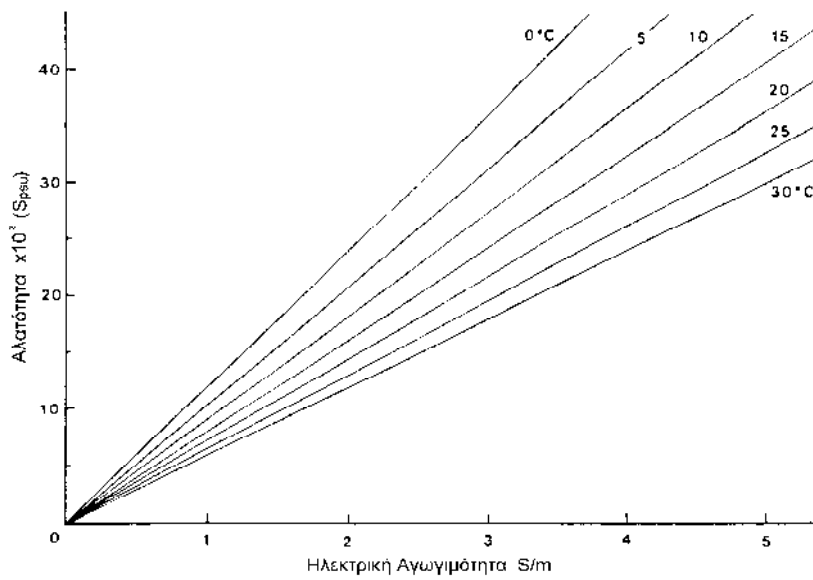
1.3.1.

(μ μ μ μ)
 μ μ . μ 150°C
 μ μ (4.0×10^9) μ
 μ , μ ,
 μ μ , (μ)
 (μ , μ , μ)
 (. 1.3.1).
 μ μ μ μ μ
 (reservoir), μ .



. 1.3.1. μ .
 μ μ " μ " μ μ
 μ μ μ μ μ
 μ . $\text{kg} \times 10^{15}$.

σ " (S_{psu})



1.3.2.

μ CTD's (Conductivity, Temperature, Depth)

“ μ μ ”

±0.003, μ μ

±0.02.

(precision)

The specific volume, v , is defined as the volume per unit mass of a substance. It is the reciprocal of the density, ρ . In SI units, v is measured in m^3/kg . In CGS units, it is measured in cm^3/g . The specific volume is an extensive property of a substance.

$$\frac{T}{p} = \frac{1}{J \cdot C_p} \cdot T$$

The specific volume, v , is a function of temperature, T , and pressure, p . The specific volume of a gas at constant pressure is a function of temperature only. The specific volume of a liquid and solid is a function of both temperature and pressure. The specific volume of a gas at constant pressure is a function of temperature only.

$J = 4.1862 \times 10^7 \text{ erg/cal}$, C_p is the specific heat capacity at constant pressure.

$$p = g \cdot z, \quad \frac{T}{z} = \frac{g \cdot z}{J \cdot C_p}$$

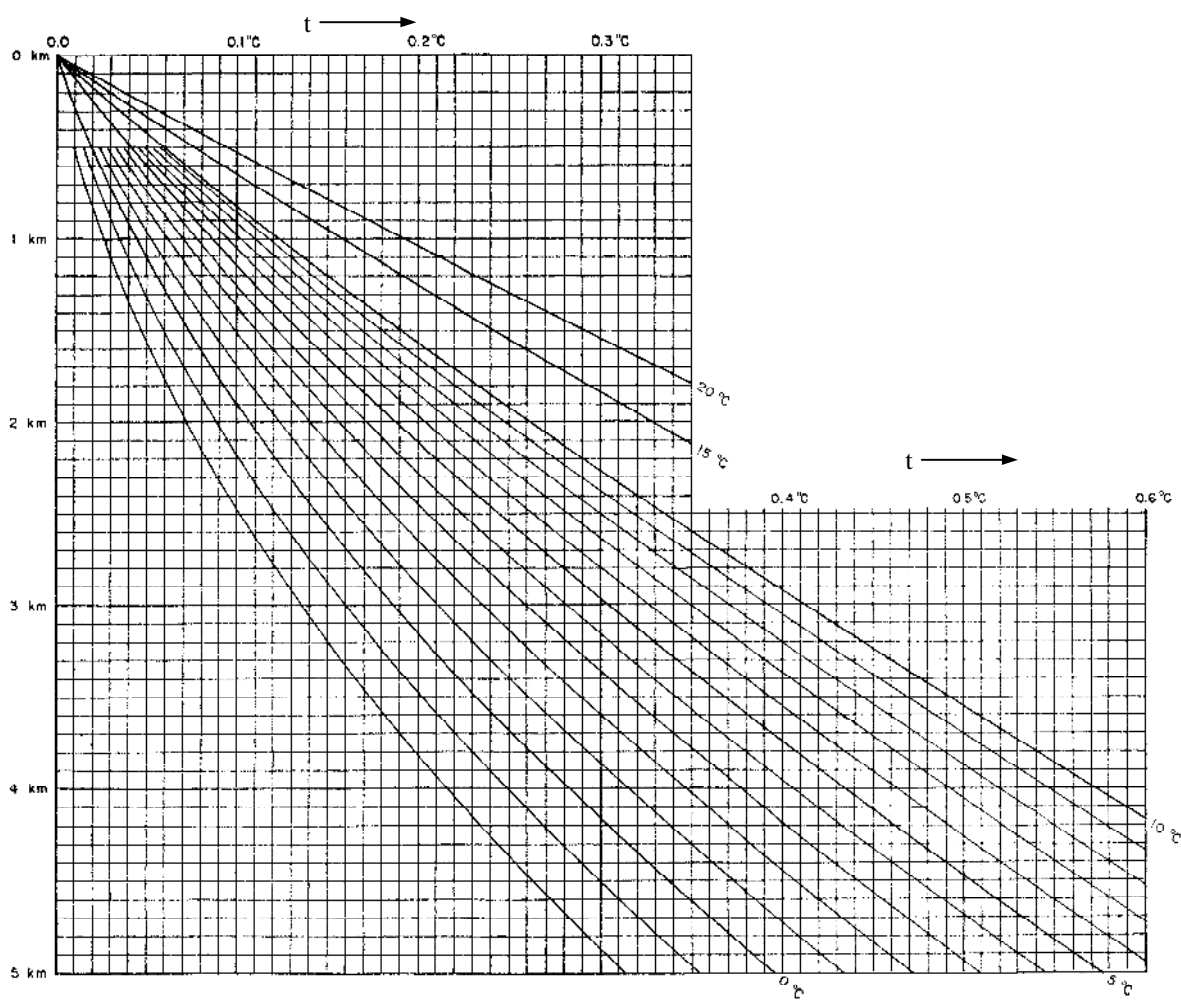
The specific volume, v , is a function of temperature, T , and pressure, p . The specific volume of a gas at constant pressure is a function of temperature only. The specific volume of a liquid and solid is a function of both temperature and pressure. The specific volume of a gas at constant pressure is a function of temperature only.

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¹ The specific volume, v , is a function of temperature, T , and pressure, p . The specific volume of a gas at constant pressure is a function of temperature only. The specific volume of a liquid and solid is a function of both temperature and pressure. The specific volume of a gas at constant pressure is a function of temperature only.

² The specific volume, v , is a function of temperature, T , and pressure, p . The specific volume of a gas at constant pressure is a function of temperature only. The specific volume of a liquid and solid is a function of both temperature and pressure. The specific volume of a gas at constant pressure is a function of temperature only.

μ . 1.3.3 μ 1.3.1 μ
 μ μ μ μ ,
 z .
 μ μ μ μ
 μ
 μ μ μ μ
 μ .



. 1.3.3. μ $\mu\mu$ μ μ
 (μ $\mu\mu$) μ μ () μ
 μ μ ()
 μ $\mu\mu$ 34.85%.

1.3.1. μ μ $(t) (\times 10^{-2} \text{ }^\circ\text{C})$ (S
= 34.85‰) μ μ $(t \text{ }^\circ\text{C})$ μ
d (m) (Helland – Hansen).

t (°C) d (m)	-2	-1	0	1	2	3	4	5	6	7	8	9	10
1000	2.6	3.5	4.4	5.3	6.2	7.0	7.8	8.6	9.5	10.2	11.0	11.7	12.4
1500	5.4	6.7	8.0	9.3	10.6	11.8	12.9	14.1	15.3	16.4	17.5	18.6	19.7
2000	7.2	8.9	10.7	12.4	14.1	15.7	17.2	18.8	20.4	21.9	23.3	24.8	26.2
2500	10.9	12.9	15.1	17.2	19.3	21.2	23.1	25.0	26.9	28.7	30.6	32.3	34.0
3000	13.6	16.1	18.7	21.2	23.6	25.9	28.2	30.5	32.7	34.9	37.1	39.2	41.2
3500	18.1	21.0	24.0	26.8	29.6	32.2	34.8	37.3	39.8	42.3	44.8	47.2	49.5
4000	21.7	25.0	28.4	31.6	34.7	37.7	40.6	43.5	46.3	49.1	51.9	54.6	57.2
4500	27.0	30.7	34.4	37.9	41.3	44.7	47.9						
5000	31.5	35.5	39.6	43.4	47.2	50.9	54.4						
5500	37.5	41.9	46.3	50.4	54.5	58.4	62.2						
6000	42.8	47.5	52.2	56.7	61.1	65.3	69.4						
6500			59.6	64.3	69.0	73.4	77.7						
7000			66.2	71.3	76.2	80.9	85.5						
7500			74.2	79.5	84.7	89.6	94.4						
8000			81.5	87.1	92.5	97.7	102.7						
8500			90.1	95.9	101.6	106.9	112.1						
9000			98.1	104.1	109.9	115.6	121.0						
9500			107.2	113.4	119.4	125.2	130.8						
10000			115.7	122.1	128.3	134.4	140.2						

μ ,
 μ
 μ :
 $= f(s, t, p)$
s, t p , μ ,
 μ μ . μ (in-situ).
 μ μ
1,000 1,500m μ , μ .
 μ μ $10^4 - 10^5$ kPa (10m)
1Atm) μ μ μ

30m

1.07000 gr/cm³ (10,000m). 1.02100 1.02800 gr/cm³

7%

$\rho_{(s,t,p)} = (\rho_{(s,t,p)} - 1 \text{ gr/cm}^3) \times 10^3$

1.02042 gr/cm³, $\rho_{(s,t,p)} = 20.42$.

$\rho_{(s,t,p)} = \rho_{(s,t,0)} (1 - \alpha t)$

5

(i) (ii) (iii)

1981

UNESCO

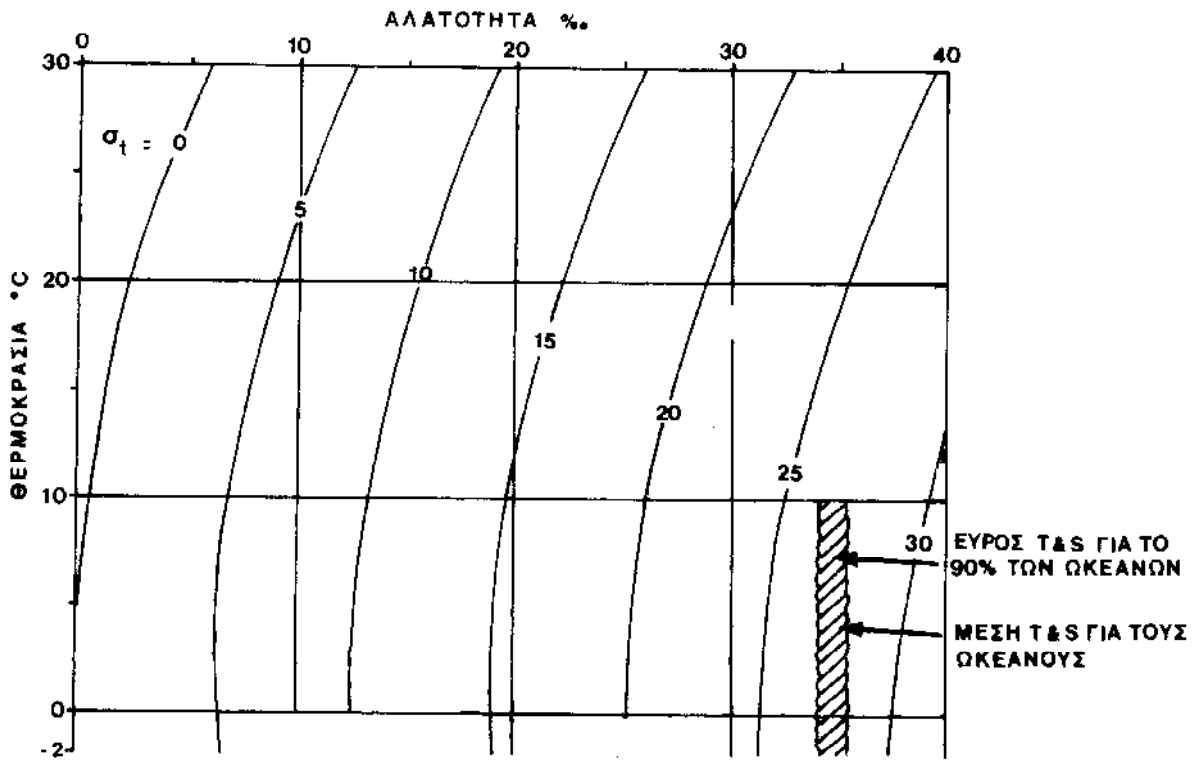
“ (International Equation of Seawater State)

IES80.

CTD

(T/S ρ_{sw}) (1.3.4),

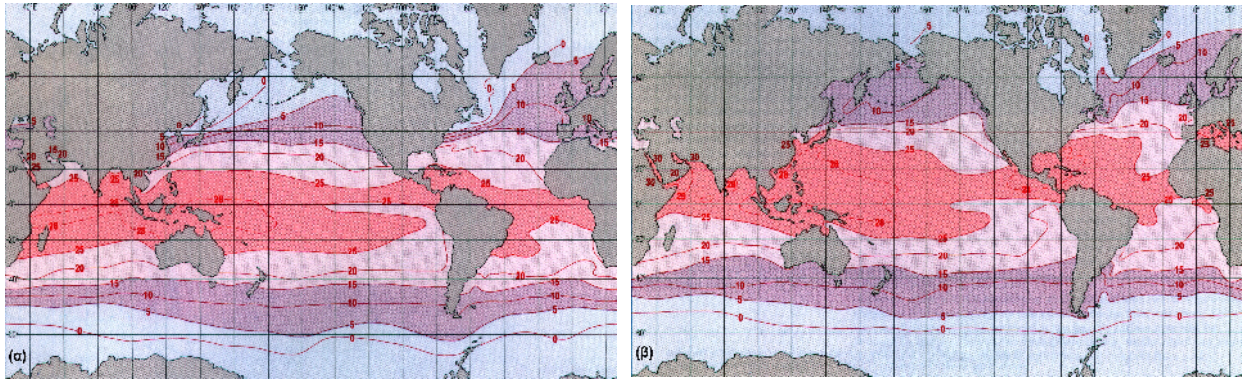
(i)



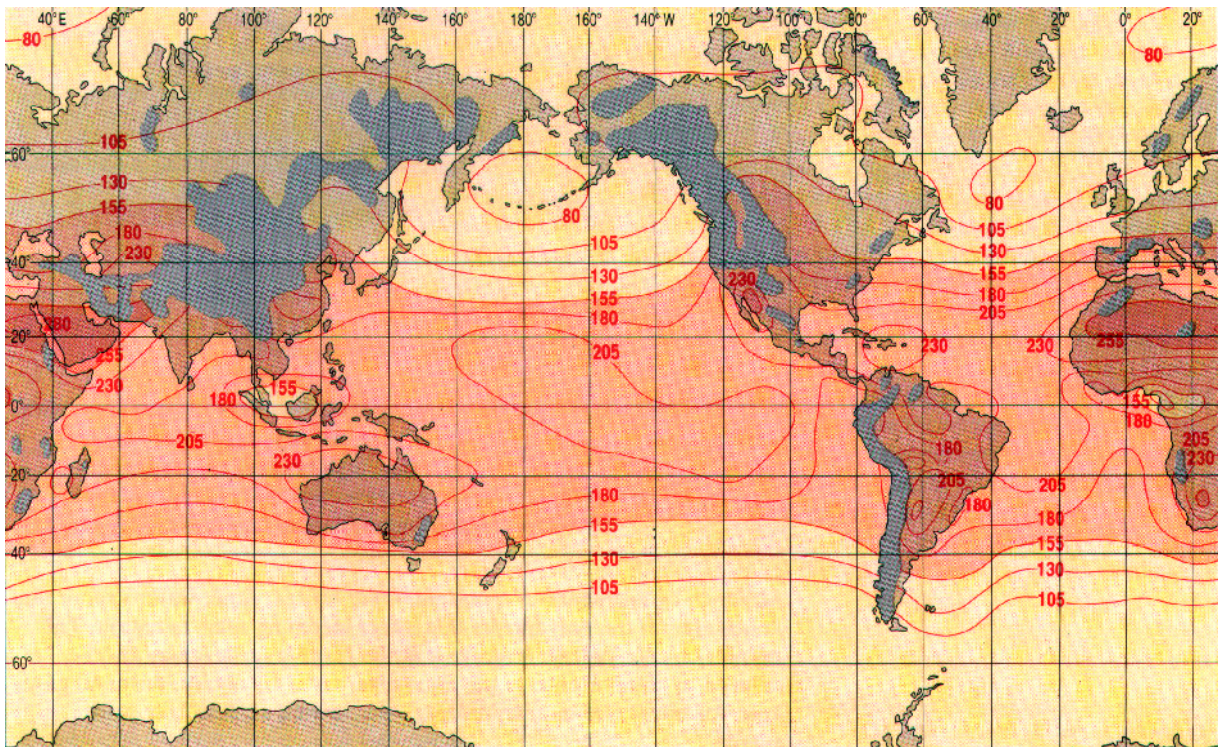
.1.3.4. $\mu\mu$ μ - (T/S) μ
 (ι).

1.3.1 μ μ
 μ - μ [] μ
 (ι) μ μ (ι) μ 1°C μ
 μ , μ μ μ -0.34 0.07.
 μ (. . 30°C) μ μ (ι =
 1°C) μ μ (≈ -0.30 -0.34)
 μ (. . 0‰, 20‰, 40‰), μ μ (. . 0°C)
 μ μ (≈ -0.17 0.07) μ
 [] μ (ι) μ
 (s) μ 0.5‰ μ μ ,
 (0.38 0.43). μ μ
 μ μ (. .)
 μ μ , μ ,
 μ .

(upwelling). μ μ μ
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 Labrador Gulf Stream μ μ
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 (≈ 1 2°C).



. 1.3.5. μ μ μ
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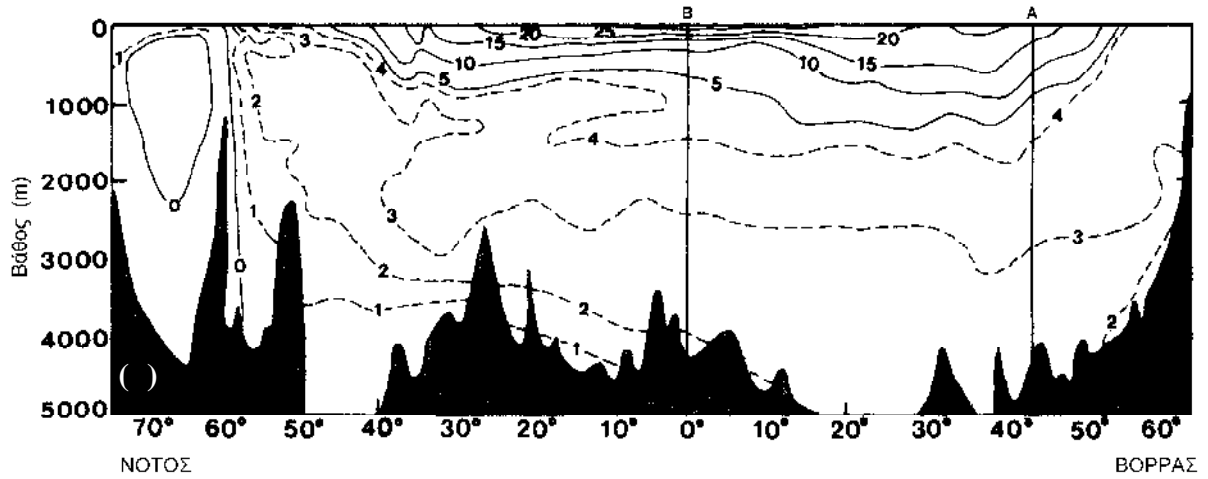


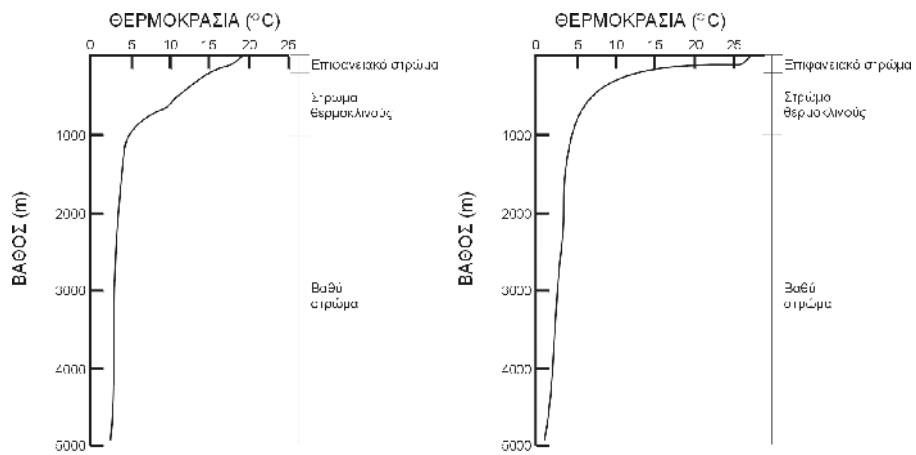
. 1.3.6.
 $\text{J}\cdot\text{m}^{-2}\cdot\text{yr}^{-1}$.

1.3.7

μ μ . μ μ

μ μ :) μ μ μ μ (well mixed layer) (.1.3.7,) . μ μ 200m μ μ μ . μ μ μ μ μ . μ μ .) μ μ μ μ (permanent thermocline) (.1.3.7,) . μ 200 – 1,000m μ μ μ μ μ μ μ) μ μ (bottom layer) (.1.3.7,) . μ 1,000m μ μ μ μ , μ μ .





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. 1.3.7. ()

μ μ μ μ μ μ μ

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5°C.

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(seasonal

thermocline)

50 – 100m (. 1.3.8).

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. 1.3.8

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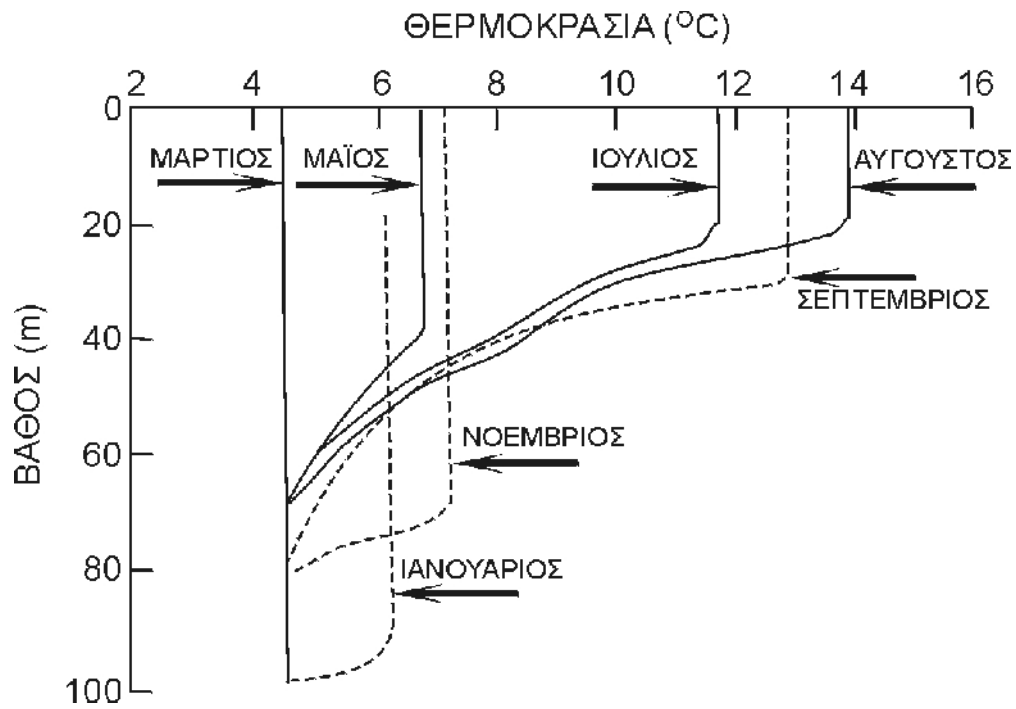
,

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μ

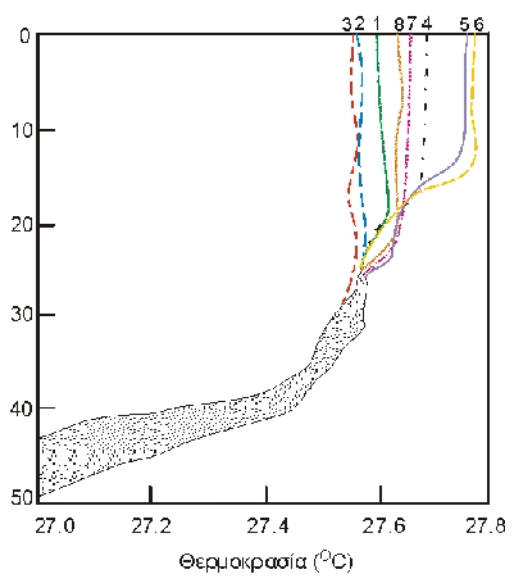
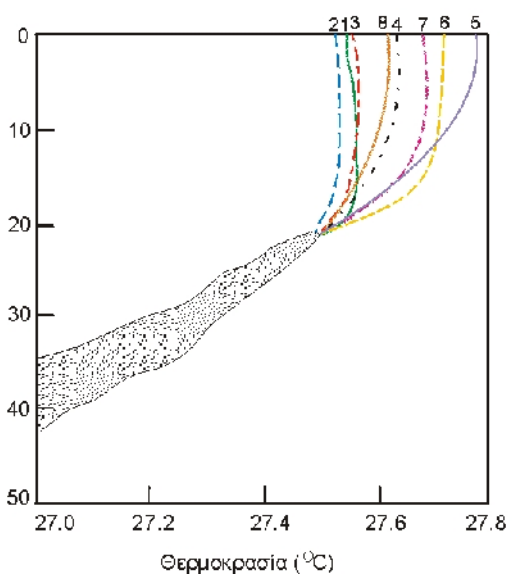
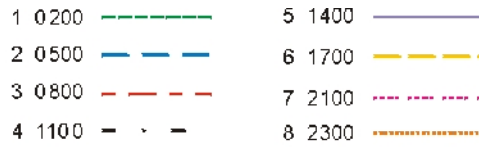
,



1.3.8.

(diurnal thermocline) (1.3.9),

1.3.7).



1.3.9.

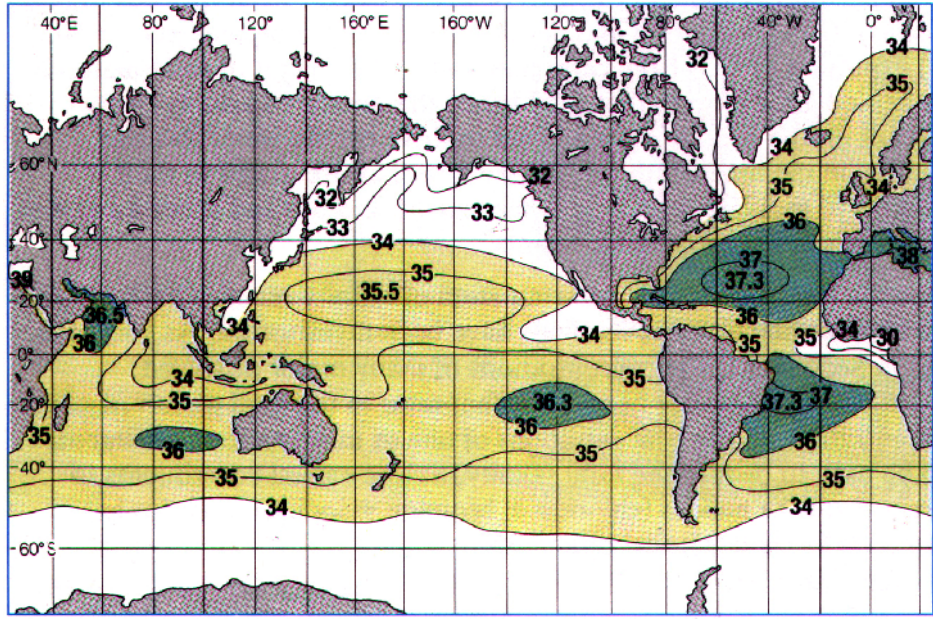
μ μ μ
μ , μ μ μ μ
μ .

32

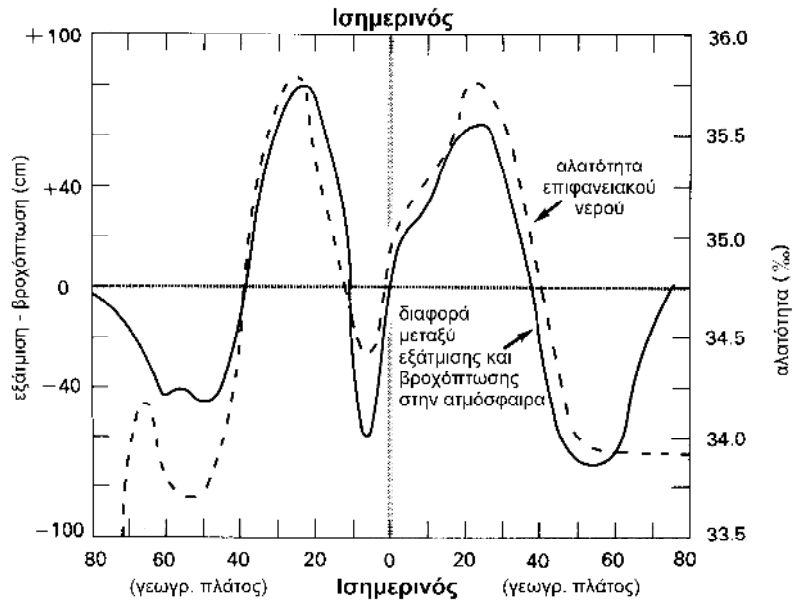
- 37‰, μ μ μ 34‰ μ (1.3.10).
μ (precipitation) μ (evaporation). μ μ ()
μ μ μ (μ) ()

1.3.11).

μ μ μ μ . . .
μ μ μ 35.5‰, . . .
μ μ 35.2‰, 35‰ . μ μ 34.2‰.

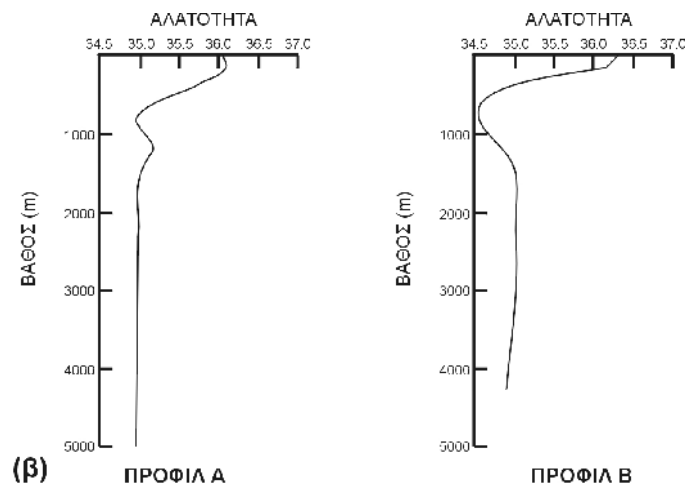
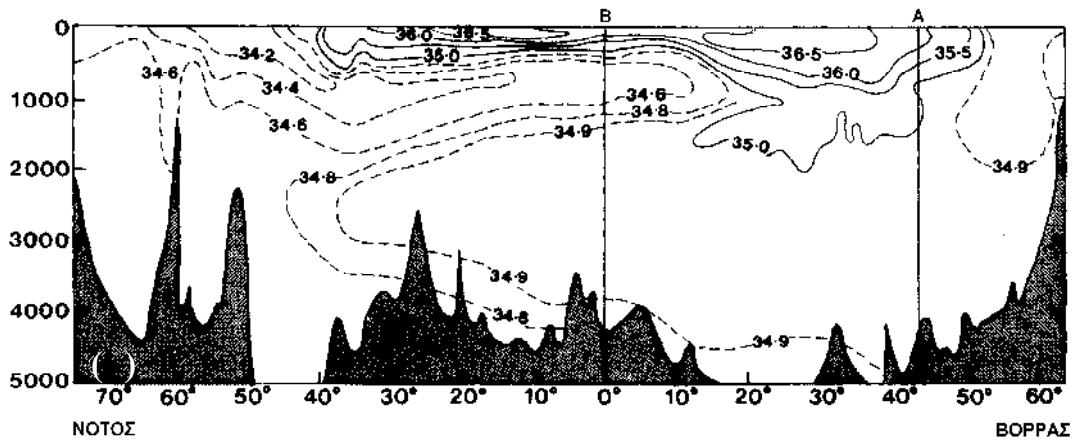


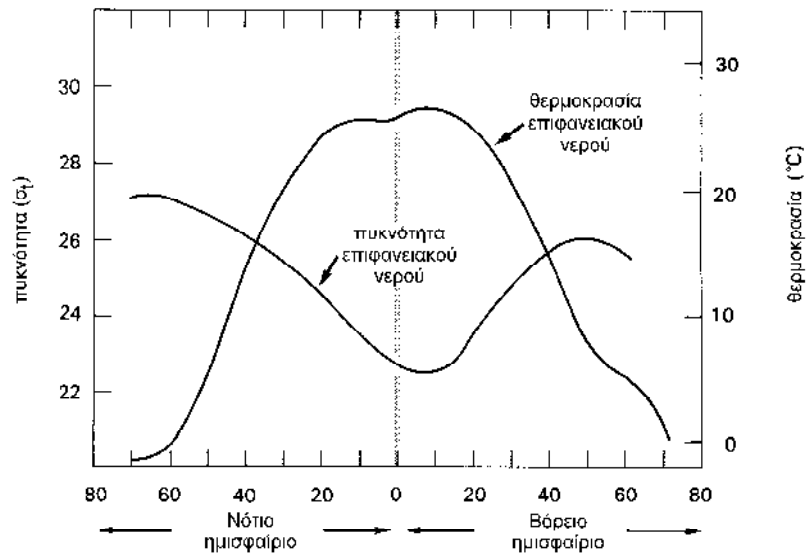
1.3.10. μ μ $\mu\mu$
 “ ”



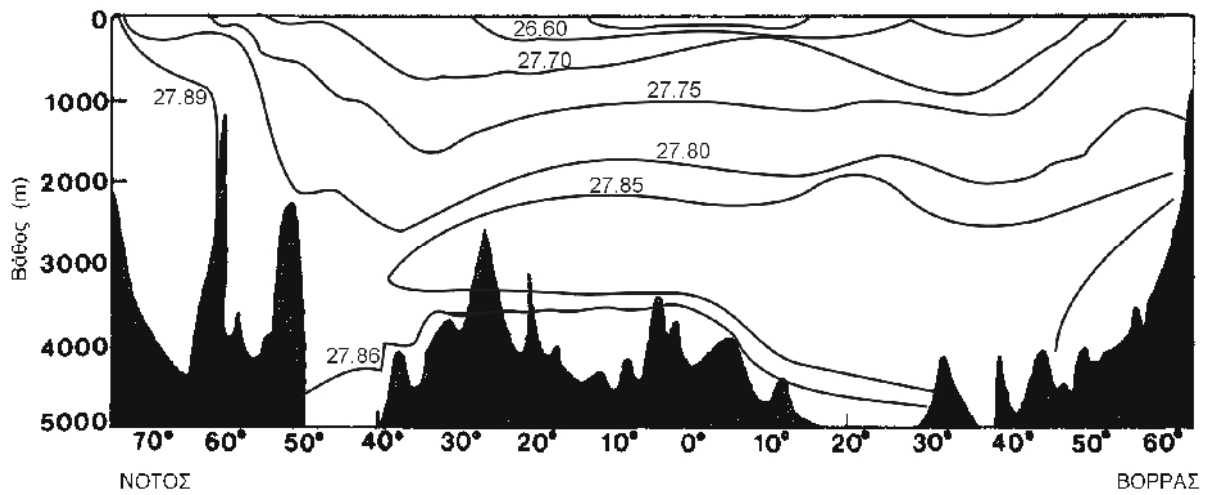
1.3.11. μ μ μ μ μ
 μ μ
 μ
 μ μ μ μ μ μ
) μ , μ , μ ,

) μ μ , , ,
 ,
 μ 17‰ μ
 (brackish), μ 47‰
 μ (hyper saline). μ μ μ
 μ , μ μ , μ
 . μ μ
 10‰. ,
 μ μ μ μ , μ μ μ
 39‰ 41‰ μ .
 . 1.3.12 , μ μ μ
 μ μ μ μ
 μ μ μ μ
 600m 900m. 900m μ 4,500m
 μ , μ μ .





1.3.13.

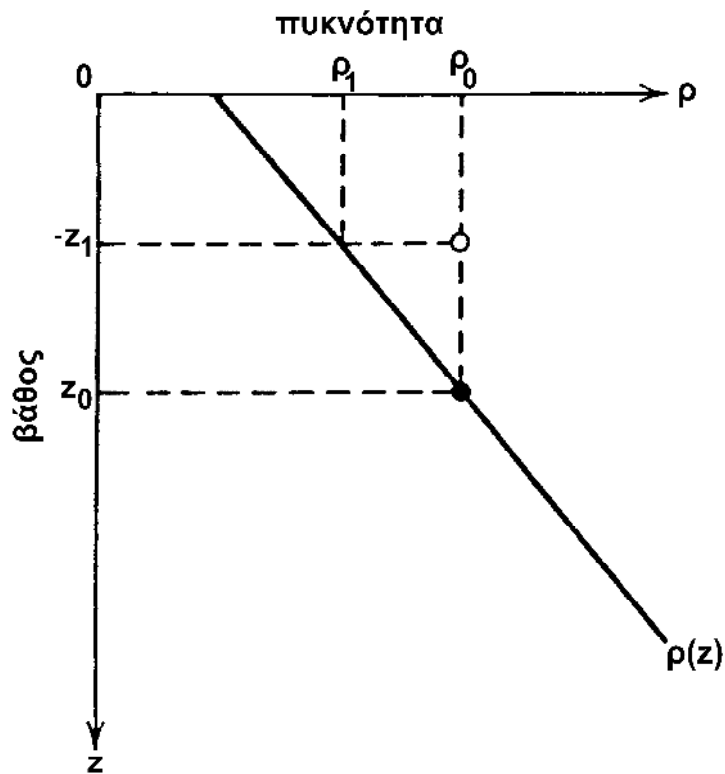


1.3.14.

1.3.4.

“ ” () μ μ
 , μ μ
 μ μ μ μ
 (. 1.3.15) μ : () μ 0
 μ 0 -Z₁, μ μ μ
 () (-Z₁) 1 0 > 1,
 μ , μ μ
 μ , μ μ (w), μ
 :

$$w = -g \cdot \left(\frac{\rho_0 - \rho_1}{\rho_0} \right)$$



. 1.3.15.

μ μ μ μ
 , μ μ
 0- 1 > 0, μ Z₀
 μ -Z₁ μ
 “ ” . 0- 1 < 0 μ
 μ
 “ ” . 1- 0 = 0

μ μ , “ ”

μ μ μ (μ)

:

$$E = -\frac{1}{g} \cdot \frac{\partial \varphi}{\partial z}$$

:

z μ .

μ μ

μ

μ

μ “ ” :

- >0
- <0
- =0

μ .

μ ,

:

$$E = -\frac{1}{c} \cdot \left(\frac{\partial \varphi}{\partial t} - \frac{g}{c^2} \right)$$

c:

:

μ

μ Brunt - Vaisala (N),

μ

Brunt - Vaisala (N) :

$$N = \left(\frac{g}{c} \cdot \frac{\partial \varphi}{\partial z} \right)^{\frac{1}{2}}$$

$$\mu N = 2 \cdot f = 2 \cdot \frac{1}{2} = 1$$

μ μ ()

μ

μ

μ μ μ

μ μ 2 4 ,

1000
 2000
 3000
 4000

60° Βόρεια 40° 20° 0° 20° 40° 60° 80° Νότια

Επιφανειακό στρώμα
 Στρώμα πυκνοκλιούς
 Βαθύ στρώμα

Υψηλά βόρεια γεωγρ. πλάτη
 Βόρεια εύκρατα (μεσαία) γεωγρ. πλάτη
 Τροπικά (χαμηλά) γεωγρ. πλάτη
 Νότια εύκρατα (μεσαία) γεωγρ. πλάτη
 Υψηλά νότια γεωγρ. πλάτη

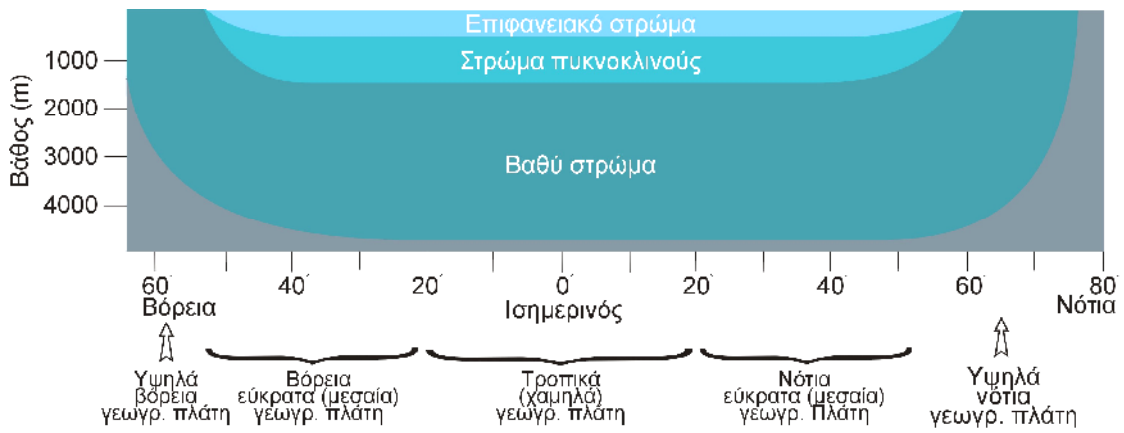
2-5

1.3.5.

1000
 2000
 3000
 4000

60° Βόρεια 40° 20° 0° 20° 40° 60° 80° Νότια

Υψηλά βόρεια γεωγρ. πλάτη
 Βόρεια εύκρατα (μεσαία) γεωγρ. πλάτη
 Τροπικά (χαμηλά) γεωγρ. πλάτη
 Νότια εύκρατα (μεσαία) γεωγρ. πλάτη
 Υψηλά νότια γεωγρ. πλάτη



1.3.16.

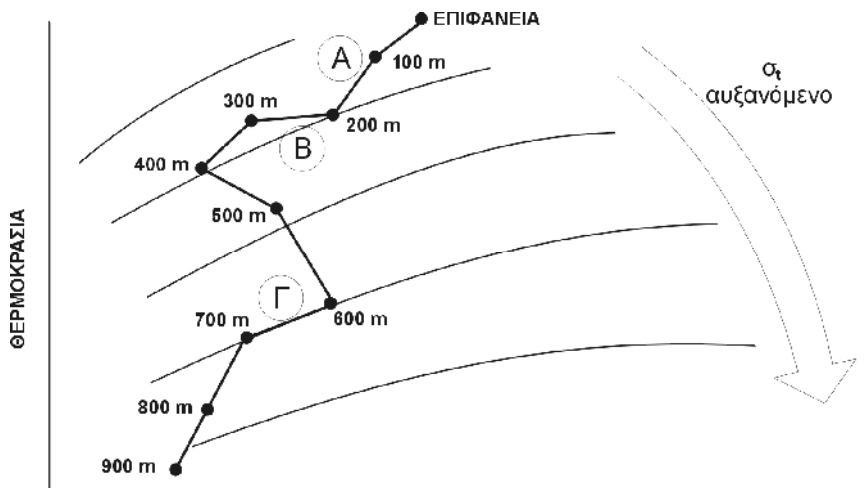
1000
 2000
 3000
 4000

60° Βόρεια 40° 20° 0° 20° 40° 60° 80° Νότια

Υψηλά βόρεια γεωγρ. πλάτη
 Βόρεια εύκρατα (μεσαία) γεωγρ. πλάτη
 Τροπικά (χαμηλά) γεωγρ. πλάτη
 Νότια εύκρατα (μεσαία) γεωγρ. πλάτη
 Υψηλά νότια γεωγρ. πλάτη

100m 200m 2%

μ
 μ μ 700-800m 18%
 μ
 μ
 μ μ (deep layer) 80%
 $\mu\mu$ T/S, () Brunt -
 Vaisala (N). 1.3.17 $\mu\mu$ T/S μ
 $\mu\mu$ μ
 μ μ μ
 μ T/S μ
 μ μ μ μ " "
 μ μ μ μ μ μ
 μ μ μ μ μ μ
 μ μ μ μ μ μ μ μ
 μ T/S, μ μ μ μ μ μ μ μ
 μ μ μ μ μ μ μ μ μ μ T/S μ
 $\mu\mu$ μ μ T/S.
 () μ 1.3.18 μ
 μ () μ μ
 μ μ μ μ (>0)
 (<0).

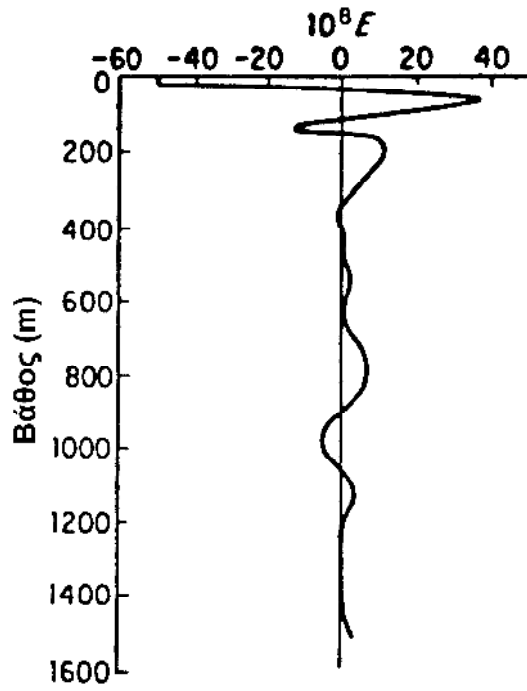


. 1.3.17.

μμ T/S

μ

μ .



. 1.3.18.

()

μ

(55°3' , 44°46'),

μ

1.3.6.

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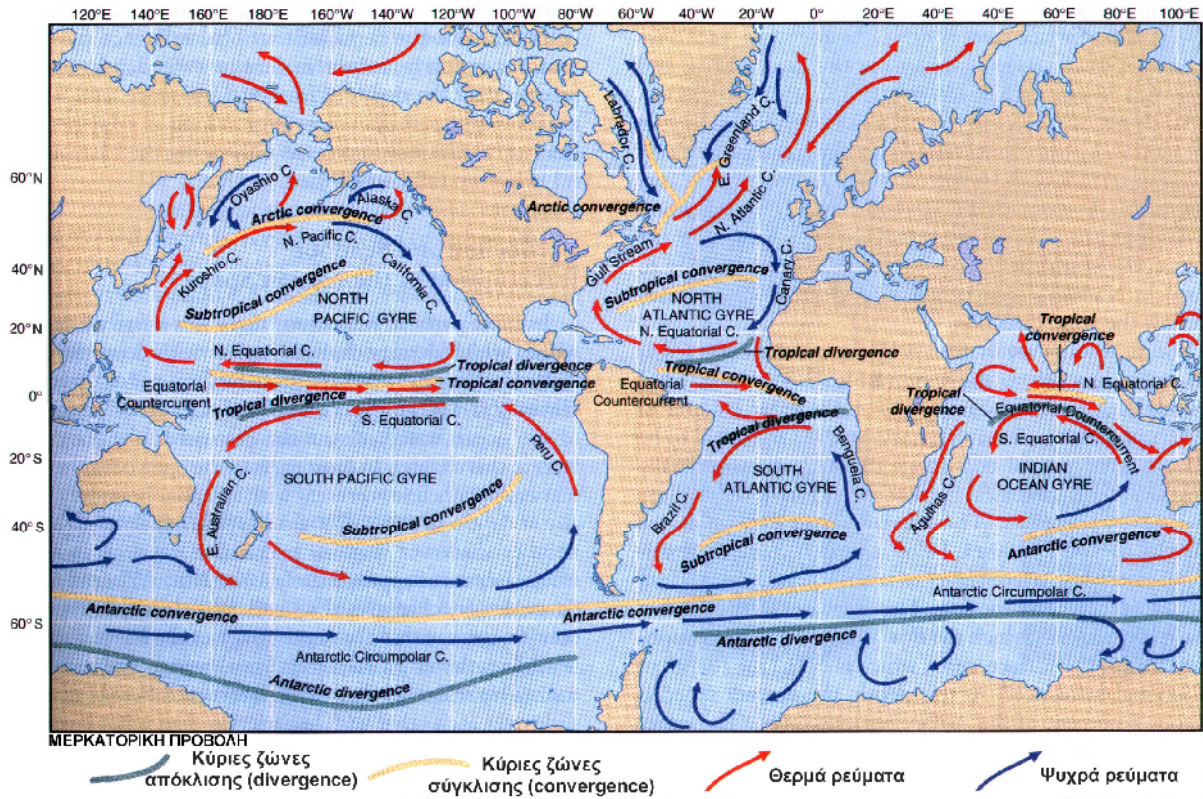
μ

,)

μ

) μ μ
 μ .
 μ μ μ μ
 , μ μ
 . μ μ
 .
 μ μ , μ μ
 . μ μ
 μ : “ μ μ ”
 “ μ ” μ μ μ
 .
 μ μ μ
 μ , μ
 , μ μ μ
 μ μ “ μ - ”.
 μ μ 10%
 , μ - 90%
 .

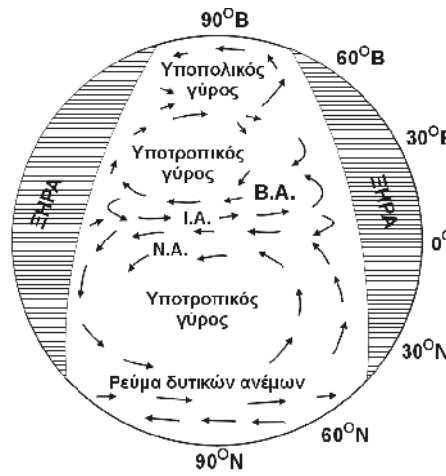
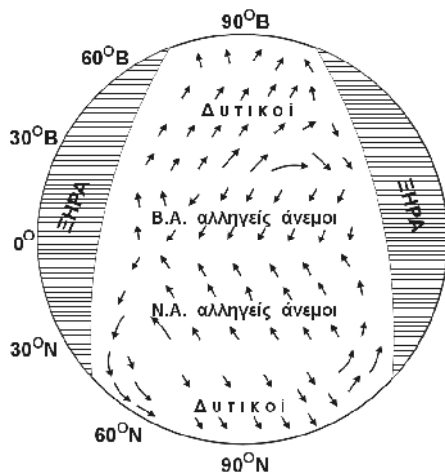
μ μ (μ μ)
 μ (gyres) (. 1.3.19).
 μ μ μ
 μ (. 1.3.20)
 μ .
 μ μ :
) μ μ μ
 μ μ
) μ Coriolis μ μ
 , μ
 .



. 1.3.19.

μ

μ



B.A.: Βόρειο Ισημερινό ρεύμα

I.A.: Ισημερινό αντίρρευμα

N.A.: Νότιο Ισημερινό ρεύμα

. 1.3.20.

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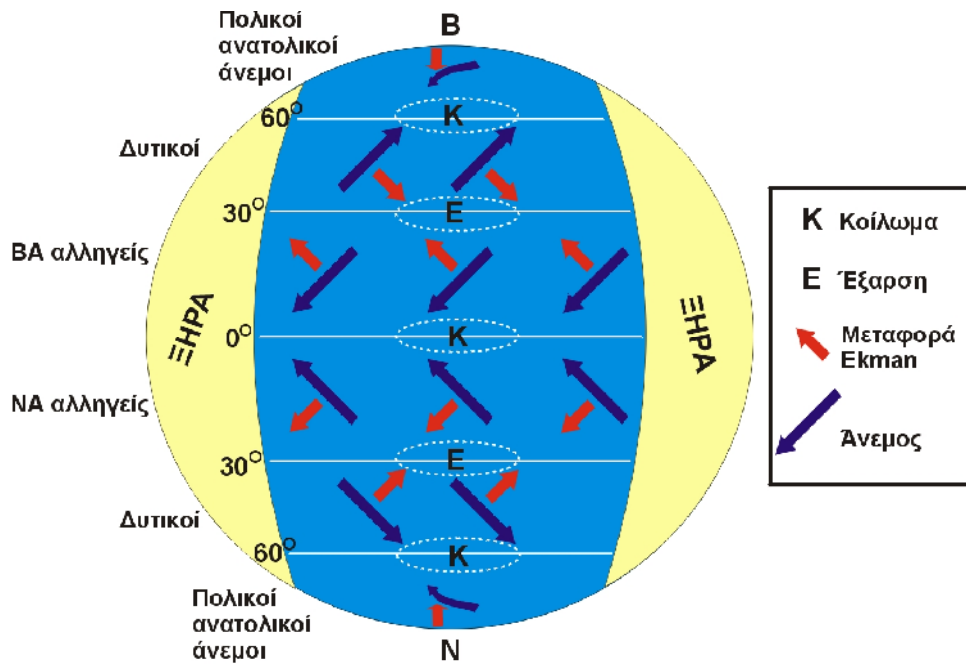
μ

μ

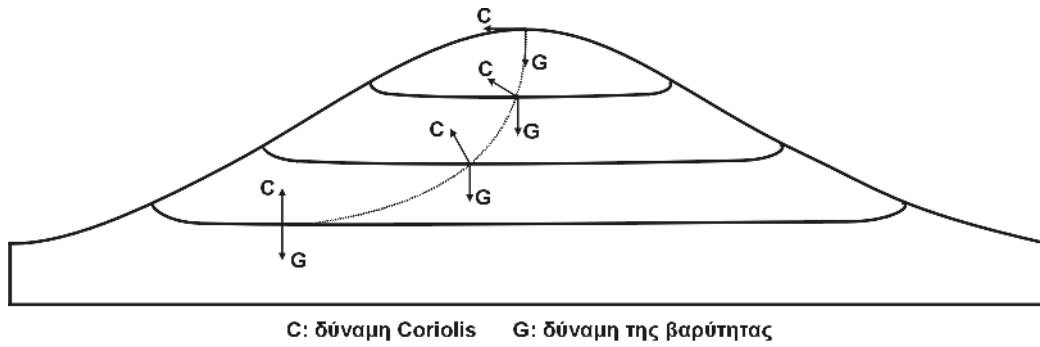
μ

μ

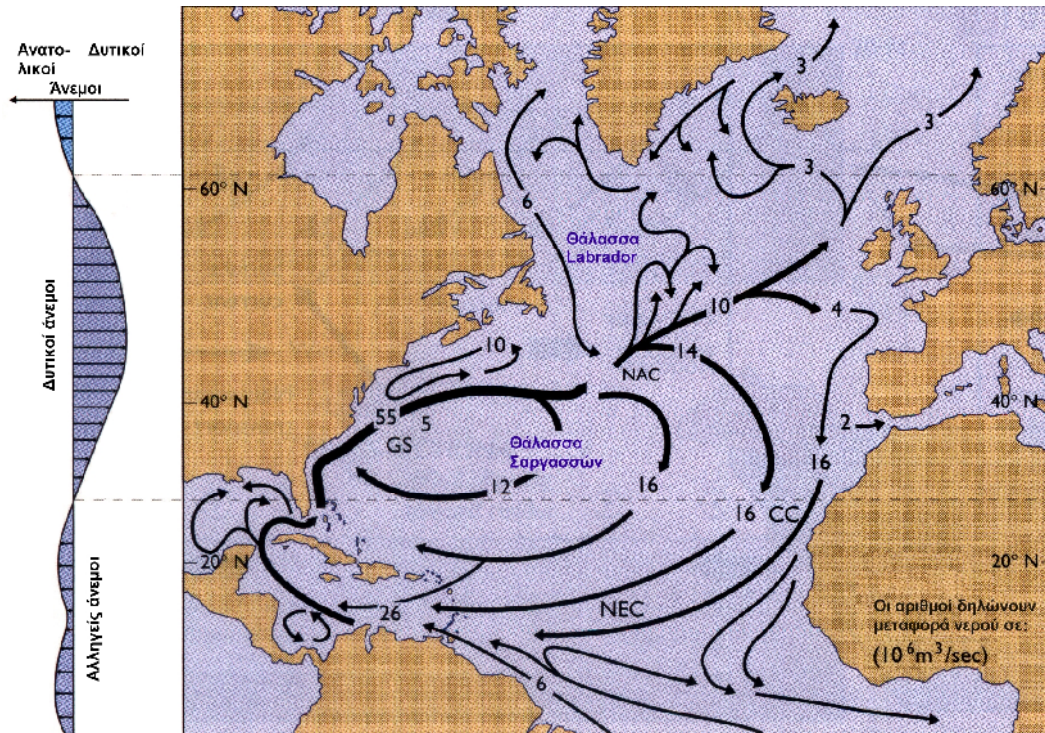
Ekman (. 1.3.22), 30° 30° 60° (convergence), (divergence) 60° (. 1.3.22). 30° 30° 60° Ekman (. 1.3.23). Coriolis, Coriolis, Coriolis (. 1.3.23). (Gulf Stream) Kurashio (. 1.3.19). (. 1.3.24), 1.2m/sec (4km/h), 2000m 70km , 0.6m/sec (2.1 km/h), 500m 800km . 26 $55 \times 10^6 \text{m}^3/\text{sec}$, $10 - 15 \times 10^6 \text{m}^3/\text{sec}$ (. 1.3.24).



1.3.22. μ μ μ
 μ μ
 (μ Ekman)



1.3.23. μ μ μ
 μ μ



. 1.3.24.

μ (GS) (CC)

μμ μ

μ μ 26 -55×10⁶m³/sec ,

μ , μ 10 - 15×10⁶m³/sec

μμ

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μ

μμ

μ

(. 1.3.25).

μμ

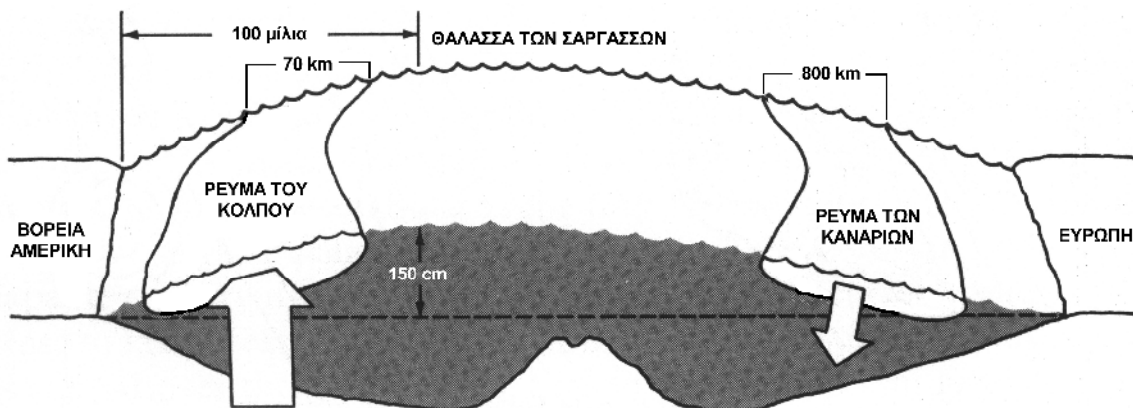
μ Coriolis

(planetary

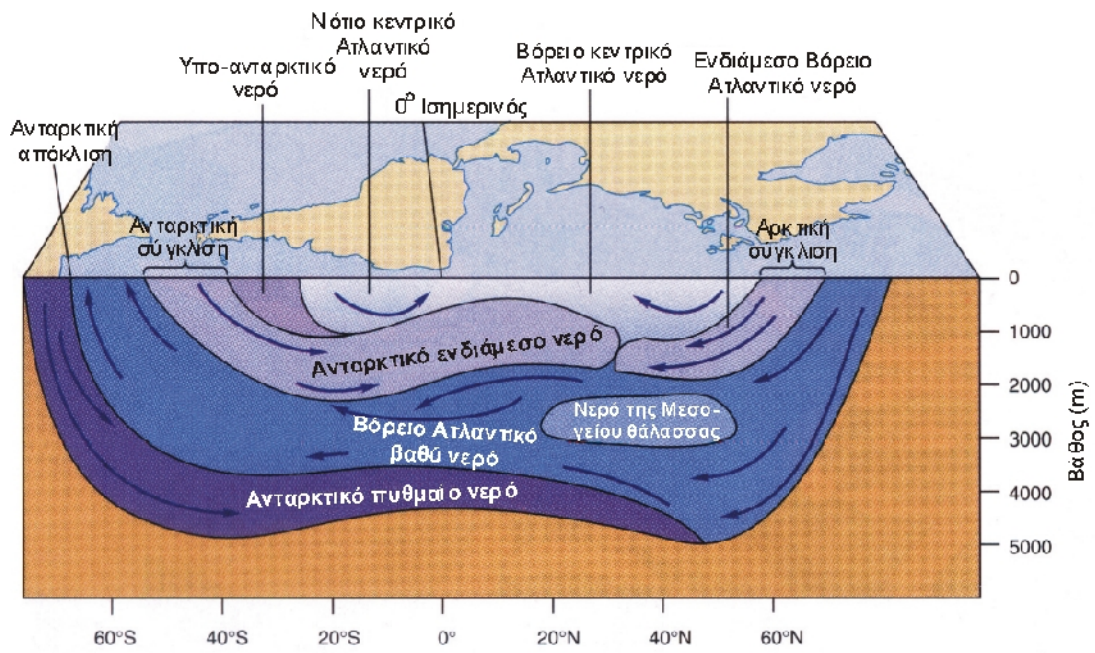
vorticity).

μ

μ



1.3.25. μ $\mu\mu$.
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 1.5m.
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 μ μ ,
 μ μ μ (. 1.3.7, 1.3.12, 1.3.14)
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 μ , μ , μ
 μ , μ 60°,
 μ (. 1.3.26).



1.3.26. μ μ - μ

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(60°) μ μ

, μ μ , μ

μ μ , 30°

μ (1.3.19),

μ , μ

μ μ , Labrador μ

μ μ μ μ ,

1.3.7.

μ μ μ μ

, μ μ μ 0.4μm () 0.8

μ_m () (. 1.3.27).

$2.2 \times 10^8 \text{ m/sec}$

μ

μ

μ

$(3 \times 10^8 \text{ m/sec}).$

μ

μ

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μ

μ

(z)

:

$$= \mu_0 \cdot e^{-z}$$

:

z,

0

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e

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m^{-1}

(absorption)

(scattering)

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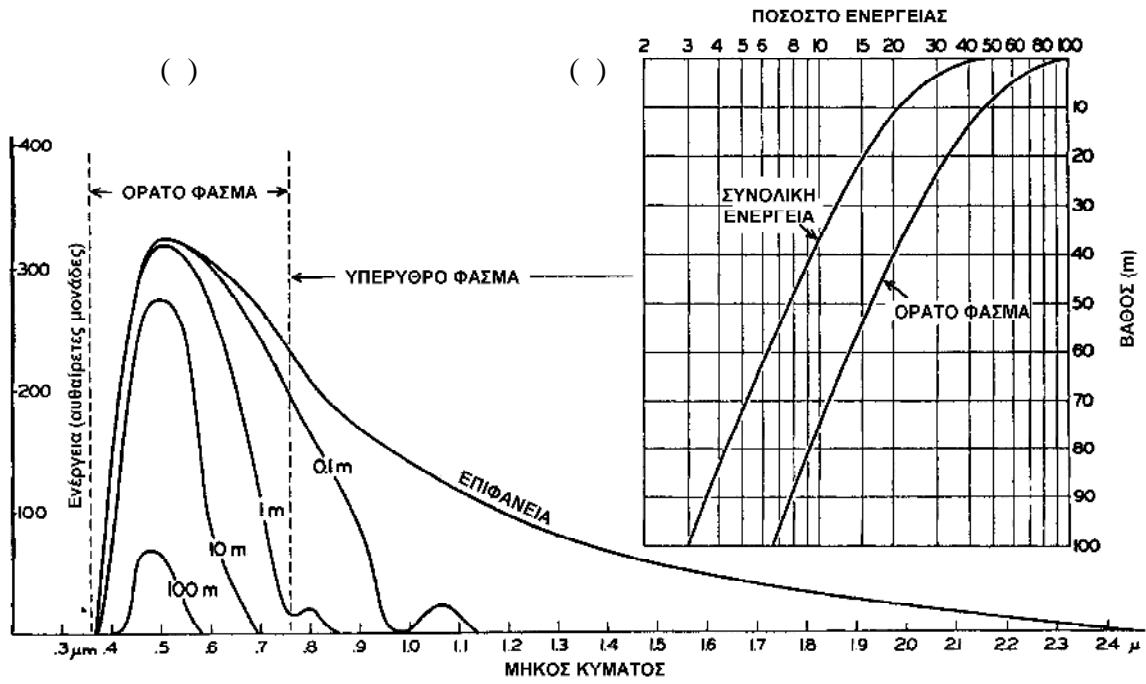
*

()

μ

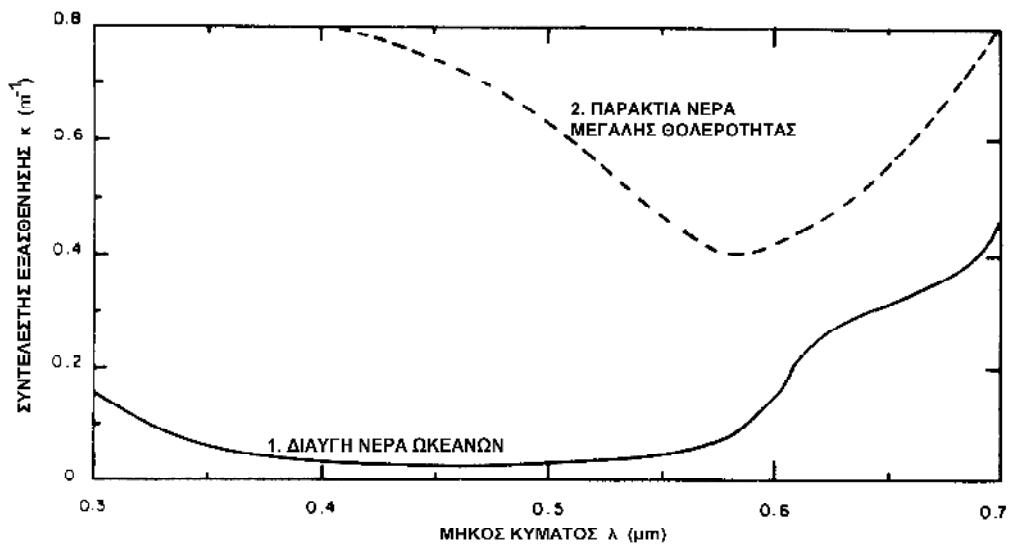
, μ

.



1.3.27. () μ μ μ
 , 0.1, 1, 10 100m .

() μ μ .
 () μ μ (. 1.3.28), μ ,
 μ μ (. 1.3.28).



1.3.28. μ μ μ .

1.3.3

() μ () μ μ μ

(o) . 0.02

m^{-1} μ , $0.2 m^{-1}$ $2 m^{-1}$ μ

μ μ () .

μ (0.45 μm) μ

(. 1.3.28)

50m 37% μ μ μ

μ μ 50m ,

10m 5% 50%

. ,

20 30m μ μ μ - . ,

μ μ 30 40m

μ . μ μ μ

μ μ μ μ

30m, μ μ , μ ,

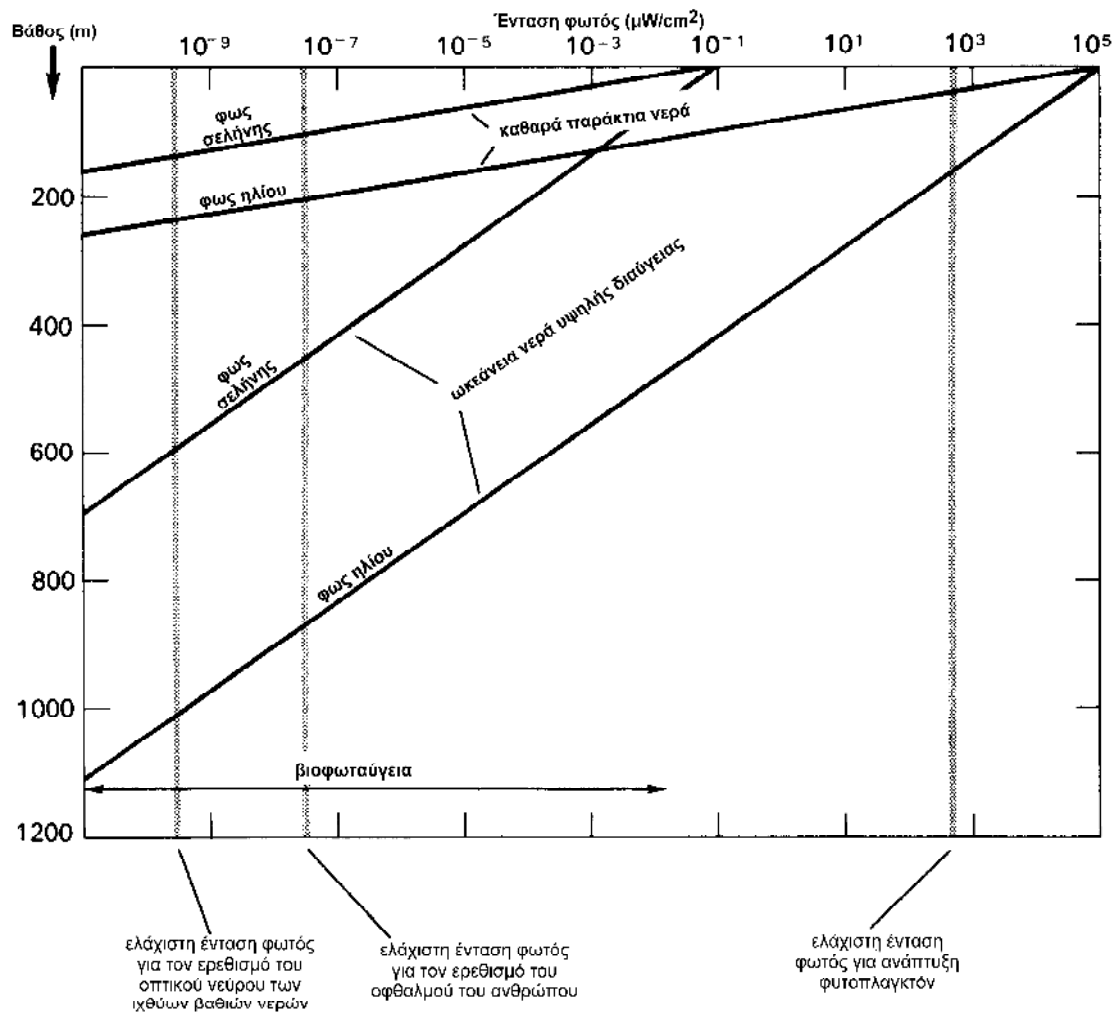
, μ μ μ

μ .

1.3.3.

z (m)	(m⁻¹)		
	0.02	0.2	2
0	$\rho_0=100$	100	100
1	98	82	14
2	96	67	2
10	82	14	0
50	37	0	0
100	14	0	0

μ
 μ (euphotic zone).
 μ
 1.3.29). μ 200m
 μ 80m
 μ 15m.
 (aphotic zone), μ
 1,000m.

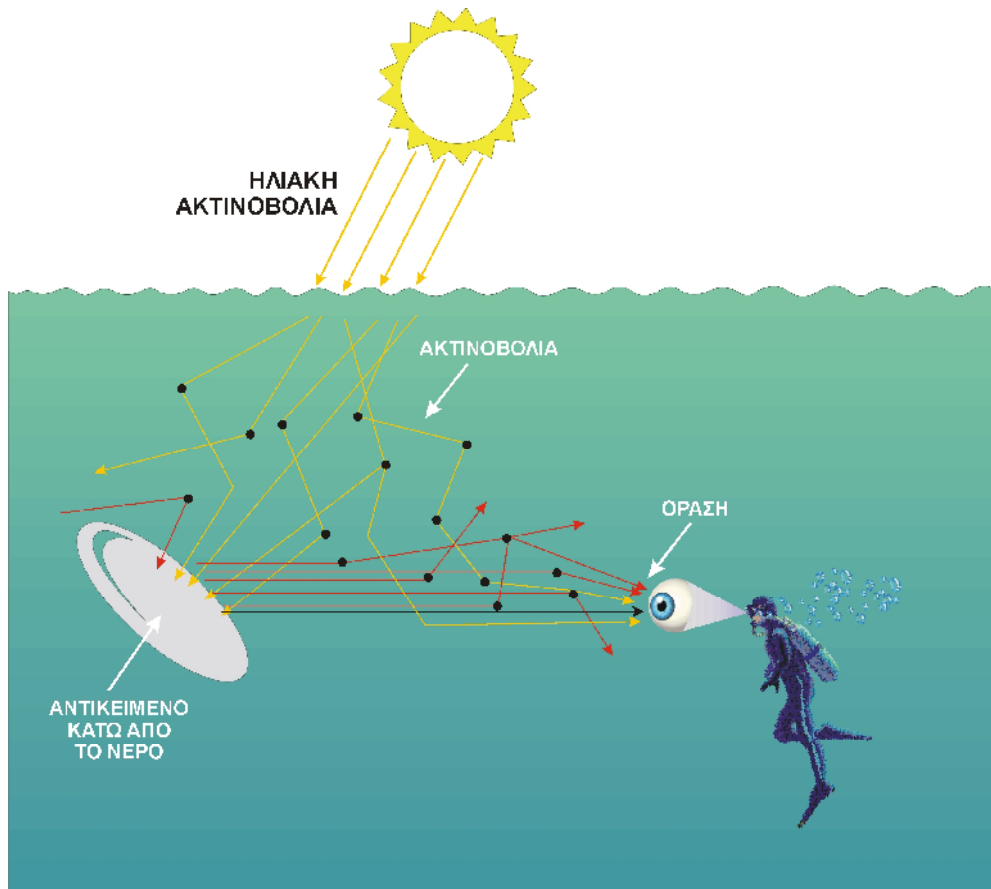


1.3.29. $\mu\mu$ μ

, μ , - ,
 , - .
 μ μ . μ
 μ , μ -
 . μ μ
 , μ . μ μ μ
 μ , μ
 μ μ μ μ
 . μ μ μ μ μ
 μ μ
 μ , μ
 μ , μ
 μ () , μ μ
 - μ , μ
 . μ μ μ μ μ
 μ , μ
 μ - μ .
 μ
 , μ .

μ , .
 μ μ , μ μ
 () μ μ : () μ
 μ μ (. 1.3.30)
 μ () μ μ μ μ μ
 μ , μ μ μ (.
 1.3.30). μ μ

μ , : ()
 μ () μ
 $\mu \mu$ $\mu \mu - \mu$
 (. 1.3.30) “ ”.



. 1.3.31. μ , $\mu \mu$, $\mu \mu - \mu$.