OPTICAL PROPERTIES IN THE GARGANO-MANFREDONIA GULF REGION

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ABSTRACT- In-situ measurements of inherent and apparent optical properties during the two DART cruises 19-20, March and 26-27, August 2006, in addition to laboratory measurements of total suspended matter and chlorophyll concentrations were analysed. Optical properties vary in space and time in the research area due to horizontal and vertical water mass displacement, currents, seasonal changes etc. Irradiance and radiance measurements with PRR800 allowed determination of attenuation downward/upward coefficients for 14 wavelengths. From AC9 measurements absorption and total attenuation coefficients were calculated for 9 wavelengths. Coefficients were compared accross the wavelengths and through vertical distribution at the stations for the two periods of measurements. The investigated waters are characterized by a sharp water color gradient from coastal to the open sea, covering a full range of optical properties. Optical water types determined through qualitative spectrum characterisation and PAR attenuation measurements vary across the spectrum of optical water types. Range of attenuation coefficients in the area dominate over differences between the seasons. High attenuation coefficients indicate that suspended sediments significantly influence optical properties of the region, in addition to high concentrations of dissolved colored substances. Linear relation is observed between absorption and total attenuation coefficients in most of the cases, and correspondence exist between suspended matter concentrations and total attenuation coefficients. Relationships are explored between optical properties and chlorophyll concentrations.

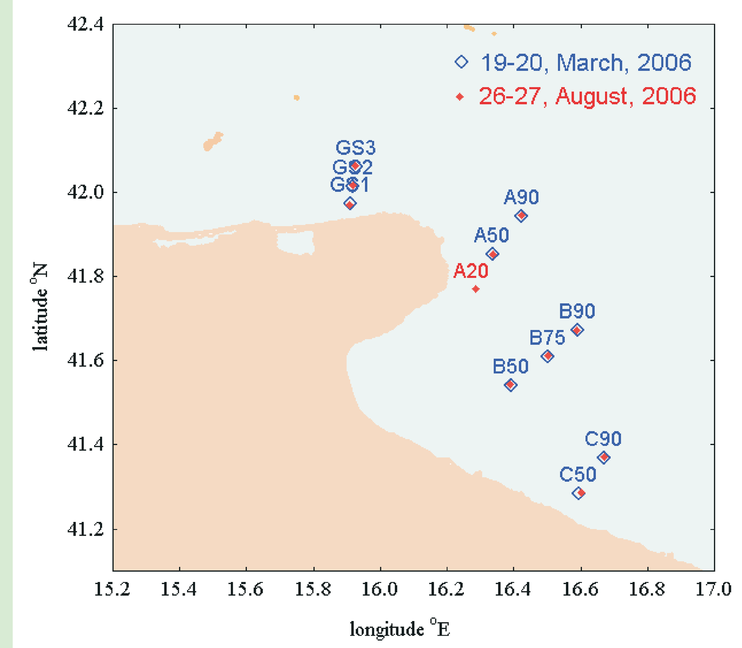

Figure 1. Location of stations during March and August cruises.

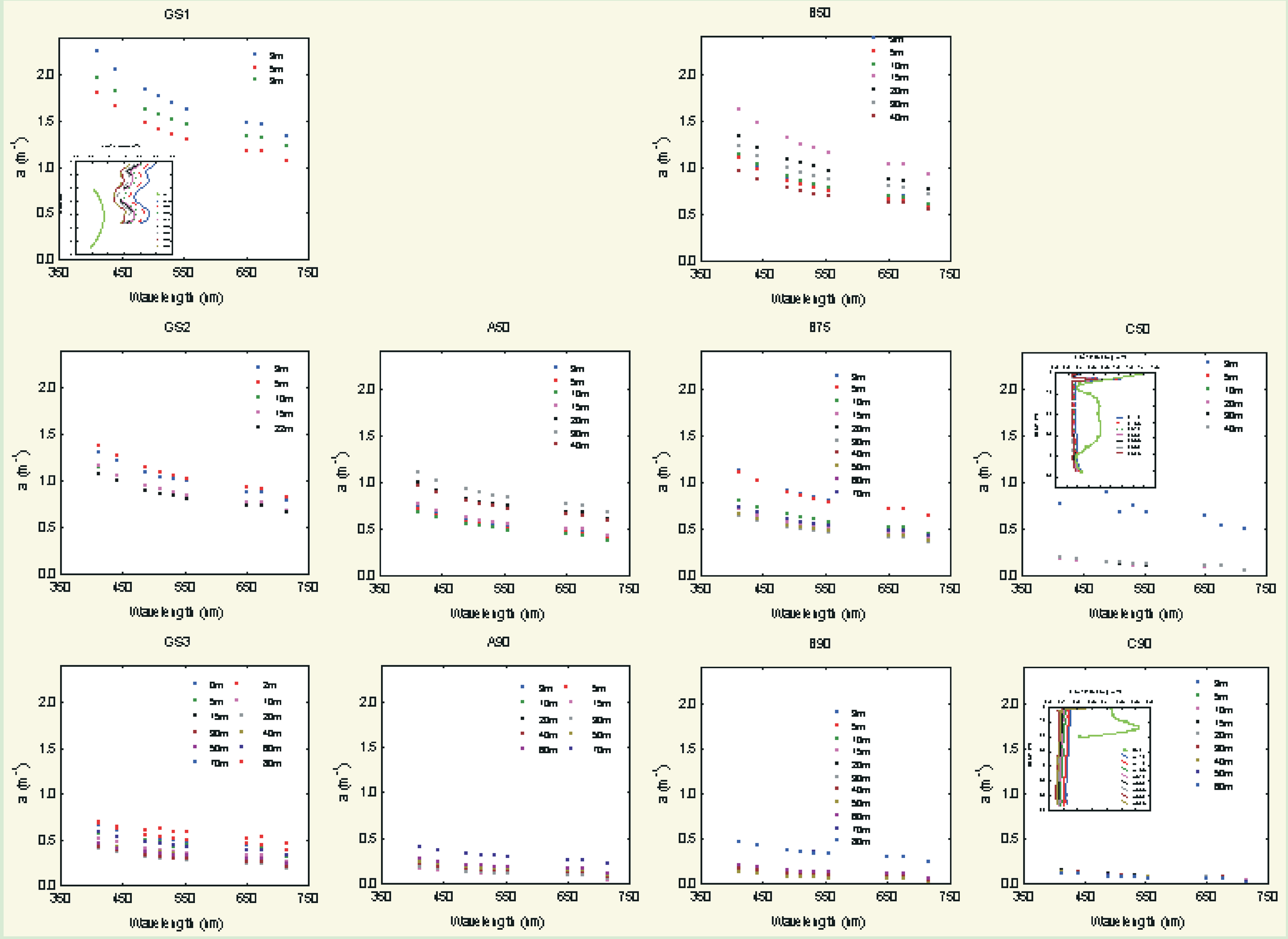
Figure 2. Absorption coefficients relative to pure water at stations in March 2006 with chlorophyll distribution for extreme chlorophyll and absorption coefficient values, measured by ac9 (WetLabs).

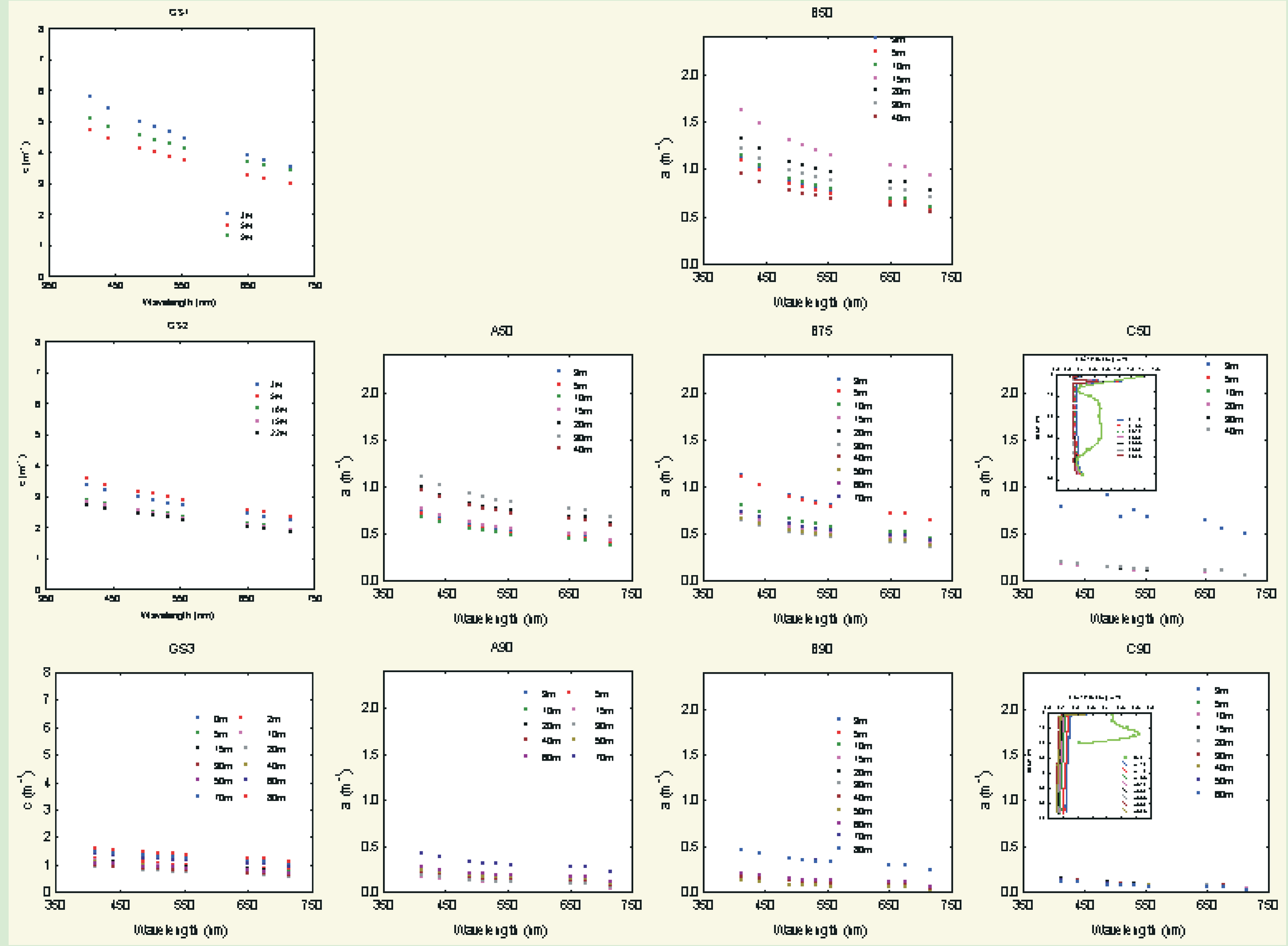
Figure 3. Attenuation coefficients relative to pure water at stations in March 2006, with TSM vertical distribution for extreme TSM and attenuation coefficients values, measured by ac9 (WetLabs).

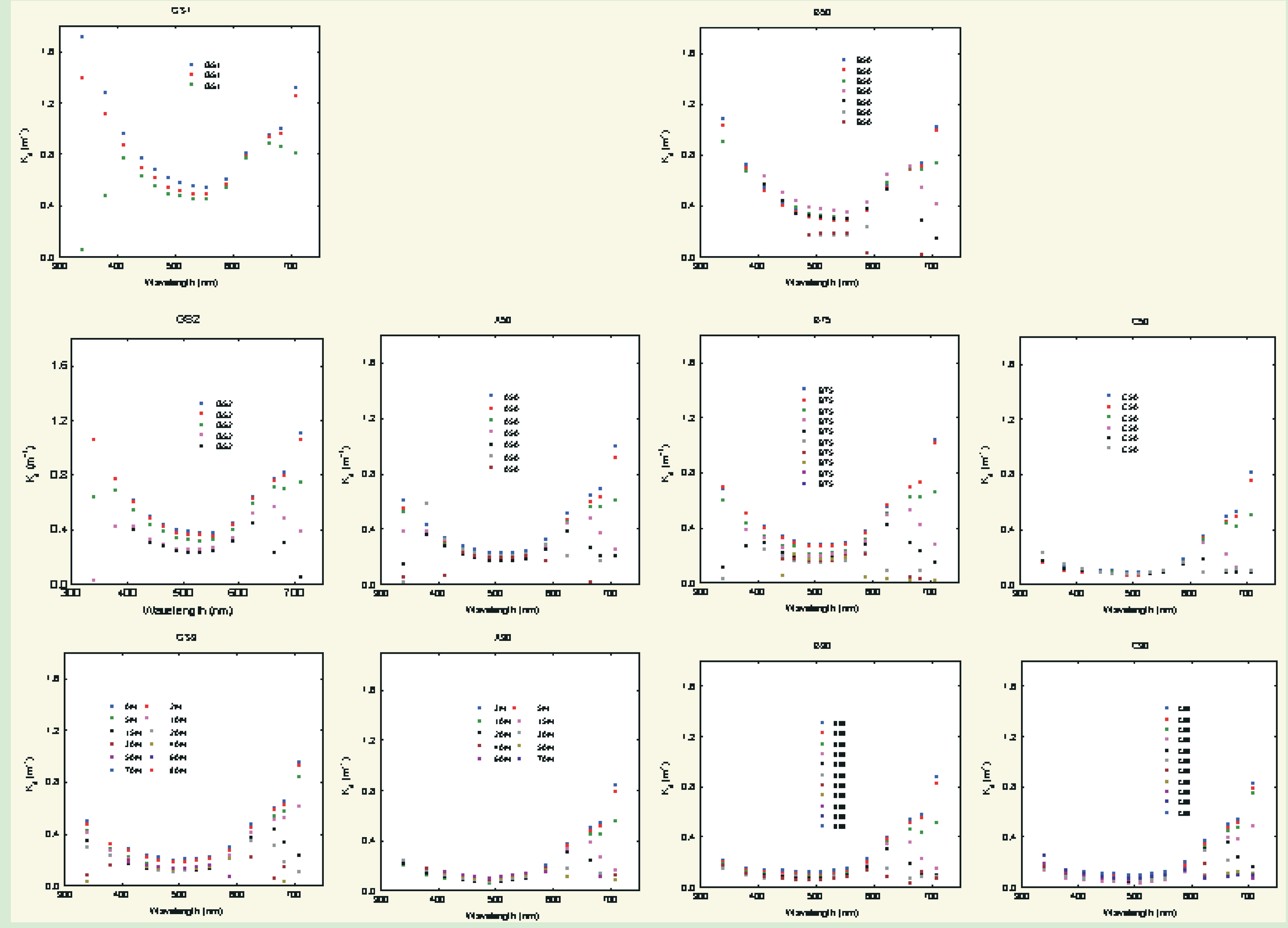
Figure 4. Diffuse attenuation coefficients at stations in March 2006, measured by irradiance/radiance spectral profiler PRR800 (Biospherical Inc.).

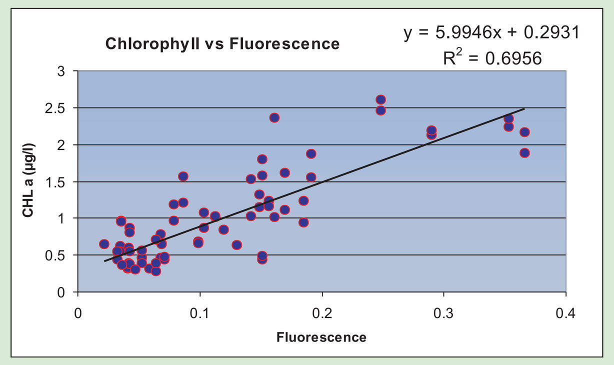

Figure 5. Comparison between the methods used for chlorophyll measurements during August cruise, for fluorometer callibration.

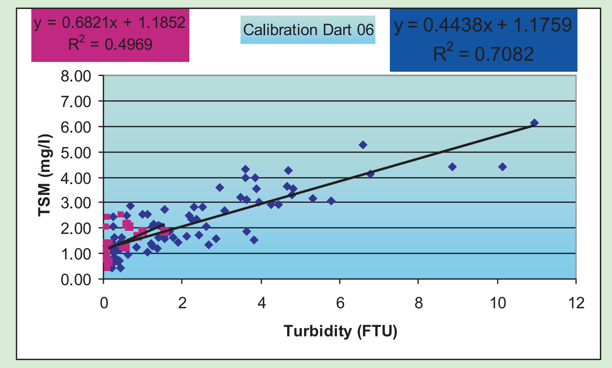

Figure 6. Comparison between the TSM gravimetric measurements to turbidity, during August cruise.

Table 1. Correlation coefficients between CHL-chlorophyll concentrations, TSM-total suspended matter and TURB-turbidity to coefficients for A-absorption, C- attenuation, Kd and Ku diffuse irradiance attenuation for downward and upward irradiance/radiance and to R-reflectance for March and Autumn cruise.

Correlations significant at p < .05000						
	MARCH			AUG		
	CHL	TSM	TURB	CHL	TSM	TURB
A412		0.68	0.79	0.47	0.30	0.71
A440		0.68	0.79	0.46	0.28	0.72
A488		0.68	0.80	0.43	0.27	0.73
A510		0.68	0.80			0.62
A532		0.68	0.80			0.62
A555		0.68	0.80			0.62
A650		0.69	0.80	0.37		0.69
A676		0.68	0.80	0.39		0.71
A715		0.68	0.81			0.71
C412		0.57	0.78	0.42	0.26	0.75
C440		0.56	0.79	0.41	0.26	0.76
C488		0.54	0.79	0.41	0.25	0.76
C510		0.55	0.79	0.42	0.26	0.73
C532		0.54	0.79	0.42	0.26	0.73
C555		0.52	0.79	0.41	0.26	0.73
C650		0.50	0.80	0.39		0.74
C676		0.52	0.80	0.39		0.75
C715		0.43	0.80	0.35		0.75
N	35-44	56-81	33-54	14-35	72.00	32-71

Correlations significant at p < .05000						
	MARCH			AUG		
	CHL	TSM	TURB	CHL	TSM	TURB
KPAR		0.67	0.90			0.71
KD340		0.46	0.44	0.58		0.73
KD380		0.64	0.86	0.74	0.34	0.85
KD412		0.72	0.95	0.71	0.33	0.84
KD443		0.70	0.89	0.65	0.32	0.82
KD465		0.70	0.92	0.61	0.30	0.80
KD490		0.70	0.91	0.56	0.29	0.77
KD510		0.70	0.91	0.47	0.26	0.73
KD532		0.70	0.92	0.40		0.69
KD555		0.71	0.92			0.65
KD589		0.61	0.74			0.57
KD625	0.36	0.48	0.64	-0.54		
KD665	0.34	0.48	0.56	-0.48		
KD683	0.32	0.43	0.44	-0.46		0.30
KD710		0.34	0.39	-0.44		0.34
KU340		0.57	0.83	0.91		
KU380		0.52	0.66	0.83		0.76
KU412		0.66	0.77	0.60		0.79
KU443		0.71	0.88	0.49		0.55
KU465		0.69	0.90			0.52
KU490		0.70	0.93			0.68
KU510		0.70	0.93			0.62
KU532		0.70	0.93			0.42
KU555		0.69	0.93			0.39
KU589		0.64	0.80			0.45
KU625		0.67	0.91			0.41
KU665		0.64	0.88			0.52
KU683		0.57	0.71			0.54
KU710		0.52	0.85			0.42
R340	0.34			-0.58		
R380				0.50		0.38
R412						0.42
R443		0.47	0.60			0.56
R465		0.24	0.16	0.55		0.61
R490		0.53	0.70	0.62		0.67
R510		0.55	0.74	0.73		0.70
R532		0.60	0.78	0.76		0.73
R555		0.63	0.80	0.81		0.70
R589		0.43	0.58	0.82		
R625	-0.32			0.62		
R665	-0.31			0.60		
R683				0.60		
R710			0.36	0.65		
N	35-44	56-81	33-54	14-35	72.00	32-71

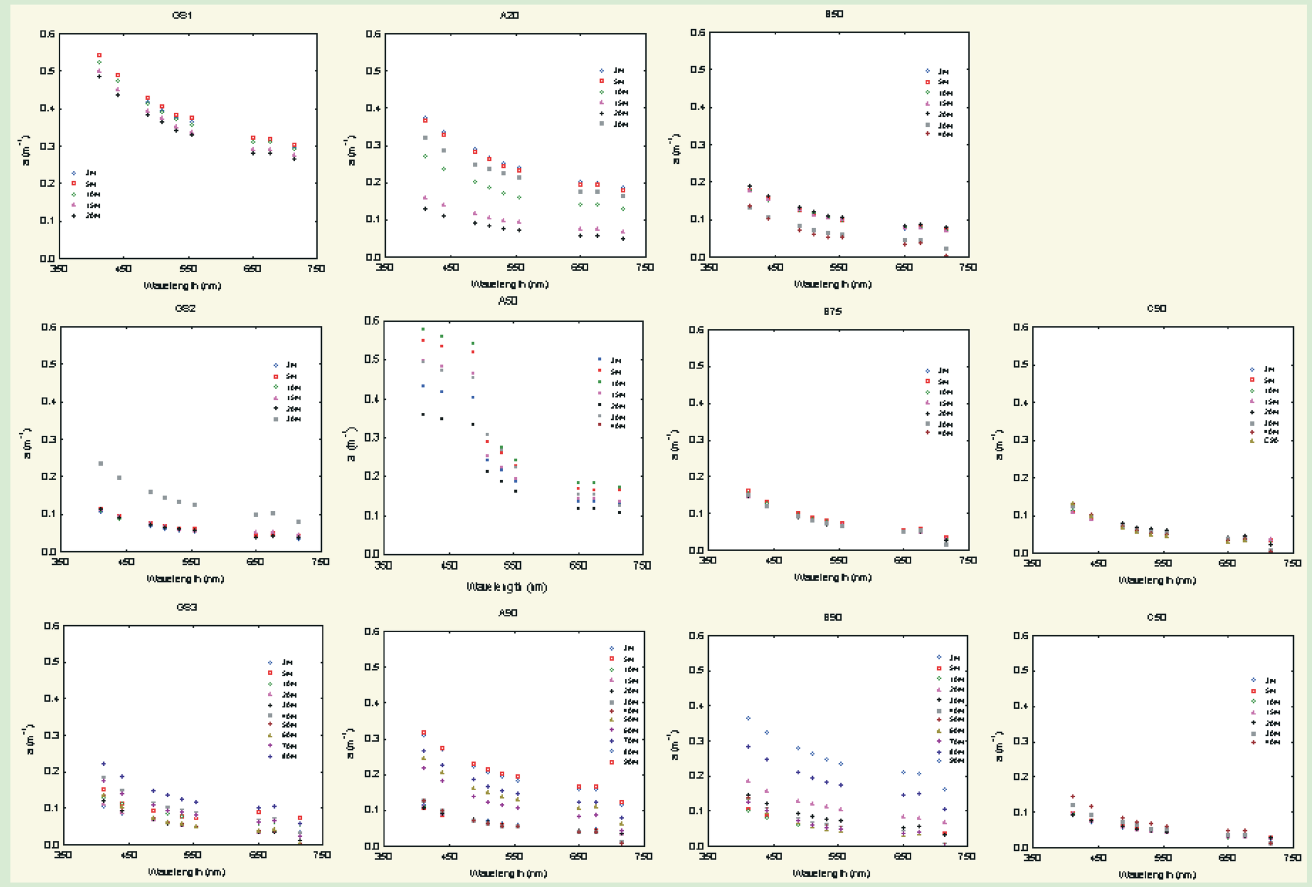
Figure 7. Absorption coefficients relative to pure water at stations in August 2006, measured by ac9 (WetLabs).

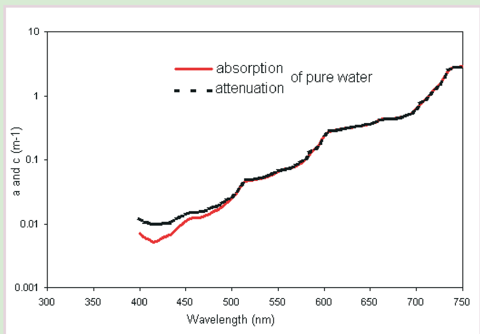

Figure 10. For comparison of "a" and "Kd" the absorption coefficients of pure water from the figure should be added to a.

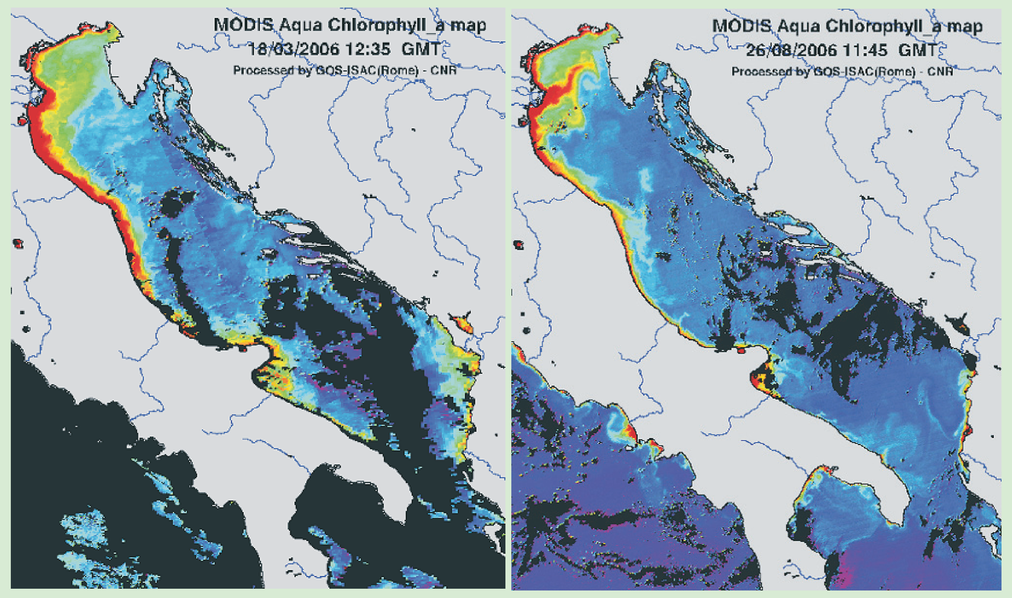

Figure 8. Closest relatively clear chlorophyll a maps to the dates of DART6 cruises from MODIS-Aqua, by GOS-ISAC Rome, CNR (ADRICOSM).

Spatial pattern of optical properties in the studied region of Manfredonia Gulf and Gargano peninsula is relatively well known via the satellite color data. General pattern of pigments distribution is a constant coastal front of turbid waters in the region, whose extension and variability depend on the Po river influence, like in the rest of north and west Adriatic. However, during the DART6 cruises for the first time the in-situ measurements of inherent and apparent optical properties were performed. The present study reveals space and time variability of inherent and apparent optical properties together with accompanying physical and biological data.

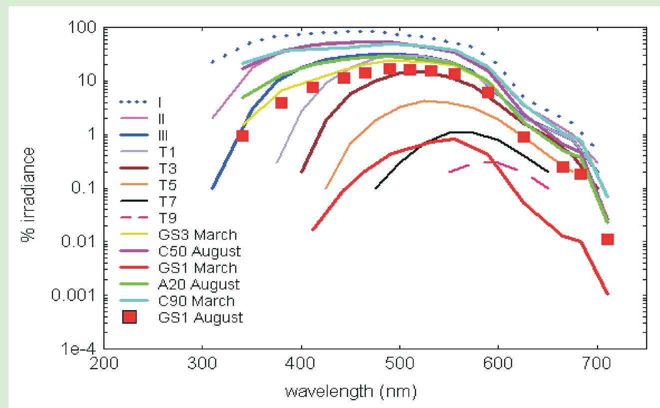

Figure 9. % spectral irradiance at 10m depth, relative to the surface, for some stations of measurements together with referent Jerlov types. The optical water types can be determined comparing % spectral irradiance attenuation to the values according to Jerlov (1978). The investigated region covers a wide range of optical types, from the open sea type II, to very turbid coastal water types.

Spectral curves for absorption coefficients (referred to pure water) show monotonous decrease of coefficients towards longer wavelengths. Surface waters at few stations show discrepancies from a typical shape. The attenuation coefficients also decrease with wavelengths. The difference between the two is related to scattering. The a and c coefficients were higher in March than in August at all stations: The ratios between coefficients in August and in March range from two times higher values for the stations C50 and C90, over five times larger for GS3 to ten times larger for the stations B50 and B75. Highest a and c values in March were measured at the stations GS1 and GS2, close to Gargano. These stations are presumably exposed more to coastal influences than other. Optically active substances are coming mainly from the Po River, when the southward flow is slowed and turned aside by Gargano coastal boundary. In August the highest values were measured at stations GS1and A20. The lowest coefficients in both months were found at the station C90, located further off the coast, beyond the reach of the coastal turbid flow. The Kd coefficients (and similarly the Ku) are also higher in March than in August. The spectral curves of Kd indicate high absorption at lower wavelengths caused by dissolved or particulate colored substances (including chlorophyll) while strong absorption at longer wavelengths is mainly due to the water itself. Higher Kd at shorter wavelengths in March indicates higher absorption in that period, probably as a cause of more dissolved organic colored substances. Higher Kd in March than in August at the wavelengths of minimum attenuation confirms generally higher level of optically active substances in March. The clearest wavelength at the outer stations was 490nm in both cruises. The wavelength of minimum of attenuation at the most turbid stations is shifted towards longer wavelengths, at GS31and B50 in March it was at 555nm, while at the same stations in August it was at 530nm.

Chlorophyll and total suspended matter concentrations were generally higher in March than in August. Very few significant correlation coefficients with chlorophyll were obtained for March, like few positive correlations for higher wavelengths of Kd and some negative correlations with reflectance. The correlation coefficient between chlorophyll and coefficients of absorption, attenuation and diffuse irradiance attenuation were statistically significant in August for most of the wavelengths and for some higher wavelengths of Kd correlations with chlorophyll were negative. TSM is in high significant positive correlation with most attenuation and absorption coefficients in March but with fewer in August.
The correlation coefficients among inherent and apparent properties is very high for any combination of the two wavelength and coefficients (r>0.5 for over 600 data).
Absorption accounts for considerable portion of the overall attenuation but with variable proportions in space and time, and since TSM can partly be organic, it is not simple to compare the conditions in the two seasons. Seasonal oceanographic conditions caused by local mixing could also have contributed to enhanced absorption and attenuation

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REA NATO DART6, Conference, Lerici, September, 2007