PHYTOPLANKTON PIGMENT DISTRIBUTION IN THE CILICIAN BASIN (NORTHEASTERN MEDITERRANEAN)

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The Graduate School of Marine Sciences

by

Nebil YÜCEL

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NEBİL YÜCEL

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FOR
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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

PHYTOPLANKTON PIGMENT DISTRIBUTION IN THE CILICIAN BASIN (NORTHEASTERN MEDITERRANEAN)

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Within the context of this thesis, it was aimed to understand spatial and temporal changes in the chlorophyll and pigment composition of the surface phytoplankton in the Cilician Basin. For this purpose, basin-wide surveys (total 8 cruises) have been conducted on board by R/V Bilim-2 of the IMS-METU to collect supplementary biological, chemical and physical data between November 2005 and September 2007. Chlorophyll and phytoplankton pigments were analyzed using a High Performance Liquid Chromatography (HPLC), a spectrofluorometer and an in-situ fluorometer. In-situ surface chlorophyll measurements were performed real-time along the cruise tracks using a field fluorometer (Turner Designs). Evaluation of the possible changes in chlorophyll content and pigment composition of the phytoplankton in the basin in time and space was made via synthesis of the other concurrent ambient biological, physical and chemical parameters being collected during the surveys.

Surface chlorophyll concentration ranged between 0.01 and 0.76 μg/L throughout the study period in the basin. Maximum chlorophyll was detected near Seyhan River in April 2007. In general, shallower shelf waters held much higher concentrations compared to areas beyond the shelf break (depths over 200m). Elevated concentrations were characteristics of the river drainage areas, inner bays where exchange with offshore waters is limited and upwelling regions. Insufficient amount of nutrients in the upper layers, chlorophyll concentrations ranged between low levels of 0.01- 0.35 μg/L during summer. Spatial changes in chlorophyll were observed to be directly linked to changes in physical (temperature, salinity, currents, and upwelling) and chemical (nutrients) properties of the surface waters.

Major rivers (Göksu, Ceyhan, Seyhan, Asi and Lamas) with increased freshwater loads during spring display a major role in determining the productivity of the basins' shelf waters. Minor increases in chlorophyll content of the offshore waters are observed due to small scale upwelling events. In general, phosphate was observed to be the limiting nutrient for the shelf and nitrogen for the offshore. All of the seven marker pigments have been observed at offshore station #33 in March and April 2007 and at station 24 located in mid-İskenderun in November 2005. Prymnesiophytes (coccolithophorid *Emiliana huxleyi)* are the most dominant group followed by diatoms and cyanobacteria in the basin. Prochlorophytes dominated the offshore waters in November 2005. Chlorophytes have been found dominant only twice throughout the study period in front of Seyhan river in April and September 2007.

Keywords: Chlorophyll, marker pigments, factors, Cilician Basin, northeastern Mediterranean,

ÖZ

KİLİKYA BASENİ FİTOPLANKTON PİGMENT DAĞILIMI
(KUZEYDOĞU AKDENİZ)

YÜCEL, Nebil
Yüksek Lisans, Deniz Bilimleri Enstitüsü
Tez Yöneticisi: Doç. Dr. Zahit UYSAL

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Bu tez kapsamında Kilikya baseni yüzey fitoplanktonu klorofil ve pigment kompozisyonundaki yer ve zamana bağlı değişimler irdelenmeye çalışılmıştır. Bu nedenle, Kasım 2005 ve Eylül 2007 tarihleri arasında destekleyici biyolojik, kimyasal ve fiziksel verileri toplamak üzere Orta Doğu Teknik Üniversitesi, Deniz Bilimleri Enstitüsü'ne ait Bilim-2 Araştırma gemisi ile tüm baseni kapsayan 8 adet sefer gerçekleştirilmiştir. Klorofil ve fitoplankton pigmentleri yüksek performanslı sıvı kromotografisi (HPLC), spektrofluorometre ve yerinde (in-situ) fluorometre kullanılarak analiz edilmişlerdir. Sefer hatları boyunca Turner marka saha fluorometresi yardımı ile yerinde (in-situ) gerçek zamanlı yüzey klorofil değerleri ölçülmüştür. Yer ve zamana bağlı olarak fitoplankton pigment ve klorofil içeriklerindeki olası değişimler, eş zamanlı toplanan ortam biyolojik, fiziksel ve kimyasal parametreleri ile birlikte sentezi yapılarak değerlendirilmiştir.

Çalışma süresince yüzey sularında klorofil derişimi 0.01 and 0.76 µg/L değerleri arasında ölçülmüştür. En yüksek klorofil derişimi Nisan 2007'de Seyhan nehri önünde ölçülmüştür. Genelde kıta sahanlığı ötesi derin sulara (200 metreden derin) oranla sığ kıta sahanlığı suları daha yüksek oranlarda klorofil içermektedir. Yüksek değerler nehir boşaltım alanlarına, açık sularla etkileşimin en aza indirgendiği iç körfezlere ve upvelling alanlarına özgüdür. Üs tabakalarda yeterli ve gerekli oranda besin tuzlarının bulunmadığı yaz dönemlerinde, klorofil derişimleri

0.01- 0.35 μg/L arasında düşük düzeylerdedir. Klorofil içeriklerindeki yerel değişimler, yüzey sularındaki fiziksel (sıcaklık, tuzluluk, akıntılar, upvelling) ve kimyasal (besin elementleri) değişimlerle ilintilidir.

Bahar aylarında yüksek oranda tatlı su girdisi sağlayan büyük nehirler (Göksu, Ceyhan, Seyhan, Asi ve Lamas) basen kıta sahanlığı sularının verimliliğinde önemli bir rol oynamaktadır. Küçük ölçekli upvelling olayları sonucu açık sularda belirgin bir klorofil artışı gözlenmiştir. Genelde kıyı suları için fosfat, açık sular için azot sınırlayıcı besin elementidir. İncelenen toplam yedi adet belirleyici pigmentin tamamı Mart ve Nisan 2007'de 33 no'lu açık istasyonda ve Kasım 2005'te 24 no'lu İskenderun Körfezi'nin ortasındaki istasyonda saptanmıştır. Genelde en baskın Prymnesiyofit'leri (kokkolithoforid- *Emiliana huxleyi*) sırası ile diyatomlar ve siyanobakteriler izlemiştir. Proklorofitler Kasım 2005'te açık sularda baskın olarak gözlenmiştir. Klorofitler çalışma süresince sadece iki kez Nisan ve Eylül 2007 dönemlerinde baskın olarak temsil edilmişlerdir.

Anahtar Kelimeler: Klorofil, iz pigmentler, etkenler, Kilikya baseni, kuzeydoğu Akdeniz.

To my family

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ABBREVIATIONS

ALLO: alloxanthin

B-CAR: β-carotene

BUT: 19-butanoyloxyfucoxanthin

CHL-a: Chlorophyll-a

Chl: Chlorophyll

DCM: Deep Chlorophyll Maximum

DIAD: diadinoxanthin

DIV-Chl-a: divinyl chlorophyll-a

FUC: fucoxanthin

HEX: 19-hexanoyloxyfucoxanthin

HPLC: High Performance Liquid Chromatography

Kd: attenuation coefficient

LUT: lutein

PER: peridinin

SF: Spectrofluorometry

ZEA: zeaxanthin

1. INTRODUCTION

Primary production is the formation of organic compounds from carbon dioxide via photosynthesis or chemosynthesis. All life relies on this event. Primary producers are known as autotrophs and they form the base of the food chain. Almost all primary production is performed by phytoplankters within the euphotic layer of the world oceans.

During the photosynthesis, solar energy is absorbed and converted via pigments from the form of electromagnetic radiation to stored chemical energy by the phytoplankton cells (URL 1, 2007). This chemical energy is stored in the organic compounds. Phytoplankton can also influence the surface temperature of the ocean. While absorbing solar energy, part of this energy is transformed into heat. During a bloom period, sea surface temperature may show a rise (Ross, 1995).

Phytoplankton has different pigments which are chemical compounds that reflect or absorb certain wavelengths of visible light. Pigments are useful for plants and other autotrophs - organisms which make own food by using photosynthesis. Plants capture the energy of sunlight for the photosynthesis by using pigments. Each pigment reacts with only narrow range of the spectrum (Figure 1.1, URL 2, 2007).

There are three basic classes of pigments; carotenoids, phycobilins and chlorophylls. Carotenoids are usually red, orange or yellow pigments (i.e. carotene which gives carrots their color). These include two small six-carbon rings connected by a “chain” of carbon atoms. So, they don’t dissolve in the water. Carotenoids can not transfer sunlight energy directly to the photosynthetic pathway, but, they pass their absorbed energy to chlorophyll. So, they are called accessory pigments. Fucoxanthin is the brown pigment which is present in brown algae and diatoms (URL1).

Phycobilins are water soluble pigments. These pigments are found in the cytoplasm. They exist only in Cyanobacteria and Rhodophyta. Phycocyanin gives the Cyanobacteria their name which is the bluish pigment. Phycoerythrin which is the reddish pigment gives the red algae their name (URL1).

Chlorophylls are greenish chlorine pigments containing a magnesium ion at the center. It is present in most plants, algae, and cyanobacteria. Its name is derived from Greek: chloros = green and phyllon = leaf. Chlorophyll absorbs light most strongly in the blue and red but poorly in the green portions of the electromagnetic spectrum; hence the green color of chlorophyll-containing tissues like plant leaves (URL 3, 2007). Chlorophyll is a stable ring-shaped molecule around which electrons migrate freely. Because the electrons move freely, the ring has the potential to gain or lose electrons easily, and thus the potential to provide energized electrons to other molecules. The chlorine ring can have several different side chains, usually including a long phytol chain. This is the fundamental process by which chlorophyll "captures" the energy of sunlight. There are a few different forms that occur naturally, but the most widely distributed form is chlorophyll-a (URL1).

Chlorophyll molecule makes photosynthesis possible by passing its energized electrons onto molecules which will manufacture sugars. All plants, algae, and cyanobacteria which photosynthesize contain chlorophyll "a". A second kind of chlorophyll is chlorophyll "b", which occurs only in "green algae" and in the plants. A third form of chlorophyll which is common is called chlorophyll "c", and is found only in the photosynthetic members of the Chromista as well as the dinoflagellates. The differences between the chlorophylls of these major groups were one of the first clues that they were not as closely related as previously thought (Freeman et al., 2000, URL 4, 2007).

Chlorophyll, and its function of converting light energy to chemical energy via the process of photosynthesis, possibly began evolving in the ocean about 2 billion years ago (Callot 1991). More than 1 billion tons of chlorophyll may be produced and destroyed each year in the ocean because of the short generation times of phytoplankton (Hendry et al., 1987).

Phytoplankton exist at a certain time and a certain place. It is termed as standing stock or standing crop. This depends on biological, physical and chemical situations. Measurement of the chlorophyll-a gives information about the plant biomass which can be related to the level of primary productivity (Ryther and Yentsch, 1957, c.f.

McAllister, 1963). In other words, chlorophyll-a is a measure of the photosynthetic capacity of the standing stock of phytoplankton and can be related to the productivity (Göçmen, 1988; Jeffrey et. al., 1997; Watson et al., 1991). Its value as a biomass indicator of phytoplankton has been recognized for over 40 years (Jeffrey et. al., 1997).

Measurements of chlorophyll distribution in the oceans have revealed areas of contrasting fertility ranging from the oligotrophic ocean gyres with low concentrations of chlorophyll in surface waters (<0.05 µg/l) and their characteristic maxima (0.1-0.5 µg/l) at depths of 60 -150 m to chlorophyll-rich waters found in upwelling areas and along continental shelf fronts, coastal seas and estuaries (1-10 µg/l). Chlorophyll measurements have been used to follow diurnal, seasonal and long term changes in biological productivity in contrasting oceanic regimes (Watson et al. 1991).

“The general structure of chlorophyll-a was elucidated by Hans Fischer in 1940 (c.f. Woodward, 1990), and by Woodward et al., 1960, when most of the stereochemistry of chlorophyll-a was known. Robert Burns Woodward published a total synthesis of the molecule as then known. In 1967, the last remaining stereo chemical elucidation was completed by Ian Fleming, and in 1990 Woodward and co-authors published an updated synthesis” (Woodward et al., 1990, page 7607).

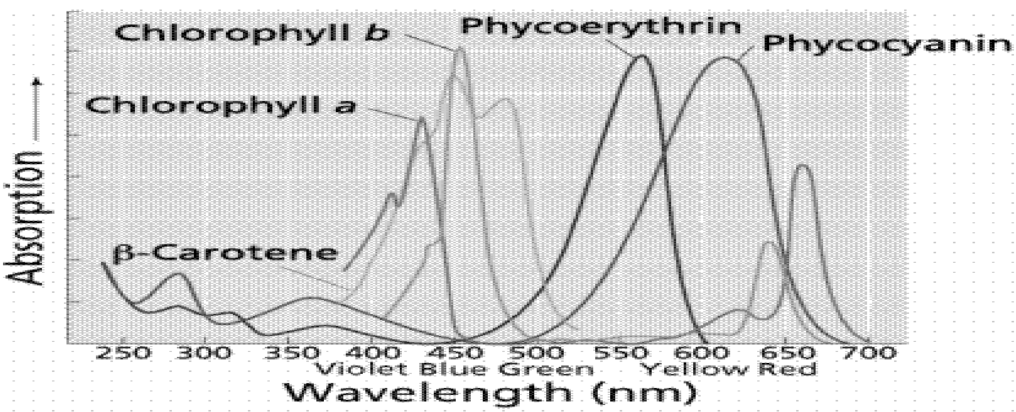


Figure 1.1. Absorption spectrum of several plant pigments (URL 1, 2007).

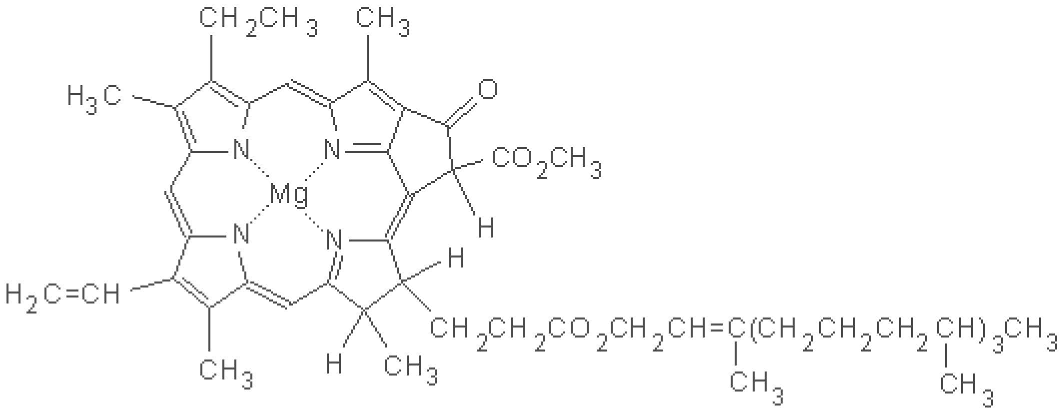


Figure 1.2. Structure of chlorophyll-a molecule (URL 2, 2007).

The key developments in pigment oceanography listed in the following rectangle were summarized from (Jeffrey et al. 1997):

- chlorophyll could not be used to quantify plant biomass until pure chlorophylls became available. Successfully extracted chlorophyll a and b from higher plants,
- recognition of chlorophyll like a selective biomarker of phytoplankton in the presence of bacteria, detritus and zooplankton,
- crystallization of chlorophyll-c and two major chlorophyll-c components respectively which these allowed accurate spectrophotometric equations for chlorophyll a, b, and c.
- fluorometric determination of chl-a was fifty times more sensitive than that of spectrophotometric methods, and in-vivo fluorescence applications achieved by,
- chlorophylls, carotenoids and their breakdown products were separated and quantified in field samples by using thin-layer chromatography
- development of automated high performance liquid chromatography (HPLC) methods for chlorophylls, carotenoids and breakdown products (1983-1987).
- satellite remote sensing of ocean color which allows global mapping of surface chlorophyll (1980-1983),
- use of epi-fluorescence to detect chlorophyll and biliprotein (1979-1983),
- application of pigment chemotaxonomy to define classes of algae in field samples was started after 1976.

At present several methods are available to measure chlorophyll. Spectrophotometry, fluorometry, high performance liquid chromotography (HPLC) and satellite imagery are those applied most recently. HPLC which is more sensitive compared to the rest has been used intensively in recent years. With this method it is possible to measure chlorophyll-a as well as any other phytoplankton pigment more precisely and determine phytoplankton composition more easily (Stauber and Jeffrey, 1988; Millie et al., 1993; Jeffrey and Vesk, 1997; Wright et al., 1996; Obayashi et al., 2001, Yılmaz, 2006). Each taxon has specific signature or marker pigments. Types of pigments used for a taxonomic purpose are presented by Jeffrey et. al., (1997) in Table 1.1. (Pigment distribution data is taken from recent modern analyses of algal cultures; very few representatives of each class or division have been examined (e.g., <0.5% of diatoms, Stauber and Jeffrey, 1988) (c.f. Jeffrey et. al., 1997).

Satellite images have been used for measuring sea surface chlorophyll concentration and temperature since 1978. The Coastal Zone Color Scanner (CZCS) was launched on the Nimbus-7 satellite from the Vandenburg Air Force Base, Calfornia, and October 24, 1978. The CZCS mission ended in 1986. After 10 years, many satellites were launched with ocean color sensors from different countries. Historical Ocean-Color Sensors are CMODIS (operation period 25/3/02-15/9/02, China), COCTS (15/5/02-1/4/04, China), CZI (15/5/02-1/4/04, China), GLI (12/1/03-24/10/03, Japan), MOS (21/3/96-31/5/04, India), OCTS (3/9/96-29/6/97, Japan), POLDER (16/9/96-29/6/97, Japan), POLDER2 (1/2/03-24/10/03, Japan). Current Ocean-Color Sensors are MERIS (launched date 1/3/02, Europe), MMRS (21/11/00, Argentina), MODIS-Aqua (4/5/02, EOS-PM1), MODIS-Terra (18/12/99, USA), OCM (26/5/99, India), OSMI (20/12/99, Korea), PARASOL (18/12/04, Myriade Series), SeaWIFS (1/8/97, Seastar) (URL 5, 2007).

Algal Division/Class

Pigment	Cyanophyta	Prochlorophyta	Rhodophyta	Cryptophyta	Chlorophyceae	Prasinophyceae	Euglenophyta	Eustigmatophyta	Bacillariophyta	Dinophyta	Prymnesiophyceae	Chrysophyceae	Raphidophyceae
Chlorophylls													
CHL-A	●	4	●	●	●	●	●	●	●	●	●	●	●
CHL-B		4			●	●	●			1			
C2				●					●	●	●	●	●
C3									2		●3	●	
DIV-A		●											
Carotens													
B-CAR	•	•			•	•	•	•	•	•	•	•	•
Xanthophylls													
BUT										1	●3	●	
FUC									●	1	●3	●	●
HEX										1	●3		
DIAD							●		●	●	●	●	●
ALLO				●									
ZEA	●	●	●		•			•					
LUT					●	•							
PER										●			

Table 1.1. Distribution of major and taxonomically significant pigments in algal divisions /classes. Code ●-Major pigment (>10%); •-Minor pigment (1-10%); •-Trace pigment (<1%) of the total chlorophylls or carotenoids (Jeffrey et al. 1997).

1) Several dinoflagellates have no trace peridinin but have pigments characteristic of their endosymbionts, e.g. chrysophyte (chlorophylls *c*1+*c*2 and fucoxanthin; *Peridinium foliaceum* and *P. Balticum*, Jeffrey et al. 1975); prymnesiophytes (fucoxanthin derivatives, *Gymnodinium galatheanum, Gyrodinium aureolum, Ptychodiscys brevis*, Bjǿrnland and Liaaen-Jensen, 1989), or green algae (chlorophyll b, *Lepidodinium viride*, Watanabe et.al., 1987, 1990; *Gymnodinium* spp., Sournia et. al., 1992).

2) 12% of diatoms tested (71 strains) had chlorophyll *c*3 instead of *c*1 (Stauber and Jeffrey, 1988).

3) Four pigments types were found in a survey of 50 prymnesiophyte strains. These were separated on the presence/absence of chlorophylls *c*1, *c*2 and/or *c*3 and fucoxanthin, 19'-butanoyloxyanthin. (Jeffrey and Wright, 1994).

4) The symbiotic *Prochloron* and the fresh water *Prochlorothrix* contain chlorophylls a and b (Jeffrey et al. 1997).

Among the factors that limit photosynthesis in the marine environment are light, temperature, nutrients and other factors. During the photosynthesis, two kinds of processes take place; photochemical (light reactions) and enzymatic processes (dark reactions). Light is required for photochemical processes (Steemann-Nielsen, 1975, c.f. Jokiel and York, 1984).

If the other factors are set constant, the rate of photosynthesis (P) can be studied as a function of light intensity (I). A typical P-I curve is shown in Fig.1.3.

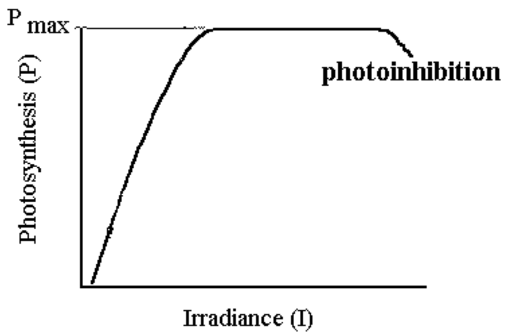


Figure 1.3. Typical P-I curve (URL6).

Initially, the slope of the P-I curve is positive and the production rate increase linearly with light intensity. If micro-organisms are exposed to a strong light above the point at which they are light saturated the P versus I curve may show a depression in photosynthetic rate. This situation is called photo inhibition. Its explanation is the damage caused by surplus light energy on photosynthetic pigments and enzymes (Steemann-Nielsen, 1975 c.f. Jokiel and York, 1984).

Temperature affects enzymatic processes in photosynthesis. Enzymes work most effective within narrow ranges of temperature. Deviations cause the enzyme to change shape (denaturation) and to become less effective. According to phytoplankton species, working temperature of the enzyme is changeable. (Steemann-Nielsen, 1975 c.f. Jokiel and York, 1984; Valiela, 1995).

Phytoplankton needs inorganic elements which are termed micro (Fe, Mn, Cu, Zn, B, Na, Mo, Cl, V and Co) and macro nutrients (C, H, O, N, Si, P, Mg, K and Ca) for growth (Parsons and Takahashi, 1975). Among these nitrogen and phosphorus are of major importance; their concentrations are generally considered first in determining possible limitations in primary production. Macro nutrients are required more than micro nutrients. But, different studies showed that micro nutrient are more important than macro nutrients in limiting photosynthesis (Valiela, 1995; Martin et al., 1991 c.f. Kirk, 1994, Parsons and Takahashi, 1975).

Finally, grazing, amount of carbon dioxide, upwelling, downwelling, diseases (algal parasites, fungi etc.); pollution (petroleum and chlorinated hydrocarbons, heavy metals, radioactive isotopes, and various other agricultural and industrial chemicals) may affect primary productivity (Waldichuk, 1977; Sparks, 2003).

Nowadays, issues related to global climate change and its relation to fertility of the oceans became prime concern of the ecologists. Indeed, phytoplankton can themselves influence global chemical budgets and climate change by a number of mechanisms;

- the utilization of carbon dioxide through photosynthesis thus affecting the global carbon dioxide budget (Williamson and Gribbin, 1991)
- contribution to seasonal warming of the surface layers of the ocean (Sathyendranath et al. 1991a) by absorbing and scattering light.
- by production of quantities of volatile compounds (e.g., dimethyl sulphide) which escape into the atmosphere and act as cloud-seeding nuclei, particularly in the north Atlantic (Malin et al. 1992).

1.1. The physical oceanography of the Cilician Basin

The Mediterranean Sea is almost completely rounded by land: on the south by Africa, on the north by Europe and on the east by Asia. It occupies approximately an area of 2.5 million km² and connects with the Atlantic via Strait of Gibraltar which is merely 14 km wide. Also, In the south-east, The Mediterranean Sea connects with the Red Sea via man made Suez Canal. Less dense Atlantic waters flow into the Mediterranean from the surface and more salty Mediterranean water flow out underneath towards Atlantic through the Gibraltar (Tomczak and Godfrey, 2003). Due to small and narrow connection with the Atlantic Ocean, tides are very limited in the Mediterranean (McElderry, 1963). Mediterranean is divided into eight smaller seas that are namely; the Alboran, the Algerian-Provencial, the Tyrrhenian, the Adriatic, the Ionian, the Aegean, the Levant and the Black Seas. The Levant Sea is located at the easternmost part of the Mediterranean. It covers an area of 7.5x105 km^3 with a maximum depth of 4300 m. It includes Lattakia (1000-1500 m), Adana-Çukurova (Cilician) (1000 m), Antalya (2000-3000 m) and Rhodes (4300 m) basins. The deepest point is 5093 meters in Hellenic Trench.

Evaporation is higher in its eastern half, for this reason, the water level decreases and the salinity increases at the eastern part. Mediterranean is more saline and warmer than the Atlantic. While Atlantic waters flow from Gibraltar towards the Levantine, it warms up and become more salty (increase from 36.15 to 38.6 psu, Özsoy et al., 1989). Also its rich nutrient content is being used on the way.

Atlantic surface waters flow towards Mediterranean through the Gibraltar strait forming the so called Atlantic Stream System (ASS) nearby Gibraltar, Alboran Sea. During its transport to the Levantine Basin the branch of the ASS entering Strait of Sicily forms the Atlantic - Ionian Stream (AIS), which travels across the basin and becomes the mid-Mediterranean Jet (MMJ). The mid-Mediterranean jet flows eastward between the cyclonic Rhodes gyre on the north and the anticyclonic Mersa-Matruh gyre and the area of the Shikmona gyre on the south. A branch of the mid-Mediterranean jet moves towards the north in the eastern side of Cyprus and forms the Asia Minor Current (AMC), which flows into İskenderun and Cilicia basins along the Turkish coast (Figure 1.4; Hecht, 1986; Özsoy *et al.*, 1989). The Modified Atlantic Water (MAW) transported by the AIS, MMJ and AMC reaches the easternmost part of the basin, mixing continuously with the surrounding waters and deepening to about a 50- to 100-m depth in the Levantine Basin. The salinity of the waters entering through Gibraltar is about 36.15 psu, while the Mid Atlantic Water (MAW) in the Levantine Basin becomes 38.6 psu" (Özsoy et al., 1989). (Demirov and Pinardi, 2002; POEM group, 1992).

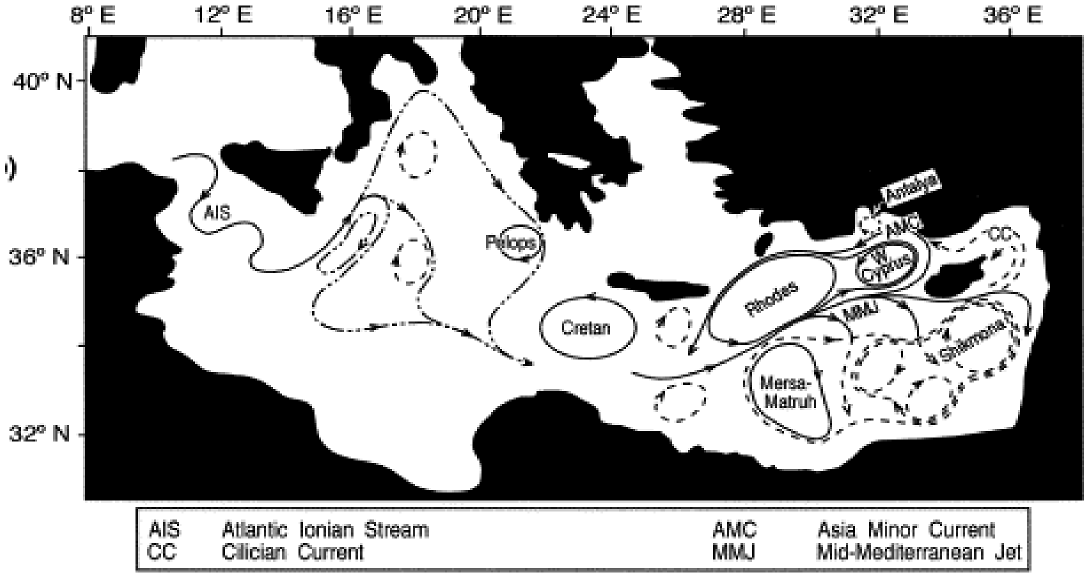


Figure 1.4. Schematic upper thermocline general circulation obtained melding the observations and model dynamics (from Robinson and Golnaraghi, 1994).

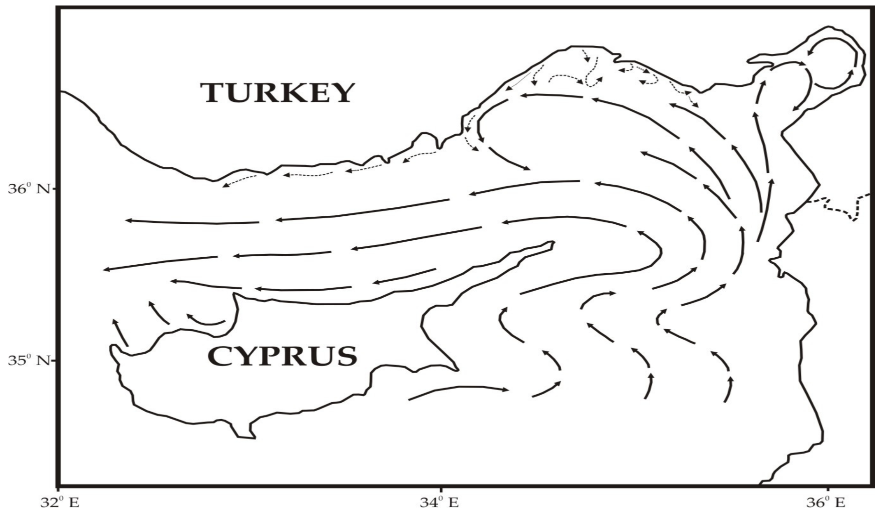


Figure 1.5. Surface circulation pattern in the northeastern Mediterranean (from Collins and Banner, 1979).

The circulation pattern is affected by the northwesterly flowing open sea currents and local winds in İskenderun Bay (Figure 1.5; İyiduvar, 1986). Open sea waters entering the İskenderun Bay create cyclonic and anticyclonic eddies (İyiduvar, 1986; Latif et al., 1989).

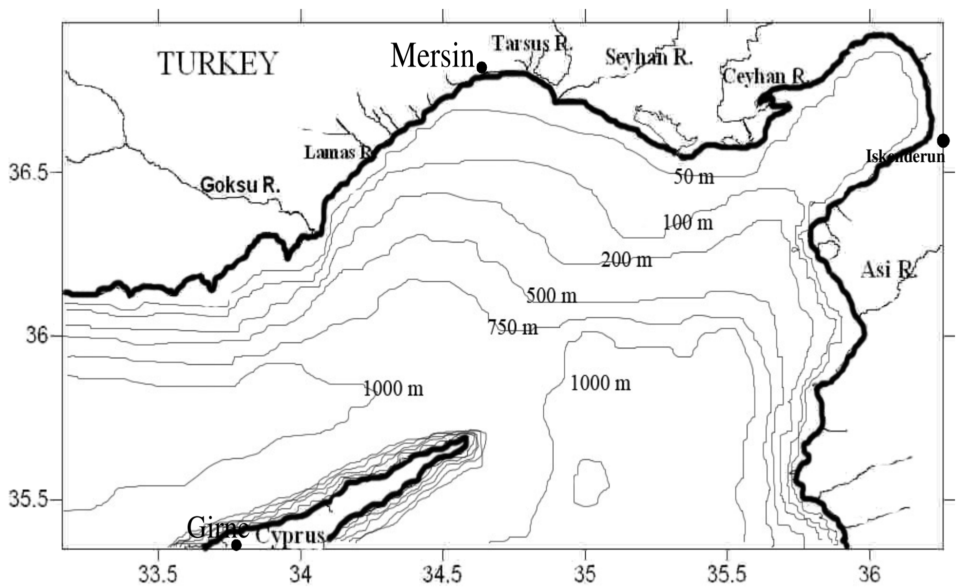


Figure 1.6. Map of the Cilician basin bathymetry (from URL7).

In the eastern Mediterranean, water column shows several stratifications that are namely, the Levantine surface water (LSW), the Atlantic water (AW), the Levantine intermediate water (LIW) and the Levantine deep water (LDW). LSW is characterized by warm (16-25 ^{o}C) and saline (38.8-39.4 psu) feature. AW which can be identified as salinity minimum is observed with a temperature of about 17 ^{o}C and salinity between 38.5 and 39.0 psu (Özsoy et al., 1993; Robinson and Golnaraghi, 1994). Below the Atlantic water, LIW is present with salinity of about 39.1 psu and typical temperature of about 15.5 ^{o}C, throughout the year (Özsoy et al., 1993; Robinson and Golnaraghi, 1994; Malanotte-Rizzoli et al., 1999). Lastly, Levantine deep water (LDW) has a temperature of $\leq$ 13.8 ^{o}C and salinity of $\leq$ 38.74 psu. This water layer can be easily identified from the temperature and salinity (T-S) diagrams and can be found in different depths during different seasons and different places (Özsoy et al., 1993; Robinson and Golnaraghi, 1994; Herut et al., 2000). But, roughly LSW found at 0-100 m range, AW at 20-100 m, LIW at 100-400 m and lastly LDW> at the depths below 600-700 m (Özsoy et al., 1991).

Mid-Mediterranean Jet which is AW entering from the Gibraltar is the main current that influences the Levantine Basin. As a results of this current, mesoscale and sub-basin-scale eddies and dynamical structures are formed in the Levantine basin. Rhodes, Mersa Matruh, Shikmona, west Cyprus Gyre and Asia Minor currents are permanent structures in the basin. Because of bifurcation position of the main current, Mersa Matruh and Shikmona are anticyclonic and the rest are cyclonic. (Robinson et al., 1991; Özsoy et al., 1993). The eastern Mediterranean is characterized by many eddies and jets (Robinson et al., 1992). The Cyprus Eddy is a quasi-stationary warm-core eddy situated in the Levantine Basin southeast of Cyprus (Brenner et al., 1991; Tanaka et al., 2007).

Hecht et al. (1988) declared that average temperature was 16.23±0.40°C in winter, 19.16±0.34°C in the spring and 24.05±2.30°C in summer for the LSW. During the winter, the LSW extends down to 100 m, in summer to 50 m. Towards spring, surface water warms and forms the spring LSW. At the end of the spring the surface water become warmer and more saline in upper mixed layer than deeper winter LSW layer. (Hecht et al., 1988; Özsoy et al., 1989; Kress and Herut, 2001). The underlying AW is cooler and less saline than the LSW (Kress and Herut, 2001). Smale scale anticyclonic eddies generally observed in the Cilician basin (Özsoy et al., 1991; 1993).

1.2. The chemical oceanography of the Cilician Basin

Surface waters in the eastern Mediterranean has extremely low nutrient content (Krom et al., 2005). Because of limited input, nutrients are very scarce in the Levantine basin the distribution of which is mainly controlled by eddies and currents. Summer-autumn surface nitrate concentration (0.2 µM) is lower than spring (0.8 µM March 1992) at the surface. Phosphate concentrations do not change significantly from season to season. In winter, surface phosphate concentrations are near detection limits (0.02 µM) in the Levantine. Surface silicate concentration increases during mild winters. Because of lateral input from the Rhodes cyclone and vertical mixing, nitrate values increases from 0.2µM (summer–autumn level) to ~2µM in March at the surface. Similar increases were recorded in the phosphate and silicate concentrations from undetectable levels (<0.02µM) to 0.06µM and from 1.3–1.5µM to 2.9µM (Yılmaz and Tuğrul, 1998).

Phosphorus is a potentially limiting factor for the algal production in the upper layer (Yılmaz and Tuğrul, 1998). It is fallowed by nitrogen for limiting role (Margalef, 1963; Berland et al., 1980; c.f. Estrada, 1996). The vertical distribution of chemical parameters in the northern Levantine basin was studied by Salihoglu et al. (1990) and Yilmaz et al. (1994) at the cyclonic Rhodos gyre and the anticyclones in the Cilician Basin and south of Rhodes. The vertical distribution of nutrients in both areas had completely reversed trends: the nutricline at the cyclonic gyre was close to the surface while at the anticyclonic areas it appeared at 250-300 m. However, the nutricline was independent of the geographical location and always appeared at isopycnal surfaces of 29.0-29.05 and 29.15 (upper and lower boundaries, respectively) (Kress and Herut, 2001).

The concentrations of silicic acid were variable. The highest concentrations were recorded during the winter–spring transition period, spring 1989 followed by winter 1989 and during summer 1991. The lowest concentrations were found in summer 1990 and spring 1995. Silicic acid content of the AW was always higher than the LSW, probably as a result of remineralization. Phosphate was close to the detection limit during all seasons. The only significant difference was found between winter 1989 and summer 1991, with phosphate higher in the latter. When both summer phosphate values were pooled there was no significant difference from winter. Phosphate in the LSW and AW was very low and close to detection limit, with no detectable seasonal differences. Nitrate concentrations decreased gradually from winter to summer in both the LSW and AW (Kress and Herut, 2001).

Silicic acid in the LSW was higher in the winter–spring transition and similar in all the other seasons, while in the AW there was a gradual decrease from winter–spring transition to summer. Phytoplankton bloom occurs during winter and the beginning of spring, so, nutrient concentration change from season to season (Azov, 1986; Kimor et al., 1987; Krom et al., 1992). While phosphate concentrations remained low, nitrate was consumed rapidly in late winter and early spring.

Phosphate can be introduced by atmospheric dry input (Herut et al., 1999b), but it is probably utilized rapidly by the phytoplankton (Buat-Menard et al., 1989) so that no changes in the concentration are detected in the water (Kress and Herut, 2001).

The eastern Mediterranean deep water is characterized by the high N:P ratio (27-28.5), it is higher than the Redfield ratio of 16. (Redfield et al., 1963, c.f. Kress 2001). Phosphorus is limiting factor for algal production in the upper layer. (Yılmaz and Tuğrul, 1998; Ediger et al., 2004).

During the spring, the N: P ratio in the LSW continued to decrease towards its lowest value in summer. There is no nutrient supply from below, due to the development of the seasonal thermocline, so the changes may be explained by: (a) biological activity and (b) atmospheric input of nutrients. (Kress and Herut, 2001).

Biological activity and consumption according to Redfield would further increase the N: P ratio, opposite to the trend found. It is assumed that phosphorus was coming from the atmosphere which reported before (Ganor and Mamane, 1982; Bergametti et al., 1992; Herut et al., 1999b) decreasing the N:P ratio (Kress and Herut, 2001). Consumption, however, is fast due to the ultra-oligotrophic character of the area. Buat-Menard et al. (1989) reported that biological removal of particulate aerosols from the sea surface is as fast as one week in the Northwestern Mediterranean. Consequently, these two processes are assumed to determine the decrease of the N:P from winter to summer (Kress and Herut, 2001).
Phosphate is consumed early than nitrate in the surface waters, this is characteristic of phosphorus limited system. In summer, after the seasonal stratification, a deep chlorophyll maximum layer goes to deeper, nitrate and phosphate concentration are measured at or below the detection limits in the surface water (Krom et al., 2005).

1.3. The biological oceanography of the Cilician Basin

The eastern Mediterranean Sea is one of the least productive seas in the world. Primary productivity and chlorophyll-a concentrations are very low (Krom et al.,1992; Yılmaz and Tuğrul, 1998; Psarra et al., 2000; Ediger et al.,1999; Tanaka et al. 2007; Krom et al., 2003).

For eastern Mediterranean, it has been estimated that the annual primary production range regionally between 16 and 60 g C m^{-2} (Dugdale and Wilkerson, 1988, Salihoğlu et al., 1990; Psarra et al., 2000).

The eastern Mediterranean is the only region of subtropical water where deep water is being formed. As is characteristic of such regions, the phytoplankton bloom occurs in winter (November–March) during the many relatively warm sunny days (Krom et al., 2003, 2005).

In the Levantine basin, distribution of the nutrient concentration is affected by the eddies and currents, in addition, these affect the production (Yılmaz and Tuğrul, 1998).

In the eastern Mediterranean, production depends almost on the regenerated production. Estrada (1996) expressed that new production so-called “recycled production”, is based on nutrient inputs originated from regeneration within the euphotic zone. High production rates have been observed generally in the cyclonic gyres and their peripheries in the offshore waters of the northeastern Mediterranean. In the cyclonic gyres, nutrients are pumped from Levantine deep water to surface (upwelling) (Yılmaz and Tuğrul, 1998).

Annual phytoplankton bloom takes place between late autumn and early spring as soon as the dissolved nutrients are mixed into photic zone (Krom et al., 2003). Yacobi et al. (1995) measured the chlorophyll by using flow cytometric analysis. They found that more than 90% of the chlorophyll at the surface was confined to particles < 10 μ in diameter and more than 60% was found in particles < 2 μ. The proportion of chlorophyll in < 2 μ particles increased with depth between the surface and the DCM (Yacobi et al., 1995). For the cyclonic and anticyclonic regions, chlorophyll a maximum were found at 70-75 m and at 100-110 m depth (Kress and Herut, 2001). Yacobi et al. (1995) described summer chl-a distribution and its relationship to the physical fields in the Southern Levantine Basin. “Chl-a ranged between 0.009 and 0.4 μg l^{-1}, and had a similar vertical distribution across the basin. Maximal chl-a values were found at 90–110 m except at the anticyclone south of Crete, where chl-a was distributed evenly in the water column. Markaki et al. (2003)

declared that “dry and wet deposition from the atmosphere dominate the new production in the open sea during the spring-autumn period when surface layer is thermally stratified. The total concentration of nutrients is so low that it favours the growth of nano- and picoplankton and mitigates against the growth of larger eukaryotic phytoplankton such as diatoms. In the eastern Mediterranean, diatom blooms occur in the coastal waters in winter and the cores of the cold core eddies such as Rhodes gyre (Krom et al., 2003).

Bacteria, heterotrophic nanoflagellates (HNF), and ciliates (heterotrophs) dominated (60-70%) the microbial carbon biomass in the euphotic layer. Heterotrophic ciliates were found to be much more abundant in the upper 50 m of the water column, while no consistent pattern was found for bacteria and HNF throughout the euphotic layer. According to recent studies, while the heterotrophic community (bacteria and microbial predators) is only P-limited, the phytoplankton community is N and P limited (Krom et al., 2005b; Thingstad et al., 2005, Tanaka et al., 2007). In the surface mixed layer, the microbial community is dominated by heterotrophs (Pitta et al., 2005). Tanaka et al. (2007) found same pattern at euphotic layer. According to studies, carried out by Azov (1986) and Kimor et al., (1987) there is a shift to smaller phytoplankton from March to August in the Levantine Basin. This can be continued by rapid nutrient regeneration. For keeping maximum relative growth rates in water body, species composition shift at elsewhere. (Harrison et al., 1986; Hutchings et al., 1995; Thingstad and Rassoulzadegan, 1995; Kress and Herut, 2001).

At the deep chlorophyll maximum (between 100 and 130 m), autotrophs showed a maximum distribution. In the euphotic layer, the relationships between biomass and production for phytoplankton and bacteria suggested a higher top-down control on the phytoplankton in the upper ~50 m and a consistently tight top-down control on the bacterial biomass throughout the euphotic layer” (Tanaka et al., 2007).

In shelf waters diatoms were reported as the most abundant group in the Cilician basin (Lakkis and Lakkis, 1981; Kıdeys et al., 1989; Eker et al., 2003; Koray, 1995; Eker and Kıdeys, 2000; Polat et al., 2000; Polat and Işık, 2002; Uysal et al., 2003; Yılmaz, 2006).

1.4. Aim of this study

Within the context of this thesis, it was aimed to understand the changes in the total chlorophyll a content as well as in the pigment composition of the phytoplankton in time and space in the surface waters of the Adana-Çukurova (Cilician basin). For this, basin scale surveys (total 8 cruises) have been carried out on board R/V Bilim-2 of the IMS-METU to collect supplementary biological, chemical and physical data between 2005-2007. Chlorophyll-a and phytoplankton pigments were measured using high performance liquid chromotography (HPLC) and compared with the outputs of the field fluorometer and satellite images. In-situ surface chlorophyll measurements were performed along the cruise tracks using a field fluorometer (Turner Designs). Changes in the surface chlorophyll content and pigment composition of the phytoplankton in the basin in time and space was tried to be assessed in relation to other concurrent ambient biological, physical and chemical parameters being collected during the surveys.

2. MATERIAL AND METHODS

2.1. Sampling area

In this thesis study samples are collected from total 78 stations (Figure 2.1) located in the Cilician basin, northeastern Mediterranean. Total 8 cruises, namely the November 2005, March and July 2006, January, March, April, June and lastly the September 2007 cruise; have been realized on board R/V Bilim-2 of the Institute of Marine Sciences of Middle East Technical University. Water samples from surface and lower depths were collected using 5 l capacity Nansen closing bottles attached to the rosette sampler which, as well, houses the CTD probe.

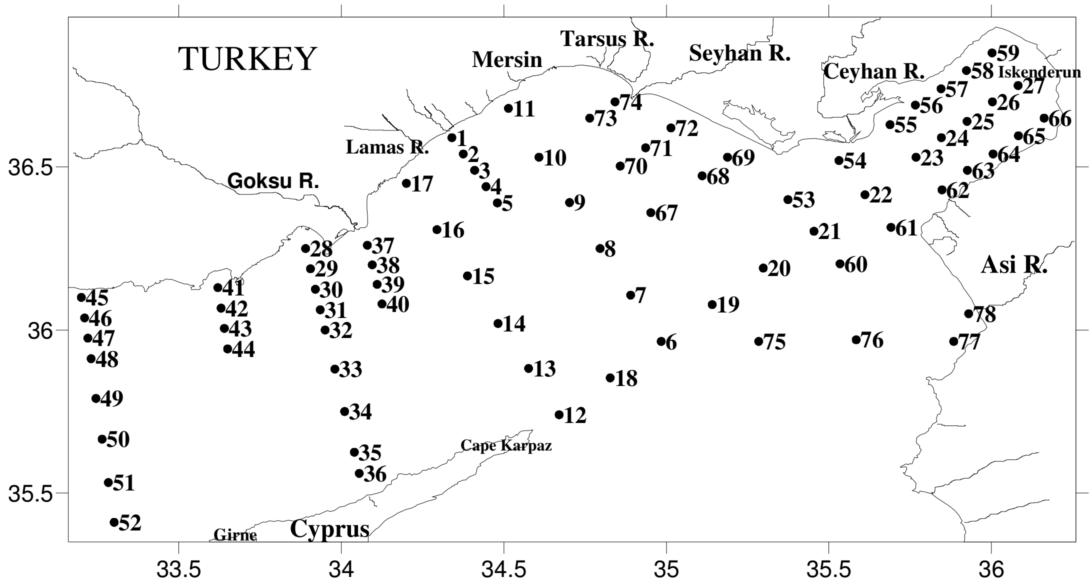


Figure 2.1. Location of the sampling stations.

2.2. Sampling methods applied in the field

The list of parameters collected and the techniques applied to measure them are given below.

	Parameters	**Technique**
Physical	Temperature	CTD
	Salinity	
	Density	
Chemical	Nitrite + Nitrate	Auto Analyzer
	Phosphate	
	Silicate	
	Total Phosphorus	Spectrophotometer
Biological	Total Chlorophyll-a	Spectrofluorometer
	Chlorophyll (in situ)	Turner Field Fluorometer
	Pigments	HPLC
	Total Chlorophyll	Satellite image

2.2.1. Physical parameters

Among the physical parameters temperature, salinity, density, oxygen saturation, PAR (Photosynthetically Active Radiation) and fluorescence were obtained in situ using a Seabird model (SBE 19 plus) CTD sensor mounted on a Rosette sampler. Density (sigma-theta σ_t) is calculated from the temperature and salinity data by the software being installed. The signals are then formatted and transferred from CTD to a PC.

2.2.2. Chemical parameters

Samples for nutrients (nitrate+nitrite, reactive silicate, phosphate) were taken parallel to (except total phosphorus) biological samples from the surface and below at standard depths.

2.2.2.1. Nutrient analyses

Standard colorimetric method (Strickland and Parsons, 1972) for nitrate+nitrite, reactive silicate and phosphate and ascorbic acid method (Koroleff, 1983) for total phosphorus were used for measuring the nutrient concentrations.

2.2.2.1a. Nitrate+nitrite, phosphate and pilicate

Sea water drawn from the Nansen bottles stored into 100 ml high density polyethylene bottles (HDPE) which were pre-cleaned with 10% HCl. Nitrate+nitrite and phosphate samples were kept frozen (-20 ^{o}C) whereas those for silicate were kept cool (at +4 ^{o}C) until analysis. Nutrient concentrations are measured using a Techicon model multi-channel auto-analyzer according to the procedure given in Standard Colorimetric Methods (Strickland and Parsons, 1972). Detection limits for nitrite+nitrate, phosphate and silicate were 0.05 µM, 0.02 µM and 0.3 µM, respectively.

2.2.2.1b. Total phosphorus

Water samples are collected with Nansen bottles from selected depths. Samples are then kept frozen until analysis at -20 ^{o}C in 100 ml polyethylene bottles which were pre-cleaned with 10% HCl. To remove orthophosphate from particulate and organic fractions, samples were disintegrated with persulfate (Menzel and Corwin, 1965; Doğan-Sağlamtimur, 2007). Total phosphate concentration was measured at 880 nm using the spectrophotometer according to the ascorbic acid method given by Koroleff, (1983).

2.2.3. Biological parameters

Different instruments are used to measure chlorophyll-a concentration.

2.2.3.1. Chlorophyll measurements (in situ)

Field Fluorometer (Turner Designs 10 AU-005-CE) was used to measure continuously the surface chlorophyll and the temperature. Surface water is pumped from the ship's engine cooling tank into a plastic container assembled to the fan tail. From the container, flow in and out the fluorometer is assured with the aid of two hoses. Much care is given to eliminate formation of air bubbles during the intake. In parallel to chlorophyll and temperature, GPS (Global Positioning System) data is also collected every 5 seconds throughout the cruises.

The instrument is calibrated before each cruise. To achieve this, a sample of sea water (standard) whose actual concentration is determined later by HPLC is used. Direct readings in the field are then multiplied by the ratio of standard concentration entered initially to actual concentration measured by HPLC later to convert field data to actual (true) values (concentration).

2.2.3.2. Spectrofluorometry in measuring chlorophyll-a concentration

Seawater samples (0.3 to 3 liters) were collected from each station for spectrofluorometric measurement of the Chl-a concentrations with Nansen bottles. Samples of seawater were then filtered over Whatman GF/F filters (0,7µm pore size and 47mm diameter) at a low vacuum (< than 0.5 atm.). The filtrates were then kept deep frozen in liquid nitrogen until analysis. The filters were extracted with 5ml 90% acetone solution by using ultrasonicator (60 Hz for 1 minute). Then, the volume of the extract increased up to exactly 10 ml. The samples are kept in the dark overnight (about 12 hours) at +4 °C (in the refrigerator). Samples were then centrifuged at 3500 rpm for 10 minutes to remove cellular debris.

Fluorometric analysis was done by using Hitachi F–3000 type fluorescence spectrophotometer. Before measurement, fluorometer was set to zero with 90% acetone (blank reading), than fluorescence intensity of 2 ml extract was measured before and after acidification at 420 nm excitation and 669 nm emission wavelength. Chlorophyll a and phaeopigment concentration was calculated by the following formula given by Strickland and Parsons (1972).

$$\textbf{Chl-a } (\mu gL^{-1}) = \frac{F_m \times (F_o - F_a) \times V_{ext} \times K_s}{(F_m - 1) \times V_{flt}}$$

$$\textbf{Phaeo } (\mu gL^{-1}) = \frac{F_m \times [(F_m \times F_a) - F_o] \times V_{ext} \times K_s}{(F_m - 1) \times V_{flt}}$$

where;

Fm, acidification coefficient (F_o/F_a) for pure chl-a (usually 2,2)

F_o, reading before acidification

F_a, reading after acidification

K_s, door factor from calibration calculations (1/slope)

V_{ext}, extraction volume (ml)

V_{flt}, filtration volume (ml)

Chlorophyll-a standard obtained from Sigma was used to quantify the sample fluorescence intensities. The concentration of the standard stock solution was determined by using spectrophotometer. A minimum of five dilutions were prepared from this standard. Then, emission and excitation wavelengths are adjusted using the same standard. Before and after acidification with 2 drops of 1 N HCl Fluorometer readings were recorded. The detection limit was about 0.01 µg/l. The precision was better than 7% (Relative Standard Deviation), (Yılmaz, 2006).

2.2.3.3. HPLC analyses

0.5 to 3 liters of seawater samples were taken from the Nansen bottles at few major stations. Samples were filtered over 25 mm GF/F filters at a vacuum of less than 0.5 atm and filtrates were then preserved in liquid nitrogen (-196 ^{o}C) until analysis in the laboratory. Extraction was carried out with 5 ml 90% HPLC grade acetone by using sonication (60Hz for 1minute). The samples kept overnight (about 12 hours) in the dark at 4°C (in the refrigerator) for extraction. Samples were centrifuged at 3500 rpm for 10 min to remove cellular debris. The method chosen in this study (Barlow et at., 1993 c.f. Yılmaz, 2006) is a modification of the reverse-phase method described in Mantoura and Llewelyn (1983, c.f. Yılmaz, 2006). Pigment analysis was done with a Agilent 1100 HPLC system using a C8 column equipped with vacuum degasser, binary pump, a UV absorbance detector and a fluorescence detector.

500 µl of the extract was filtered through 0.2µm pore size Millipore filters and mixed with 500 µl 1M ammonium acetate ion pairing solution for the measurement. Buffered extracts were injected (100µl) into a Thermo Hypersil MOS-2 C8 column (150x4.6mm, 3µm particle size, 120Å pore size and 6.5% carbon loading) using an Agilent HPLC system (Quaterner pump, manual injector) having 100µl loop. Using a binary mobile phase system pigments were separated with linear gradient.

Mobile phases used in the gradient elution consisted of primary eluant (A) consisting of methanol and 1 M ammonium acetate (80:20 v/v), and a secondary eluant (B) consisting of 100 % methanol. Pigments were separated at a flow rate of 1 ml min^{-1} by a linear gradient programmed as follows (minutes; % solvent A; % solvent B): (0;75;25), (1;50;50), (20;30;70), (25;0;100), (32;0;100). Then, the column was reconditioned to original conditions over a further 7 min. Ammonium acetate was used as an ion pairing reagent, and it is recommended that it should be present in both the sample and mobile phase to improve pigment separation and suppressed dissociation of isolated compounds. Pigments were detected by absorbance at 440nm using an Agilent variable wavelength detector (Mantoura and Llewellyn, 1983, c.f. Yılmaz, 2006).

By using a PC-based Chemstation Chromatography Package data collection and integration were performed. The HPLC system was calibrated for each pigment with commercial standards chlorophyll a, b provided by Sigma Co; chlorophyll c2, chlorophyllc3, peridinin, 19-butanoyloxyfucoxanthin, fucoxanthin, 19-hexanoyloxyfucoxanthin, diadinoxanthin, alloxanthin, lutein, zeaxanthin, divinyl chlorophyll-a and β-carotene provided by VKI, Denmark. The detection limit for chl-a and marker pigments was about 0.005-0.007 µg/l. The precision was better than 7% (Relative Standard Deviation), (Yılmaz, 2006).

Concentrations of pigments calculated according to equation below named 'external standard' equation (Jeffrey et al., 1997).

Cp = (Ap x Vext x 10) / (B x Vflt x Vinj x 1000 x Rf)   where;

Cp($\mu g L^{-1}$); concentration of a particular pigment
Ap (mAU*s); peak area of the eluting pigment
Rf (ng mAU^{-1}); the slope of the calibration curve (ng $column^{-1}$)
Vfilt (l); the volume of filtered seawater
Vext (ml); the solvent used for the extraction;
Vinj (µl); the solvent injected onto the chromatographic system and
B; the buffer dilution factor.

2.2.4. Classification

In this study, 13 different pigments were measured with Chlorophyll-a via chromatographic method. These are respectively chlorophyll c_3 and c_2, peridinin

(PER), buthanoloxyfucuxanthin (BUT), fucuxanthin (FUC), 19'hexonoloyxyfucoxanthin (HEX), diadinixanthin (DIAD), alloxanthin (ALLO), zeaxanthin (ZEA), chlorophyll-b (CHL-B), divinil chlorophyll-a (DIV-A), lutein (LUT) and ß-carotene (B-CAR). Seven of them are marker pigments for certain phytoplankton groups (Jeffrey et al., 1997).

These marker pigments are fucoxanthin for diatoms (Barlow et al., 1993), 19'hexonoloyxyfucoxanthin for prymnesiophyceae (Coccolithophorids e.g. Emiliania huxleyi) (Bjornland and Liaaen-Jansen, 1989; Wright and Jeffrey, 1987), peridinin for Dinoflagellates, chlorophyll-b for Chlorophytes, zeaxanthin for Cyanophyta, buthanoloxyfucuxanthin for Chrysophyta (Bjornland and Liaaen-Jansen, 1989). Divinyl chlorophyll-a is marker pigment for Prochlorophyceae. Others are accessory pigments which are present in all phytoplankton groups (Jeffrey et al., 1997).

Table 2.1. Marker pigments. (Species in bold=major taxonomic pigment) (c.f. Jeffrey et al., 1997).

Pigment	**Occurrence**
Buthanoloxyfucuxanthin	Chrysophytes, prymnesiophytes
Chlorophyll-b	Chlorophytes, parasinophytes
Divinil chlorophyll-a	Prochlorophytes
19'hexonoloyxyfucoxanthin	Prymnesiophytes
Fucuxanthin	Diatoms, prymnesiophytes, chrysophytes
Peridinin	Dinoflagellates
Zeaxanthin	Cyanobacteria

2.2.5. Satellite

Chlorophyll-a is the most important pigment in the light harvesting mechanism of plants. According to investigations, there is a direct relation between Chlorophyll-a and phytoplankton biomass (Jeffrey et. al., 1997). "Because chlorophyll's photosynthetic function makes it a unique indicator of plant biomass and productivity, it is the most frequently measured biochemical parameter in oceanography" (Watson et al. 1991; Jeffrey et. al., 1997). Satellites have been used for measuring sea surface chlorophyll concentration and temperature since 1978 (URL 5, 2007).

Sea surface temperature and surface chlorophyll-a data were derived from Moderate Resolution Imaging Spectroradiometer (MODIS-Aqua). MODIS-Aqua is part of the Earth Observing System (EOS). It was launched during winter, 2001. EOS helps scientists in evaluation of the inter-relationships between the ocean, land and atmosphere for climate change. Data including ocean color, sea surface temperature and ocean primary productivity archived every day. Processed Level 2 MODIS-Aqua data were obtained from Ocean Color Web for North Eastern Mediterranean region (URL 7, 2007). Satellite data were processed (in IMS-METU) from Level 2 (which is not mapped includes geophysical and atmospheric correction data) to Level 3 (mapped), by using SeaDAS (SeaWiFS Data Analysis System) version 5.0.5.

Sea surface Chlorophyll-a and temperature data were obtained from satellite for each cruise period. Because of bad weather (cloud coverage), Satellite data were not obtained for the November 2005, March 2006 and April 2007 cruises.

2.2.6. Statistical analysis

In order to evaluate the effect of relation between physical, chemical and biological parameters, Spearman rank-order correlation analysis is performed. The formula for the Spearman rank-order correlation coefficient is below:

$$r_s = \frac{\left[\sum (x-\bar{x})(y-\bar{y})\right]}{\sqrt{\sum (x-\bar{x})\sum (y-\bar{y})}}$$

Where;

$\bar{x}$: mean rank of the sample from variable 1,

$\bar{y}$: mean rank of the sample from variable 2,

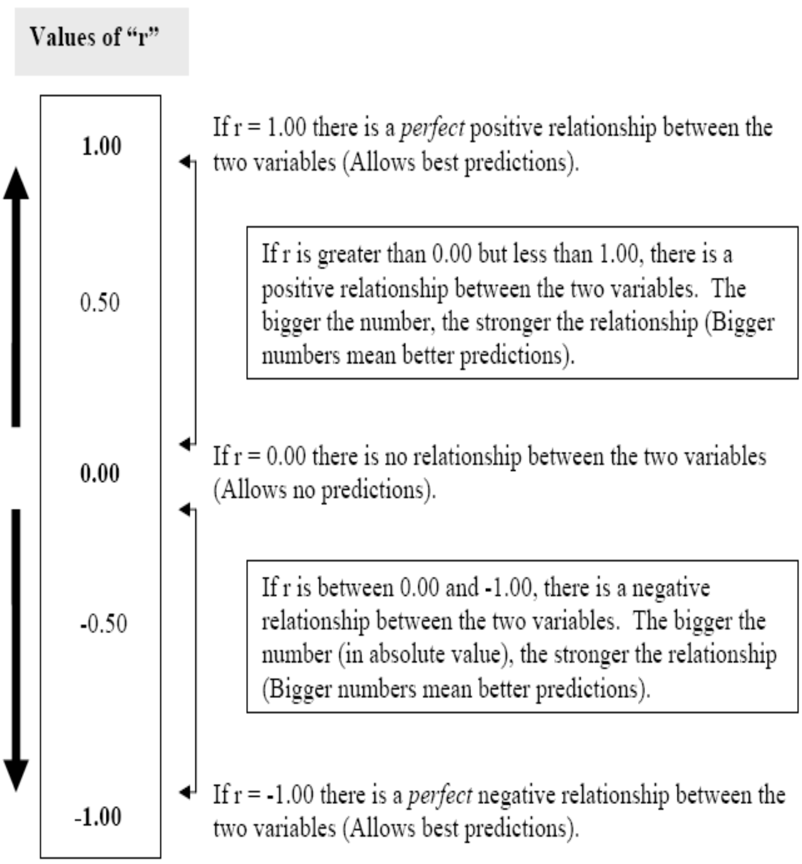
Degrees of freedom = n-2, where n = sample size.

If $r_s \geq r_s$ critical: significant result and if $r_s \leq r_s$ critical: non-significant result.

This analysis tells;

- whether the relationship is positive or negative,
- how large the relationship between variables.

The evaluation of the value of r_s is given in scheme below.



(from URL 9, 2008).

3. RESULTS

3.1. Physical parameters

Surface temperature and salinity distribution in the basin is presented in this section.

3.1.1. November 2005

During this month, total 70 stations were visited and the CTD data were collected from the surface to near bottom at all stations. Surface temperature was also recorded real time along the ship track by Turner fluorometer, throughout the cruise.

3.1.1.1. Temperature distribution at surface waters

At first glance, it is clearly seen from the Figure 3.1 that warmer surface water occupy the eastern part of the study area covering the entire İskenderun Bay and part of the Mersin Bay to the east. Continuous surface temperature plots collected via the Turner fluorometer along the cruise track also agree well with this (Figure 3.2). The temperature decrease towards west. Surface temperature ranged between 18.2 - 21.2 ^{o}C, being lowest at station 9 and highest at station 53 (Figure 2.1), in the area. The average surface temperature of the basin waters was 20.1 ^{o}C. Freshwater input from the local Seyhan River also reduced the surface temperature in its drainage area near station 74 (Figure 2.1). Cold water formation at surface is observed at stations 9 and 16 (Figure 2.1). Cross-shore (basin) temperature and density profiles indicate an upwelling at both stations (Figure 3.3). The depth of thermocline was situated at around 80 m in the shelf station #2 off Erdemli, at around 70 m in the mid station #24 in the İskenderun Bay and finally at a depth of 50 m in the offshore station # 8 located in the mid basin (Figure 3.4).

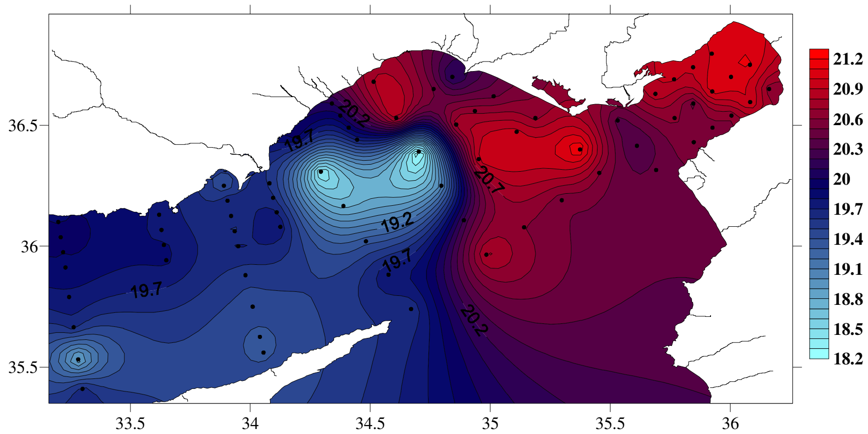


Figure 3.1. Surface temperature (^oC) distribution (from the CTD data) in the Cilician basin in November 2005.

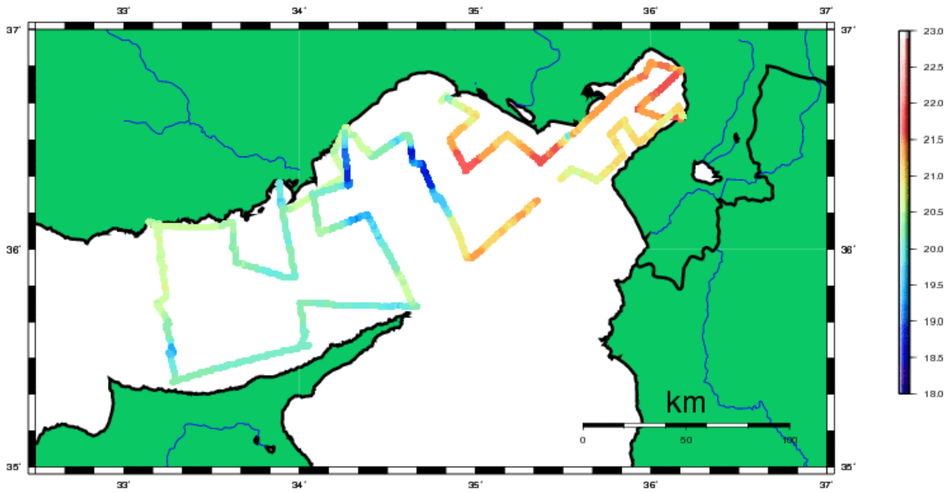


Figure 3.2. Surface temperature (^oC) distribution (from the fluorometer data) in the Cilician basin in November 2005.

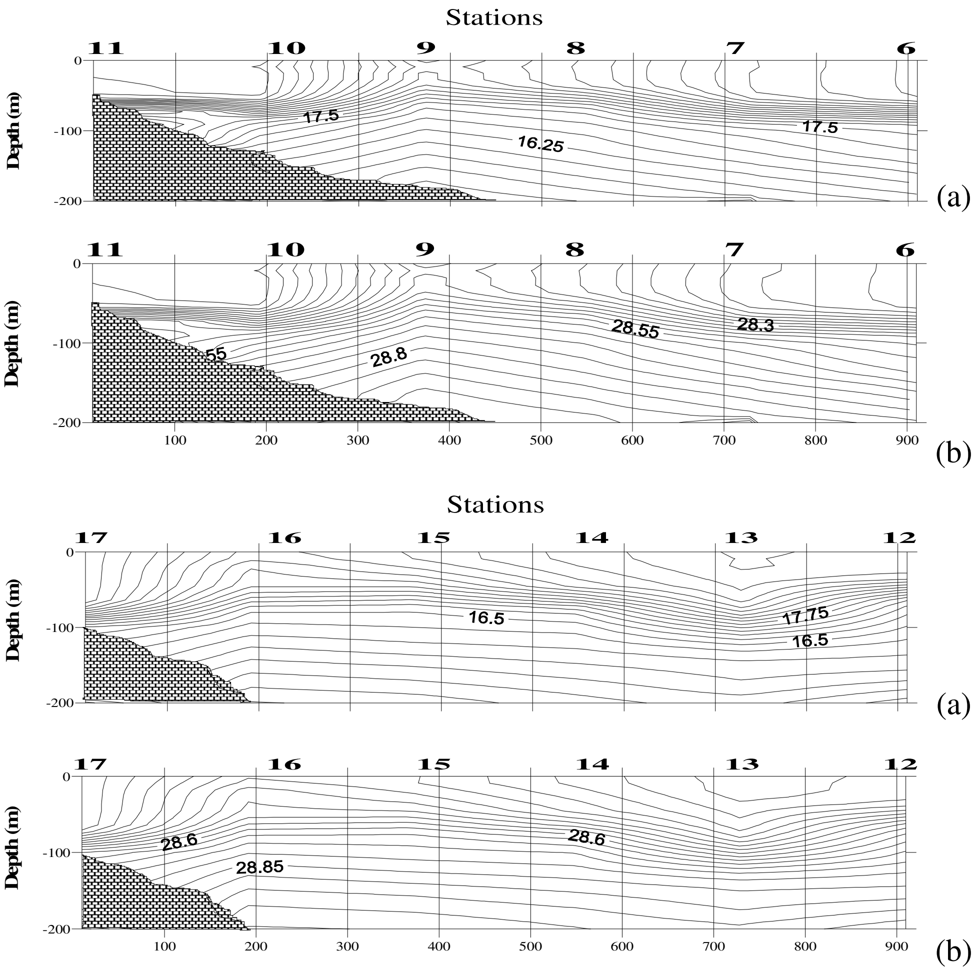


Figure 3.3. Cross-basin temperature (a) and density (b) profiles for transects including stations 9, 13 and 16 (Figure 2.1) in November 2005.

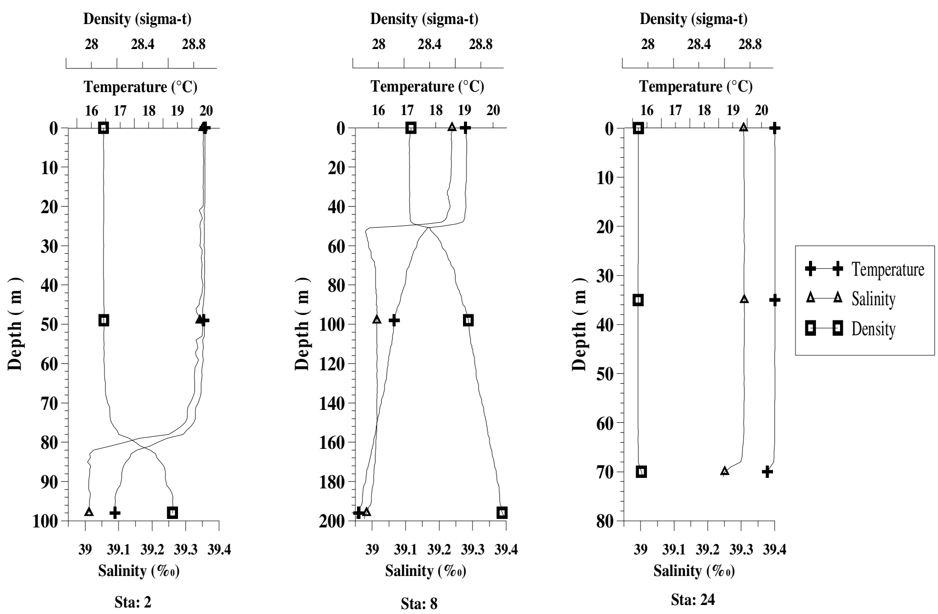


Figure 3.4. Temperature, salinity, and density profiles at station 2 (shelf, Figure 2.1), 8 (offshore Figure 2.1) and 24 (central İskenderun Bay, Figure 2.1) in November 2005.

3.1.1.2. Salinity distribution at surface waters

Salinity varied in the range 37.83 - 39.44 psu at the surface, with lowest value recorded at station 54 and highest at station 6 (Figure 2.1) in November. The average surface salinity was 39.31 psu. Impact of freshwater input from the Ceyhan River is highly pronounced in the area (Figure 3.5). Same is true for the Seyhan River inflow area (near station 74) and also for the area where upwelling was observed (the area covered by stations 8, 9, 15 and 16 (Figure 2.1)).

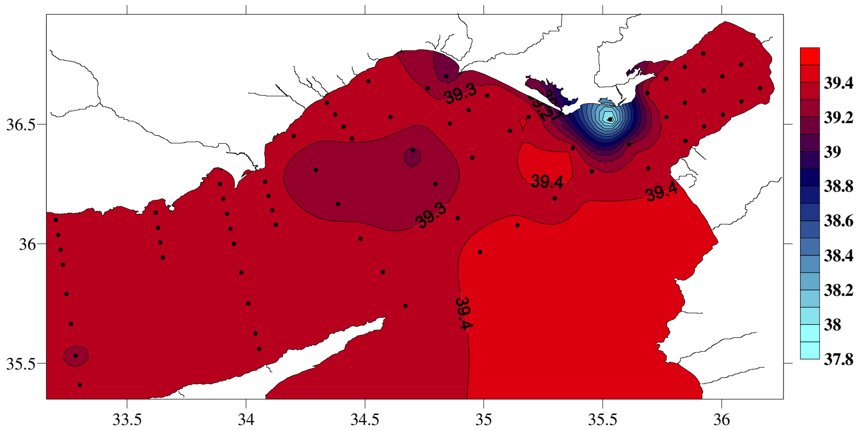


Figure 3.5. Surface salinity (psu) distribution (from the CTD data) in the Cilician basin in November 2005.

3.1.2. March 2006

During this month, CTD casts were performed from surface to near bottom at total 71 stations. Surface temperature was also recorded real time, by Turner fluorometer along the ship track, throughout the cruise.

3.1.2.1. Temperature distribution at surface waters

It is clearly seen from the Figure 3.6 that warmer surface water occupies the central basin forming a sharp contrast with the surrounding cold water. Same feature is also seen in surface temperature plot derived from the Turner fluorometer data (Figure 3.7). Surface temperature ranged between 16.24 - 17.71 ^{o}C, being lowest at station 69 and highest at station 15 (Figure 2.1) in the area. The average surface temperature was 16.95 ^{o}C. A patch of relatively colder water is formed between Seyhan and

Ceyhan Rivers. Temperature, salinity and density profiles for selected areas (shelf region, inner bay and offshore waters) are provided in Figure 3.8. Figures clearly illustrate gradual warming of the surface waters with depth at both shelf stations (Sta.s 2 and 24) as well as at the offshore station (Sta. 8) (Figure 2.1).

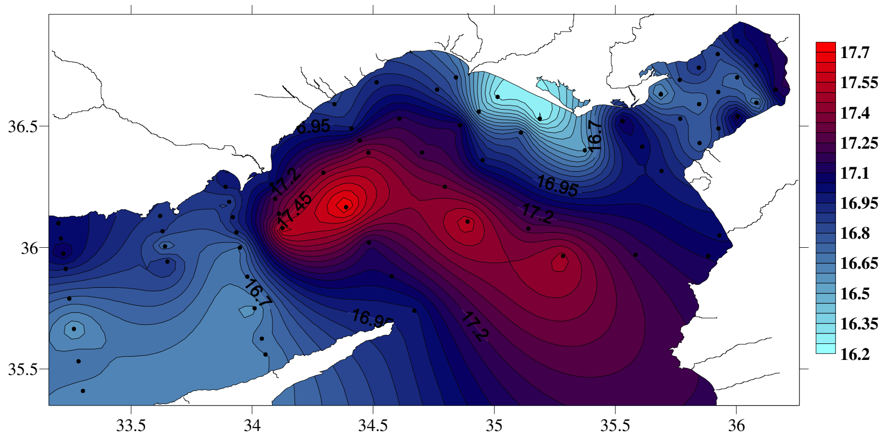


Figure 3.6. Surface temperature (^{o}C) distribution (from the CTD data) in the Cilician basin in March 2006.

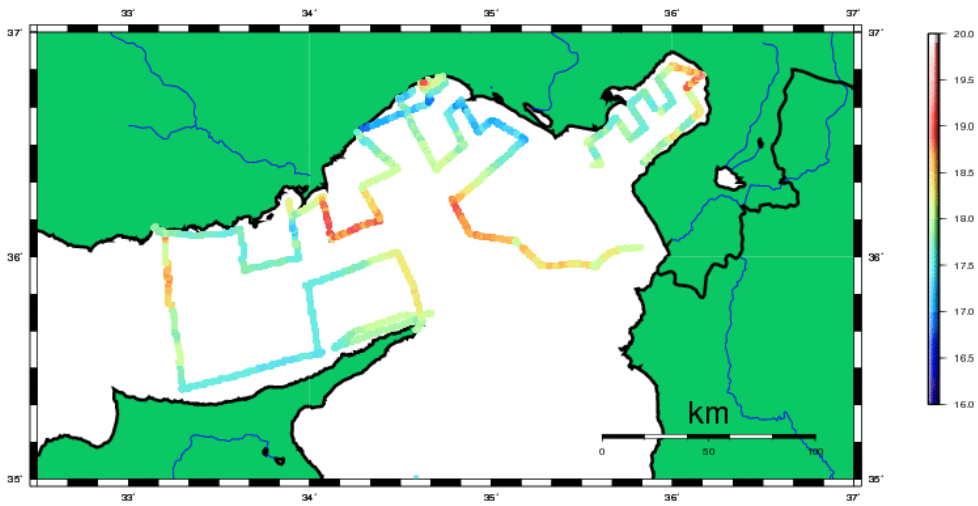


Figure 3.7. Surface temperature (^{o}C) distribution (from the fluorometer data) in the Cilician basin in March 2006.

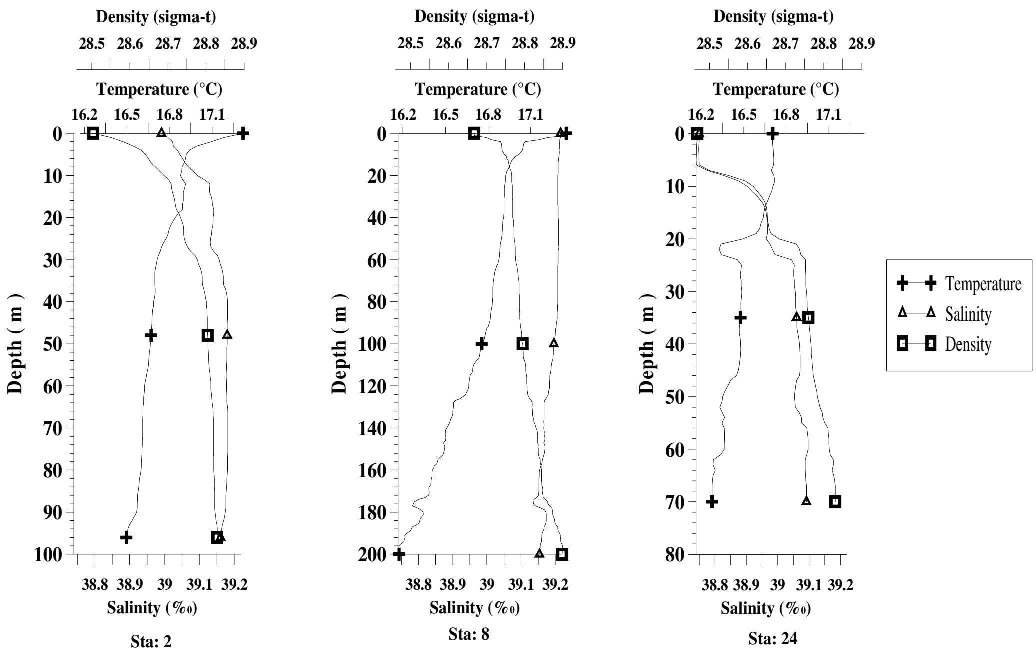


Figure 3.8. Temperature, salinity, and density profiles at station 2 (shelf, Figure 2.1), 8 (offshore, Figure 2.1) and 24 (central İskenderun Bay, Figure 2.1) in March 2006.

3.1.2.2. Salinity distribution at surface waters

Salinity varied in the range 37.08 - 39.22 psu at the surface waters, with lowest value recorded at station 69 and highest at station 75 (Figure 2.1) in March. The average surface salinity was 38.73 psu. Increased freshwater input from the Ceyhan River reduced the surface salinity significantly in the coastal area between Ceyhan and Seyhan Rivers (Figure 3.9). Similar but relatively small changes in surface salinity are also observed near Göksu River.

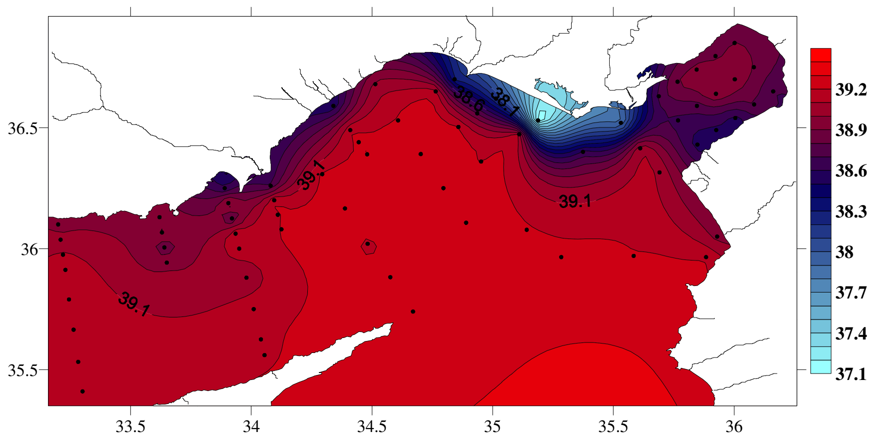


Figure 3.9. Surface salinity (psu) distribution (from the CTD data) in the Cilician basin in March 2006.

3.1.3. July 2006

During this month, CTD data were collected from total 78 stations. Real time surface temperature data is missing for this cruise.

3.1.3.1. Temperature distribution at surface waters

Figure 3.10 clearly illustrates the formation of warmer surface water both in the inner Mersin and İskenderun Bays. It got colder towards offshore. Surface temperature ranged between 26.65 - 28.5 ^oC, being lowest at station 42 (Figure 2.1) and highest at station 66 (Figure 2.1) (near İskenderun) in the area. The average surface temperature was 27.43 ^oC. A downwelling event was observed at station 40 (Figure 3.11) and inversely an upwelling was observed at station 18 offshore Cape Karpaz. An apparent thermocline is observed between 15-25 m depths at the offshore station #8 (Figure 2.1). Although the real thermocline is not observed at both shelf stations (sta.s 17 and 24 (Figure 2.1)) a sharp salinity gradient between 20-28 m depths at the central station #24 (Figure 2.1) in the İskenderun Bay (Figure 3.12) is observed.

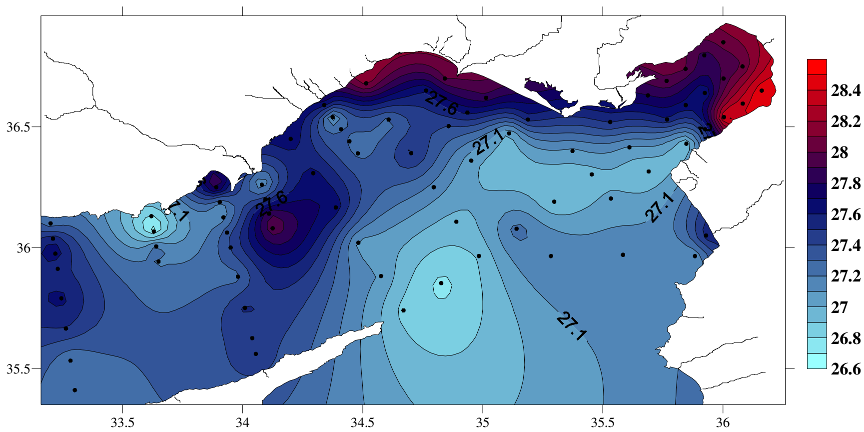


Figure 3.10. Surface temperature (^oC) distribution (from the CTD data) in the Cilician basin in July 2006.

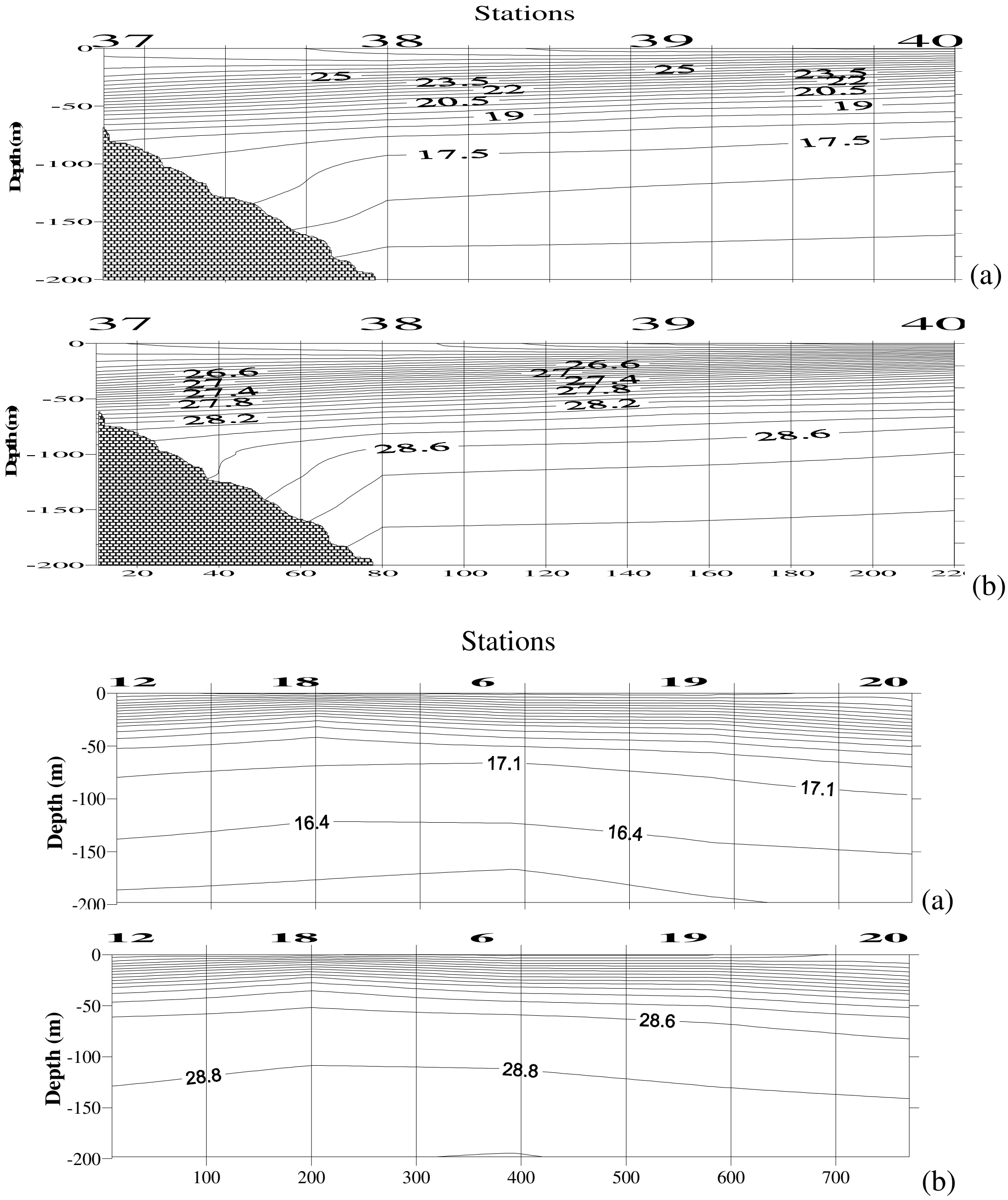


Figure 3.11. Cross-basin temperature (a) and density (b) profiles for transects including stations 18 and 40 (Figure 2.1) in July 2006.

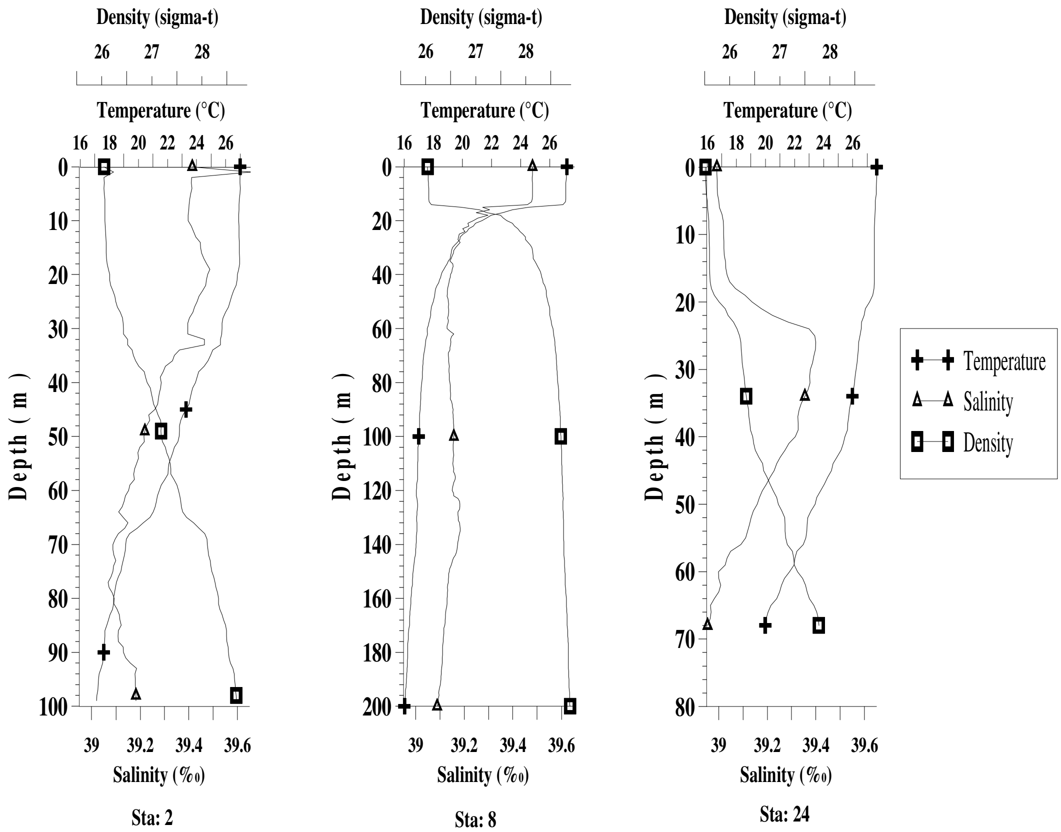


Figure 3.12. Temperature, salinity, and density profiles at station 2 (shelf, Figure 2.1), 8 (offshore, Figure 2.1) and 24 (central İskenderun Bay, Figure 2.1) in July 2006.

3.1.3.2. Salinity distribution at surface waters

Salinity varied in the range 38.3 - 39.53 psu at surface waters., with a lowest level recorded at station 55 and a highest at station 48 (Figure 2.1) in July (Figure 3.13). The average surface salinity was 39.32 psu. River impact is most pronounced in between Seyhan and Ceyhan Rivers as well as in the shallower, inner İskenderun Bay. Almost no change in surface salinity is observed near Göksu River.

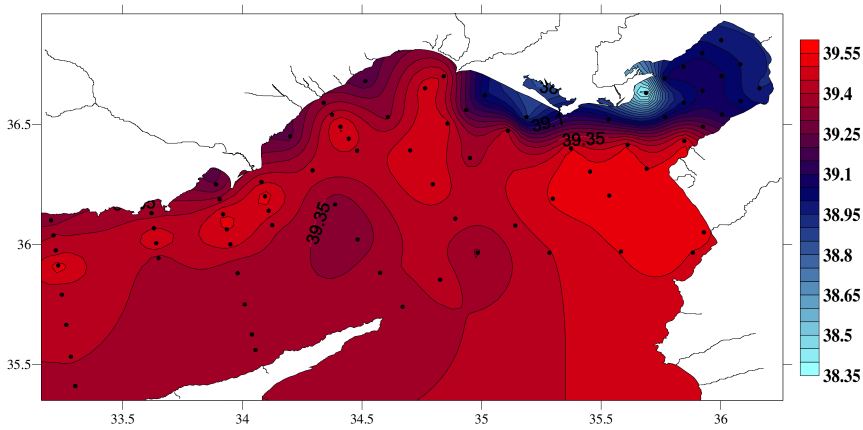


Figure 3.13. Surface salinity (psu) distribution (from the CTD data) in the Cilician basin in July 2006.

3.1.4. January 2007

During this month, total 77 stations were visited and the CTD data were collected from the surface to near bottom at all stations. Surface temperature was also recorded real time, by Turner fluorometer along the ship track, throughout the cruise.

3.1.4.1. Temperature distribution at surface waters

The basins' waters surface temperature ranged between 16.34 - 17.66 ^{o}C, being lowest at station 69 and highest at station 76 (Figure 2.1) during January 2007 (Figure 3.14). The average surface temperature was 16.96 ^{o}C. Intrusion of relatively warmer water near the Syrian border towards the mid basin is clearly seen also from the figure. Cold waters mostly occupied the inner bays and the coastline between Seyhan and Ceyhan Rivers. Cold water is also formed at offshore areas between Cyprus and Turkey to the west. Similar features are also observed in continuous surface temperature plots along the cruise track (Figure 3.15). Cross-stations hydrographic sections indicate downwelling at stations 6, 7-8, 30-31, 76 and 34 (Figure 2.1) and upwelling at offshore stations 49-50, 32-33, 35-36 (Figure 2.1) between Turkey and Cyprus and at station 75 (Figure 3.16).

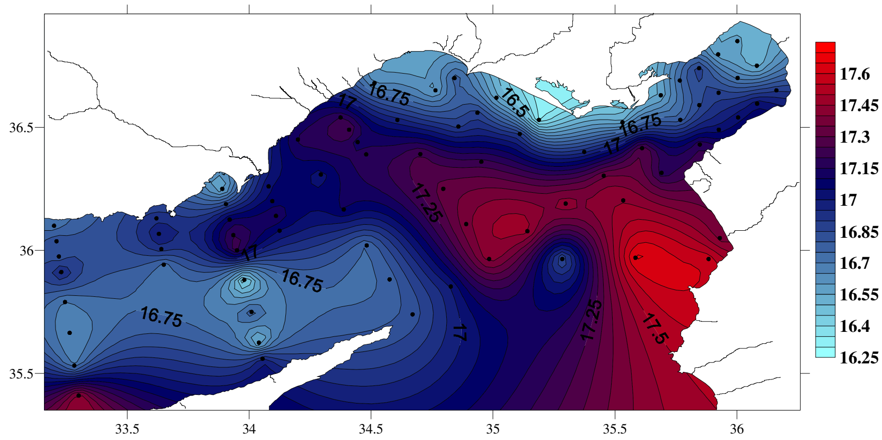


Figure 3.14. Surface temperature (°C) distribution (from the CTD data) in the Cilician basin in January 2007.

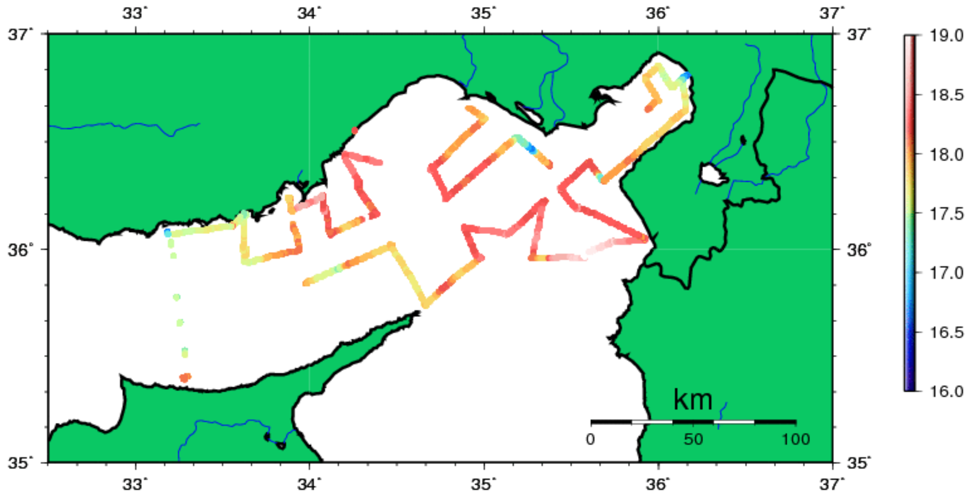


Figure 3.15. Surface temperature (°C) distribution (from the fluorometer data) in the Cilician basin in January 2007.

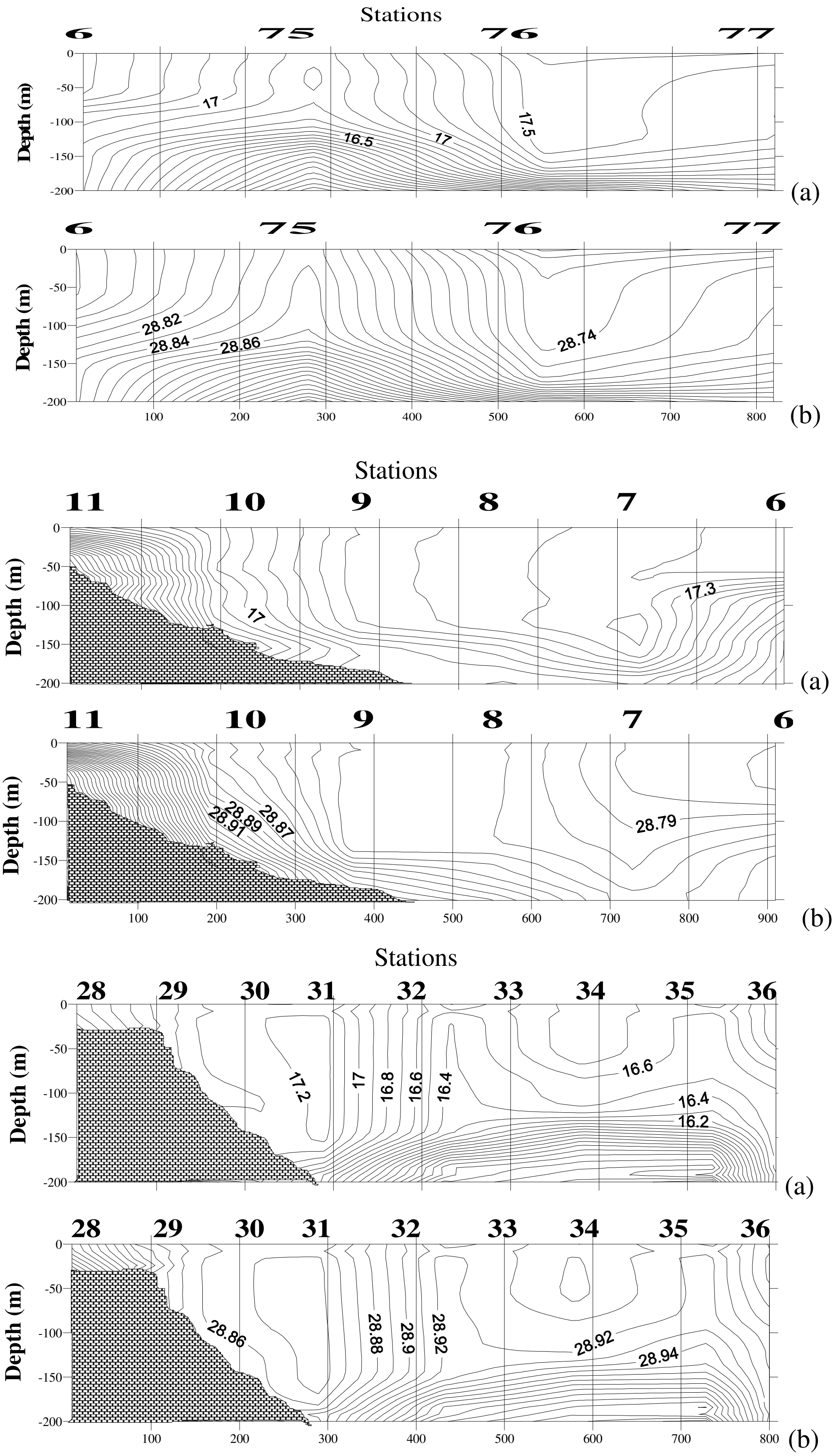


Figure 3.16. Cross-basin temperature (a) and density (b) profiles for transects including stations 6, 7-8, 30-31, 49-50, 32-33 and 35-36 (Figure 2.1) in January 2007.

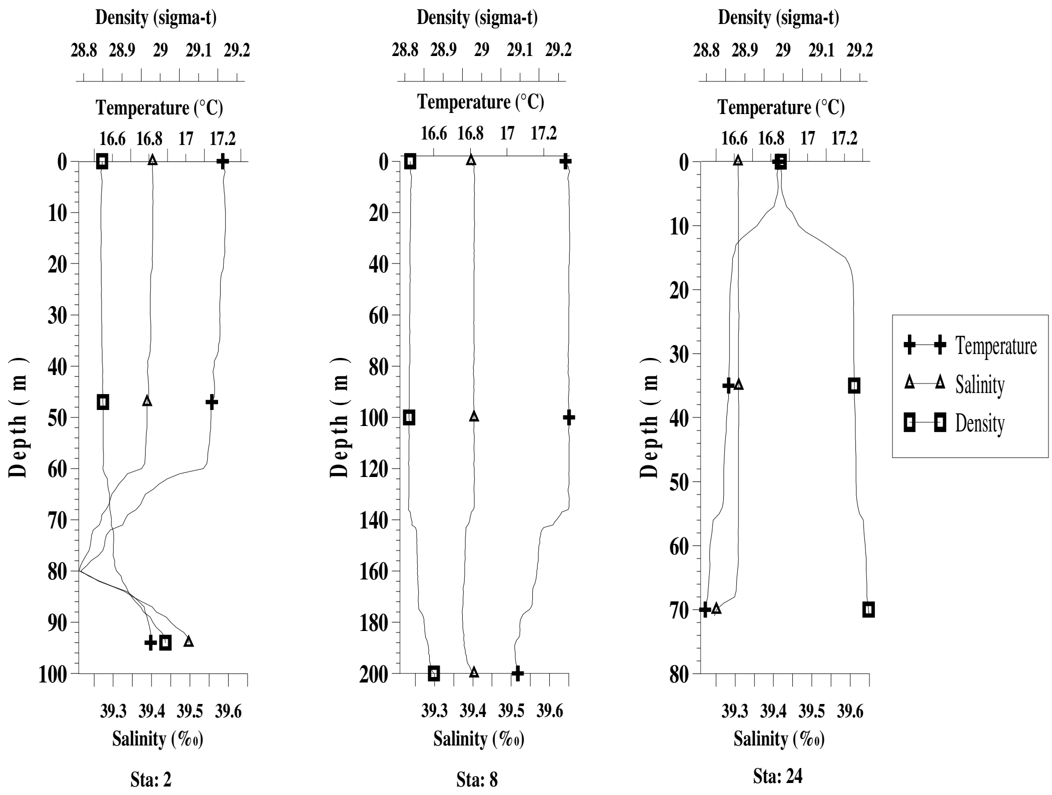


Figure 3.17. Temperature, salinity, and density profiles at station 2 (shelf, Figure 2.1), 8 (offshore, Figure 2.1) and 24 (central İskenderun Bay, Figure 2.1) in January 2007.

Depth of thermocline differ between regions. In the shelf region off Erdemli (station 2) (Figure 2.1), the surface mixed layer extended from surface to a depth of 60 m. Underneath the thermocline formed between 60-80 m depth. Surface mixed layer was very thin (about top 10 meters) at the mid station 24 (Figure 2.1) in İskenderun Bay. Below it a pronounced thermocline is observed between 10-15 m depths. Below thermocline temperature continued to decrease slightly towards bottom. Almost no significant changes in any of the parameters are observed at the top 170 m in the offshore station 7. A significant change in parameters is observed below 170 m towards bottom (Figure 3.17).

3.1.4.2. Salinity distribution at surface waters

During this period an decrease in surface salinity from near shore to offshore is observed in the basin (Figure 3.18). Salinity varied in the range 39.18 - 39.64 psu at the surface, with a lowest level recorded at station 78 and highest at station 55

(Figure 2.1). The average surface salinity was 39.40 psu. The inner shallower part of the İskenderun Bay to the west had much higher salinities compared to the rest.

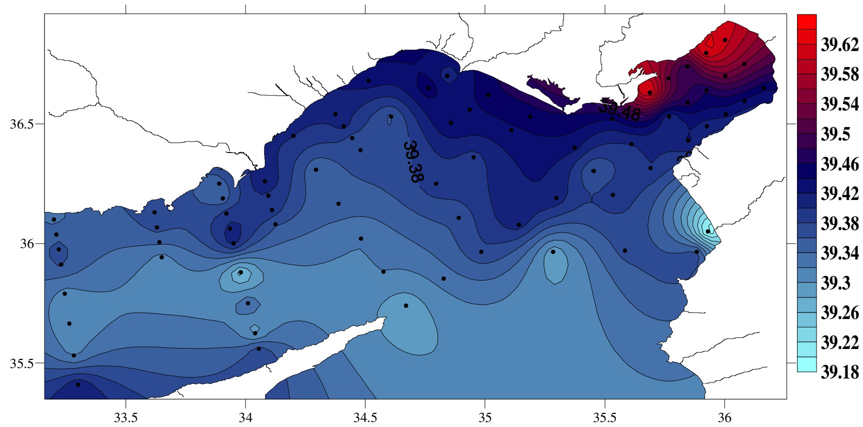


Figure 3.18. Surface salinity (psu) distribution (from the CTD data) in the Cilician basin in January 2007.

3.1.5. March 2007

Total 74 stations were visited during this month and the CTD data were collected from the surface to near bottom at all of them. Surface temperature and chlorophyll data were also recorded real time, by Turner fluorometer along the ship track, throughout the survey.

3.1.5.1. Temperature distribution at surface waters

Patches of warm water are formed in both bays and in the mid-basin (Figure 3.19). Presence of colder and less saline surface waters in the vicinity of Ceyhan River indicate increasing amounts of freshwater discharge to the basin during March. This is also clearly seen from the continuous surface temperature plots derived from the in situ fluorometer surface temperature readings (Figure 3.20). Surface temperature ranged between 16.13 - 17.68 ^{o}C, being lowest at station 1 and highest at station 73 (Figure 2.1). in the area. The average surface temperature was 16.86 ^{o}C. Cold water is also formed at offshore stations 33, 34 and 35. Cross-station hydrographic sections indicate an upwelling in this area and downwelling at stations 8, 9 and 30 (Figure 2.1) (Figure 3.21). Thermocline was observed in between 5 to 15 m in the shelf station #2 off Erdemli, in between 5-8 m in the mid station #24 in the İskenderun Bay and finally at around 20 m depth in the offshore station # 8 (Figure 2.1)located in the mid basin (Figure 3.22).

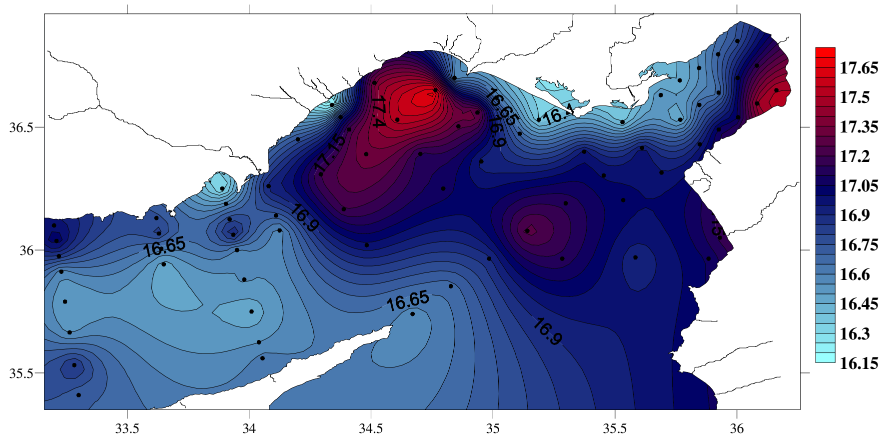


Figure 3.19. Surface temperature (°C) distribution (from the CTD data) in the Cilician basin in March 2007.

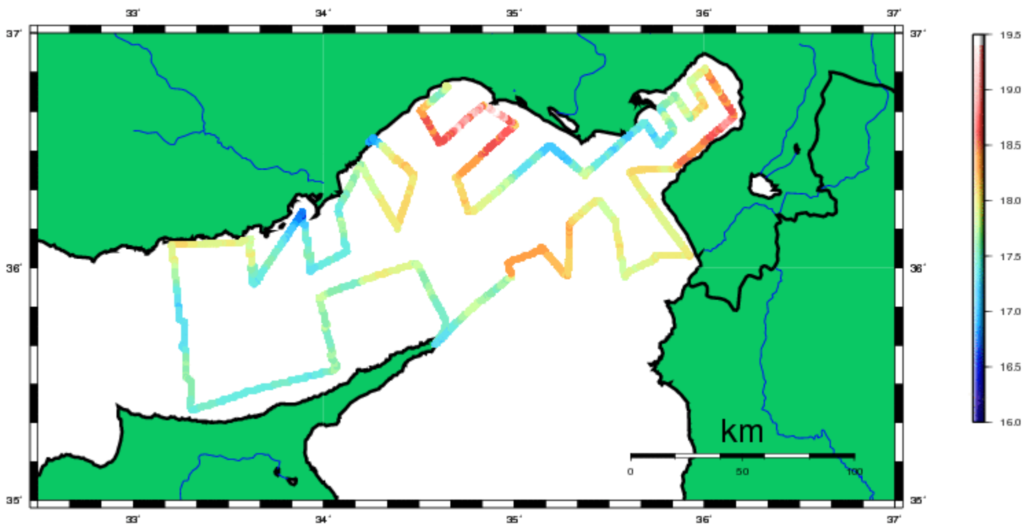


Figure 3.20. Surface temperature (°C) distribution (from the fluorometer data) in the Cilician basin in March 2007.

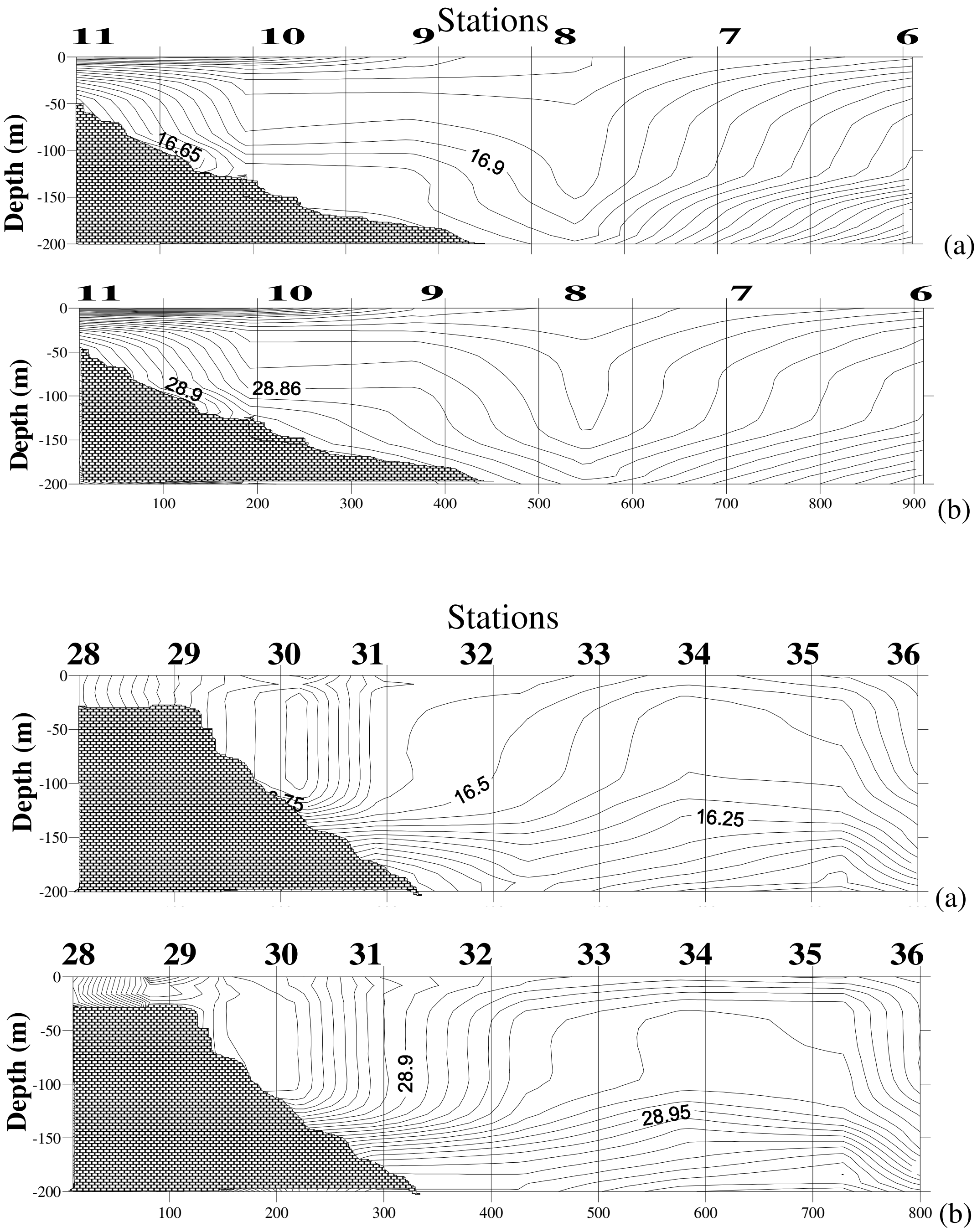


Figure 3.21. Cross-basin temperature and density profiles for transects including stations 8, 9 30 and 33-34-35 (Figure 2.1) in March 2007.

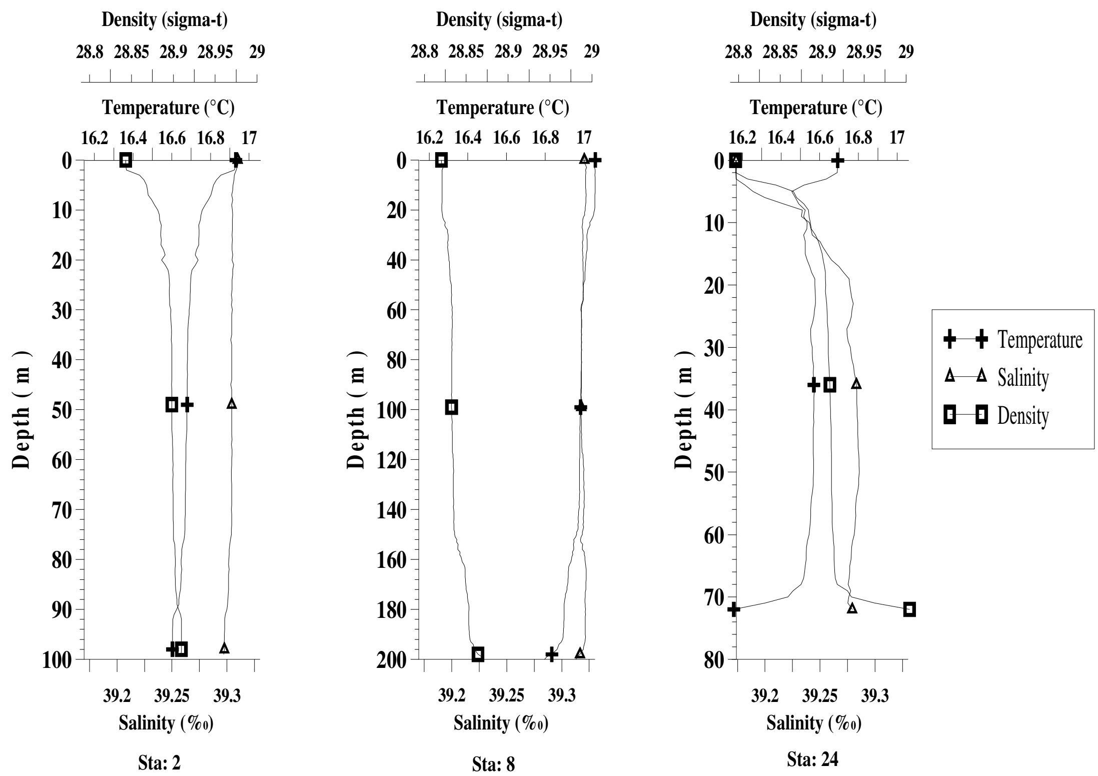


Figure 3.22. Temperature, salinity, and density profiles at station 2 (shelf, Figure 2.1), 8 (offshore, Figure 2.1) and 24 (central İskenderun Bay, Figure 2.1) in March 2007.

3.1.5.2. Salinity distribution at surface waters

Salinity varied in the range 38.70 - 39.35 psu at the surface, with a lowest level recorded at station 23 and a highest at station 15 (Figure 2.1) in March (Figure 3.23). The average surface salinity was 39.24 psu. Impact of increased freshwater input from the Ceyhan River is highly pronounced in this figure. Same is true for the Lamas River inflow area. In offshore waters surface salinity was measured slightly higher in the east compared to the west.

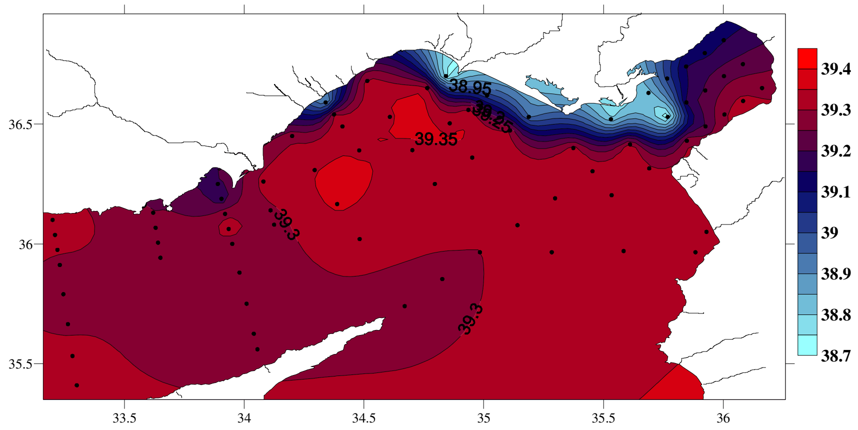


Figure 3.23. Surface salinity (psu) distribution (from the CTD data) in the Cilician basin in March 2007.

3.1.6. April 2007

CTD data from the surface to near bottom were collected at total 72 stations during this month. Surface temperature and chlorophyll were also recorded real time, by Turner fluorometer along the ship track, throughout the cruise.

3.1.6.1. Temperature distribution at surface waters

Decrease in surface temperature from near shore to offshore is clearly illustrated in Figure 3.24. Colder surface water occupied the western part of the study area. Surface temperature ranged between 17.14 - 19.27 ^{o}C, being lowest at station 36 and highest at station 74 (Figure 2.1). The average surface temperature was 17.82 ^{o}C. Highest temperatures are recorded in both bays (Figure 3.25). Cold water formation at surface is observed at station 7 (Figure 2.1). Cross-shore (basin) temperature and density profiles indicate an upwelling at this station (Figure 3.26). Thermocline was observed at around 40 m depth in the shelf station #2 and at near surface both in mid-İskenderun (Sta. 24) and offshore station #8 (Figure 2.1), (Figure 3.27). A second deep (90 m) temperature gradient is also observed in the offshore station.

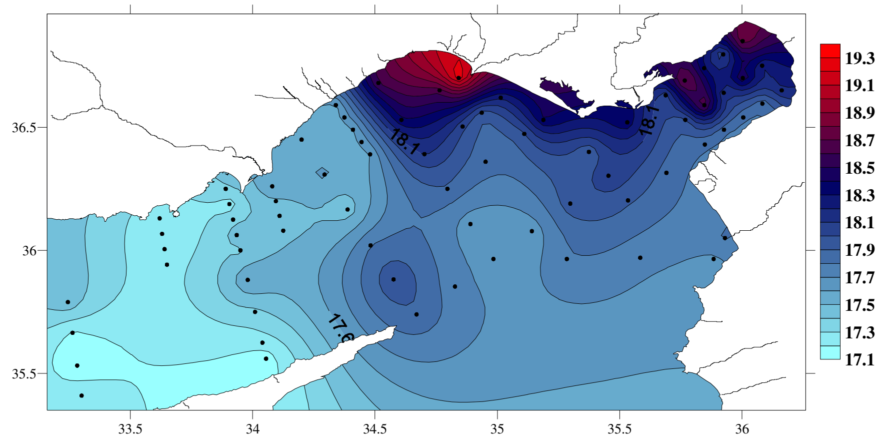


Figure 3.24. Surface temperature (°C) distribution (from the CTD data) in the Cilician basin in April 2007.

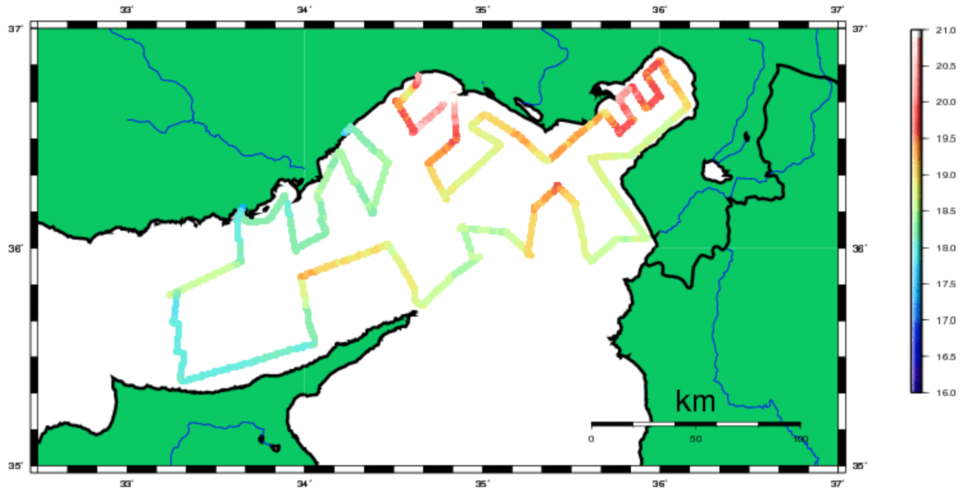


Figure 3.25. Surface temperature (°C) distribution (from the fluorometer data) in the Cilician basin in April 2007.

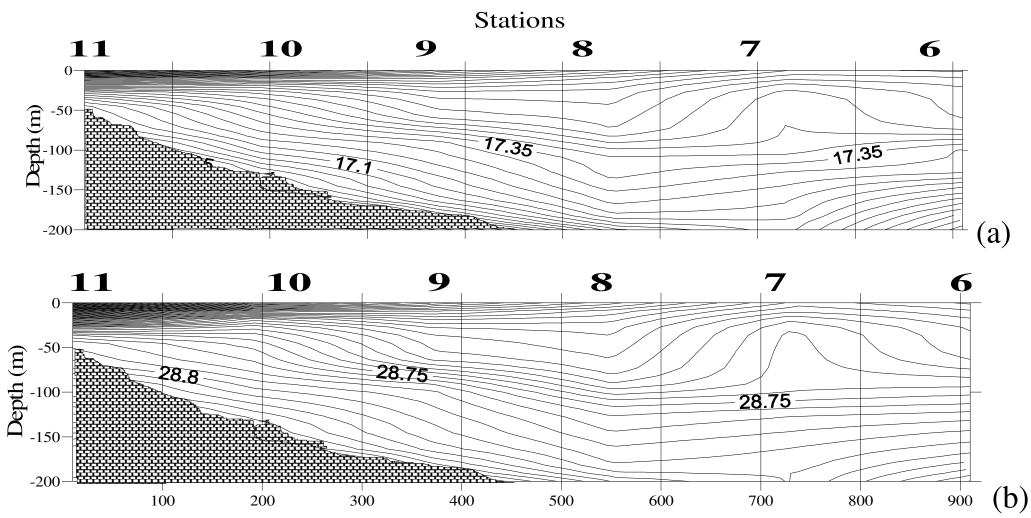


Figure 3.26. Cross-basin temperature (a) and density (b) profiles for transects including station 7 in April 2007.

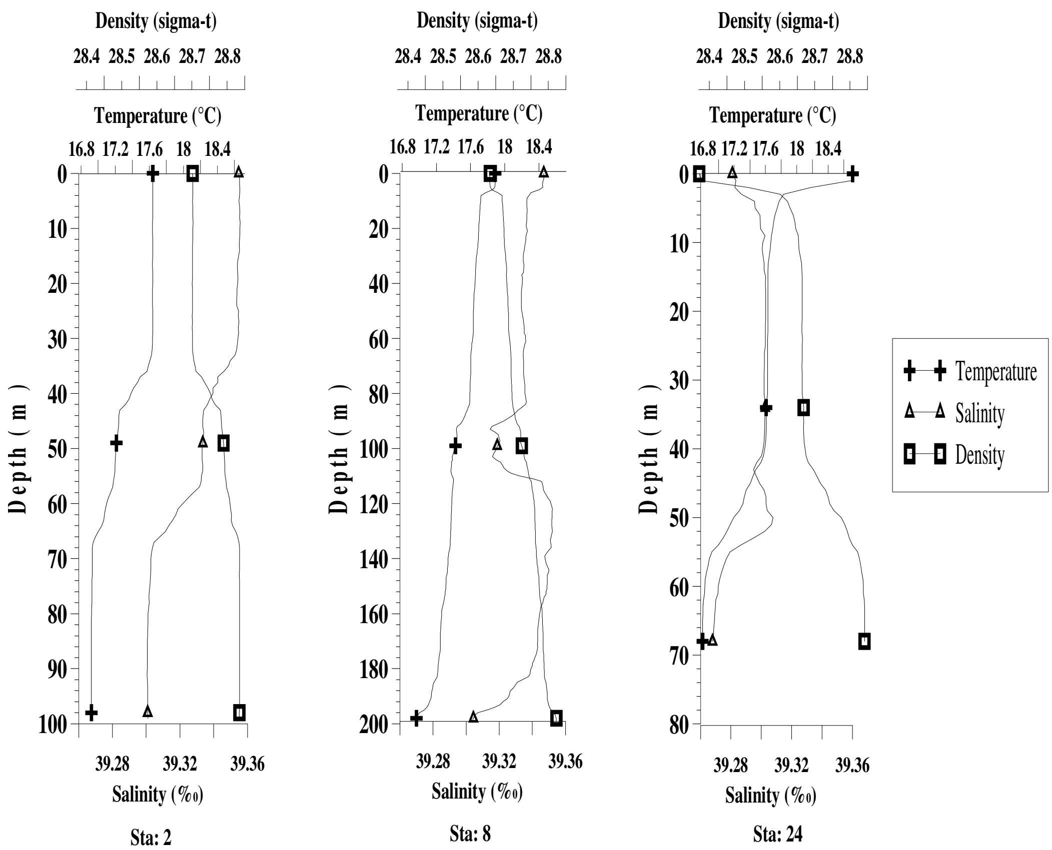


Figure 3.27. Temperature, salinity, and density profiles at station 2 (shelf, Figure 2.1), 8 (offshore, Figure 2.1) and 24 (central İskenderun Bay, Figure 2.1) in April 2007.

3.1.6.2. Salinity distribution at surface waters

Salinity varied in the range 38.48 - 39.36 psu at the surface, with a lowest level recorded at station 74 and a highest at station 10 (Figure 2.1) in April. The average surface salinity was 38.6 psu. An increase in surface salinity towards offshore is observed in the basin. Areas receiving direct River discharge hold less saline and warmer surface waters. The magnitude of variation in salinity with the surrounding waters is most pronounced near Seyhan River drainage area (Figure 3.28).

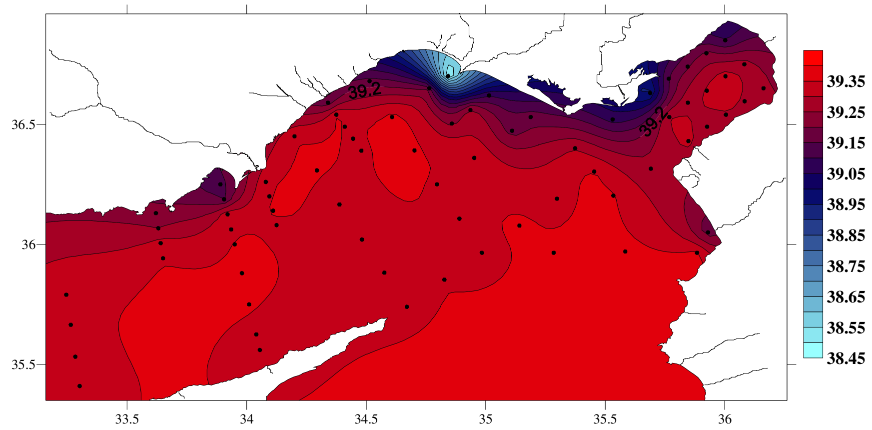


Figure 3.28. Surface salinity (psu) distribution (from the CTD data) in the Cilician basin in April 2007.

3.1.7. June 2007

During this month, total 78 stations (Figure 2.1) were visited and the CTD data were collected from the surface to near bottom at all stations. Surface temperature was also recorded real time, by Turner fluorometer along the ship track, throughout the cruise.

3.1.7.1. Temperature distribution at surface waters

Patches of warm and cold water are observed during June in the basin. It is clearly seen from the Figure 3.29 that warmer surface water occupy the eastern part of the study area. It got colder in the westernmost near shore and offshore regions (Figure 3.30). Cold water is also formed in the entrance of the İskenderun Bay. Surface temperature ranged between 24.87 - 27.84 ^{o}C, being lowest at station 17 and highest at station 65 (Figure 2.1) in the area. The average surface temperature was 26.47 ^{o}C. Cross-station hydrographic sections indicated upwelling event taking place at station 22 (Figure 3.31). Formation of a permanent thermocline is not observed neither at shelf nor offshore stations (Figure 3.32). However a gradual warming of the water column is observed at all stations.

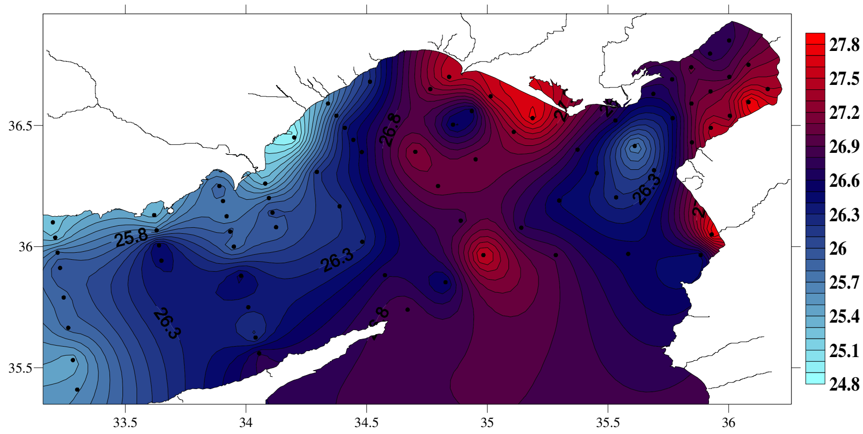


Figure 3.29. Surface temperature (°C) distribution (from the CTD data) in the Cilician basin in June 2007.

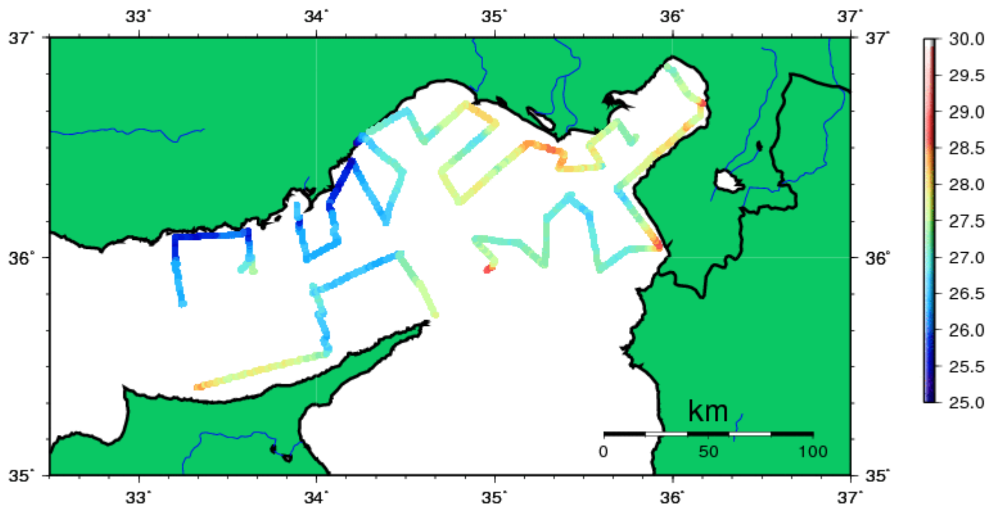


Figure 3.30. Surface temperature (°C) distribution (from the fluorometer data) in the Cilician basin in June 2007.

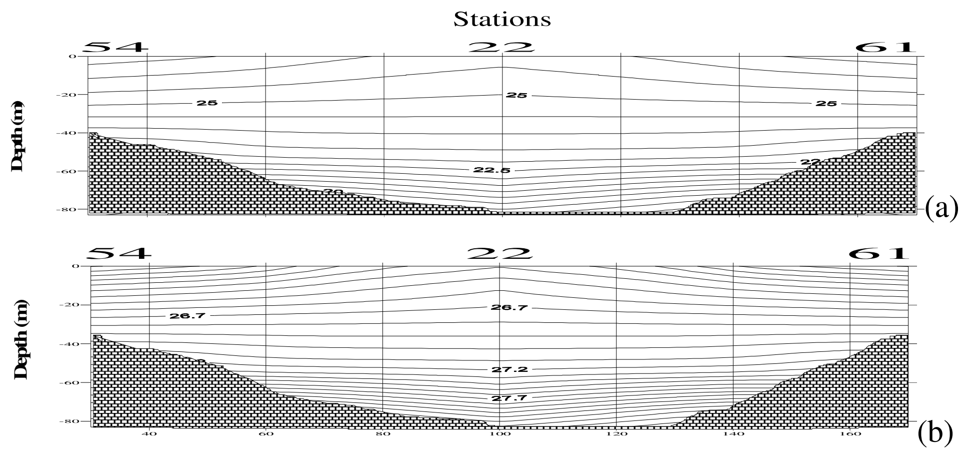


Figure 3.31. Cross-basin temperature (a) and density (b) profiles for transects including station 22 (Figure 2.1) in June 2007.

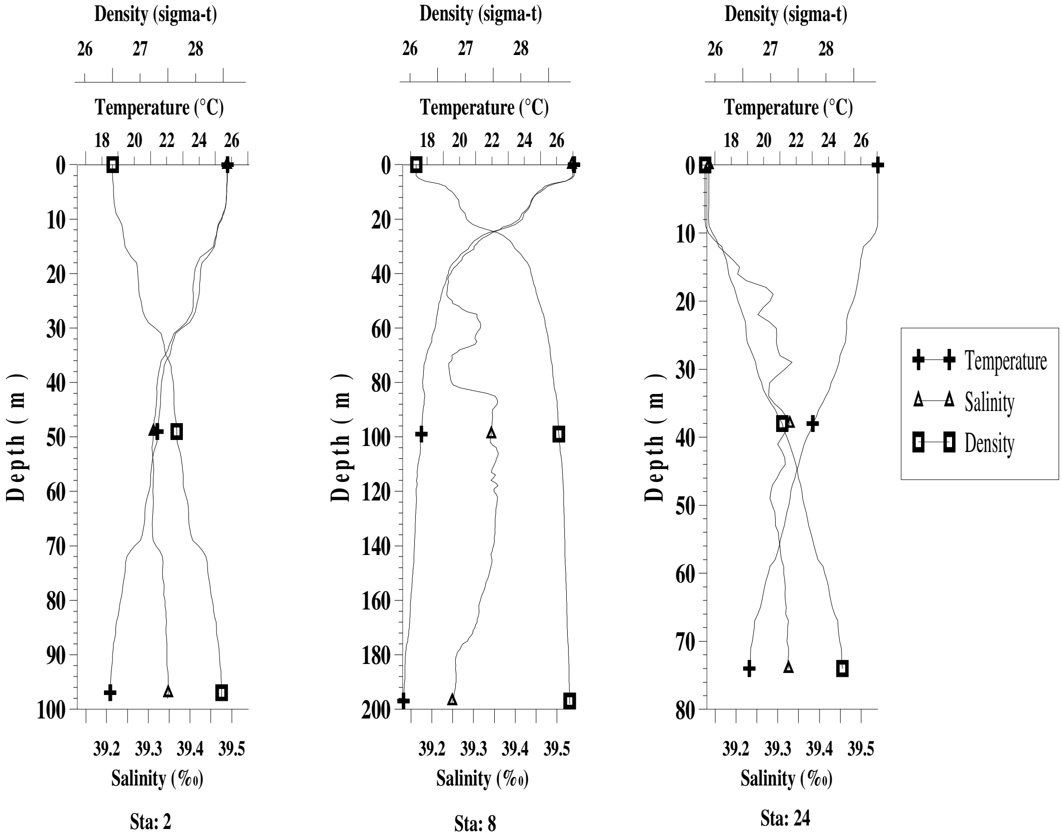


Figure 3.32. Temperature, salinity, and density profiles at station 2 (shelf, Figure 2.1), 8 (offshore, Figure 2.1) and 24 (central İskenderun Bay, Figure 2.1) in June 2007.

3.1.7.2. Salinity distribution at surface waters

Salinity varied in the range 38.82 - 39.69 psu at the surface, with a lowest level recorded at station 74 and a highest at station 61(Figure 2.1) in June. The average surface salinity was 39.39 psu. Impact of freshwater input from the Seyhan, Ceyhan and Göksu Rivers are highly pronounced in the Figure 3.33.

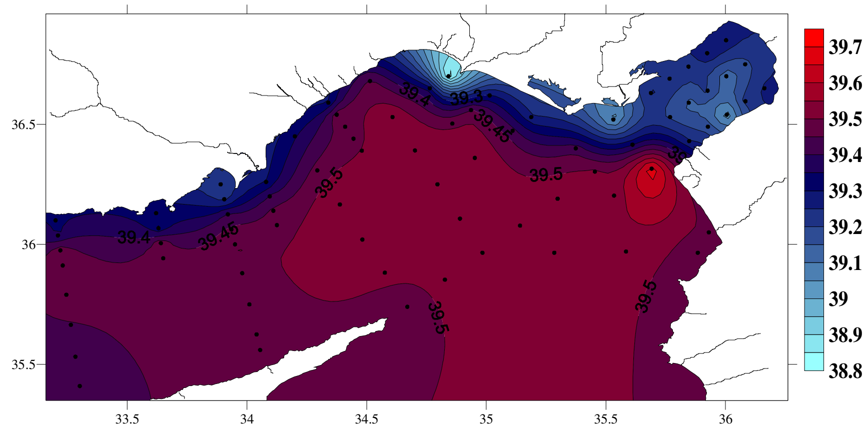


Figure 3.33. Surface salinity (psu) distribution (from the CTD data) in the Cilician basin in June 2007.

3.1.8. September 2007

In addition to CTD casts performed at total 77 stations (Figure 2.1) continuous surface temperature and chlorophyll data were also collected by means of a field fluorometer along the ship track throughout the cruise.

3.1.8.1. Temperature distribution at surface waters

At first glance, an increase in surface temperature from west to east with two adjacent central warm and cold eddies is observed in the basin (Figures 3.34 and 3.35). Surface temperature ranged between 26.65 - 29.15 ^{o}C, being lowest at station 39 and highest at station 65 in the area. The average surface temperature was 27.91 ^{o}C. Thermocline is observed between 45-50 m depth ranges at the shelf (Sta. 2), and between 60-80 m at the offshore stations (Sta. 8). Instead of a thermocline, a deep (around 50 m) salinity gradient is observed in mid-İskenderun station # 24 (Figure 3.36). Surface mixed layer extended from surface to a depth of 30 m at Sta. 2, to 60 m at Sta. 8 and lastly to 50 m at Sta. 24. Cold water formation at surface is observed at stations 31, 32, 33, 39 and 40 (Figure 2.1). Cross-basin hydrographic sections indicate an upwelling at these stations (Figure 3.37). Warm water formation at surface is observed at stations 7, 8 and 9 (Figure 2.1).

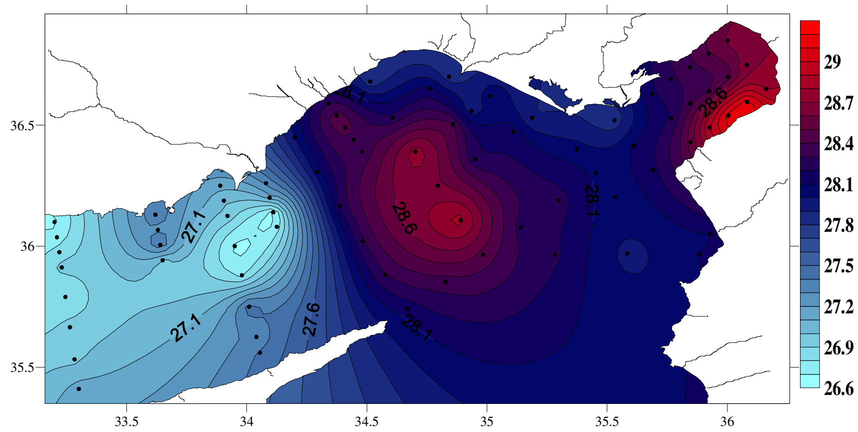


Figure 3.34. Surface temperature (^{o}C) distribution (from the CTD data) in the Cilician basin in September 2007.

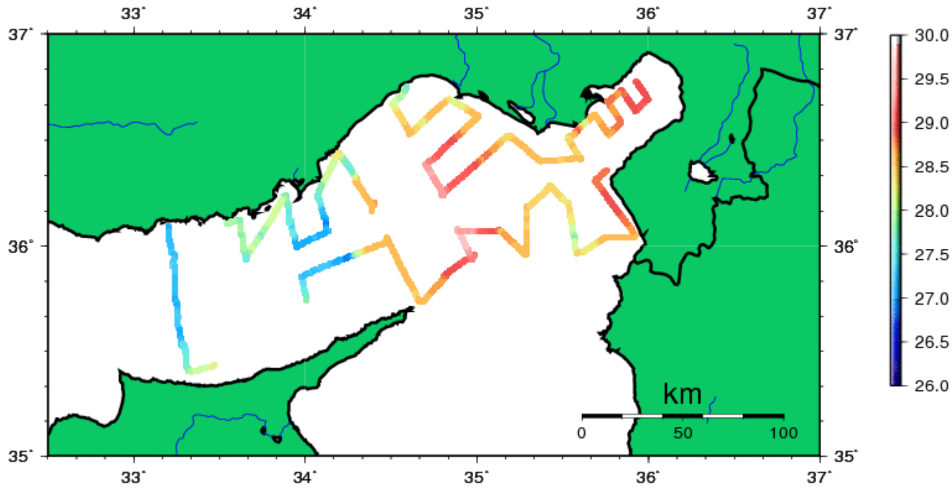


Figure 3.35. Surface temperature (^{o}C) distribution (from the fluorometer data) in the Cilician basin in September 2007.

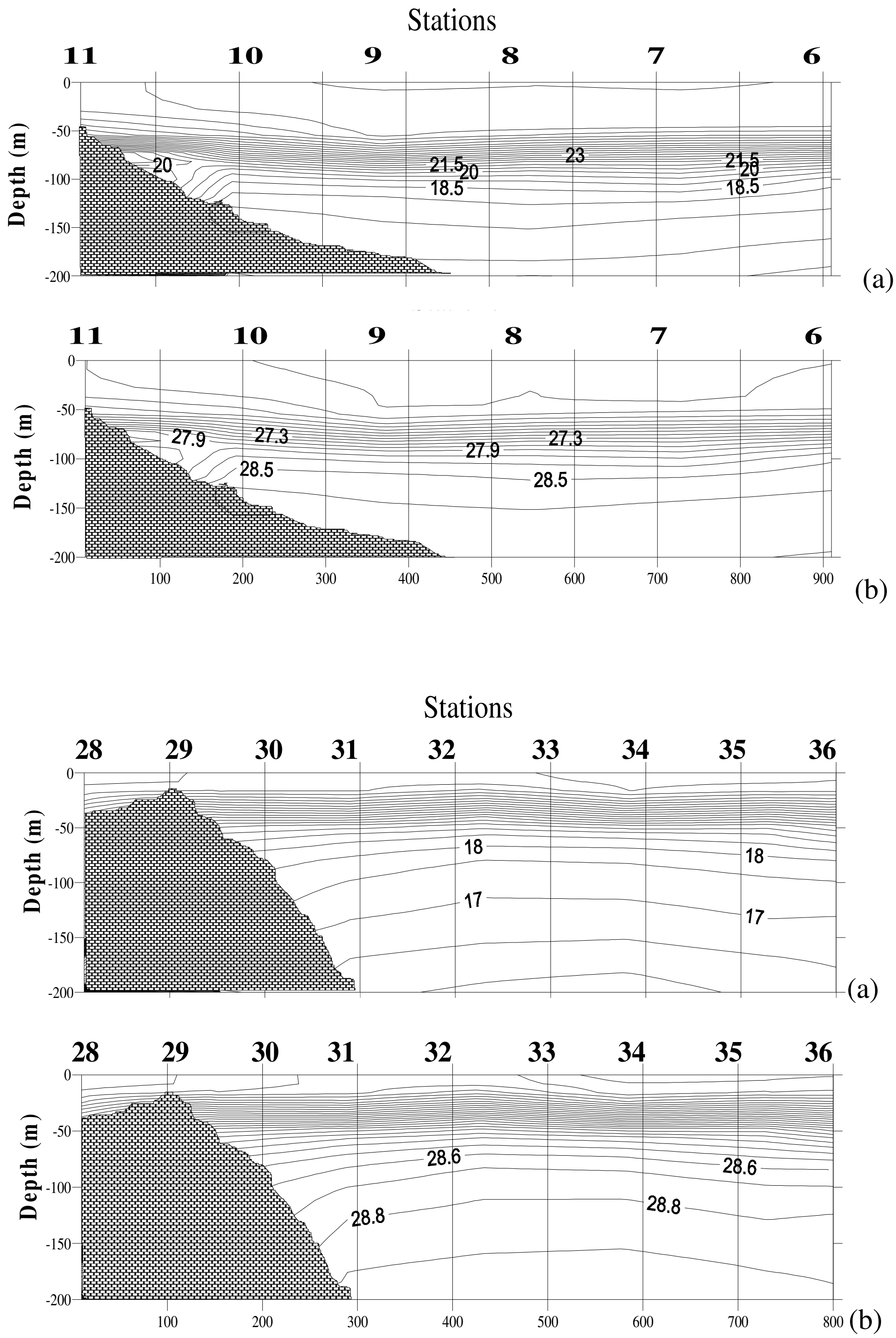


Figure 3.36. Cross-basin temperature (a) and density (b) profiles for transects including stations 31, 32, 33, 39 and 40 (Figure 2.1) in September 2007.

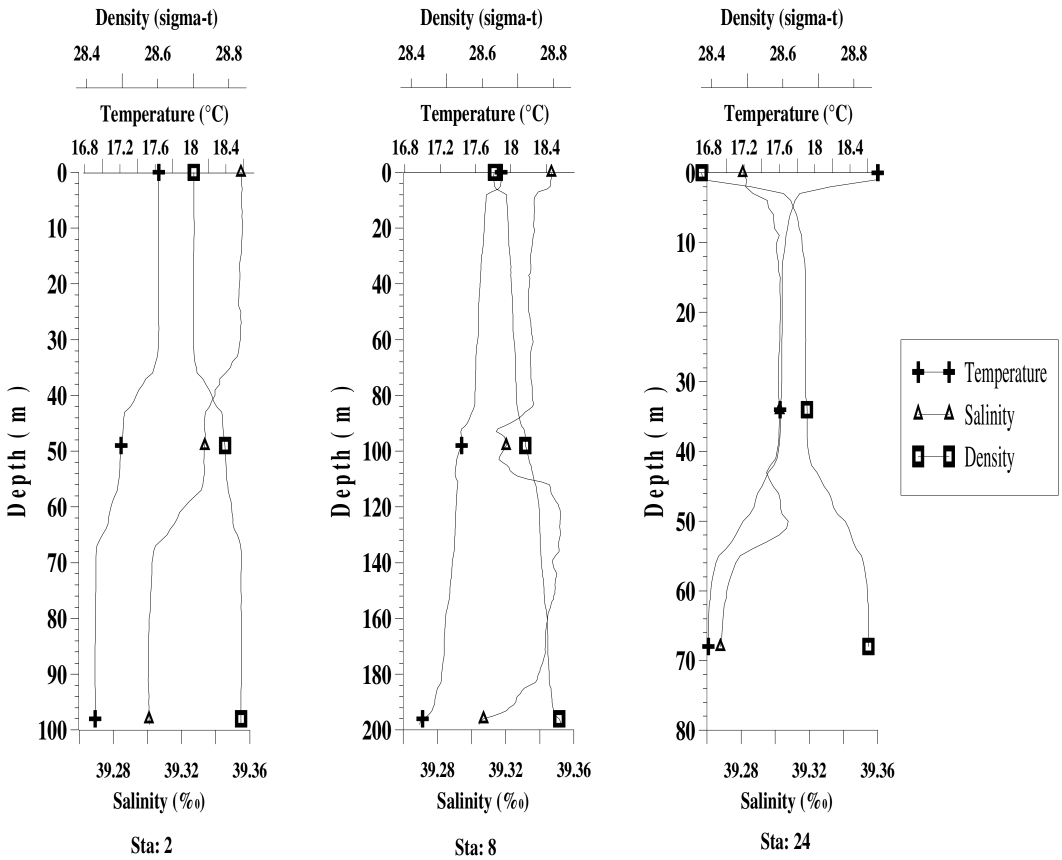


Figure 3.37. Temperature, salinity, and density profiles at station 2 (shelf, Figure 2.1), 8 (offshore, Figure 2.1) and 24 (central İskenderun Bay, Figure 2.1) in September 2007.

3.1.8.2. Salinity distribution at surface waters

Salinity varied in the range 38.62 - 39.73 psu at the surface, with a lowest level recorded at station 54 and a highest at station 33 (Figure 2.1) in September (Figure 3.38). The average surface salinity was 39.56 psu. Impact of freshwater input from the Ceyhan River is highly pronounced in the Figure 3.4. Same is true for the Seyhan River inflow area (near station 74).

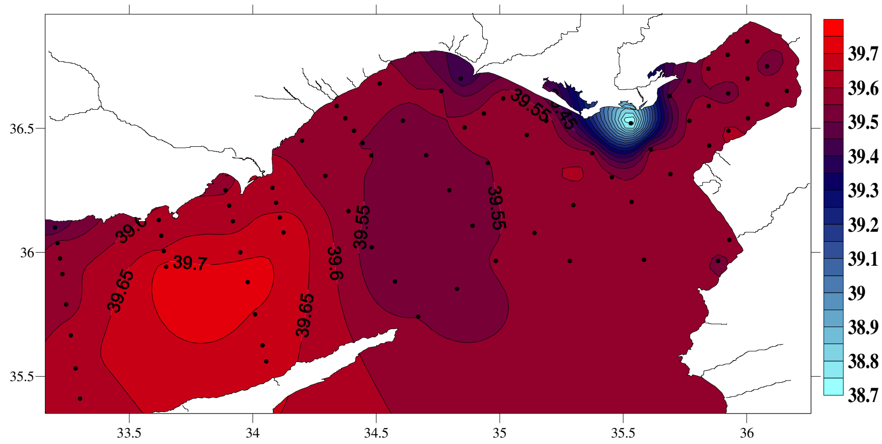


Figure 3.38. Surface salinity (psu) distribution (from the CTD data) in the Cilician basin in September 2007.

3.2. Chemical parameters

Changes in nutrient concentrations (nitrate+nitrite, reactive silicate, phosphate and total phosphorus) at surface with time in the basin are described in this section.

3.2.1. November 2005

Surface nutrient concentrations were measured at total 42 stations except for the total phosphorus measurements made only at 20 stations.

3.2.1.1. Nitrate+nitrite distribution at surface waters

Surface nitrate+nitrite concentration varied in the range 0.05-3.27 µM with an average surface concentration of 0.615 µM in the area. To a maximum concentration was reached near Ceyhan River (station 54, Figure 3.39). Both the western shelf and offshore regions were devoid of nitrate-nitrite compared to the high levels measured in Mersin and İskenderun Bays. Coastal areas supplied by River input held much higher concentrations. However, not even a slight increase is observed in the vicinity of the Göksu River drainage area.

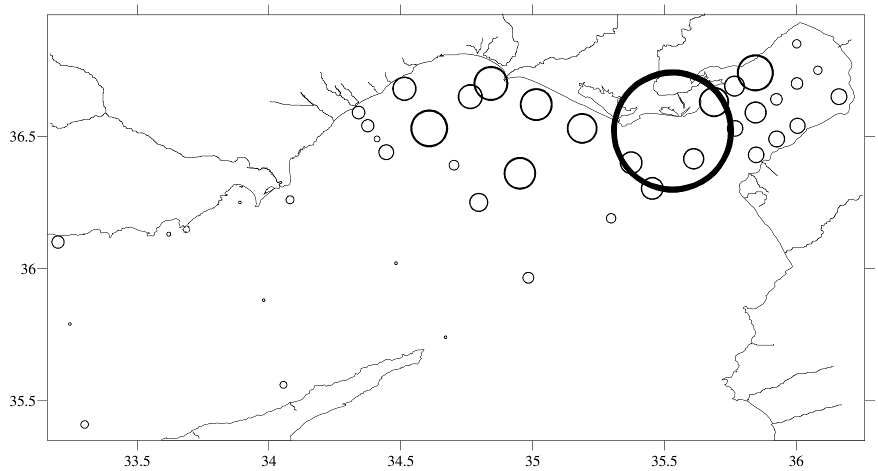


Figure 3.39. Surface nitrate-nitrite distribution in the Cilician basin in November 2005.

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3.2.1.2. Silicate distribution at surface waters

Surface silicate concentrations ranged between 1.16 - 7.3 µM at surface (Figure 3.40). Similar to nitrate-nitrite, maximum concentration was again measured at station 54 (Figure 2.1). The surface average for this period was 1.92 µM. Coastal areas as well as the entire İskenderun Bay seemed to hold relatively higher concentrations compared to offshore waters.

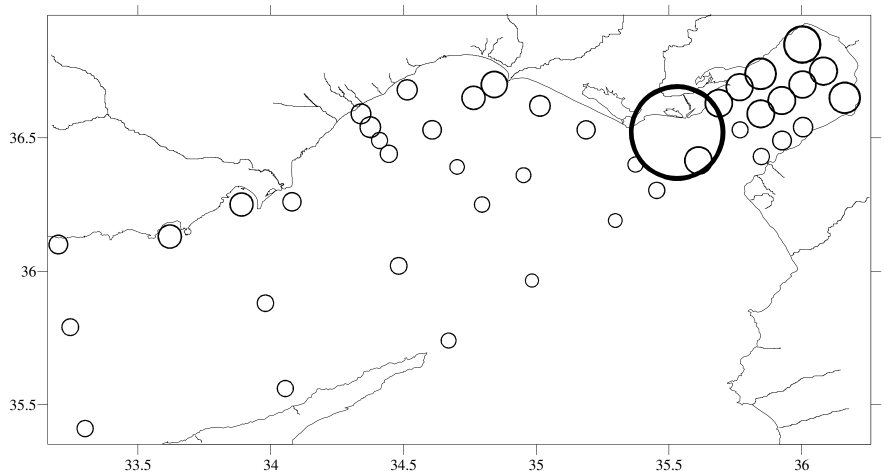

Figure 3.40. Surface silicate distribution in the Cilician basin in November 2005.

3.2.1.3. Phosphate distribution at surface waters

Surface phosphate concentration ranged between 0.02 - 0.09 µM in the area (Figure 3.41). Much higher concentrations were observed in the near shore areas. Highest concentration was measured in the shallower eastern corner of the İskenderun Bay (station 66) (Figure 2.1). Central parts of the study area were almost devoid of phosphate.

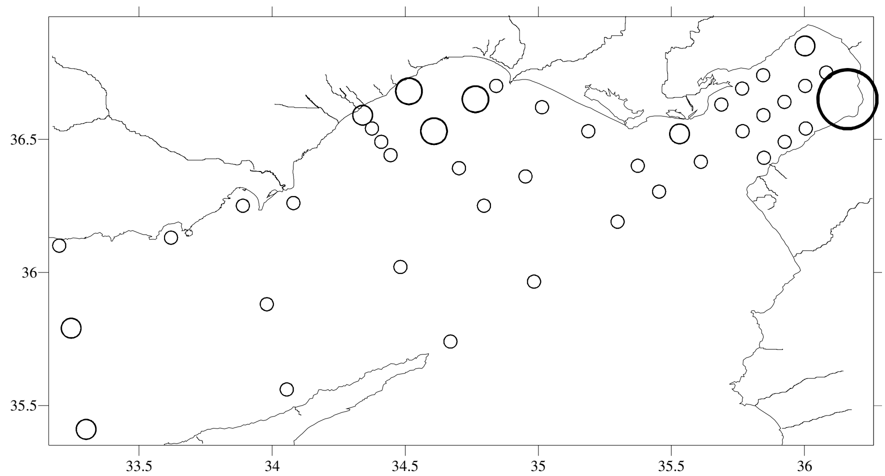

Figure 3.41. Surface phosphate distribution in the Cilician basin in November 2005.

3.2.1.4. Total phosphorus distribution at surface waters

Total phosphorus concentrations ranged between 0.068 - 0.586 µM at the surface (Figure 3.42). Maximum value was attained at Sta. 57 (Figure 2.1). Similar to phosphate, offshore surface waters were low in total phosphorus content. Concentrations peaked near River mouths.

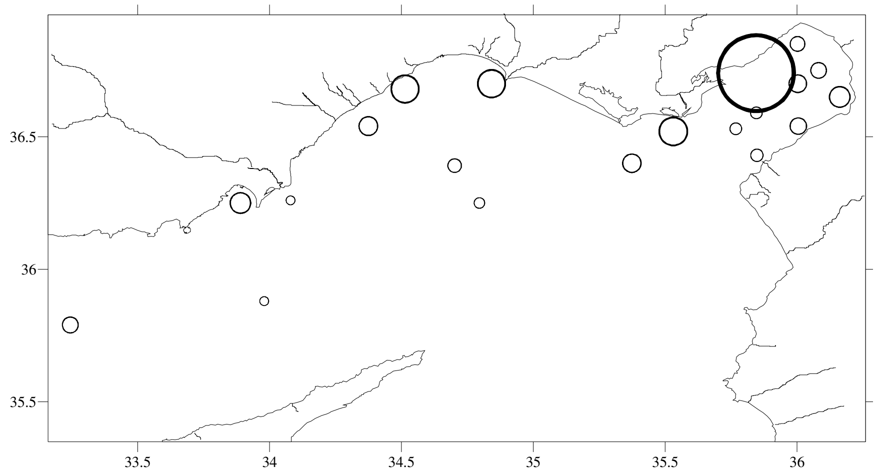

Figure 3.42. Surface total phosphorus distribution in the Cilician basin in November 2005.

3.2.2. March 2006

Except total phosphorus (measured only at 18 stations (Figure 2.1)) rest of the nutrients were measured at total 40 stations. Surface minimum, maximum and average values for the basin waters will be evaluated below.

3.2.2.1. Surface nitrate+nitrite distribution in the basin

Surface nitrate+nitrite concentrations varied in the range 0.04 - 3.67 µM with an average surface concentration of 0.452 µM in the area. The maximum concentration was measured at station 54 located near Ceyhan River (Figure 3.43). Minimum concentrations are observed in the western half of the basin (station 14) including the inner Mersin Bay to the west. In the eastern part of the basin, coastal areas supplied by River input gained much higher concentrations. However, not even a slight increase is observed in the vicinity of the Göksu River drainage area as was the case during November 2005. The magnitude of variation in surface nitrate+nitrite concentrations in both sides of the İskenderun Bay is remarkable.

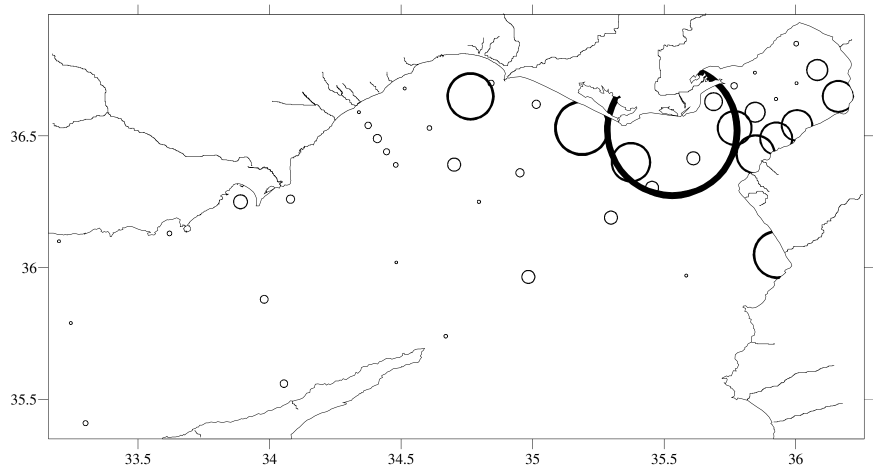

Figure 3.43 Surface nitrate-nitrite distribution in March 2006 in the basin.

3.2.2.2. Silicate distribution at surface waters

Silicate concentrations ranged between 0.32 - 6.54 µM at surface (Figure 3.44). Similar to nitrate-nitrite, maximum concentration was again measured at station 54. The surface average for this period was 1.8 µM. Coastal areas as well as the entire İskenderun Bay seemed to hold relatively higher concentrations compared to offshore waters.

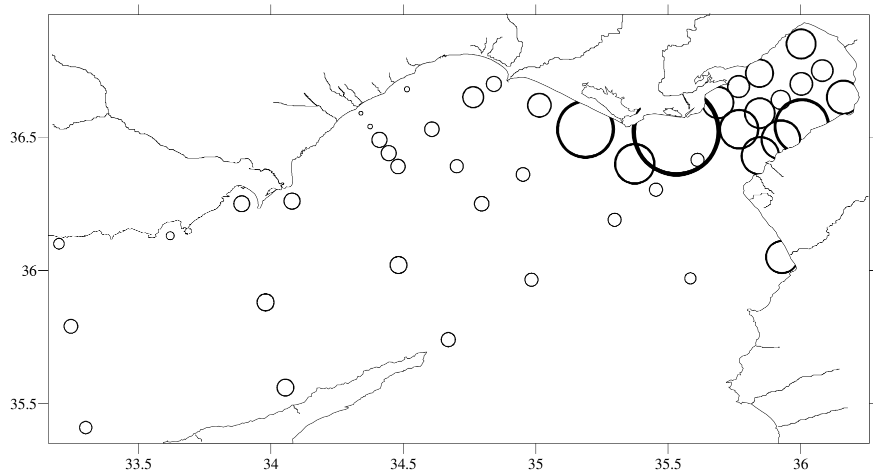

Figure 3. 44 Surface silicate distribution in the Cilician basin in March 2006.

3.2.2.3. Phosphate distribution at surface waters

Surface phosphate concentration ranged between 0.02 - 0.09 µM in the area (Figure 3.45). The highest value was measured at station 73 (Figure 2.1) near Seyhan River. Lowest concentrations are met in the western half of the basin as well as on both sides of the İskenderun Bay. Surface average for the basin was 0.024 µM. Some high values are recorded offshore Mersin.

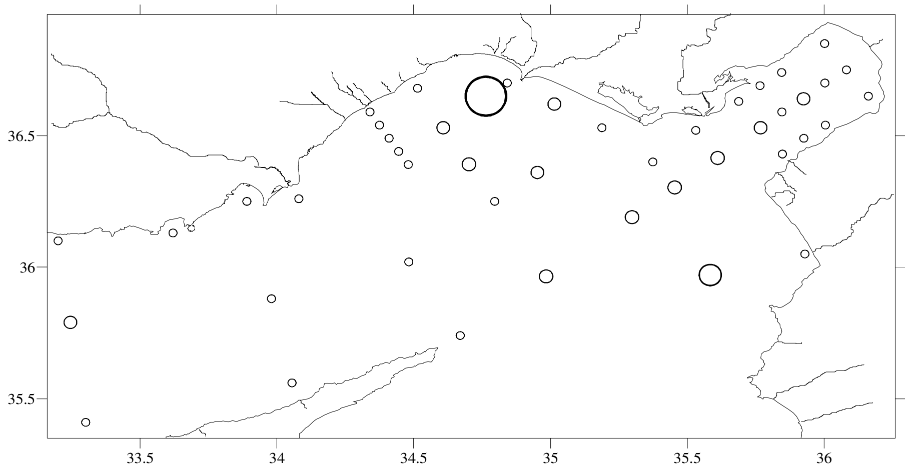

Figure 3.45 Surface phosphate distribution in the Cilician basin in March 2006.

3.2.2.4. Total phosphorus distribution at surface waters

Total phosphorus concentrations ranged between 0.073 - 0.529 µM at the surface waters (Figure 3.46). Maximum and minimum values are recorded at stations 74 and 23 respectively. Concentrations peaked near Seyhan River mouth and northwestern corner of the İskenderun Bay.

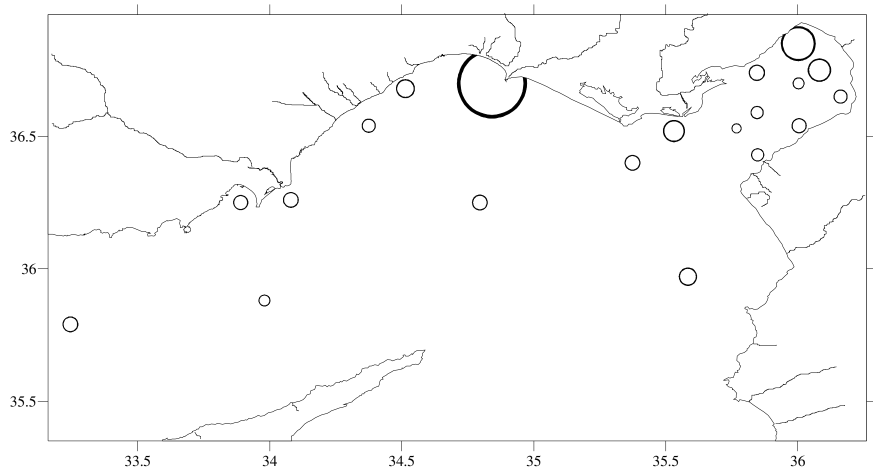

Figure 3.46. Surface total phosphorus distribution in the Cilician basin in March 2006.

3.2.3. July 2006

Except for total phosphorus (measured only at 19 stations (Figure 2.1)) rest of the nutrients were measured at total 44 stations.

3.2.3.1. Nitrate+nitrite distribution at surface waters

Surface nitrate+nitrite concentration varied in the range 0.05-2.97 µM with an average surface concentration of 0.26 µM in the area. To a maximum concentration was reached at station 55 (Figure 2.1) located near Ceyhan River (Figure 3.47). Minimum concentration was observed at station 52. Despite the elevated levels retained in the İskenderun Bay, much lower concentrations are observed in the inner Mersin Bay and in offshore waters.

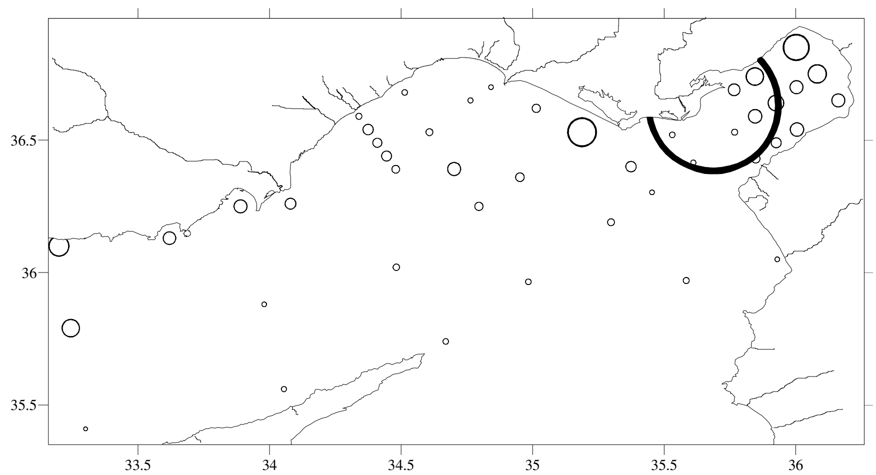

Figure 3.47. Surface nitrate-nitrite distribution in the Cilician basin in July 2006.

3.2.3.2. Silicate distribution at surface waters

Surface silicate concentrations varied in the range 0.42 to 4.69 µM in the basin (Figure 3.48). Similar to nitrate-nitrite, maximum concentration was again measured at station 55 (Figure 2.1). To a minimum concentration was met at station 67 (Figure 2.1). The surface average for this period was 1.09 µM. Coastal areas enriched by the River runoff as well as the entire İskenderun Bay seemed to hold relatively higher concentrations compared to offshore waters.

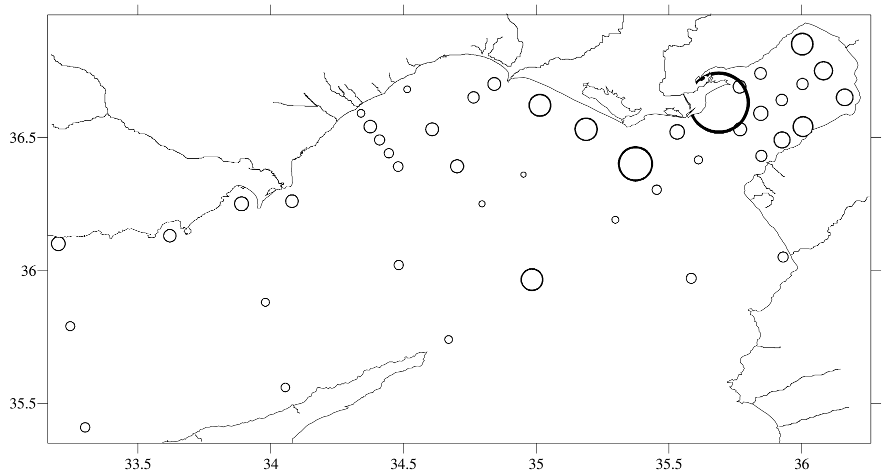

Figure 3.48. Surface silicate distribution in the Cilician basin in July 2006.

3.2.3.3. Phosphate distribution at surface waters

Phosphate concentration ranged between 0.02 - 0.03 μM at surface in the area (Figure 3.49). Relatively higher concentrations were observed at stations 2, 53, 76 and 74 (Figure 2.1). Phosphate levels yield almost a homogenous distribution in the basin.

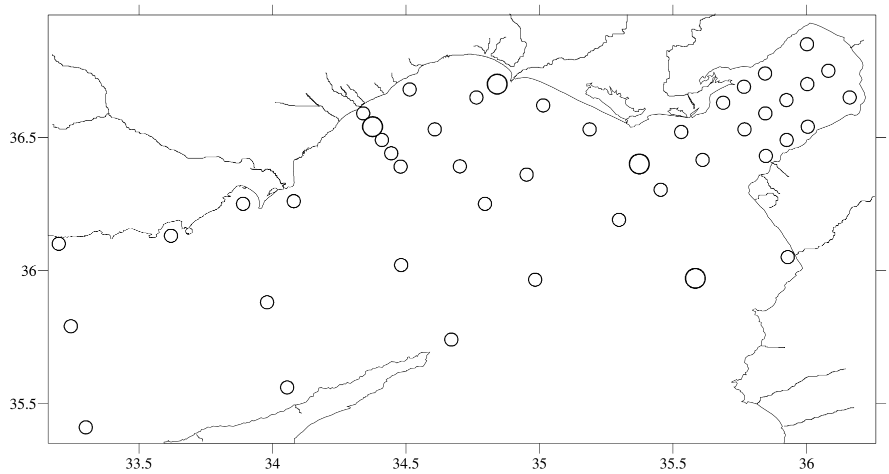

Figure 3.49. Surface phosphate distribution in the Cilician basin in July 2006.

3.2.3.4. Total phosphorus distribution at surface waters

Surface total phosphorus concentrations ranged from a low level of 0.06 to a maximum of 0.57 μM in the basin (Figure 3.50). Maximum values are recorded in the inner İskenderun Bay area (max at station 57). However concentrations measured in

Mersin Bay as well as those measured in the entrance to the İskenderun Bay was too low. Higher values are also recorded near Göksu River in the west.

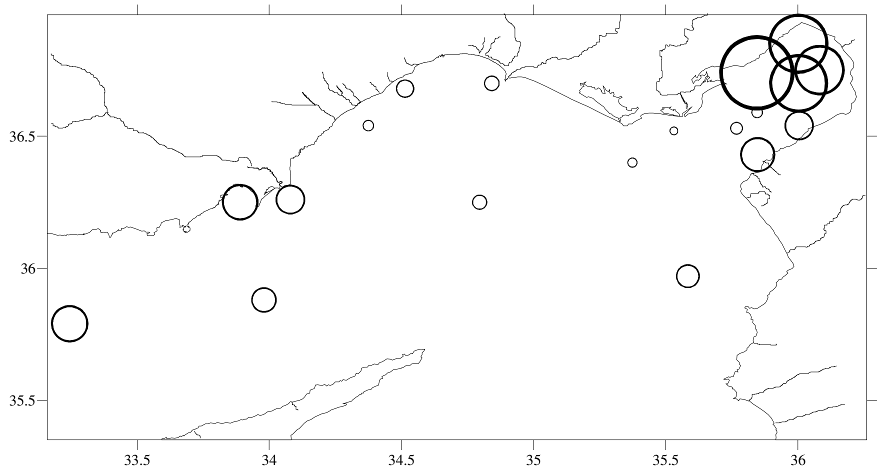

Figure 3.50. Surface total phosphorus distribution in the Cilician basin in July 2006.

3.2.4. January 2007

Except total phosphorus (measured only at 19 stations) rest of the nutrients were measured at total 43 stations.

3.2.4.1. Nitrate+nitrite distribution at surface waters

Surface nitrate+nitrite concentrations varied in the range 0.05 to 0.76 µM with an average surface concentration of 0.22 µM in the area. The maximum concentration was measured at station 33 (Figure 2.1) located in the middle of the basin (Figure 3.51). High values are also recorded at several other central stations (at stations 49 and 14; Figure 2.1) adjacent to station 33. Shelf waters displayed both high and low values even in the same area.

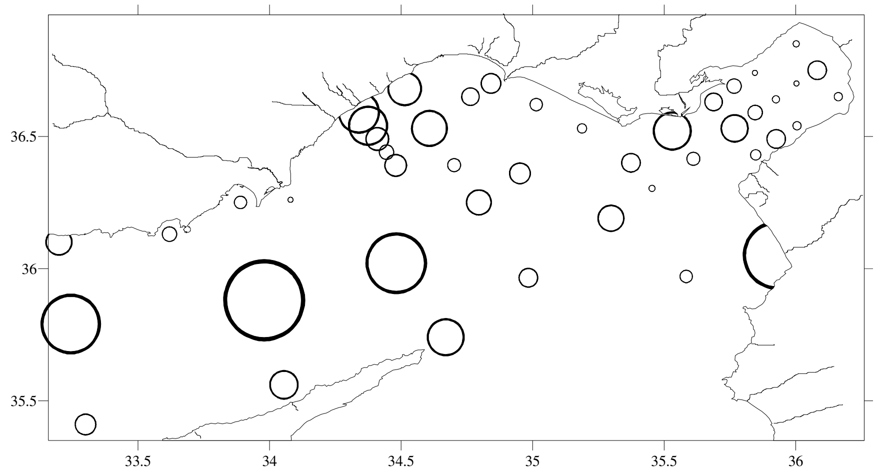

Figure 3.51. Surface nitrate-nitrite distribution in the Cilician basin in January 2007.

3.2.4.2. Silicate distribution at surface waters

Silicate concentrations ranged between 0.98 - 2.03 µM at surface (Figure 3.52). Maximum concentration was measured at station 54 (Figure 2.1) located near Ceyhan River. Station 2 (Figure 2.1) held the minimum surface silicate concentration. The surface average for this period was 1.42 µM. Areas fed by River runoff exhibited slightly higher silicate compared to other shelf and offshore waters.

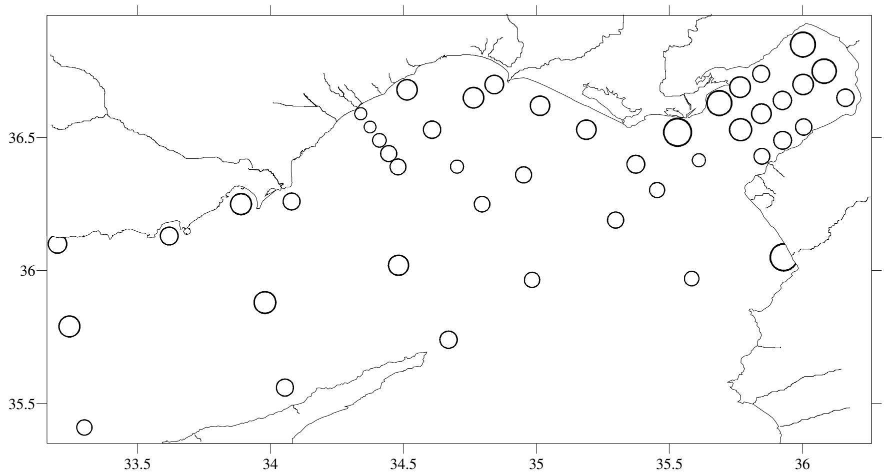

Figure 3.52. Surface silicate distribution in the Cilician basin in January 2007.

3.2.4.3. Phosphate distribution at surface waters

Surface phosphate concentration ranged between 0.02 - 0.04 µM in the area (Figure 3.53). Relatively higher concentrations were observed in the near shore areas. Highest concentration was measured at stations 24 and 56 (Figure 2.1).

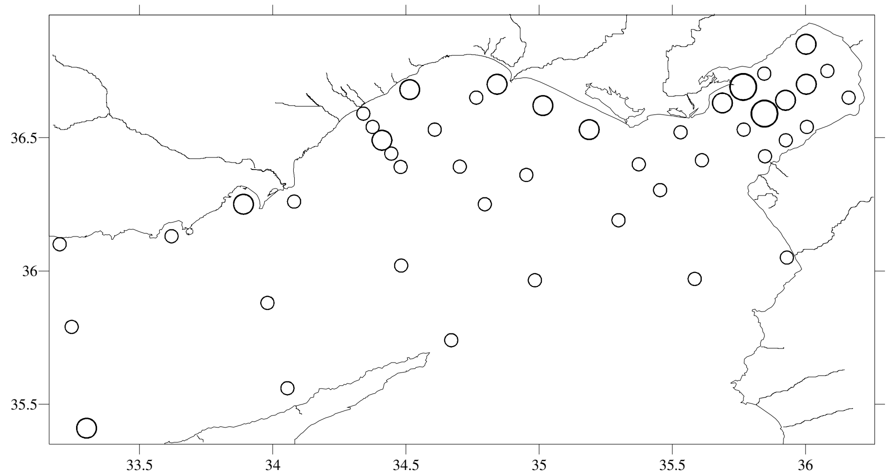

Figure 3.53. Surface phosphate distribution in the Cilician basin in January 2007.

3.2.4.4. Total phosphorus distribution at surface waters

Total phosphorus concentrations ranged between 0.055 - 0.156 µM at the surface (Figure 3.54). The maximum value was measured at station 11(Figure 2.1). Total Phosphorus concentration was high near Mersin and İskenderun as well as near River discharge areas.

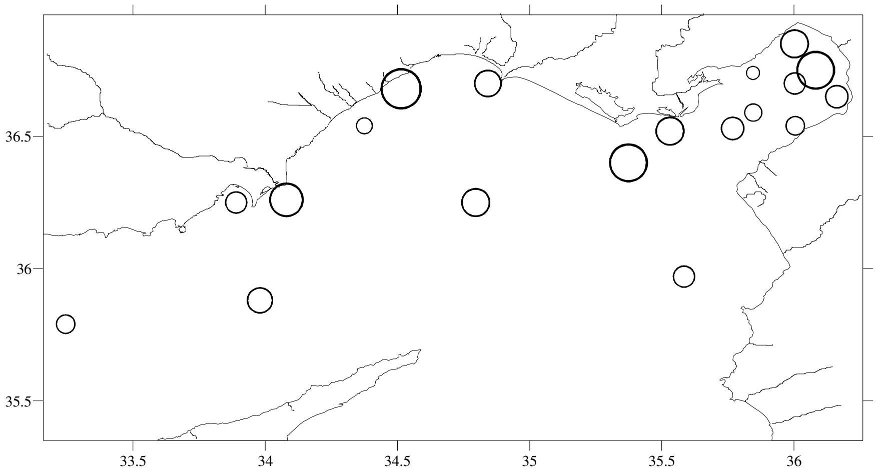

Figure 3.54. Surface total phosphorus distribution in the Cilician basin in January 2007.

3.2.5. March 2007

Except total phosphorus (measured only at 20 stations) rest were measured at total 42 stations.

3.2.5.1. Nitrate+nitrite distribution at surface waters

Surface nitrate+nitrite concentration varied in the range 0.05 and 2.30 μM with an average surface concentration of 0.36 μM in the area. The maximum concentration was measured at station 23 (Figure 2.1) located in İskenderun Bay (Figure 3.55). Minimum concentration is observed at station 28 (Figure 2.1) placed near Göksu River. Coastal areas fed by Seyhan and Ceyhan runoff held much higher concentrations in the east. Offshore areas were almost devoid of this nutrient.

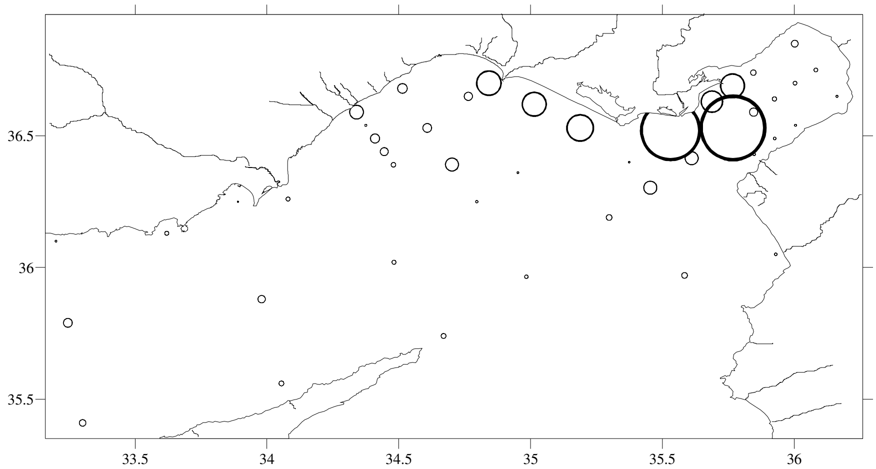

Figure 3.55. Surface nitrate-nitrite distribution in the Cilician basin in March 2007.

3.2.5.2. Silicate distribution at surface waters

Silicate concentrations ranged between 0.36 - 3.33 μM at surface (Figure 3.56). Similar to nitrate-nitrite, maximum concentration was again measured at station 23 (Figure 2.1). The surface average for this period was 1.16 μM. Coastal areas as well as the entire İskenderun Bay seemed to hold relatively higher concentrations compared to offshore waters. Concentrations fell down to lowest levels near Mersin and Göksu River discharge area.

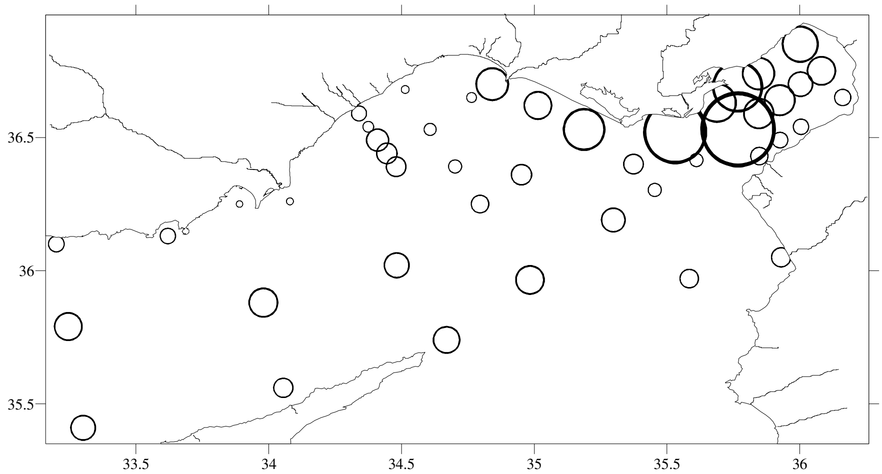

Figure 3.56. Surface silicate distribution in the Cilician basin in March 2007.

3.2.5.3. Phosphate distribution at surface waters

The phosphate concentration ranged between 0.02 - 0.06 µM at surface in the area (Figure 3.57). The higher concentrations were observed in front of the Göksu River and north of the İskenderun Bay. Highest concentration was measured at station 59 (Figure 2.1).

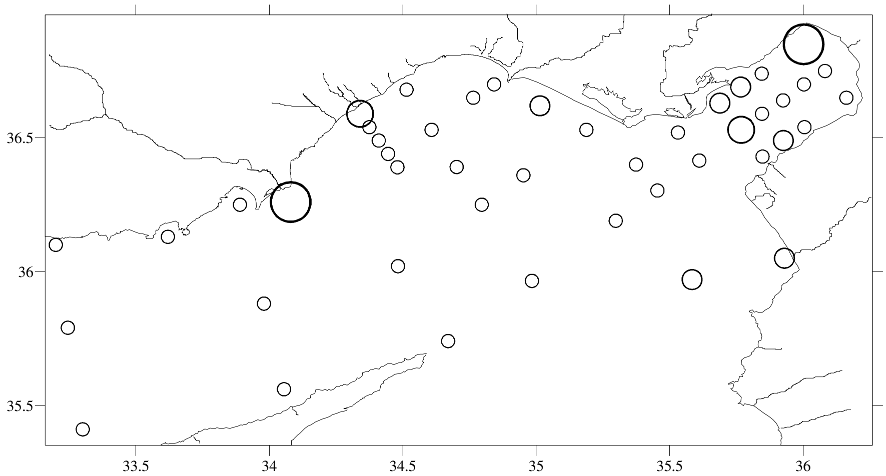

Figure 3.57. Surface phosphate distribution in the Cilician basin in March 2007.

3.2.5.4. Total phosphorus distribution at surface waters

Total phosphorus concentrations ranged between 0.071 - 0.399 µM at the surface (Figure 3.58). Maximum value was measured at station 74 (Figure 2.1). Concentrations peaked near Seyhan River mouth. Minimum value was measured at station 2, near Erdemli (Figure 2.1).

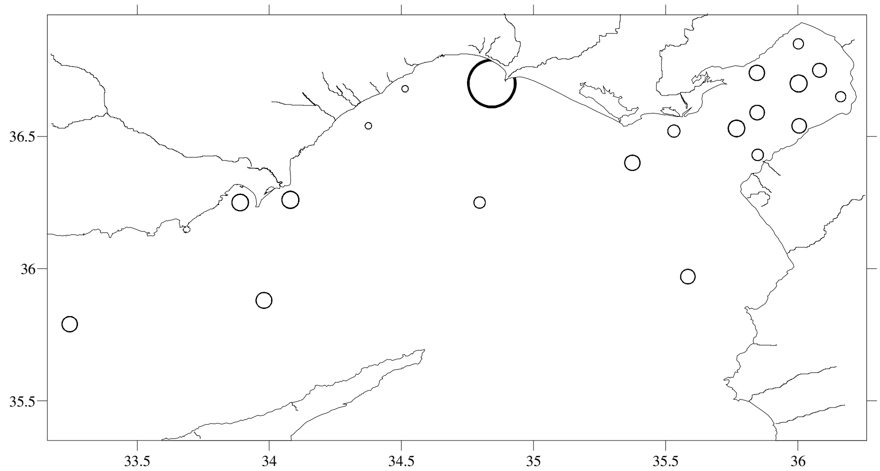

Figure 3.58. Surface total phosphorus distribution in the Cilician basin in March 2007.

3.2.6 April 2007

Except total phosphorus (measured only at 19 stations) rest were measured at total 41 stations.

3.2.6.1. Nitrate+nitrite distribution at surface waters

Surface nitrate+nitrite concentration varied in the range 0.05-0.94 µM with an average surface concentration of 0.145 µM in the area. To a maximum concentration was reached at station 55 (Figure 2.1) located near Ceyhan River (Figure 3.59). Concentrations decreased drastically from inshore towards offshore. Coastal areas supplied by River input held much higher concentrations.

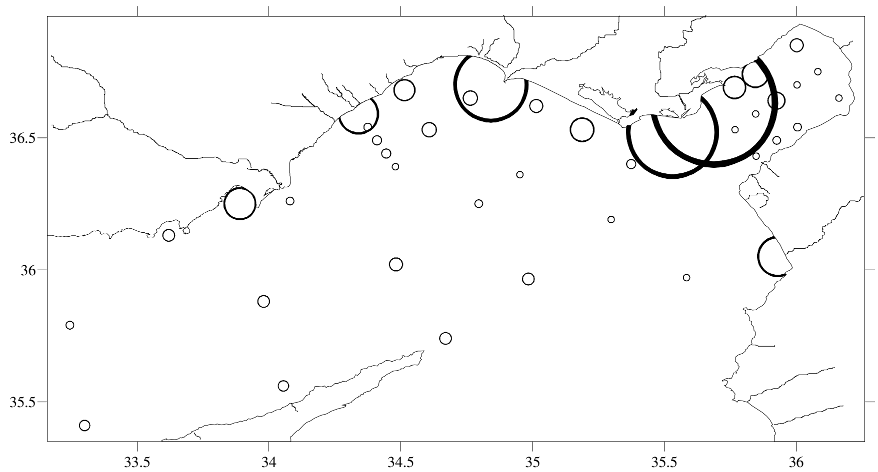

Figure 3.59. Surface nitrate-nitrite distribution in the Cilician basin in April 2007.

3.2.6.2. Silicate distribution at surface waters

Silicate concentrations ranged between 0.61 - 2.66 µM at surface (Figure 3.60). Maximum value was measured at station 55 near Ceyhan River. The average for the basin was 1.40 µM. The north east of the Gulf of İskenderun was rich in silicate. Inshore areas receiving freshwater form major Rivers in the basin (except Göksu River) were rich in this nutrient content.

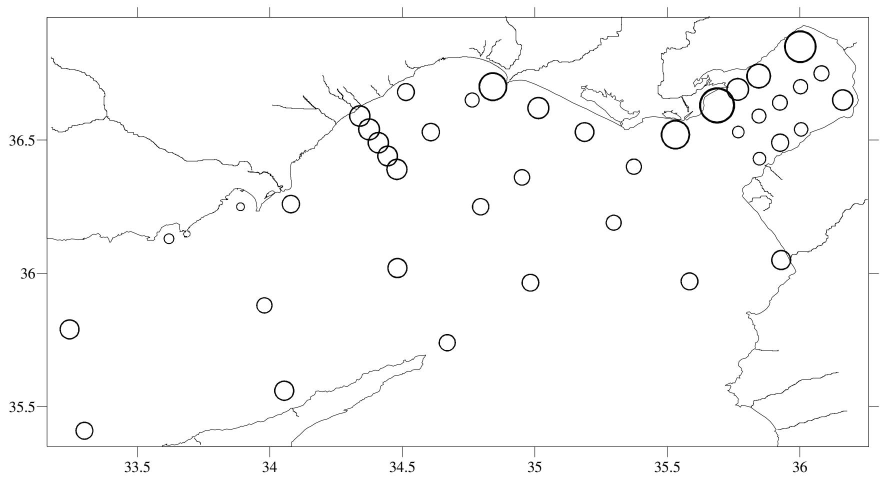

Figure 3.60. Surface silicate distribution in the Cilician basin in April 2007.

3.2.6.3. Phosphate distribution at surface waters

Surface phosphate concentration ranged between 0.02 - 0.04 µM in the area (Figure 3.61). In general a decrease in concentrations from inshore towards offshore is observed in the entire basin. Elevated levels are mostly observed near River mouths. Highest concentration was measured in the İskenderun Bay (station 64) (Figure 2.1).

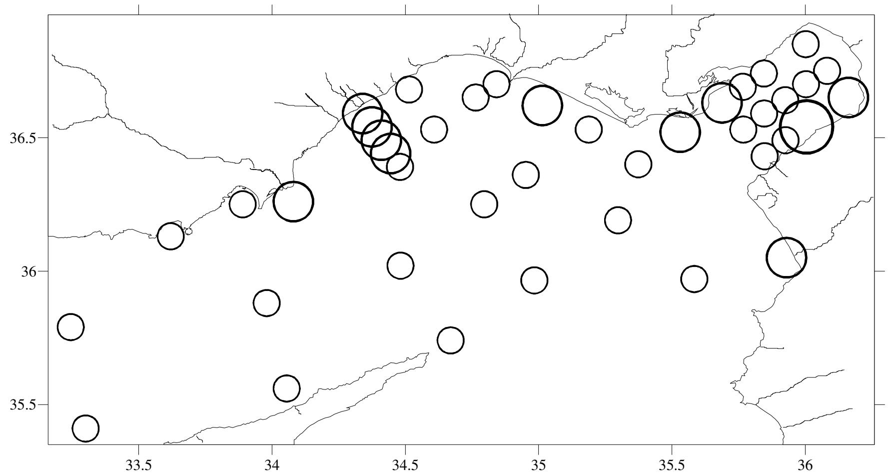

Figure 3.61. Surface phosphate distribution in the Cilician basin in April 2007.

3.2.6.4. Total phosphorus distribution at surface waters

Total phosphorus concentrations ranged between 0.089 - 0.886 μM at surface in the basin (Figure 3.62). Maximum value was measured at station 74 (Figure 2.1) near Seyhan River mouth. Except this high value, although the magnitude of variation among rest of the stations was minor, still an increase in concentrations from west to east was observed in the basin. Minimum value was measured at the central deep station 49 (Figure 2.1). As was the case for phosphate, offshore surface waters remained low in total phosphorus content.

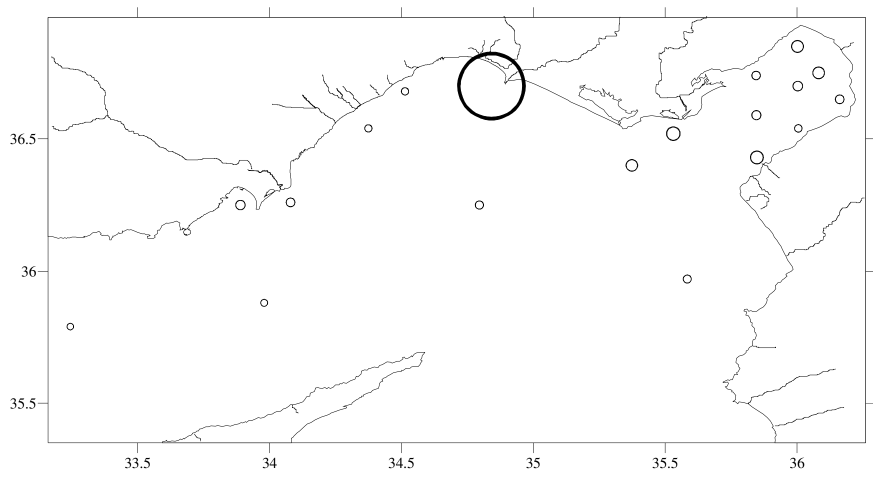

Figure 3.62. Surface total phosphorus distribution in the Cilician basin in April2007.

3.2.7 June 2007

Except for total phosphorus (measured only at 20 stations) rest of the nutrients were measured at total 42 stations (Figure 2.1).

3.2.7.1. Nitrate+nitrite distribution at surface waters

Surface nitrate+nitrite concentration varied in the range 0.05 and 0.67 μM with an average surface concentration of 0.1 μM in the area. The Ceyhan inflow area (Station 54, Figure 2.1) bears the highest concentration (Figure 3.63). Minimum concentrations are observed especially in western offshore stations. Similarly, low values are also observed inner Mersin Bay, near Göksu and Seyhan Rivers.

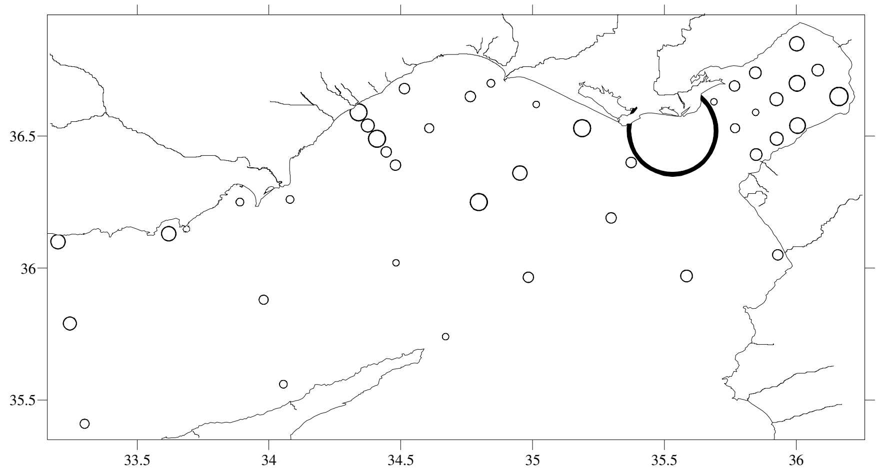

Figure 3.63. Surface nitrate-nitrite distribution in the Cilician basin in June 2007.

3.2.7.2. Silicate distribution at surface waters

Surface silicate concentrations ranged between 0.75 - 2.56 μM with a maximum value measured at station 54 (Figure 2.1) near Ceyhan River. The surface average for this period was 0.98 μM. High concentrations are measured at the stations under the influence of Ceyhan and Asi Rivers. Inner İskenderun Bay was found poor in silicate.

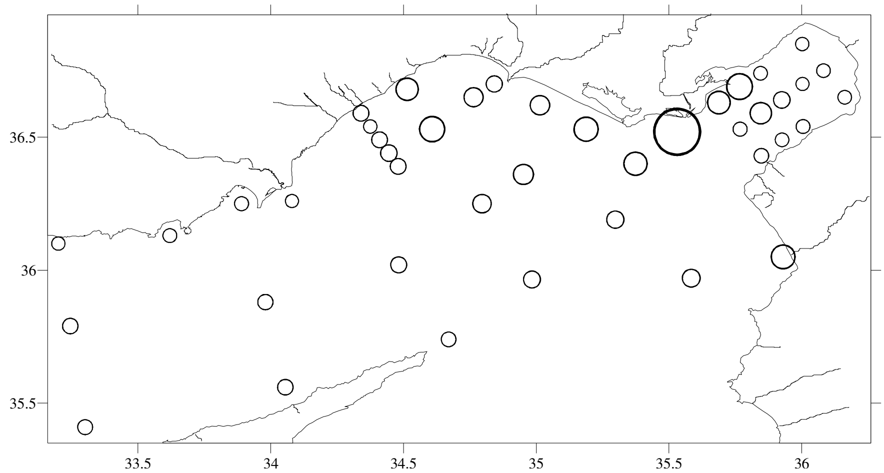

Figure 3.64. Surface silicate distribution in the Cilician basin in June 2007.

3.2.7.3. Phosphate distribution at surface waters

The phosphate concentration ranged between 0.02 - 0.05 μM at surface in the area (Figure 3.65). Highest concentration was measured in the central basin at station 8 (Figure 2.1). Except Göksu and Ceyhan, the inflow areas of the Seyhan, Lamas and Asi Rivers are enriched in phosphate. In shelf waters fluctuations are more pronounced compared to offshore areas.

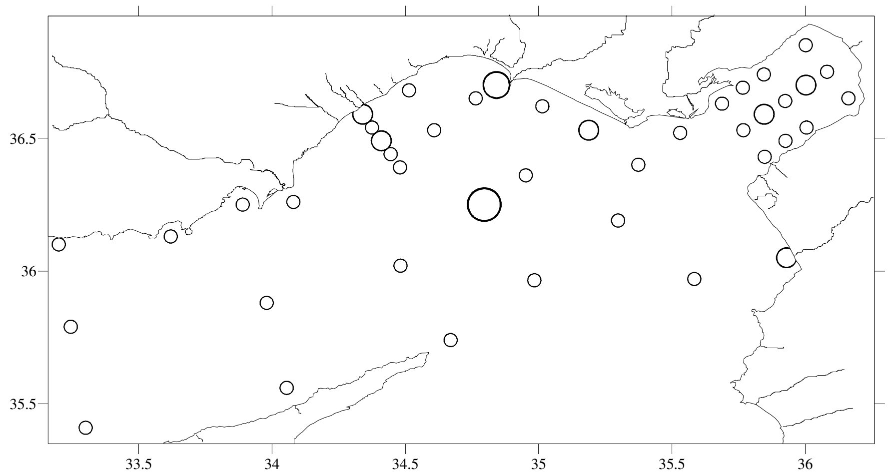

Figure 3.65. Surface phosphate distribution in the Cilician basin in June 2007.

3.2.7.4. Total phosphorus distribution at surface waters

Total phosphorus concentration ranged between 0.101 - 0.303 µM at the surface (Figure 3.66). Maximum value was measured at station 74 (Figure 2.1) near Seyhan River mouth. . Minimum value was measured at the central deep station 49 (Figure 2.1).

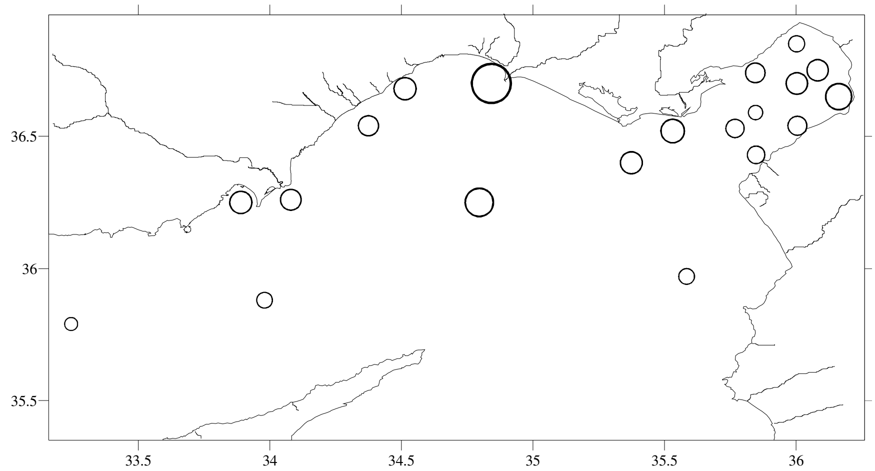

Figure 3. 66. Surface total phosphorus distribution in the Cilician basin in June 2007.

3.2.8 September 2007

Except total phosphorus (measured only at 20 stations, Figure 2.1) rest were measured for total 42 stations.

3.2.8.1. Nitrate+nitrite distribution at surface waters

Surface nitrate+nitrite concentration varied in the range 0.05 - 1.46 µM with an average surface concentration of 0.13 µM in the area. The maximum concentration was measured in Ceyhan River inflow area at station 54 (Figure 3.67). Low levels are observed both in shallower shelf areas as well as in offshore waters.

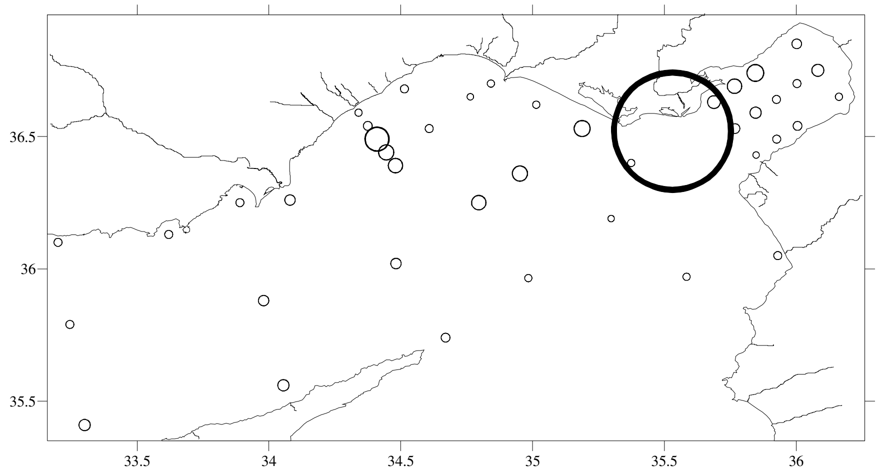

Figure 3.67.Surface nitrate-nitrite distribution in the Cilician basin in September 2007.

3.2.8.2. Silicate distribution at surface waters

Silicate concentrations ranged between 1.27 - 7.24 µM at surface (Figure 3.68). Similar to nitrate-nitrite, maximum concentration was measured at station 54 (Figure 2.1). The surface average of this period was 2.07 µM. İskenderun Bay held relatively much higher concentrations compared to Mersin Bay and offshore areas.

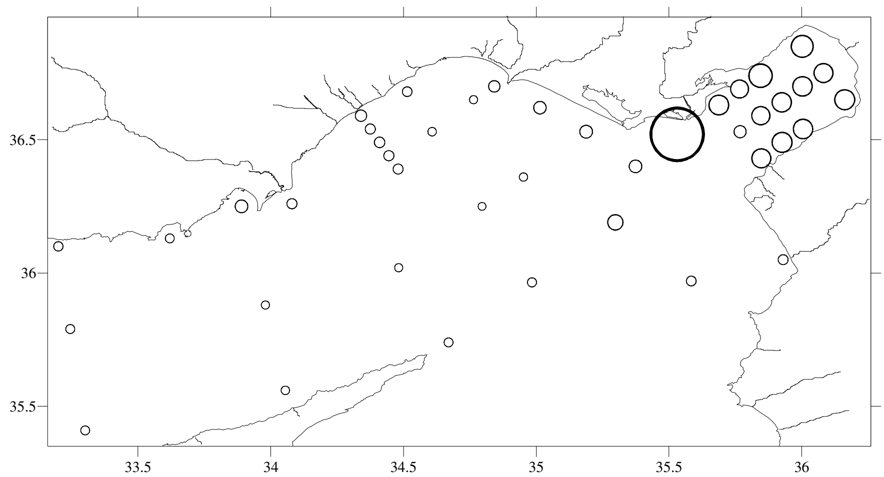

Figure 3.68. Surface silicate distribution in the Cilician basin in September 2007.

3.2.8.3. Phosphate distribution at surface waters

Phosphate seemed to be homogenously distributed over the basin during September. It ranged between 0.02 - 0.03 µM at the surface in the area (Figure 3.69). Highs and lows are observed both in shelf and offshore areas respectively.

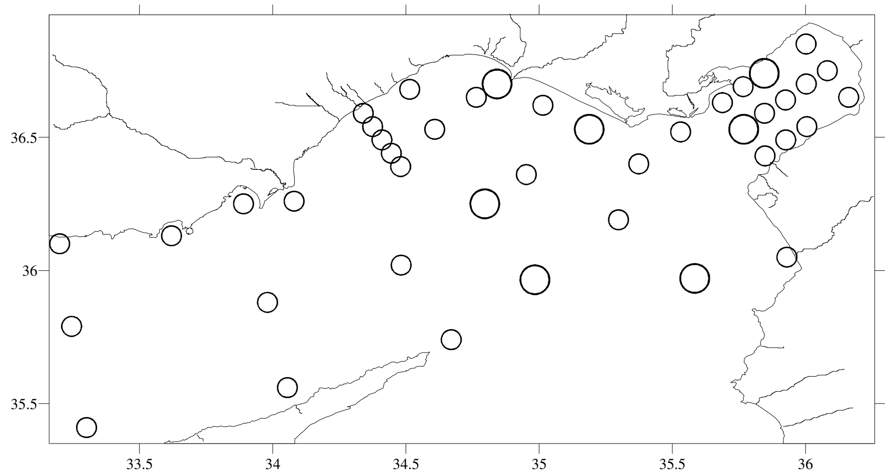

Figure 3.69. Surface phosphate distribution in the Cilician basin in September 2007.

3.2.8.4. Total phosphorus distribution at surface waters

Total phosphorus concentrations ranged between 0.07 - 0.9 µM at the surface (Figure 3.70). Maximum and minimum values are measured at station 54 and 62, respectively (Figure 2.1).

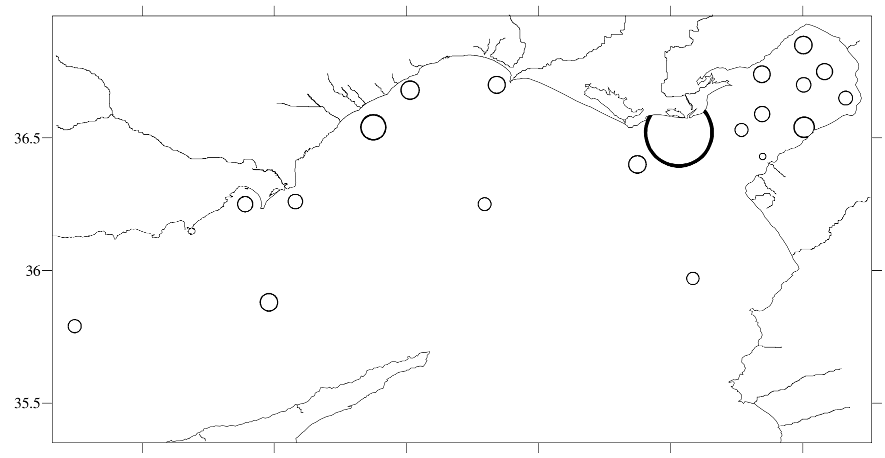

Figure 3.70. Surface total phosphorus distribution in the Cilician basin in September 2007.

3.3. Biological parameters

Surface spatial distribution of chlorophyll, the concentration of which was measured by spectrofluorometry, HPLC and in-situ field fluorometry (except July 2006 cruise) will be presented hereafter.

3.3.1. November 2005

As given in material and methods surface chlorophyll measurements are carried at total 40 stations during the November cruise.

3.3.1.1. Chlorophyll distribution at surface waters (concentrations measured by the fluorometric method)

In the study area, total chlorophyll concentration ranged between 0.09 - 0.51 µg/L at surface (Figure 3.71). Maximum value was measured at station 2 and 74 (Figure 2.1) both located in the coastal part of Mersin Bay. Minimum value was measured at station 63 (Figure 2.1) located in İskenderun Bay. In general, shallower shelf waters hold much higher concentrations compared to areas beyond shelf break (depths over 200m). Elevated concentrations were characteristics of the River drainage areas.

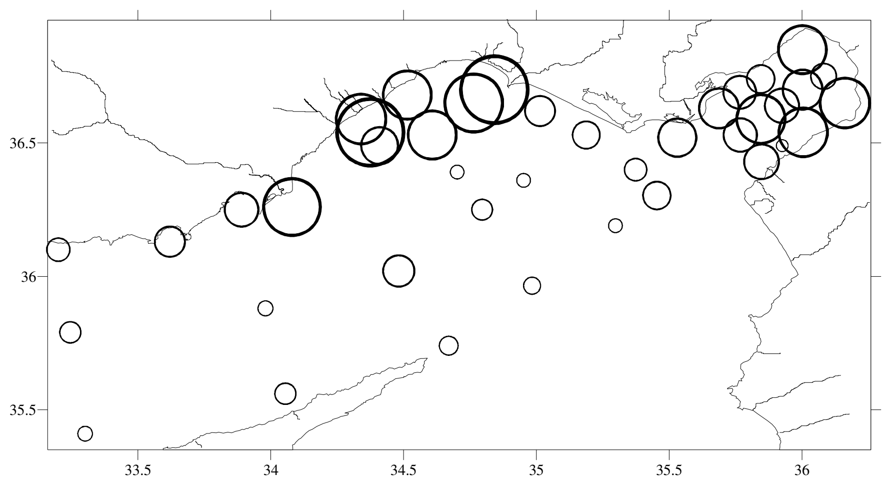

Figure 3.71. Surface chlorophyll distribution (from spectrofluorometer) in the Cilician basin in November 2005.

3.3.1.2. Chlorophyll distribution at surface waters along the ship track (based on in-situ fluorometer readings)

In-situ chlorophyll concentrations recorded every 5 seconds along the ship track ranged between 0.91 - 3.03 µg/L at surface. Similar to extracted chl readings, in-situ readings peaked near station 74 (Figure 3.72). High readings (concentrations) also recorded in front of the Göksu (stations 37, 38, 39 and 40, Figure 2.1) and Lamas Rivers (station 2, Figure 2.1). Chlorophyll-a in station 14 (Figure 2.1) displayed relatively much higher concentration compared to other offshore stations (Figure 2.1).

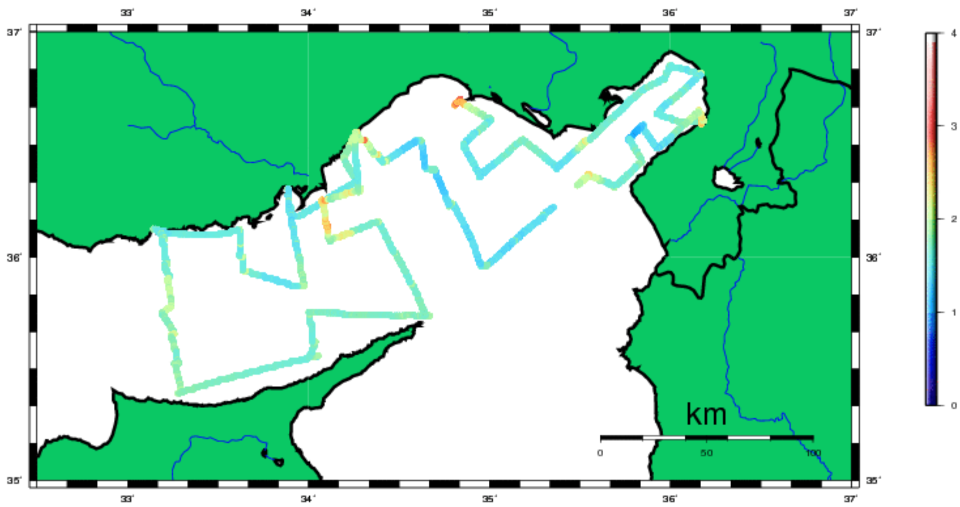

Figure 3.72. Surface chlorophyll distribution (based on in-situ fluorometer readings) in the Cilician basin in November 2005.

3.3.1.3. Chlorophyll & pigment distribution at surface waters (measured by HPLC)

Chl and other pigment concentrations were measured by this technique only at four stations (14, 24, 28 and 33 in Figure 2.1). Based on these limited measurements, total chlorophyll-a including divinyll chlorophyll-a ranged between 0.122 - 0.534 µg/L at surface (Figure 3.73). The highest concentration was measured in the mid-İskenderun Bay at station 24 and the minimum at the central offshore station # 33 (Figure 2.1). Chlorophyll-a was dominant at all stations except station 14 (Figure 2.1), where in the latter, divinyll chlorophyll-a was dominant.

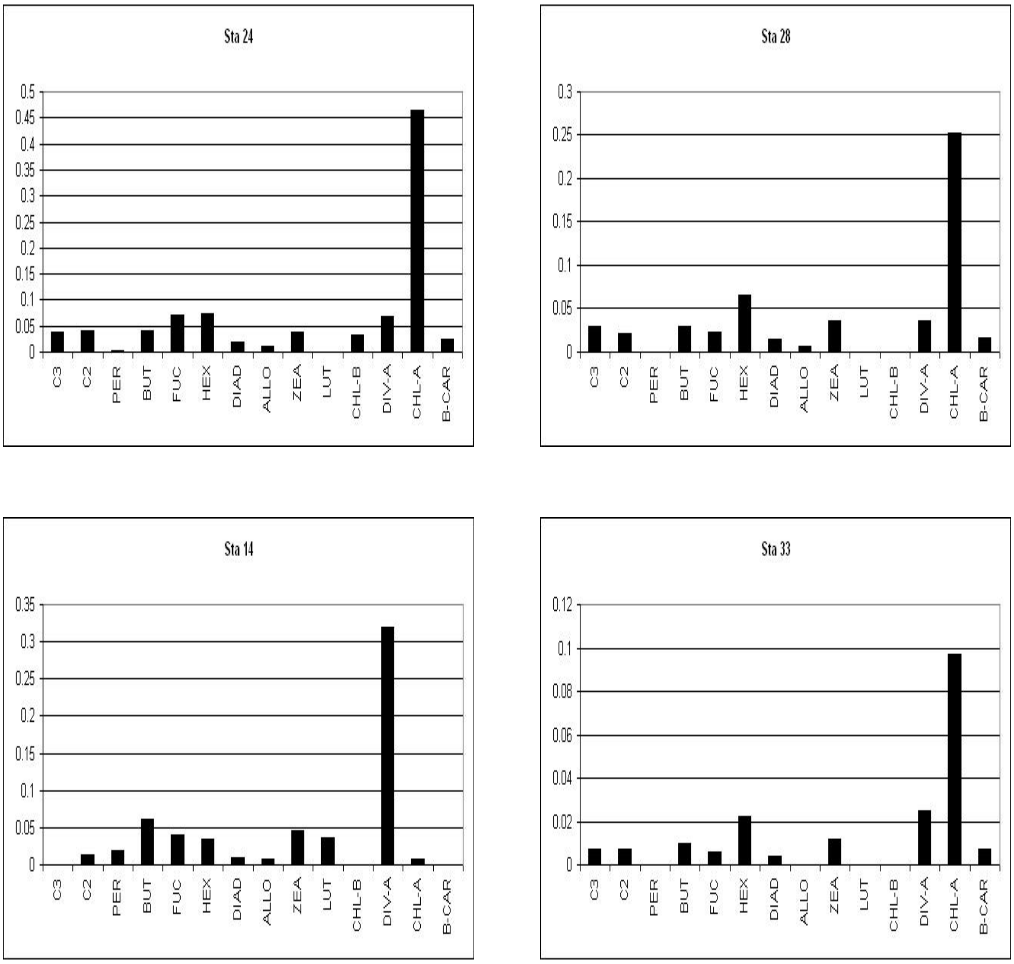

Figure 3.73. Pigment distribution (µg/L) at surface in coastal (Sta 24 and 28, Figure 2.1) and offshore (Sta 14 and 33, Figure 2.1) in November 2005.

Chlorophyll-a, (CHL-A), Chlorophyll c_3 (C3) and c_2 (C2), peridinin (PER), buthanoloxyfucuxanthin (BUT), fucuxanthin (FUC), 19'hexonoloyxyfucoxanthin (HEX), diadinixanthin (DIAD), alloxanthin (ALLO), zeaxanthin (ZEA), chlorophyll-b (CHL-B), divinil chlorophyll-a (DIV-A), lutein (LUT) and ß-carotene (B-CAR).

3.3.2. March 2006

Surface chlorophyll data was collected from total 38 stations during the March cruise.

3.3.2.1. Chlorophyll distribution at surface waters (concentrations measured by the fluorometric method)

In the study area, total chlorophyll-a concentration ranged between 0.07 - 0.61 µg/L at surface (Figure 3.74). Maximum value was measured at the shallow shelf station 1 (Figure 2.1) which receives substantial amount of freshwater from the nearby Lamas River. Minimum value was measured at the central basin station 8 (in Figure 2.1). In general, shallower shelf waters held much higher concentrations compared to areas beyond shelf break. Concentrations peaked at shallow shelf stations near River drainage areas.

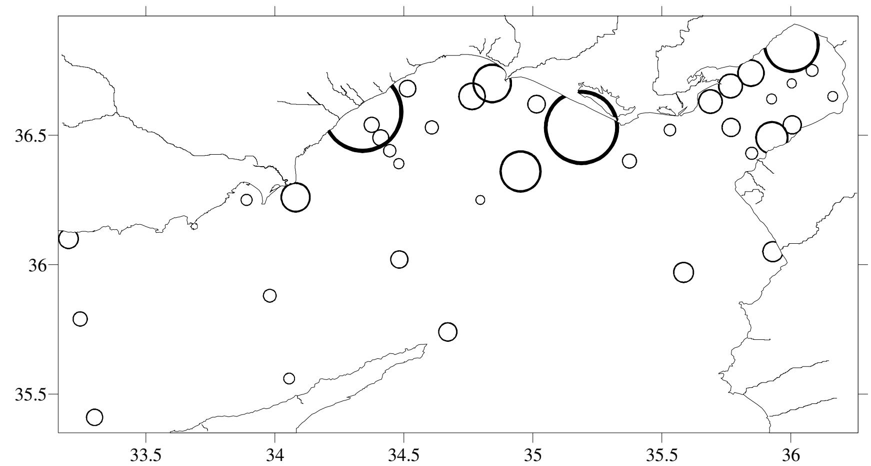

Figure 3.74. Surface chlorophyll distribution (from spectrofluorometer) in the Cilician basin in March 2006.

3.3.2.2. Chlorophyll distribution at surface waters along the ship track (based on in-situ fluorometer readings)

In-situ chlorophyll concentrations recorded every 5 seconds along the ship track ranged between 0.00 - 6.81 µg/L at surface (Figure 3.75). Similar to extracted chlorophyll readings, in-situ readings peaked near Lamas River at stations 1 and 2, and inner Mersin Bay at stations 11, 73 and 74 (Figure 2.1) where the latter two receive direct freshwater input from the nearby Seyhan River.

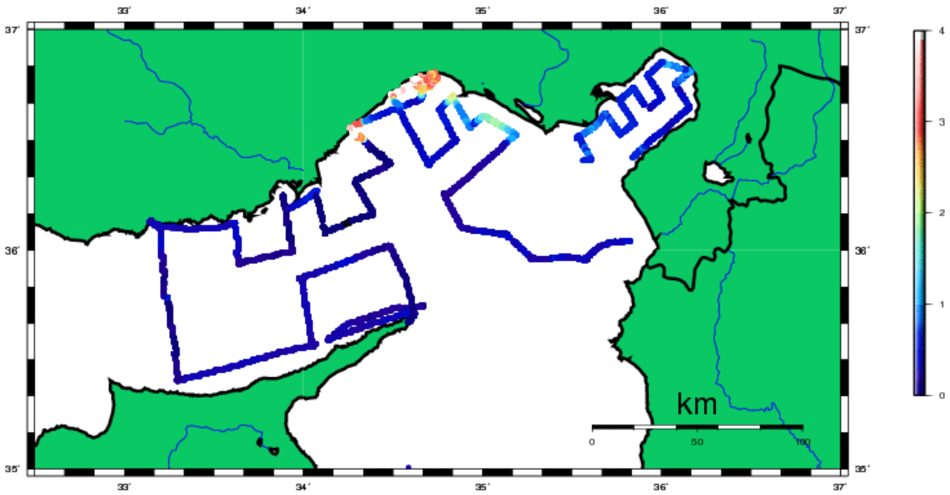

Figure 3.75. Surface chlorophyll distribution (based on in-situ fluorometer readings) in the Cilician basin in March 2006.

3.3.2.3. Chlorophyll & pigment distribution at surface waters (measured by HPLC)

Chl-a and other pigment concentrations were measured by this technique at two offshore (stations 8 and 33, Figure 2.1) and at three shelf stations (11, 28 and 37, Figure 2.1). Based on these limited measurements, total chlorophyll-a including divinyll chlorophyll-a ranged between 0.04 - 0.48 µg/L at surface (Figure 3.76). The highest concentration was measured at station 37 and to the minimum at station 33 (Figure 2.1). Chlorophyll-a was dominant at all stations except at offshore station 8 where divinyll chlorophyll-a formed the majority.

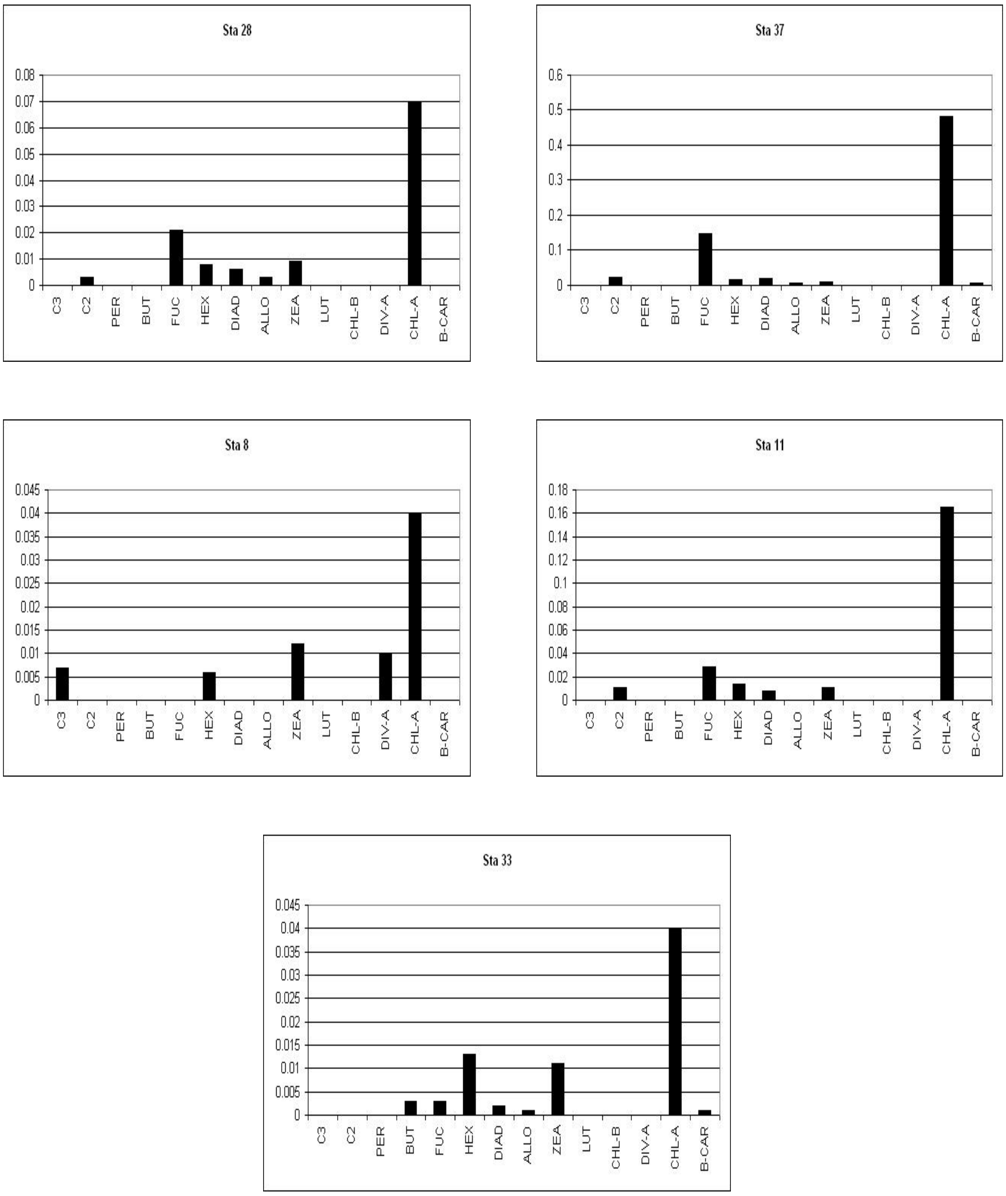

Figure 3.76. Pigment distribution (µg/L) at surface in coastal (Sta 28, 37 and 11, Figure 2.1) and offshore (Sta 8 and 33, Figure 2.1) in March 2006.

Chlorophyll-a, (CHL-A), Chlorophyll c_3 (C3) and c_2 (C2), peridinin (PER), buthanoloxyfucuxanthin (BUT), fucuxanthin (FUC), 19'hexonoloyxyfucoxanthin (HEX), diadinixanthin (DIAD), alloxanthin (ALLO), zeaxanthin (ZEA), chlorophyll-b (CHL-B), divinil chlorophyll-a (DIV-A), lutein (LUT) and ß-carotene (B-CAR).

3.3.3. July 2006

During this month, samples were collected from total 41 stations. Real time surface chlorophyll data is missing for this cruise due to malfunctioning of the in-situ fluorometer.

3.3.3.1. Chlorophyll distribution at surface waters (concentrations measured by the fluorometric method)

In the study area, total chlorophyll concentration ranged between 0.01 - 0.20 µg/L at surface (Figure 3.77). Maximum value was measured at station 74 located in front of the Seyhan River (Figure 2.1). In general, shallower shelf waters coupled with freshwater input from major Rivers in the basin held much higher concentrations compared to areas beyond shelf break.

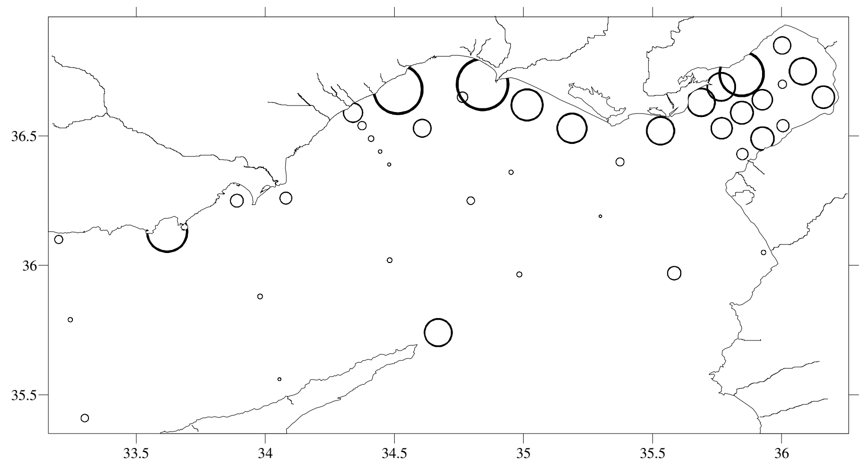

Figure 3.77. Surface chlorophyll-a distribution (from spectrofluorometer) in the Cilician basin in July 2006.

3.3.3.2. Chlorophyll & pigment distribution at surface waters (measured by HPLC)

Chl-a and other pigment concentrations were measured at seven stations (8, 11, 24, 27, 28, 37 and 41 in Figure 2.1). Based on these limited measurements, total chlorophyll-a including divinyll chlorophyll-a ranged between 0.024 - 0.530 µg/L at surface (Figure 3.78). The highest concentration was measured at station 24 and the minimum at station

8. Chlorophyll-a was dominant at all stations, where in the latter, zeaxanthin was dominant.

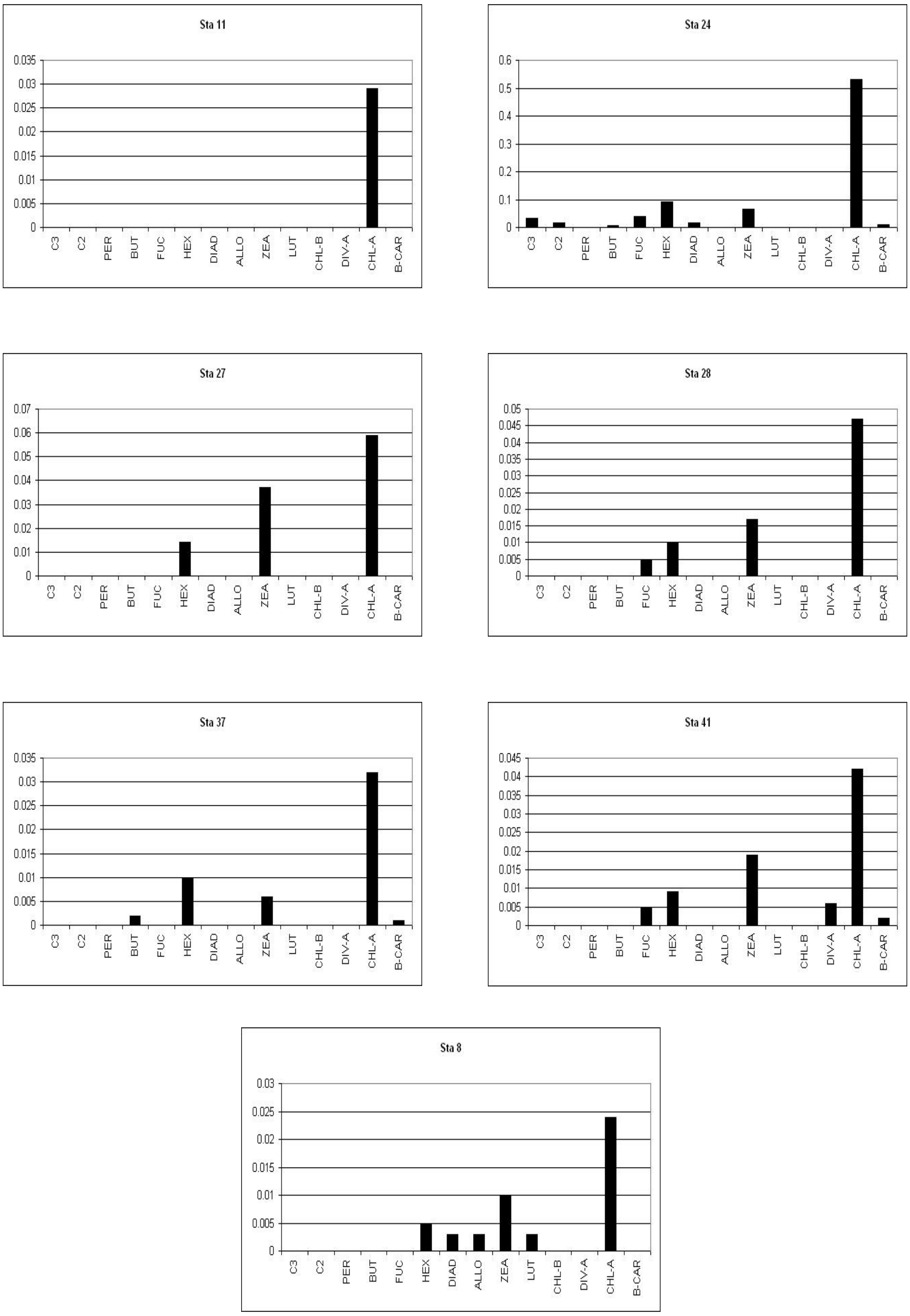

Figure 3.78. Pigment distribution (µg/L) at surface in coastal (Sta 11, 24, 27, 28, 37 and 41, Figure 2.1) and offshore (Sta 8, Figure 2.1) in July 2006.

Chlorophyll-a, (CHL-A), Chlorophyll c_3 (C3) and c_2 (C2), peridinin (PER), buthanoloxyfucuxanthin (BUT), fucuxanthin (FUC), 19'hexonoloyxyfucoxanthin (HEX), diadinixanthin (DIAD), alloxanthin (ALLO), zeaxanthin (ZEA), chlorophyll-b (CHL-B), divinil chlorophyll-a (DIV-A), lutein (LUT) and ß-carotene (B-CAR).

3.3.4. January 2007

Surface chlorophyll concentrations were measured at total 41 stations during this month.

3.3.4.1. Chlorophyll distribution at surface waters (concentrations measured by the fluorometric method)

In the study area, total chlorophyll concentration ranged between 0.07 - 0.41 µg/L at surface (Figure 3.79). The highest concentration was measured at station 11 in the vicinity of Mersin. Minimum value was measured at station 52 (Figure 2.1) near Girne. Shallow shelf areas including both the bays reflected higher concentrations compared to deep, offshore waters.

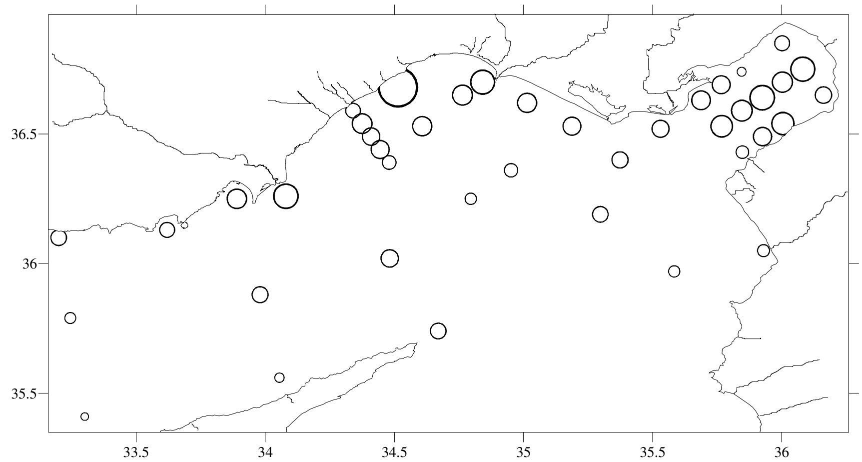

Figure 3.79. Surface chlorophyll distribution (from spectrofluorometer) in the Cilician basin in January 2007.

3.3.4.2. Chlorophyll distribution at surface waters along the ship track (based on in-situ fluorometer readings)

In-situ chlorophyll concentrations recorded every 5 seconds along the ship track ranged between 0.01 - 1.64 µg/L at surface (Figure 3.80). Surface spatial distribution of extracted chlorophyll mimic well the along cruise track in-situ readings for this period. Higher concentrations are recorded near Ceyhan (stations 55, 56 and 57, Figure 2.1), Lamas (stations 1, 2, 3, 4 and 5 (Figure 2.1)) and Göksu Rivers. Station 33 displayed relatively much higher concentration compared to other offshore stations.

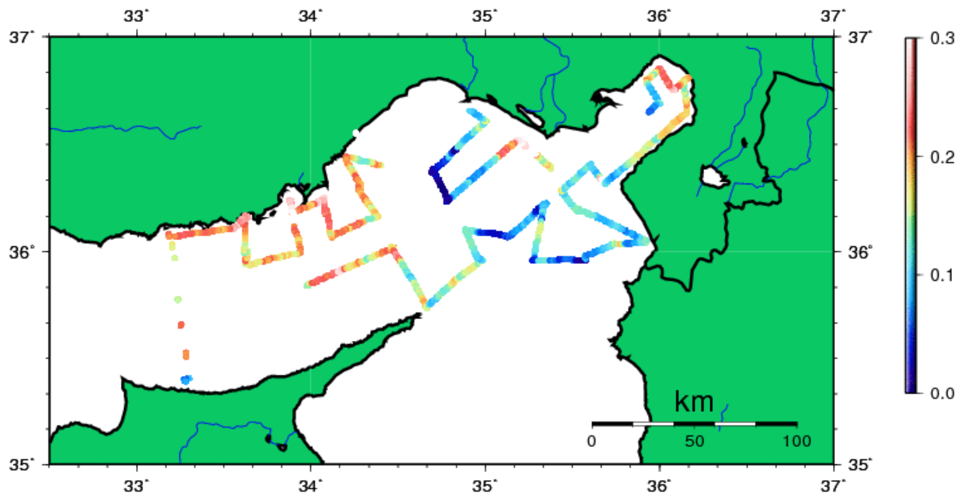

Figure 3.80. Surface chlorophyll distribution (based on in-situ fluorometer readings) in the Cilician basin in January 2007.

3.3.4.3. Chlorophyll-a & pigment distribution at surface waters (measured by HPLC)

Chl-a and other pigment concentrations were measured by this technique only at four stations (8, 11, 24 and 33, Figure 2.1). Based on these limited measurements, total chlorophyll-a including divinyll chlorophyll-a ranged between 0.045 - 0.101 µg/L at surface (Figure 3.81). The highest concentration was measured at station 33 and the minimum at station 24 (Figure 2.1). 19-hexanoyloxyfucoxanthin was dominant pigment at all stations.

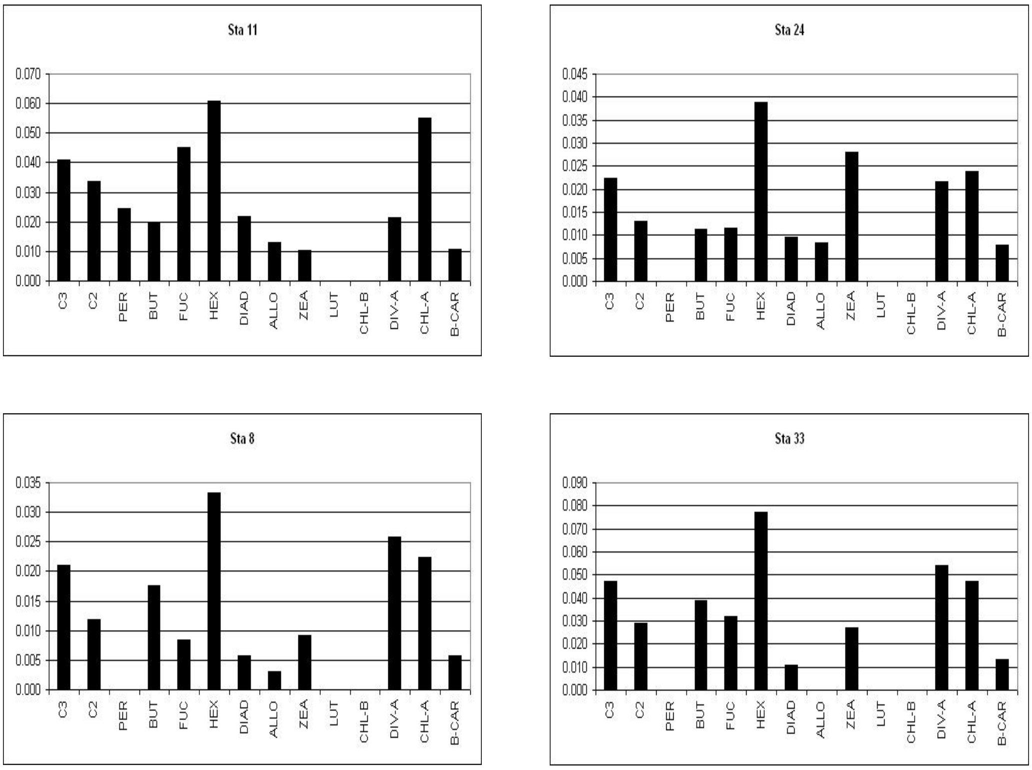

Figure 3.81. Pigment distribution (µg/L) at surface in coastal (Sta 11 and 24, Figure 2.1) and offshore (Sta 8 and 33, Figure 2.1) stations in January 2007.

Chlorophyll-a, (CHL-A), Chlorophyll c_3 (C3) and c_2 (C2), peridinin (PER), buthanoloxyfucuxanthin (BUT), fucuxanthin (FUC), 19'hexonoloyxyfucoxanthin (HEX), diadinixanthin (DIAD), alloxanthin (ALLO), zeaxanthin (ZEA), chlorophyll-b (CHL-B), divinil chlorophyll-a (DIV-A), lutein (LUT) and ß-carotene (B-CAR).

3.3.5. March 2007

Measurements are performed at total 41 stations during this month. Surface Chlorophyll was also recorded real time, by Turner fluorometer along the ship track, throughout the cruise.

3.3.5.1. Chlorophyll distribution at surface waters (concentrations measured by the fluorometric method)

In the study area, total chlorophyll concentration ranged between 0.17 - 0.61 µg/L at surface (Figure 3.82). Maximum value was measured at the entrance of the İskenderun Bay (station 23). Both the shallow waters and almost the entire İskenderun

Bay were rich in chlorophyll content. Some high values are also measured near Cyprus (Figures 2.1 and 3.82).

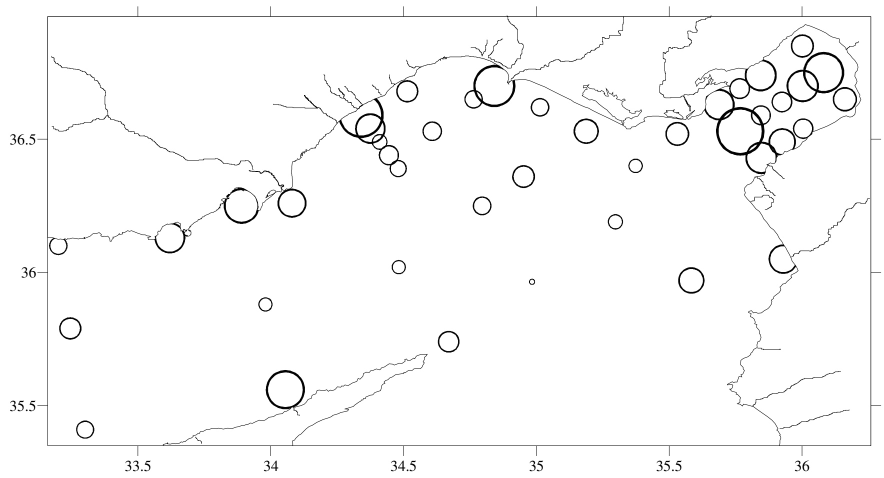

Figure 3.82. Surface chlorophyll distribution (from spectrofluorometer) in the Cilician basin in March 2007.

3.3.5.2. Chlorophyll distribution at surface waters along the ship track (based on in-situ fluorometer readings)

In-situ chlorophyll concentrations recorded at every 5 seconds along the ship track ranged between 0.001 - 2.37 μg/L at surface (Figure 3.83). Similar to extracted chlorophyll readings, in-situ readings peaked near station 23. High readings (concentrations) also measured in front of the Lamas (stations 1, 2, 3 and 4 (Figure 2.1)) and Seyhan Rivers (station 74). Western half of the İskenderun Bay reflected highest concentrations in the basin.

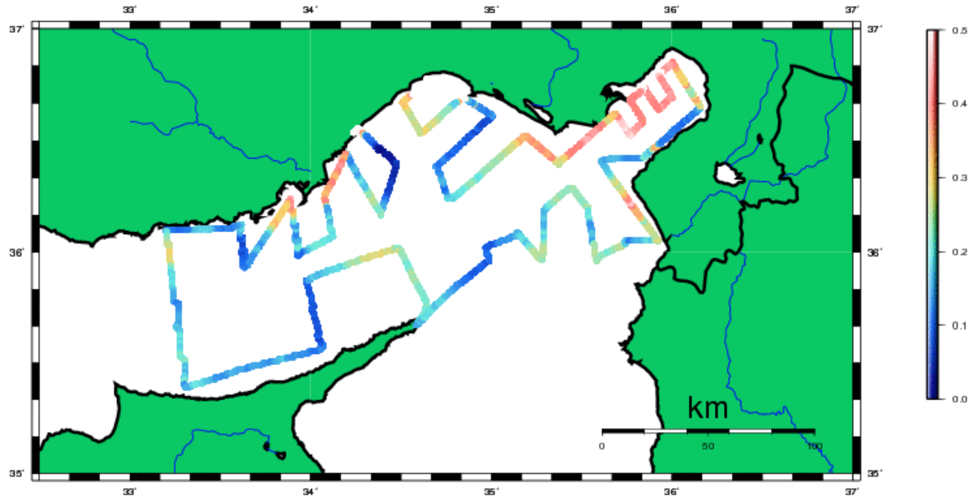

Figure 3.83. Surface chlorophyll distribution (based on in-situ fluorometer readings) in the Cilician basin in March 2007.

3.3.5.3. Chlorophyll-a & pigment distribution at surface waters (measured by HPLC)

Chl-a and other pigment concentrations were measured by this technique only at five stations (8, 11, 24, 33 and 49, Figure 2.1). Based on these limited measurements, total chlorophyll-a including divinyll chlorophyll-a ranged between 0.129 - 0.240 μg/L at surface (Figure 3.84). The highest concentration was measured at station 33 (Figure 2.1) and the minimum at station 8 (Figure 2.1). Chlorophyll-a was dominant at all stations.

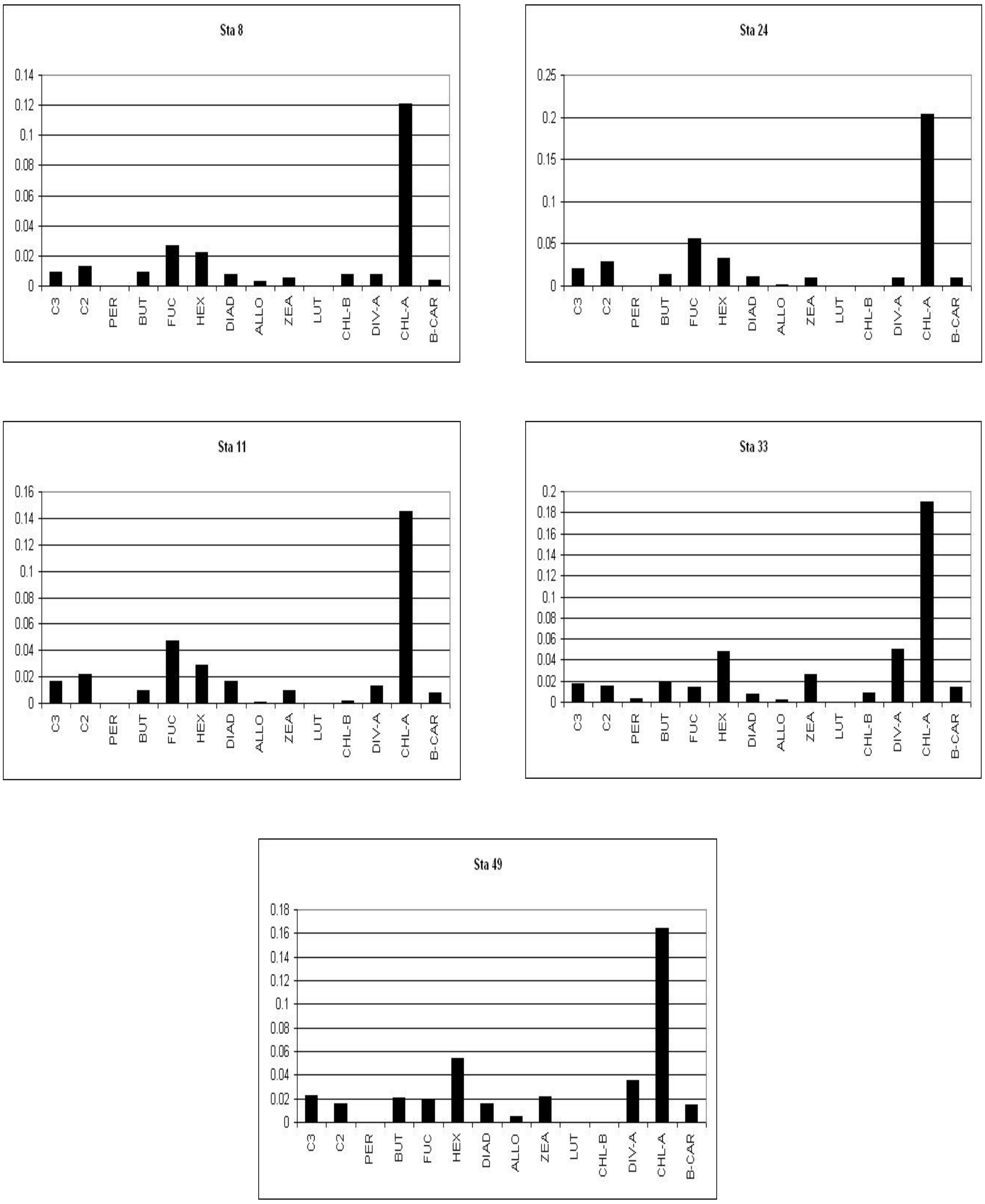

Figure 3.84. Pigment distribution (µg/L) at surface in coastal (Sta 11 and 24, Figure 2.1) and offshore (Sta 8, 33 and 49, Figure 2.1) stations in March 2007.

Chlorophyll-a, (CHL-A), Chlorophyll c_3 (C3) and c_2 (C2), peridinin (PER), buthanoloxyfucuxanthin (BUT), fucuxanthin (FUC), 19'hexonoloyxyfucoxanthin (HEX), diadinixanthin (DIAD), alloxanthin (ALLO), zeaxanthin (ZEA), chlorophyll-b (CHL-B), divinil chlorophyll-a (DIV-A), lutein (LUT) and ß-carotene (B-CAR).

3.3.6. April 2007

During this month, surface chlorophyll measurements are measured at total 40 stations.

3.3.6.1. Chlorophyll distribution at surface waters (concentrations measured by the fluorometric method)

In the study area, total chlorophyll concentration ranged between 0.03 - 0.76 µg/L at surface (Figure 3.85). Maximum value was measured at station 74 located near Seyhan River. Minimum value was measured at the central basin station # 8 located in between Turkey and Cyprus (Figure 2.1). Areas near Seyhan, Asi and Lamas Rivers (Figure 2.1) had higher chlorophyll concentrations compared to other freshwater sources (Figure 2.1). High chlorophyll concentration was also measured near Cape Karpaz (Figure 2.1).

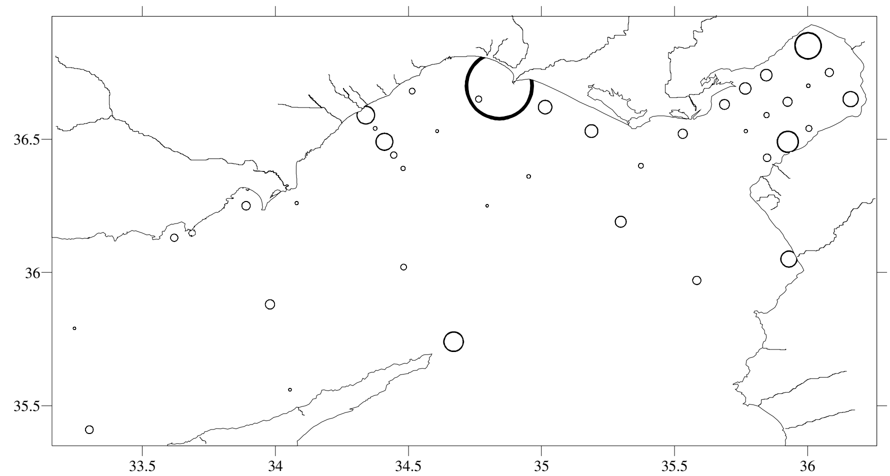

Figure 3.85. Surface chlorophyll distribution (from spectrofluorometer) in the Cilician basin in April 2007.

3.3.6.2. Chlorophyll distribution at surface waters along the ship track (based on in-situ fluorometer readings)

In-situ chlorophyll concentrations recorded at every 5 seconds along the ship track ranged between 0.02 - 2.98 µg/L at surface (Figure 3.86). Similar to extracted chlorophyll results, in-situ readings peaked at station 74. High readings (concentrations) also recorded in front of the Lamas (station 1 and 2, Figure 2.1) and Ceyhan Rivers (station 54 and 55, Figure 2.1) and Mersin Bay (station 11, Figure 2.1). İskenderun Bay was rich of chlorophyll content.

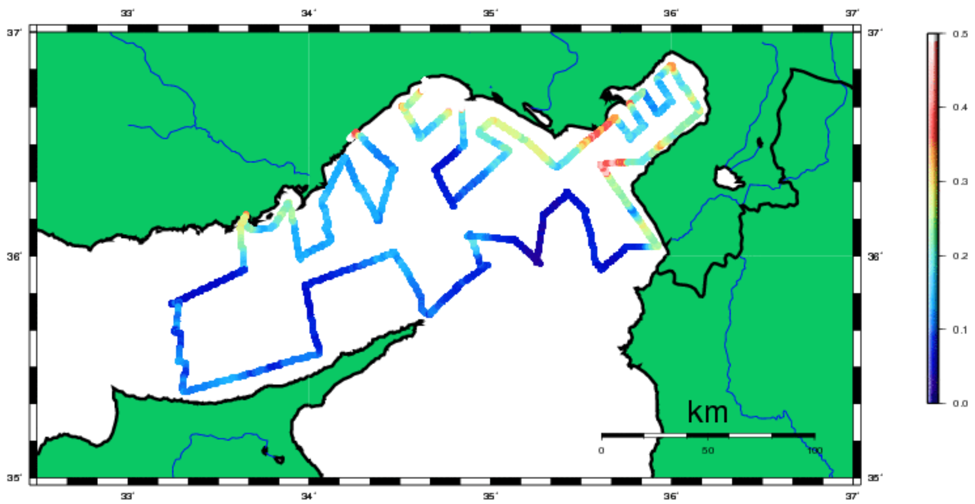

Figure 3.86. Surface chlorophyll distribution (based on in-situ fluorometer readings) in the Cilician basin in April 2007.

3.3.6.3. Chlorophyll-a & pigment distribution at surface waters (measured by HPLC)

Chl-a and other pigment concentrations were measured by this technique only at six stations (8, 11, 24, 33, 49 and 74 (Figure 2.1)). Based on these limited measurements, total chlorophyll-a including divinyll chlorophyll-a ranged between 0.44 - 1.827 µg/L at surface (Figure 3.87). The highest concentration was measured at station 74 and the minimum at station 49. Chlorophyll-a was dominant at all stations.

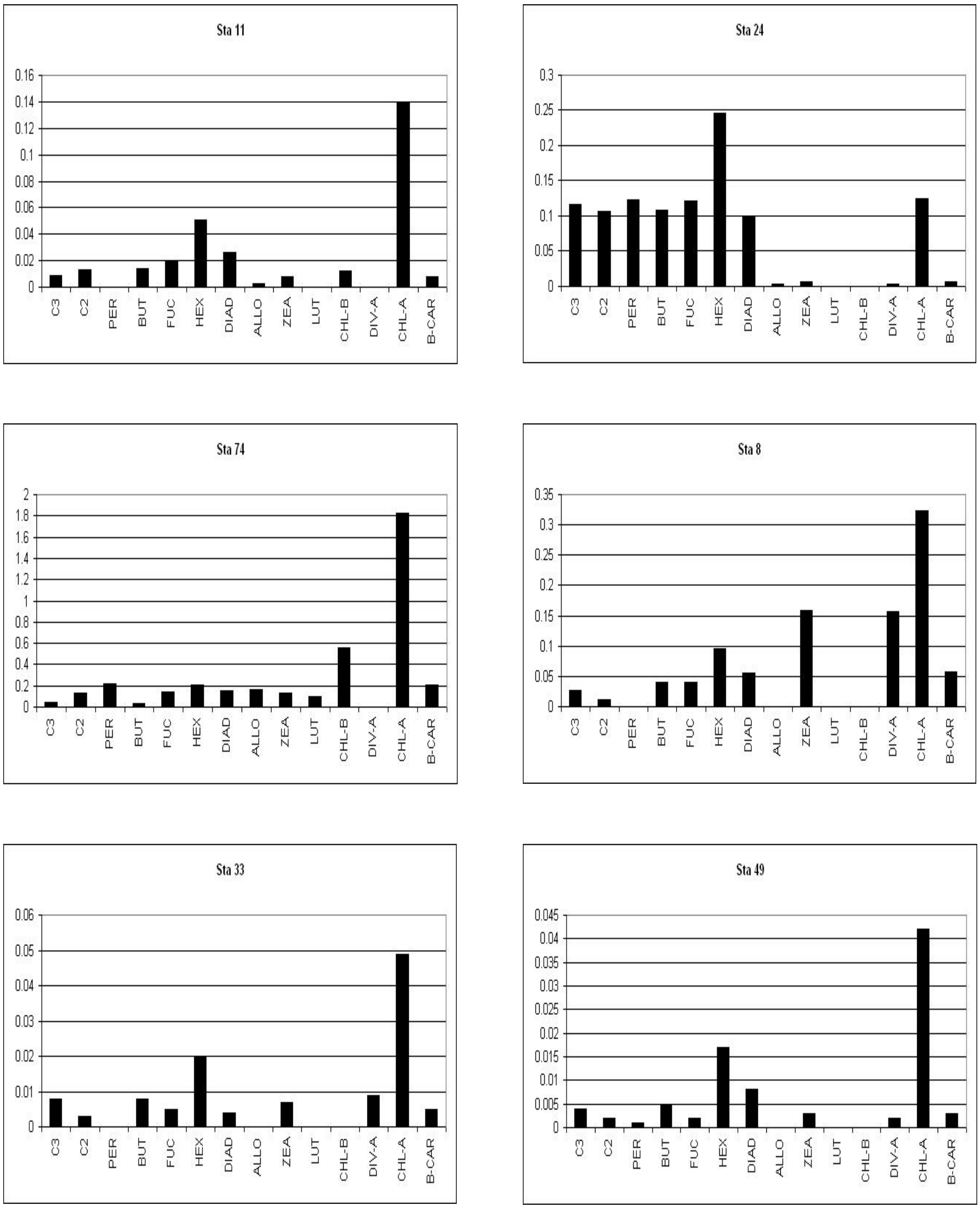

Figure 3.87. Pigment distribution (μg/L) at surface in coastal (Sta 11, 24 and 74, Figure 2.1) and offshore (Sta 8, 33 and 49, Figure 2.1) stations in April 2007.

Chlorophyll-a, (CHL-A), Chlorophyll c_3 (C3) and c_2 (C2), peridinin (PER), buthanoloxyfucuxanthin (BUT), fucuxanthin (FUC), 19'hexonoloyxyfucoxanthin (HEX), diadinixanthin (DIAD), alloxanthin (ALLO), zeaxanthin (ZEA), chlorophyll-b (CHL-B), divinil chlorophyll-a (DIV-A), lutein (LUT) and ß-carotene (B-CAR).

3.3.7. June 2007

During this month, surface chlorophyll measurements are measured at total 40 stations.

3.3.7.1. Chlorophyll distribution at surface waters (concentrations measured by the fluorometric method)

In the study area, total chlorophyll concentration ranged between 0.014 - 0.350 µg/L at surface (Figure 3.88). Maximum value was measured at station 1 located in front of the Lamas River. Minimum value was measured at station 67. In general, shallower shelf waters held much higher concentrations compared to areas beyond shelf break (depths over 200m).

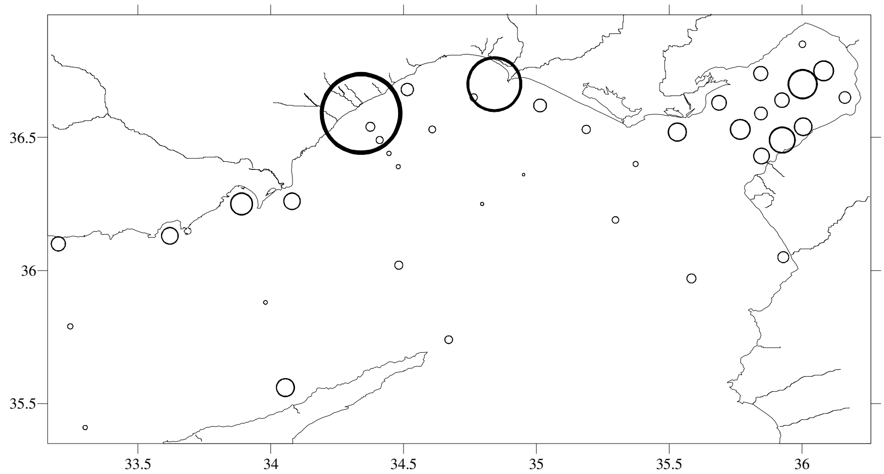

Figure 3.88. Surface chlorophyll distribution (from spectrofluorometer) in the Cilician basin in June 2007.

3.3.7.2. Chlorophyll distribution at surface waters along the ship track (based on in-situ fluorometer readings)

In-situ chlorophyll concentrations recorded every 5 seconds along the ship track ranged between 0.001 - 3.94 µg/L at surface (Figure 3.89). Similar to extracted chlorophyll readings, in-situ readings peaked near station 1 (Figure 2.1). High readings (concentrations) also recorded in front of the Ceyhan (stations 73 and 74, Figure 2.1) and Göksu Rivers (stations 37 and 17, Figure 2.1).

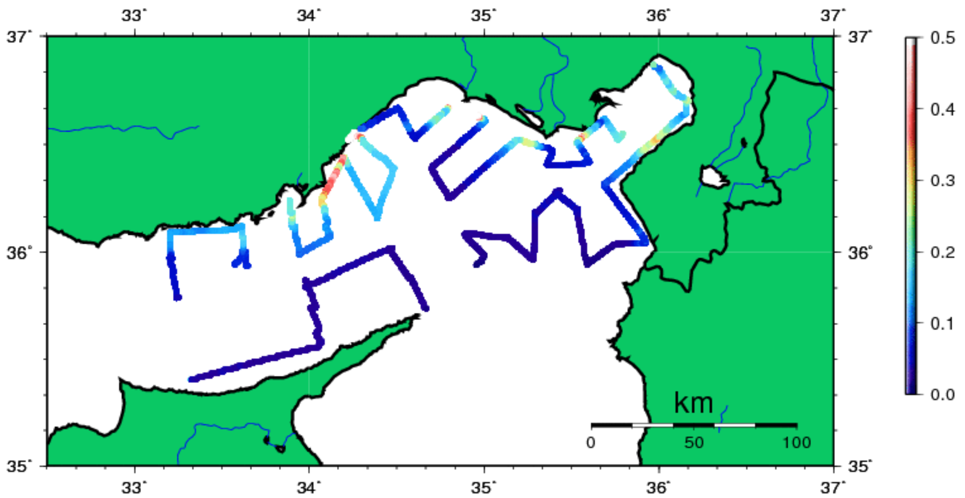

Figure 3.89. Surface chlorophyll distribution (based on in-situ fluorometer readings) in the Cilician basin in June 2007.

3.3.7.3. Chlorophyll-a & pigment distribution at surface waters (measured by HPLC)

Chl-a and other pigment concentrations were measured by this technique only at six stations (8, 11, 24, 33, 49 and 74, Figure 2.1). Based on these limited measurements, total chlorophyll-a including divinyll chlorophyll-a ranged between 0.019 - 0.945 µg/L at surface (Figure 3.90). The highest concentration was measured at station 74 and the minimum at station 33 (Figure 2.1). Chlorophyll-a was dominant pigment at all stations.

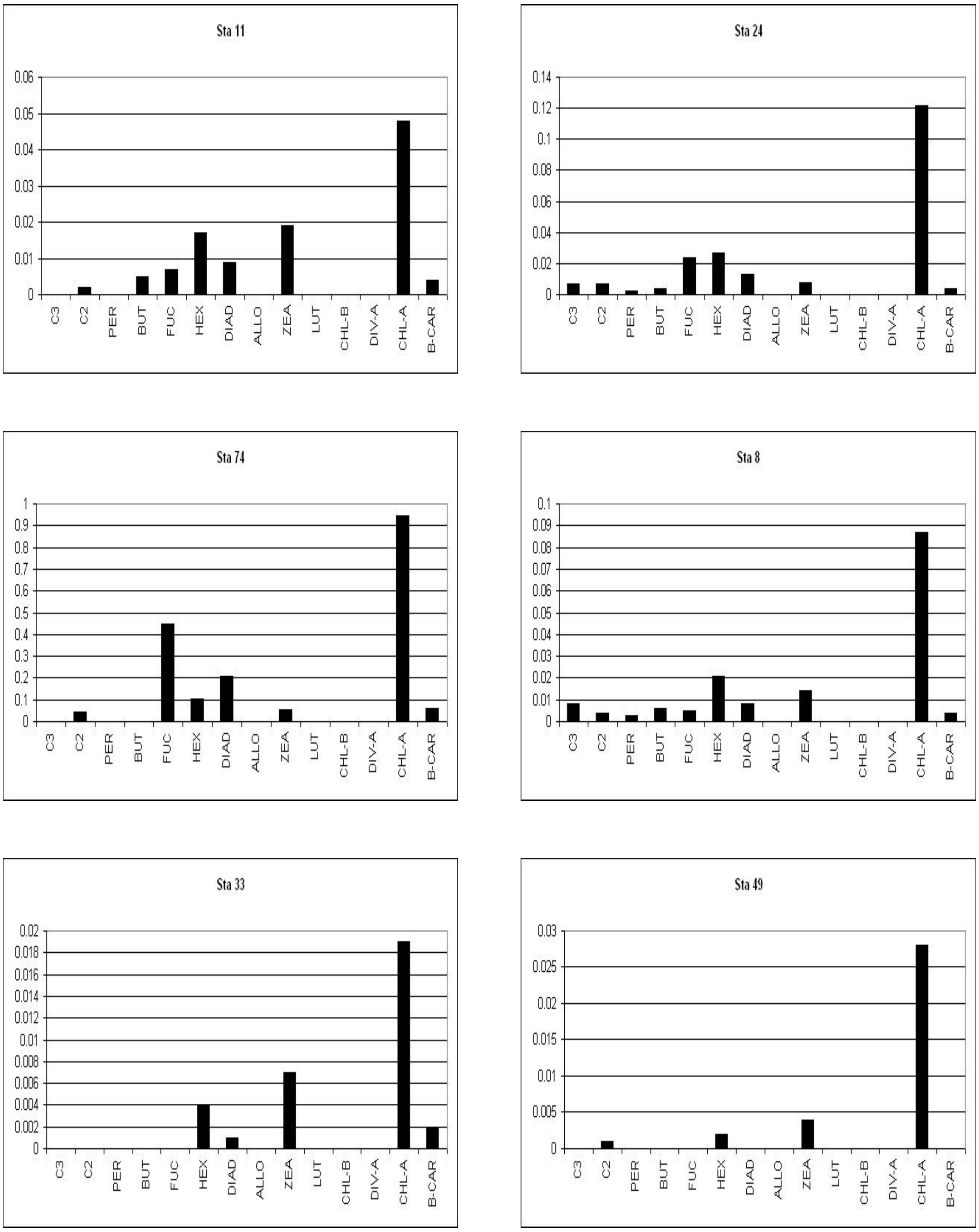

Figure 3.10. Pigment distribution (µg/L) at surface in coastal (Sta 11, 24 and 74, Figure 2.1) and offshore (Sta 8, 33 and 49, Figure 2.1) stations in June 2007.

Chlorophyll-a, CHL-A, Chlorophyll c_3 (C3) and c_2 (C2), peridinin (PER), buthanoloxyfucuxanthin (BUT), fucuxanthin (FUC), 19'hexonoloyxyfucoxanthin (HEX), diadinixanthin (DIAD), alloxanthin (ALLO), zeaxanthin (ZEA), chlorophyll-b (CHL-B), divinil chlorophyll-a (DIV-A), lutein (LUT) and ß-carotene (B-CAR).

3.3.8. September 2007

During this month, surface chlorophyll measurements are measured at total 42 stations.

3.3.8.1. Chlorophyll distribution at surface waters (concentrations measured by the fluorometric method)

In the study area, total chlorophyll concentration ranged between 0.027 - 0.350 µg/L at surface (Figure 3.91). Maximum value was measured at station 74 (Figure 2.1) located near the Seyhan River. Minimum value was measured at the central deep station 33 (Figure 2.1) located in between Turkey and Cyprus (Figure 2.1). In general, shallower shelf waters held much higher concentrations compared to areas beyond shelf break. Peaks are met near Seyhan and Ceyhan Rivers (Figure 2.1).

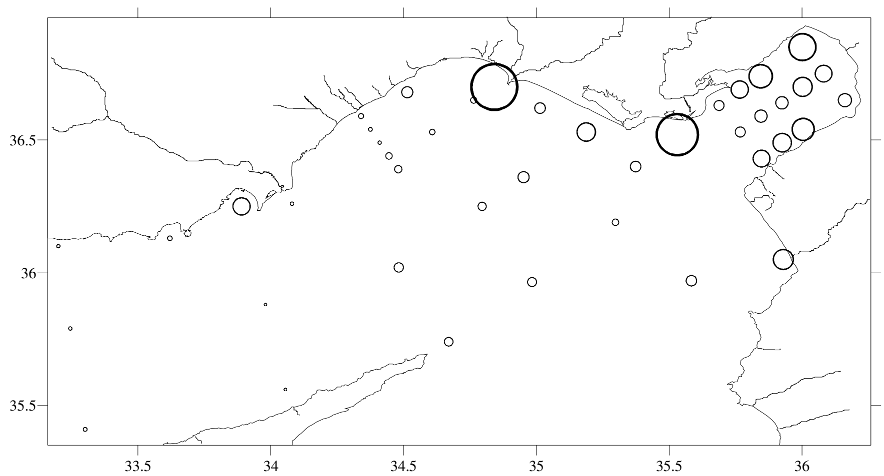

Figure 3.11. Surface chlorophyll distribution (from spectrofluorometer) in the Cilician basin in September 2007.

3.3.8.2. Chlorophyll distribution at surface waters along the ship track (based on in-situ fluorometer readings)

In-situ chlorophyll concentrations recorded every 5 seconds along the ship track ranged between 0.002 - 1.47 µg/L at surface (Figure 3.92). Similar to extracted chlorophyll readings, in-situ readings peaked at station 74 (Figure 2.1). High readings (concentrations) also recorded in Mersin Bay (station 11, Figure 2.1) and near Seyhan and Ceyhan Rivers (stations 74 and 54, Figure 2.1).

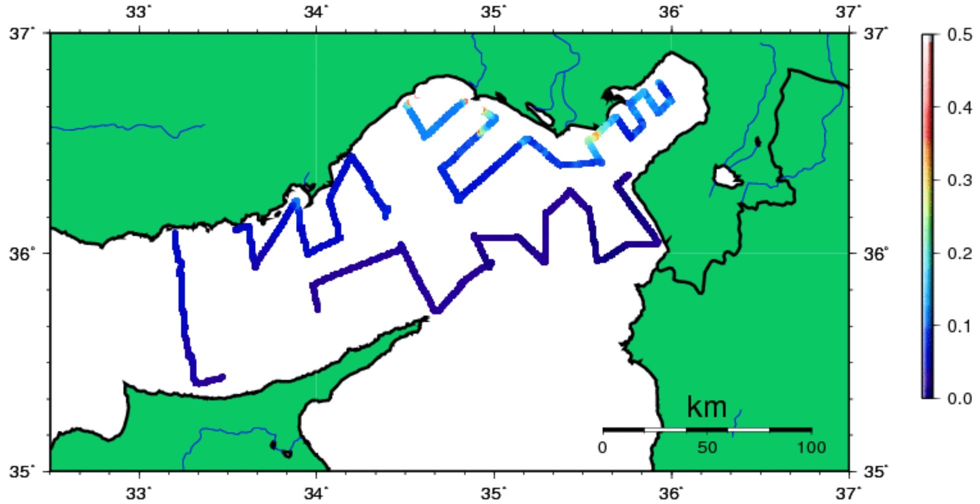

Figure 3.12. Surface chlorophyll distribution (based on in-situ fluorometer readings) in the Cilician basin in September 2007.

3.3.8.3. Chlorophyll-a & pigment distribution at surface waters (measured by HPLC)

Chl-a and other pigment concentrations were measured by this technique only at six stations (8, 11, 24, 33, 49 and 74, Figure 2.1). Based on these limited measurements, total chlorophyll-a including divinyll chlorophyll-a ranged between 0.011 - 0.144 µg/L at surface (Figure 3.93). The highest concentration was measured at station 11 and the minimum at station 33 (Figure 2.1). Chlorophyll-a was dominant at all stations.

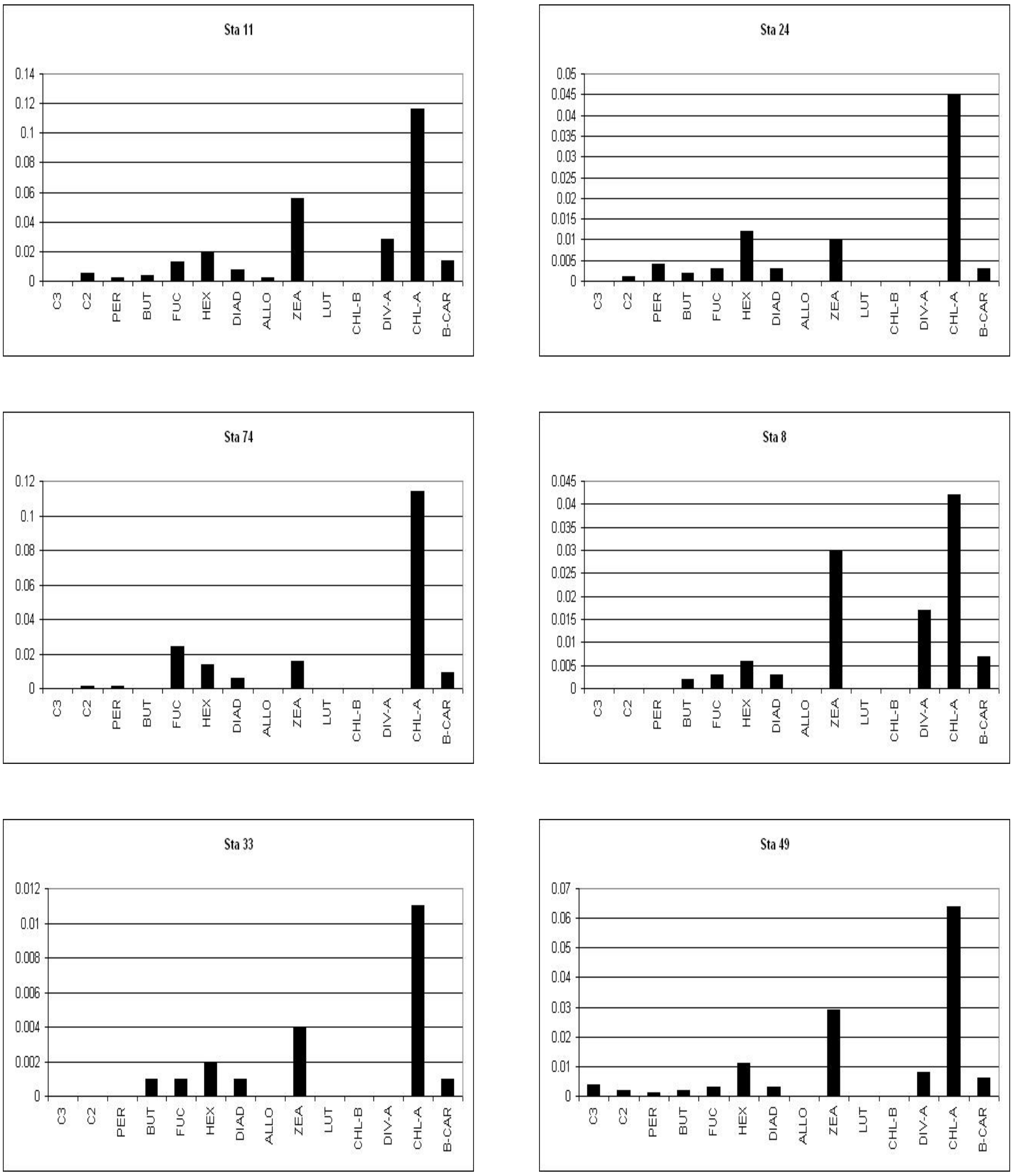

Figure 3.13. Pigment distribution (μg/L) at surface in coastal (Sta 11, 24 and 74, Figure 2.1) and offshore (Sta 8, 33 and 49, Figure 2.1) stations in September 2007.

Chlorophyll-a, CHL-A, Chlorophyll c_3 (C3) and c_2 (C2), peridinin (PER), buthanoloxyfucuxanthin (BUT), fucuxanthin (FUC), 19'hexonoloyxyfucoxanthin (HEX), diadinixanthin (DIAD), alloxanthin (ALLO), zeaxanthin (ZEA), chlorophyll-b (CHL-B), divinil chlorophyll-a (DIV-A), lutein (LUT) and ß-carotene (B-CAR).

3.4. Statistical analysis

Spearman rank-order correlation was done to look for relationship between chlorophyll, physical and chemical parameters. Highly significant ($p < 0.01$) and significant ($p < 0.05$) correlation were found between chlorophyll and other parameters (Table 3.1.) in different months. There was no relationship between some of the parameters (Table 3.1.).

Table 3. 1. Correlations between chlorophyll, physical and chemical parameters during study period.

		Temperature	Salinity	Phosphate	Nitrite+ nitrate	Silicate
November 2005	Correlation Coefficient	0.098	-0.241	.337(*)	.307(*)	.572(**)
	Sig. (1-tailed)	0.278	0.072	0.019	0.03	0
	N	38	38	38	38	38
March 2006	Correlation Coefficient	-0.116	-.318(*)	0.075	0.042	-0.062
	Sig. (1-tailed)	0.242	0.025	0.325	0.4	0.354
	N	38	38	38	38	38
July 2006	Correlation Coefficient	.459(**)	-.597(**)	0.055	0.221	.515(**)
	Sig. (1-tailed)	0.001	0	0.364	0.081	0
	N	41	41	41	41	41
January 2007	Correlation Coefficient	-.412(**)	.381(**)	.355(*)	-0.234	.321(*)
	Sig. (1-tailed)	0.003	0.007	0.011	0.07	0.02
	N	41	41	41	41	41
March 2007	Correlation Coefficient	-.409(**)	-.586(**)	.313(*)	0.0281	-0.003
	Sig. (1-tailed)	0.004	0	0.023	0.43	0.491
	N	41	41	41	41	41
April 2007	Correlation Coefficient	0.23	-.534(**)	0.192	.442(**)	.377(**)
	Sig. (1-tailed)	0.0763	0	0.116	0.002	0.008
	N	40	40	40	40	40
June 2007	Correlation Coefficient	0.062	-.743(**)	0.117	0.022	-.323(*)
	Sig. (1-tailed)	0.351	0	0.234	0.444	0.021
	N	40	40	40	40	40
September 2007	Correlation Coefficient	.358(**)	-0.179	0.218	0.02	.691(**)
	Sig. (1-tailed)	0.009	0.128	0.082	0.448	0
	N	42	42	42	42	42

**. Correlation is significant at the 0.01 level (1-tailed).

*. Correlation is significant at the 0.05 level (1-tailed).

4. DISCUSSION

Topics related to phytoplankton pigment distribution in the northeastern Mediterranean will be discussed chronogically in the following pages, starting with November 2005 and ending with September 2007.

4.1. November 2005

Total chlorophyll concentration ranged between 0.09 and 0.51 µg/L at surface waters. in November. Maximum values were measured at station 2 and 74 both located in the coastal part of Mersin Bay. In addition, phytoplankton cell count as well as the chlorophyll concentration was maximum at station 2 (Uysal et al., 2008).
Despite the low chlorophyll content measured at station 63 located in the İskenderun Bay (Figure 2.1), rest of the stations in the entire bay had higher chlorophyll compared to offshore areas. In general, shallower shelf waters hold much higher concentrations compared to areas beyond shelf break (depths over 200m). Elevated concentrations were characteristics of the River drainage areas and inner part of both bays. The offshore station 14 (Figure 2.1) displayed relatively higher concentration compared to other offshore stations.
Chlorophyll concentrations measured by Spectrofluorometer and insitu fluorometer agree well with each other (Figures 3.71 and 3.72). Chlorophyll concentration tends to decrease slowly from inshore towards offshore. Similarly, Uysal *et al*. (2008) also have shown decrease in total phytoplankton cell counts from shallow towards deep stations. Areas enriched by nutrients via terrestrial inputs yield higher chlorophyll content. Maximum nitrate-nitrite (3.27 µM) and silicate (7.3 µM) concentrations were measured near Ceyhan River drainage area. Seyhan and Ceyhan River waters contained high nitrogen and silicate. Although the nutrients were almost extinguished considerable amount of chlorophyll were measured in the offshore area between Turkey and Cyprus. At first glance, there seem to exist a positive relationship between nutrients and the total chlorophyll. Based on Spearman rank correlation analysis, a significant correlation between total chlorophyll and nitrate-nitrite (n: 38, r: 0,307, $P < 0,05$) and phosphate (n: 38, r: 0,337, $P < 0,05$) as well as a highly significant one with silicate (n: 38, r: 0,572, $P < 0,01$) was found. Silicate distributed

almost homogenously in offshore waters. High concentrations are observed in İskenderun Bay, in front of Seyhan and Ceyhan Rivers and in the periphery of Göksu River drainage area.

In general the Mediterranean is nutrient poor from the outset because its surface waters (top 100m) come from the eastern Atlantic. Nutrients are used by phytoplankters along its route from Gibraltar towards the eastern Mediterranean. Nutrient rich Atlantic water leaves the Mediterranean as the intermediate waters (Murdoch and Onuf, 1974; Özsoy et al., 1993). Low nutrient concentrations are characteristic of offshore waters from surface to 125-150 m in northeastern Mediterranean (Salihoğlu et al., 1990; Yılmaz and Tuğrul, 1998; Krom et al., 2005; Herut et al., 2000; Uysal et al., 2008).

In offshore stations, very low nutrient concentrations yield slightly high total chlorophyll. In the case of Mersin Bay and İskenderun Bay, a positive relationship between nutrient levels and total chlorophyll do exist. Much faster recycling of nutrients within the water column in shallow shelf waters compared to offshore ones coupled with steady input from the Rivers enhance the nutrient and chlorophyll content of both Mersin and İskenderun Bays. This is mostly true for the inner part of the bays when the exchange with offshore waters is limited. An inverse relationship between chl and nutrients is also observed in the Göksu River drainage area. This River is situated in the western corner of the Mersin Bay where the wide shelf area constricts in front of it. When all these processes combine with the persisting flow regime one can conclude that the residence time of incoming freshwater is shorter compared to inner bay. Göksu River induced local blooms or nutrient enrichment of surface waters mostly take place to the west or south west of the River mouth (Figure 3.71).

Among the offshore stations, the deep basin station #14 (Figure 2.1) which is located in between Cape Karpaz (Cyprus) and Erdemli (Mersin/Turkey, Figure 2.1) had the highest total chlorophyll concentration during November. Generally, Cilician offshore surface waters contain low nutrient and low chlorophyll. An upwelling event occurred near the station 14 (Figure 2.1) led transportation of nutrient rich deep waters towards surface and hence promoted the phytoplankton growth (Figure 3.71).

Nutrient enrichment in surface waters of the İskenderun Bay occurs in several ways. One mechanism is the local wind induced mixing in the water column. The other is the penetration of northwesterly flowing open sea waters from the northwest corner of the bay where the Ceyhan River drains. As this branch of flow move in from this corner, it carries and spreads substantial amount of the River water to the entire bay with the help of clockwise and anticlockwise eddies formed in the area (Figure 1.4, İyiduvar, 1986; Latif *et al*., 1989).

Remarkable regional variations in surface nutrient concentrations are observed in the basin. River discharges, discharge from major settlements in the form of sewage, drainage channels carrying underground water from agricultural fields, wind induced mixing in shallow shelf areas, phytoplankton consumption and upwelling regulate the nutrient budget of the basin waters. Based on Spearman rank correlation analysis, significant correlation was obtained between phosphate and total chlorophyll (n: 38, r: 0,337, $P< 0,05$). Results also indicated that there exist no relationship between the total chlorophyll content of the surface waters and the surface temperature and salinity.

According to Codispoti (1989), a healthy marine ecosystem should maintain a N:P ratio near 16:1. The mean molar ratios of nitrate+nitrite (NO_2+NO_3) to phosphate (PO_4) were calculated as 25 for shelf and 12.16 for offshore surface waters in November 2005. It is found higher than the Redfield ratio (16:1). Production stops when system runs out of phosphate, but there still remains some nitrate. Rivers contain poor phosphate and high nitrogen (Figure 4.1), so, surface N:P ratio increase in shelf waters and bays that are subject to River discharge. Much of the phosphate is utilized by phytoplankton in the River drainage areas, inner bays and within the shelf area. For this reason offshore waters remain very poor in terms of phosphate. Although atmospheric input add a certain amount to the nutrient deficit offshore waters in northeastern Mediterranean (Herut et al., 1999a,b, 2002; Justic et al., 1995 ; Markaki et al., 2003) they are utilized readily by the existing flora.

In this study, 13 different pigments were measured besides chlorophyll-a via chromatographic method. The contribution of marker pigments to total chlorophyll-a in offshore and shelf stations are given as pie charts (Figure 4.2). Based on Jeffreys' *et al*., (1997) algal classification, among all taxons Prymnesiophyceae is the dominant group in the central İskenderun Bay (Sta 24, Figure 2.1) and near the Göksu River (Sta. 28, Figure 2.1). Similarly Uysal *et al*., (2008) reported the coccolithophorid *Emiliana huxleyi* (Prymnesiophyceae) as the dominant species in these stations (formed 93% and 89% of the total surface cell counts at stations 24 and 28, respectively (Figure 2.1)). Diatoms formed the second major group in central İskenderun Bay.

On the other hand, in the mid-basin stations 14 and 33 (Figure 2.1), Prochlorophytes is found to be the dominant group followed by Prymnesiophyceae (Table 4.1). Prochlorophytes have been also regarded as the major contributor to total chlorophyll in the highly oligotrophic eastern Mediterranean offshore waters (Li et al., 1993).

HPLC approach is used to characterize phytoplankton communities, however, precise identification and quantification of phytoplankton classes in water samples are often difficult because;

(i) the pigment compositions of many algal classes are not known,
(ii) symbionts within phytoplankton often possess pigments (Jeffrey at al., 1975; Watanabe et al.,1987; Bjornland and Liaaen-Jansen, 1989; Watanabe et al., 1990)
(iii) heterotrophic or mixotrophic protists often retain photosynthetic pigments from their prey (Lewitus et al.,1999; Li et al.,1999), and
(iv) pigment composition varies depending on the light regimens, nutrient concentrations, and physiological status of the phytoplankton (Lewitus and Kana, 1994; Delgiorgio and Cole, 1998; Georicke and Montoya, 1998; Schluter at al., 2000; Evens at al., 2001).

HPLC has provided us with the ability to study fragile (e.g. flagellates) and sub-micron (e.g. prochlorophytes) species that are often missed in the microscopic enumeration of phytoplankton (Gibb et al., 2001)

Based on Spearman rank correlation analysis, there is highly significant relationship between HPLC and spectrofluorometer results (n: 43, r: 0.564, P < 0, 01). HPLC and

Spectrofluorometer results show that Spectrofluorometer underestimate total chlorophyll concentration (Figure 4.3).

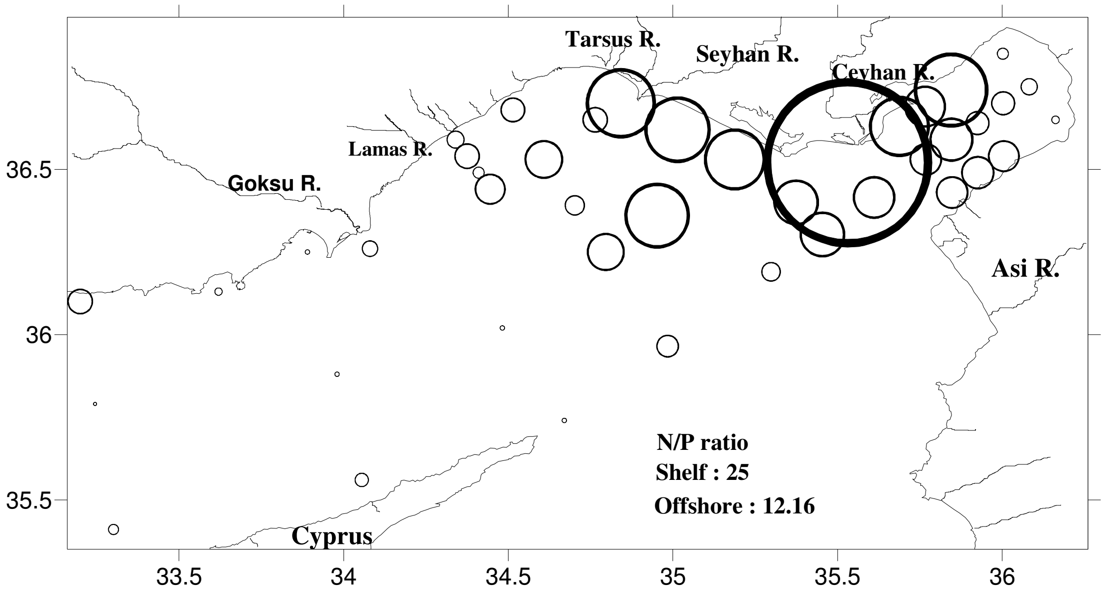

Figure 4.1. N/P ratios in November 2005.

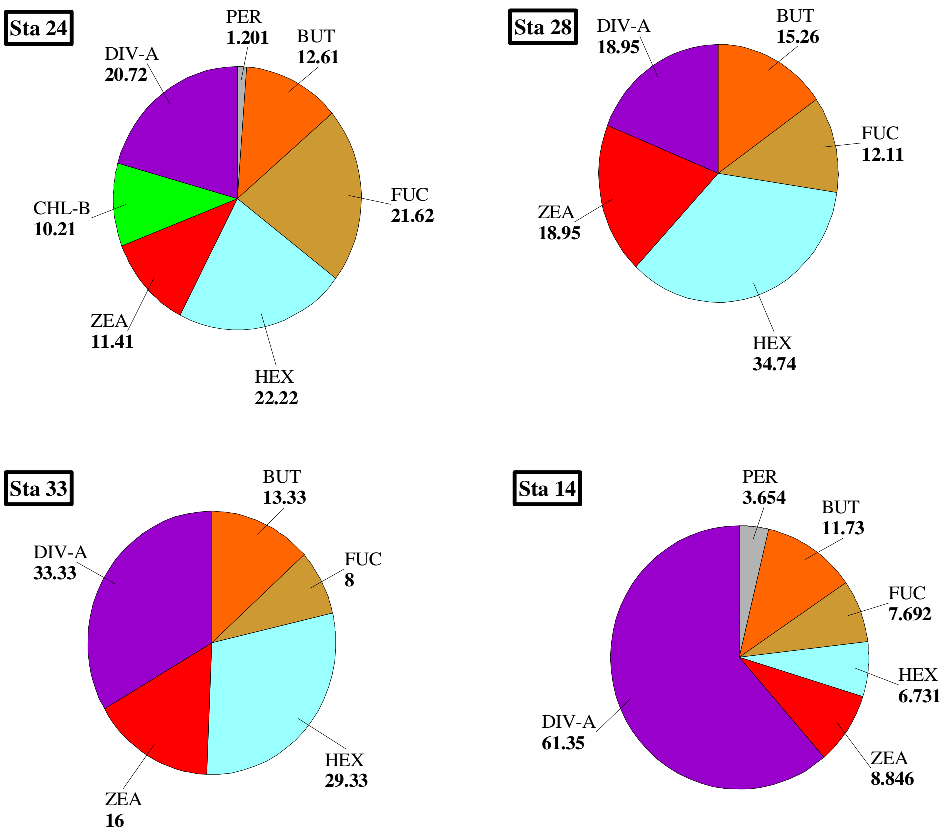

Figure 4.2. Marker pigment contiribution to chlorophyll-a in November 2005. Station were given in this figure can be seen in Figure 2.1.

Chlorophyll-a, CHL-A, Chlorophyll c_3 (C3) and c_2 (C2), peridinin (PER), buthanoloxyfucuxanthin (BUT), fucuxanthin (FUC), 19'hexonoloyxyfucoxanthin (HEX), diadinixanthin (DIAD), alloxanthin (ALLO), zeaxanthin (ZEA), chlorophyll-b (CHL-B), divinil chlorophyll-a (DIV-A), lutein (LUT) and ß-carotene (B-CAR).

Table 4.1. Dominant phytoplankton groups in the basin in November 2005.

Stations (Fig. 2.1)	**1st dominant**	**2nd dominant**	**3rd dominant**
14	Prochlorophytes	Chrysophytes	Cyanobacteria,Diatoms, Prymnesiophyceae
24	Prymnesiophyceae	Diatoms	Prochlorophytes,Chrysophytes, Cyanobacteria,Chlorophytes
28	Prymnesiophyceae	Cyanobacteria Prochlorophytes	Chrysophytes, Diatoms
33	Prochlorophytes	Prymnesiophyceae	Cyanobacteria, Chrysophytes

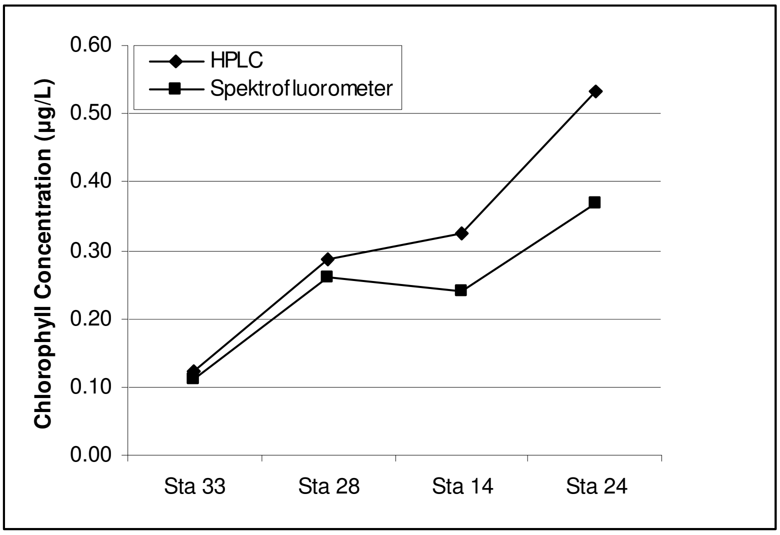

Figure 4.3. Chlorophyll concentrations measured by HPLC and spectrofluorometer in November 2005.

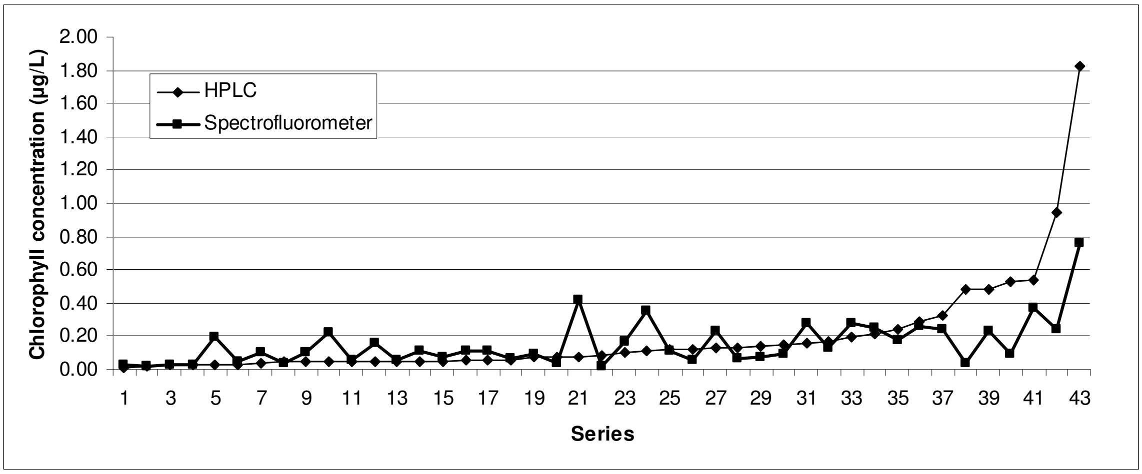

Figure 4.4. Chlorophyll concentrations measured by HPLC and spectrofluorometer during November 2005-September 2007.

4.2. March 2006

In March 2006, total chlorophyll concentration ranged between 0.07 and 0.61 µg/L at surface (Figure 3.74) in the Cilician basin. Maximum value was measured at the shallow shelf station 1 (Figure 2.1) which receives substantial amount of freshwater from the nearby Lamas River. Minimum value was measured at the central basin station 8 (Figure 2.1). Two gyres, a cyclonic one in the west and a anticyclonic one in the east are observed during this period (Uysal *et al*., 2008). Station 8 (Figure 2.1) with its warmer surface water is included in the anticylonic gyre. In general, relatively colder, shallow shelf regions held much higher chlorophyll compared to areas beyond shelf break. Concentrations peaked at shallow shelf stations near River drainage areas. The coastal sector receiving freshwater from the Seyhan and Ceyhan Rivers, remained rich in chlorophyll content. The impact of Lamas River to shelf waters has been formerly discussed by Uysal et al., (2004). Lamas River discharges a large basin (1055 km^2). The average annual discharge is about 6.7 m^3 sec^{-1} (Okyar, 1991). During March 2006, phytoplankton cell counts made a peak at station 1 (Figure 2.1) which is located nearby the Lamas River.

Discrete station based surface chlorophyll contents measured by Spectrofluorometer and continuous measurements achieved along the cruise track from the in-situ fluorometer agreed well with each other except those much higher concentrations measured near Mersin harbor within the project MEDPOL (Figures 3.74-3.75). In general, the surface chlorophyll content of the basin waters decreased appreciably from colder inshore waters towards warmer offshore areas.

The highest nitrate-nitrite and silicate concentration was measured near Ceyhan River mouth. Intrusion of an anticyclone which carries much warmer and saline waters from the east of Cyprus towards Mersin Bay is observed in March (Uysal et al., 2008). Inshore movement of this huge mass of water blocks and squeezes the shelf waters to inner Mersin Bay. As the exchange with offshore waters are ceased production increases in inner Mersin Bay with increasing rates of freshwater input. Shelf waters enriched by Seyhan and Ceyhan River input contained much higher nutrients (nitrate+nitrite and silicate) compared to offshore areas. Although there seemed to remain trace amounts of nitrate-nitrite in the central basin between Turkey and Cyprus, the total chlorophyll concentration was found relatively high at offshore station #14 (Figure 2.1). Phosphorus and T-P were maximum in front of the Seyhan River. Overall, basin surface waters were poor in phosphorus (near detection limits).

Rank correlation analysis revealed a significant correlation between chlorophyll and salinity (n: 38, r: -0,318, $P < 0, 05$) and almost no correlation with temperature and nutrients. High nitrogen and silicate levels however did not yield high chlorophyll in front of the Ceyhan River. The calculated N:P ratio of 183.5:1 was higher than the Redfield ratio of 16. It is clearly evident from the N:P ratios obtained during March, that production in shelf waters is P-limited (N:P is 28.1:1) whereas in offshore waters it is N-limited (N:P is 5.2:1). The average phosphate concentration for the surface waters in the entire basin was 0.024 µM, which is very low. It is clearly evident that phosphate is the limiting nutrient in the basin during March. Available nutrients are readily utilized by phytoplankton in areas near Lamas, Seyhan and Göksu Rivers, (Uysal et al., 2008). Presence of excess silicate is also observed almost in the entire İskenderun Bay. In the Mediterranean, enrichment of surface waters by nutrients are via Rivers (nitrogen and silicate) and atmospheric deposition (especially phosphate) (Herut et al., 1999a,b, 2002; Justic et al., 1995; Migon et al., 1999; Markaki et al., 2003).

HPLC results declared diatoms as the dominant algal group in coastal areas and Prymnesiophyceae as the dominant group in offshore waters (Figure 4.6). Diatoms are followed by Prymnesiophyceae and Cyanobacteria in shelf waters. Cyanobacteria and Prochlorophytes dominated the central basin (Sta 8, Figure 2.1).

Deviations in HPLC and Spectrofluorometer readings are observed with increasing chlorophyll concentration. For example spectrofluorometer overestimates chlorophyll concentrations in low ranges compared to HPLC and underestimates in high ranges (Figure 4.7).

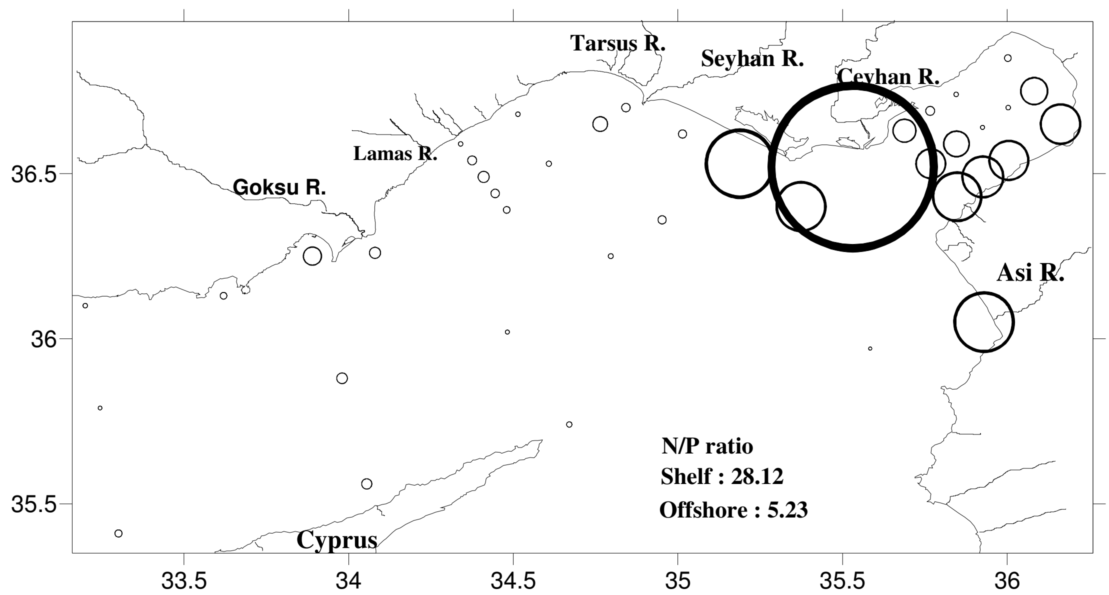

Figure 4.5. N/P ratios in March 2006.

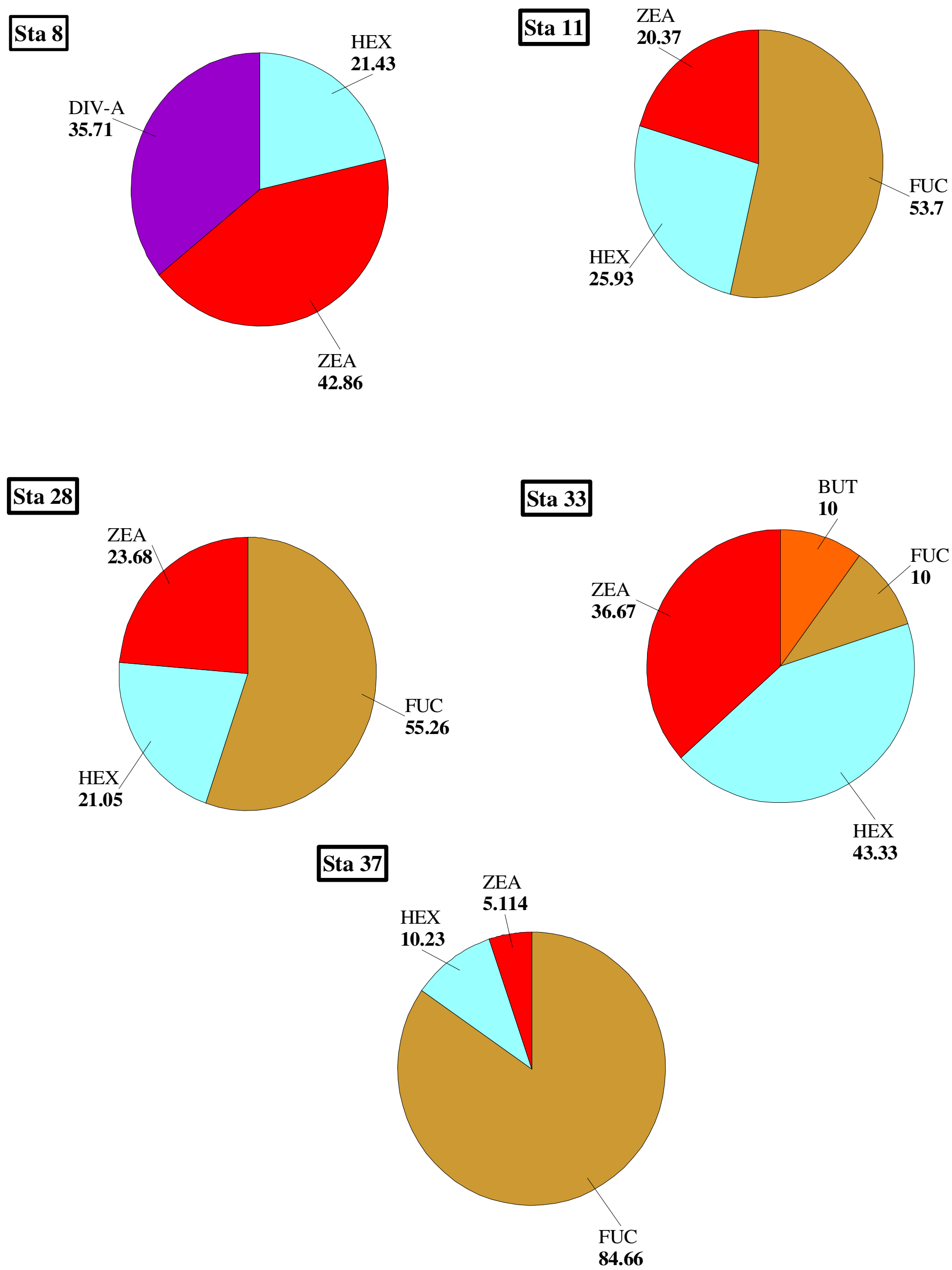

Figure 4.6. Marker pigment contiribution to chlorophyll-a in March 2006.
Station were given in this figure can be seen in Figure 2.1.

Chlorophyll-a, CHL-A, Chlorophyll c_3 (C3) and c_2 (C2), peridinin (PER), buthanoloxyfucuxanthin (BUT), fucuxanthin (FUC), 19'hexonoloyxyfucoxanthin (HEX), diadinixanthin (DIAD), alloxanthin (ALLO), zeaxanthin (ZEA), chlorophyll-b (CHL-B), divinil chlorophyll-a (DIV-A), lutein (LUT) and ß-carotene (B-CAR).

Table 4. 2. Dominant phytoplankton groups in the basin in March 2006.

Stations (Fig. 2.1)	1st dominant	2nd dominant	3rd dominant
8	Cyanobacteria	Prochlorophytes	Prymnesiophyceae
11	Diatoms	Prymnesiophyceae	Cyanobacteria
28	Diatoms	Cyanobacteria	Prymnesiophyceae
33	Prymnesiophyceae	Cyanobacteria	Chrysophytes-Diatoms
37	Diatoms	Prymnesiophyceae	Cyanobacteria

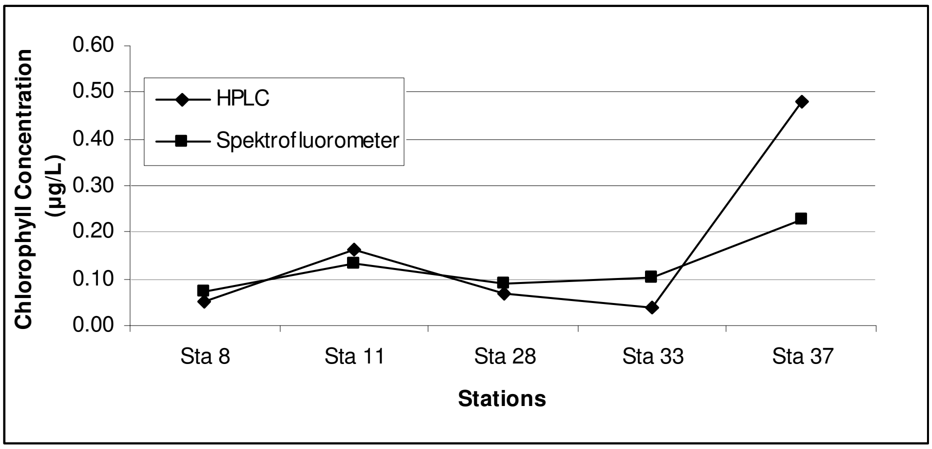

Figure 4.7. Chlorophyll concentrations measured by HPLC and spectrofluorometer in March 2006.

4.3. July 2006

Total chlorophyll concentration ranged between 0.01 and 0.20 µg/L at surface in the basin in July 2006. Shelf regions supplied by River inputs held higher concentrations compared to offshore areas with a peak value met at station 74 (Figure 2.1) near Seyhan River. The westward alongshore extension of waters with high chlorophyll content is mainly due to the prevailing intense cyclonic Asia Minor Current flowing west during July (Uysal et al., 2008). Chlorophyll images from the satellite and chlorophyll data collected from the field match with each other very well for this period (Figures 3.77-4.9). In general the surface chlorophyll content of the basin waters decreased appreciably from inshore towards offshore.

The highest nitrate-nitrite and silicate concentrations were measured near Ceyhan River mouth. Phosphorus distributed almost homogenously at detection limits (ranged between 0.02-0.03) in the basin. T-P was measured maximum in the inner İskenderun Bay. Nutrients of River origin are further dispersed westward along the shelf via the Asia Minor Current. Along their path much of the nutrients are taken up by phytoplankton the extent of which is also clearly depicted in the satellite reflections of surface chlorophyll (Figure 4.9). Although there seemed to remain trace amounts of nitrate-nitrite and silicate in front of Cape Karpaz (Cyprus), the total chlorophyll concentration was found relatively high at offshore station #12 (Figure 2.1). Hydrographic sections indicate formation of an upwelling in the area (Figure 3.11).

Based on Spearman rank correlation analysis, a highly significant positive correlation exists between chlorophyll and temperature & silicate and a negative correlation between chlorophyll and salinity (Table 3.1). With increasing salinity a decrease in chlorophyll is observed in the basin. Inversely with increasing surface temperature an increase in chlorophyll is observed. Rain and atmospheric deposition are the only sources of nitrogen and phosphorus for primary production in offshore waters during summer (Krom et al., 1991; Yılmaz and Tuğrul, 1998; Herut et al., 1999a, b, 2002; Markaki et al., 2003; Kress et al., 2005; Ediger et al., 2005). N:P ratio was calculated very low (6.3) for offshore surface waters during July and almost the same with Redfield ratio(16.2) for the shelf area (Appendix 1).

Phytoplankton pigment analysis via HPLC indicated Prymnesiophyceae and Cyanobacteria as the dominant groups in the basin (Table 4.3). One is dominant over other or vice versa depending on the site. Areas where Cyanobacteria were dominant are the central basin (Sta. 8, Figure 2.1), the area to the west of Göksu River (Stas. 28 and 41, Figure 2.1) and the inner İskenderun Bay (Sta. 27, Figure 2.1). Prymnesiophyceae was dominant near Göksu River to the east (Sta. 37, Figure 2.1) and in the central İskenderun Bay (Sta. 24, Figure 2.1).

If it is considered that the HPLC results more reliable than the Spectrofluorometer results then one could suggest that, except the high concentration achieved in mid

İskenderun Bay (Sta. 24), spectrofluorometer overestimates chl concentrations below 0.2 µg/l compared to HPLC (Figure 4.4).

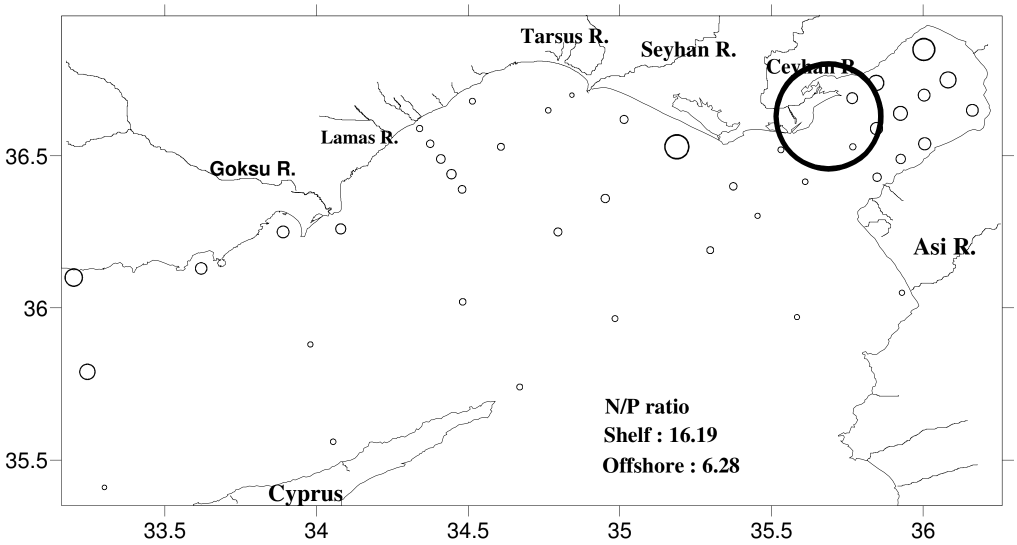

Figure 4.8. N/P ratios in July 2006.

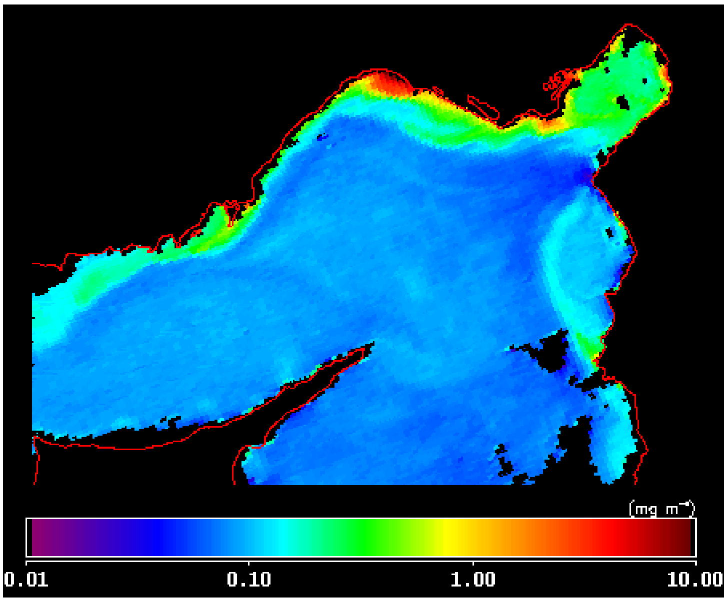

Figure 4.9. Satellite photo taken in July 2006.

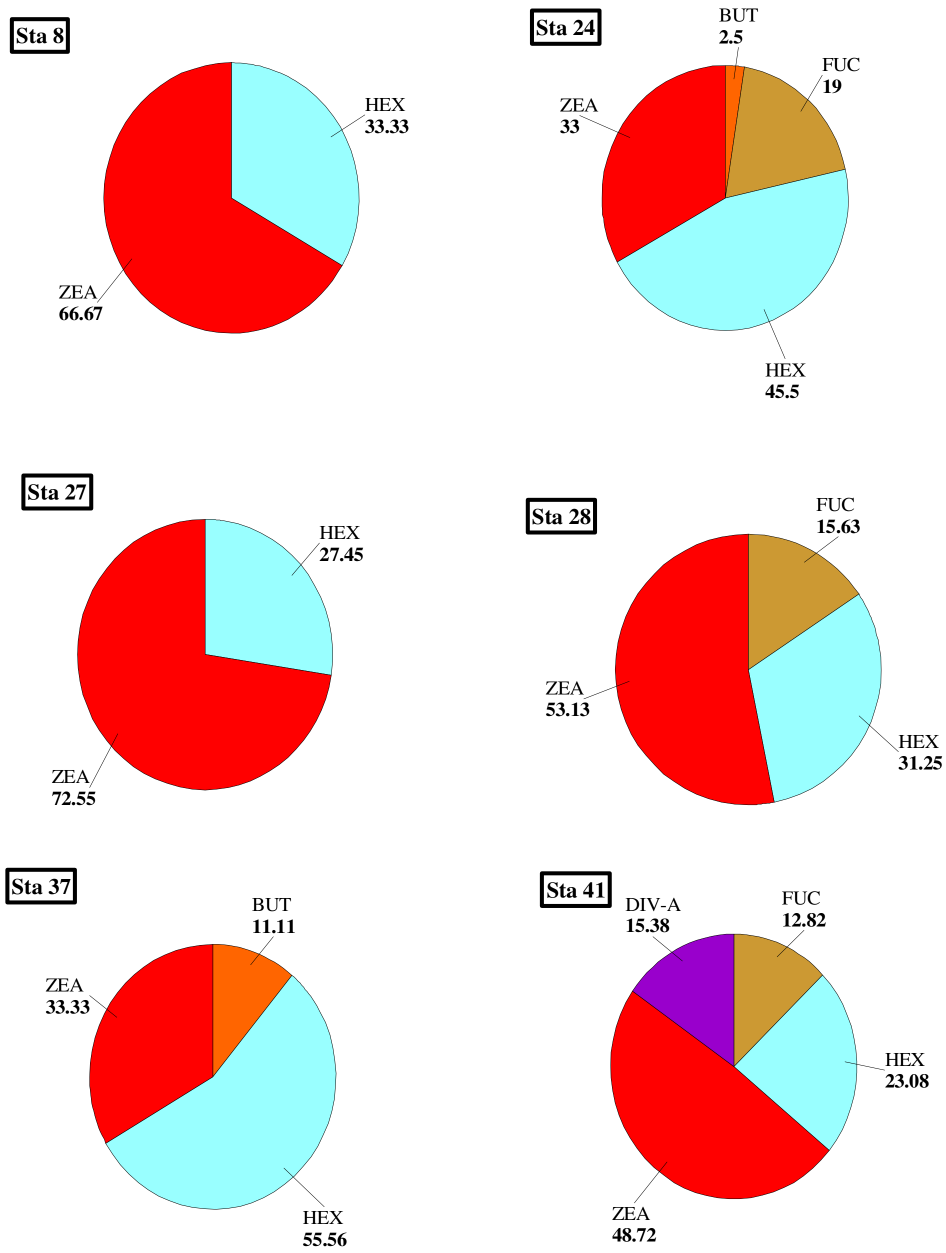

Figure 4.10. Marker pigment contiribution to chlorophyll-a in July 2006.
Station were given in this figure can be seen in Figure 2.1.

Chlorophyll-a, CHL-A, Chlorophyll c_3 (C3) and c_2 (C2), peridinin (PER), buthanoloxyfucuxanthin (BUT), fucuxanthin (FUC), 19'hexonoloyxyfucoxanthin (HEX), diadinixanthin (DIAD), alloxanthin (ALLO), zeaxanthin (ZEA), chlorophyll-b (CHL-B), divinil chlorophyll-a (DIV-A), lutein (LUT) and ß-carotene (B-CAR).

Table 4. 3. Dominant phytoplankton groups in the basin in July 2006.

Stations (Fig. 2.1)	**1st dominant**	**2nd dominant**	**3rd dominant**
8	Cyanobacteria	Prymnesiophyceae	
24	Prymnesiophyceae	Cyanobacteria	Diatoms
27	Cyanobacteria	Prymnesiophyceae	
28	Cyanobacteria	Prymnesiophyceae	Diatoms
37	Prymnesiophyceae	Cyanobacteria	Chrysophytes
41	Cyanobacteria	Prymnesiophyceae	Prochlorophytes-Diatoms

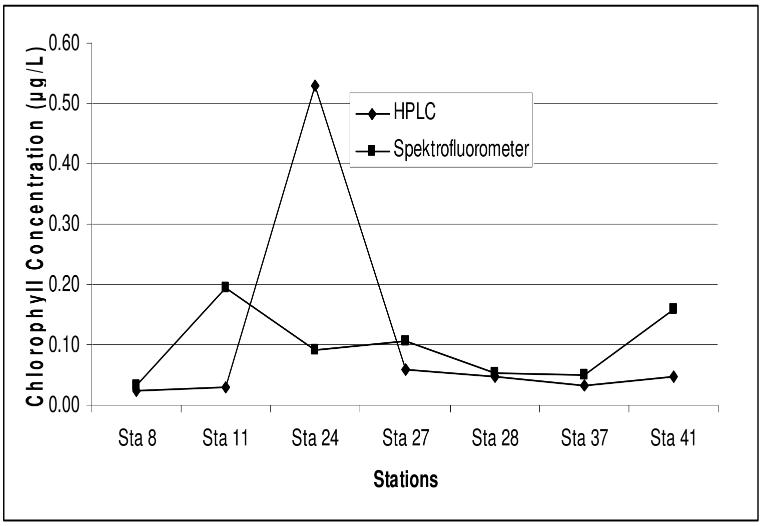

Figure 4.11. Chlorophyll concentrations measured by HPLC and spectrofluorometer in July 2006.

4.4. January 2007

In the study area, total chlorophyll-a concentration ranged between 0.07 and 0.41 μg/L at surface (Figure 3.79) which is much lower than the expected levels especially for the shelf areas during winter. Apart from the nutrients entering via Rivers to the basins' shelf waters, winter mixing also contributes significantly to the nutrient budget of the surface layers via transport from lower layers. If it is looked at the temperature salinity profiles (Figure 3.17) it is concluded that mixing is limited only to top 50-60 m of the water column in shelf areas which is not thick enough to homogenize the deep nutrient pool to the entire water column. Once the surface to bottom mixing is accomplished only after this one can expect enhanced production rates in shelf areas. The highest concentration was reached at station 11 (Figure 2.1) in the vicinity of Mersin. Minimum value was measured at station 52 (Figure 2.1) near Girne (Cyprus). An anticyclonic circulation which penetrates the İskenderun and Mersin Bays from south does exist during January. The eastern central basin waters were warmer compared to those in the west and to shelf regions. The colder western sector and the inner Mersin Bay as well as the central İskenderun Bay contained slightly higher chlorophyll than the warmer eastern central basin waters. Except phosphorus, an unusual increase in surface nitrogen and silicate levels in western central basin waters is observed during January (Figures 3.51-52). The levels surpassed those observed in front of Asi, Ceyhan and Lamas Rivers (Figure 2.1). This is mainly due to the upwelling event that took place between Turkey and Cyprus (Figure 3.16). Such deep water transport to surface layers enhances primary production in the basin (Yılmaz and Tuğrul, 1998; Ediger et al., 2005). Higher chlorophyll is observed in areas where nitrate-nitrite was high.

Surface distribution of chlorophyll obtained via Spectrofluorometer, in-situ fluorometer and satellite imagery agree well with each other for most of the areas (Figures 3.79, 3.80 and 4.12). Minor discrepancies are due to shifts in time of sampling. Satellite imagery gives us a synoptic view of the features for that particular time period. Changes and modifications in any property (physical or biological) in unit area with time are inevitable in the marine environment. Changes in biological or physical properties of the basin waters are even much faster during winter (Uysal et al., 2008).

Based on Spearman rank correlation analysis, highly significant correlation is observed between chlorophyll and temperature & salinity. The negative correlation with temperature indicates increase in chlorophyll with decreasing temperature. Significant relationships are also observed between chlorophyll and phosphate & silicate. The mean molar ratios of nitrate+nitrite to phosphate (N:P) were calculated as 7.8 for the shelf and as 14.4 for offshore waters during January.

Pigment analysis of the surface phytoplankton in the basin indicated that Prymnesnesiophyceae is the dominant group during January. This is followed by Prochlorophytes (in offshore waters), diatoms (in Mersin Bay) and Cyanobacteria (in İskenderun Bay) (Figure 4.14 and Table 4.4). Chrysophytes and dinoflagellates also made minor contributions to the bulk.

Spectrofluorometer overestimated HPLC chlorophyll measurements performed at all four stations in the basin (Figure 4.15).

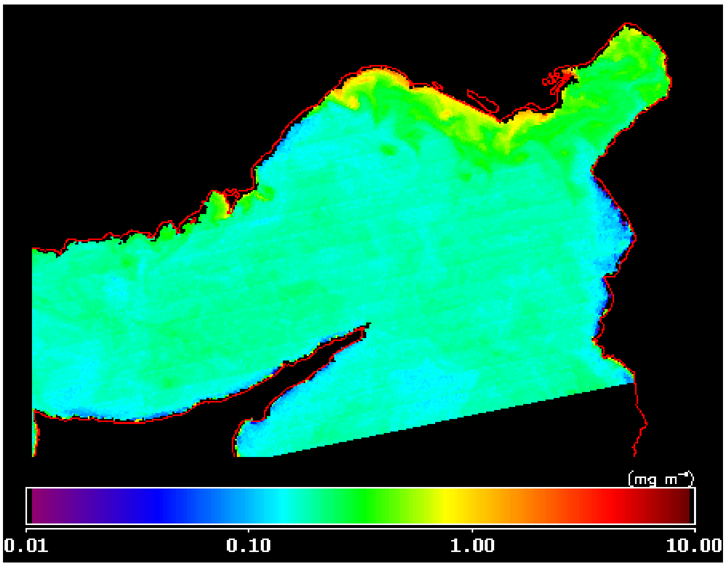

Figure 4.12. Satellite photo taken in January 2007.

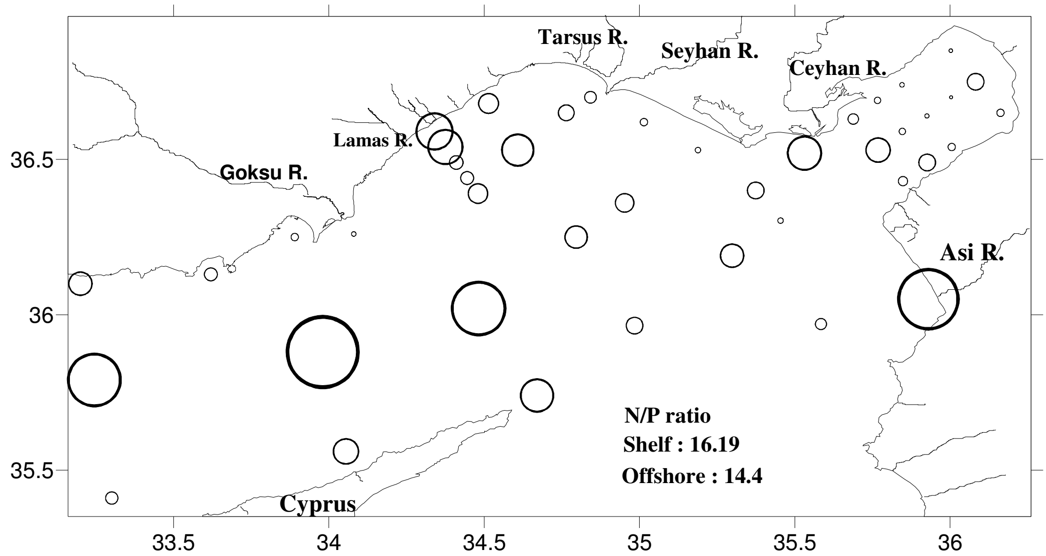

Figure 4.13. N/P ratios in January 2007.

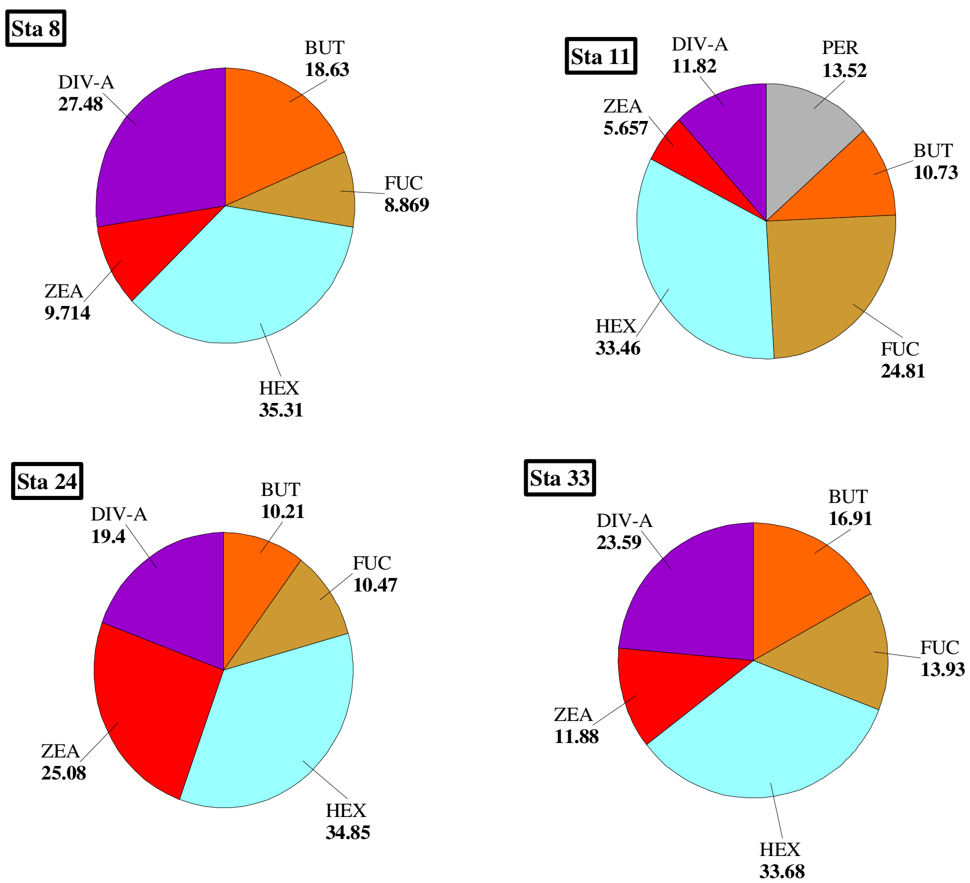

Figure 4.104. Marker pigment contiribution to chlorophyll-a in January 2007. Station were given in this figure can be seen in Figure 2.1.

Chlorophyll-a, CHL-A, Chlorophyll c_3 (C3) and c_2 (C2), peridinin (PER), buthanoloxyfucuxanthin (BUT), fucuxanthin (FUC), 19'hexonoloyxyfucoxanthin (HEX), diadinixanthin (DIAD), alloxanthin (ALLO), zeaxanthin (ZEA), chlorophyll-b (CHL-B), divinil chlorophyll-a (DIV-A), lutein (LUT) and ß-carotene (B-CAR).

Table 4.4. Dominant phytoplankton groups in the basin in January 2007.

Stations (Fig. 2.1)	1st dominant	2nd dominant	3rd dominant
8	Prymnesiophyceae	Prochlorophytes	Chrysophytes
11	Prymnesiophyceae	Diatoms	Dinoflagellates Prochlorophytes
24	Prymnesiophyceae	Cyanobacteria	Prochlorophytes
33	Prymnesiophyceae	Prochlorophytes	Chrysophytes Diatoms

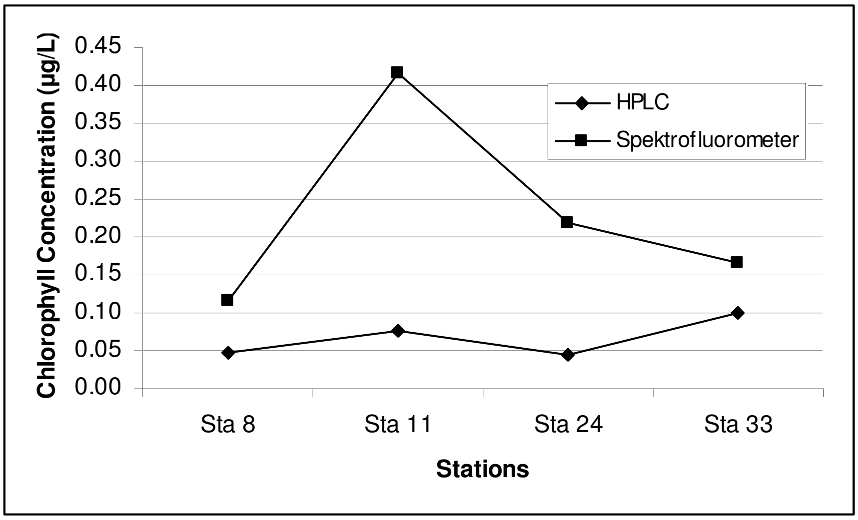

Figure 4.15. Chlorophyll concentrations measured by HPLC and spectrofluorometer in January 2007.

4.5. March 2007

Total chlorophyll-a concentration ranged between 0.17 and 0.61 µg/L at surface (Figure 3.82) in this period. Maximum value was measured at the entrance of the İskenderun Bay (station 23, Figure 2.1). Coastal areas in Mersin Bay, near Taşucu & Göksu River, and the inner periphery of İskenderun Bay were rich in chlorophyll content. The satellite image of surface chlorophyll taken on 21 March also supports the measurements on ship board during the cruise (Figure 4.16, Figure 2.1). Some upwelling induced high values are also exist near Cyprus at stations 12 and 36

(Figures 3.21, Figure 2.1). Enrichment of shelf waters and coastal areas with nutrients via upwelling of nutrient rich Levantine Deep Water to sunlit layers do occur time to time in the basin (Ediger et al., 2005, Uysal and Köksalan, 2006). An apparent decrease in chlorophyll from inshore towards offshore near Lamas River points out the impact of freshwater input to local production. Freshwater flow from Lamas River to the basin increases with the onset of spring as the snow in Taurus mountains continue to melt till early summer. Its role in enhancing the local production was also previously studied by Uysal et al., (2004). Rivers, rain waters and atmospheric dust are important nutrient sources for the Mediterranean (Herut et al., 1999a, b, 2002; Justic et al., 1995; Martin et al., 1989; Migon et al., 1999; Markaki et al., 2003).

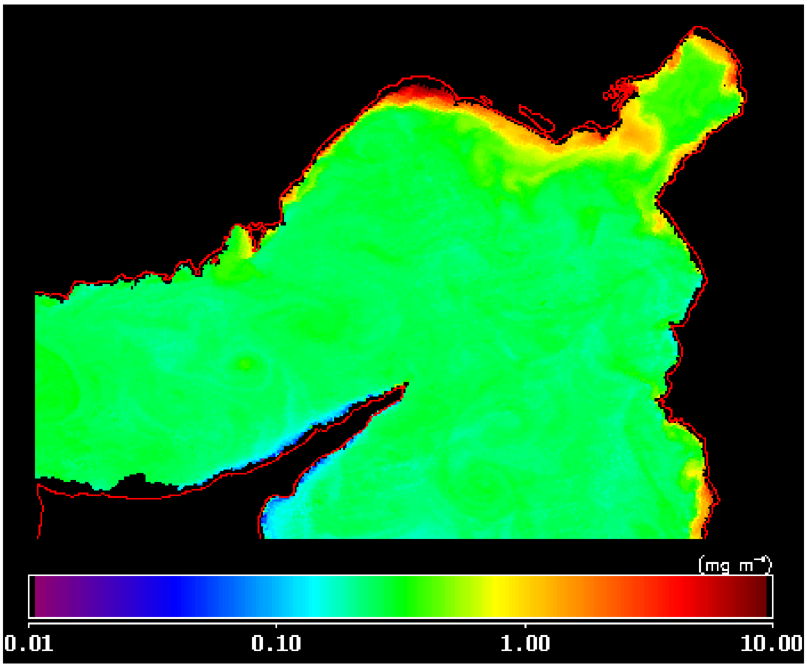

Figure 4.16. Satellite photo taken in March 2007.

Besides an apparent flow from east of Cyprus towards Cilician basin a cyclonic system is observed in the western sector of the study area (Uysal et al., 2008). Nitrogen was measured very low in the basin surface waters except the coastal areas fed by Seyhan and Ceyhan Rivers. Silicate was high both at inshore and offshore areas. Phosphate was near detection limits for most of the study area except some highs observed near Göksu (0.06 µM), Lamas (0.04 µM) Rivers and north of İskenderun Bay (0.06 µM). Nitrogen and silicate seemed to be utilized more intensely compared to phosphate by phytoplankton near Göksu (N:P ratio is 2.5) and Taşucu. N:P ratios for the shelf and offshore areas were 17.6 and 10.3, respectively. Based on Spearman rank correlation analysis, significant negative correlation was obtained between chlorophyll and temperature & salinity. Chlorophyll increased with decreasing temperature and salinity in the shallow coastal areas where freshwater input via major Rivers is most pronounced. During March 2006 and 2007 average phytoplankton cell counts exceeded $3.0x10^5$ cells/l in the basin (Uysal et al., 2008). Among nutrients, only significant positive relationship is observed between chlorophyll and phosphate.

Based on HPLC results performed at few stations, diatoms dominated the bulk in the east (at stations 8, 11 and 24, Figure 2.1) followed by Prymnesiophyceae (Table 4.5). In the west, Procholorophytes and Prymnesiophyceae formed the dominant groups at mid-basin stations 33 and 49 (Figure 2.1). Seven different algal taxons were present during March in the basin. Spectrofluorometric assessment of chlorophyll exceeded HPLC values at four of five measurements performed in March.

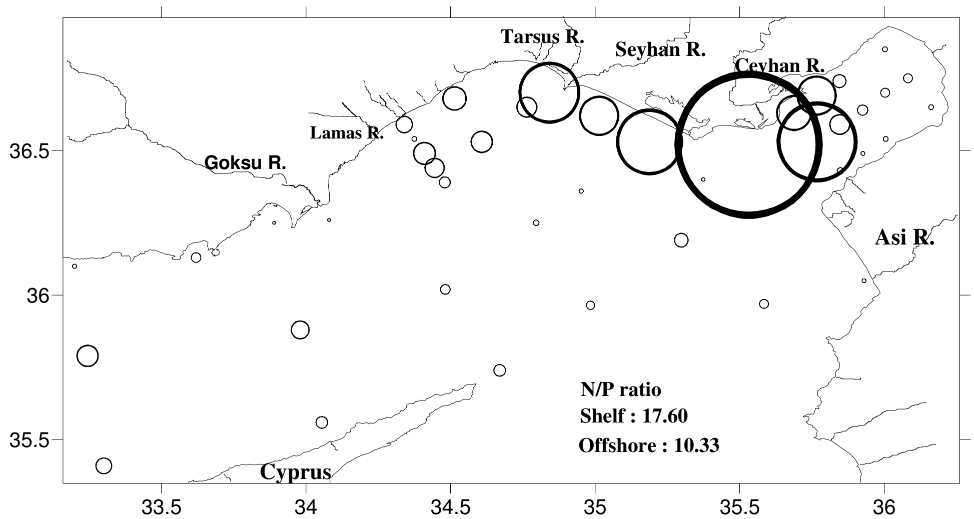

Figure 4.17. N/P ratios in March 2007.

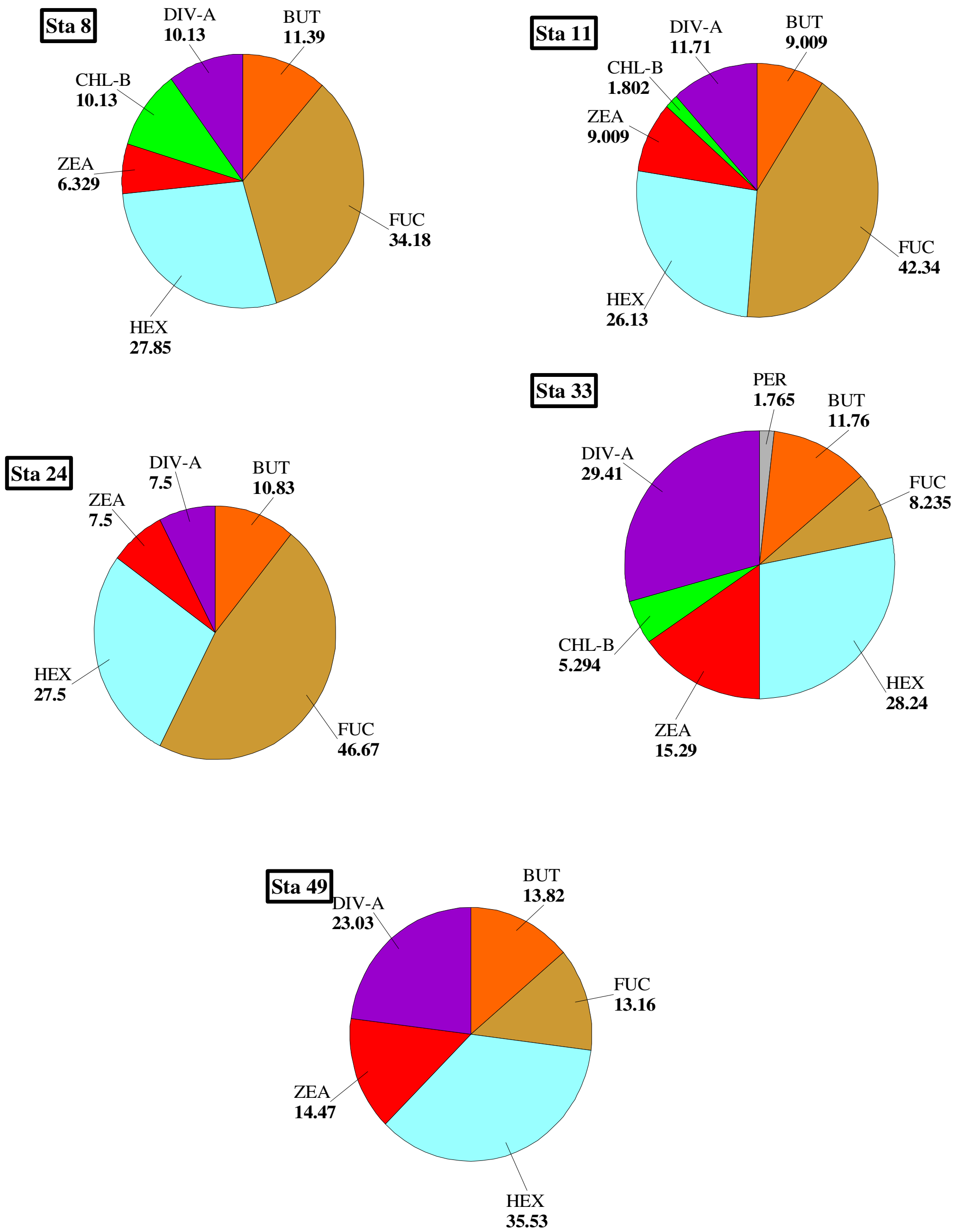

Figure 4.18. Marker pigment contribution to chlorophyll-a in March 2007. Station were given in this figure can be seen in Figure 2.1.

Chlorophyll-a, CHL-A, Chlorophyll c_3 (C3) and c_2 (C2), peridinin (PER), buthanoloxyfucuxanthin (BUT), fucuxanthin (FUC), 19'hexonoloyxyfucoxanthin (HEX), diadinixanthin (DIAD), alloxanthin (ALLO), zeaxanthin (ZEA), chlorophyll-b (CHL-B), divinil chlorophyll-a (DIV-A), lutein (LUT) and ß-carotene (B-CAR).

Table 4.5. Dominant phytoplankton groups in the basin in March 2007.

Stations (Fig 2.1)	1st dominant	2nd dominant	3rd dominant
8	Diatoms	Prymnesiophyceae	Chrysophytes Prochlorophytes Chlorophytes
11	Diatoms	Prymnesiophyceae	Chrysophytes Chlorophytes Cyanophyta
24	Diatoms	Prymnesiophyceae	Chrysophytes Prochlorophytes
33	Prochlorophytes	Prymnesiophyceae	Chrysophytes,Cyanophyta Diatoms,Chlorophytes Dinoflagellate
49	Prymnesiophyceae	Prochlorophytes	Chrysophytes,Cyanophyta Diatoms

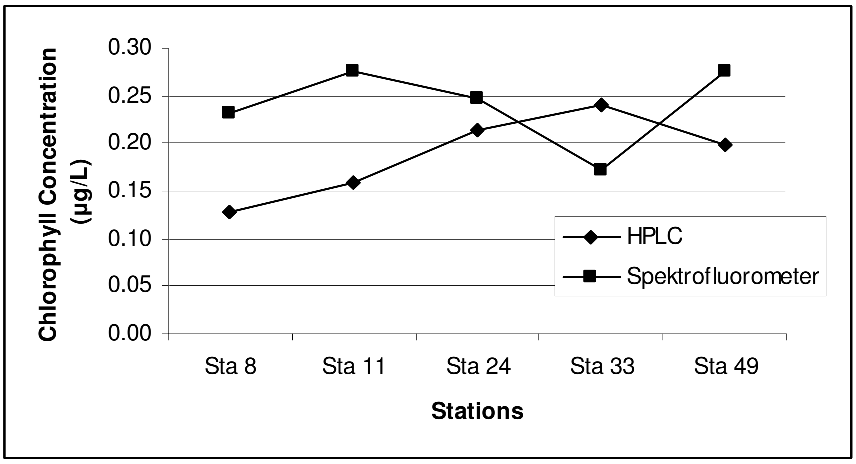

Figure 4.19. Chlorophyll concentrations measured by HPLC and spectrofluorometer in March 2007.

4.6. April 2007

An anticyclonic circulation in the east and a cyclonic one in the west are the two main features observed during April in the basin. Relatively warmer surface waters occupy the eastern sector of Mersin and western sector of İskenderun Bays. From Asi River to İskenderun a band of cold surface water exist in the bay. The west and east side of İskenderun Bay displays contrasting environments in their physical and chemical properties. In case of chlorophyll its exit to open waters is much more productive than the inner bay. Discrepancies also exist in Mersin Bay, where the bulk of chlorophyll is present in the east coast enriched with River sourced nutrients. Chlorophyll concentration ranged between 0.03 and 0.76 µg/L at surface being much higher near River mouths and coastal sectors of both bays (Figure 3.85). Such areas were also rich in nitrogen and phosphate. Maximum chlorophyll was measured at station 74 located near Seyhan River. Minimum value was measured at the central basin station # 8 (Figure 2.1) located in between Mersin Bay and Cape Karpaz. Phosphate was present slightly over detection limits (0.02µM). April coincides with the period of increasing freshwater input from major Rivers to the basin. Nutrients coming from Rivers merge with those coming from winter mixing and enhance the productivity of shelf waters starting from late winter till early summer. The average phytoplankton cell count in the basin for this period was almost half of that observed in March ($1.5x10^5$ cells/l, Uysal et al., 2008) and to maximum cell count was met near Lamas River.

In the vicinity of Seyhan and Ceyhan Rivers nutrients were abundant. This further enhanced the primary production mainly in the shelf area where freshwater flows in from surface. Mostly due to the nature of the dominant current regime in the basin it tends to expand towards west following the shelf topography. Sometimes this enhanced production near Ceyhan flows east into the inner İskenderun Bay and becomes widespread there with the help of clockwise and anticlockwise eddies formed in the area (Figure 1.5, İyiduvar, 1986; Latif *et al*., 1989). The observed N:P ratios for the offshore (3.5) and shelf (7.7) areas indicate that nitrogen is the limiting nutrient for this sampling period in the basin.

Based on Spearman rank correlation analysis, highly significant correlation was obtained between chlorophyll and nitrogen & silicate. Shelf areas rich in chlorophyll held also high concentrations of nitrate and silicate due to increasing River input to shelf waters during April. For this a highly significant negative correlation was observed between chlorophyll and salinity. In other words with increasing chlorophyll content a decrease in surface salinity is observed.

HPLC results indicated that among the phytoplankton a group Prymnesiophyceae was the dominant taxon at stations 11, 24, 33 and 49 in Figure 2.1 (Table 4.6). On the other hand, at station 8 Prochlorophytes and Cyanobacteria are found as the dominant taxons. At station 74 near Seyhan River (Figure 2.1) Chlorophytes and Prasinophytes were found as the dominant groups.

Chlorophyll estimations by HPLC and Spectrofluorometer showed that the specrofluorometer underestimated chlorophyll concentrations compared to HPLC results (Figure 4.22).

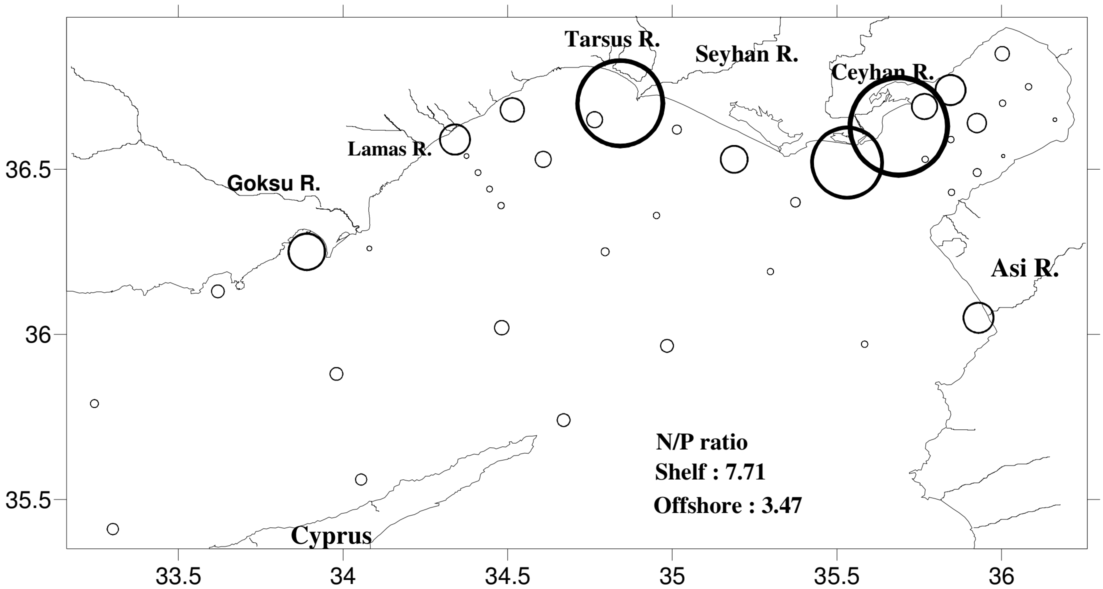

Figure 4.2011. N/P ratios in April 2007.

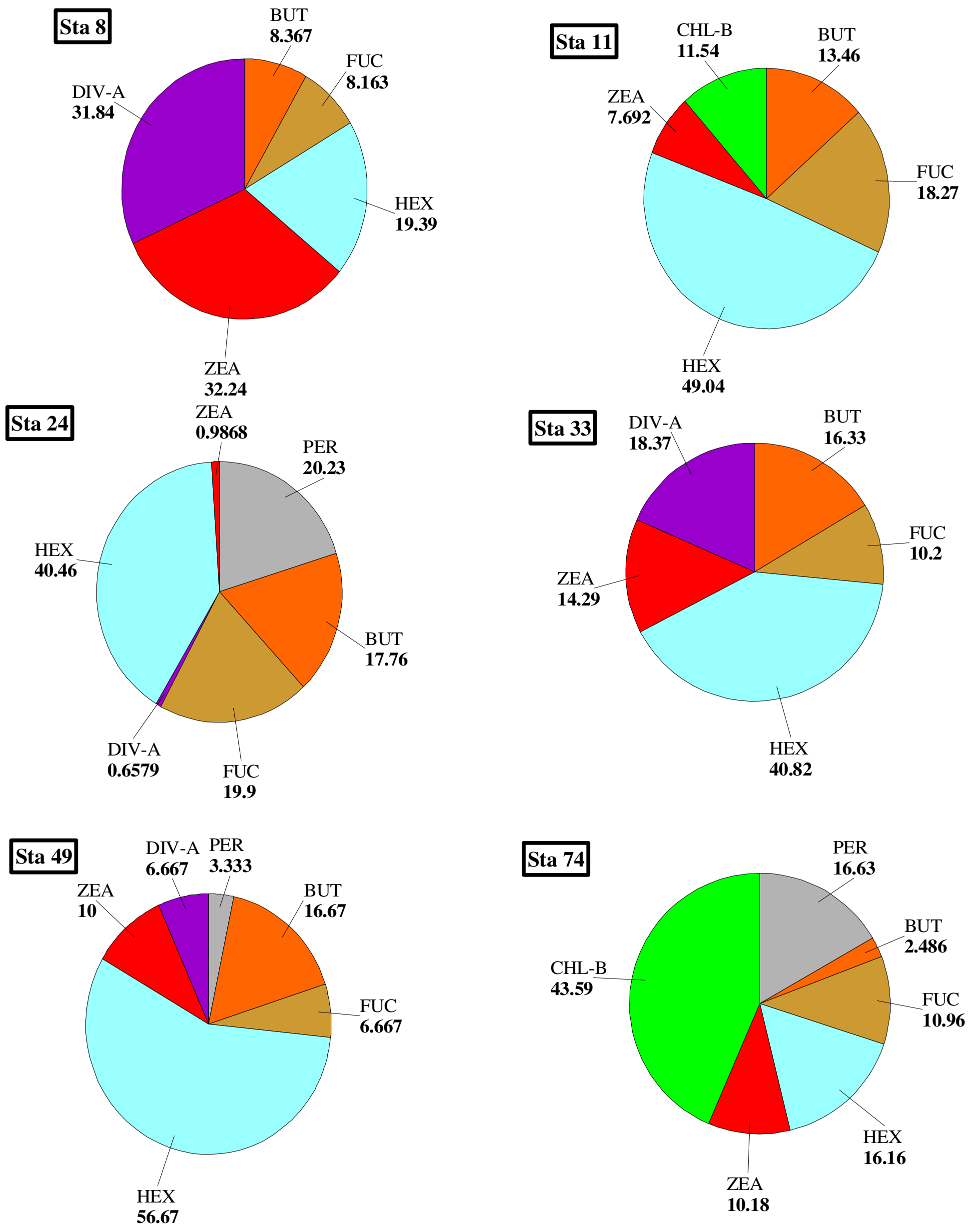

Figure 4.21. Marker pigment contiribution to chlorophyll-a in April 2007.
Station were given in this figure can be seen in Figure 2.1.

Chlorophyll-a, CHL-A, Chlorophyll c_3 (C3) and c_2 (C2), peridinin (PER), buthanoloxyfucuxanthin (BUT), fucuxanthin (FUC), 19'hexonoloyxyfucoxanthin (HEX), diadinixanthin (DIAD), alloxanthin (ALLO), zeaxanthin (ZEA), chlorophyll-b (CHL-B), divinil chlorophyll-a (DIV-A), lutein (LUT) and ß-carotene (B-CAR).

Table 4.6. Dominant phytoplankton groups in the basin in April 2007.

Stations (Fig 2.1)	**1st dominant**	**2nd dominant**	**3rd dominant**
8	Prochlorophytes	Cyanophyta	Prymnesiophyceae Chrysophytes,Diatoms
11	Prymnesiophyceae	Diatoms	Chrysophytes,Chlorophytes
24	Prymnesiophyceae	Dinoflagellate	Chrysophytes, Diatoms
33	Prymnesiophyceae	Prymnesiophyceae	Chrysophytes,Cyanophyta
49	Prymnesiophyceae	Chrysophytes	Cyanophyta,Chrysophytes, Diatoms,Prochlorophytes
74	Chlorophytes	Dinoflagellate	Prymnesiophyceae, Chrysophytes,Diatoms, Cyanophyta

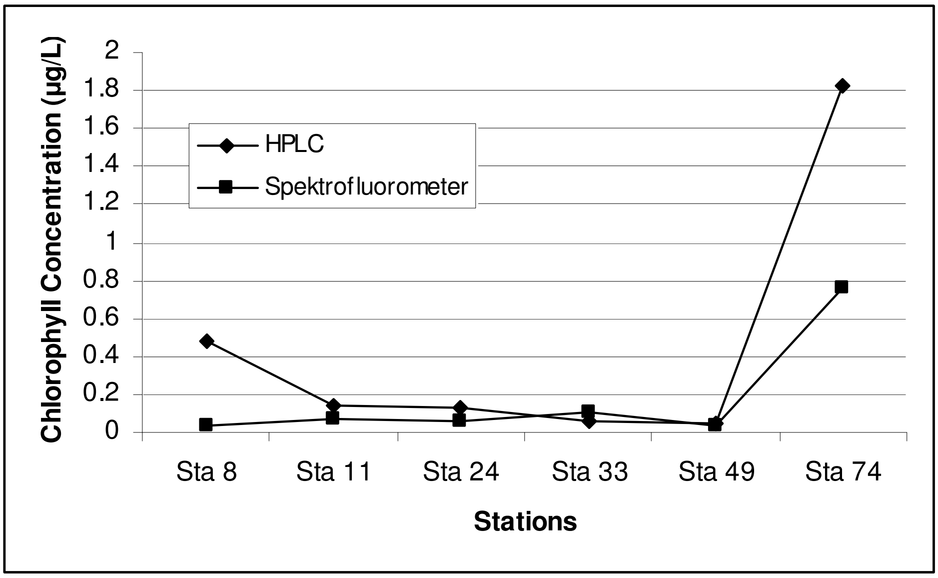

Figure 4.22. Chlorophyll concentrations measured by HPLC and spectrofluorometer in April 2007.

4.7. June 2007

During June relatively warmer surface waters occupy the Mersin & İskenderun Bays and the Cyprus coast. Surface temperature drops significantly in the coastal area between Anamur - Taşucu and in the area east of Göksu River delta due to usual upwelling events occurring this time of the year (Uysal et al., 2008). With the onset of summer productivity weakens and the productive layer deepens in the basin. Offshore waters become denuded of chlorophyll and increases are seen only near River drainage areas and inner bays. An increase in surface salinity due to evaporation in offshore waters occurs during summer in the basin. Expansion of warmer surface waters towards shelf and deepening of thermocline (20-30 m) along the coast together support the prevailing westward flow in the basin (Uysal et al., 2008).

In June 2007, total chlorophyll-a concentration ranged between 0.014 and 0.350 μg/L at surface (Figure 3.88). Maximum value was measured at station 1 located in front of the Lamas River. As clearly seen from the satellite image of surface chlorophyll, high concentrations are also observed near Seyhan River and in İskenderun Bay (Figure 4.23). Nitrate was utilized in excess amount compared to phosphate near Seyhan River (N:P ratio = 1.5).

Based on Spearman rank correlation analysis, a highly significant negative correlation is found between salinity and chlorophyll (Table 3.1). This indicates both the River induced phytoplankton growth in coastal waters of the basin and the apparent contrast in productivity of the shelf and offshore waters. A significant negative correlation also do exist between chlorophyll and silicate.

Surface chlorophyll distributions based on spectrofluorometer, satellite image (Figure 4.23) and in-situ fluorometer measurements seem to agree well with each other except for few sites (especially at station 1 near Lamas River). The satellite image does not reflect the high chlorophyll observed in this location. Actually the satellite image is taken after two days of the original sampling in the sea. Phytoplankton composition might have changed within this short period of time.

N:P ratio was found very low for the shelf (5.2) and even lower for the offshore (3.7) waters during June. These are lower than the expected Redfield ratio of 16:1.
Prymnesiophytes formed the dominant taxon at stations 8 and 24 (Figure 2.1), (Table 4.7). Cyanophyta was dominant at station 11 located in inner Mersin Bay, and at

central basin stations 33 and 49 followed by Prymnesiophytes. Diatoms dominated the Seyhan River delta (station 74, Figure 2.1). HPLC and Spectrofluorometer results show that Spectrofluorometer underestimate total chlorophyll concentrations especially at elevated concentrations compared to HPLC (Figure 4.26).

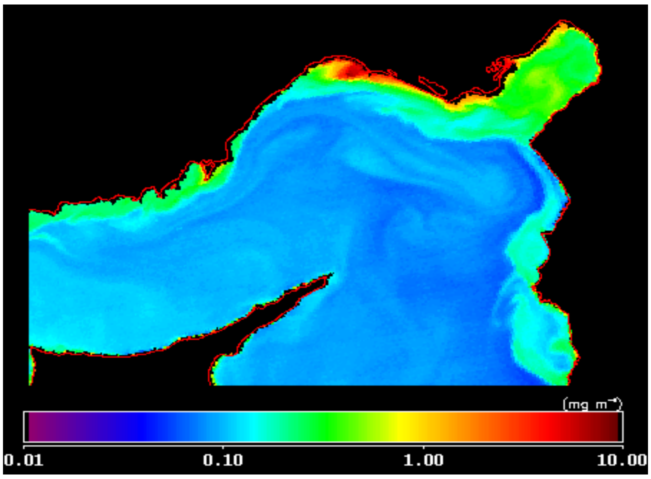

Figure 4.23. Satellite photo taken in June 2007.

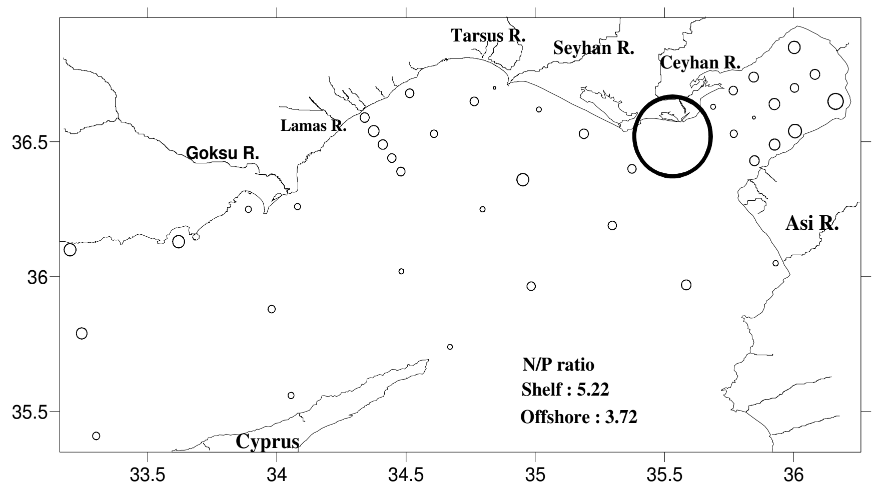

Figure 4.24. N/P ratios in June 2007.

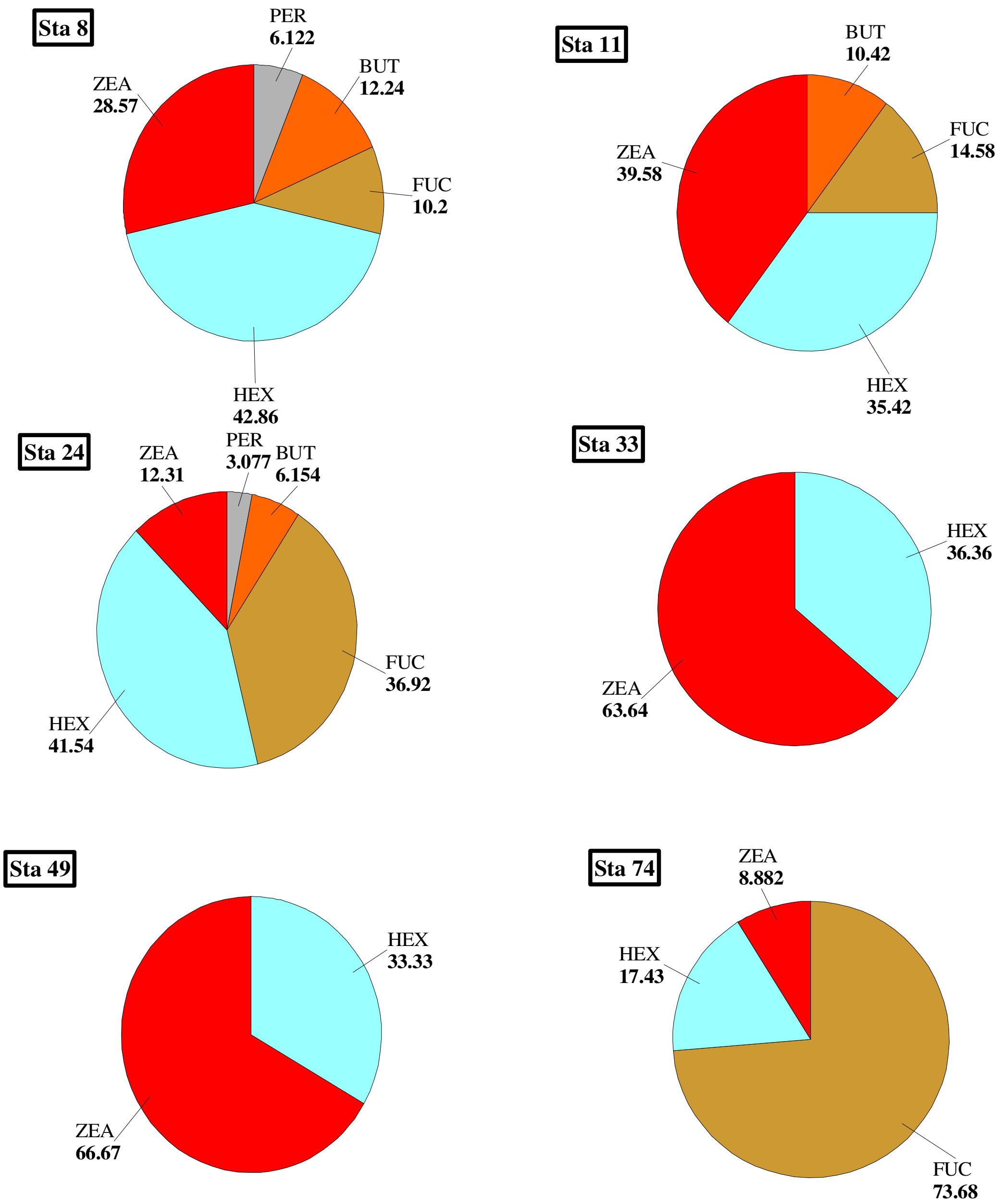

Figure 4.25. Marker pigment contiribution to chlorophyll-a in June 2007
Station were given in this figure can be seen in Figure 2.1.

Chlorophyll-a, CHL-A, Chlorophyll c_3 (C3) and c_2 (C2), peridinin (PER), buthanoloxyfucuxanthin (BUT), fucuxanthin (FUC), 19'hexonoloyxyfucoxanthin (HEX), diadinixanthin (DIAD), alloxanthin (ALLO), zeaxanthin (ZEA), chlorophyll-b (CHL-B), divinil chlorophyll-a (DIV-A), lutein (LUT) and ß-carotene (B-CAR).

Table 4.7. Dominant phytoplankton groups in the basin in June 2007.

Stations (Fig 2.1)	1st dominant	2nd dominant	3rd dominant
8	Prymnesiophytes	Cyanophyta	Chrysophytes,Diatoms, Dinoflagellate
11	Cyanophyta	Prymnesiophytes	Diatoms, Chrysophytes
24	Prymnesiophytes	Diatoms	Cyanophyta,Chrysophytes, Dinoflagellate
33	Cyanophyta	Prymnesiophytes	
49	Cyanophyta	Prymnesiophytes	
74	Diatoms	Prymnesiophytes	Cyanophyta

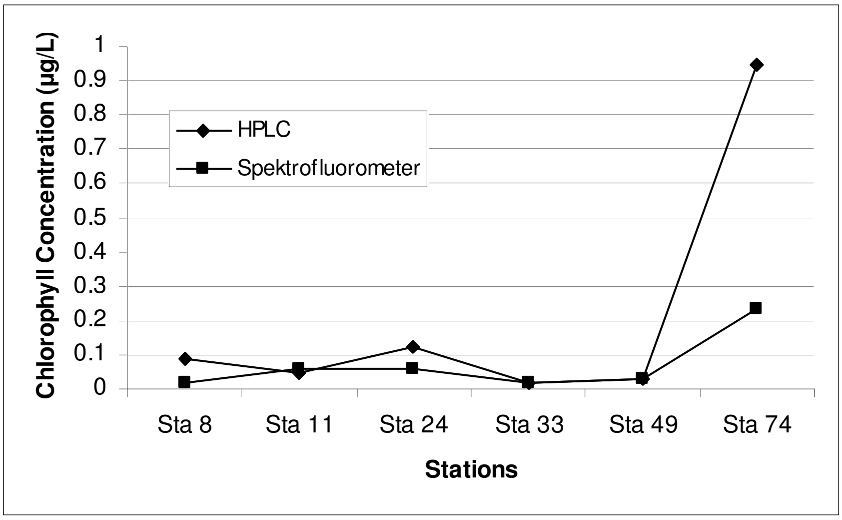

Figure 4.26. Chlorophyll concentrations measured by HPLC and spectrofluorometer in June 2007.

4.8. September 2007

A well defined anticyclonic flow in the east (located offshore Mersin Bay and to the northeast of Cyprus) and a cyclonic flow in the west (between Turkey and Cyprus) control the biological, chemical and physical properties of the basin waters during September (Uysal et al., 2008). In accord with these, colder surface waters in the west and relatively warmer water in the east is observed. A decreasing trend in chlorophyll from inshore towards offshore is the main feature of this period. The observed high chlorophyll concentrations in the central part of the anticyclone is mainly due to inward transport of peripheral shelf waters influenced from Seyhan and Ceyhan River inputs. In a similar manner, the productive surface waters near Göksu River flow west and then veer to south as a result of the cyclonic flow. It is suggested that, at lower depths (at about 50 m) the anticyclone extends towards northeast and replaces the bottom waters of the İskenderun Bay (Uysal et al., 2008). Hydrographic sections (salinity) indicate increase in surface salinity due to evaporation. Right below the upper mixed layer, intrusion of Atlantic waters in the form of slices to the basin was observed.

In September 2007, chlorophyll concentration ranged between 0.027 and 0.35 μg/L at surface (Figure 3.91). Maximum value was measured at station 74 (Figure 2.1) located near the Seyhan River. Minimum value was measured at the central deep station 33 (Figure 2.1) located in between Turkey and Cyprus. In general, shallower shelf waters held higher concentrations compared to areas beyond shelf break. Peaks are met near Seyhan and Ceyhan Rivers which contain high nitrate and silicate. The low N:P ratio (2) observed near Seyhan River indicate how efficiently the nitrate has been utilized by the phytoplankton in the area. Spectrofluorometer (Figure 3.91), satellite image (Figure 4.27) and in-situ fluorometer (Figure 3.91) measurements agree well with each other. In all figures chlorophyll is most accumulated in the shallow coastal areas and inner bays.
The calculated N:P ratios for the shelf (6.7) and offshore (5.1) (Figure 4.28) are lower than the expected value (16). In June, July, August and September, rain water input is very low in the basin. But, atmospheric deposition may increase nitrogen concentration. Hot weather converts atmospheric nitrogen to particulate nitrogen. So, this particulate drop in water and increase nitrogen concentration in the sea (Uysal et al., 2008; Bethoux and Copin-Montegut, 1986).

Based on Spearman rank correlation analysis, a highly significant relationship between temperature and total chlorophyll (n: 42, r: 0,358, P < 0, 01) was observed.
Prymnesiophyceae was the dominant taxon at stations 11, 24, 33 and 49 (Figure 2.1) followed by different groups. Prochlorophyta and Cyanophyta were the two dominant taxons found at station 8 (Figure 2.1). Lastly Chlorophyta was found as the major group at station 74 (Figure 2.1) located near Seyhan River (Table 4.8).

HPLC and Spectrofluorometer results do not yield a standard pattern and exceed the other in different stations (Figure 4.30).

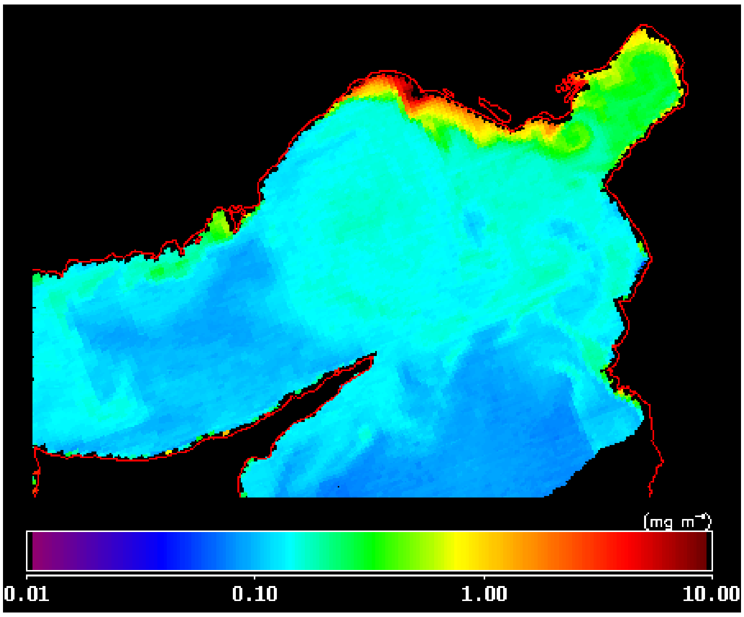

Figure 4.27. Satellite photo taken in September 2007.

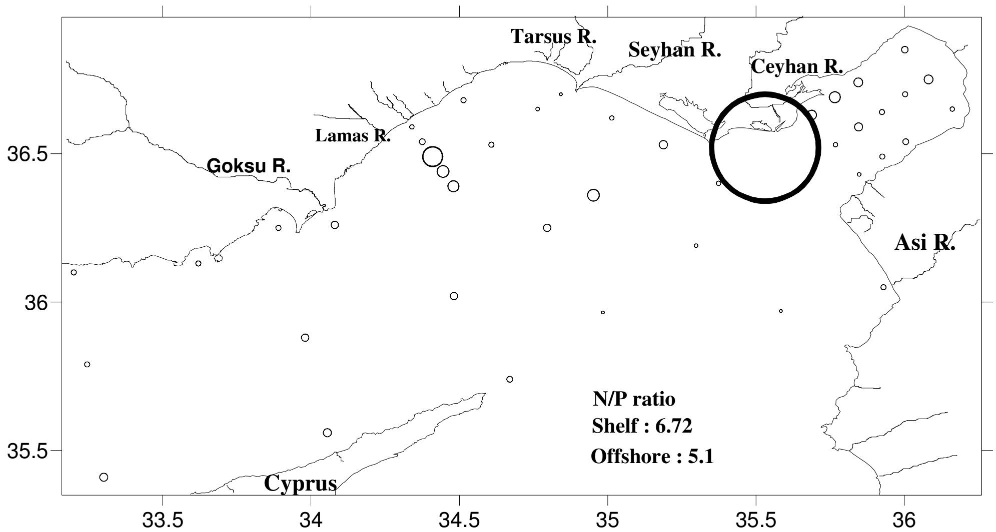

Figure 4.28. N/P ratios in September 2007.

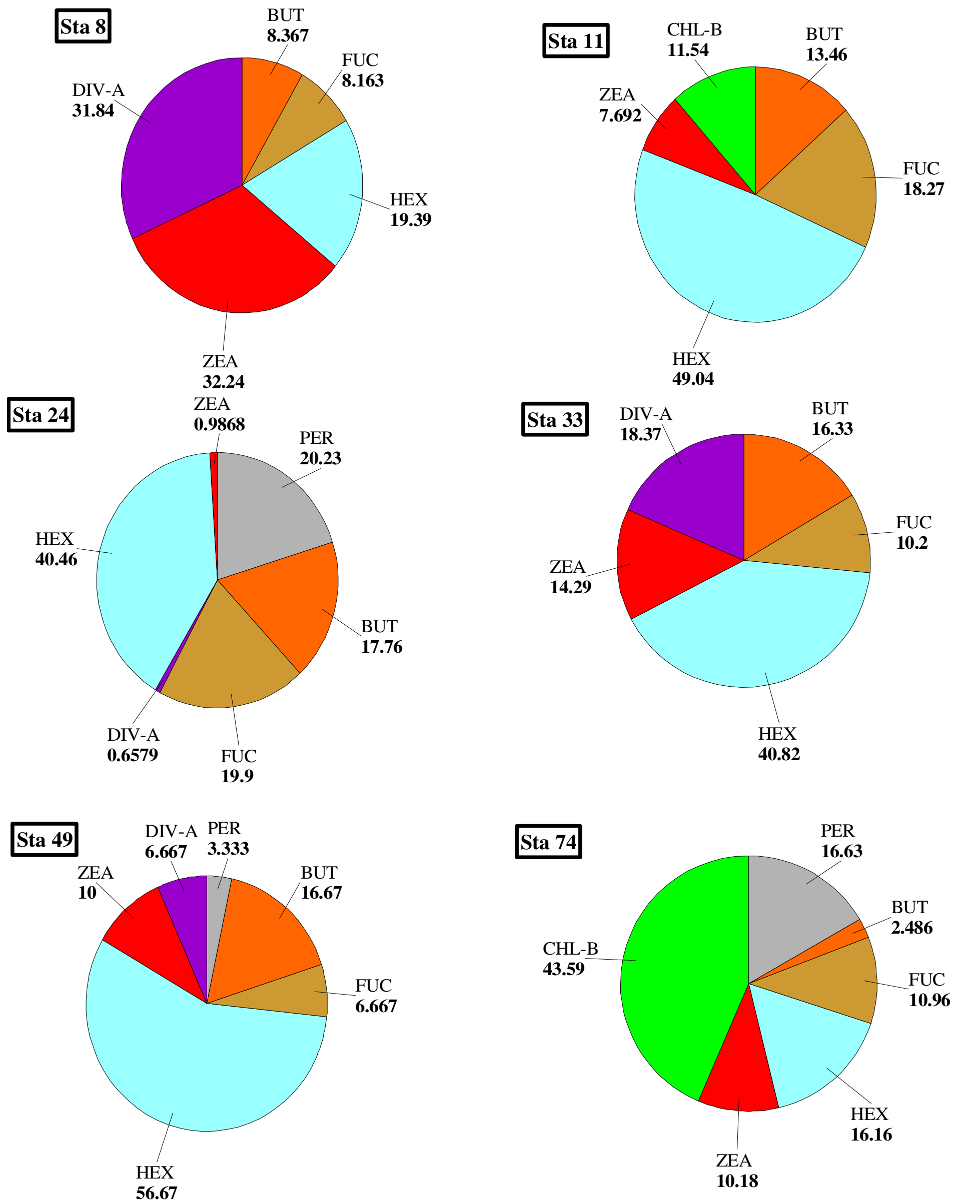

Figure 4.29. Marker pigment contiribution to chlorophyll-a in September 2007. Station were given in this figure can be seen in Figure 2.1.

Chlorophyll-a, CHL-A, Chlorophyll c_3 (C3) and c_2 (C2), peridinin (PER), buthanoloxyfucuxanthin (BUT), fucuxanthin (FUC), 19'hexonoloyxyfucoxanthin (HEX), diadinixanthin (DIAD), alloxanthin (ALLO), zeaxanthin (ZEA), chlorophyll-b (CHL-B), divinil chlorophyll-a (DIV-A), lutein (LUT) and ß-carotene (B-CAR).

Table 4.8. Dominant phytoplankton groups in the basin in September 2007.

Stations (Fig 2.1)	1st dominant	2nd dominant	3rd dominant
8	Cyanophyta	Prochlorophytes	Prymnesiophytes Diatoms, Chrysophytes
11	Prymnesiophytes	Diatoms	Chrysophytes,Chlorophytes Cyanophyta
24	Prymnesiophytes	Dinoflagellate	Diatoms, Chrysophytes
33	Prymnesiophytes	Prochlorophytes	Chrysophytes,Cyanophyta Diatoms
49	Prymnesiophytes	Chrysophytes	Cyanophyta
74	Chlorophytes	Dinoflagellate	Prymnesiophytes Diatoms, Cyanophyta

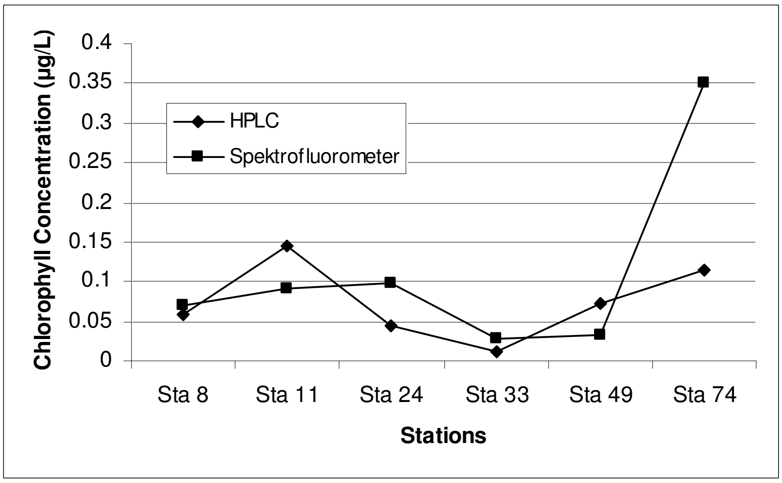

Figure 4.30. Chlorophyll concentrations measured by HPLC and spectrofluorometer in September 2007.

5. CONCLUSIONS

Shallow shelf waters enriched with River water held much higher concentrations compared to areas beyond the shelf break (depths over 200m). Major Rivers (Göksu, Ceyhan, Seyhan, Asi and Lamas) with increased freshwater loads during spring display a major role in determining the productivity of the basins' shelf waters. Elevated concentrations were characteristics of the River drainage areas, inner bays where exchange with offshore waters is limited and upwelling regions. Lacking the necessary, sufficient amount of nutrients in the upper layers, chlorophyll concentrations ranged between low levels of 0.01- 0.35 μg/L during summer. Minor increases in chlorophyll content in offshore waters are observed due to small scale upwelling events.

Spatial changes in chlorophyll were observed to be directly linked to changes in physical (temperature, salinity, currents, and upwelling) and chemical (nutrients) properties of the surface waters. Chlorophyll concentrations showed close relationships with temperature, salinity and nutrients during the study period. The present cyclonic current in the basin helps to extend the productive surface waters towards west. The productive surface waters near Ceyhan enter and become widespread in İskenderun Bay via the clockwise and anticlockwise eddies formed in the area. In general, phosphate was found as the limiting nutrient for the shelf waters and nitrogen for the offshore areas. Prymnesiophytes (coccolithophorid *Emiliana huxleyi)* are the most dominant group followed by Diatoms and Cyanobacteria in the basin.

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APPENDICES

Appendix 1. Nutrient, N:P ratio and total chlorophyll datas.

	Stas	Latitude	Longitude	Tot.chl-a	T-P	PO4	NO2+NO3	Sİ	N:P
	1	36.59	34.34	0.38		0.03	0.33	1.68	11
	2	36.54	34.375	0.51	0.144	0.02	0.32	1.74	16
	3	36.49	34.41	0.28		0.02	0.14	1.39	7
	4	36.44	34.445			0.02	0.39	1.48	19.5
	6	35.965	34.984	0.13		0.02	0.28	1.16	14
	8	36.25	34.796	0.16	0.081	0.02	0.48	1.33	24
	9	36.391	34.702	0.10	0.104	0.02	0.25	1.27	12.5
	10	36.53	34.608	0.37		0.04	0.98	1.58	24.5
	11	36.68	34.514	0.37	0.212	0.04	0.62	1.7	15.5
	12	35.74	34.67	0.14		0.02	0.05	1.3	2.5
	14	36.02	34.482	0.24		0.02	0.05	1.44	2.5
	20	36.19	35.298	0.10		0.02	0.24	1.21	12
	21	36.303	35.454	0.21		0.02	0.58	1.4	29
	22	36.415	35.611			0.02	0.54	2.25	27
	23	36.53	35.768	0.25	0.09	0.02	0.41	1.38	20.5
	24	36.59	35.846	0.37	0.09	0.02	0.56	2.26	28
November 2005	25	36.64	35.925	0.26		0.02	0.3	2.26	15
	26	36.7	36.003	0.30	0.135	0.02	0.3	2.22	15
	27	36.75	36.082	0.19	0.12	0.02	0.21	2.28	10.5
	28	36.25	33.89	0.26	0.158	0.02	0.05	1.93	2.5
	33	35.88	33.98	0.11	0.068	0.02	0.05	1.42	2.5
	36	35.56	34.055	0.16		0.02	0.17	1.39	8.5
	37	36.26	34.08	0.43	0.068	0.02	0.2	1.56	10
	41	36.13	33.62	0.23		0.02	0.09	1.94	4.5
	45	36.1	33.2	0.18		0.02	0.32	1.59	16
	49	35.79	33.245	0.16	0.122	0.03	0.05	1.44	1.67
	52	35.41	33.301	0.11		0.03	0.19	1.4	6.33
	53	36.4	35.374	0.17	0.141	0.02	0.58	1.32	29
	54	36.52	35.531	0.29	0.216	0.03	3.27	7.3	109
	55	36.63	35.688	0.30		0.02	0.78	2.25	39
	56	36.69	35.766	0.25		0.02	0.53	2.21	26.5
	57	36.74	35.845	0.21	0.586	0.02	0.96	2.53	48
	59	36.85	36.002	0.37	0.113	0.03	0.21	2.96	7
	62	36.43	35.848	0.26	0.095	0.02	0.41	1.4	20.5
	63	36.49	35.926	0.09		0.02	0.42	1.6	21
	64	36.54	36.005	0.37	0.126	0.02	0.4	1.64	20
	66	36.65	36.162	0.38	0.158	0.09	0.42	2.52	4.67
	67	36.36	34.952	0.10		0.02	0.84	1.29	42
	69	36.53	35.188	0.21		0.02	0.79	1.55	39.5
	72	36.62	35.014	0.23		0.02	0.85	1.74	42.5
	73	36.65	34.764	0.44		0.04	0.64	1.94	16
	74	36.7	34.842	0.51	0.212	0.02	0.9	2.16	45

	Stas	Latitude	Longitude	Tot.chl-a	T-P	PO4	NO2+NO3	Sİ	N:P
	1	36.59	34.34	0.61		0.02	0.05	0.32	2.5
	2	36.54	34.375	0.12		0.02	0.15	0.38	7.5
	3	36.49	34.41	0.13		0.02	0.2	1.18	10
	4	36.44	34.445	0.10		0.02	0.14	1.17	7
	5	36.39	34.48	0.08		0.02	0.1	1.12	5
	8	36.25	34.796	0.07	0.117	0.02	0.06	1.13	3
	10	36.53	34.608	0.11		0.03	0.1	1.13	3.33
	11	36.68	34.514	0.13	0.141	0.02	0.05	0.42	2.5
	12	35.74	34.67	0.15		0.02	0.07	1.1	3.5
	14	36.02	34.482	0.14		0.02	0.04	1.31	2
March 2006	23	36.53	35.768	0.14	0.073	0.03	0.93	2.96	31
	24	36.59	35.846		0.097	0.02	0.53	2.31	26.5
	25	36.64	35.925	0.08		0.03	0.06	1.47	2
	26	36.7	36.003	0.08	0.087	0.02	0.05	1.73	2.5
	27	36.75	36.082	0.10	0.175	0.02	0.56	1.66	28
	28	36.25	33.89	0.09	0.112	0.02	0.36	1.23	18
	33	35.88	33.98	0.10	0.087	0.02	0.19	1.32	9.5
	36	35.56	34.055	0.09		0.02	0.18	1.3	9
	37	36.26	34.08	0.23	0.117	0.02	0.2	1.25	10
	41	36.13	33.62			0.02	0.1	0.63	5
	45	36.1	33.2	0.16		0.02	0.05	0.83	2.5
	49	35.79	33.245	0.11	0.117	0.03	0.05	1.07	1.67
	52	35.41	33.301	0.13		0.02	0.11	0.96	5.5
	53	36.4	35.374	0.11	0.117	0.02	1.06	3.03	53
	54	36.52	35.531	0.09	0.165	0.02	3.67	6.54	184
	55	36.63	35.688	0.19		0.02	0.47	2.41	23.5
	56	36.69	35.766	0.19		0.02	0.15	1.68	7.5
	57	36.74	35.845	0.21	0.121	0.02	0.05	2.12	2.5
	59	36.85	36.002	0.42	0.262	0.02	0.1	2.26	5
	62	36.43	35.848	0.10	0.097	0.02	1.05	2.88	52.5
	63	36.49	35.926	0.25		0.02	0.88	2.98	44
	64	36.54	36.005	0.14	0.112	0.02	0.84	4.13	42
	66	36.65	36.162	0.08		0.02	0.85	2.56	42.5
	67	36.36	34.952	0.32		0.03	0.2	1.06	6.67
	69	36.53	35.188	0.56		0.02	1.48	4.31	74
	72	36.62	35.014	0.14		0.03	0.2	1.81	6.67
	73	36.65	34.764	0.21		0.09	1.27	1.61	14.1
	74	36.7	34.842	0.30	0.529	0.02	0.14	1.17	7
	76	35.97	35.584	0.16	0.136	0.05	0.05	0.88	1
	78	36.05	35.93	0.16		0.02	1.29	2.47	64.5

	Stas	Latitude	Longitude	Tot.chl-a	T-P	PO4	NO2+NO3	Sİ	N:P
	1	36.59	34.34	0.08		0.02	0.1	0.61	5
	2	36.54	34.375	0.03	0.08	0.03	0.2	1	6.67
	3	36.49	34.41	0.02		0.02	0.17	0.81	8.5
	4	36.44	34.445	0.02		0.02	0.19	0.74	9.5
	5	36.39	34.48	0.01		0.02	0.14	0.77	7
	6	35.965	34.984			0.02	0.09	1.71	4.5
	8	36.25	34.796	0.03	0.11	0.02	0.15	0.49	7.5
	10	36.53	34.608	0.07		0.02	0.12	1.02	6
	11	36.68	34.514	0.19	0.13	0.02	0.09	0.54	4.5
	12	35.74	34.67	0.11		0.02	0.09	0.62	4.5
July 2006	14	36.02	34.482	0.02		0.02	0.11	0.74	5.5
	20	36.19	35.298	0.01		0.02	0.12	0.55	6
	21	36.303	35.454			0.02	0.07	0.74	3.5
	22	36.415	35.611			0.02	0.08	0.65	4
	23	36.53	35.768	0.09	0.09	0.02	0.1	1.04	5
	24	36.59	35.846	0.09	0.08	0.02	0.27	1.13	13.5
	25	36.64	35.925	0.08		0.02	0.32	0.91	16
	26	36.7	36.003	0.03	0.42	0.02	0.26	0.9	13
	27	36.75	36.082	0.11	0.36	0.02	0.38	1.44	19
	28	36.25	33.89	0.05	0.26	0.02	0.26	1.11	13
	33	35.88	33.98	0.02	0.18	0.02	0.07	0.64	3.5
	36	35.56	34.055	0.01		0.02	0.08	0.68	4
	37	36.26	34.08	0.05	0.21	0.02	0.21	1	10.5
	41	36.13	33.62	0.16		0.02	0.25	0.99	12.5
	45	36.1	33.2	0.03		0.02	0.42	1.1	21
	49	35.79	33.245	0.02	0.27	0.02	0.36	0.72	18
	52	35.41	33.301	0.03		0.02	0.05	0.75	2.5
	53	36.4	35.374	0.03	0.07	0.03	0.2	2.65	6.67
	54	36.52	35.531	0.11	0.06	0.02	0.09	1.15	4.5
	55	36.63	35.688	0.11		0.02	2.97	4.69	149
	56	36.69	35.766	0.11		0.02	0.23	1.02	11.5
	57	36.74	35.845	0.18	0.54	0.02	0.36	0.93	18
	59	36.85	36.002	0.07	0.431	0.02	0.55	1.71	27.5
	62	36.43	35.848	0.05	0.25	0.02	0.16	0.88	8
	63	36.49	35.926	0.09		0.02	0.19	1.27	9.5
	64	36.54	36.005	0.05	0.21	0.02	0.27	1.57	13.5
	66	36.65	36.162	0.09		0.02	0.26	1.32	13
	67	36.36	34.952	0.02		0.02	0.16	0.42	8
	69	36.53	35.188	0.12		0.02	0.61	1.76	30.5
	72	36.62	35.014	0.13		0.02	0.15	1.72	7.5
	73	36.65	34.764	0.04		0.02	0.08	0.9	4
	74	36.7	34.842	0.20	0.11	0.03	0.07	1.02	2.33
	76	35.97	35.584	0.05	0.17	0.03	0.1	0.8	3.33
	78	36.05	35.93	0.02		0.02	0.07	0.81	3.5

	Stas	Latitude	Longitude	Tot.chl-a	T-P	PO4	NO2+NO3	Sİ	N:P
	1	36.59	34.34	0.15		0.02	0.39	1	19.5
	2	36.54	34.375	0.21	0.066	0.02	0.37	0.98	18.5
	3	36.49	34.41	0.18		0.03	0.22	1.1	7.33
	4	36.44	34.445	0.19		0.02	0.14	1.26	7
	5	36.39	34.48	0.14		0.02	0.21	1.25	10.5
	6	35.965	34.984			0.02	0.18	1.21	9
	8	36.25	34.796	0.11	0.111	0.02	0.24	1.23	12
	10	36.53	34.608	0.20		0.02	0.34	1.35	17
	11	36.68	34.514	0.41	0.156	0.03	0.32	1.55	10.7
	12	35.74	34.67	0.16		0.02	0.35	1.34	17.5
January 2007	14	36.02	34.482	0.18		0.02	0.57	1.53	28.5
	20	36.19	35.298	0.16		0.02	0.25	1.27	12.5
	21	36.303	35.454			0.02	0.06	1.2	3
	23	36.53	35.768	0.23	0.091	0.02	0.26	1.66	13
	24	36.59	35.846	0.22	0.071	0.04	0.14	1.5	3.5
	25	36.64	35.925	0.26		0.03	0.07	1.41	2.33
	26	36.7	36.003	0.21	0.086	0.03	0.05	1.55	1.67
	27	36.75	36.082	0.25	0.147	0.02	0.18	1.8	9
	28	36.25	33.89	0.20	0.086	0.03	0.12	1.59	4
	33	35.88	33.98	0.17	0.101	0.02	0.76	1.64	38
	36	35.56	34.055	0.09		0.02	0.27	1.33	13.5
	37	36.26	34.08	0.26	0.131	0.02	0.05	1.32	2.5
	41	36.13	33.62	0.15		0.02	0.14	1.38	7
	45	36.1	33.2	0.16		0.02	0.25	1.42	12.5
	49	35.79	33.245	0.11	0.076	0.02	0.56	1.58	28
	52	35.41	33.301	0.07		0.03	0.2	1.21	6.67
	53	36.4	35.374	0.17	0.147	0.02	0.18	1.38	9
	54	36.52	35.531	0.18	0.111	0.02	0.36	2.03	18
	55	36.63	35.688	0.20		0.03	0.17	1.84	5.67
	56	36.69	35.766	0.19		0.04	0.14	1.57	3.5
	57	36.74	35.845	0.09	0.055	0.02	0.05	1.32	2.5
	59	36.85	36.002	0.15	0.111	0.03	0.06	1.84	2
	62	36.43	35.848	0.13		0.02	0.1	1.25	5
	63	36.49	35.926	0.19		0.02	0.18	1.38	9
	64	36.54	36.005	0.24	0.076	0.02	0.08	1.28	4
	66	36.65	36.162	0.17	0.091	0.02	0.08	1.35	4
	67	36.36	34.952	0.14		0.02	0.2	1.27	10
	69	36.53	35.188	0.19		0.03	0.09	1.49	3
	72	36.62	35.014	0.20		0.03	0.12	1.49	4
	73	36.65	34.764	0.21		0.02	0.17	1.56	8.5
	74	36.7	34.842	0.25	0.106	0.03	0.19	1.43	6.33
	76	35.97	35.584	0.11	0.086	0.02	0.12	1.16	6
	78	36.05	35.93	0.12		0.02	0.64	1.98	32

	Stas	Latitude	Longitude	Tot.chl-a	T-P	PO4	NO2+NO3	Sİ	N:P
	1	36.59	34.34	0.57		0.04	0.5	0.74	12.5
	2	36.54	34.375	0.38	0.071	0.02	0.08	0.55	4
	3	36.49	34.41	0.19		0.02	0.33	1.06	16.5
	4	36.44	34.445	0.25		0.02	0.29	0.99	14.5
	5	36.39	34.48	0.21		0.02	0.17	0.95	8.5
	6	35.965	34.984			0.02	0.13	1.33	6.5
	8	36.25	34.796	0.23	0.111	0.02	0.09	0.86	4.5
	10	36.53	34.608	0.24		0.02	0.32	0.61	16
	11	36.68	34.514	0.28	0.071	0.02	0.35	0.42	17.5
	12	35.74	34.67	0.27		0.02	0.18	1.25	9
March 2007	14	36.02	34.482	0.17		0.02	0.15	1.18	7.5
	20	36.19	35.298	0.19		0.02	0.21	1.13	10.5
	23	36.53	35.768	0.61	0.152	0.04	2.3	3.33	57.5
	24	36.59	35.846	0.25	0.136	0.02	0.3	1.41	15
	25	36.64	35.925	0.26		0.02	0.16	1.43	8
	26	36.7	36.003	0.41	0.156	0.02	0.14	1.16	7
	27	36.75	36.082	0.52	0.131	0.02	0.14	1.33	7
	28	36.25	33.89	0.45	0.152	0.02	0.05	0.36	2.5
	33	35.88	33.98	0.17	0.146	0.02	0.27	1.35	13.5
	36	35.56	34.055	0.49		0.02	0.18	0.93	9
	37	36.26	34.08	0.36	0.156	0.06	0.15	0.38	2.5
	41	36.13	33.62	0.39		0.02	0.15	0.76	7.5
	45	36.1	33.2	0.23		0.02	0.07	0.78	3.5
	49	35.79	33.245	0.27	0.142	0.02	0.32	1.3	16
	52	35.41	33.301	0.22		0.02	0.24	1.17	12
	53	36.4	35.374	0.17	0.142	0.02	0.06	0.95	3
	54	36.52	35.531	0.30	0.117	0.02	2.1	2.82	105
	55	36.63	35.688	0.39		0.03	0.77	1.78	25.7
	56	36.69	35.766	0.26		0.03	0.86	2.27	28.7
	57	36.74	35.845	0.40	0.142	0.02	0.2	1.5	10
	59	36.85	36.002	0.29	0.101	0.06	0.25	1.66	4.17
	62	36.43	35.848	0.40	0.111	0.02	0.1	0.85	5
	63	36.49	35.926	0.34		0.03	0.1	0.77	3.33
	64	36.54	36.005	0.25	0.136	0.02	0.08	0.76	4
	66	36.65	36.162	0.30	0.101	0.02	0.08	0.8	4
	67	36.36	34.952	0.28		0.02	0.07	0.98	3.5
	69	36.53	35.188	0.31		0.02	0.95	1.9	47.5
	72	36.62	35.014	0.23		0.03	0.86	1.3	28.7
	73	36.65	34.764	0.23		0.02	0.3	0.51	15
	74	36.7	34.842	0.53	0.399	0.02	0.88	1.51	44
	76	35.97	35.584	0.33	0.136	0.03	0.21	0.9	7
	78	36.05	35.93	0.37		0.03	0.1	0.93	3.33

	Stas	Latitude	Longitude	Tot.chl-a	T-P	PO4	NO2+NO3	Sİ	N:P
	1	36.59	34.34	0.21		0.03	0.3	1.58	10
	2	36.54	34.375	0.05	0.099	0.03	0.06	1.62	2
	3	36.49	34.41	0.20		0.03	0.07	1.58	2.33
	4	36.44	34.445	0.08		0.03	0.07	1.53	2.33
	5	36.39	34.48	0.05		0.02	0.05	1.56	2.5
April 2007	6	35.965	34.984			0.02	0.09	1.3	4.5
	8	36.25	34.796	0.03	0.111	0.02	0.06	1.27	3
	10	36.53	34.608	0.04		0.02	0.11	1.35	5.5
	11	36.68	34.514	0.07	0.099	0.02	0.16	1.31	8
	12	35.74	34.67	0.23		0.02	0.09	1.25	4.5
	14	36.02	34.482	0.07		0.02	0.1	1.48	5
	20	36.19	35.298	0.13		0.02	0.05	1.16	2.5
	23	36.53	35.768	0.04		0.02	0.05	0.9	2.5
	24	36.59	35.846	0.06	0.123	0.02	0.05	1.08	2.5
	25	36.64	35.925	0.11		0.02	0.13	1.15	6.5
	26	36.7	36.003	0.05	0.13	0.02	0.05	1.1	2.5
	27	36.75	36.082	0.10	0.157	0.02	0.05	1.17	2.5
	28	36.25	33.89	0.10	0.128	0.02	0.24	0.61	12
	33	35.88	33.98	0.11	0.094	0.02	0.09	1.18	4.5
	36	35.56	34.055	0.04		0.02	0.08	1.48	4
	37	36.26	34.08	0.04	0.118	0.03	0.06	1.35	2
	41	36.13	33.62	0.09		0.02	0.09	0.76	4.5
	49	35.79	33.245	0.03	0.089	0.02	0.06	1.47	3
	52	35.41	33.301	0.09		0.02	0.08	1.31	4
	53	36.4	35.374	0.06	0.155	0.02	0.07	1.18	3.5
	54	36.52	35.531	0.11	0.18	0.03	0.68	2.17	22.7
	55	36.63	35.688	0.12		0.03	0.94	2.66	31.3
	56	36.69	35.766	0.14		0.02	0.17	1.68	8.5
	57	36.74	35.845	0.14	0.115	0.02	0.2	1.83	10
	59	36.85	36.002	0.30	0.159	0.02	0.1	2.4	5
	62	36.43	35.848	0.09	0.172	0.02	0.05	0.98	2.5
	63	36.49	35.926	0.24		0.02	0.06	1.33	3
	64	36.54	36.005	0.07	0.102	0.04	0.06	1.04	1.5
	66	36.65	36.162	0.18	0.117	0.03	0.05	1.58	1.67
	67	36.36	34.952	0.05		0.02	0.05	1.2	2.5
	69	36.53	35.188	0.15		0.02	0.18	1.45	9
	72	36.62	35.014	0.16		0.03	0.1	1.63	3.33
	73	36.65	34.764	0.07		0.02	0.11	1.09	5.5
	74	36.7	34.842	0.76	0.868	0.02	0.55	2.12	27.5
	76	35.97	35.584	0.10	0.109	0.02	0.05	1.31	2.5
	78	36.05	35.93	0.19		0.03	0.3	1.47	10

	Stas	Latitude	Longitude	Tot.chl-a	T-P	PO4	NO2+NO3	Sİ	N:P
	1	36.59	34.34	0.35		0.03	0.13	0.88	4.33
	2	36.54	34.375	0.04	0.156	0.02	0.1	0.75	5
	3	36.49	34.41	0.03		0.03	0.13	0.88	4.33
	4	36.44	34.445	0.02		0.02	0.08	0.92	4
	5	36.39	34.48	0.02		0.02	0.08	0.88	4
	6	35.965	34.984			0.02	0.08	0.94	4
	8	36.25	34.796	0.02	0.218	0.05	0.13	1.03	2.6
	10	36.53	34.608	0.03		0.02	0.07	1.4	3.5
	11	36.68	34.514	0.06	0.172	0.02	0.08	1.24	4
	12	35.74	34.67	0.04		0.02	0.05	0.82	2.5
June 2007	14	36.02	34.482	0.04		0.02	0.05	0.89	2.5
	20	36.19	35.298	0.03		0.02	0.08	0.96	4
	23	36.53	35.768	0.09	0.142	0.02	0.07	0.78	3.5
	24	36.59	35.846	0.06	0.111	0.03	0.05	1.19	1.67
	25	36.64	35.925	0.07		0.02	0.1	0.92	5
	26	36.7	36.003	0.13	0.167	0.03	0.12	0.73	4
	27	36.75	36.082	0.09	0.165	0.02	0.09	0.76	4.5
	28	36.25	33.89	0.10	0.172	0.02	0.06	0.78	3
	33	35.88	33.98	0.02	1.22	0.02	0.07	0.85	3.5
	36	35.56	34.055	0.08		0.02	0.06	0.86	3
	37	36.26	34.08	0.08	0.161	0.02	0.06	0.73	3
	41	36.13	33.62	0.08		0.02	0.11	0.77	5.5
	45	36.1	33.2	0.07		0.02	0.11	0.74	5.5
	49	35.79	33.245	0.03	0.101	0.02	0.1	0.86	5
	52	35.41	33.301	0.02		0.02	0.07	0.83	3.5
	53	36.4	35.374	0.03	0.17	0.02	0.08	1.29	4
	54	36.52	35.531	0.08	0.182	0.02	0.67	2.56	33.5
	55	36.63	35.688	0.07		0.02	0.05	1.26	2.5
	56	36.69	35.766			0.02	0.08	1.43	4
	57	36.74	35.845	0.06	0.152	0.02	0.09	0.76	4.5
	59	36.85	36.002	0.03	0.126	0.02	0.11	0.74	5.5
	62	36.43	35.848	0.07	0.136	0.02	0.09	0.81	4.5
	63	36.49	35.926	0.12		0.02	0.1	0.76	5
	64	36.54	36.005	0.08	0.147	0.02	0.12	0.77	6
	66	36.65	36.162	0.05	0.202	0.02	0.14	0.76	7
	67	36.36	34.952	0.01		0.02	0.11	1.12	5.5
	69	36.53	35.188	0.04		0.03	0.13	1.34	4.33
	72	36.62	35.014	0.06		0.02	0.05	1.08	2.5
	73	36.65	34.764	0.04		0.02	0.08	1.06	4
	74	36.7	34.842	0.24	0.303	0.04	0.06	0.9	1.5
	76	35.97	35.584	0.04	0.122	0.02	0.09	0.99	4.5
	78	36.05	35.93	0.05		0.03	0.08	1.32	2.67

	Stas	Latitude	Longitude	Tot.chl-a	T-P	PO4	NO2+NO3	Sİ	N:P
	1	36.59	34.34	0.05		0.02	0.06	1.74	3
	2	36.54	34.375	0.04	0.324	0.02	0.08	1.57	4
	3	36.49	34.41	0.03		0.02	0.27	1.62	13.5
	4	36.44	34.445	0.06		0.02	0.16	1.58	8
	5	36.39	34.48	0.06		0.02	0.15	1.55	7.5
	6	35.965	34.984	0.07		0.03	0.06	1.43	2
	8	36.25	34.796	0.07	0.158	0.03	0.15	1.27	5
	10	36.53	34.608	0.05		0.02	0.07	1.36	3.5
	11	36.68	34.514	0.09	0.232	0.02	0.07	1.51	3.5
	12	35.74	34.67	0.07		0.02	0.08	1.42	4
September 2007	14	36.02	34.482	0.08		0.02	0.1	1.31	5
	20	36.19	35.298	0.06		0.02	0.05	2.26	2.5
	23	36.53	35.768	0.08	0.16	0.03	0.09	1.84	3
	24	36.59	35.846	0.10	0.19	0.02	0.11	2.64	5.5
	25	36.64	35.925	0.10		0.02	0.07	2.79	3.5
	26	36.7	36.003	0.15	0.18	0.02	0.07	2.82	3.5
	27	36.75	36.082	0.13	0.201	0.02	0.12	2.74	6
	28	36.25	33.89	0.14	0.19	0.02	0.07	1.91	3.5
	33	35.88	33.98	0.03	0.221	0.02	0.1	1.31	5
	36	35.56	34.055	0.03		0.02	0.11	1.35	5.5
	37	36.26	34.08	0.03	0.18	0.02	0.1	1.57	5
	41	36.13	33.62	0.04		0.02	0.07	1.41	3.5
	45	36.1	33.2	0.03		0.02	0.07	1.46	3.5
	49	35.79	33.245	0.03	0.16	0.02	0.07	1.42	3.5
	52	35.41	33.301	0.04		0.02	0.11	1.41	5.5
	53	36.4	35.374	0.09	0.221	0.02	0.06	1.9	3
	54	36.52	35.531	0.32	0.9	0.02	1.46	7.24	73
	55	36.63	35.688	0.08		0.02	0.13	2.85	6.5
	56	36.69	35.766	0.14		0.02	0.15	2.61	7.5
	57	36.74	35.845	0.18	0.21	0.03	0.18	3.33	6
	59	36.85	36.002	0.21	0.221	0.02	0.09	3.13	4.5
	62	36.43	35.848	0.13	0.07	0.02	0.05	2.75	2.5
	63	36.49	35.926	0.15		0.02	0.07	2.87	3.5
	64	36.54	36.005	0.17	0.261	0.02	0.08	2.8	4
	66	36.65	36.162	0.11	0.17	0.02	0.06	2.88	3
	67	36.36	34.952	0.09		0.02	0.16	1.33	8
	69	36.53	35.188	0.15		0.03	0.17	1.92	5.67
	72	36.62	35.014	0.09		0.02	0.06	1.89	3
	73	36.65	34.764	0.05		0.02	0.05	1.31	2.5
	74	36.7	34.842	0.35	0.214	0.03	0.06	1.74	2
	76	35.97	35.584	0.09	0.15	0.03	0.06	1.52	2
	78	36.05	35.93	0.16		0.02	0.07	1.54	3.5

Appendix 2. PIGMENT DATA

Date	STATION	C3	C2	PER	BUT	FUC	HEX	DIAD	ALLO	ZEA	LUT	CHL-B	DIV-A	CHL-A	B-CAR	Total CHL
Nov 2005	14		0.013	0.019	0.061	0.04	0.035	0.009	0.007	0.046	0.036		0.319	0.007		0.326
Nov 2005	24	0.038	0.041	0.004	0.042	0.072	0.074	0.02	0.012	0.038		0.034	0.069	0.465	0.025	0.534
Nov 2005	28	0.029	0.022		0.029	0.023	0.066	0.014	0.007	0.036			0.036	0.252	0.017	0.288
Nov 2005	33	0.007	0.007		0.01	0.006	0.022	0.004		0.012			0.025	0.097	0.007	0.122
	Station	**C3**	**C2**	**PER**	**BUT**	**FUC**	**HEX**	**DIAD**	**ALLO**	**ZEA**	**LUT**	**CHL-B**	**DIV-A**	**CHL-A**	**B-CAR**	**Total Chl**
March2006	8	0.007					0.006			0.012			0.01	0.04		0.05
March2006	11		0.011			0.029	0.014	0.008	0	0.011				0.165		0.165
March2006	28		0.003			0.021	0.008	0.006	0.003	0.009				0.07		0.07
March2006	33				0.003	0.003	0.013	0.002	0.001	0.011				0.04	0.001	0.04
March2006	37		0.024			0.149	0.018	0.02	0.007	0.009				0.481	0.006	0.481
	Station	**C3**	**C2**	**PER**	**BUT**	**FUC**	**HEX**	**DIAD**	**ALLO**	**ZEA**	**LUT**	**CHL-B**	**DIV-A**	**CHL-A**	**B-CAR**	**Total Chl**
July 2006	8						0.005	0.003	0.003	0.01	0.003			0.024		0.024
July 2006	11													0.029		0.029
July 2006	24	0.032	0.016		0.005	0.038	0.091	0.018		0.066				0.53	0.011	0.53
July 2006	27						0.014			0.037				0.059		0.059
July 2006	28					0.005	0.01			0.017				0.047		0.047
July 2006	37				0.002		0.01			0.006				0.032	0.001	0.032
July 2006	41					0.005	0.009			0.019			0.006	0.042	0.002	0.048
	Station	**C3**	**C2**	**PER**	**BUT**	**FUC**	**HEX**	**DIAD**	**ALLO**	**ZEA**	**LUT**	**CHL-B**	**DIV-A**	**CHL-A**	**B-CAR**	**Total Chl**
Jan 2007	8	0.021	0.012		0.018	0.008	0.033	0.006	0.003	0.009			0.026	0.022	0.006	0.048
Jan 2007	11	0.041	0.034	0.025	0.019	0.045	0.061	0.022	0.013	0.010			0.021	0.055	0.011	0.077
Jan 2007	24	0.022	0.013		0.011	0.012	0.039	0.010	0.008	0.028			0.022	0.024	0.008	0.045
Jan 2007	33	0.047	0.029		0.039	0.032	0.077	0.011		0.027			0.054	0.047	0.013	0.101
	Station	**C3**	**C2**	**PER**	**BUT**	**FUC**	**HEX**	**DIAD**	**ALLO**	**ZEA**	**LUT**	**CHL-B**	**DIV-A**	**CHL-A**	**B-CAR**	**Total Chl**
March 2007	8	0.009	0.013		0.009	0.027	0.022	0.008	0.003	0.005		0.008	0.008	0.121	0.004	0.129
March 2007	11	0.017	0.022		0.01	0.047	0.029	0.017	0.001	0.01		0.002	0.013	0.145	0.008	0.158
March 2007	24	0.021	0.029		0.013	0.056	0.033	0.011	0.002	0.009			0.009	0.204	0.01	0.213

March 2007	33	0.017	0.015	0.003	0.02	0.014	0.048	0.008	0.002	0.026		0.009	0.05	0.19	0.014	0.24
March 2007	49	0.023	0.016		0.021	0.02	0.054	0.016	0.005	0.022			0.035	0.164	0.015	0.199
	Station	**C3**	**C2**	**PER**	**BUT**	**FUC**	**HEX**	**DIAD**	**ALLO**	**ZEA**	**LUT**	**CHL-B**	**DIV-A**	**CHL-A**	**B-CAR**	**Total Chl**
April 2007	8	0.026	0.012		0.041	0.04	0.095	0.056		0.158			0.156	0.324	0.057	0.48
April 2007	11	0.009	0.013		0.014	0.019	0.051	0.026	0.003	0.008		0.012		0.14	0.008	0.14
April 2007	24	0.117	0.106	0.123	0.108	0.121	0.246	0.098	0.003	0.006			0.004	0.124	0.007	0.129
April 2007	33	0.008	0.003		0.008	0.005	0.02	0.004		0.007			0.009	0.049	0.005	0.058
April 2007	49	0.004	0.002	0.001	0.005	0.002	0.017	0.008		0.003			0.002	0.042	0.003	0.044
April 2007	74	0.041	0.13	0.214	0.032	0.141	0.208	0.15	0.168	0.131	0.094	0.561		1.827	0.206	1.827
	Station	**C3**	**C2**	**PER**	**BUT**	**FUC**	**HEX**	**DIAD**	**ALLO**	**ZEA**	**LUT**	**CHL-B**	**DIV-A**	**CHL-A**	**B-CAR**	**Total Chl**
June 2007	8	0.008	0.004	0.003	0.006	0.005	0.021	0.008		0.014				0.087	0.004	0.087
June 2007	11		0.002		0.005	0.007	0.017	0.009		0.019				0.048	0.004	0.048
June 2007	24	0.007	0.007	0.002	0.004	0.024	0.027	0.013		0.008				0.122	0.004	0.122
June 2007	33						0.004	0.001		0.007				0.019	0.002	0.019
June 2007	49		0.001				0.002			0.004				0.028	0	0.028
June 2007	74		0.046			0.448	0.106	0.207		0.054				0.945	0.061	0.945
	Station	**C3**	**C2**	**PER**	**BUT**	**FUC**	**HEX**	**DIAD**	**ALLO**	**ZEA**	**LUT**	**CHL-B**	**DIV-A**	**CHL-A**	**B-CAR**	**Total Chl**
Sept 2007	8				0.002	0.003	0.006	0.003		0.03			0.017	0.042	0.007	0.059
Sept 2007	11		0.005	0.002	0.004	0.013	0.02	0.008	0.002	0.056			0.028	0.116	0.014	0.144
Sept 2007	24		0.001	0.004	0.002	0.003	0.012	0.003		0.01				0.045	0.003	0.045
Sept 2007	33				0.001	0.001	0.002	0.001		0.004				0.011	0.001	0.011
Sept 2007	49	0.004	0.002	0.001	0.002	0.003	0.011	0.003		0.029			0.008	0.064	0.006	0.073
Sept 2007	74		0.001	0.001		0.024	0.014	0.006		0.016				0.114	0.009	0.114

Appendix 3. Temperature, Salinity and Density data.

	November 2005						March 2006				
Sta	Latitude	Longitude	Temperature	Salinity	Density	Sta	Latitude	Longitude	Temperature	Salinity	Density
1	36.59	34.34	20.0926	39.3722	28.0759	1	36.59	34.34	16.8465	38.5048	28.2446
2	36.54	34.375	19.968	39.3514	28.0936	3	36.49	34.41	16.9404	39.1985	28.7555
3	36.49	34.41	19.9165	39.3536	28.1093	4	36.44	34.445	17.2454	39.2136	28.692
4	36.44	34.445	19.74	39.3086	28.1222	5	36.39	34.48	17.383	39.1923	28.6416
6	35.965	34.984	20.828	39.4427	27.9281	7	36.107	34.89	17.5441	39.2185	28.6216
7	36.107	34.89	20.2284	39.3449	28.0181	8	36.25	34.796	17.3508	39.2156	28.6674
8	36.25	34.796	19.0379	39.2384	28.2547	9	36.391	34.702	17.212	39.2069	28.6951
9	36.391	34.702	18.1659	39.1741	28.4307	10	36.53	34.608	17.1674	39.2041	28.704
10	36.53	34.608	20.9166	39.3872	27.8612	11	36.68	34.514	16.9277	39.0373	28.6344
11	36.68	34.514	20.8113	39.3892	27.8919	12	35.74	34.67	16.9851	39.2017	28.7469
12	35.74	34.67	19.6095	39.3265	28.1709	13	35.882	34.576	17.1024	39.2095	28.7241
13	35.882	34.576	19.809	39.3248	28.1162	14	36.02	34.482	17.1483	39.1935	28.7005
14	36.02	34.482	19.3685	39.3261	28.2347	15	36.166	34.388	17.7152	39.2229	28.5821
15	36.166	34.388	18.7589	39.2766	28.3568	16	36.308	34.294	17.393	39.2195	28.66
16	36.308	34.294	18.3488	39.195	28.4001	19	36.078	35.141	17.2724	39.2076	28.6808
17	36.45	34.2	19.9331	39.3577	28.1078	22	36.415	35.611	17.035	39.1085	28.663
19	36.078	35.141	20.5963	39.4072	27.965	23	36.53	35.768	16.8348	38.6704	28.3747
20	36.19	35.298	20.5196	39.3611	27.9509	24	36.59	35.846	16.7036	38.7496	28.4674
21	36.303	35.454	20.5956	39.3396	27.9136	25	36.64	35.925	16.7583	39.0096	28.6543
22	36.415	35.611	20.2749	39.237	27.9229	26	36.7	36.003	16.7086	38.9698	28.6357
23	36.53	35.768	20.6367	39.3596	27.9172	27	36.75	36.082	16.9998	38.8964	28.5084
24	36.59	35.846	20.4626	39.3075	27.9256	28	36.25	33.89	16.9776	38.5808	28.271
25	36.64	35.925	21.0822	39.3575	27.7924	29	36.188	33.905	16.8241	39.0839	28.6955
26	36.7	36.003	21.0458	39.3487	27.7959	30	36.125	33.92	16.9289	38.755	28.4169
27	36.75	36.082	21.1268	39.3515	27.7753	31	36.062	33.935	16.8926	39.205	28.7719

Sta	Latitude	Longitude	Temperature	Salinity	Density	Sta	Latitude	Longitude	Temperature	Salinity	Density
28	36.25	33.89	19.3908	39.3962	28.2824	32	36	33.95	16.6755	39.1617	28.7915
29	36.188	33.905	19.6978	39.2952	28.1233	33	35.88	33.98	16.7098	39.0024	28.6605
30	36.125	33.92	19.6208	39.3192	28.1622	34	35.75	34.01	16.5841	39.1836	28.8304
31	36.062	33.935	19.5794	39.302	28.1602	35	35.625	34.04	16.6905	39.1865	28.8069
32	36	33.95	19.7245	39.3337	28.1456	36	35.56	34.055	16.6407	39.1864	28.8189
33	35.88	33.98	19.5192	39.3247	28.1935	37	36.26	34.08	17.0068	38.6741	28.3357
34	35.75	34.01	19.4608	39.3406	28.2213	38	36.2	34.095	17.2862	39.2098	28.6789
35	35.625	34.04	19.3685	39.318	28.2284	39	36.14	34.11	17.2747	39.1913	28.6677
36	35.56	34.055	19.3877	39.3158	28.2217	40	36.08	34.125	17.6002	39.2023	28.5951
37	36.26	34.08	19.5977	39.3311	28.1776	41	36.13	33.62	16.8821	38.992	28.6107
38	36.2	34.095	19.619	39.3272	28.1689	42	36.067	33.63	16.87	39.003	28.6221
39	36.14	34.11	19.7139	39.3493	28.1605	43	36.005	33.64	16.6766	38.8218	28.5295
40	36.08	34.125	19.7766	39.3568	28.1493	44	35.942	33.65	16.9215	38.9758	28.5887
41	36.13	33.62	19.7835	39.3753	28.1617	45	36.1	33.2	17.0389	38.9895	28.5705
42	36.067	33.63	19.7405	39.3443	28.1494	46	36.037	33.21	17.0181	39.0078	28.5897
43	36.005	33.64	19.82	39.3585	28.139	47	35.975	33.22	17.1144	39.1195	28.652
44	35.942	33.65	19.8225	39.363	28.1417	48	35.912	33.23	16.9484	39.1607	28.7243
45	36.1	33.2	19.8801	39.3776	28.1373	49	35.79	33.245	16.7353	39.1607	28.7762
46	36.037	33.21	20.0102	39.3415	28.0747	50	35.665	33.264	16.5487	39.1689	28.8276
47	35.975	33.22	19.9015	39.3551	28.1144	51	35.532	33.283	16.7088	39.1845	28.8009
48	35.912	33.23	19.8784	39.379	28.1389	52	35.41	33.301	16.6214	39.1616	28.8044
49	35.79	33.245	19.7708	39.3539	28.1487	53	36.4	35.374	16.5304	38.6401	28.4248
50	35.665	33.264	19.6524	39.3709	28.1934	54	36.52	35.531	17.132	37.8619	27.6807
51	35.532	33.283	18.7994	39.2689	28.3403	55	36.63	35.688	16.5772	38.7456	28.4948
52	35.41	33.301	19.6752	39.3547	28.1749	56	36.69	35.766	16.8048	38.9081	28.5649
53	36.4	35.374	21.2142	39.3893	27.7798	57	36.74	35.845	16.9056	38.9308	28.5579
54	36.52	35.531	20.3549	37.8364	26.8314	58	36.796	35.923	16.7885	38.8733	28.5421
55	36.63	35.688	20.8819	39.3573	27.848	59	36.85	36.002	17.0277	38.9087	28.511
56	36.69	35.766	20.9212	39.34	27.8239	61	36.315	35.691	16.9764	39.0798	28.6552
57	36.74	35.845	20.9086	39.336	27.8243	62	36.43	35.848	16.744	38.5441	28.2995

Sta	Latitude	Longitude	Temperature	Salinity	Density	Sta	Latitude	Longitude	Temperature	Salinity	Density
58	36.796	35.923	21.0036	39.3268	27.7909	63	36.49	35.926	16.8341	38.5803	28.3056
61	36.315	35.691	20.4255	39.3429	27.9628	64	36.54	36.005	17.1562	38.5578	28.2097
62	36.43	35.848	20.5972	39.357	27.9265	65	36.596	36.083	16.5964	38.8008	28.5327
63	36.49	35.926	20.5693	39.3565	27.9337	66	36.65	36.162	17.1354	38.6982	28.3228
64	36.54	36.005	20.6097	39.3567	27.9228	67	36.36	34.952	16.9665	39.1913	28.7434
65	36.596	36.083	21.0268	39.3321	27.7885	68	36.473	35.11	16.7923	39.1376	28.7446
66	36.65	36.162	20.63	39.308	27.8799	69	36.53	35.188	16.2427	37.0856	27.2963
67	36.36	34.952	20.9507	39.3313	27.809	70	36.503	34.858	17.1446	39.2027	28.7085
68	36.473	35.11	20.9422	39.3743	27.8442	71	36.559	34.936	16.5143	38.799	28.551
69	36.53	35.188	20.6561	39.4103	27.9509	72	36.62	35.014	16.2626	38.1967	28.1472
70	36.503	34.858	20.7977	39.3753	27.8851	73	36.65	34.764	16.8621	39.1662	28.7496
71	36.559	34.936	20.6666	39.3726	27.9193	74	36.7	34.842	16.7602	38.2789	28.0915
72	36.62	35.014	20.4728	39.3598	27.9628	75	35.965	35.284	17.4767	39.2234	28.6422
73	36.65	34.764	20.4978	39.2944	27.9059	76	35.97	35.584	17.1897	39.2035	28.698
74	36.7	34.842	20.0471	39.1488	27.9173	77	35.965	35.884	17.0955	39.1951	28.7147
						78	36.05	35.93	17.0347	38.9629	28.551

	July 2006						January 2007				
Sta	Latitude	Longitude	Temperature	Salinity	Density	Sta	Latitude	Longitude	Temperature	Salinity	Density
1	36.59	34.34	27.66	39.33	25.77	2	36.54	34.375	17.2012	39.4026	28.8483
2	36.54	34.38	27.03	39.42	26.04	3	36.49	34.41	17.2666	39.4099	28.8378
3	36.49	34.41	27.32	39.52	26.02	4	36.44	34.445	17.1187	39.3703	28.8438
4	36.44	34.45	27.29	39.47	26.00	5	36.39	34.48	17.1754	39.3802	28.8375
5	36.39	34.48	27.27	39.44	25.98	6	35.965	34.984	17.4318	39.3764	28.771
6	35.97	34.98	26.91	39.34	26.02	7	36.107	34.89	17.3806	39.3644	28.7745
7	36.11	34.89	26.96	39.42	26.06	8	36.25	34.796	17.3183	39.3954	28.8137
8	36.25	34.80	27.17	39.48	26.04	9	36.391	34.702	17.2587	39.3819	28.8181
9	36.39	34.70	27.54	39.49	25.93	10	36.53	34.608	16.9703	39.3536	28.8674
10	36.53	34.61	27.26	39.33	25.90	11	36.68	34.514	16.6352	39.4318	29.0092
11	36.68	34.51	28.16	39.21	25.51	12	35.74	34.67	16.8218	39.2867	28.8521
12	35.74	34.67	26.87	39.35	26.04	13	35.882	34.576	16.7738	39.3205	28.8898
13	35.88	34.58	27.09	39.40	26.01	14	36.02	34.482	16.7452	39.3213	28.8974
14	36.02	34.48	27.06	39.31	25.95	15	36.166	34.388	17.1074	39.352	28.8325
15	36.17	34.39	27.67	39.31	25.75	16	36.308	34.294	17.0204	39.341	28.8454
16	36.31	34.29	27.63	39.42	25.84	17	36.45	34.2	17.1645	39.4011	28.8562
17	36.45	34.20	27.68	39.23	25.68	18	35.853	34.827	16.9998	39.3293	28.8415
18	35.85	34.83	26.77	39.43	26.13	19	36.078	35.141	17.4717	39.4126	28.7889
19	36.08	35.14	27.25	39.44	25.98	20	36.19	35.298	17.4325	39.4144	28.8
20	36.19	35.30	26.91	39.51	26.15	21	36.303	35.454	17.353	39.3538	28.7732
21	36.30	35.45	26.97	39.51	26.13	22	36.415	35.611	17.3217	39.3985	28.8153
22	36.42	35.61	27.07	39.50	26.09	23	36.53	35.768	16.7661	39.3968	28.9505
23	36.53	35.77	27.60	39.06	25.59	24	36.59	35.846	16.8398	39.476	28.9935
24	36.59	35.85	27.66	38.99	25.51	25	36.64	35.925	16.8746	39.4613	28.9737
25	36.64	35.93	27.58	39.06	25.59	26	36.7	36.003	16.687	39.5341	29.0754
26	36.70	36.00	27.93	39.06	25.47	27	36.75	36.082	16.5112	39.5388	29.1216
27	36.75	36.08	28.00	39.00	25.41	28	36.25	33.89	16.537	39.3515	28.971

Sta	Latitude	Longitude	Temperature	Salinity	Density	Sta	Latitude	Longitude	Temperature	Salinity	Density
28	36.25	33.89	27.93	39.24	25.61	29	36.188	33.905	16.854	39.3438	28.8883
29	36.19	33.91	27.16	39.37	25.96	30	36.125	33.92	17.1128	39.3908	28.8611
30	36.13	33.92	27.15	39.51	26.07	31	36.062	33.935	17.1967	39.4052	28.8514
31	36.06	33.94	27.37	39.50	25.99	32	36	33.95	17.2375	39.4122	28.8467
32	36.00	33.95	27.41	39.46	25.95	33	35.88	33.98	16.3901	39.2484	28.9269
33	35.88	33.98	27.26	39.35	25.91	34	35.75	34.01	16.7963	39.3397	28.8992
34	35.75	34.01	27.53	39.36	25.83	35	35.625	34.04	16.5012	39.2852	28.9286
35	35.63	34.04	27.39	39.39	25.90	36	35.56	34.055	16.9934	39.3761	28.8791
36	35.56	34.06	27.46	39.40	25.88	37	36.26	34.08	17.0437	39.4205	28.9009
37	36.26	34.08	27.08	39.44	26.04	38	36.2	34.095	17.0639	39.3948	28.8761
38	36.20	34.10	27.45	39.53	25.98	39	36.14	34.11	17.1501	39.3951	28.8551
39	36.14	34.11	27.90	39.47	25.80	40	36.08	34.125	17.0462	39.3617	28.855
40	36.08	34.13	27.98	39.41	25.72	41	36.13	33.62	16.9305	39.3705	28.8901
41	36.13	33.62	26.78	39.37	26.09	42	36.067	33.63	16.994	39.3675	28.8723
42	36.07	33.63	26.65	39.45	26.19	43	36.005	33.64	16.9387	39.3458	28.8691
43	36.01	33.64	27.27	39.51	26.03	44	35.942	33.65	16.7218	39.3111	28.8952
44	35.94	33.65	27.18	39.37	25.95	45	36.1	33.2	16.7044	39.3312	28.9149
45	36.10	33.20	27.20	39.32	25.91	46	36.037	33.21	16.8538	39.3568	28.8984
46	36.04	33.21	27.59	39.41	25.85	47	35.975	33.22	16.8004	39.3638	28.9167
47	35.98	33.22	27.67	39.41	25.83	48	35.912	33.23	16.9748	39.3633	28.8737
48	35.91	33.23	27.50	39.54	25.97	49	35.79	33.245	16.6868	39.3108	28.9035
49	35.79	33.25	27.63	39.40	25.83	50	35.665	33.264	16.6685	39.312	28.9089
50	35.67	33.26	27.50	39.41	25.88	51	35.532	33.283	16.6848	39.3133	28.9059
51	35.53	33.28	27.20	39.40	25.97	52	35.41	33.301	17.4515	39.4205	28.8
52	35.41	33.30	27.27	39.39	25.94	53	36.4	35.374	16.9367	39.427	28.9321
53	36.40	35.37	27.07	39.51	26.10	54	36.52	35.531	16.5504	39.4369	29.0337
54	36.52	35.53	27.52	39.10	25.64	55	36.63	35.688	16.5587	39.6371	29.1858
55	36.63	35.69	27.80	38.30	24.94	56	36.69	35.766	16.7535	39.521	29.0491
56	36.69	35.77	27.98	39.07	25.47	57	36.74	35.845	16.8874	39.4781	28.9835

Sta	Latitude	Longitude	Temperature	Salinity	Density	Sta	Latitude	Longitude	Temperature	Salinity	Density
57	36.74	35.85	28.01	39.06	25.44	58	36.796	35.923	16.5591	39.6273	29.1782
58	36.80	35.92	27.85	39.04	25.49	59	36.85	36.002	16.5681	39.6073	29.1605
59	36.85	36.00	28.05	38.97	25.37	60	36.203	35.534	17.4452	39.3958	28.7826
60	36.20	35.53	27.03	39.50	26.10	61	36.315	35.691	17.1642	39.4007	28.8559
61	36.32	35.69	26.94	39.50	26.13	62	36.43	35.848	17.1916	39.4247	28.8677
62	36.43	35.85	26.90	39.50	26.15	63	36.49	35.926	17.0218	39.4093	28.8977
63	36.49	35.93	27.49	39.23	25.75	64	36.54	36.005	17.0271	39.4267	28.9097
64	36.54	36.01	28.44	39.09	25.33	65	36.596	36.083	17.04	39.4339	28.9121
65	36.60	36.08	28.35	39.02	25.31	66	36.65	36.162	16.8951	39.4461	28.957
66	36.65	36.16	28.50	38.94	25.20	67	36.36	34.952	17.2198	39.3908	28.8346
67	36.36	34.95	27.03	39.37	26.00	68	36.473	35.11	16.9037	39.4361	28.9472
68	36.47	35.11	26.98	39.43	26.07	69	36.53	35.188	16.3423	39.4503	29.094
69	36.53	35.19	27.55	38.89	25.47	70	36.503	34.858	16.8814	39.4427	28.9577
70	36.50	34.86	27.40	39.47	25.96	71	36.559	34.936	16.8786	39.4341	28.9518
71	36.56	34.94	27.63	39.19	25.67	72	36.62	35.014	16.5601	39.4532	29.0438
72	36.62	35.01	27.87	39.00	25.45	73	36.65	34.764	16.58	39.456	29.0411
73	36.65	34.76	27.60	39.48	25.90	74	36.7	34.842	16.7837	39.4052	28.9527
74	36.70	34.84	28.00	39.45	25.74	75	35.965	35.284	16.8225	39.2823	28.8486
75	35.97	35.28	27.21	39.45	26.00	76	35.97	35.584	17.6629	39.3676	28.7065
76	35.97	35.58	27.21	39.50	26.05	77	35.965	35.884	17.5858	39.3726	28.7296
77	35.97	35.88	27.10	39.50	26.08	78	36.05	35.93	17.3745	39.179	28.6335
78	36.05	35.93	27.57	39.51	25.94						

	March 2007						April 2007				
Sta	Latitude	Longitude	Temperature	Salinity	Density	Sta	Latitude	Longitude	Temperature	Salinity	Density
1	36.59	34.34	16.1323	38.8743	28.7001	1	36.59	34.34	17.5772	39.1603	28.5687
2	36.54	34.375	16.932	39.3098	28.843	2	36.54	34.375	17.6417	39.3548	28.702
3	36.49	34.41	17.2211	39.3314	28.7886	3	36.49	34.41	17.5914	39.3478	28.7092
5	36.39	34.48	17.3298	39.3448	28.772	4	36.44	34.445	17.6287	39.343	28.6962
6	35.965	34.984	16.8854	39.2978	28.8452	5	36.39	34.48	17.597	39.338	28.7003
8	36.25	34.796	17.0801	39.3206	28.815	6	35.965	34.984	17.673	39.3321	28.6767
9	36.391	34.702	17.1218	39.3368	28.8173	7	36.107	34.89	17.6384	39.3463	28.6963
10	36.53	34.608	17.5332	39.3418	28.719	8	36.25	34.796	17.8893	39.3448	28.632
11	36.68	34.514	17.3705	39.3227	28.7449	9	36.391	34.702	18.1121	39.3574	28.5851
12	35.74	34.67	16.5735	39.2833	28.9097	10	36.53	34.608	18.3898	39.3655	28.5205
14	36.02	34.482	16.9891	39.3185	28.8357	11	36.68	34.514	18.6066	39.1649	28.3106
15	36.166	34.388	17.1998	39.3576	28.814	12	35.74	34.67	17.8845	39.3402	28.6297
16	36.308	34.294	17.2102	39.3481	28.8041	13	35.882	34.576	17.9777	39.3414	28.6071
17	36.45	34.2	16.7652	39.2845	28.8642	14	36.02	34.482	17.8016	39.3369	28.6481
18	35.853	34.827	16.6744	39.2885	28.8894	15	36.166	34.388	17.44	39.3231	28.728
19	36.078	35.141	17.2833	39.3479	28.7859	16	36.308	34.294	17.6255	39.353	28.7047
20	36.19	35.298	17.1329	39.34	28.8169	17	36.45	34.2	17.5498	39.3414	28.7147
21	36.303	35.454	16.9874	39.3242	28.8406	18	35.853	34.827	17.7329	39.3496	28.6751
22	36.415	35.611	16.9708	39.3318	28.8505	19	36.078	35.141	17.6301	39.3579	28.7072
23	36.53	35.768	16.4445	38.703	28.4939	20	36.19	35.298	17.9607	39.3269	28.6001
24	36.59	35.846	16.6928	39.1737	28.7965	21	36.303	35.454	18.083	39.352	28.5884
25	36.64	35.925	16.6374	39.2021	28.8317	23	36.53	35.768	17.9514	39.3045	28.5855
26	36.7	36.003	17.0107	39.2287	28.7613	24	36.59	35.846	18.7143	39.2809	28.3715
27	36.75	36.082	17.1629	39.2204	28.7176	25	36.64	35.925	18.084	39.3066	28.5533
28	36.25	33.89	16.2692	39.1968	28.9161	26	36.7	36.003	18.5147	39.3215	28.4545
29	36.188	33.905	16.5833	39.1638	28.8154	27	36.75	36.082	18.1897	39.274	28.5014

Sta	Latitude	Longitude	Temperature	Salinity	Density	Sta	Latitude	Longitude	Temperature	Salinity	Density
30	36.125	33.92	16.7893	39.2868	28.86	28	36.25	33.89	17.388	39.1331	28.5949
31	36.062	33.935	16.9175	39.333	28.8644	29	36.188	33.905	17.2464	39.1405	28.6357
32	36	33.95	16.5626	39.2617	28.8958	30	36.125	33.92	17.3719	39.3466	28.763
33	35.88	33.98	16.5612	39.2863	28.9149	31	36.062	33.935	17.4557	39.3412	28.7381
34	35.75	34.01	16.4635	39.2536	28.9134	32	36	33.95	17.3772	39.3512	28.7653
35	35.625	34.04	16.546	39.2817	28.9152	33	35.88	33.98	17.5975	39.3523	28.7111
36	35.56	34.055	16.624	39.2914	28.9038	34	35.75	34.01	17.3711	39.3519	28.7672
37	36.26	34.08	16.9302	39.3179	28.8498	35	35.625	34.04	17.252	39.3437	28.7905
39	36.14	34.11	16.7233	39.2899	28.8786	36	35.56	34.055	17.1443	39.33	28.8065
40	36.08	34.125	16.5698	39.2804	28.9084	37	36.26	34.08	17.5978	39.3351	28.6978
41	36.13	33.62	16.7684	39.2512	28.8378	38	36.2	34.095	17.4798	39.347	28.7364
42	36.067	33.63	16.8241	39.3065	28.8669	39	36.14	34.11	17.3883	39.3542	28.7647
43	36.005	33.64	16.606	39.2744	28.895	40	36.08	34.125	17.4697	39.3421	28.7352
44	35.942	33.65	16.4687	39.2646	28.9205	41	36.13	33.62	17.2321	39.2178	28.6985
45	36.1	33.2	16.9686	39.3428	28.8595	42	36.067	33.63	17.2068	39.2465	28.7269
46	36.037	33.21	17.0536	39.3415	28.8376	43	36.005	33.64	17.2346	39.3228	28.7787
47	35.975	33.22	16.8421	39.3112	28.8661	44	35.942	33.65	17.2714	39.3458	28.7873
48	35.912	33.23	16.5614	39.2769	28.9077	49	35.79	33.245	17.4765	39.3439	28.7349
49	35.79	33.245	16.5095	39.2835	28.9253	50	35.665	33.264	17.1835	39.336	28.8015
50	35.665	33.264	16.5322	39.2838	28.9201	51	35.532	33.283	17.1135	39.3389	28.821
51	35.532	33.283	16.8738	39.3298	28.8727	52	35.41	33.301	17.2856	39.3318	28.773
52	35.41	33.301	16.7065	39.3069	28.8957	53	36.4	35.374	17.9147	39.2994	28.5908
53	36.4	35.374	16.9773	39.326	28.8444	54	36.52	35.531	18.3793	39.0807	28.3046
54	36.52	35.531	16.3703	38.7917	28.5799	55	36.63	35.688	18.0179	38.9369	28.2863
55	36.63	35.688	16.5462	38.8331	28.5696	56	36.69	35.766	18.7835	39.1573	28.2593
56	36.69	35.766	16.4501	39.0199	28.7365	57	36.74	35.845	18.3121	39.1924	28.4074
57	36.74	35.845	16.555	39.1527	28.8136	58	36.796	35.923	17.9961	39.2125	28.5033
58	36.796	35.923	16.6985	39.1317	28.7627	59	36.85	36.002	18.8	39.0927	28.2052
59	36.85	36.002	16.7665	39.1478	28.7587	60	36.203	35.534	17.9164	39.3535	28.6318

Sta	Latitude	Longitude	Temperature	Salinity	Density	Sta	Latitude	Longitude	Temperature	Salinity	Density
60	36.203	35.534	17.0126	39.3221	28.8328	61	36.315	35.691	17.8604	39.2585	28.573
61	36.315	35.691	16.9507	39.3071	28.8364	62	36.43	35.848	17.8295	39.3095	28.6199
62	36.43	35.848	16.9367	39.2892	28.826	63	36.49	35.926	17.8377	39.269	28.5868
63	36.49	35.926	17.0801	39.1973	28.7202	64	36.54	36.005	17.8273	39.2965	28.6106
64	36.54	36.005	17.049	39.2939	28.8022	65	36.596	36.083	17.8212	39.2929	28.6093
65	36.596	36.083	17.458	39.3159	28.7178	66	36.65	36.162	18.197	39.2601	28.4888
66	36.65	36.162	17.5044	39.2768	28.6764	67	36.36	34.952	17.8495	39.3415	28.6396
67	36.36	34.952	16.9225	39.3287	28.8599	68	36.473	35.11	17.9778	39.1747	28.479
68	36.473	35.11	16.6861	39.2967	28.8929	69	36.53	35.188	18.4036	39.1767	28.372
69	36.53	35.188	16.3471	38.9394	28.6992	70	36.503	34.858	18.0319	39.2361	28.5124
70	36.503	34.858	17.2572	39.3358	28.7831	71	36.559	34.936	17.9304	39.2718	28.5656
71	36.559	34.936	17.3641	39.3288	28.7514	72	36.62	35.014	18.2058	39.0967	28.3612
72	36.62	35.014	16.6327	39.017	28.6904	73	36.65	34.764	18.6328	39.1995	28.3305
73	36.65	34.764	17.6796	39.338	28.6795	74	36.7	34.842	19.2734	38.4814	27.6131
74	36.7	34.842	16.5679	38.7311	28.4859	75	35.965	35.284	17.7884	39.3535	28.6641
75	35.965	35.284	17.1338	39.3266	28.8064	76	35.97	35.584	17.737	39.3609	28.6827
76	35.97	35.584	16.9105	39.3157	28.8529	77	35.965	35.884	17.6762	39.3632	28.6998
77	35.965	35.884	17.058	39.3278	28.826	78	36.05	35.93	17.8154	39.1668	28.5139
78	36.05	35.93	17.1636	39.3263	28.7989						

	June 2007						September 2007				
Sta	Latitude	Longitude	Temperature	Salinity	Density	Sta	Latitude	Longitude	Temperature	Salinity	Density
1	36.59	34.34	25.5767	39.2875	26.4057	1	36.59	34.34	28.3028	39.5769	25.7402
2	36.54	34.375	26.0185	39.4952	26.4234	2	36.54	34.375	28.4561	39.5571	25.6739
3	36.49	34.41	26.3974	39.4616	26.2771	3	36.49	34.41	28.4373	39.5614	25.6834
4	36.44	34.445	26.4578	39.4755	26.2682	4	36.44	34.445	28.3833	39.547	25.6907
5	36.39	34.48	26.5201	39.5019	26.2681	5	36.39	34.48	28.3225	39.5538	25.7161
6	35.965	34.984	27.5871	39.5413	25.9507	6	35.965	34.984	28.4656	39.5612	25.6738
7	36.107	34.89	26.8319	39.5145	26.1771	7	36.107	34.89	28.8565	39.5168	25.5086
8	36.25	34.796	27.0745	39.5364	26.115	8	36.25	34.796	28.6069	39.5281	25.6014
9	36.391	34.702	27.227	39.5302	26.0605	9	36.391	34.702	28.7608	39.5132	25.5383
10	36.53	34.608	26.7997	39.5352	26.2032	10	36.53	34.608	28.2193	39.5287	25.7318
11	36.68	34.514	26.184	39.4611	26.3448	11	36.68	34.514	27.8264	39.582	25.9025
12	35.74	34.67	26.9108	39.4819	26.1269	12	35.74	34.67	28.1395	39.5505	25.7748
13	35.882	34.576	26.6928	39.509	26.2179	13	35.882	34.576	28.299	39.5032	25.6859
14	36.02	34.482	26.2522	39.5142	26.3628	14	36.02	34.482	28.2862	39.5245	25.7062
15	36.166	34.388	26.1857	39.545	26.4078	15	36.166	34.388	28.2357	39.57	25.7575
16	36.308	34.294	26.1768	39.47	26.354	16	36.308	34.294	28.0544	39.5649	25.814
17	36.45	34.2	24.8721	39.3457	26.6692	17	36.45	34.2	28.0059	39.5756	25.8382
18	35.853	34.827	26.4641	39.5128	26.2943	18	35.853	34.827	28.3543	39.5009	25.6657
19	36.078	35.141	26.6968	39.5044	26.2131	19	36.078	35.141	28.2578	39.5668	25.7476
20	36.19	35.298	26.4881	39.5336	26.3024	20	36.19	35.298	28.2428	39.5768	25.7602
21	36.303	35.454	26.4278	39.5095	26.3036	21	36.303	35.454	28.0846	39.562	25.8018
22	36.415	35.611	25.6652	39.3425	26.4194	22	36.415	35.611	28.1123	39.5676	25.7967
23	36.53	35.768	26.4773	39.1888	26.0453	23	36.53	35.768	28.2054	39.569	25.7668
24	36.59	35.846	27.0455	39.1347	25.821	24	36.59	35.846	28.356	39.5538	25.705
25	36.64	35.925	27.0912	39.2143	25.8663	25	36.64	35.925	28.3806	39.5279	25.6771
26	36.7	36.003	26.9569	39.1097	25.8309	26	36.7	36.003	28.4369	39.5642	25.6857

Sta	Latitude	Longitude	Temperature	Salinity	Density	Sta	Latitude	Longitude	Temperature	Salinity	Density
27	36.75	36.082	27.1478	39.1821	25.8236	27	36.75	36.082	28.6605	39.5328	25.5869
28	36.25	33.89	25.8818	39.2236	26.2612	28	36.25	33.89	27.1367	39.5949	26.1389
29	36.188	33.905	25.7823	39.214	26.2854	29	36.188	33.905	27.0144	39.6178	26.1959
30	36.125	33.92	25.6673	39.4226	26.4795	30	36.125	33.92	26.9721	39.6248	26.215
31	36.062	33.935	25.9631	39.455	26.4105	32	36	33.95	26.6791	39.686	26.3562
32	36	33.95	25.7709	39.5037	26.5082	33	35.88	33.98	26.7684	39.7309	26.3612
33	35.88	33.98	26.5521	39.4816	26.2426	34	35.75	34.01	27.4559	39.6951	26.1101
34	35.75	34.01	26.3226	39.4812	26.3158	35	35.625	34.04	27.2911	39.6766	26.1501
35	35.625	34.04	26.1629	39.4795	26.3656	36	35.56	34.055	27.4199	39.6705	26.1033
36	35.56	34.055	26.7352	39.4788	26.1814	37	36.26	34.08	27.3161	39.6479	26.1203
37	36.26	34.08	25.3091	39.2966	26.4964	38	36.2	34.095	27.1694	39.6131	26.142
38	36.2	34.095	25.8197	39.4073	26.4199	39	36.14	34.11	26.6546	39.6734	26.3545
39	36.14	34.11	26.0726	39.4599	26.3795	40	36.08	34.125	26.7453	39.6972	26.3432
40	36.08	34.125	25.9013	39.4761	26.4461	41	36.13	33.62	27.3647	39.6173	26.0813
41	36.13	33.62	25.3261	39.3347	26.5199	42	36.067	33.63	27.2674	39.6266	26.1201
42	36.067	33.63	25.6585	39.2932	26.3843	43	36.005	33.64	27.4124	39.6519	26.0917
43	36.005	33.64	26.6038	39.4953	26.2363	44	35.942	33.65	26.9642	39.7237	26.2923
44	35.942	33.65	26.4176	39.4607	26.27	45	36.1	33.2	26.6739	39.4563	26.1843
45	36.1	33.2	25.2746	39.3514	26.5486	46	36.037	33.21	26.7482	39.5658	26.243
46	36.037	33.21	25.2701	39.3384	26.5402	47	35.975	33.22	26.842	39.5928	26.233
47	35.975	33.22	25.8182	39.4893	26.4823	48	35.912	33.23	26.9338	39.5821	26.1952
48	35.912	33.23	26.0147	39.4882	26.4193	49	35.79	33.245	26.782	39.5728	26.2373
49	35.79	33.245	25.8467	39.4769	26.4639	50	35.665	33.264	26.9456	39.6265	26.2249
50	35.665	33.264	25.8521	39.4468	26.4394	51	35.532	33.283	26.973	39.6402	26.2263
51	35.532	33.283	25.4272	39.4114	26.5464	52	35.41	33.301	27.1453	39.6098	26.1473
52	35.41	33.301	25.5866	39.4099	26.4953	53	36.4	35.374	28.0481	39.5724	25.8217
53	36.4	35.374	26.6796	39.4282	26.161	54	36.52	35.531	27.828	38.6196	25.1763
54	36.52	35.531	26.6301	39.0276	25.8743	55	36.63	35.688	28.1873	39.5027	25.7228
55	36.63	35.688	26.6469	39.2584	26.0433	56	36.69	35.766	28.2853	39.5178	25.7015

Sta	Latitude	Longitude	Temperature	Salinity	Density	Sta	Latitude	Longitude	Temperature	Salinity	Density
56	36.69	35.766	26.7265	39.2381	26.0023	57	36.74	35.845	28.3742	39.572	25.7126
57	36.74	35.845	27.0428	39.2083	25.8775	58	36.796	35.923	28.4993	39.5682	25.6677
58	36.796	35.923	26.7036	39.3011	26.0574	59	36.85	36.002	28.618	39.5753	25.6332
59	36.85	36.002	26.7464	39.2842	26.0308	60	36.203	35.534	28.0461	39.5678	25.8188
60	36.203	35.534	26.2167	39.514	26.3745	61	36.315	35.691	28.1726	39.5856	25.7902
61	36.315	35.691	26.1652	39.6882	26.5227	62	36.43	35.848	28.5373	39.5775	25.662
62	36.43	35.848	27.0226	39.2542	25.9187	63	36.49	35.926	28.9061	39.6091	25.5613
63	36.49	35.926	27.495	39.1812	25.7094	64	36.54	36.005	29.1555	39.5843	25.4578
64	36.54	36.005	27.2104	39.0156	25.6774	65	36.596	36.083	29.154	39.5892	25.462
65	36.596	36.083	27.8394	39.225	25.629	66	36.65	36.162	28.7775	39.5785	25.5818
66	36.65	36.162	27.3743	39.2596	25.8081	67	36.36	34.952	28.2145	39.5458	25.7462
67	36.36	34.952	27.1176	39.5314	26.0972	68	36.473	35.11	28.1654	39.5834	25.7909
68	36.473	35.11	27.2641	39.4186	25.9641	69	36.53	35.188	27.8998	39.5867	25.8817
69	36.53	35.188	27.7552	39.2583	25.682	70	36.503	34.858	28.4322	39.5618	25.6854
70	36.503	34.858	26.4634	39.4833	26.2723	71	36.559	34.936	27.9148	39.5665	25.8616
71	36.559	34.936	26.4973	39.4704	26.2517	72	36.62	35.014	28.0821	39.5902	25.8238
72	36.62	35.014	27.5036	39.3144	25.8071	73	36.65	34.764	28.1439	39.5618	25.7818
73	36.65	34.764	27.1841	39.3368	25.9285	74	36.7	34.842	27.8324	39.3966	25.7608
74	36.7	34.842	27.5119	38.817	25.4291	75	35.965	35.284	28.2206	39.5592	25.7543
75	35.965	35.284	26.8865	39.5161	26.1607	76	35.97	35.584	27.9681	39.5728	25.8486
76	35.97	35.584	26.5572	39.5201	26.27	77	35.965	35.884	28.1029	39.5456	25.7833
77	35.965	35.884	26.3934	39.4542	26.2727	78	36.05	35.93	28.088	39.5597	25.7989
78	36.05	35.93	27.8055	39.4888	25.8391						