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IRRADIANCE OBSERVATIONS IN THE NORWEGIAN AND BARENTS SEAS

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Eyvind Aas and Grim Berge *

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ABSTRACT

Irradiance observations from 71 stations during summer season are presented. The Atlantic waters separate from the surrounding waters by the vertical attenuation coefficient at 465 nm of less than 0.1 m^{-1}, and the 1% irradiance transmittance depth at 465 nm greater than 40 m. Integrated irradiance transmittances may be obtained from irradiance measurements at 465 nm.

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CONTENTS

1. INTRODUCTION

The majority of the light measurements presented here were made to determine the approximate depth of the photosynthetic layer and the different sampling depths for simulated *in situ* primary production measurements according to BERGE (1958-61) Only the more recent measurements were aimed at a broader description of the optical properties of the different water masses in the Norwegian and Barents Seas. Even then, the cruises have always had other main purposes and the selection of stations is based more upon opportunity than on careful coverage of optically interesting areas. Also during the first years, different filter combinations were used, and this has made the interpretation more complicated and with less accuracy.

However, since no other irradiance measurements from these areas to our knowledge have been published, we hope that our results may be useful to other workers in the marine field.

2. THE IRRADIANCE METERS.

Two different irradiance meters have been used, both of the same simple type, consisting of a selenium cell protected from the water by a metal housing with a glass window. The window is covered by exterior glass filters from Schott & Genossen, Jena, and an opal glass. The photocurrent from the selenium cell is recorded on deck by means of a cable and a microampere meter. (A deck photometer is used for normalizing purposes in case of changing light conditions).

The spectral sensitivity and the immersion coefficients for one of the irradiance meters were calibrated according to AAS (1969), and the other instrument was then calibrated against this one.

Fig. 1 shows the spectral sensitivity in water of one of the irradiance meters with opalglass and the filter combinations N3, B12, B12+G5 and B12+V9. The curves have been normalized with 1 at their peak value.

3. SOURCES OF ERROR.

Some of the practical problems at sea have been discussed earlier by AAS (1969a). One of these is the shadow effect of the ship. The effect depends upon the radiance distribution in the sea and the solid angle from the instrument to the ship (Fig. 2). Calculations on the dimensions of R/V "Johan Hjort" and radiance data from Lake Pend Oreille (TYLER and PREISENDORFER 1962) give the table below (AAS, 1969b), which shows the reduction in irradiance when the radiance within the solid angle from the instrument to the ship is lost, assuming instrument and sun on the same side of the ship. The results show that the reduction in cloudy weather may amount to about 20%.

Irradiance reduction (%)

Depth	Clear sky	Overcast sky
5 m	1	6
10 m	4	19
20 m	7	22
30 m	9	14
40 m	12	14
50 m	6	6

Waves, currents, the ship's movements and other factors may give errors of the same order in the instrument readings.
In plotting all the readings at a station as a function of depth on semilogarithmic scale, taking into account the possible errors, and the adapting the smoothest curve, it is felt that an accuracy of within ± 10% or better is obtained. The mean vertical attenuation coefficient in the range 0 - 20 m depth, will then have an accuracy of within ± 0.005 m^{-1}.

4. MATERIAL AND METHODS.

4.1. The basic measurements.

The stations are listed in Table 1, and their location is shown on Fig. 3.

The basic irradiance measurements (photocurrents) with different filter combinations are given in Table 2, together with observed temperature and salinity. The photocurrents are given in per cent of their surface value (by surface is meant subsurface).

In order to make the irradiance measurements comparable, it is necessary to relate all recordings to the same wavelength and sun height. Since JERLOV (1974) has recommended and pointed out the usefulness of measurements at 465 nm, this wavelength has been chosen as the reference wavelength. The mean sun height at the 71 stations presented here (Table 1) was 35°, which then has been used as the reference sun height.

4.2. Transformation to equal wavelength.

To cover the whole range of variation four stations, representing extreme irradiance conditions, have been chosen.

They represent the most turbid and the clearest coastal waters off Norway (Station 457, 1969 and St. 201, 1968), and the most turbid and clearest waters in the Norwegian Sea (St. 430, 1973, St. 287, 1971). The spectral irradiance distributions on these stations have been calculated according to the method described by JERLOV (1951) (also by AAS (1971)), and are shown in Figs. 12, 14, 16 and 18. The spectral irradiance distribution from four other stations (St. a,b and c, 1967 and St. 172, 1968), previously analysed, was included for the purpose of calculating the photocurrents produced by the applied filter combinations, and thereby the relations between the photocurrents and the irradiance at 465 nm.

The filter combinations B12+G5 and B12+V9, Fig. 1, demonstrate sharply defined wavelength regions. Consequently the relations between their photocurrents and the irradiance E_λ at 465 nm in percent of their surface values, Figs. 4 and 5 are very good. The sensitivity region of B12 is broader, but still the relation between photocurrent and irradiance, Fig. 6, is well defined. The sensitivity region of the neutral filter N3, however, calls for a different procedure in transforming the photocurrent to irradiance transmittance at 465 nm: From an observed value of the photocurrent at a certain depth, the mean vertical attenuation coefficient K at 465 nm between the surface and that depth is given, Fig. 7. The relation between K, E_λ and the irradiance transmittance T at 465 nm, is

$$\frac{E_\lambda(z)}{E_\lambda(0)} = T(z) = e^{-Kz} \qquad (1)$$

where z is the depth.

The result of transformations of the photocurrents in Table 2 is given in Table 3, as the depth of 1% irradiance transmittance at 465 nm, and as the transmittance at 20 m depth.

3.2. Transformation to equal sun height.

As a second step in the comparison of the measurements, the influence of the sun height is considered. In a non-scattering fluid where the direct sunrays were dominating the irradiance, the vertical attenuation coefficient K would follow the relation

$$K = K_S = \frac{K_O}{\cos j} = K_O \sec j \qquad (2)$$

Here j is the angle of refraction of the sun rays, and K_O is consequently the coefficient for a zenith sun. The relation between j and the sun height h is given by SNELL's law

$$\cos h = n \sin j, \qquad (3)$$

where n is the index of refraction.

The mean sun height of the stations is 35^o with a standard deviation of 8^o. This means that if the relation in eq. 2 were valid, most of the coefficients would be changed less than 5% if they were normalized to a 35^o sun height. However, as the investigated waters often are rich in plankton and the sky often is overcast, the dependence of the coefficient on the sun height in eq. 2 is likely to be overestimated, that is, the changes due to sun height might be significantly less than 5%. Considering the sources of error, which were discussed in the preceding chapter, it may then seem unnecessary to normalize for different sun heights.

Still, since it may be instructive, it shall be done here. In an earlier work AAS (1976) has proposed the following formula for the vertical attenuation coeffisient:

$$K = a(1 + 3R)(\sec \theta_D + (\sec i - \sec \theta_D)r). \qquad (4)$$

Here a is the absorption coefficient, R is the irradiance ratio or reflectance, $\sec \theta_D$ is the downward distribution function (TYLER and PREISENDORFER, 1962) of diffuse light, and r is the ratio between the direct solar contribution to the irradiance and the total (solar and diffuse) irradiance.

The value of r just beneath the surface may be written r_o. Repeated measurements of r_o on the roof of the institute building in Oslo all gave higher values than the eralier chosen function. Consequently r_o for clear weather has been changed to

$$r_o = (1 + 0.09 \operatorname{cosec} h \, e^{0.19 \operatorname{cosec} h})^{-1} \qquad (5)$$

This new relationship also influences the function $\sec \theta_D$, which now gets the form

$$\sec \theta_D = 1.42 - 0.16 \, e^{-Kz} \qquad (6)$$

In the privious work AAS constructed a correction term for cloudiness on the assumption that when the cloudiness was C, C part of the sun would be screened by clouds, or the sun would be screened by clouds C parts of the time. During our measurements, however, the sun was usually unscreened, except in the case of a totally overcast sky. By the same procedure then, the correction term for the present case will be

$$(1 - 0.5 \, C + r_o \, C)^{-1} \qquad (7)$$

when the cloudiness is given in parts of one. The function of r_o with clouds will then be

$$r_o' = r_o(1 - 0.5\,C + r_o\,C)^{-1} \tag{8}$$

The function r in the depth z is approximately

$$r = r_o'\,e^{-Kz} \tag{9}$$

It may then be deduced that the mean vertical attenuation coefficient between the surface and 20 m depth, with 35° sun height and clear sky, K_{35}, is related to the observed coefficient K by

$$K_{35} = K\,f(h, K, C) \tag{10}$$

where

$$f = \frac{\sec\theta_D + (1.27 - \sec\theta_D)0.82\,e^{-K\bar{\bar{z}}}}{\sec\theta_D + (\sec j - \sec\theta_D)r} \tag{11}$$

$$\sec\theta_D = 1.42 - 0.16\,e^{-K\bar{\bar{z}}} \tag{12}$$

$$r = r_o'\,e^{-K\bar{\bar{z}}} \tag{13}$$

r_o' is given by eq. 8, and $\bar{\bar{z}}$ is 10m.

3.3. Optical classification of water types.

JERLOV (e.g. 1968) has classified ocean waters I - III ($h = 90^{\circ}$) and coastal waters 1 - 9 ($h = 45^{\circ}$) according to their irradiance transmittance in the upper layers. The following table is calculated from his transmittance values and the corresponding vertical attenuation coefficients, and gives the mean vertical attenuation coefficients in the layer 0-20 m at 35° sun height, K_{35}, according to eq. 10.

Water type	JERLOV's CLASSIFICATION h degr.	T per 20 m %	K m^{-1}	K_{35} m^{-1}	K_{S35} m^{-1}
Ocean water I	90	70.	.0178	.0213	.0226
-"- IA	90	61.	.0247	.0291	.0314
-"- IB	90	52.	.0327	.0380	.0415
-"- II	90	29.	.0619	.0690	.0786
-"- III	90	9.6	.117	.124	.149
Coastal water 1	45	6.76	.135	.137	.145
-"- 3	45	1.00	.230	.232	.247
-"- 5	45	.0324	.402	.402	.433
-"- 7	45	$9.5 \cdot 10^{-5}$	.691	.691	.744
-"- 9	45	$1.77 \cdot 10^{-9}$	1.24	1.24	1.33

For comparison the values according to the "secans relation" eq.2, K_{S35}, are added. The two equations give results which do not differ much for clear water, but for turbid water the "secans relation" gives significantly higher values. Fig. 8 shows the coefficients at $h = 35^{\circ}$ according to eq. 10. The classification at this sun height is characterized by an almost constant ratio between succeeding coefficients, type IA excluded.

5. RESULTS AND DISCUSSION.

Spectrally integrated (350-750 nm) irradiance E and integrated quanta irradiance Q for some of the stations were calculated by integration of the spectral irradiance distribution $E_{\lambda}(\lambda)$, or by correlation formulas based on photocurrents (AAS, 1971), and are listed in Table 4.

Fig. 9 shows examples of transmittances of E. The functional relationships between E, Q and $E_\lambda(\lambda)$ are

$$E = \int_{350}^{750} E_\lambda(\lambda)d\lambda \tag{14}$$

$$Q = \frac{1}{hc}\int_{350}^{750} E_\lambda(\lambda)\lambda d\lambda \tag{15}$$

where h is Plancks constant and c is the velocity of light in air.

It now becomes possible to obtain E in percent of the surface value from the observed mean value of K at 465 nm and the corresponding depth, as demonstrated in Fig. 10.

AAS (1971) found for Norwegian fjord and coastal waters that the ratio Q/E was $(2.7 \pm 0.2) \cdot 10^{18}$ quanta s^{-1}/W. (The number after ± is the standard deviation). Table 4 confirms this constancy by having a mean ratio of $(2.6 \pm 0.1) \cdot 10^{18}$ quanta s^{-1}/W.

Consequently the relation between K at 465 nm and Q must be equal to the relation between K and E in Fig. 10. Another consequence of this is that while JERLOV (1974) has found that the ratio $Q/E_\lambda(465)$ is only a function of depth for the optical ocean water types I-III, it will in the Norwegian and Barents Seas also be a function of the vertical attenuation coefficient.

When the depth of 1% irradiance transmittance at 465 nm, Z_B, is known, the depth of 1% integrated quanta irradiance transmittance, Z_Q, may be found from Fig. 11, which is based on Table 3 and 4. Correlation analysis on our results gives the regression line in Fig. 11, which is described by

$$Z_Q = 7\ m + 0.67\ Z_B \quad (16)$$

This line coincides very well with JERLOV's (1974) results for optical ocean water types, as is demonstrated in the figure.

Thus in the Norwegian and Barents Seas, by measuring the depth Z_B where the photocurrent with filters B12 + G5 is reduced to 1% of its surface value, Z_Q may be found by eq. 16. Z_E, the depth of 1% integrated irradiance transmittance, will be almost equal to Z_Q.

The clear waters of Station 201, 1968 and Station 287, 1971 are characterized by their high transmittance in the blue part of the spectrum (Figs. 12-15). At Station 287 for instance, the depth of 1% irradiance transmittance at 465 nm is found by extrapolation to be 81 m (Table 3), while the integrated irradiance (350-750 nm) obtains 1% transmittance at 67 meters depth (Fig. 9 and Table 4).

Station 457, 1969, and Station 430, 1973 showed both greenish water colours, an observation which conforms with their spectral irradiance distribution and transmittances (Fig. 16-19). The latter station was remarable due to a anomaliously high attenuation in the red part of the spectrum compared with the attenuation in the blue part, a phenomenon which undoubtedly was caused by a dense brown coloured phytoplankton population. The surface water, when observed in a bucket, was clearly brown spotted due to *Phaeocystis pouchetii*, while at 10 m depth the plankton population was dominated by *Chaetoceros* diatoms in a concentration of $43 \cdot 10^4$ cells/litre. Spectral irradiance at these stations is given for some wavelengths in Table 5.

The correction factor f (Table 3), by which the observed vertical attenuation coefficients are corrected to 35° sun height and clear sky, alter the basic values with max. 3%. The small correction is due to the fact that the actual sun heights did not deviate much from 35°, and that the few greater deviations from 35° sun height all were in waters with great attenuation.

Fig. 20 gives the relation between the salinity at 10 m depth and the depth of the 1% irradiance transmittance at 465 nm. In spite of a high scattering of the values, the greatest depths are obviously found at the highest salinities. The same phenomenon is found in Fig. 21, where the mean vertical attenuation coefficient in the range 0-20 m depth as a function of the salinity is given. The values are highly scattered, but the smallest coefficients are found for the highest salinities.

Figs. 22-24 show the horizontal distribution of salinity at 10 m, the depth of 1% irradiance transmittance at 465 nm, and the vertical attenuation coefficient. It should be noted that the maps are based on measurements from several years and do not give a synoptic picture of any situation. (Only one or two isopleths, representing the most significant features, are drawn). Fig. 25 shows the horizontal distribution of the optical water types, using JERLOV's classification of irradiance at 465 nm (Table 6). Even in oceanic areas, and especially in mixing zones, "coastal" types may ocur due to high plankton content. However, an important difference between these "virtual" coastal types and the "true" coastal types is that the former lack the high yellow substance contents of the latter.

Figs. 22-25 also illustrate that the Atlantic waters (:salinity higher than 35°/oo) are roughly characterized by a vertical attenuation coefficient at 465 nm less than 0.1 m^{-1}, and a 1% irradiance transmittance depth at the same wavelength greater than 40 m. The border line between optical coastal and ocean waters roughly follows the 35°/oo isohaline.

This does not mean that arctic or polar waters can not be as clear as Atlantic waters; some of the measurements here (Fig. 20 and 21) prove the contrary. But most of the present measurements are restricted to Atlantic waters and the mixing areas.

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TABLE 1

Ship	Station No.	Lat. °	Lat. '	Long. °	Long. '	NSEW	Date Yr.	Date Mo.	Date Day.	St. time	Depth to bottom	Wind Dir.	Wind Sp. kn.	Weather	Cloud	Sea	Solar altitude
S	251	69	46	005	37	1	954	05	29	12	3040	09	13	2	8	2	41
-	269	70	53	009	14	1	-	05	31	10	0238	05	09	4	7		38
-	285	71	30	008	19	1	-	06	02	12	2910	36	13	2	8		41
-	293	70	15	006	48	0	-	06	03	12	3270	23	09	1	6	3	42
-	321	71	56	010	07	0	-	06	09	12	2380	32	13	1	7	2	41
-	334	73	30	000	23	0	-	06	11	10	3150						37
S	166	66	46	008	28	0	955	03	26	11	0275	99		0	0	1	25
-	178	65	33	008	34	0	-	03	27	13	0350	36	09	1	4	2	24
-	190	64	49	006	06	0	-	03	28	12	0310			2	8	4	27
-	204	63	20	006	05	0	-	03	29	12	0205	32	13	1	6	4	28
-	213	61	46	004	04	0	-	03	30	12	0215						31
-	652	71	30	043	06	0	-	07	28	11	0255	32	09	1	6	3	36
-	657	71	09	040	50	0	-	07	29	10	0232		05	2	8	2	36
-	663	70	23	032	34	0	-	07	31	11	0256	32	09	1	4		37
H	150	66	15	010	47	0	958	05	21	20	0300	05	05	1	4	3	05
-	166	67	22	007	15	0	-	05	22	13	1600	02	18	1	6	4	39
-	178	68	54	002	00	0	-	05	23	13	3200	36	13	1	6	3	40
-	187	70	04	002	10	1	-	05	24	12	2760					3	40
-	207	70	53	012	53	1	-	05	26	12	0510	23	05	1	6	2	38
-	221	71	26	013	35	1	-	05	27	12	1280	03	02	1	7	2	39
-	232	71	30	005	05	1	-	05	28	11	2460	32	05	1	4	2	39
-	244	71	15	002	20	0	-	05	29	12	3240	14	05	1	3	1	40
-	256	69	44	008	22	0	-	05	30	12	3220	05	05	1	3	1	42
-	298	71	01	015	35	0	-	06	06	11	2040	36	05	1	6		41
-	323	73	09	002	16	0	-	06	08	12	2880	36	13	1	3	3	38
-	336	73	09	005	58	1	-	06	09	12	2820	34	13	1	6		38
-	346	74	30	011	45	1	-	06	10	13	3010	36	01		0	0	38
-	368	74	34	005	41	0	-	06	17	10	3140	32	09		8	3	37
H	117	66	05	012	45	1	962	05	29	09	0170	01	04	1	2	2	31
-	132	66	28	014	20	1	-	05	31	13	0100	18	07	1	4	3	45
-	134	67	00	014	00	1	-	05	31	16	0255	19	04	1	4	2	34
-	141	67	47	014	05	1	-	06	01	10	1200	12	01	1	2	1	37
-	142	68	05	013	40	1	-	06	01	13	1550	15	04	1	4	2	44
-	151	70	52	012	37	1	-	06	03	14	0560	99	01	1	2	2	41
-	152	70	52	014	25	1	-	06	03	17	0900	15	08	1	3	1	29
-	156	68	46	015	25	1	-	06	04	13	1450	15	10	2	8	2	43
-	221	67	35	014	34	1	-	06	18	13	0980	12	07	1	7	2	45
-	225	67	30	015	51	1	-	06	19	13	0965	05	10	2	8	3	46
-	226	68	30	017	00	1	-	06	19	15	1112	04	11	1	7	3	41
-	227	68	10	017	00	1	-	06	19	17	1340	03	12	2	8	3	30
-	228	67	56	017	00	1	-	06	19	19	1100	04	15	2	8	3	21
-	235	67	47	015	00	1	-	06	20	13	1018	04	10	2	8	3	46
-	236	68	08	015	00	1	-	06	20	16	1180	04	07	2	8	2	40
-	246	67	37	016	30	1	-	06	21	13	0880	08	11	1	7	3	46

TABLE 1 cont.

Ship	Station No.	Lat. °	Lat. '	Long. °	Long. '	N S E W	Date Yr.	Date Mo.	Date Day.	St. time	Depth to bottom	Wind Dir.	Wind Sp. kn.	Weather	Cloud	Sea	Solar altitude
H	a	63	18	007	13	0	967	03	11	13				1	2	3	22
-	b	62	30	005	48	0	-	03	14	13	0032		11	5	8	4	23
H	c	62	24	006	06	0	-	03	15	10	0044		2	2	8	1	20
S	161	63	06	005	09	0	968	04	19	12	0350	11	05	1	2	1	37
-	172	63	17	007	53	0	-	04	20	11	0215	23	05	5	8	2	38
-	201	65	49	010	27	0	-	04	23	12	0310	05	05	1	4	2	25
H	403	63	47	007	07	0	969	05	03	09	0175	08	18	0	0	3	37
-	418	64	24	008	29	0	-	05	04	13	0260	12	15	1	2	3	39
-	429	65	20	010	34	0	-	05	05	10	0300	17	07	1	4	2	40
-	430	65	39	011	08	0	-	05	05	13	0166	16	03	1	3	2	37
-	443	66	59	011	39	0	-	05	06	11	0300	02	08	0	0	1	40
-	450	67	42	011	06	0	-	05	07	14	0180	32	03	2	8	2	32
-	457	68	34	014	06	0	-	05	08	13	0235	99	01	1	3	2	35
-	470	68	08	014	38	0	-	05	09	10	0310	04	16	2	8	3	37
S	d	64	23	009	33	0	971	04	21	12	0220			8	7	3	37
-	249	62	35	004	19	0	-	04	27	12	0190	36	19	1	4	4	40
-	258	64	42	000	32	1	-	04	28	13	2790	35	15	1	6	4	37
-	260	62	10	002	31	0	-	04	29	13	0423	05	03	1	2	2	40
-	287	62	40	008	00	1	-	05	05	15	0509	23	09	1	3	3	37
S	415	70	35	020	08	0	973	05	25	16	0255	34	20	2	8	3	24
	423	74	15	019	10	0	-	05	26	14	0062	31	16	2	8	3	30
	430	76	37	015	52	0	-	05	27	12	0041	11	07	1	6	1	34
	435	77	30	011	24	0	-	05	28	01	0318	34	12	2	8	2	11
	450	73	52	025	40	0	-	05	30	16	0450	32	07	2	8	2	20
	462	76	30	031	13	0	-	06	01	09	0317	32	05	1	3	1	35
	484	75	30	036	00	0	-	06	04	12	0164	18	10	2	8	2	34
	497	75	00	048	52	0	-	06	06	00	0258	25	10	4	8	2	13

EXPLANATION

Column ship: H = "Johan Hjort",
S = "G.O. Sars".

Column solar altitude: units in degrees.

Other columns in units according to ICES Hydro Master Card.

TABLE 2

Station	Year		0 m	5 m	10 m	20 m	30 m	40 m	50 m
251	1954	T	05.16		05.05	04.57			02.91
		S	35.02		35.01	35.03			35.02
		B	100.0	35.1	15.0	3.51	1.65	(0.75)	
269	-	T	00.23		-0.38	00.20			-0.86
		S	33.91		33.89	34.15			34.45
		N	100.0	20.8	5.33	1.59			
285	-	T	05.61		05.62	05.59	05.61		05.61
		S	34.14		34.14	35.13	35.13		35.13
		N	100.0	44.3	27.0	12.7	7.14	3.60	1.73
293	-	T	06.82		06.73	06.70	06.68		05.82
		S	35.12		35.11	35.10	35.12		35.13
		N	100.0	38	13.6	2.1			
321	-	T	06.26		06.15	05.99	05.98		05.92
		S	35.16		35.16	35.17	35.15		35.15
		N	100.0	31.2	8.44	1.69			
334	-	T	-0.14			-0.21	-0.43		-1.63
		S	34.52		34.45	34.46	34.45		34.63
		N	100.0	40.3	23.2	14.1	9.50	5.25	2.68
166	1955	T	06.25		06.2	06.2			
		S	35.00		34.97	34.99			
		N	100.0	49	26.2	10.1	5.5	2.95	1.66
178	-	T	06.58						
		S	35.11						
		N	100.0	62	38	18	8.9	2.33	
190	-	T	06.86		06.73	06.75			
		S	35.14		35.11	35.11			
		N	100	49	27	11	1.53		
204	-	T	04.71		04.75				
		S	33.81		33.86				
		N	100	49	16.6	(0.16)			
213	-	T	0.445						
		S							
		N	100	31.3	8.26	(0.31)			
652	-	T	06.32		06.20	06.19	04.90		03.95
		S	34.81		34.80	34.81	34.89		34.93
		N	100	48	25.5	8.9	4.8	2.7	1.5
657	-	T	07.03		06.77	06.76	04.74		03.88
		S	34.75		34.76	34.78	34.82		34.89
		N	100	40	20.8	6.8	2.6	(0.97)	
663	-	T	07.50						
		S	34.55						
		N	100	31.3	10.93	4.7			
150	1958	T	07.05		06.65	06.61	06.71		06.62
		S	34.63		34.66	34.69	34.88		34.94
		B	100	52	20.7	1.5			
166	-	T	06.30		06.26	06.25	06.25		05.74
		S	35.15		35.15	35.15	35.15		35.15
		B	100	54	39.5	9.2	1.44		

TABLE 2 cont.

Station	Year		0 m	5 m	10 m	20 m	30 m	40 m	50 m
178	1958	T	05.70		05.72	05.68	05.65		05.65
		S	35.15		35.13	35.13	35.13		35.15
		B	100	44.5	33	20.3	6.7		
187	-	T	05.4		05.4	05.4	05.4		05.3
		S	35.12						
		B	100	41.0	17.1	2.26			
207	-	T	00.2		00.2	00.3	00.3		00.2
		S	34.90						
		B	100	34.2	11.4	1.14			
221	-	T	0.6		0.4	0.4	0.3		0.3
		S	34.90						
		B	100	62	42	9.1	4.35	2.08	(0.99)
232	-	T	02.45		02.29	02.18	02.17		01.34
		S	34.99		34.98	34.98	34.98		34.98
		B	100	56.3	39.2	19.6	11.3	4.62	2.17
244	-	T	05.40		05.30	05.21	05.16		05.11
		S	35.15		35.14	35.14	35.14		35.14
		B	100	53.2	31.9	10.6	4.22	0.951	
256	-	T	06.75		06.71	06.62	06.54		06.44
		S	35.17		35.17	35.17	35.17		35.17
		B	100	44.5	29.6	11.4	5.13	3.2	2.03
298	-	T	05.9		05.8	05.8	05.8		05.7
		S	35.10						
		B	100	53.6	39.9	18.2	7.41	2.85	
323	-	T	03.15		03.18	03.13	03.12		03.10
		S	35.05		35.09	35.06	35.06		35.06
		B	100	70.7	39.9	10.3	3.99	(1.58)	
336		T	00.42		00.36	00.35	00.32		-0.09
		S	34.65		34.65	34.65	34.67		34.78
		B	100	23.9	7.41	(0.43)			
346	-	T	01.23		01.29	01.04	01.03		00.94
		S	34.63		34.69	34.72	34.72		34.81
		B	100	36.5	14.3	2.28			
368	-	T	03.90		03.84	03.22	02.93		01.23
		S	35.11		35.07	35.02	35.04		34.96
		B	100	49.6	28.5	7.07	1.14		
117	1962	T	04.00		03.71	02.90	02.21		02.00
		S	34.82		34.79	34.81	34.80		34.82
		B+V	100	90.2	65.7	30.7	7.54	(1.02)	
132	-	T	03.61		03.43	03.33	02.99		01.51
		S	34.71		34.71	34.71	34.69		34.79
		B+V	100	74.2	50.7	26.2	15.4	8.15	(4.4)
134	-	T	04.03		03.92	03.80	03.74		03.70
		S	34.86		34.88	34.86	34.86		34.87
		B+V	100.0	71.3	53.0	26.4	11.6	4.96	(2.13)
141	-	T	02.12		01.55	01.37	01.34		00.95
		S	34.83		34.83	34.82	34.81		34.82
		B+V	100	26.1	1.45	(0.007)			

TABLE 2 cont.

Station	Year		0 m	5 m	10 m	20 m	30 m	40 m	50 m
142	1962	T	02.43		01.25	01.12	01.06		00.93
		S	34.83		34.84	34.82	34.82		34.81
		B+V	100.0	29.6	5.15	0.638			
151	-	T	01.40		00.35	00.22	00.18		-0.03
		S	34.87		34.86	34.68	34.85		34.85
		B+V	100.0	14.5	2.17	(0.01)			
152	-	T	00.82		00.56	00.11	00.13		00.03
		S	34.83		34.82	34.81	34.82		34.81
		B+V	100.0	27.8	4.58	(0.143)			
156	-	T	01.19		01.06	00.98	00.93		00.78
		S	34.85		34.83	34.82	34.82		34.83
		B+V	100.0	21.6	3.32	(0.09)			
221	-	T	02.40		02.28	02.12	02.08		01.97
		S	34.83		34.83	34.83	34.83		34.83
		B+V	100.0	74.5	28.1	3.32			
225	-	T	02.13		02.07	01.44	01.45		01.40
		S	34.84		34.84	34.80	34.84		34.83
		B+V	100.0	18.2	3.32	(0.095)			
226	-	T	02.2		02.2	02.7	02.6		02.5
		S	34.83						
		B+V	100.0	15.7	3.13	(0.8)			
227	-	T	01.7		01.7	01.7	01.7		01.7
		S	34.73						
		B+V	100.0	35.0	10.8	(0.71)			
228	-	T	02.5		02.5	02.5	02.5		02.3
		S	34.89						
		B+V	100.0	52.4	33.6	15.0	(3.6)		
235	-	T	02.90		02.75	02.61	02.26		01.90
		S	34.86		34.83	34.82	34.81		34.85
		B+V	100.0	74.9	39.2	8.93	0.893		
236	-	T	02.0		02.0	01.9	01.8		01.5
		S	34.88						
		B+V	100.0	34.8	9.28	(0.185)			
246	-	T	03.52		03.40	03.44	02.87		02.65
		S	34.86		34.87	34.90	34.89		34.89
		B+V	100.0	85.8	47.3	23.7	17.2	9.67	6.03
a	1967	T							
		S							
		B+G	100.0	47.3	35.6	14.5	6.40	3.20	1.45
b	-	T							
		S							
		B+G	100.0	53.5	28.3	10.4	3.78	(1.33)	
c	-	T							
		S							
		B+G	100.0	33.8	18.4	7.11	1.48	0.405	0.0973
161	1968	T	06.10		05.93	06.83	07.01		07.17
		S	34.16		34.54	34.93	35.06		35.16
		B+G	100.0	28.6	8.43	0.733	0.176	0.0829	0.0405

TABLE 2 cont.

Station	Year		0 m	5 m	10 m	20 m	30 m	40 m	50 m
172	1968	T	06.48		06.19	06.34	06.03		06.48
		S	34.39		34.39	34.60	34.59		34.78
		B+G	100.0	33.6	11.4	2.40	0.580	0.116	
201	-	T	06.80		06.06	06.17	06.32		
		S	34.45		34.42	34.58	34.70		
		B+G	100.0	52.4	28.6	7.26	2.94	1.35	0.618
403	1969	T	06.82	06.77	06.75				
		S	34.39	34.38	34.38				
		B+G	100.0	53.8	28.5	7.85	2.23	1.09	0.569
418	-	T	07.22		07.19	07.16	07.18		07.22
		S	34.88		34.88	34.88	34.99		35.19
		B+G	100.0	48.9	25.3	6.12	1.51	0.767	0.404
429	-	T	06.10		05.90	05.83	05.84		05.96
		S	33.81		33.78	33.78	33.98		34.37
		B+G	100.0	52.9	22.5	3.37	1.24	0.443	0.192
430	-	T	06.08		05.54	05.43	05.69		
		S	33.83		33.81	33.82	33.93		
		B+G	100.0	56.7	33.0	10.4	3.58	1.17	0.467
443	-	T	06.82		06.53	06.50	06.28		
		S	34.10		34.10	34.31	34.39		
		B+G	100.0	53.6	32.1	11.4	5.14	2.29	1.21
450	-	T	06.58		05.88	05.35	05.31		05.44
		S	34.04		34.31	34.37	34.40		34.52
		B+G	100.0	61.6	38.1	13.8	4.67	0.684	0.0835
457	-	T	05.01		04.51	04.39	04.58		04.78
		S	33.77		33.82	33.83	33.91		34.11
		B+G	100.0	28.2	8.0	06.40	0.0529	.00592	.00066
470	-	T	03.78		03.57	03.54	03.04		05.64
		S	33.26		33.11	33.77			34.40
		B+G	100.0	55.8	33.2	12.5	5.06	1.96	0.786
d	1971	T							
		S							
		B+G	100.0	23.2	6.84	0.651	0.0742		
249	-	T	05.29	05.29	05.29	05.29	05.29	05.68	06.47
		S	33.24	33.23	33.24	33.24	33.24	33.86	34.36
		B+G	100.0	53.2	28.4	5.25	1.41	0.565	0.260
258	-	T			06.20	06.20	06.13	06.03	05.87
		S			35.21	35.21	35.21	35.19	35.23
		B+G	100.0	66.8	45.2	20.4	9.28	5.06	3.18
260	-	T	07.72		07.36	07.27	07.47	07.88	08.67
		S	34.69		34.69	34.78	35.08	35.14	35.33
		B+G	100.0	67.4	46.0	18.3	8.25	4.06	2.26
287	-	T			08.40	08.26	08.17	08.12	08.06
		S			35.30	35.27	35.29	35.27	35.30
		B+G	100.0	73.5	53.0	29.0	15.9	9.32	5.29
415	1973	T	05.97		05.95	05.95	05.97		05.97
		S	34.58		34.47	34.45	34.45		34.46
		B+G	100.0	67.1	44.7	20.0	8.94	4.71	2.23

TABLE 2 . cont.

Station	Year		0 m	5 m	10 m	20 m	30 m	40 m	50 m
423	1973	T	00.80		00.75	00.72	00.76		00.75
		S	34.75		34.74	34.75	34.75		34.75
		B+G	100.0	10.7	2.14	0.057			
430	-	T	00.31		00.31	00.65	00.94		
		S	34.46		34.47	34.64	34.70		
		B+G	100.0	26.3	10.7	1.84	0.389	0.0973	
435	-	T	00.59		01.05	01.11	03.05		04.04
		S	34.44		34.53	34.55	34.90		35.07
		B+G	100.0	12.3	2.19	0.0842	0.00139		
450	-	T	04.29		04.25	04.09	03.97		03.96
		S	35.12		35.11	35.12	35.11		35.11
		B+G	100.0	46.5	25.8	9.75	3.82	1.78	0.819
462	-	T	02.20		02.08	02.15	02.57		02.53
		S	34.98		34.96	34.99	35.06		35.06
		B+G	100.0	55.1	33.4	10.5	4.31	2.10	1.02
484	-	T	00.90		00.76	00.70	00.71		00.64
		S	35.03		35.02	35.02	35.02		35.02
		B+G	100.0	23.0	7.13	0.890	0.0959		
497		T	00.31		00.19	00.18	00.20		00.20
		S	34.91		34.89	34.90	34.89		34.89
		B+G	100.0	6.80	0.491	(0.0105)			

EXPLANATION

Column three: T = temperature in ^{o}C, S = salinity in ^{o}/oo, N = photocurrent with filter N3, B = photocurrent with filter B12, B+V = photocurrent with filter B12+V9, B+G = photocurrent with filter B12+G5, all photocurrents in percent of the surface value. Numbers in parenthesis are extrapolated.

TABLE 3

Station	Year	h	Cloud	1%	Tr	K	f	K_{35}	T	S
251	1954	41	08	47	7.2	.132	0.98	.129	05.05	35.01
269	-	38	07	21	1.25	.219	1.00	.219	-0.38	33.89
285	-	41	08	78	22.3	.075	0.98	.073	05.62	35.14
293	-	42	06	23	2.2	.421	1.00	.421	06.73	35.11
321	-	41	07	22	1.38	.214	1.00	.214	06.15	35.16
334	-	37		90	25.5	.068	1.01	.069	-0.17	34.45
166	1955	25	00	88	19	.083	0.98	.081	06.20	34.97
178	-	24	04	52	28.2	.063	0.97	.061		
190	-	27	08	34	20.1	.080	0.98	.079	06.73	35.11
204	-	28	06	15	0.01	.461	1.00	.460	04.75	33.86
213	-	31		15	0.04	.391	1.00	.391		
652	-	36	06	85	17.2	.088	1.00	.088	06.20	34.80
657	-	36	08	48	14.4	.097	0.98	.095	06.77	34.76
663	-	37	04	26	9.8	.116	1.00	.116		
150	1958	05	04	25	3.4	.169	0.98	.167	06.65	34.66
166	-	39	06	35	15.5	.093	1.00	.094	06.26	35.15
178	-	40	06	41	29	.062	1.01	.062	05.72	35.13
187	-	40		27	5.0	.150	1.01	.151	05.40	
207	-	38	06	21	2.63	.182	1.00	.182	00.20	
221	-	39	07	60	15.4	.094	1.00	.094	00.40	
232	-	39	04	75	28.1	.063	1.01	.064	02.29	34.98
244	-	40	03	45	17.4	.087	1.01	.088	05.30	35.14
256	-	42	03	82	18.3	.085	1.01	.086	06.71	35.17
298	-	41	06	59	26.8	.066	1.01	.067	05.80	
323	-	38	03	53	17.1	.088	1.00	.089	03.18	35.09
336	-	38	06	20	0.95	.233	1.00	.233	00.36	34.65
346	-	38	00	29	5.05	.149	1.00	.150	01.29	34.69
368	-	37	08	35	12.8	.103	1.00	.103	03.84	35.07
117	1962	31	2	39	29.5	.061	0.99	.060	03.71	34.79
132	-	45	4	69	25.2	.069	1.02	.071	03.43	34.71
134	-	34	4	56	25.4	.069	0.99	.068	03.92	34.88
141	-	37	2	10	.0033	.516	1.00	.516	01.55	34.83
142	-	44	4	15	0.44	.271	1.00	.272	01.25	34.84
151	-	41	2	11	.0049	.496	1.00	.496	00.35	34.86
152	-	29	3	14	.089	.351	1.00	.351	00.56	34.82
156	-	43	8	13	.054	.376	1.00	.375	01.06	34.83
221	-	45	7	23	2.72	.180	1.00	.181	02.28	34.83
225	-	46	8	13	.057	.373	1.00	.372	02.07	34.84
226	-	41	7	16	0.56	.259	1.00	.259	02.20	
227	-	30	8	18	0.49	.266	0.99	.264	01.70	
228	-	21	8	37	14.3	.097	0.98	.095	02.50	
235	-	46	8	29	8.3	.124	0.98	.122	02.75	34.83
236	-	40	8	15	.115	.338	1.00	.337	02.00	
246	-	46	7	64	22.6	.074	1.02	.076	03.40	34.87

TABLE 3 cont.

Station	Year	h	Cloud	1%	Tr	K	f	K_{35}	T	S
a	1967	22	2	55	15.2	.094	0.97	.092		
b	-	23	8	43	10.5	.113	0.98	.111		
c	-	20	8	23	7.6	.129	0.98	.127		
161	1968	37	2	19	0.73	.246	1.00	.246	05.93	34.54
172	-	38	8	26	2.52	.184	0.99	.182	06.19	34.60
201	-	25	4	44	7.8	.128	0.98	.126	06.06	34.42
403	1969	37	0	42	8.4	.124	1.00	.124	06.75	34.38
418	-	39	2	36	6.6	.136	1.00	.137	07.19	34.88
429	-	40	4	32	3.75	.164	1.00	.165	05.90	33.78
430	-	37	3	42	10.9	.111	1.00	.111	05.54	33.81
443	-	40	0	53	12.0	.106	1.01	.107	06.53	34.10
450	-	32	8	38	14.5	.097	0.98	.095	05.88	34.31
457	-	35	3	18	0.63	.253	1.00	.253	04.51	33.82
470	-	37	8	48	13.1	.102	0.98	.100	03.57	33.11
d	1971	37	7	18	0.64	.253	1.00	.252		
249	-	40	4	34	5.7	.143	1.00	.144	05.29	33.24
258	-	37	6	78	21.1	.078	1.00	.078	06.20	35.21
260	-	40	2	65	19.0	.083	1.01	.084	07.36	34.69
287	-	37	3	81	30.0	.060	1.00	.060	08.40	35.30
415	1973	24	8	62	20.7	.079	0.98	.077	05.95	34.47
423	-	30	8	12	.053	.377	1.00	.376	00.75	34.74
430	-	34	6	24	1.9	.198	1.00	.198	00.31	34.47
435	-	11	8	13	.079	.357	1.00	.356	01.05	34.53
450	-	20	8	48	10.3	.114	0.98	.112	04.25	35.11
462	-	35	3	51	11.0	.110	1.00	.110	02.08	34.96
484	-	34	8	20	0.89	.236	0.99	.234	00.76	35.02
497	-	13	8	9	.0094	.464	1.00	.463	00.19	34.89

EXPLANATION

Column h: solar altitude in degrees.

Column 1%: the depth in meters of 1% irradiance transmittance at 465 nm.

Column Tr: the irradiance transmittance at 465 nm and 20 m depth in %

Column K: vertical attenuation coefficient at 465 nm in m^{-1}

f and K_{35} are explained in the text.

TABLE 4

Station	Year		0 m	5 m	10 m	20 m	30 m	40 m	50 m
a	1967	E	168	83	44	13.0	4.3	2.0	0.98
		%	100	49	26	7.7	2.5	1.19	0.58
		Q	450	220	110	33	10.5	4.9	2.4
		%	100	49	25	7.3	2.4	1.11	0.54
b	-	E	23	7.1	3.0	0.86	0.31		
		%	100	31	12.7	3.7	1.32		
		Q	65	18.9	7.6	2.2	0.77		
		%	100	29	11.7	3.3	1.18		
c	-	E	38	6.1	2.3	0.58	0.20	.060	
		%	100	16.2	6.2	1.53	0.54	.158	
		Q	109	16.8	6.3	1.52	0.53	.154	
		%	100	15.5	5.8	1.40	0.49	.142	
161	1968	E	147	32	9.5	1.42	0.43	0.181	.085
		%	100	22	6.4	0.97	0.29	0.123	.058
		Q	400	84	24	3.7	1.11	0.47	.22
		%	100	21	6.1	0.92	0.28	0.117	.055
172	-	E	38	9.7	3.3	0.69	.197	.046	.0144
		%	100	26	8.7	1.84	0.52	.121	.038
		Q	105	25	8.4	1.79	0.51	.117	.037
		%	100	24	8.0	1.71	0.48	.111	.035
201	-	E	280	90	39	9.0	3.4	1.50	0.72
		%	100	32	13.8	3.2	1.23	0.54	0.26
		Q	780	230	97	23	8.6	3.7	1.79
		%	100	30	12.5	2.9	1.11	0.48	0.23
418	1969	E	340	125	54	12.2	3.5	1.62	.75
		%	100	37	16.0	3.6	1.05	.48	.22
		Q	930	330	136	31	8.9	4.1	1.88
		%	100	35	14.6	3.3	.95	.44	.20
429	-	E	137	65	24	4.5	1.52	.57	.24
		%	100	47	17.7	3.3	1.11	.42	.176
		Q	360	169	63	11.6	3.9	1.46	.62
		%	100	47	17.3	3.2	1.07	.40	.171
450	-	E	104	44	21	6.6	2.3	.57	.087
		%	100	42	19.8	6.4	2.2	.55	.084
		Q	280	114	51	16.5	5.8	1.45	.22
		%	100	40	18.2	5.9	2.1	.52	.079
457		E	270	65	17.2	2.2	0.35	.071	.0148
		%	100	24	6.4	0.81	.130	.026	.0056
		Q	730	171	45	5.7	0.93	.189	.040
		%	100	24	6.2	0.78	.128	.026	.0055
470	-	E	70	27	12.8	4.4	1.80	.79	.34
		%	100	38	18.3	6.3	2.6	1.12	.48
		Q	186	68	32	11.0	4.5	1.99	.85
		%	100	36	17.4	5.9	2.4	1.07	.46

TABLE 4 cont.

Station	Year		0 m	5 m	10 m	20 m	30 m	40 m	50 m
d	1971	E	67	14.8	4.4	.59	.102		
		%	100	22	6.5	.88	.152		
		Q	178	39	11.3	1.51	.26		
		%	100	22	6.3	.85	.147		
249	-	E	198	73	35	6.4	1.90	.73	.28
		%	100	37	17.5	3.3	.96	.37	.143
		Q	530	196	90	16.4	4.9	1.86	.71
		%	100	37	17.0	3.1	.92	.35	.135
258	-	E	210	113	67	27	11.5	5.3	2.8
		%	100	53	31	12.6	5.4	2.5	1.32
		Q	560	280	164	66	28	12.9	6.9
		%	100	50	29	11.8	5.0	2.3	1.23
260	-	E	193	91	61	20	8.6	4.0	2.1
		%	100	47	31	10.4	4.4	2.1	1.07
		Q	510	220	151	50	21	10.0	5.1
		%	100	43	30	9.7	4.2	1.96	.99
287	-	E	195	104	67	32	16.8	9.4	5.4
		%	100	53	34	16.6	8.7	4.8	2.8
		Q	520	250	161	76	40	22	13.0
		%	100	49	31	14.8	7.7	4.3	2.5
430	1973	E	184	36	14.0	2.6	0.55		
		%	100	19.6	7.6	1.41	0.30		
		Q	480	90	35	6.7	1.42		
		%	100	18.7	7.3	1.39	0.30		

EXPLANATION

Column three: E = integrated irradiance (350-750 nm) in W m^{-2}

Q = integrated quanta irradiance in 10^{18} quanta $s^{-1}m^{-2}$.

TABLE 5

Irradiance $E_\lambda(\lambda)$ in mW $m^{-2}nm^{-1}$, at different wavelengthe and depths.

λ(nm)	0 m	5 m	10 m	20 m	30 m	40 m	50 m
Station 457, 1969							
380	370	60	10.6	.196	.0033	.000045	
470	830	250	73	5.6	.47	.043	.0039
530	1150	390	140	31	6.8	1.51	.37
620	730	142	16.5	.42	.0148	.00031	
Station 201, 1968							
380	390	91	23	1.65	.24	.045	.0113
470	860	470	250	71	29	12.4	5.3
530	970	500	230	69	25	7.5	2.8
620	780	126	26	.68	.058		
Station 430, 1973							
380	510	80	21	1.93	.162		
470	600	140	59	10.5	2.3		
530	610	210	95	22	6.4		
620	400	24	2.2	.0143			
Station 287, 1971							
380	280	179	111	42	17.3	7.7	3.5
470	1040	760	560	310	173	104	60
530	460	360	240	114	48	29	15.3
620	450	98	18.1	1.06	.072	.0054	.00046

TABLE 6

Station	Year	Watertype
251	1954	1
269	-	3
285	-	II
293	-	5
321	-	3
334	-	II
166	1955	II
178	-	II
190	-	II
204	-	5
213	-	5
652	-	II
657	-	III
663	-	III
150	1958	2
166	-	III
178	-	II
187	-	1
207	-	2
221	-	III
232	-	II
244	-	II
256	-	II
298	-	II

Station	Year	Watertype
323	1958	II
336	-	3
346	-	1
368	-	III
117	1962	II
132	-	II
134	-	II
141	-	6
142	-	4
151	-	6
152	-	4
156	-	5
221	-	2
225	-	5
226	-	3
227	-	3
228	-	III
235	-	III
236	-	4
246	-	II
a	1967	II
b	-	III
c	-	III

Station	Year	Watertype
161	1968	3
172	-	2
201	-	III
403	1969	III
418	-	1
429	-	2
430	-	III
443	-	III
450	-	III
457	-	3
470	-	III
d	1971	3
249	-	1
258	-	II
260	-	II
287	-	II
415	1973	II
423	-	5
430	-	2
435	-	4
450	-	III
462	-	III
484	-	3
497	-	6

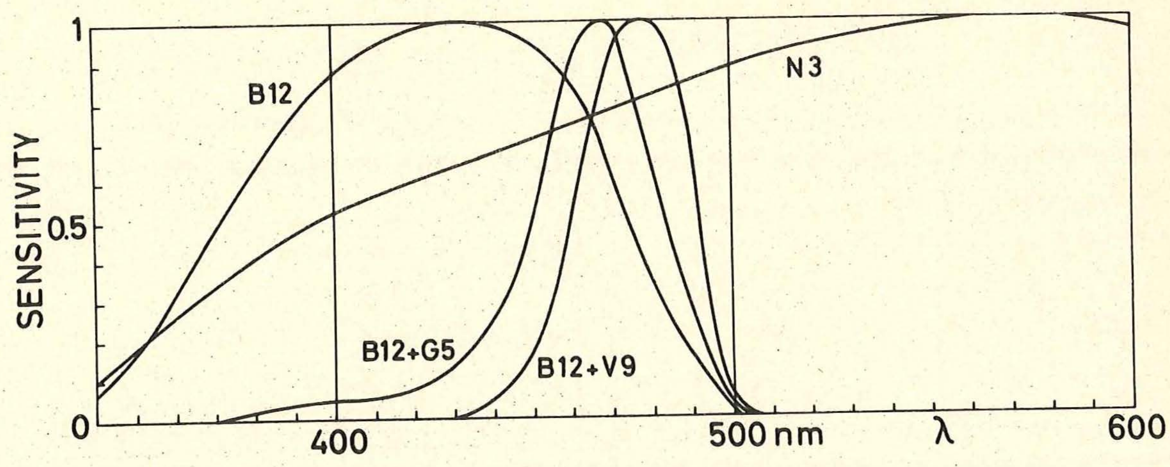


Fig. 1. Spectral sensitivity distribution of the irradiance meter with different filters. The curves are normalized with 1 at their peak value.

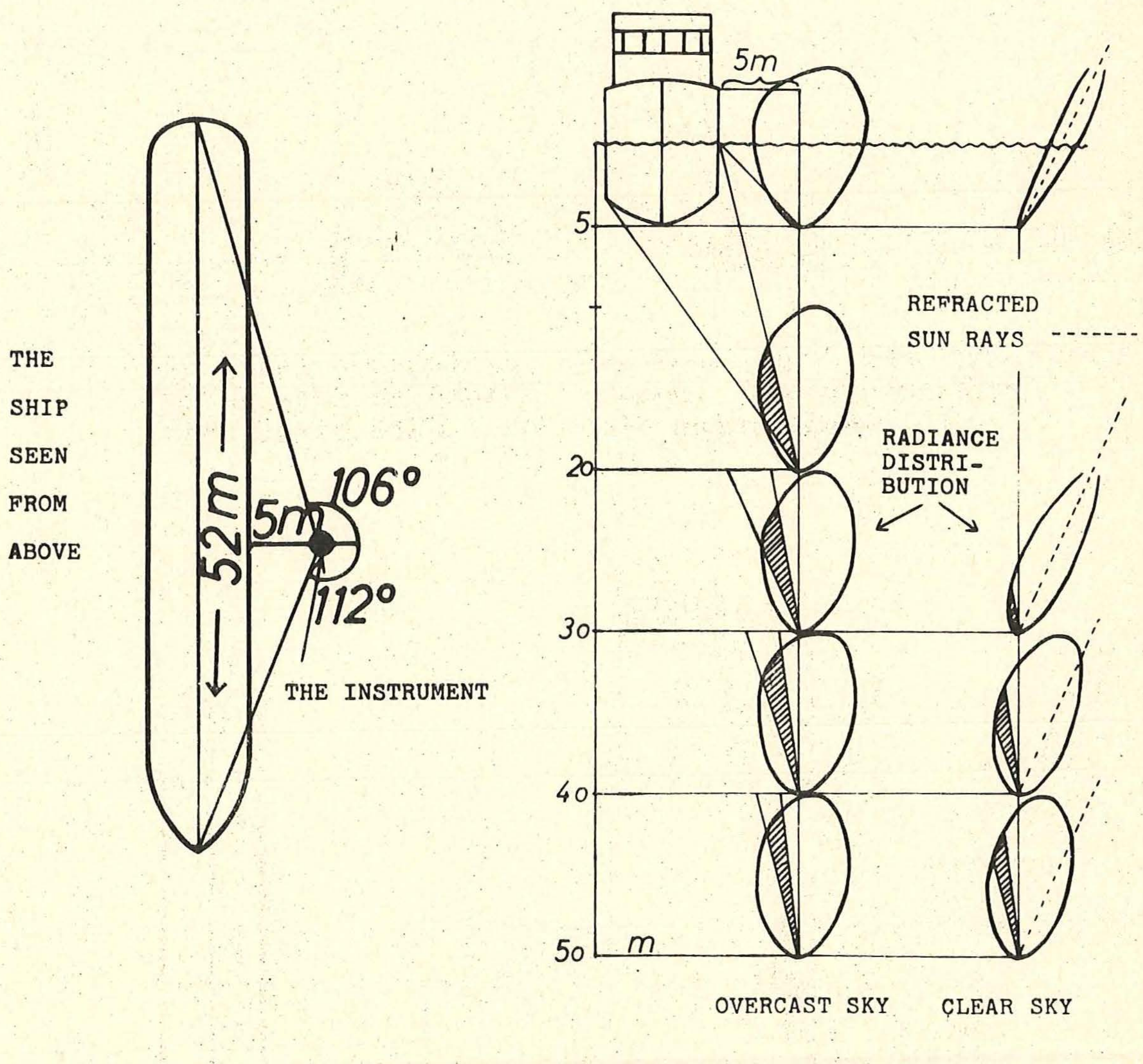


Fig. 2 Radiance distribution at different depths, and the lost radiance (scratched areas) within the solid angle from the irradiance meter to the boat. The left part shows the solid angle seen from above.

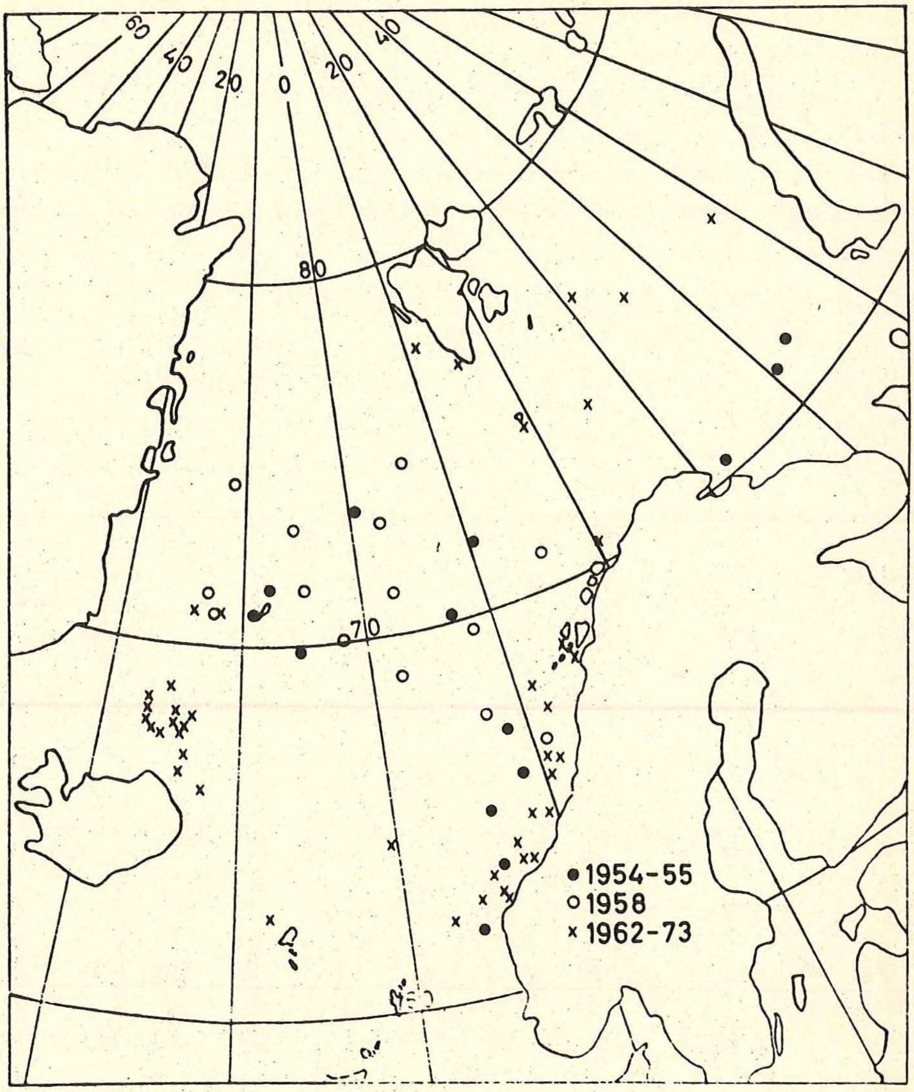


Fig. 3.
Location of the stations.

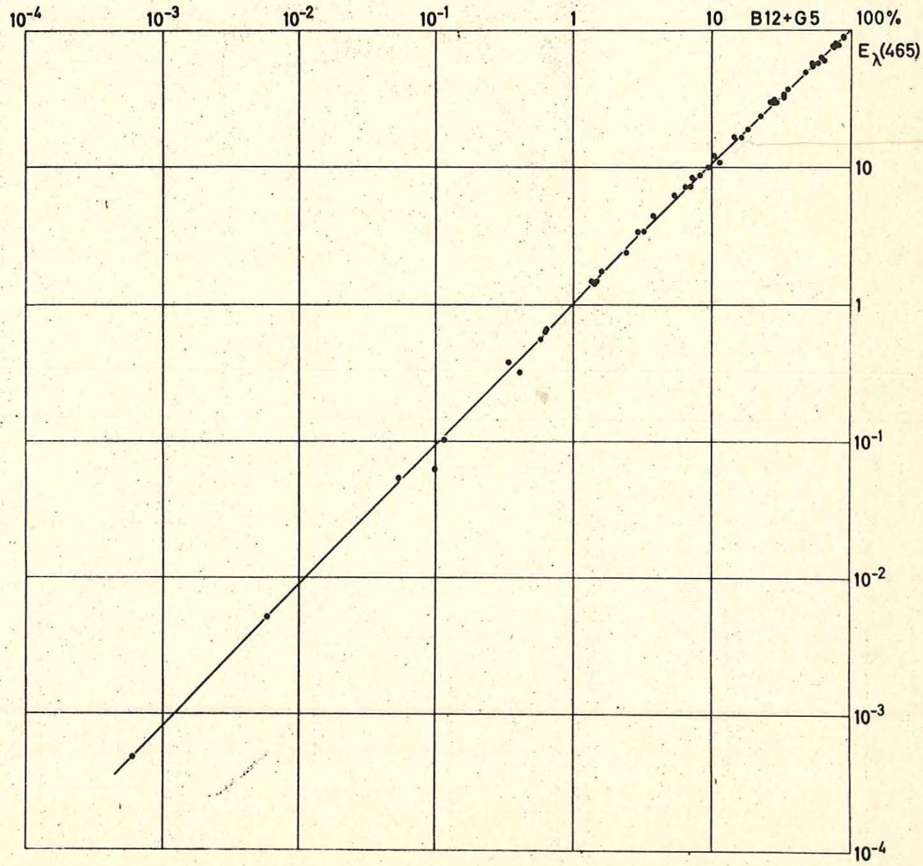


Fig. 4.
Irradiance E_λ at 465 nm as a function of the photocurrent with filter B12+G5, in percent of their surface values

Fig. 5. Irradiance E_λ at 465 nm as a function of the photocurrent with filter B12+V9, in percent of their surface values.

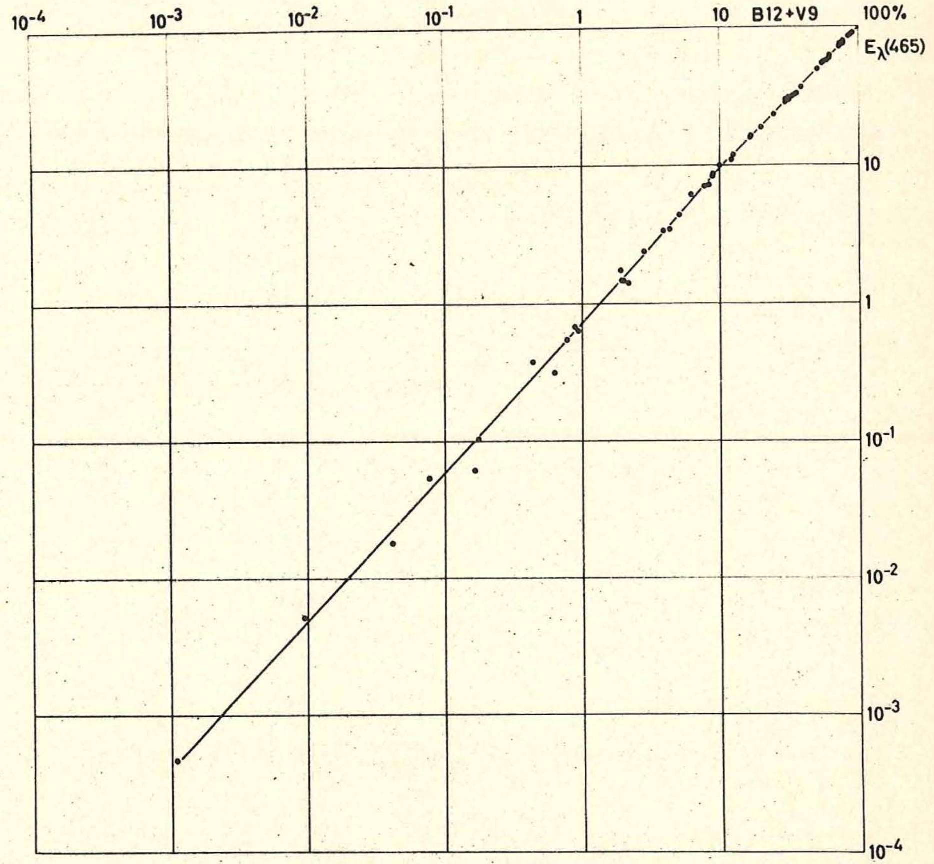
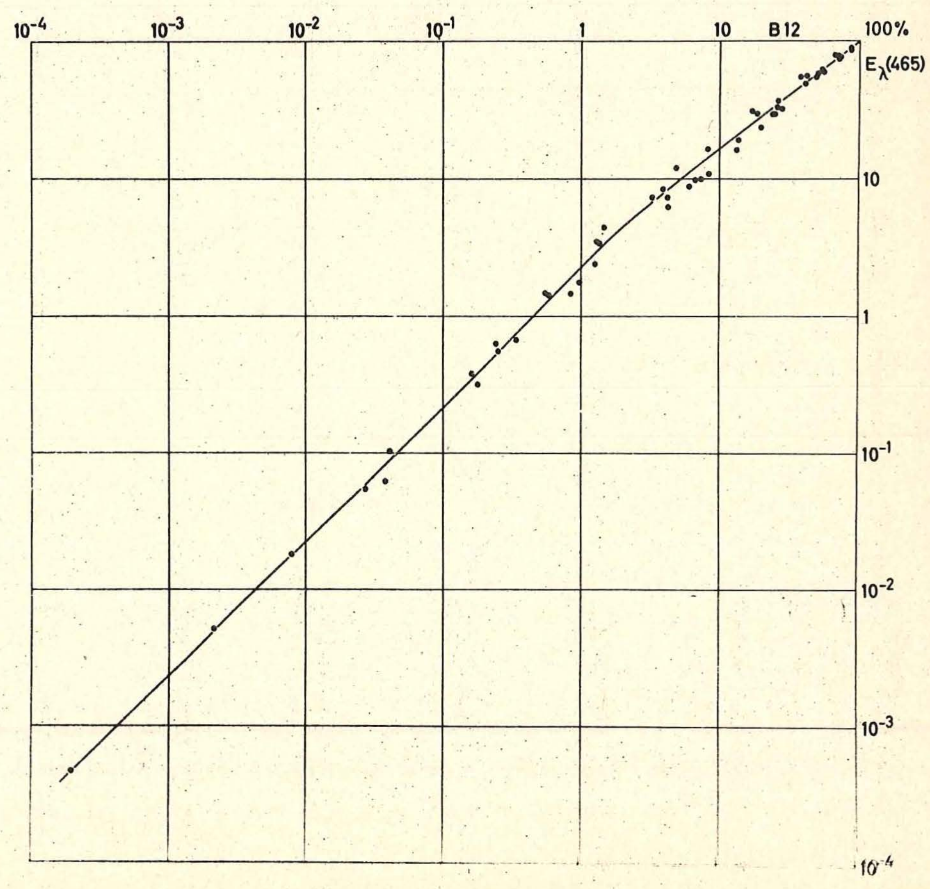


Fig. 6. Irradiance E_λ at 465 nm as a function of the photocurrent with filter B12, in percent of their surface values.



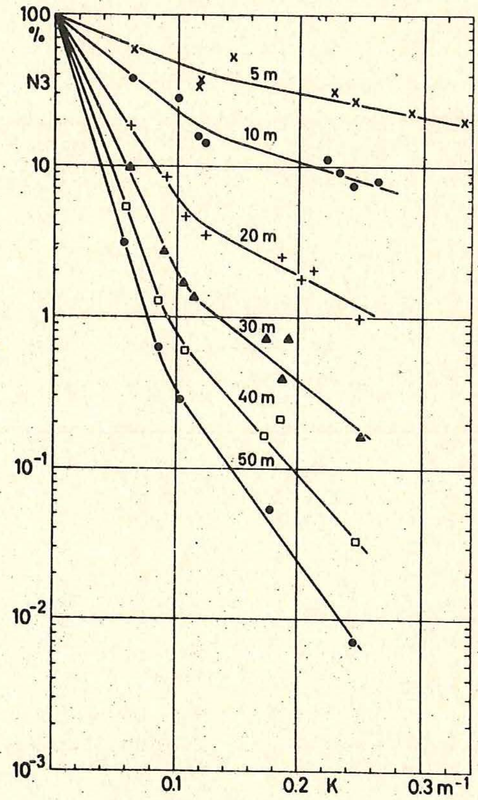


Fig. 7.

Vertical attenuation coefficient at 465 nm K, as a function of the photocurrent with filter N3 in percent of its surface value for different depths.

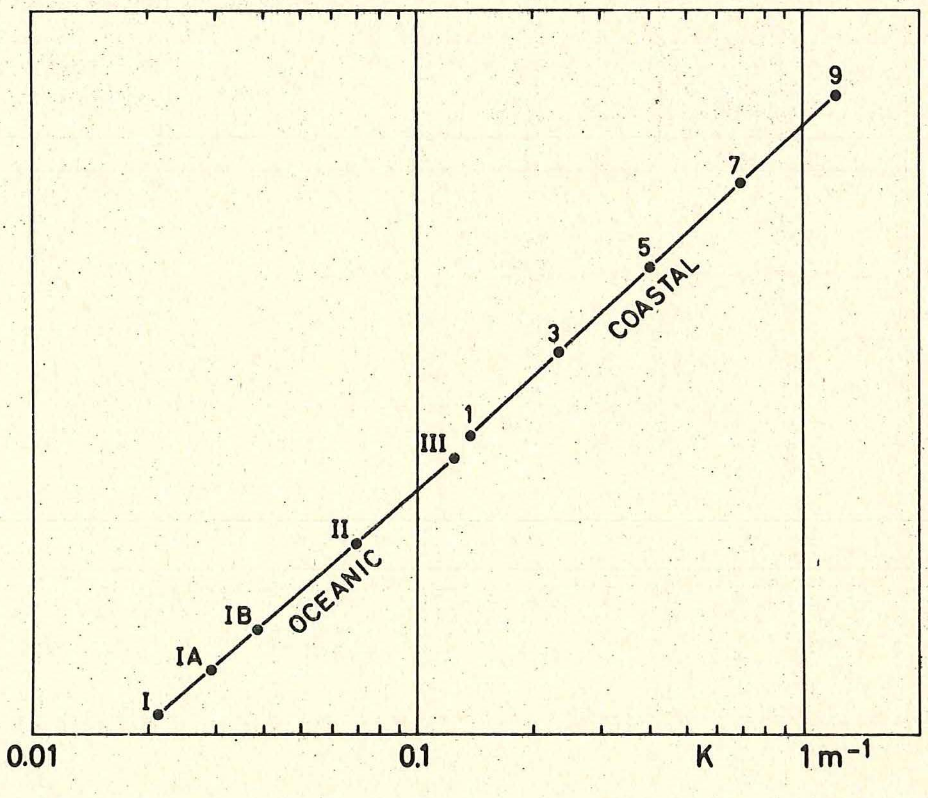


Fig. 8. JERLOV's optical classification of oceanic (I-III) and coastal (1-9) water types, according to their vertical attenuation coefficient K_{35} at 465 nm and sun height 35^{o}.

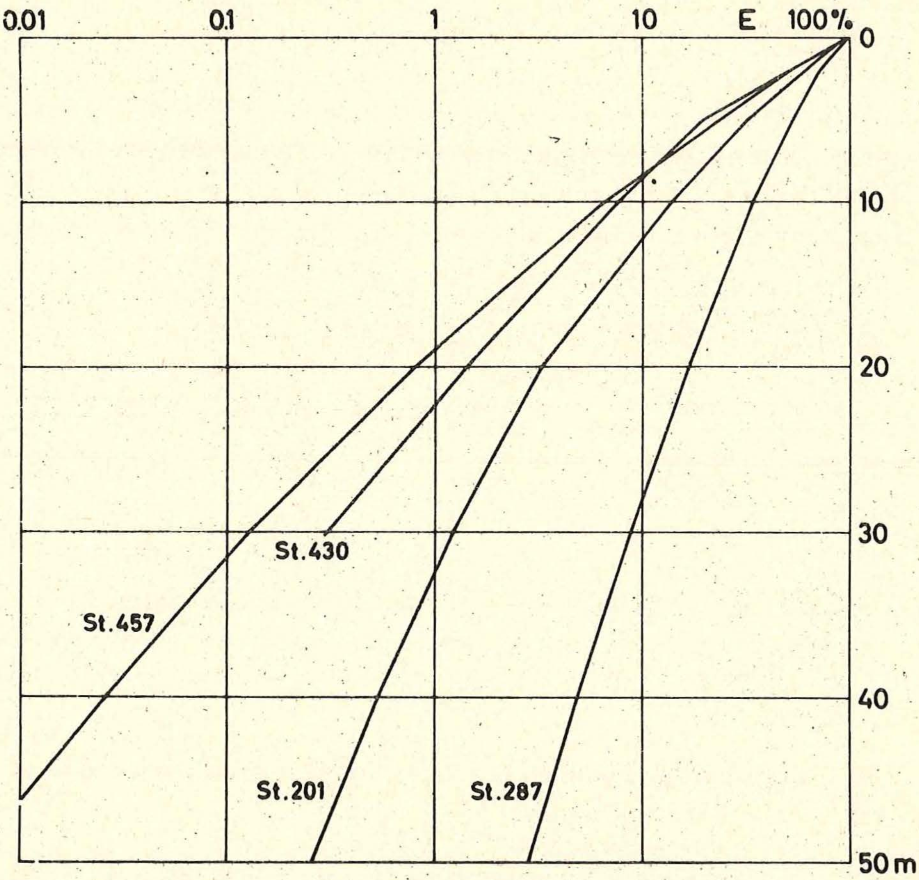


Fig. 9. The spectrally integrated (350-750 nm) irradiance E in percent of its surface value, as a function of depth at different stations.

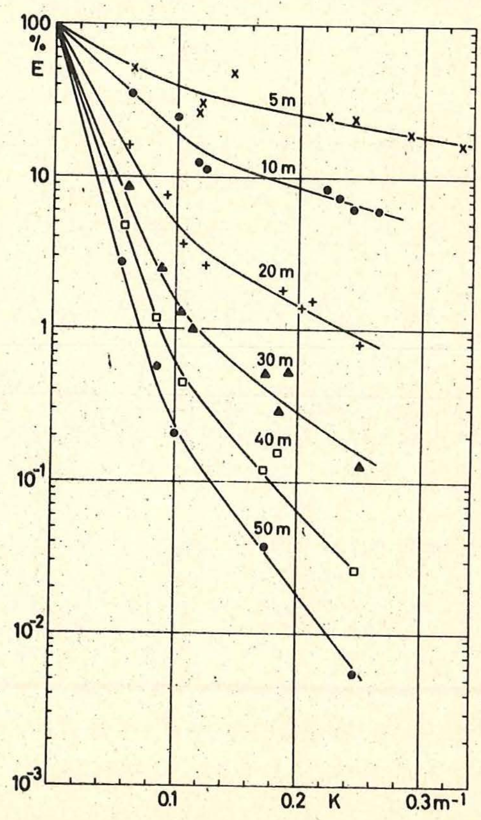


Fig. 10. Integrated (350-750 nm) irradiance E in percent of its surface value, as a function of the vertical attenuation coefficient K at 465 nm for different depths.

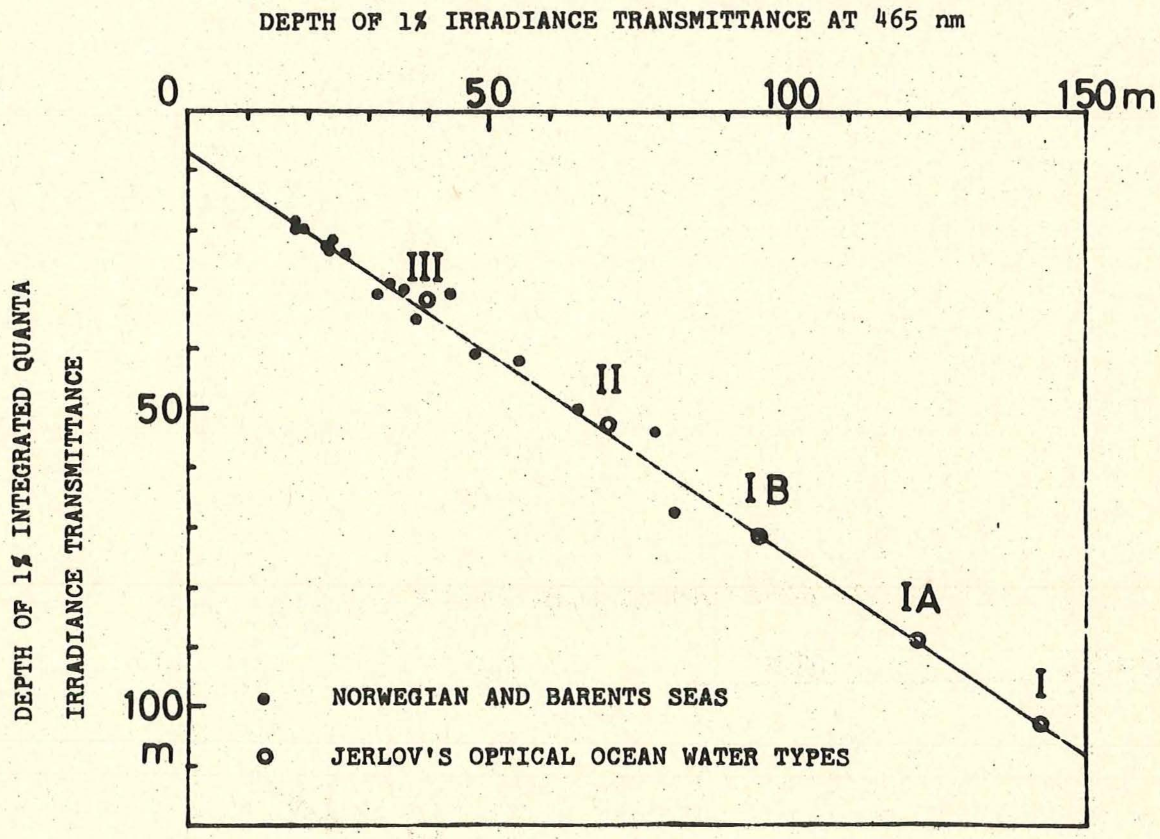


Fig. 11. The depth of 1% integrated quanta irradiance transmittance as a function of the depth of 1% irradiance transmittance at 465 nm.

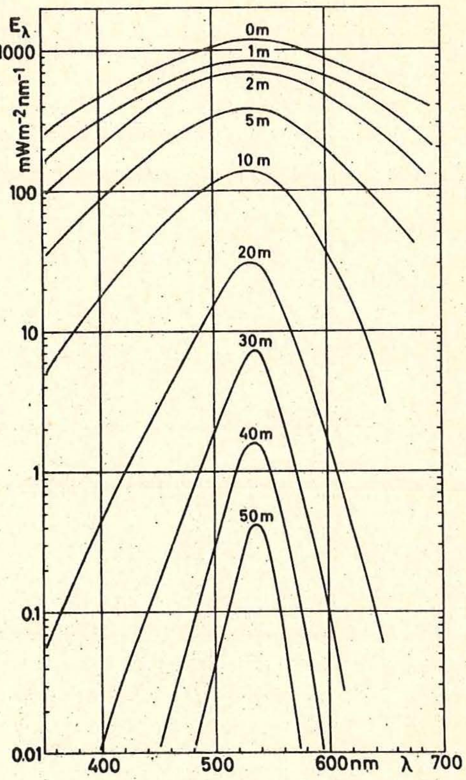


Fig. 12. Spectral irradiance distribution $E_\lambda(\lambda)$ at Station 201, Trænabanken, April, 1968

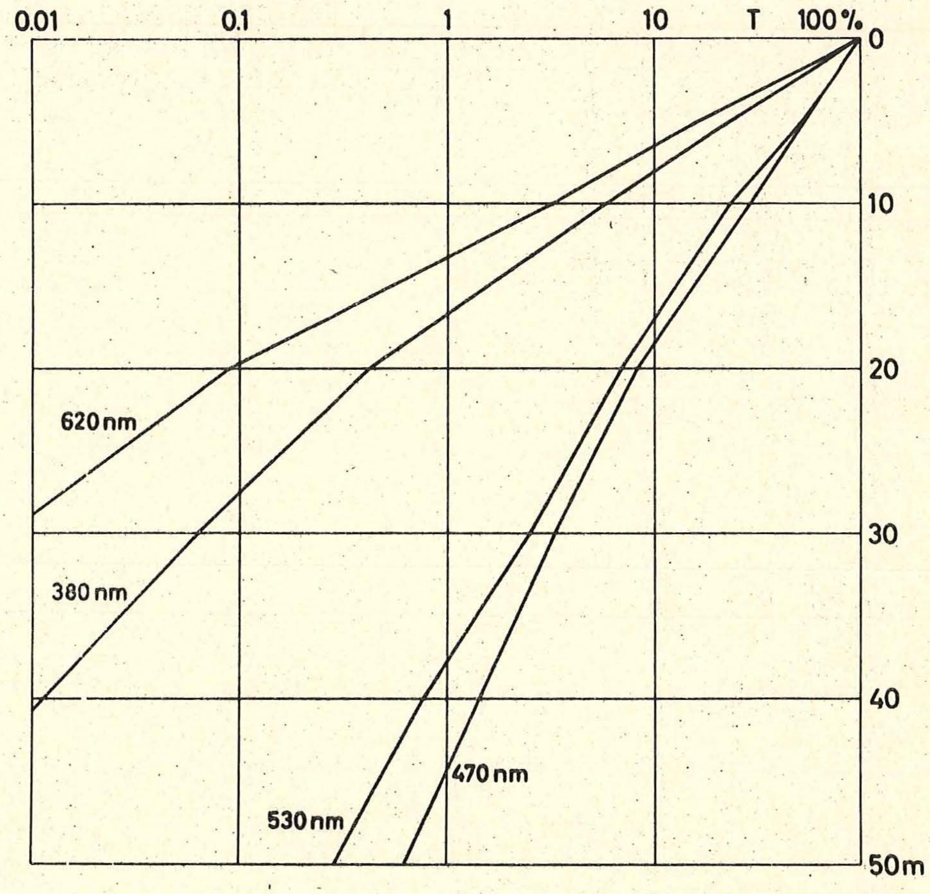


Fig. 13. Irradiance transmittance T at different wavelengths as a function of depth at Station 201.

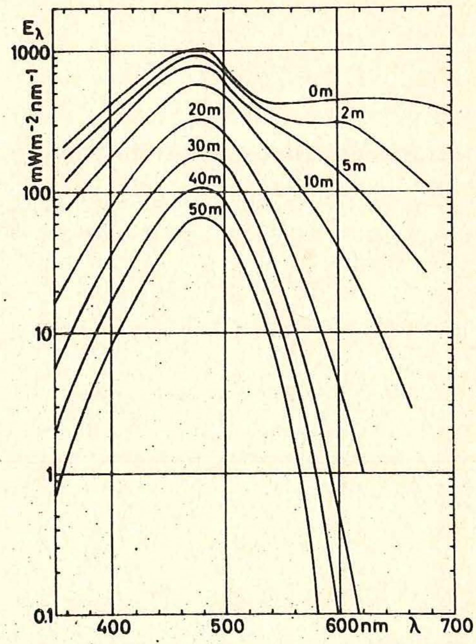


Fig. 14. Spectral irradiance distribution $E_{\lambda}(\lambda)$ at Station 287, west of the Faeroe Islands, May, 1971

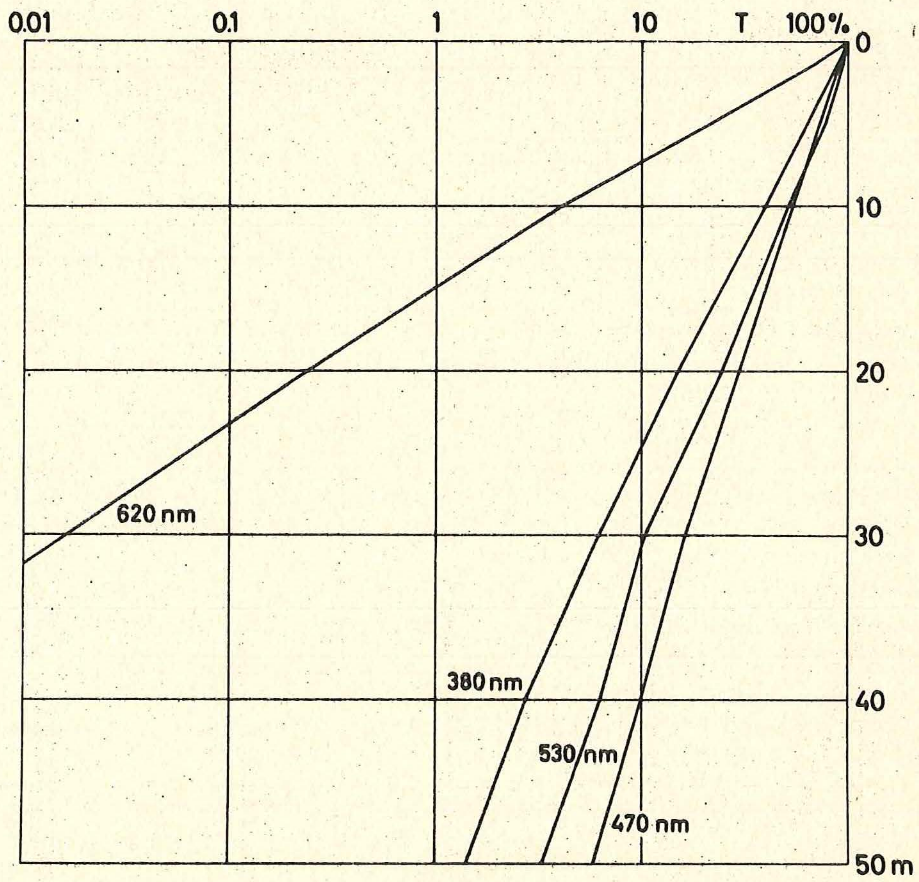


Fig. 15. Irradiance transmittance T at different wavelengths as a function of depth at Station 287.

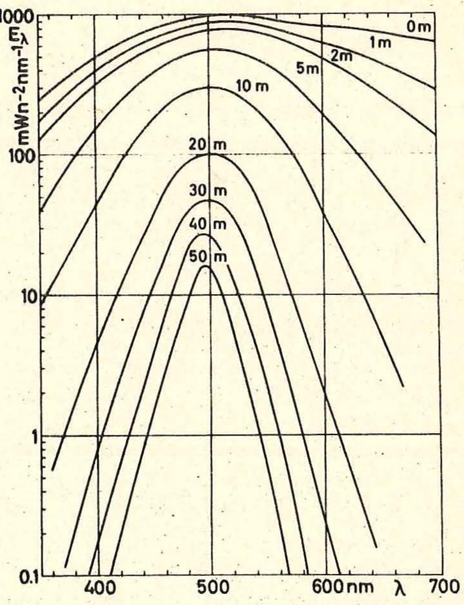


Fig. 16. Spectral irradiance distribution $E_\lambda(\lambda)$ at Station 457, west of Langøy, Vesterålen, May, 1969.

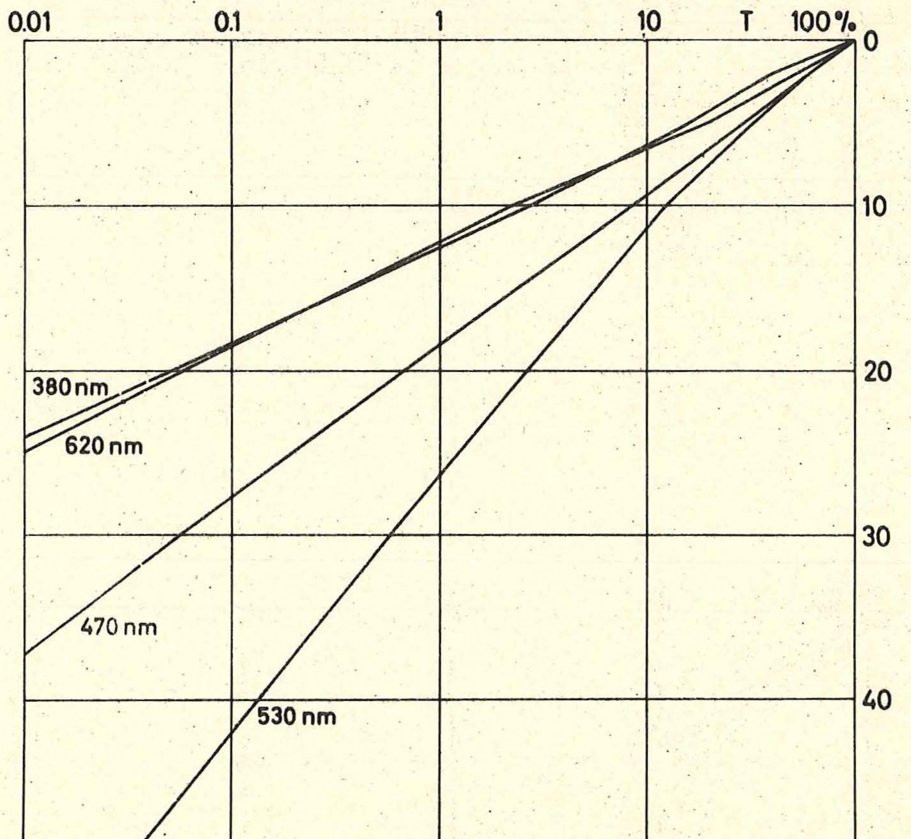


Fig. 17. Irradiance transmittance T at different wavelengths as a function of depth at Station 457.

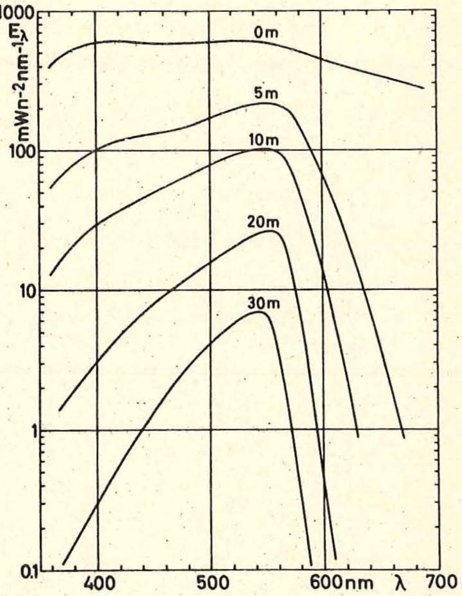


Fig. 18. Spectral irradiance distribution $E_\lambda(\lambda)$ at Station 430, west of Sørkapp, West Spitzbergen, May, 1973.

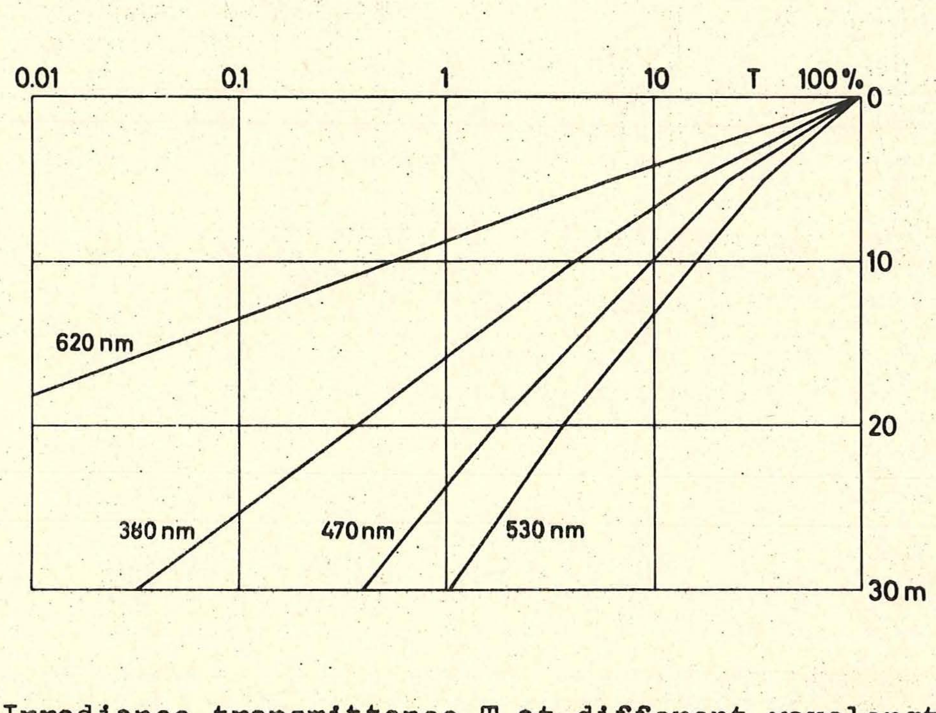


Fig. 19. Irradiance transmittance T at different wavelengths as a function of depth at Station 430.

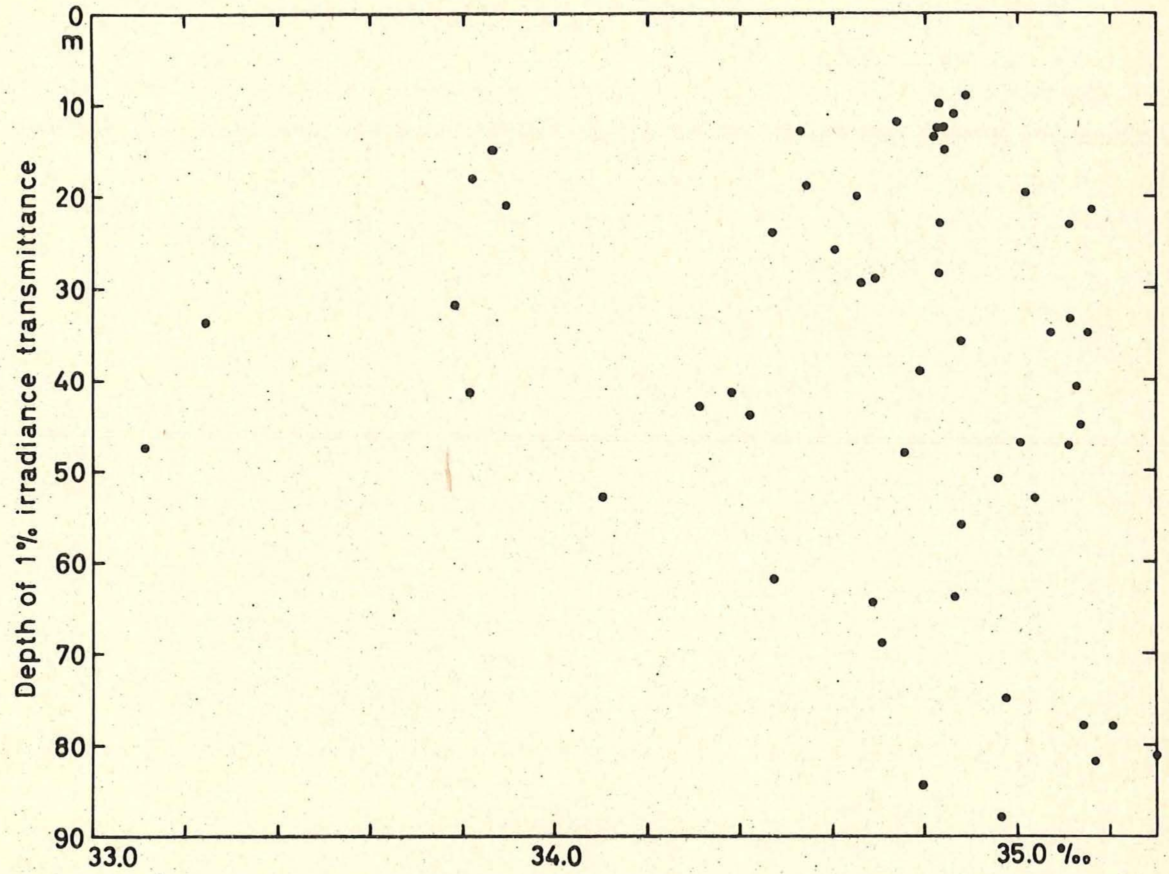


Fig. 20. Depth of 1% irradiance transmittance at 465 nm as a function of the salinity at 10 m depth.

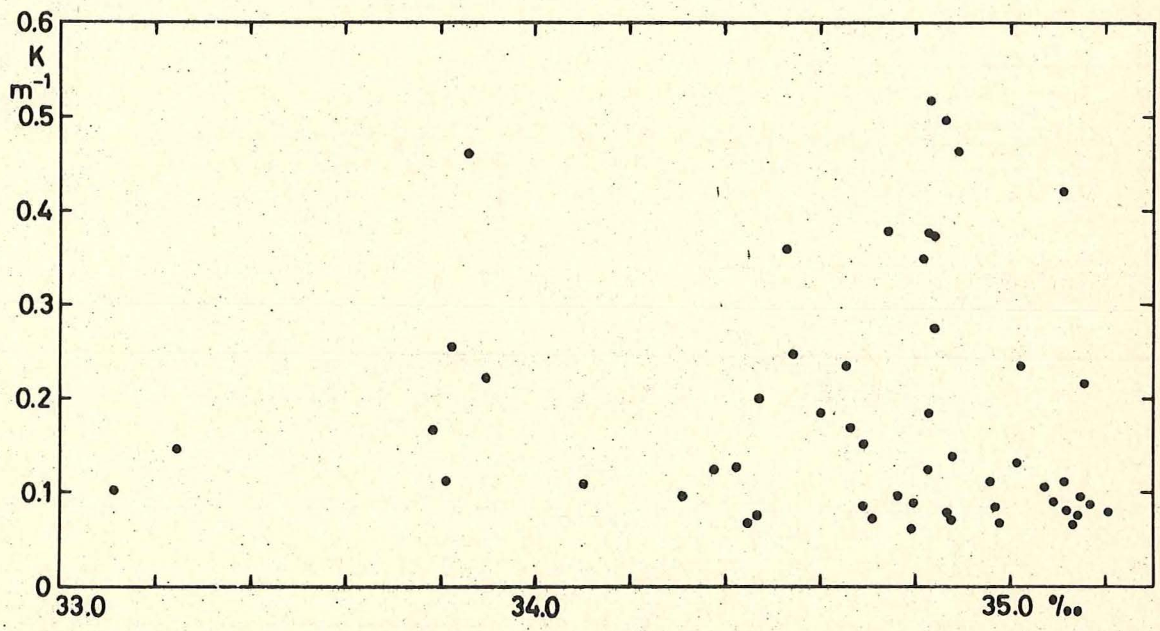


Fig. 21. The mean vertical attenuation coefficient K_{35} in the layer 0-20 m at 465 nm and sun heigh 35^{o} as a function of salinity at 10 m depth.

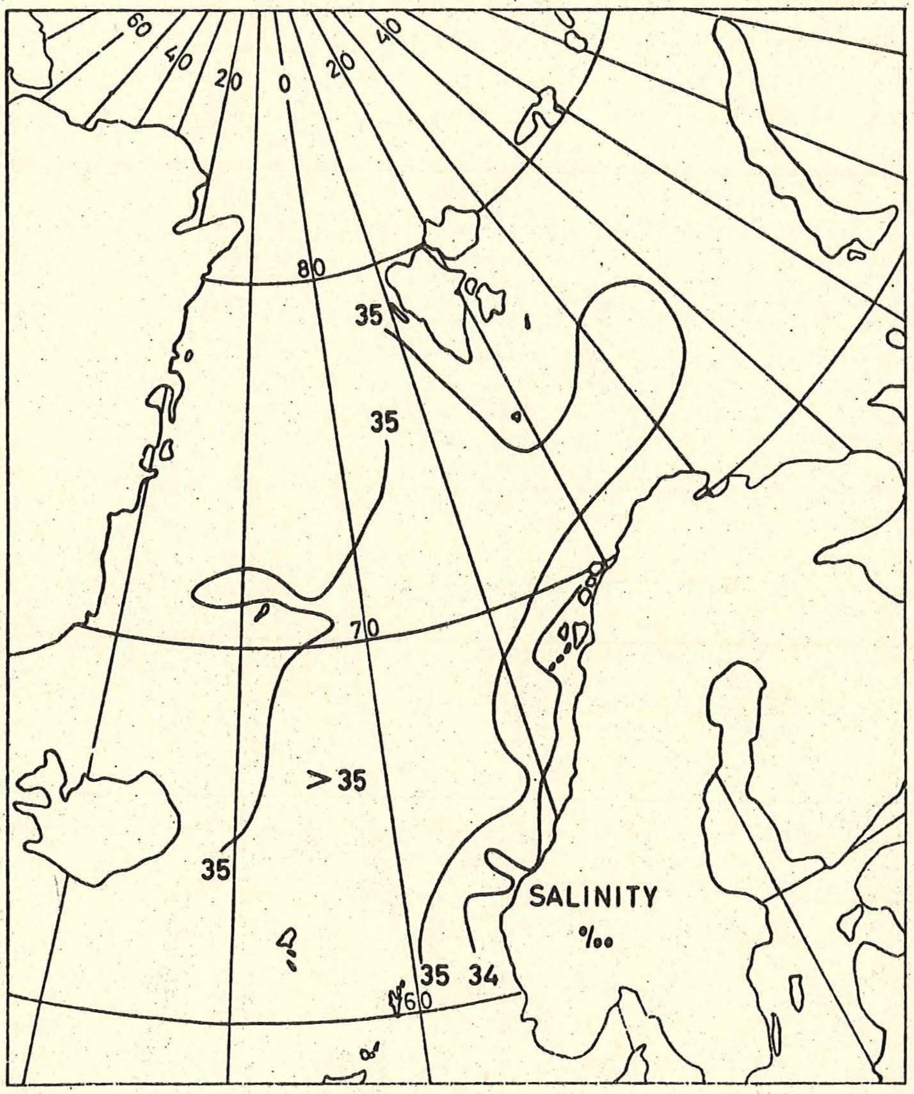


Fig. 22. Horizontal distribution of salinity at 10 m depth.

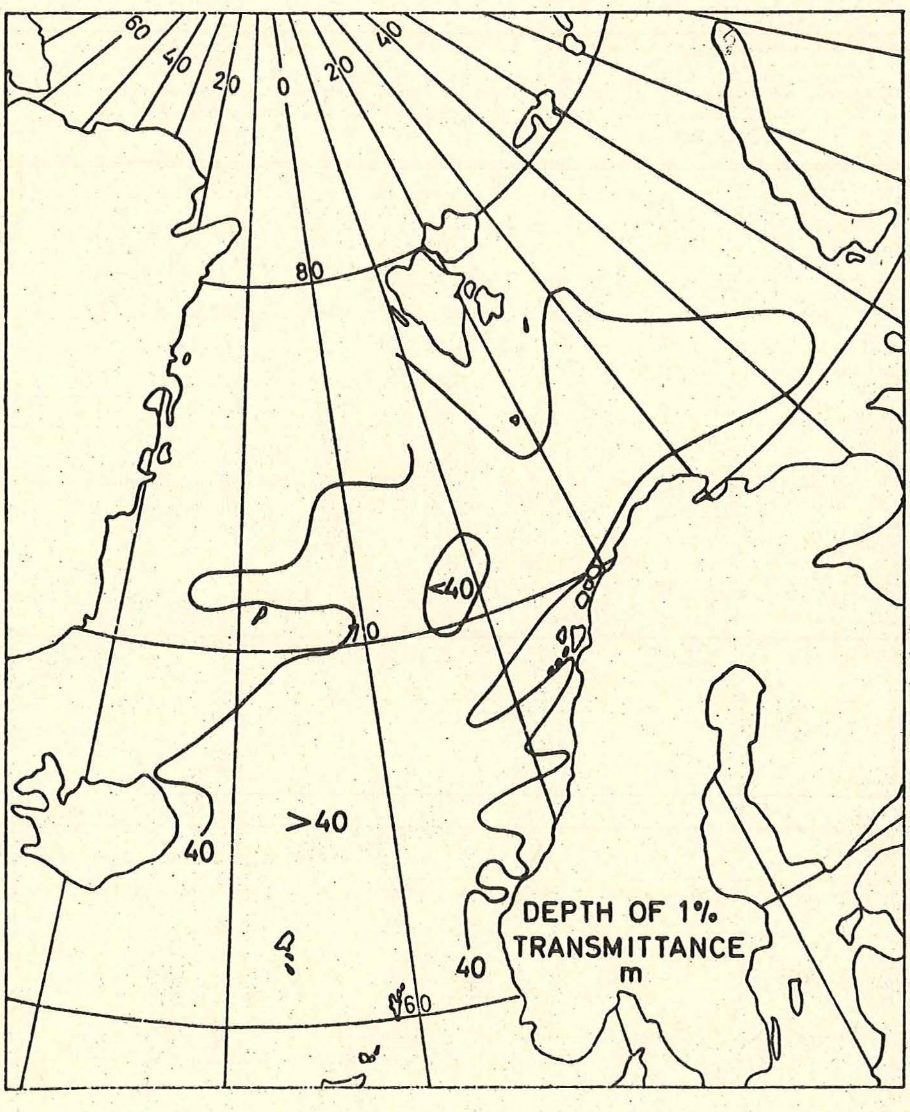


Fig. 23. Horizontal distribution of the depth of 1% irradiance transmittance at 465 nm.

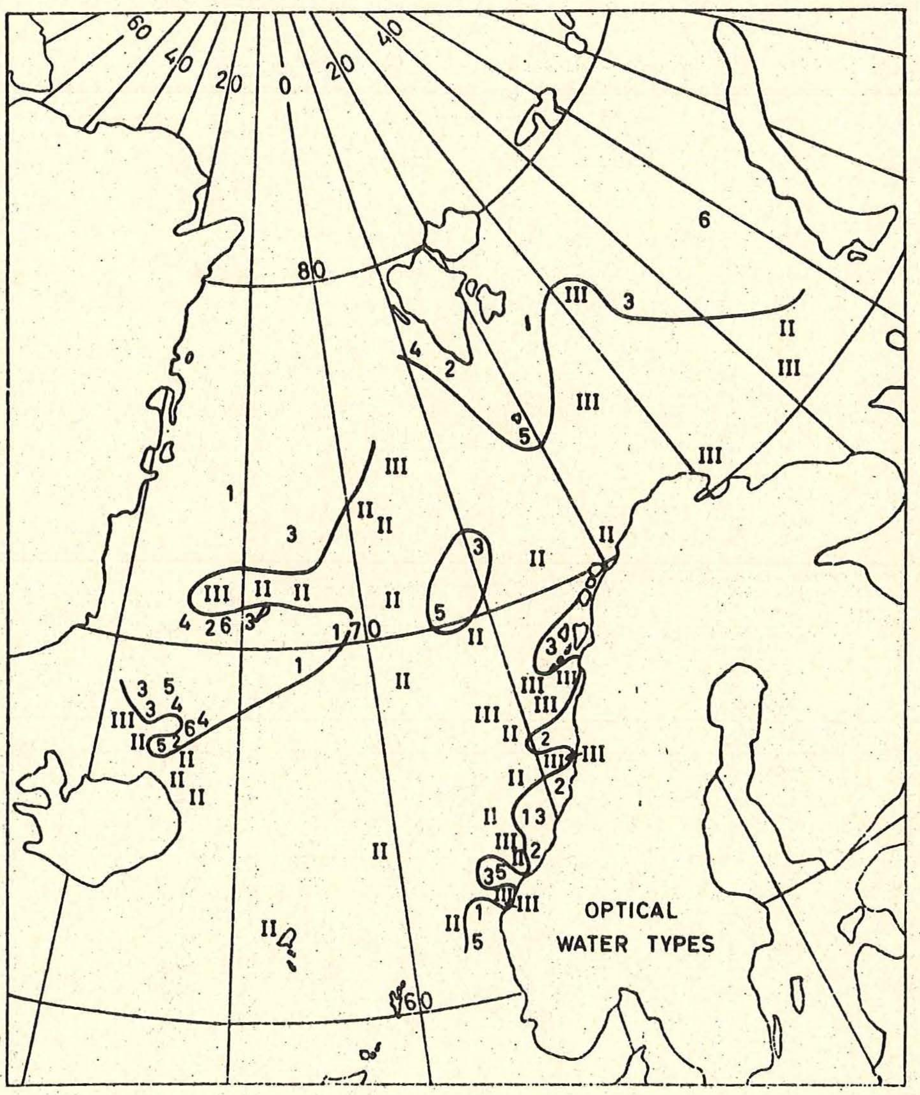


Fig. 25. Horizontal distribution of the optical ocean (I-III) and coastal (1-9) water types, according to JERLOV's classification.