

**INTERACTIONS BETWEEN RAZOR CLAMS (*Solen* spp)
AND ENVIRONMENTAL FACTORS
AT DON HOI LOT TIDAL FLAT,
SAMUT SONGKHRAM PROVINCE, THAILAND**

NARONG VEERAVAITAYA

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ABSTRACT

Don Hoi Lot Tidal Flat is located at the mouth of the Mae Klong River. There are several main factors that affect the depletion of the Razor clam population. This research was conducted from June 2008 to May 2009 to study the biological aspects, abundance, distribution and to illustrate interactions between biological characters and environmental factors in Razor clams.

The results show that the dominant species are *Solen corneus* Lamarck, 1818 (76.7%), followed by *S. strictus* Gould, 1861 (19.5%) and *S. regularis* Dunker, 1861 (3.8%). The high peak of spawning period of *S. corneus* is from July to December and February to March. The major species of phytoplankton found in their stomachs was diatoms (94.37%). Soil and water temperature ranged from 19.78-35.18 °C and 22.4 to 32.3 °C, respectively. Average total organic matter, average sand composition in soil, and average median grain size in upper and lower soil layers were 35.08, 35.73 mg/g dry weight, 75.8, 73.9 %, and 74.8, 74.1 µm, respectively. A total of 187 phytoplankton species and 14 mollusk species were found during the study period. The average density of Razor clams (*S. corneus*, *S. strictus* and *S. regularis*) was less than 1 individual/m². High populations occurred at stations with a high percentage of sand composition, and occurred in September and December. Interactions between densities of *S. corneus* and the combination of sand composition, organic matter and water content in the upper soil layer showed a high correlation. The major variables affecting the development of mature eggs were amount of water discharge from upstream, water temperature, and soil temperature. The total catch in Don Hoi Lot was 11.22 tons/year. A major threat to the environmental situation of Don Hoi Lot Tidal Flat was the increment of organic matter and eutrophication, which affected soil composition and impacted to the Razor clam habitat.

KEY WORDS: INTERACTION/ RAZOR CLAM/ ENVIRONMENTAL FACTORS
/ BIOLOGY/ TIDAL FLAT

355 pages

ความสัมพันธ์ระหว่างหอยหลอด สกุล *Solen* spp และปัจจัยทางด้านสิ่งแวดล้อมบริเวณคอนหอยหลอด จังหวัดสมุทรสงคราม ประเทศไทย

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บทคัดย่อ

คอนหอยหลอดตั้งอยู่บริเวณปากแม่น้ำแม่กลอง ประชากรของหอยหลอดมีจำนวนลดลงเนื่องจากหลายสาเหตุ การศึกษาวิจัยนี้ดำเนินการ ช่วงเดือนมิถุนายน พ.ศ.2551 ถึงเดือนพฤษภาคม 2552 โดยมีวัตถุประสงค์เพื่อศึกษาลักษณะทางชีววิทยา ปริมาณ การแพร่กระจายของหอยหลอดและศึกษาความสัมพันธ์ระหว่างลักษณะชีววิทยาของหอยหลอดกับปัจจัยด้านสิ่งแวดล้อม

ผลการศึกษาพบว่าหอยหลอดชนิดเด่นที่พบคือ *Solen corneus* Lamarck 1818 (76.7%) ตามด้วย *S. strictus* Gould 1861 (19.5%) และ *S. regularis* Dunker 1861 (3.8%) หอยหลอดชนิด *S. corneus* มีช่วงไข่สูงสุดในเดือนกรกฎาคมถึงธันวาคมและเดือนกุมภาพันธ์ถึงมีนาคม กลุ่มแพลงก์ตอนเด่นที่พบในกระเพาะของหอยหลอดคือ ไดอะตอม (94.37%) อุณหภูมิเฉลี่ยของดินและน้ำมีค่าระหว่าง 19.78-35.18 องศาเซลเซียส และ 22.4 ถึง 32.3 องศาเซลเซียส ตามลำดับ และปริมาณเฉลี่ยของสารอินทรีย์ทั้งหมด ปริมาณเฉลี่ยของทรายในดินและขนาดของดินตะกอนบริเวณดินชั้นบนและชั้นล่างมีค่า 35.08 35.73 มิลลิกรัมต่อกรัมน้ำหนักแห้ง 75.8 73.9 % และ 74.8 74.1 ไมโครเมตร ตามลำดับ การศึกษาพบแพลงก์ตอนพืช 187 ชนิด และหอย 14 ชนิด ปริมาณความหนาแน่นของหอยหลอดแต่ละชนิด มีค่าน้อยกว่า 1 ตัวต่อตารางเมตร หอยหลอดมีประชากรหนาแน่นในบริเวณสถานีเก็บตัวอย่างที่มีอัตราส่วนของทรายในดินสูงและพบประชากรหอยหลอดหนาแน่นในเดือนกันยายนและธันวาคม ผลการศึกษาระบุได้ว่าความหนาแน่นของ *S. corneus* มีความสัมพันธ์สูงกับปัจจัยร่วมระหว่างปริมาณของทรายในดิน ปริมาณสารอินทรีย์และปริมาณน้ำในดินบริเวณดินชั้นบน ส่วนปริมาณน้ำที่ไหลออกสู่บริเวณคอน อุณหภูมิน้ำและอุณหภูมิดินมีผลต่อการพัฒนาของไข่ของหอยหลอด ปริมาณการจับหอยทั้งหมดในคอนหอยหลอดมีปริมาณเท่ากับ 11.22 ต้นต่อปี สภาพแวดล้อมในคอนหอยหลอดมีความเสื่อมโทรมลงเนื่องจากการเพิ่มขึ้นของสารอินทรีย์และการเพิ่มขึ้นอย่างรวดเร็วของแพลงก์ตอนส่งผลต่อองค์ประกอบของดิน และมีผลต่อเนื้อที่ถิ่นที่อยู่อาศัยของหอยหลอด

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LIST OF ABBREVIATIONS

CCA	Canonical correspondence analysis
cm	Centimeter
CPUE	Catch per unit effort
E value	Exploitation rate
g	Gram
GR	Growth rate
GS	Grain size
m	Meter
mm	Millimeter
month	Month
RP	Redox potential
Tom	Total organic matter
TL	Total length
wc	Water content
Wt	Weight

CHAPTER I

INTRODUCTION

1.1 Background and justification

Coastal area consists of several types of habitats such as estuaries, mangrove, beaches, tidal flats, coral reefs, sea grass beds etc. These habitats are important in term of human uses. In the past man had settled near to the coastline and estuaries as a transport artery to inland areas. The coastal areas also provided a source of food and aesthetic value for human being. At present, anthropogenic effects due to population growth pressure are a major agent influencing the morphology of coastal area either directly by means of engineering works or indirectly by modifying the physical, biological and chemical characteristics in the coastal ecosystem. For example, a port expansion, marine development or barrage could alter its morphology. Pollutants released from inland industries and households reduced water quality. Tidal flat is one important habitat found in coastal area which can be divided into 3 main characteristics; sand flats, mud flats and rocky shore. It plays an important role in the natural environment as habitats for marine organisms and in the purification of pollutants. It also contains a number of fishery resources which significantly contribute to the economy of coastal communities. Erfteimeijer and Jukmongkol (1999) reported that tidal flats form a very important feeding habitat for migratory shorebirds and other water birds in all parts of the world. Major threats to tidal flats mostly come from human activities. Mangrove afforestation on mudflats is one of several activities that reduced the mudflat area. In Thailand, coastal area of the inner Gulf is mainly characterized by tidal flats (in some places extending more than 2 km from the shore) and Don Hoi Lot is a large area of tidal flats located in the inner Gulf of Thailand.

Don Hoi Lot tidal flat locates at the mouth of the Mae Klong River in Samut Songkhram Province, the Inner Gulf of Thailand. This area was declared as the Ramsar site No.1099 since July 5, 2001 due to its highly significant biodiversity and

importance as shorebird stopover site during the winter season. In term of existing biodiversity, there were at least 18 species of shorebirds recorded at the site including endangered and threatened species such as Grey Heron (*Ardea cinerea*) and Brahminy Kite (*Haliastur indus*). At least 42 species of invertebrates and 10 species of mollusks can be found in the area (Office of Environmental Policy and Planning, 1999). The area is a rare and unique type of natural wetland of Thailand, comprising sandbars at the mouth of the Mae Klong River with a vast area of intertidal mudflats, an extremely productive location for the Razor clams, an economically important mollusk unique to this region. Mangroves are present along the shoreline on the East side. The site is also important for tourism, local identity, traditional fisheries and fishing technologies, seafood and other fishery products. Moreover 81.33 % of local people believed that Don Hoi Lot was the symbol of Samut Songkhram Province (Oiamsomboon, 2000).

Nowadays there are several main causes that affect Razor clam's population at Don Hoi Lot. Internal sources of change especially over harvesting of Razor clams by using quick lime by local fishermen have led to significant reduction in their population. External sources of change are such as waste water from nearby factories, restaurants, shrimp farms, rubbish from inland and enhancement of sedimentation rate by illegal use of fine net around Don Hoi Lot, resulting in premature destruction of aquatic animals before becoming viable fishery resources. The practices also increased suspended sediments, reduced transparency and decreased effectiveness of algae's photosynthesis as well as affected filter feeding mollusks. Several researches reported that density of Razor clams in Don Hoi Lot from 1990-2004 rapidly declined. In 1990-1991, the density of Razor clams was 26.88 individuals/m² (Khumsupha *et al.*, 1991), then reduced to only 4.10 individuals/m² in 1996-1997 (Ruffolo *et al.*, 1999) and 3.72 individuals/m² in 2003-2004 (Papawasit *et al.*, 2004). Change of environment in the area would directly impact the survival and existence of Razor clams. So the study on interaction between Razor clams and environmental factors in the area is needed before Razor clams become extinct in the near future.

1.2 Statement of problems

Even though in the past there were studies on Razor clams such as their biology, distribution and abundance including their habitats and relevant environment conducted by many researchers and involved several agencies especially Department of Fisheries but the problems still occurred. Wastewater discharged from inland caused degradation of their habitats. Excessive harvest of Razor clam using of quick lime caused declining abundance of Razor clams. Lack of knowledge of relationship between their biology and habitats, interactions between environmental factors and biology, existence and distribution of Razor clams at this tidal flat is a big problem. Another problem is lack of knowledge about the sustainable yield of Razor clams. Therefore, no proper management has been applied in the area.

This study aims to find out what are the key factors that affect the existence of Razor clams in Don Hoi Lot and to describe the interactions between their biology and environmental factors. Further more the outcomes and derived ecological map of Razor clams in Don Hoi Lot can be used as tools to explore and understand their growth, density, population and distribution. The results of this study can be also applied and used to determine potential measures to conserve and utilize Razor clams in sustainable manner in order to support local livelihood in Don Hoi Lot as well as other tidal flats in other places.

1.3 Conceptual framework

The research consists of four main steps which are as follows:

1. Assessment of current status of Razor clams at Don Hoi Lot in terms of species diversity, abundance, distribution patterns, population and some biological aspects. The first step is also composed of 3 main parts which are biology, distribution and abundance of Razor clams.
2. Assessment of environmental characteristics of Don Hoi Lot such as physical factors and soil properties; chemical factors and water quality; and biological factors.

3. Assessment of existing production, total catch and yield of Razor clams and the contribution to socioeconomic conditions.
4. Establishment of ecological map and interactions between density and development of egg stages of Razor clams and environment factors.

The diagram of conceptual framework is shown in Figure 1.1.

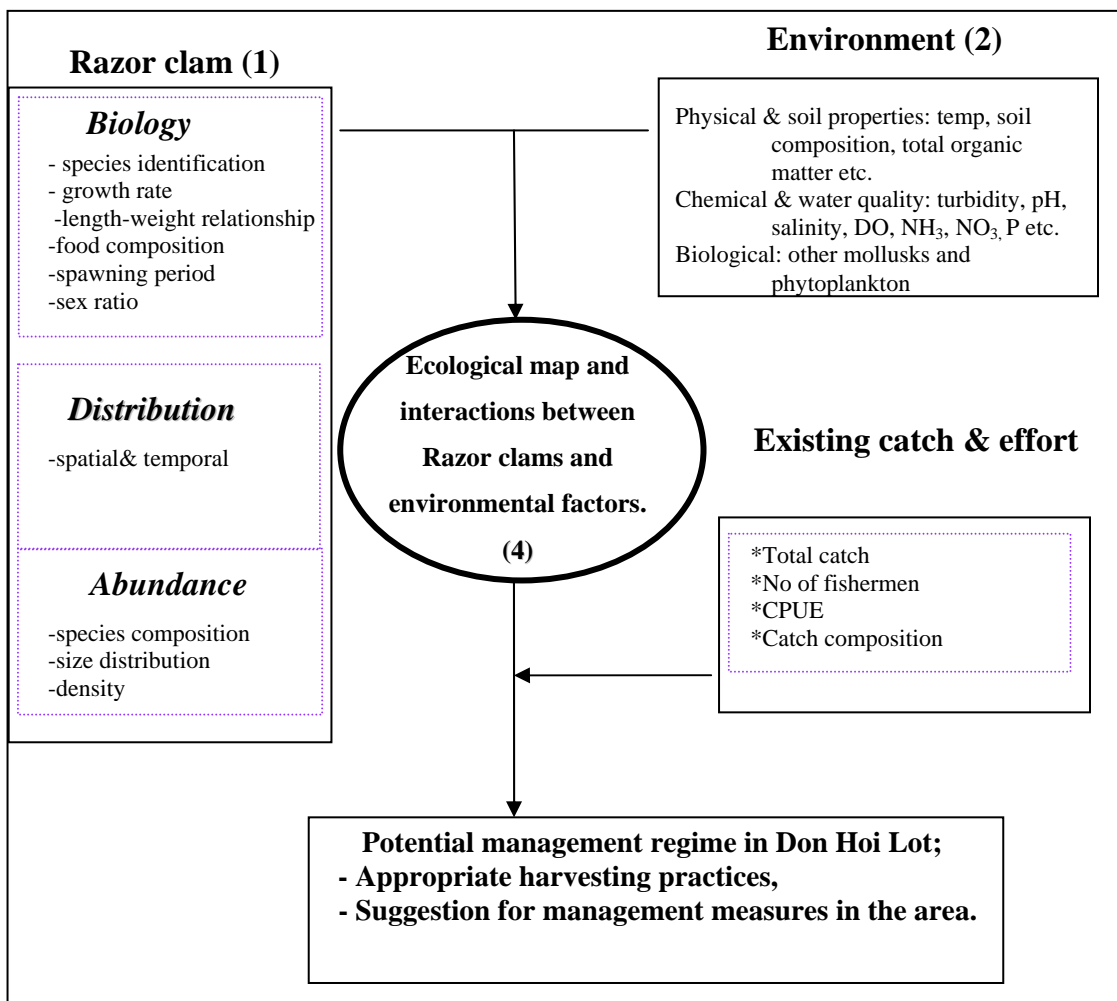


Figure 1.1: Conceptual framework of the study

1.4 Research objectives

- To study population and reproductive biology of Razor clams.
- To assess the existence, abundance, distribution of Razor clams.

- To develop ecological map to illustrate interactions between Razor clams and environmental factors at Don Hoi Lot.

1.5 Research questions

1. What are the growth patterns of different Razor clam species of Don Hoi lot?
2. What are the main environmental characteristics that affect biology, distribution and abundance of Razor clams at Don Hoi Lot?
3. What is the existing environmental situation at Don Hoi Lot.?

1.6 Hypothesis

1. Spatial and temporal distributions of Razor clams are not homogeneous at Don Hoi Lot.
2. Biology and behavior of Razor clams found at Don Hoi Lot are different.

1.7 Originality

Ecological map and interactions between Razor clams and environmental factors can be used as tools for sustainable management of Don Hoi Lot as well as other tidal flats.

1.8 Expected outputs

The results of this study can provide better understanding and inputs for developing management measures for Don Hoi Lot such as appropriate harvesting practices, conservation and sustainable use of Razor clams in order to support local livelihood. Methodology and results of this study can be applied to other tidal flats in other places.

CHAPTER II

LITERATURE REVIEW

2.1 Overview of Razor clams: species, distribution, population, ecology and life history

Razor clams were identified in Phylum Mollusca, Class Bivalvia, Order Eulamellibranchia and Family Solenidae. There are several genera such as *Solen* (Linn.), *Ensis* (Schum.), *Solecurtus* (Blainv.) etc. In general, the genus *Solen* has a shell long, thin, narrow, straight, with parallel margins; short foot, blunt; hinge teeth, one in each valve; mantle closed, except in front; siphonal sheath (Figure 2.1). Razor clams have eyes like the scallops, ocelli or pigment spots, fringing the mantle edge around the siphons. By pigment spots, they distinguish light from darkness. A shadow cast across the sand will cause the quick disappearance of protruding siphon (Rogers, 1939). Razor calms are a long white or light yellowish-green cylinder bivalve, with siphon tube and foot muscle at the both tips of shell (Tuaycharoen and Voraingtara, 1991).



Figure 2.1 Photo of Razor clam (*Solen* spp)

Razor clams in genus *Solen* are world-wide bivalves, except in cold seas. There are thirty-seven living species and forty fossil recorded. Sheath Razor clam (*S. vagina*, Linn.) is the largest size of them all which its length is about 6 to 10 inches and found in Europe whereas Blunt Razor clam (*S. sicarius*, Gld.) is the common Razor of the Pacific coast and Rosy Razor clam (*S. rosaceus*, Cpr.) found in southern California (Rogers, 1939). In Asia, most of genus *Solen* are found in the lower part of the intertidal zone and distributed in Indonesia, Philippines, China and Japan (Tuaycharoen and Matsukuma, 2001). In Thailand, Razor clams can be found generally in estuary area and some provinces along the coast line in the Upper Gulf of Thailand such as in Chao-Phraya estuary in Samut Prakran Province in Tambon New Bang Pu, Amphoe Muang and Tambon Leam Fapa, Amphoe Pra-Sumut-Jadee (Tuaycharoen *et al.*, 2002) and in Phuket and Song Kla Provinces (Department of Fisheries, 1995).

Tuaycharoen (1999) reported that there were three species of Razor clams found in Samut Songkhram Province, i.e. *S. strictus* Gould, 1861, *S. corneus* Lamarck, 1818 and *Solen* sp. whereas only *S. corneus* found in Samut Prakarn Province and only *Solen* sp. in Phetchaburi Province. Base on shell and the soft part morphology, Tuaycharoen and Matsukuma (2001) reported that there were three species of Razor clams (*S. brevis* Gray, 1832; *S. grandis* Dunker, 1861, and *S. exiguous* Dunker, 1862) found along the coast of the Andaman Sea such as in Trang and Satun Provinces whereas six species were recorded in the Gulf of Thailand such as in Chantaburi, Samut Prakarn, Samut Songkhram and Phetchaburi Provinces: *S. corneus*, *S. regularis* Dunker, 1861, *S. strictus*, *S. malaccensis* Dunker, 1862, *Solen* sp.(1) and *Solen* sp.(2). Later on, Tuaycharoen and Kongrabeab (2005) surveyed species diversity of Razor clams in Samut Songkhram Province and found that there were 4 species at Don Hoi Lot ; *S. strictus*, *S. thailandicus* Cosel, 2002 (the former name is *Solen* sp.(1)), *S. corneus* and *S. regularis* (Table 2.1).

Table 2.1: Characters of Razor clam species found in Don Hoi Lot

Characters	<i>S. corneus</i>	<i>S. regularis</i>	<i>S. strictus</i>	<i>S. thailandicus</i>
Type locality	Java	Malacca	Hakodadi (Hakodate) , Hokkaido, Japan	Upper part of Gulf of Thailand
Length of shell (mm)	48.3-73.5	48.3-64.4	59.9-73.3	36.1-50.8
Width of shell (mm)	8.7-12.5	8.7-12.1	10.8-12.4	7.7-9.1
Convexity (mm)	7.1-10.6	6.0-9.2	8.1-10.6	5.3-6.5
Length-width ratio (time)	3.6-5.5	4.6-5.5	5.4-5.9	4.4-5.8
Shell	Straight, very narrowly elongate and anterior end very oblique	Elongate rhombiform, thin, fragile and anterior end obliquely truncated	Cylindrical and straight	Small elongate, Cylindrical straight, narrow, fragile and transparent
Periostracum	Yellowish brown and glossy	Yellowish-green	Greenish and glossy	Greenish-yellow or creamed-colored
Cardinal tooth	A small single tooth each valve	NA	A small single tooth each valve	A small single tooth each valve
Foot	Rounded , long and color creamy	Triangular at the tip and color creamy	NA	Rounded triangular
Habitat	Fine sand flats and muddy sand	Offshore sand and mud	Sand and muddy sand	Sandy mud and muddy sand
Anterior end of shell	Obliquely truncated	sharp, slightly obliquely truncated	Obliquely truncated	Obliquely truncated

Table 2.1: Characters of Razor clam species found in Don Hoi Lot (cont.).

Characters	<i>S. corneus</i>	<i>S. regularis</i>	<i>S. strictus</i>	<i>S. thailandicus</i>
Posterior end of shell	Slightly rounded corner and margin	truncated	Slightly curved	Vertically truncated
Siphon	Clearly separated in exhalant and inhalant parts at the tip	Clearly separated in exhalant and inhalant parts at the tip	Exhalant and inhalant parts of siphon connected at the tip	Clearly separated in exhalant and inhalant parts at the tip and no segment siphon
Ligament	Dark brown	NA	Dark brown and short	NA
Tentacle	Two long dark color tentacles	No tentacle	Two small and unpigmented tentacles	Two short tentacles
Anterior adductor muscle scar	Elongate-oval and shorter than external ligament	Elongate-oval	Elongate-oval and narrow	Elongate-oval , as large as and parallel to external ligament
Posterior adductor muscle scar	Triangular-oval	Triangular-oval	Elongate-oval and with two lobes	Elongate-oval
Internal surface color	white	white	white	white

Source: Modified from Tuaycharoen and Kongrabeab, 2005; Tuaycharoen and Matsukuma, 2001. NA= Not available

2.2 Biology of Razor clams: life cycle, reproductive system, growth, density, food and feeding habit

2.2.1 Life cycle and reproductive system

Sriprathumwong *et al.* (2002) reported that life cycle of Razor clam could be observed by conducting experiment on breeding of Razor clam (*S. regularis*) at Samut Sakhon Coastal Aquaculture Station. Three kilograms of Razor clams were collected from Don Hoi Lot. They were transported to the station for induced breeding by using temperature cycling method. Spawning occurred after induction 80 minutes. Fertilized eggs had diameter of 56-80 micron and developed to trochophore stage within 4 hours, D-shape stage within 5 hours and setting stage within 8 days. The metamorphosis stage took about 18-22 days to juvenile stage. 860,000 fertilized eggs were collected and hatched in 1 ton fiberglass tank. They were fed with *Isochrysis galbana* at $1-2 \times 10^4$ cells/ml in the first day and *Tetraselmis* sp. was added on the 8th day when they reached setting stage. Water was changed every other day. The fertilized eggs developed to setting stage, size 184 x 224 micron about 60,000 eggs. The survival rate was 7.05% juvenile stage; size 520 x 1,040 micron survived about 6,000 individuals (0.70%). All young Razor clams died within 54 days at the size of 1,040 x 2,000 micron.

Referring to life cycle of Pacific Razor clam (*Siliqua patula* Dixon, 1789) locating in temperate zone in British Columbia, generalized male and female clams spawn in late May and June at Long Beach and in July and early August in Queen Charlotte Islands and mass fertilization occurs in water column. Fertilized eggs develop into ciliated, motile larvae within 12 hours of fertilization. Larval phase includes several stages (*i.e.* trochophore, veliger and umbone) and lasts for about 3-4 weeks, during which time the larvae drift in the plankton and are dispersed by water currents. The larval phase ends when larvae settle from the plankton and attach themselves to sand or broken shell by abyssal threads, referred to as spatting. At about 5 mm the spat or juvenile clam burrows into sand, but no permanent burrow can be constructed due to instability of sand. Recruitment of juvenile clams has occurred at low levels in Queen Charlotte beaches since 1971. Adult clams may live to over 10 years and reach a maximum shell length of 18 cm (Williams, 1989).

Tuaycharoen and Voraingtara (1991) studied the reproductive biology of Razor clams (*S. strictus* Gould) and environmental condition of clam bed. Specimens were collected from coastal area of Ban Bangboo, Samut Songkhram Province. The length of 618 specimens varied from 40.1 to 79.2 mm. The maturation period was observed during November to April and July to September. The spawning period was found during December to April and June to October. The highest percentages of spawning clams were approximately 80.56, 38.47 and 88.24% of the total specimens collected in March, September and December, respectively. Of the clams studied, the mature gonad was found in the clam length at least 42.4 mm. The fatness of Razor clams was found in April, July, August and November. The Razor clams had the sexual ratio 1:1 and the environmental conditions in the natural bed were as follows: salinity ranged 22-31 part per thousand, oxygen ranged 1.3-8.6 mg/l and temperature averaged 22.39°C. The bottom of the natural bed was clay loam in texture with sediment composition of 35% sand, 37% silt and 29% clay.

Khumsupha *et al.* (1991) reported that a study on the biological and ecological aspects of Razor clam brood stocks (*S. strictus* Gould) along the Mae Klong Estuary, Samut Songkhram Province from August to September 1990 was carried out. The survey area was about 70% the total area which was estimated to be 24.09 km². This area was divided into 58 stations (approximately 0.25 km² each). In each station, the Razor clam was sampled from randomized area of 1 m². Razor clam was found in 34 stations or 58.6% of the total stations with average mature size of 1.83 cm in the survey area. Water salinity averaged 10.28 ppt, dissolved oxygen ranged 3.0-4.5 mg/l, pH ranged 7.7-8.1, orthophosphate ranged 0.0260-0.6876 mg-P/l and temperature ranged 27-31°C. The bottom condition was sandy soil in texture.

Razor clams have 1 pair of sex organs (Sriburi and Gajaseni, 1996) which consist of soft meat attaching with inner layer of foot part and expanding to stomach (Pradatsundarasar *et al.*, 1989) and distance from the tip of siphon around 2 to 3 of shell length (Pradatsundarasar, 1982). Tube of sex organ open at their kidney or mantle and light yellow gonad found in female whereas white sperm found in male (Tuaycharoen and Voraingtara, 1991). The Razor clam (*S. regularis*) has so called external fertilization. This means that both sexes release their eggs and sperms into the water. The fertilized eggs hatch to larvae that swim freely in the water. After a week

the larvae transform and become setting and develop to become juvenile within one month (Sriprathumwong *et al.*, 2002).

In term of reproductive organ of Razor clam, Tuaycharoen and Voraingtara (1991) reported that their gonad development could be divided into 6 stages as follows: prefollicular development stage, initial development stage, developing stage, mature stage, partially spawned stage and spent stage.

Razor clams can spawn all year round. There are two peaks for spawning starting from November to April and June to October. The size of mature Razor clams starts from 42.4 mm in shell length (Tuaycharoen and Voraingtara, 1991).

Salinity has an effect on their distribution, growth and development of sex organ. Tuaycharoen and Voraingtara found that 22 to 31 ppt were optimal salinity for stimulating development of their gonad to stage 4 (mature stage). Water temperature (22-39°C) and soil temperature (21-38°C) stimulate development of sex organ and improvement of efficiency of laying eggs (Tuaycharoen and Voraingtara, 1991).

2.2.2 Growth and density

There are several studies on density of Razor clam found in Don Hoi Lot. In 1981, there were 10.00 ± 1.23 individuals/m² (Pradatsundarasar, 1982) whereas in 1982, their density ranged from 0-72 individuals/m² (Jongpepian *et al.*, 1985). In 1986 and 1988, their densities were 26.80 ± 11.59 individuals/m² and 65.51 ± 57.60 individuals/m², respectively (Pradatsundarasar *et al.*, 1989). In 1991, 1994-1995 and 1996-1997, their density were 0-175 individuals/m² (Khumsupha *et al.*, 1991), 49.86 ± 37.38 individuals/m² (Sriburi and Gajaseni, 1996) and 4.6 ± 3.7 individuals/m² (Boutong, 1997) respectively. From above information, it was found that density of Razor clam declined rapidly in 1996-1997 comparing with 1994-1995.

Tuaycharoen and Charoenpornthip (1997) reported that in 1995, density of Razor clam (*Solen* sp.) along the coast line from Ban Bang Kunsai to Laem Panoen, Phetchaburi Province was between 4-67 individuals/m² with the size distributed between 25.63-41.04 mm. in length. Tuaycharoen and Charoenporntip (1995) reported that the biomass of Razor clams in Don Hoi Lot between 1992-1994 was 5,693.87 tons, 5,224.87 tons and 6,503.37 tons, respectively.

Tuaycharoen and Charoenporntip (1995) also reported that growth rate of Razor clams surveyed in Samut Songkhram in 1992-1994 varied according to their age. Growth rate of Razor clams aging from 1 to 6 months was 6.54 – 12.20 mm/month; 7-12 months was 3.09-5.77 mm/month and 13-37 months was 0.04-2.73 mm/month. Average growth rate of Razor clams was 1.2 mm/month. In case of increment of their weight aging from 6-9 months was 1.02-1.15 g/month and 10-37 months was 0.07 g/month.

Various factors could affect the variation of density and biomass of Razor clams.

2.2.3 Food and feeding habit

Razor clams are infauna and live buried vertically in the sand ranging from 1 – 12 inches deep. They can move up and down with remarkable speed and can swim to escape dangerous situation. During high tide, they live near soil surface (1 inch deep) in order to filter their food such as plankton and detritus suspending in water by using an inhalant and exhalant siphon (Swennen, 2001). When the clam has buried in the sand, only the upper parts of its siphons are visible.

2.3 Ecological role of Razor clams and analysis of their interaction and environmental factors.

2.3.1 Ecological role of Razor clams and environmental factors

2.3.1.1 Physical factors and soil characters

Tumnoi (1996) studied grain size composition and organic matter in sediments from two habitats of Razor clams, Don Hoi Lot, Samut Songkhram Province and Don Bangpoo, Samut Prakarn Province. Sediment samples were collected during 2 periods in 1996, May to June and September to October. Temperature, salinity and pH of interstitial water were measured and sediment was analyzed for organic matter by titration. The result showed that organic matter in the same delta was similar and the percentage of organic content was higher during the

second period. In both areas, the range of organic matter was 0.24-0.57% during the first period and 0.34-0.74% during the second period. Sediment was sieved for analyzing the grain size. The fractions of silt and clay from the sediment were low in the range of 0.00-4.30% and 0.00-6.49%. In the second period, the fraction of silt and clay was higher. Analysis of variance showed that the content of mud in two areas was different but the fractions of very fine sand in both areas were not different. Meanwhile, Tuaycharoen and Charoenpornthip (1997) studied the soil composition and density of Razor clams in Ban Bang Kunsai to Laem Panoen, Phetchaburi Province and found that the density was 4-67 individuals/m² and the area consisted of average percentage of sand, silt, clay and organic matter 59.30±3.455, 36.07±2.604, 4.93±2.254 and 1.35±0.669, respectively. In 1996-1998, Tuaycharoen studied the habitat of Razor clams at the mouth of the Chao Phraya River, Samut Prakarn Province and reported that the soil composition of average percentage of sand, silt, clay and organic matter, in Phra Samut Jadee, Maung and Bang Bo Districts, Samut Prakarn Province were 60.12±8.265, 26.97±4.196, 12.80±2.447, 1.31 ±0.522 and 69.27±3.282, 19.93±2.614, 13.27±5.172, 1.55±1.817 and 73.03±14.807, 21.68±10.256, 5.29±4.612, 0.68±0.238, respectively (Tuaycharoen *et al.*, 2002).

Pradatsundarasar (1982) reported that the distribution of *S. regularis* was limited within the sandbar of the estuary where the average sediment grain size was 0.125 mm. It contained large amount of sand but rather low proportion of water content and organic matter. *S. regularis* was never found in the area where the sediment contained high amount of mud. Pradatsundarasar also concluded that distribution of Razor clam did not depend on amount of organic matter because they were filter feeder. This finding was also supported by Purchon (1968) stating that bivalves were filter feeders and sediment in the substrate had no effect on their feeding whereas other factors such as water currents, dissolved gases and coherent force in sediment had more impacts. Samut Sakhon Coastal Aquaculture Development Center also reported that Razor clam could be found at high density when the percentage of sand was more than 80% in the soil composition and lower density could be found in muddy soil (Department of Fisheries, 1995).

According to above information, it has not clear about interaction between physical factors and soil characters (soil composition and organic matter) and Razor clams, so this research tried to find out their relationship.

2.3.1.2 Chemical factors and water quality

Mongkulmann (2001) reported that the chemical factors that had effects on density and size of Razor clams were amount of dissolved oxygen, nitrite, ammonia, water temperature and pH. Phuwapanich *et al.* (2003) studied the correlation between environmental factors and Razor clam abundance during January 1999 to December 2000 and found the moderately positive correlation between abundance and pH whereas pH showed moderately negative correlation with weight ($p < 0.01$). pH also affected the growth of Razor clams. Samut Sakhon Coastal Aquaculture Development Center reported that optimal pH ranged 6.9-8.5 whenever pH was below 6.5, the feeding rate of Razor clams would decline and lead to their slow growth. If water pH reached 9.1, the clams would die (Department of Fisheries, 1995).

Nitrate and phosphate showed moderately positive correlation with abundance ($p < 0.01$). Phuwapanich *et al.* (2003) also found that water temperature affected the growth of Razor clams. When the temperature increased, their width and weight also increased whereas their length decreased.

In term of relationship between Razor clams and heavy metal, Tuaycharoen *et al.* (2000) studied the heavy metal residues in Razor clams, seawater and sediment in coastal area of Samut Songkhram Province from February to December 1991. The results showed that the concentrations of arsenic, zinc and lead were found in Razor clams, ranged from 0.001-0.002 mg/kg, 14.4-24.5 mg/kg, and 0.01-0.02 mg/kg, respectively. Zinc and lead were found in sediment at concentration ranged from 0.30-0.85 and 0.010-0.045 mg/kg respectively. Arsenic, lead and zinc were found in sea water at 0.001-0.003 ug/l, less than 0.05 ug/l to about 50 ug/l and from ND to 0.02 ug/l, respectively. However, the concentration found in Razor clams, were within the ranges of considered safe for human consumption.

Kanthom and Sukawong (1991) reported that traditional method for catching Razor clams in Don Hoi Lot by using small stick with lime allowed local harvesters to select the size of Razor clams they need whereas bestrewing method by

splashing lime solution would kill all Razor clams. The study also showed the effect of concentration of quick lime on Razor clams mortality rate. Lethal concentration (LC50) value for 48 hours of small size clam having shell length of 1.5-2.9 cm was 321.50 mg/l, whereas LC 50 value for 48 hrs of medium size (3.1-4.4 cm) and large size (4.2-7.0 cm.) was 376.21 mg/l and 338.32 mg/l, respectively. Safety concentrations of small, medium and large size were 32.15 mg/l, 37.62 mg/l and 33.83 mg/l, respectively.

According to above information, it has not been clear about interaction between chemical factors, water quality, and Razor clam habitats.

2.3.1.3 Biological factors

Boutong (1997) reported that population density of Razor clams (*S. regularis* and *S. vitreas*) and their breeding season were related to abundance of phytoplankton. He reported that the density of Razor clams had a positive relation with the number of planktons in several genera such as *Eutetramorus* and *Teilingia* in phylum Chlorophyta. Ruffolo *et al.* (1999) reported that the growth rate of Razor clam was 1 cm/month. Razor clams are plankton feeders so plankton in phyla Bacillariophyta, Chlorophyta and Chrysophyta are quite important food for them. Plankton in genera *Coscinodiscus*, *Planktoniella*, *Nitzchia* and *Heterothrix* could be found in their stomach (Boutong, 1997).

According to above information, phytoplankton was one of several biological factors affecting the availability of Razor clams in the nature.

2.3.2 Ecological analysis of Razor clams and environmental factors.

Ecology is the scientific study of the distribution, abundance, share effects, and relations of organisms and their interactions with each other in a common environment. The word ecology is also used in the medical field which has a different meaning. The definition here applies to the study of Nature. Ecology is the study of the interactions between life and its physical environment; the relationship between animals and plants and how one species affect another. A component in ecological study usually focuses on the ecosystem of an area. An ecosystem is the unique network of animal and plant species that depend on the others to sustain life. The interactions between and among organisms at every stage of life and death can impact

the system. An ecosystem can be a small area or big as the ocean. In fact, one can say the whole world is one big ecosystem. So an ecologist could be studying and researching everything from the tiniest forms of life like bacteria to every chain of organisms it affects and how those organisms can impact the tropical rain forests, the deserts, the oceans, the atmosphere, etc (Begon *et al.*, 2006; Allee *et al.*, 1949; and Smith and Smith, 2000).

An Ecological map or Eco-map is a graphical representation that shows all of the systems at play in an individual's life. These ecological maps or ecomaps were developed by Hartman in 1975 as a means of depicting the ecological system that encompasses a family or individual (Hartman, 1995). There are several tools and models to interpret results of ecological study such as mathematical models and software in microcomputer program packages.

2.3.2.1 Mathematical models in ecological studies

Mathematical model is a representation of a process, device, or concept by means of a number of variables which are defined to represent the inputs, outputs, and internal states of the device or process, and a set of equations and inequalities describing the interaction of these variations (McGraw-Hill Companies, Inc, 2003). The mathematical model serves the following purposes: (1) to find an optimal solution to a planning or decision problem; (2) to answer a variety of what-if questions; (3) to establish understandings of the relationships among the input data items within a model; and (4) to attempt to extrapolate past data to drive meaning (Barron's Educational Series, Inc, 2005). In this study, mathematic models were used to find out growth rate of Razor clams by applying the von Bertalanffy growth model (Sparre and Venema, 1998) and the length-weight relationship was also analyzed using the regression technique (Ricker, 1975); Rounsefell and Everhart, 1953). The meaning of regression analysis is a statistical methodology that utilizes the relation between two or more quantitative variables so that a response or outcome variable can be predicted from the other, or others. This methodology is widely used in business, the social and behavioral science, the biological sciences, and much other discipline (Kutner *et al.*, 2004).

2.3.2.2 Microcomputer program packages in ecological studies

There are several microcomputer packages which can be used in ecological studies such as FiSAT or FAO-ICLARM Stock Assessment Tools developed by FAO and ICLARM. This program consists of several options including COMPLETE ELEFAN which is quite important to use for analyzing fish stock assessment including growth parameter and mortality rate based on length-frequency data. The basic purpose of fish stock assessment is to provide advice on the optimum exploitation of aquatic living resources such as fish and shrimp. Living resources are limited but renewable and fish stock assessment may be described as the search for the exploitation level which in the long run gives the maximum yield in weight from the fishery (Sparre and Venema, 1998). There is an important computer software package relevant to ecological studies naming PRIMER (Plymouth Routines In Multivariate Ecological Research) developed at the Plymouth Marine Laboratory, United Kingdom, for the study of community structure and intended for use by ecologists with no more than a minimal background in statistics. PRIMER program consists of several methods to analyze ecological data such as analyzing multivariate by using multidimensional scaling (MDS), principal component analysis (PCA) and hierarchical clustering (CLUSTER) (Clarke and Warwick, 1994). McCune and Grace (2002) described that hierarchical methods were used to find groups that were composed of subgroups. In other words, groups nested within groups and were represented in a dendrogram. Clarke and Warwick (1994) explained that the purpose of MDS could be construction of a map or configuration of samples in a specified number of dimensions which attempted to satisfy all conditions imposed by the rank (dis)similarity matrix. PCA is the longest established method which is more useful for analyzing multivariate of environmental data rather than species abundance or biomass. The BIOENV program in PRIMER also optimizes the match overall combinations of abiotic variables by computing correlation to biotic similarity matrices (Clarke and Warwick, 1994). Ter Braak and Verdonschot (1995) explained that Canonical correspondence analysis (CCA) was a multivariate method to elucidate the relationships between biological assemblages of species and their environment. The method is designed to extract synthetic environmental gradients from ecological data-sets. The gradients are the basis for succinctly describing and visualizing the differential habitat preferences (niches) of taxa *via* an ordination diagram.

2.4 Economic role and total catch of Razor clams at Don Hoi Lot

According to the statistics of Department of Fisheries, the total catch of Razor clams from 1983 to 1989 was 1,275, 299, 395, 299, 414, 267 and 795 tons/year, respectively (Department of Fisheries, 1989) whereas the total catch of Razor clams from 1998 to 2004 was 74, 318, 298, 54, 21, 206, 95 tons/year respectively (Department of Fisheries, 2000; 2001; 2002; 2003; 2004; 2005; and 2006). From above mentioned figures, it shows that trend of total catch of Razor clams decreased continuously from 1983 to 2006 due to high demand consumption and degradation of environment. Therefore, this research would be conducted in order to solve this problem.

Economic role of Razor clams at Don Hoi Lot is related to ecotourism using this flagship species as a symbol of the area every year. According to Jarinrattanakorn (2001), the production values of Razor clams harvested by local fishermen were more than million Baht/year since 1983. Furthermore Razor clams can be used as raw material for food processing by local fishermen to increase its value.

2.5 Characteristics and major threats to Don Hoi Lot Tidal Flat

Tidal flats are areas of generally bare or algal covered sediment between the high and low-water marks. Tidal flats consist of two main habitat types which are intertidal sand flats or sandy beaches and intertidal mudflats. The characteristics of intertidal sand flats depend on the geomorphology of the adjacent land and waves, currents and tides and also the nature, size, type and quality of available beach material. Sand particles size varied from 0.05-2.00 mm in diameter are dominant constituent of intertidal sand flats. Intertidal mudflats are formed by the deposition of finely inorganic material and organic debris in particulate form. Normally mudflats are formed in the sheltered parts of embayment, inlets, and estuaries or behind the protection of shingle spits or dune systems where the turbulence of the sea is abated (McIntyre, 1977). Tidal flats support the higher density of invertebrates such as polychaetes and other worms, crabs, shell-fish, shrimps, amphipods, hermit crabs, mud-dwelling and juvenile fishes, gastropod snails and bivalve shells. Tidal flats are

very important feeding habitats for many shorebird populations during winter and migration. Many bird species feed on intertidal benthic invertebrates during low tides. For instance, in Europe there are at least 38 estuaries with tidal flats which hold more than 20,000 waders each winter and 2.6 million birds in total. In 1999, there were about 100,000-135,000 shorebirds found in the Inner Gulf of Thailand and at least 50 % used the tidal flats as feeding habitat (Erfteijer and Jukmongkol, 1999). Intertidal flats also serve a valuable coastal defense role by dissipating wave energy. The principle natural threat is erosion. Human induced losses are associated with land conversion to industrial and port developments and, in long term, tidal barrages and pollution. Generally estuaries have lost almost all their intertidal habitats due to urban development over the last hundred years (Gilbert and Anderson, 1998). In Thailand, the total area of intertidal flats found in the Inner Gulf of Thailand was estimated about 235 km² between 1989 and 1993. They are especially wide and extensive around the mouths of the Mae Klong River; these tidal flats are locally known as Don Hoi Lot. Most of the tidal flats in the Inner Gulf are composed of soft mud, but in some areas such as Don Hoi Lot, they are much more sandy (Erfteijer and Jukmongkol, 1999).

Don Hoi Lot is identified mainly as tidal flat consisting of muddy sand. Its geographical coordinates are 13° 18' 22" N and 100° 00' 04" E in the Muang District, Samut Songkhram Province. It is a unique coastal area created by river sedimentation at the estuary of the Mae Klong River. The tidal flat extends approximately 8 km into the sea and is 4 km wide during the low tide. The area is consisted of fine silt and rich in nutrient. Three canals separate the tidal flat into 5 sections. The tides occur in the area twice a day, with water rising north during high tide and receding south during low tide. A report by Oiamsomboon (2000) indicates that Don Hoi Lot covers an area of 24.09 km². This site can be divided 5 sections of elevated sediment deposits or islets, covering approximately 0.69, 1.51, 4.64, 8.45 and 8.80 km², respectively. Don Klang is the largest islet occupying 8.80 km² and locating in the middle of Don Hoi Lot (Figure 2.2). The area is already designated as a Ramsar Site (under Ramsar convention) covering total area of 875 km² which is larger than the area of Don Hoi Lot Tidal Flat itself due to inclusion of inland areas. Don Hoi Lot has become the Ramsar site no 1099th since July 5, 2001 (Office of Environmental Policy and

Planning, 2002). The Convention on Wetlands of International Importance, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. At the centre of the Ramsar philosophy is the “wise use” concept. The wise use of wetlands is defined as "the maintenance of their ecological characters, achieved through the implementation of ecosystem approaches, within the context of sustainable development". "Wise use" therefore has at its heart the conservation and sustainable use of wetlands and their resources, for the benefit of humankind. Upon joining the Ramsar convention, each contracting party is obliged by article 2.4 of the treaty to designate at least one wetland site as a Ramsar site for inclusion in the list of Wetlands of International Importance (<http://www.ramsar.org>; accessed 30 May 2010).

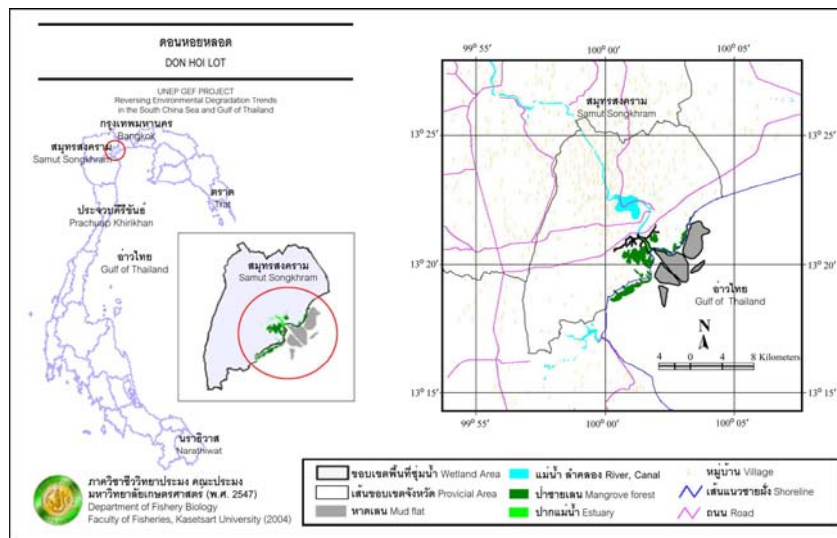


Figure 2.2: Location of Don Hoi Lot ; Source: UNEP. 2004

According to the Ramsar Information Sheet of Don Hoi Lot, the major problems and threats are development projects potentially affecting the site including construction projects e.g. saltwater intrusion protection system and coastal roads in Bang Cha Kreng and Bang Kaew Sub-Districts. Water pollution in the Mae Klong River from industries, tourism activities, urban areas and agriculture is another major problem, having great impacts on noteworthy fauna of mudflats at the river mouth. Encroachment of mangroves for aquaculture development and construction of food

shops, restaurants, roads and parking lots; as well as construction of earth dams along riverbanks to prevent sediments flowing into mudflats can have long-term impacts on the site. Over harvesting of *S. regularis* and spreading lime solution on mudflats caused depletion of mollusks. Unless there is effective management of habitats of *Solen regularis*, this species may soon become extinct in the wild. Marine pollution affecting coastal zones and mudflats include oil pollution from oil carriers, cargo ships and fishing boats. Wastewater from shrimp farms and garbage from tourists are also problems (Welands International, 2010).

CHAPTER III

MATERIALS AND METHODS

3.1 Research design

Don Hoi Lot is the large prominent tidal flat at the mouth of the Mae Klong River. The area is at Moo 4, Bangjakreng Sub-district, and Moo 6 and 8, Bangkaew Sub-district, Muang District in Samut Songkhram Province. Don Hoi Lot covers tidal flat area of about 24.09 km² in which is divided into 5 islets covering approximately 0.69, 1.51, 4.64, 8.45 and 8.80 km², respectively.

The sand dune named Don Na San was selected because it was the large sand dune and good representative of the study area in Don Hoi Lot. The study site as considered appropriate, having Razor clams activities, locating in front and beside of the Mae Klong River mouth, and accessibility for collecting field data (Figure 3.1).

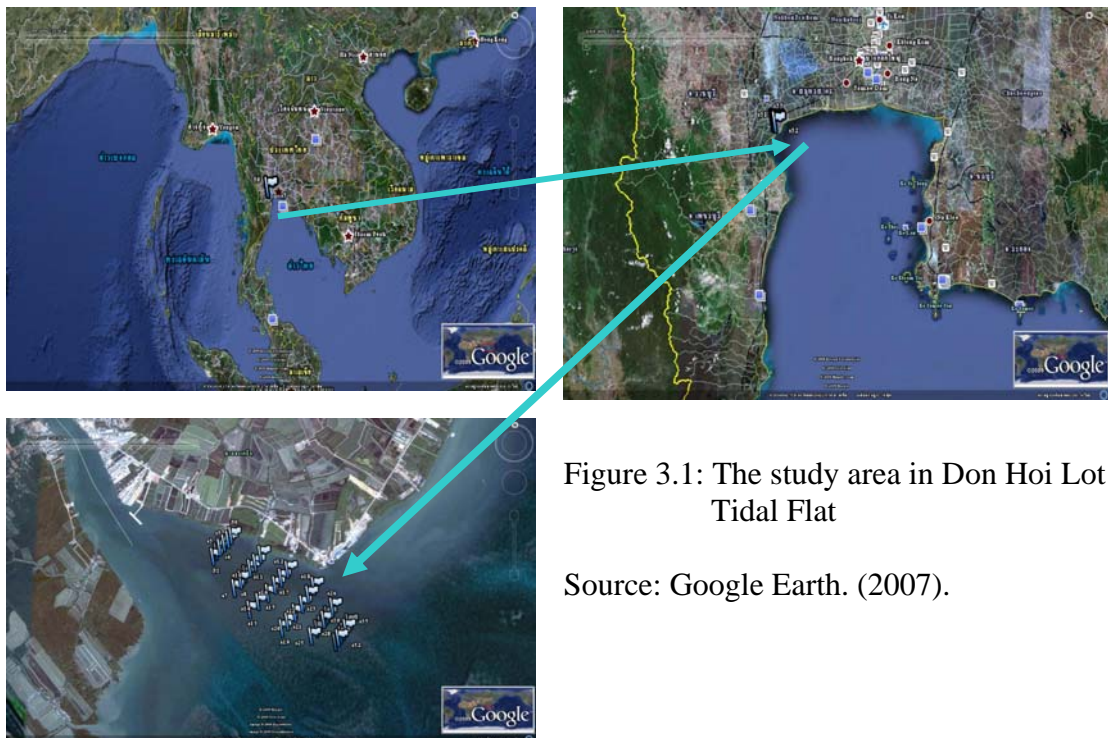


Figure 3.1: The study area in Don Hoi Lot Tidal Flat

Source: Google Earth. (2007).

The study period was during June 2008 to May 2009 and samples were collected every month. Data collection involve 4 key aspects: (a) biology and population of Razor clams i.e., life cycle, fecundity, length-weight relationship, sex ratio, growth rate and species diversity; (b) environmental characteristics i.e., physical factors (rainfall), soil characters (particle size, grain size), chemical factors and water quality (organic matter, dissolved oxygen, salinity, pH, temperature, nutrient compounds (N and P) and biological characteristics (other mollusks, plankton-species richness, evenness, diversity index); (c) socio-economic issues i.e., total catch, harvesting rate, market values and number of fishermen; and (d) ecological map of interactions between Razor clams and environmental factors. The ecological map would be used as a tool for analyzing and proposing potential management measures in the area. The study scheme was designed and categorized into 4 main components:

Component 1: Assessment of the current status of Razor clams at Don Hoi Lot in terms of existence, species diversity, abundance, distribution patterns, population and some biological aspects.

Component 2: Assessment of environmental characteristics of Don Hoi Lot i.e., physical, chemical and biological factors.

Component 3: Assessment of harvesting rate and total catch

Component 4: Establishment of ecological map and analysis of interactions between Razor clams and environmental factors.

3.2 Sampling site

The study site is located in Don Klang which is the largest islet occupying 8.80 km² and can be divided into 3 small parts by small shallow channels. Each part named locally as Don Na San, Don Na Po and Don Tal or Do Hua Jua Tawantok. However only Don Na San covering about 6 km² (4.5 km long and 1.33 km wide) and locating closest to coast line was selected as the sampling area.

The research planned to conduct a sampling of Razor clams at 36 sampling stations which could be divided into 2 dimensions; transverse and longitudinal transects referring to Mae Klong River mouth. Each transect consisted of 6 sampling

stations. Positions of 36 sampling stations including their distance from Mae Klong River mouth were shown in Table 3.1.

Temporal and spatial variations were assessed during the study period of one year. Physical factors and soil characters were measured at 36 stations while chemical factors and water analysis were measured and conducted at only 18 stations which could cover and represent the whole study area. For physical factors, one transect consisted of 6 stations in both transverse and longitudinal direction. For chemical factors, one transverse transect consisted of 3 stations and one longitudinal consisted of 6 stations. Distance between transverse transects coded as T1, T2, T3, T4, T5 and T6 and the coastline were 0.38, 0.84, 1.2, 1.6, 2.0 and 2.3 km, respectively. Distance between transects T1, T2, T3, T4, T5 and T6 and the Mae Klong River mouth were 0.99, 1.4, 1.8, 2.2, 2.6 and 2.9 km, respectively. Different codes for longitudinal transects were given as TA, TB, TC, TD, TE and TF. These transects were 1.1, 1.0, 0.86, 0.72, 0.58 and 0.45 km, respectively from the coastline and were 0.7, 0.81, 0.90, 1.0, 1.1 and 1.2 km, respectively from the nearest Mae Klong channel. Distance between transect lines ranged from 300-460 m with an average distance 384 ± 59 m whereas distance between longitudinal transects ranged from 100-144 m with an average 130 ± 17 m (Figure 3.2-3.5 and Table 3.2).

The study area at Don Na San was 1.043 km^2 divided into 5 consecutive transect parts: T1-T2, T2-T3, T3-T4, T4-T5 and T5-T6. Each part covered an area of 0.213, 0.221, 0.296, 0.201 and 0.113 km^2 , respectively. The study area was also divided into 5 consecutive longitudinal parts: TA-TB, TB-TC, TC-TD, TD-TE and TE-TF, covering area of 0.224, 0.205, 0.201, 0.195 and 0.218 km^2 , respectively (Table 3.3).

The relative altitude among transects, both transverse and longitudinal, ranged from 0.0-0.3 m. For transverse transects, T1 was located at the highest altitude comparing to another whereas TC had the highest altitude among longitudinal transects (Figure 3.6-3.7).



Figure 3.2: Location of 36 sampling stations at Don Na San in Don Hoi Lot.



Figure 3.3: Location of 18 sampling stations for collecting water samples at Don Na San in Don Hoi Lot.

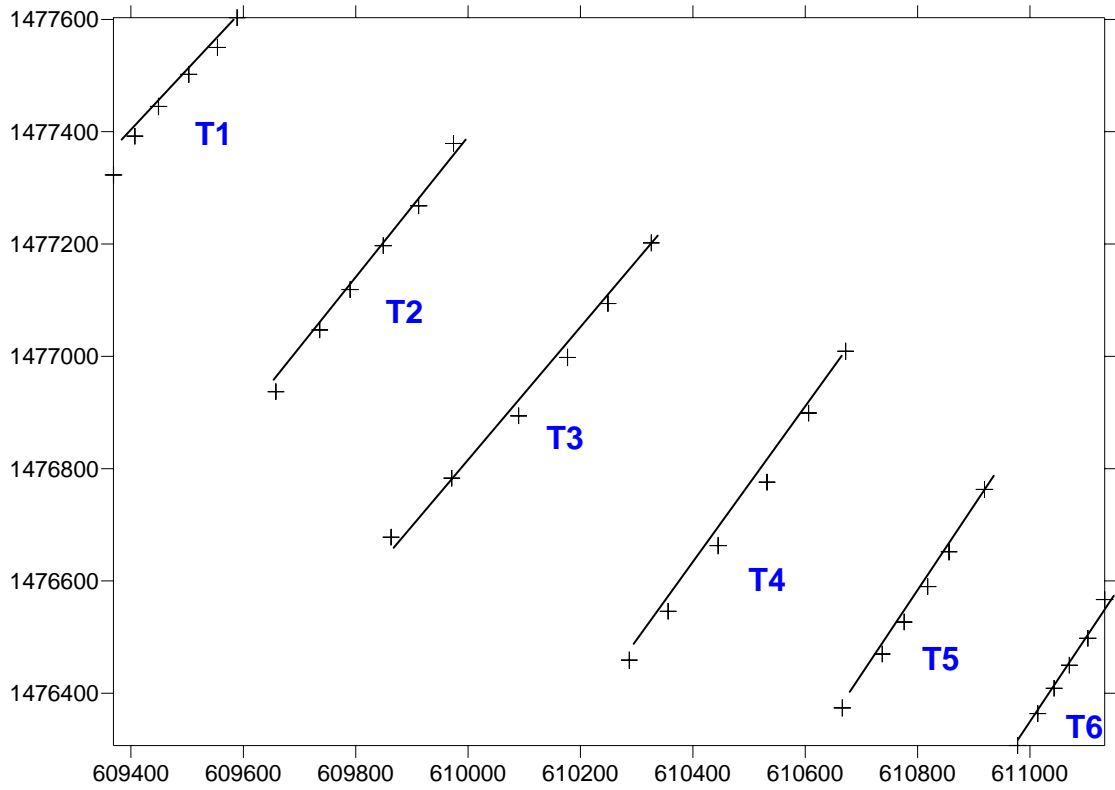


Figure 3.4: Locations of transverse transects T1-T6.

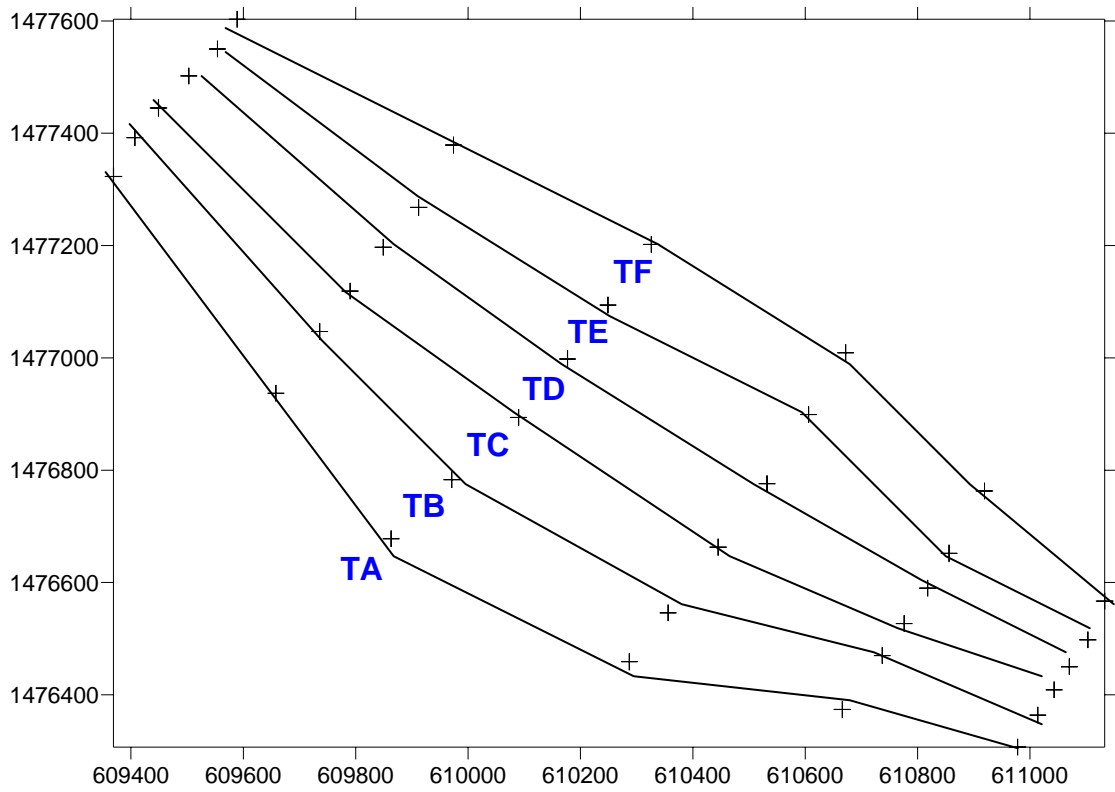


Figure 3.5: Locations of longitudinal transects TA-TF

Table 3.1: Positions of sampling stations in Don Hoi Lot, Samut Songkram Province
by UTM (Universal Transverse Mercator) grids during June 2008-May 2009

Transverse Transect	Longitudinal Transect	Station	UTM (North)	UTM (East)	Distance from Mae Klong River mouth (m)
T1	TA	1	47 P 609369	1477323	1541
T1	TB	2	47 P 609407	1477392	1553
T1	TC	3	47 P 609449	1477445	1578
T1	TD	4	47 P 609503	1477502	1615
T1	TE	5	47 P 609554	1477550	1655
T1	TF	6	47 P 609589	1477603	1678
T2	TA	7	47 P 609658	1476937	1964
T2	TB	8	47 P 609736	1477047	1984
T2	TC	9	47 P 609790	1477119	2005
T2	TD	10	47 P 609849	1477197	2032
T2	TE	11	47 P 609912	1477268	2071
T2	TF	12	47 P 609974	1477379	2101
T3	TA	13	47 P 609863	1476678	2272
T3	TB	14	47 P 609971	1476783	2313
T3	TC	15	47 P 610090	1476894	2368
T3	TD	16	47 P 610177	1476998	2406
T3	TE	17	47 P 610249	1477094	2441
T3	TF	18	47 P 610326	1477202	2483
T4	TA	19	47 P 610287	1476459	2745
T4	TB	20	47 P 610356	1476546	2763
T4	TC	21	47 P 610445	1476663	2788
T4	TD	22	47 P 610532	1476776	2819
T4	TE	23	47 P 610606	1476899	2843
T4	TF	24	47 P 610672	1477009	2871
T5	TA	25	47 P 610666	1476374	3114

Table 3.1: Positions of sampling stations in Don Hoi Lot, Samut Songkram Province by UTM (Universal Transverse Mercator) grids during June 2008-May 2009 (cont.).

Transverse Transect	Longitudinal Transect	Station	UTM (North)	UTM (East)	Distance from Mae Klong River mouth (m)
T5	TB	26	47 P 610737	1476470	3131
T5	TC	27	47 P 610776	1476527	3143
T5	TD	28	47 P 610818	1476590	3154
T5	TE	29	47 P 610856	1476652	3166
T5	TF	30	47 P 610919	1476763	3182
T6	TA	31	47 P 610978	1476307	3421
T6	TB	32	47 P 611014	1476364	3428
T6	TC	33	47 P 611043	1476409	3435
T6	TD	34	47 P 611070	1476450	3440
T6	TE	35	47 P 611103	1476498	3453
T6	TF	36	47 P 611133	1476567	3452

Table 3.2: Distance between transverse and longitudinal transects and coastline, and Mae Klong River mouth and channel.

Transverse transect	Distance from A (km)	Distance from B (km)	Longitudinal transect	Distance from C (km)	Distance from D (km)
T1	0.38	0.99	TA	1.10	0.70
T2	0.84	1.40	TB	1.00	0.81
T3	1.20	1.80	TC	0.86	0.90
T4	1.60	2.20	TD	0.72	1.00
T5	2.00	2.60	TE	0.58	1.10
T6	2.30	2.90	TF	0.45	1.20

Remark;

A = Distance from the nearest coastline at UTM 609215 E 1477758 N

B = Distance from the Mae Klong River mouth at UTM 608522 E 1477702 N

C = Distance from the nearest coastline at UTM 610734 E 1477484 N

D = Distance from the nearest Mae Klong channel at UTM 609172 E 1476438 N

Table 3.3: Area of different part and distance between lines in transverse and longitudinal transects.

Transverse transect	Area (km ²)	Distance between lines (m)	Longitudinal transect	Area (km ²)	Distance between lines (m)
T1-T2	0.213	460	TA-TB	0.224	100
T2-T3	0.221	360	TB-TC	0.205	144
T3-T4	0.296	400	TC-TD	0.201	139
T4-T5	0.201	400	TD-TE	0.195	133
T5-T6	0.112	300	TE-TF	0.218	134
Total	1.043	Average 384 \pm 59	Total	1.043	Average 130 \pm 17

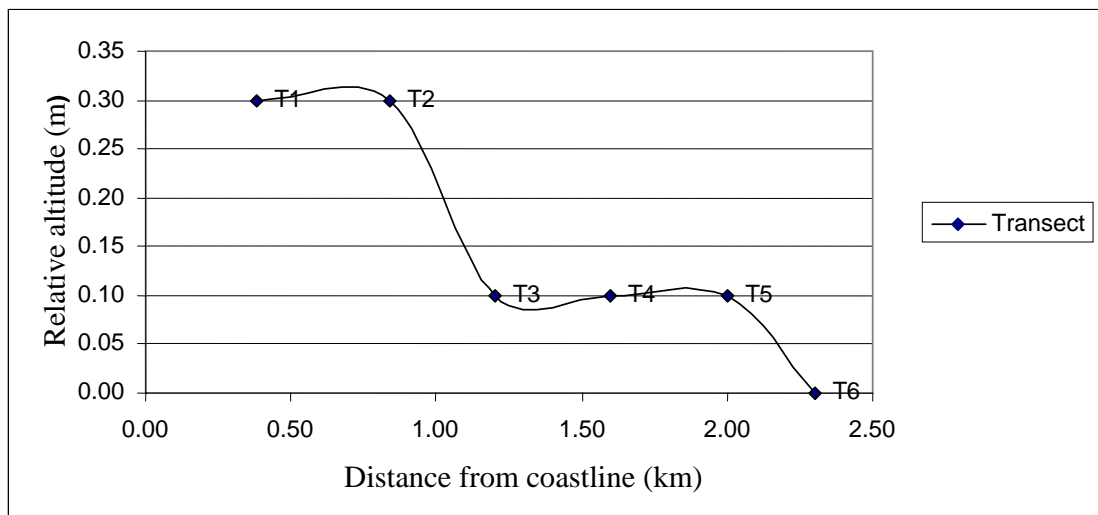


Figure 3.6: Relative altitude of transverse transects in Don Na San

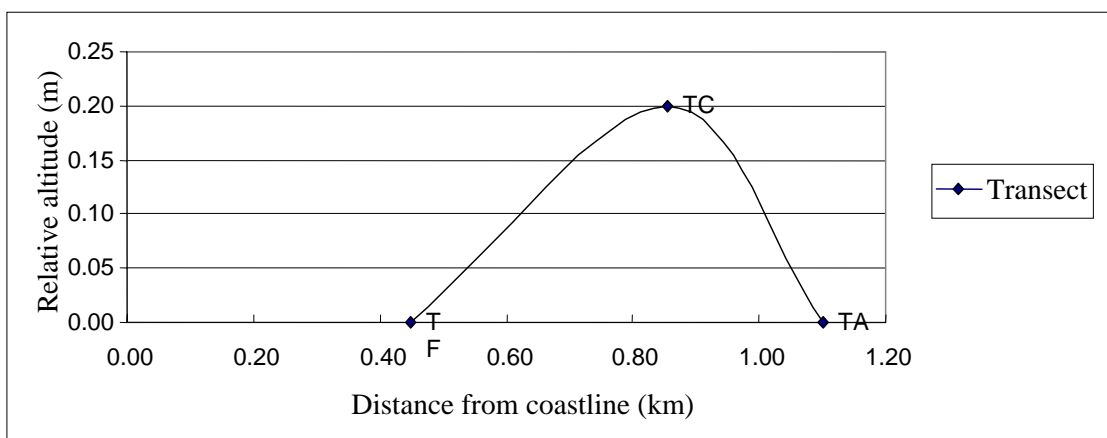


Figure 3.7: Relative altitude of longitudinal transects in Don Na San

3.3 Assessment of the current status of Razor clams

This study assessed current status of Razor clams at Don Hoi Lot, Samut Songkhram Province in terms of species diversity, density, distribution patterns, population dynamics, reproductive system and feeding habit.

3.3.1 Species diversity, density and distribution patterns

Razor clam samples were collected from 36 stations. Each station was 10 m² (5 m long and 2 m wide) during low tide. Razor clams were collected by using a bamboo stick, dipped in lime and dropped into their holes. Samples from each station were identified to species level. Weight, length and width of the shell were measured and number of individuals/station was counted. Species identification was done according to Tuaycharoen and Kongrabeab (2005). The samples then were preserved in 10 % formalin for other parts of study.

Data analysis was carried out in 3 parts.

1. Diversity of Razor clams: Comparison of the existing number of species of Razor clams by graph and explanation.

2. Density of Razor clams: Density of clam from each sampling station was calculated as number of individuals per area on monthly basis. Density of Razor clams (individuals/10m²) in each station was compared and analyzed by using cluster analysis and MDS (ordination multidimensional scaling).

3. Comparison of Razor clams density by graphical technique showing its distribution in the study area.

3.3.2 Analysis of Razor clam's population dynamics, reproductive system and feeding habit

This component aimed at assessing three main biological aspects as follows.

3.3.2.1 Population dynamics

Growth parameters, maximum length, mortality coefficient and exploitation rate from the monthly compiled length frequency of Razor clams were analysed according to the method of Sparre and Venema (1998).

Total length and weight of Razor clams collected from 36 sampling stations monthly during June 2008 to May 2009, were measured.

Data analysis was carried out by analyzing the Length-weight relationship using the Regression technique (Ricker, 1975; and Rounsefell and Everhart, 1953), as follows.

$$W = aL^b \quad \text{or} \quad \log W = \log a + b \log L$$

whereas W = weight in gram
 L = length in millimeter
 a, b = constant value

Growth parameter assessment was conducted using length frequency data and growth model of age-length and age-weight of von Bertalanffy (1938). Maximum length of clam (L_{∞}) was assessed following method of Ford-Walford (Walford, 1946) and Powell-Wetherall (Sparre and Venema, 1998). Using assumed age of clam at the zero length (t_0) of Beverton (1954), growth parameter (K) was analyzed by ELEFAN (Gayanilo *et al.*, 1994; Sparre and Venema, 1998; and Bhattacharya, 1967). The derived K value was used in equation of von Bertalanffy (von Bertalanffy, 1938) as follows.

$$L(t) = L_{\infty} \left(1 - e^{-K(t-t_0)} \right)$$

$$W(t) = W_{\infty} \left(1 - e^{-K(t-t_0)} \right)^3$$

whereas L_t = Total length at the age t (cm)
 L_{∞} = Maximum total length (cm)
 W_t = Weight at the age t (gm)
 W_{∞} = Maximum weight (gm)
 t = age (year)
 t_0 = Theoretical age at first born ; length = 0
 K = growth constant (per year)

Mortality coefficient was calculated by using the K value derived from growth parameter assessment and the method of Pauly's empirical formula (FAO, 1983). Fishing mortality coefficient (F) was estimated by the difference between the natural mortality coefficient (M) and total mortality coefficient (Z). Z was calculated according to the method of Jone and van Zalinge (1981) and linearized catch curve by FiSAT II version 1.2.2 (Fish Stock Assessment Tool) provided by FAO-ICLARM) (Sparre and Venema, 1998).

$$Z = F + M$$

whereas Z = total mortality coefficient

F = fishing mortality coefficient

M = natural mortality coefficient

Pauly (1980) had estimated M from the following equation:

$$\log(M) = -0.0066 - 0.279 \log(L_{\infty}) + 0.6543 \log(K) + 0.463 \log(T)$$

whereas T = average temperature of water (°C)

Exploitation rate (E) was calculated as follows.

$$E = F/Z$$

whereas E = exploitation rate

Z = total mortality coefficient

F = fishing mortality coefficient

Optimum E should be equal to 0.5 which means that the utilization of that fish species does not exceed the maximum production. But if E is larger than 0.5, it means over exploitation (Gulland, 1971).

3.3.2.2 Reproductive system

Sex ratio, size at first maturity, and spawning season were studied. Samples were collected at the same time as the assessment of the current status of Razor clam from 3 main transverse zones on monthly basis during June 2008 to May 2009. Zone 1 was located 1,541-2,101 m from Mae Klong River mouth, whereas zone 2 and 3 were situated about 2,272-2,843 m and 3,114-3,452 m from the river mouth respectively. Soil composition in zone 1 was muddier than in zone 2 and zone 3 respectively (Figure 3.8).

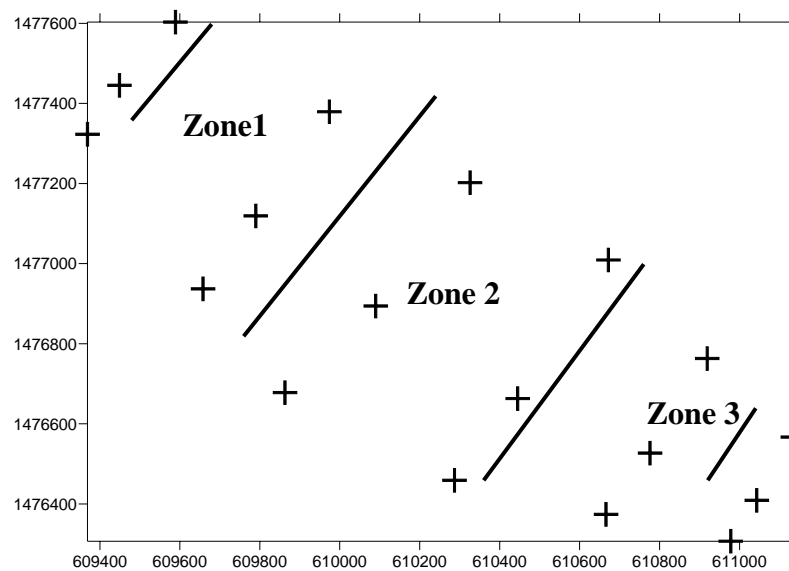


Figure 3.8: Locations for collecting Razor clams for reproductive study

All samples collected from 3 zones in each month were identified into male and female by dissecting tissue of sexual organ. The result was analyzed in percentage of sex-ratio and displayed in graph and table.

Size at first maturity was determined by observing gonad development of 30 samples of female clams collected every month. Gonad development was studied by dissecting tissue of sexual organ and preparing permanent slide. The prepared slide was investigated later for the 4th stage development (mature stage). The first maturation would be obtained by relating the mature stage with the minimum size.

Spawning season was studied by preparing permanent slides by dissecting gonad of 30 clams in each month using the technique of Tuaycharoen and Voraingtara

(1991). Investigation of the development of prepared gonad was done under high magnification microscope. All details were recorded and taken photograph. Trend of spawning season was obtained by converting the highest development of sex organ found in each month into percentage. Tuaycharoen and Voraingtara (1991) categorized gonad development into 6 stages: prefollicular development stage, initial development stage, developing stage, mature stage, partially spawned stage and spent stage.

3.3.2.3 Feeding habit

Feeding habit was studied through the Razor clam's stomach content. Samples were collected from 3 main transverse zones on monthly basis during June 2008 to May 2009. Weight and length of Razor clams were measured and then the intestinal system was removed and preserved in 10% formalin. The intestine was dissected. Food and food composition was identified and estimated. Types of food were categorized using the method of Hyslop (1980). Food intaked was identified by occurrence methods and compared between different times and different sizes of clams in percentage.

3.4 Assessment of environmental characteristics at Don Hoi Lot

This study focused on 3 main groups of environmental factors as follows:

1. Physical factors and soil characters: soil composition, particle size, % water content in soil, organic matter, redox potential and soil temperature.
2. Chemical factors and water quality: water temperature, salinity, pH, dissolved oxygen, alkalinity, hardness, ammonia nitrogen, nitrate nitrogen, phosphate phosphorus and chlorophyll-a.
3. Biological factors: phytoplankton and other mollusks.

All physical factors were measured at 36 stations in the same area and at the same time with Razor clams specimen collection during low tide. All chemical factors were measured at 18 stations during high tide on monthly basis in the same area and at the same period.

3.4.1. Physical factors and soil characters

All physical factors were measured at 36 stations during low tide every month for a period of one year. Cylindrical core sampling with diameter 3.57 cm or surface area of 10 cm² was used to collect soil vertically to the depth of 30 cm. Soil samples were collected from upper part (1-15 cm deep) and lower part (15-30 cm deep) for analyzing soil composition, water content, grain size and total organic matter. Most parameters were analyzed on monthly basis for one year except acid volatile sulfide (AVS) which was measured only three times in August 2008, December 2008 and April 2009. The methods and techniques used for analyzing soil parameters were indicated in Table 3.4.

Table 3.4: Parameters and technique using for soil sample analysis

Parameters	Method
Soil composition	Sieving method
% Water content in soil	Conventional oven – method
Grain size	Sieving method
Total organic matter	Ignition loss
Soil temperature	Thermometer probe
Soil pH	pH meter
Acid volatile sulfide	Dosimeter tube

Rain fall data were obtained from Hydrographic Department and amount of water discharge from Mae Klong dam was received from Royal Irrigation Department.

Pearson correlation, analysis of variance (ANOVA) and cluster analysis and MDS (multidimensional scaling) were used for data analysis. The results were presented in graphs and tables.

3.4.2. Chemical factors and water quality

All chemical factors were measured 18 stations during high tide on monthly basis in the same area and at the same period. Water temperature, depth, salinity, pH, dissolved oxygen and transparency were analyzed. Water samples were

collected by Ruttner Water Sampler at the middle depth at each sampling station and were analyzed according to standard methods (American Public Health Association, American Water Work Association, and Water Environment Federation, 1995) in laboratory for alkalinity, hardness, turbidity, ammonia nitrogen, nitrate nitrogen, phosphate phosphorus and chlorophyll a. Parameters and techniques were indicated in Table 3.5.

Table 3.5: Parameters and technique used for water sample analysis

Parameter	Method
Water depth	Depth sounder
Water temperature	Thermometer probe
DO	DO meter
pH	pH meter
Chlorophyll a	Standard method
Salinity	Salinometer
Turbidity	Spectrophotometer
Transparency	Secchi disc
NH ₃ -N	Phenate method
NO ₃ -N	Cadmium reduction method
Orthophosphate	Ascorbic acid method

Pearson correlation, analysis of variance (ANOVA) and cluster analysis and MDS (multidimensional scaling) were used for data analysis. The results were presented in graphs and tables.

3.4.3. Biological factors

3.4.3.1 Phytoplankton

Plankton samples were collected one sample per station from 18 sampling stations during high tide once a month, using Ruttner Water Sampler at the depth of 0.5 meter and filtered through 22 µm plankton net. The sample was preserved in 4% formalin solution and adjusted volume to the preserved sample 50 ml.

The sample was homogenized then 1 ml taken to Sedgwick Rafter cell and covered with cover glass. All specimens were enumerated and identified under high magnification microscope following Ricard (1987), Sournia (1986), Tomas (1997) and Wongrat (1982).

Three ecological indices of phytoplankton were analyzed.

Richness index (RI) indicating the richness of species in each sample was calculated using the method of Margalef Index (Ludwig and Reynolds, 1988; Clarke and Warwick, 1994) and the following formula.

$$R = \frac{(S - 1)}{\ln(n)}$$

whereas R = Richness index S = the total species found
 n = the total number found ln = natural logarithm

Diversity index (DI) indicating the level of diversity and quality of environment was calculated using the method of Shannon-Weiner Diversity Index (Krebs, 1985; Washington, 1984) and the following formula.

$$H = -\sum(p_i \log_2 p_i)$$

whereas H = diversity index
 p_i = proportion of organism i to total number of organisms

Evenness index (EI) indicating the number, composition and distribution of organisms in each station and each sampling was calculated using the method of Pielou Index (Washington, 1984; Ludwig and Reynolds, 1988; Clarke and Warwick, 1994) and the following formula.

$$E = \frac{H}{\ln(S)} \quad \text{or} \quad = \frac{H}{H_{\max}}$$

whereas E = evenness index

H = diversity index

S = number of species found at the station being measured

H_{\max} = Maximum of Diversity Index from all sampling stations

Cluster analysis and MDS (multidimensional scaling) were used to compare phytoplankton abundance between stations and months. Pearson correlation was used to analyze relationship between physical and chemical factors and phytoplankton abundance. The results were presented in graphs and tables.

3.4.3.2 Other Mollusks

Other mollusk samples were collected from 36 sampling stations, two sampling quadrants (1 m long and 1 m wide in each quadrant) per station during low tide in the same area and at the same time with Razor clams specimen collection. Samples from each station were identified to species level and number of individuals/station was counted. Samples collected were preserved in 70% alcohol. Identification of mollusk was done following Tuaycharoen and Kongrabeab (2005), Tuaycharoen and Matsukuma (2001), Habe (1971), Kira (1965), Carpenter and Niem (1998), Lamprell and Healy (1998), Okutani (2000) and Vongpanich (1996).

Abundance of other mollusks was compared between stations and months using cluster analysis and MDS. Relationship between physical and chemical factors and mollusk abundance was analyzed using Pearson correlation.

3.5 Assessment of harvesting rate and total catch

This study assessed total catch, total value and catch per unit effort (CPUE) at Don Hoi Lot. Data were collected from local fishermen in Bangjakreng and Bangkaew Sub-districts in Muang District, Samut Songkhram Province, using questionnaires for interviewing at least 10% of total fishers at fishing port at Don Na San. Questionnaires consisted of questions relevant to harvesting method, marketing price, fishing status, socio-economics, fishing ground, number of fishers, collectors and sellers, and attitude of community on the management of Don Hoi Lot Tidal flat.

Fishing status i.e. total households, total fisher households, primary and secondary occupation, fishing practice i.e.type, number and technique of fishing gears

used, fishing season, catch amount of Razor clam and fish, proportion of utilization economic return per household, and fishing accountable problems were recorded.

Monthly catch, average monthly unit effort, and average catch per unit effort were calculated, using Caddy and Bazigos (1985) and Stamatopoulos (2002) methods.

Monthly catch (kg/month)	=	Average catch per unit effort (kg/fisherman/day)	X	Average monthly unit effort (fisherman x day)
Average monthly unit effort (fisherman x day)	=	Number of fishermen per Month (Number)	X	No. of day for fishing /month (days)
Average catch per unit effort (kg/fisherman/day)	=	$\frac{\text{Average monthly catch of fisherman (kg/month)}}{\text{Average monthly unit effort (fisherman x day)}}$		

3.6 Establishment of ecological map and interactions between Razor clams and environmental factors

Interactions between density and development of egg stage of Razor clams and environmental factors were analyzed using Pearson correlation and ecological program PRIMER which consisted of several methods for ecological data analysis, such as multidimensional scaling (MDS), principal component analysis (PCA), hierarchical clustering (CLUSTER) and BIO-ENV (Clarke and Warwick, 1994) and Canonical Correspondence Analysis (CCA). The results derived from analysis of interactions were used to develop ecological map.

CHAPTER IV

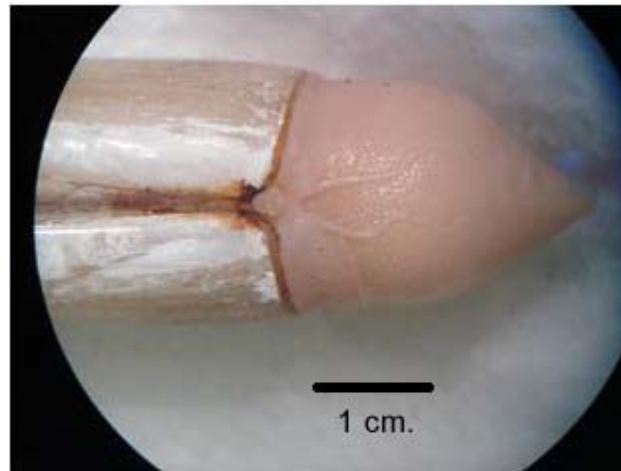
BIOLOGY OF RAZOR CLAMS IN DON HOI LOT

This chapter presents the results on biological characteristics of Razor clams including species composition, population parameters, reproductive biology, stomach contents, and finally followed by discussion and conclusion.

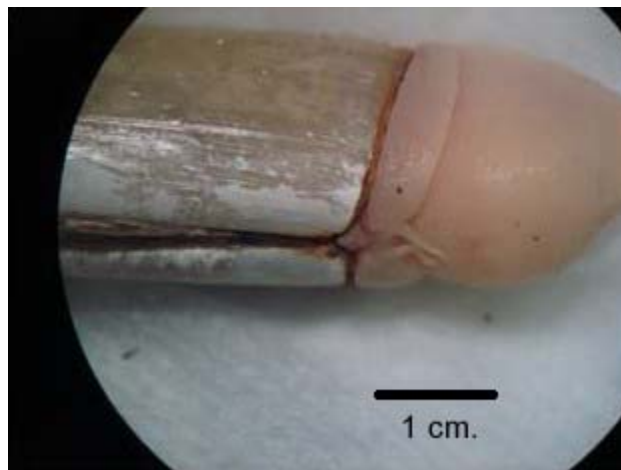
4.1 Razor clams assemblage in Don Hoi Lot

4.1.1 Species composition

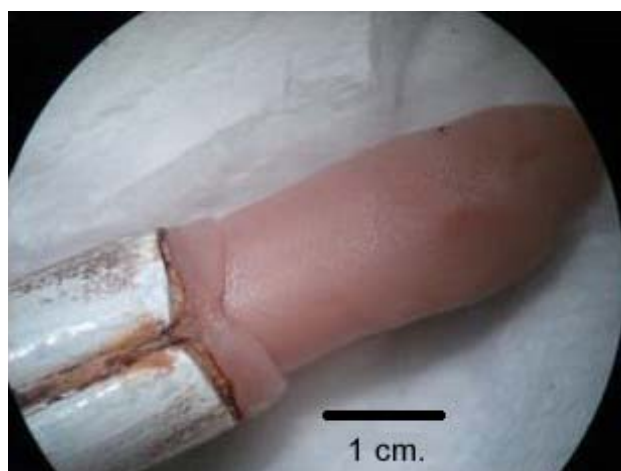
According to Tuaycharoen and Kongrabeab (2005), there were four species of Razor clams recorded in Don Hoi Lot whereas only three species consisting of *S. corneus*, *S. strictus* and *S. regularis* were found in this study. The main characteristic used to identify these Razor clams was tentacle. *S. corneus* has one long pair of tentacles whereas *S. strictus* and *S. regularis* had a short pair of tentacles and no tentacles respectively (Figure 4.1). During June 2008 to May 2009, a total of 1,762 Razor clams were collected on monthly basis from three zones: zone 1 (T1& T2), zone 2 (T3&T4) and zone 3 (T5&T6). The dominant species found in all zones were *S. corneus* averaging 76.7 %, followed by *S. strictus* (19.5 %) and *S. regularis* (3.8 %) (Table 4.1-4.2 and Figure 4.2-4.3). The maximum ratio of *S. corneus* was found in zone 3 (80%) whereas the maximum of *S. regularis* was found in zone 1 (8 %). In term of annual variation, the species composition of Razor clams were fluctuated with spatial variation (zones) and the highest percentage of *S. corneus* was peaked in April (91.8 %) while the highest percentage of *S. strictus* was found in January (43.8 %).



(A)



(B)



(C)

Figure 4.1 Tentacle characteristic of Razor clams: *S. corneus* with long tentacles (A), *S. strictus* with short tentacles (B) and *S. regularis* with no tentacle (C)

Table 4.1: Species composition of Razor clams in each zone in Don Hoi Lot during June 2008-May 2009

Species	Zone1		Zone2		Zone3		Total		
	Ind.	%	Ind.	%	Ind.	%	Ind.	AVG (%)	SD
<i>S. corneus</i>	196	71	592	76	562	80	1,350	76.7	4.3
<i>S. strictus</i>	59	21	165	21	120	17	344	19.5	2.5
<i>S. regularis</i>	21	8	23	3	24	3	68	3.8	2.6
Total	276		780		706		1,762		

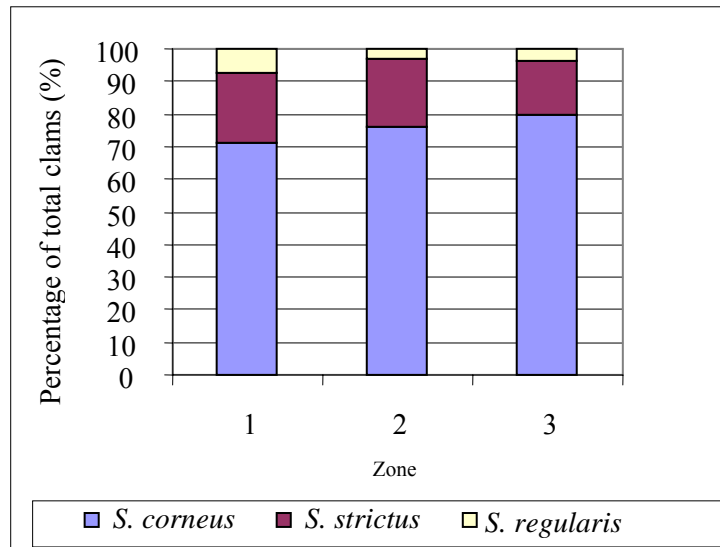


Figure 4.2: Species composition of Razor clams in each zone in Don Hoi Lot during June 2008-May 2009

Table 4.2: Species composition of Razor clams in each month in Don Hoi Lot during June 2008-May 2009

Month	<i>S. corneus</i>		<i>S. strictus</i>		<i>S. regularis</i>		Total
	Ind.	%	Ind.	%	Ind.	%	Ind.
Jun-08	138	81.7	18	10.7	13	7.7	169
Jul-08	116	89.9	10	7.8	3	2.3	129
Aug-08	138	69.0	52	26.0	10	5.0	200
Sep-08	158	66.9	76	32.2	2	0.8	236
Oct-08	124	73.4	30	17.8	15	8.9	169
Nov-08	75	63.6	35	29.7	8	6.8	118
Dec-08	115	80.4	25	17.5	3	2.1	143
Jan-09	39	53.4	32	43.8	2	2.7	73
Feb-09	128	90.8	12	8.5	1	0.7	141
Mar-09	101	73.2	31	22.5	6	4.3	138
Apr-09	101	91.8	7	6.4	2	1.8	110
May-09	117	86.0	16	11.8	3	2.2	136
AVG		76.7		19.5		3.8	
SD		12.1		11.6		2.7	

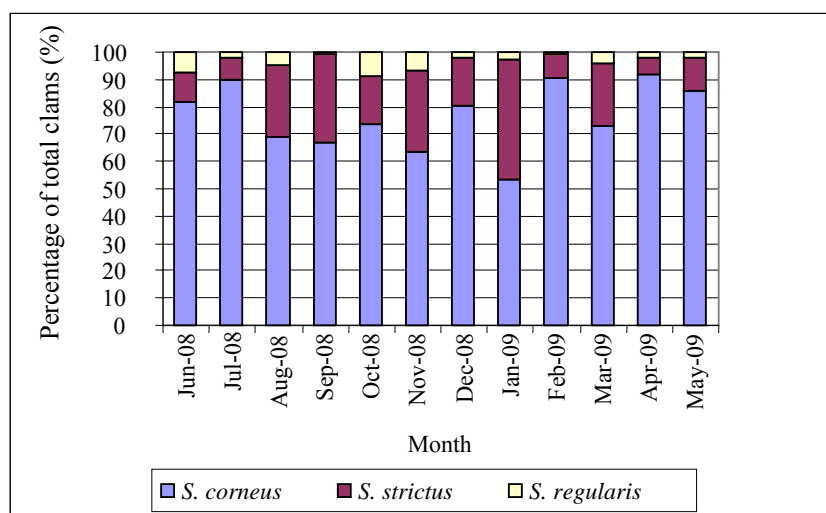


Figure 4.3: Species composition of Razor clams in each month in Don Hoi Lot during June 2008-May 2009

4.1.2. Density, distribution and assemblage structure of Razor clams

4.1.2.1 Spatial distribution

A total of 379 Razor clams consisting of *S. corneus*, *S. strictus* and *S. regularis* (291, 82 and 6 specimens, respectively) were collected monthly from 36 stations during June 2008-May 2009 and transverse, longitudinal and stations variation were analyzed. The results showed that in term of transverse transect, the average density was slightly low, 0.67 ± 0.57 , 0.19 ± 0.13 and 0.01 ± 0.02 individuals/10 m² of *S. corneus*, *S. strictus* and *S. regularis* respectively (Table 4.3). The minimum average abundance of *S. corneus* and *S. strictus* were found in the same transverse transect (T1) and these two species could be found in all transverse and longitudinal transects. In term of longitudinal transect, the minimum average abundance of *S. corneus* and *S. strictus* occurred in the same transect (TF) as well. *S. regularis* was only found in some transverse transects (T2, T3 and T5) and in some longitudinal transects (TA, TC and TD). In transverse transect, the density of Razor clams gradually increased from T1 and reached the maximum in T5 whereas the maximum density occurred in TC locating in the middle of the study site (Figure 4.4-4.5). In term of spatial variation, the average density of *S. corneus*, *S. strictus* and *S. regularis* were 0.67 ± 0.835 , 0.19 ± 0.210 , 0.01 ± 0.037 individuals/10 m² respectively and the high values were found at the 25th to 27th station (Figure 4.6).

Assemblage structure of Razor clams was analyzed to define similarity of every pair of species in each transect by using cluster analysis. The results showed that Razor clams in Don Hoi Lot could be divided into three groups at 60 % of similarity according to transverse transect: T1 (group I), T4&5 (group II) and T2, T3 & T6 (group III) (Figure 4.7). In case of longitudinal transect, Razor clams could be separated in three groups at 85 % of similarity: group I (TA, TB, TC and TD), group II (TE), and group III (TF) (Figure 4.8). When computing the similarity of abundance of Razor clams in each station by using cluster analysis and the majority of Razor clam species in each group by using SIMPER, it was found that all stations could be divided into five groups at 60 % of similarity as follows (Figure 4.9):

Group I: This group was consisted of S1, S4, S9, S4, S18, S29, S35 and S36. At average similarity 75.76 %, major species contributing to this group was *S. corneus* (98.79 %).

Group II: This group was consisted of S10, S11, S14, S15, S16, S17, S19, S23, S28, S32, S33 and S34. At average similarity 75.39 %, the majority of species contributing to this group were *S. corneus* and *S. strictus* (77.66 and 22.15 % respectively).

Group III: This group was consisted of S21, S21, S22 S25, S26, S27 and S31. At average similarity 81.60 %, major species of this group were *S. corneus* and *S. strictus* (80.91 and 18.95 % respectively).

Group IV: This group was consisted of S1, S12 and S24. At average similarity 77.78 %, major species of this group were *S. strictus* and *S. corneus* (78.58 and 21.43 % respectively).

Group V: This group was consisted of S13 and S30. At average similarity 100 %, the only species in this group was *S. corneus* (100 %).

The remaining stations (S2, S5, S6, S7 and S8) were not grouped in the cluster due to the absence of Razor clams in these stations during the study period. In conclusion, for spatial distribution, average high density of Razor clams in Don Hoi Lot could be found at the 20th to 22nd and 25th to 27th stations (Figure 4.10).

Table 4.3: Spatial distribution (transverse and longitudinal transects) of average abundance of Razor clams in Don Hoi Lot during June 2008-May 2009 (individuals/10m²)

Transverse transect							
Species	T1	T2	T3	T4	T5	T6	AVG
<i>S. corneus</i>	0.08±0.11	0.24±0.26	0.42±0.25	1.18±0.90	1.53±1.35	0.60±0.42	0.67±0.57
<i>S. strictus</i>	0.03±0.04	0.08±0.07	0.17±0.19	0.32±0.20	0.38±0.30	0.17±0.17	0.19±0.13
<i>S. regularis</i>	0.00±0.00	0.03±0.04	0.01±0.03	0.00±0.00	0.04±0.07	0.00±0.00	0.01±0.02
Longitudinal transect							
Species	TA	TB	TC	TD	TE	TF	AVG
<i>S. corneus</i>	0.75±0.98	0.89±1.19	1.06±1.04	0.89±0.74	0.36±0.23	0.10±0.10	0.67±0.37
<i>S. strictus</i>	0.26±0.27	0.28±0.26	0.25±0.25	0.26±0.16	0.06±0.07	0.03±0.04	0.19±0.12
<i>S. regularis</i>	0.01±0.03	0.00±0.00	0.06±0.07	0.01±0.03	0.00±0.00	0.00±0.00	0.01±0.02

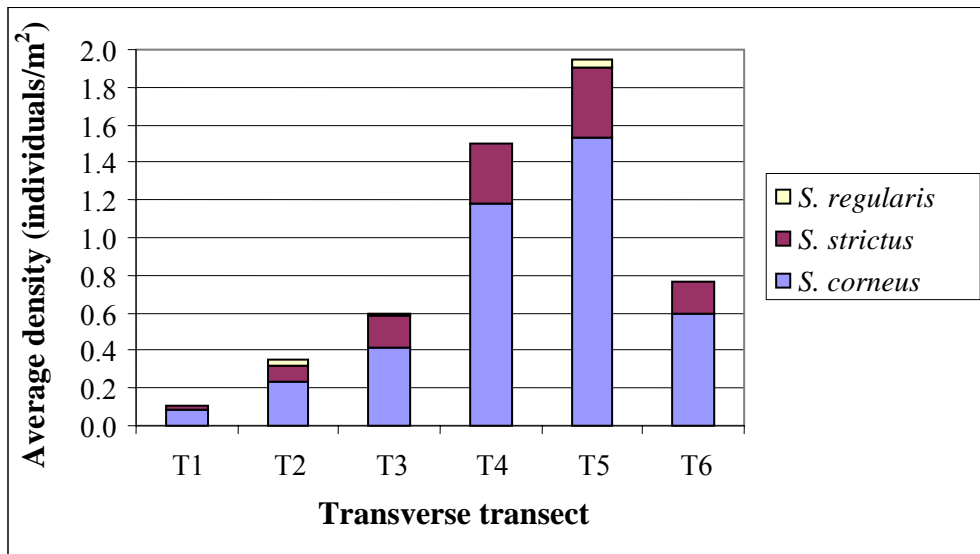


Figure 4.4: Spatial distribution (transverse transect) of average abundance of Razor clams in Don Hoi Lot.

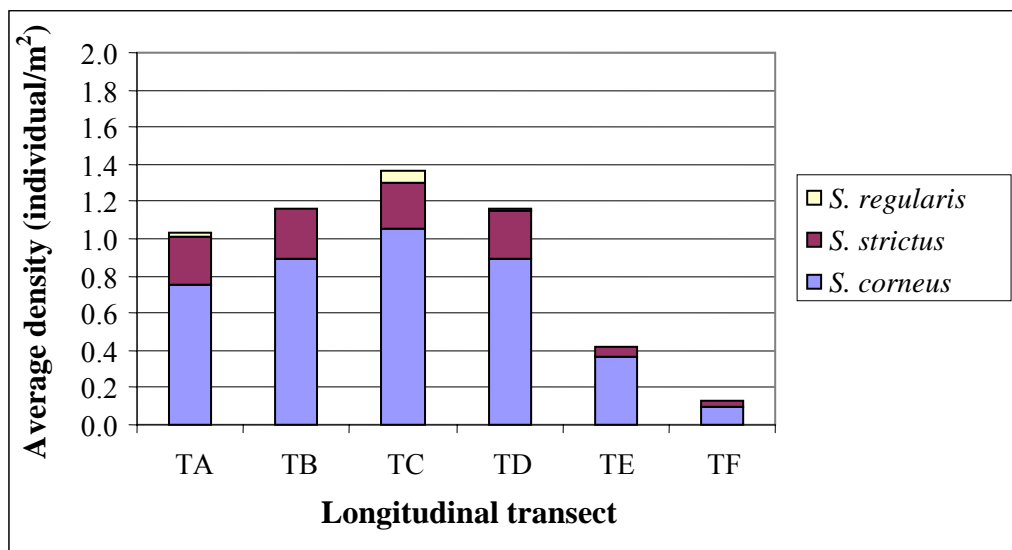


Figure 4.5: Spatial distribution (longitudinal transect) of average abundance of Razor clams in Don Hoi Lot.

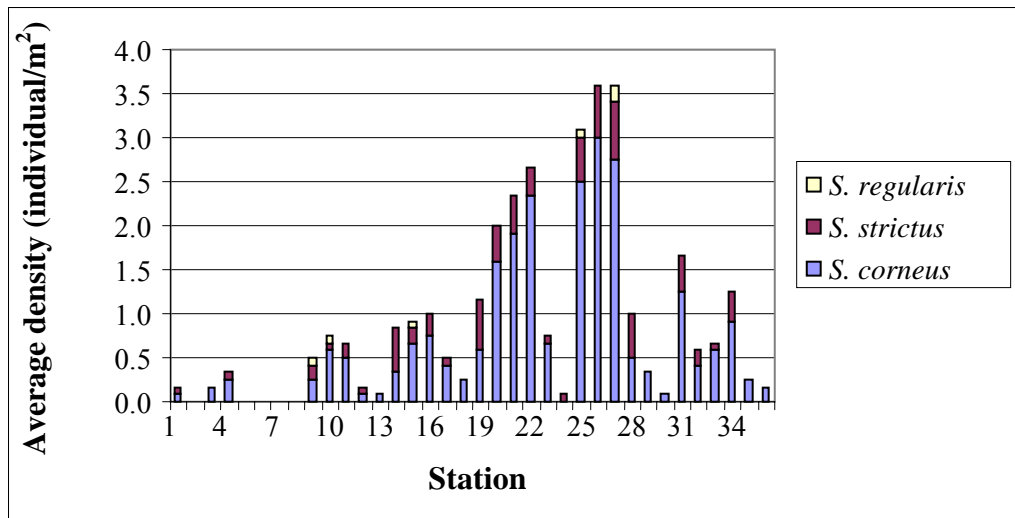


Figure 4.6: Spatial distribution of average abundance of Razor clams in each station in Don Hoi Lot

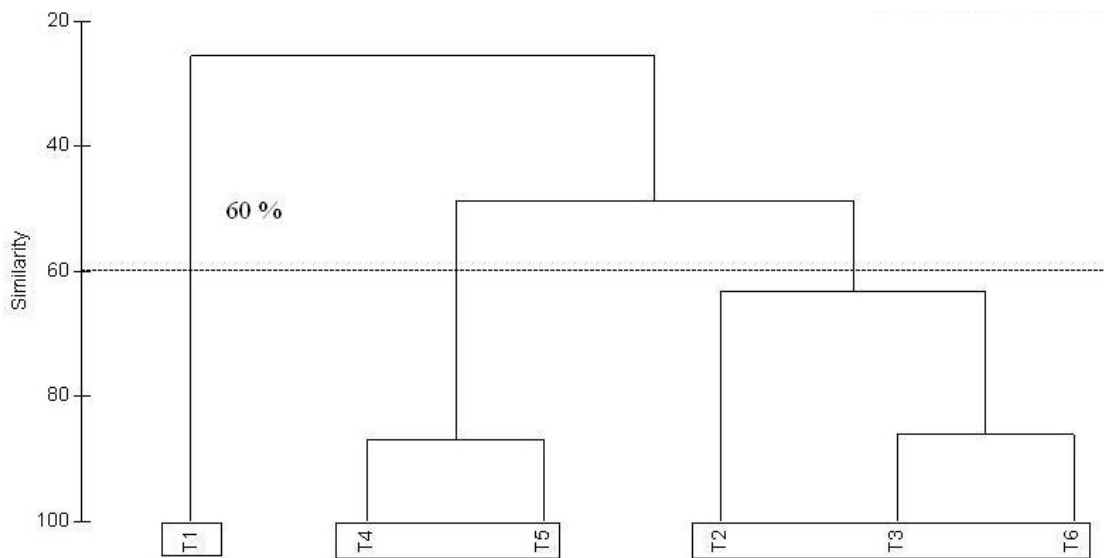


Figure 4.7: Dendrogram for hierarchical clustering of Razor clams in each transverse transect classified into three groups.

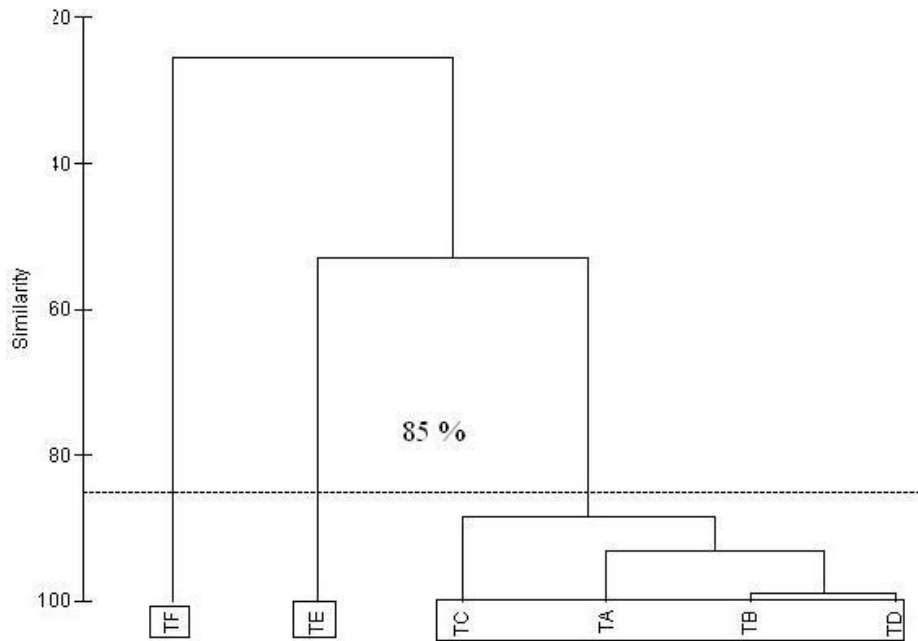


Figure 4.8: Dendrogram for hierarchical clustering of Razor clams in each longitudinal transect classified into three groups.

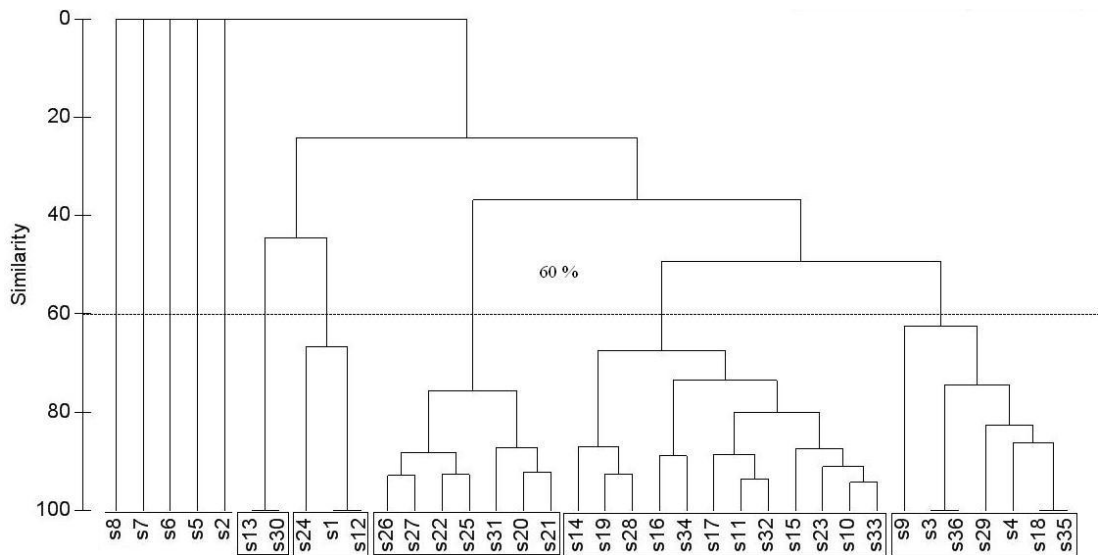


Figure 4.9: Dendrogram for hierarchical clustering of Razor clams in each station classified into three groups.

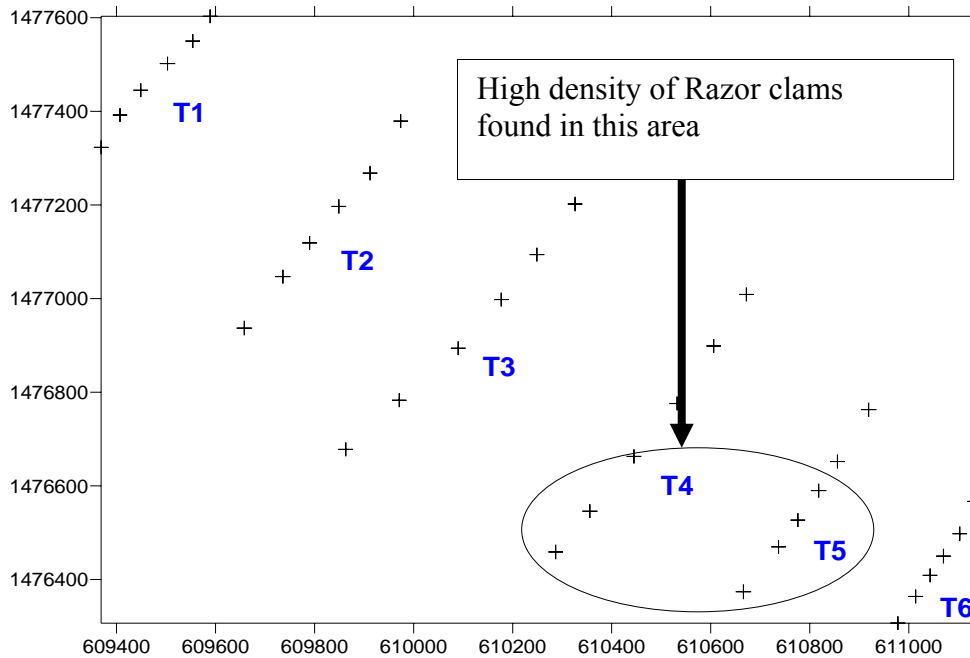


Figure 4.10: Spatial distribution of average high density of Razor clams in Don Hoi Lot

4.1.2.2 Temporal distribution

The highest density of Razor clams was occurred in September and followed by December. The low density was recorded in several months, for instance in October and November and lowest in January. *S. regularis* was only found in August, January and May, comparing with other two species which could be found in every month (Table 4.4).

Assemblage structure of Razor clams was analyzed to define similarity of every pair of species in each month by using cluster analysis at 68 % of similarity and the major species of Razor clams in each group by using SIMPER. The results could be divided into three groups (Figure 4.11-4.12) as follows:

Group I: This group was consisted of November and January. At average similarity 70.18 %, the major species contributing to this group were *S. corneus* and *S. strictus* (85.00 and 15.00 % respectively).

Group II: This group was consisted of June, August, September, December, February, and March. At average similarity 84.72 %, the major species contributing to this group were *S. corneus* and *S. strictus* (87.29 and 12.71 % respectively).

Group III: This group was consisted of July, October, April and May. At average similarity 81.68 %, the major species contributing to this group were *S. corneus* and *S. strictus* (82.70 and 17.30 % respectively).

Table 4.4: Annual variation of average abundance of Razor clams (individuals/10m²) in Don Hoi Lot during June 2008 to May 2009

Species	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08
<i>S. corneus</i>	0.83	0.64	1.08	0.97	0.44	0.17	1.00
<i>S. strictus</i>	0.08	0.08	0.06	0.64	0.08	0.14	0.39
<i>S. regularis</i>	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Species	Jan-09	Feb-09	Mar-09	Apr-09	May-09	AVG	SD
<i>S. corneus</i>	0.17	0.94	0.92	0.53	0.39	0.67	0.33
<i>S. strictus</i>	0.03	0.33	0.14	0.14	0.17	0.19	0.18
<i>S. regularis</i>	0.06	0.00	0.00	0.00	0.08	0.01	0.03

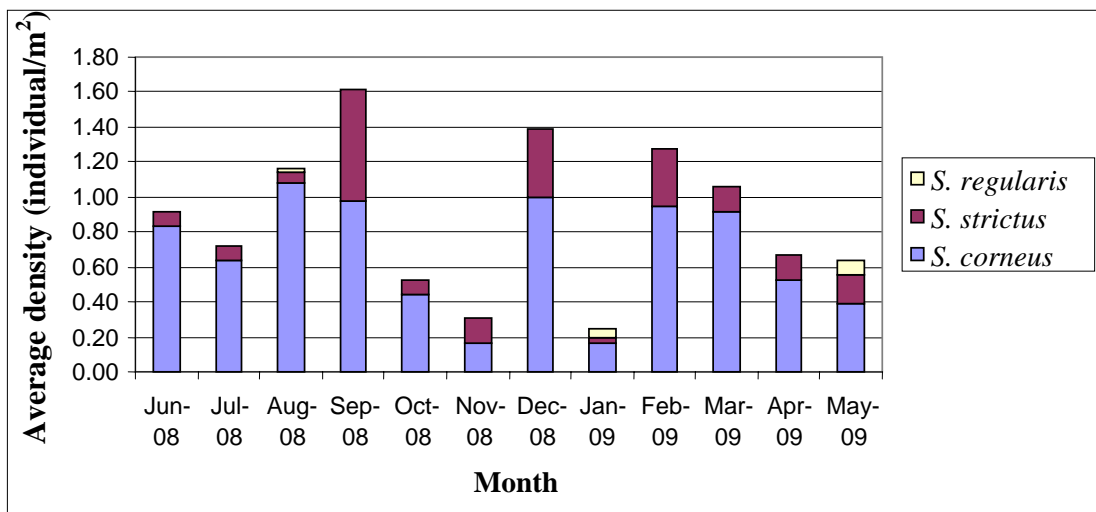


Figure 4.11: Annual distribution of average abundance of Razor clams in each month in Don Hoi Lot

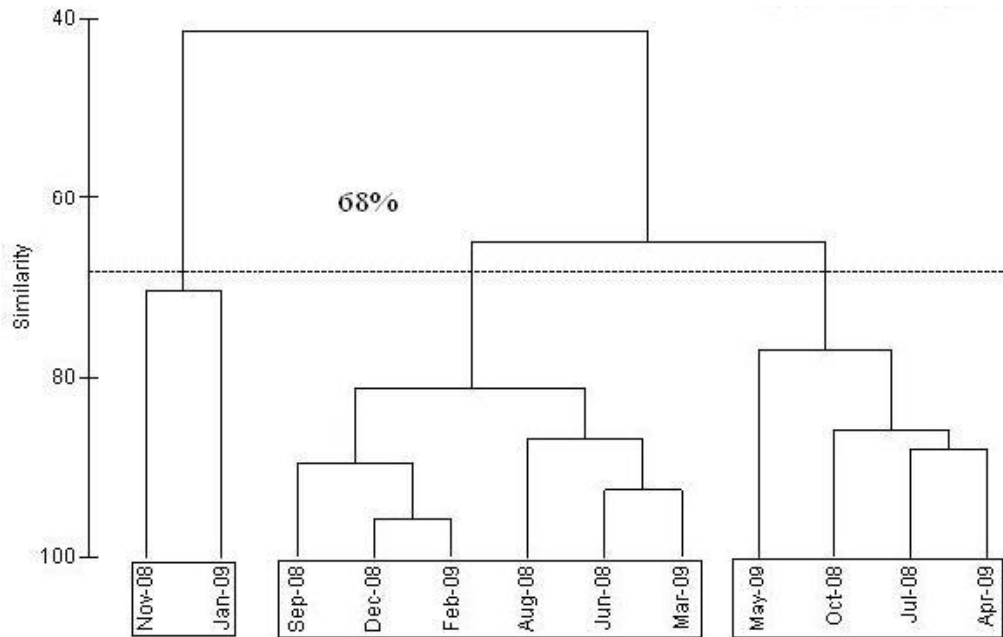


Figure 4.12: Dendrogram for hierarchical clustering of Razor clams in each month classified into three groups.

4.2 Population parameters

4.2.1 Length-weight relationship of Razor clams

A total of 1,762 specimens of Razor clams were randomly collected from June 2008 to May 2009 from three zones in the study site. The monthly collections were classified into each species. Due to the limitation of availability of collected specimens and the difficulty to identify sex organ from external features of the clams, therefore the analysis of length-weight relationship was done in a combination of male and female. The average total length and average weight of *S. corneus*, *S. strictus* and *S. regularis* were 5.12 ± 1.19 , 5.73 ± 1.13 , 5.38 ± 1.00 cm and 4.34 ± 2.72 , 5.49 ± 2.78 , 4.90 ± 2.13 g respectively (Table 4.5-4.7). The length-weight relationship of Razor clams was calculated as follows.

$$S. \textit{corneus} \quad W = 0.0365 L^{2.8263}; R^2 = 0.8378, n = 1350 \text{ (Figure 4.13)}$$

$$S. \textit{strictus} \quad W = 0.0689 L^{2.4542}; R^2 = 0.7795, n = 344 \text{ (Figure 4.14)}$$

$$S. \textit{regularis} \quad W = 0.1999 L^{1.8613}; R^2 = 0.6264, n = 68 \text{ (Figure 4.15)}$$

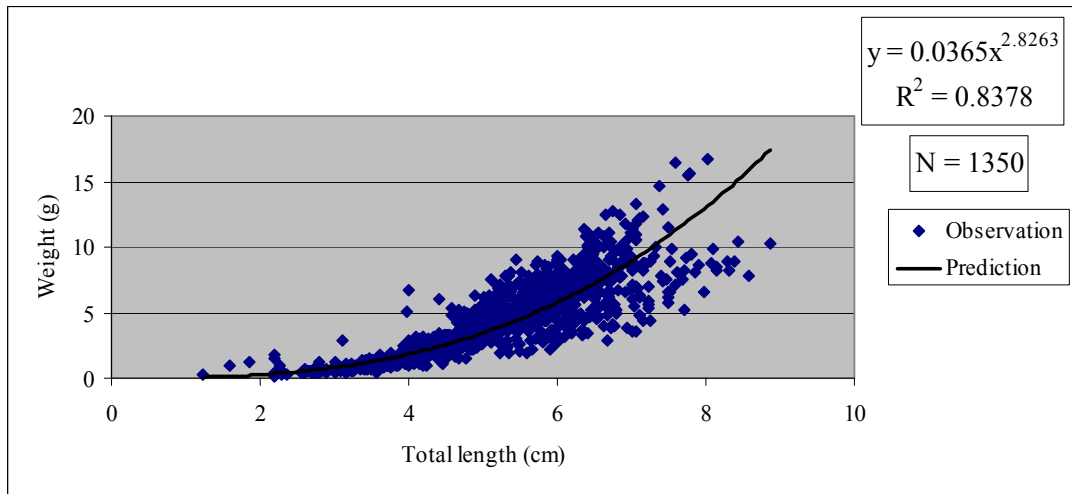


Figure 4.13: Length-weight relationship of *S. corneus* in Don Hoi Lot

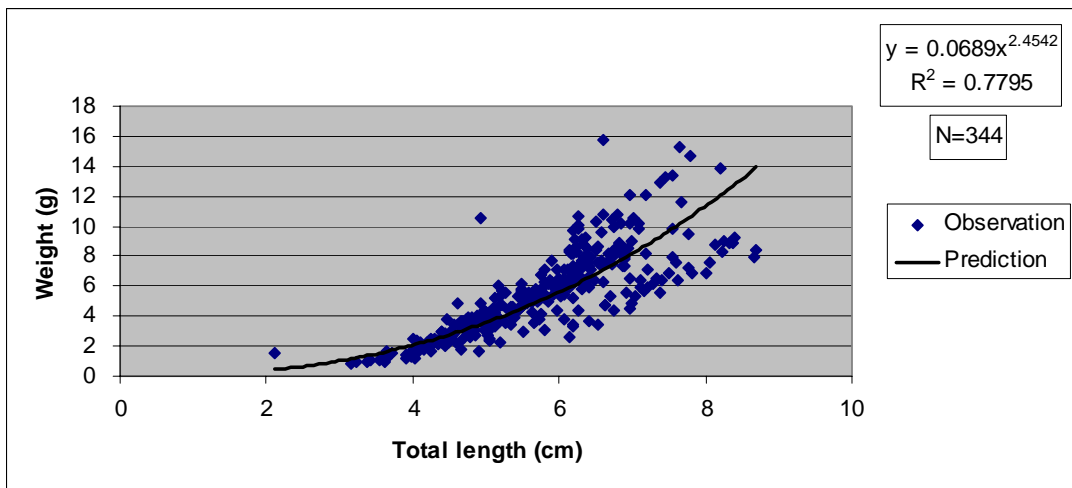


Figure 4.14: Length-weight relationship of *S. strictus* in Don Hoi Lot

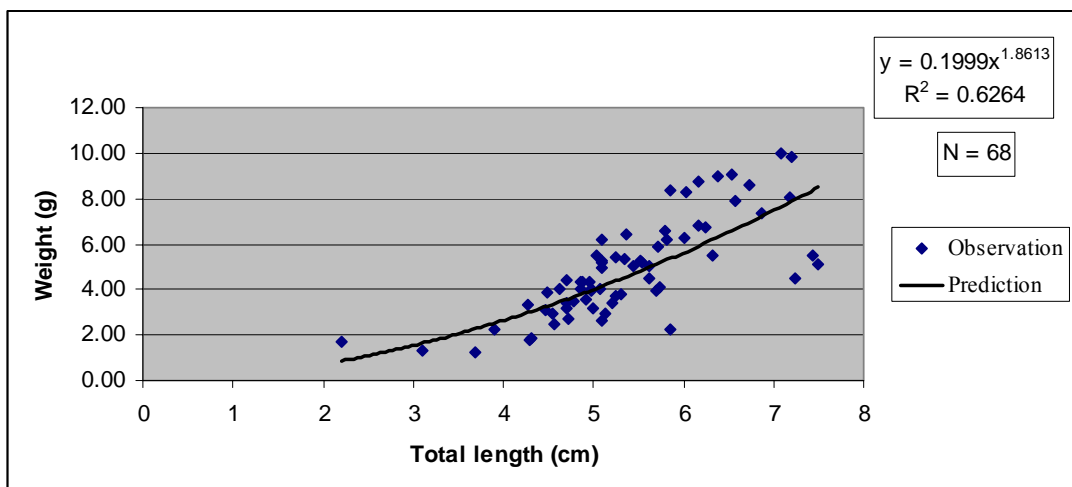


Figure 4.15: Length-weight relationship of *S. regularis* in Don Hoi Lot

The exponent (b) value in each equation was not close to 3 according to cubic law and was not between the lower and upper value at 95 % of confident interval. Therefore the growth patterns of three species of Razor clams were allometric (Chaidee and Sawusdee, 2007).

Table 4.5: Number of specimens, maximum, minimum and average total length and weight of *S. corneus* in each month in Don Hoi Lot

TL	Jun -08	Jul -08	Aug -08	Sep -08	Oct -08	Nov -08	Dec -08	Jan -09	Feb -09	Mar -09	Apr -09	May -09	Total
No	138	116	138	157	124	76	114	39	128	101	101	118	1350
Max	7.98	8.58	8.87	8.38	7.06	7.54	7.58	7.26	8.02	7.42	7.78	7.68	8.87
Min	3.16	3.42	3.20	3.34	3.37	4.04	2.20	2.60	2.35	1.24	2.70	1.60	1.24
AVG	5.42	5.77	5.98	5.38	5.18	5.76	5.25	4.63	4.18	4.36	4.77	4.36	5.12
SD	0.73	1.10	1.06	1.08	0.89	0.63	1.29	1.32	1.22	1.17	0.89	0.88	1.19
Wt	Jun -08	Jul -08	Aug -08	Sep -08	Oct -08	Nov -08	Dec -08	Jan -09	Feb -09	Mar -09	Apr -09	May -09	Total
Max	12.45	15.46	10.43	9.83	9.66	10.99	16.42	8.84	16.68	12.92	15.61	12.25	16.68
Min	0.47	0.88	0.84	0.37	0.89	1.78	0.14	0.37	0.26	0.32	0.38	0.27	0.14
AVG	5.84	6.45	5.11	4.14	4.30	5.99	5.06	3.32	2.49	2.96	3.13	2.74	4.34
SD	2.20	3.42	2.06	2.04	2.04	1.87	3.26	2.67	2.67	2.36	2.05	1.69	2.72

Table 4.6: Number of specimens, maximum, minimum and average total length and weight of *S. strictus* in each month in Don Hoi Lot

TL	Jun -08	Jul -08	Aug -08	Sep -08	Oct -08	Nov -08	Dec -08	Jan -09	Feb -09	Mar -09	Apr -09	May -09	Total
No	18	10	52	76	30	35	25	32	13	30	7	16	344
Max	6.98	8.12	8.70	8.66	7.55	6.73	7.54	7.64	7.80	7.37	6.80	8.20	8.70
Min	4.60	4.24	5.49	4.20	3.65	4.98	4.10	3.16	3.42	3.41	3.64	2.10	2.10
AVG	5.41	6.47	6.51	5.78	5.09	5.86	5.98	5.20	5.64	5.28	4.89	5.67	5.73
SD	0.73	1.30	0.82	1.03	0.86	0.49	0.96	1.38	1.34	1.17	1.28	1.77	1.13
Wt	Jun -08	Jul -08	Aug -08	Sep -08	Oct -08	Nov -08	Dec -08	Jan -09	Feb -09	Mar -09	Apr -09	May -09	Total
Max	10.84	10.79	9.24	9.44	13.44	10.41	13.22	15.31	14.66	12.85	9.08	15.76	15.76
Min	1.64	2.44	3.03	2.18	1.39	3.71	2.22	0.88	1.02	1.10	1.22	0.96	0.88
AVG	5.18	7.79	6.18	4.76	4.28	6.24	6.71	4.56	7.02	4.86	3.93	6.95	5.49
SD	2.07	2.95	1.39	1.90	2.44	1.65	2.99	3.50	4.30	2.97	3.57	5.02	2.78

Table 4.7: Number of specimens, maximum, minimum and average total length and weight of *S. regularis* in each month in Don Hoi Lot

TL	Jun -08	Jul -08	Aug -08	Sep -08	Oct -08	Nov -08	Dec -08	Jan -09	Feb -09	Mar -09	Apr -09	May -09	Total
No	13	3	10	2	15	8	3	3	1	6	2	3	68
Max	5.86	6.54	7.50	4.57	7.18	5.80	6.74	7.08	6.86	7.20	5.82	3.68	7.50
Min	4.27	6.03	5.30	4.31	3.90	4.85	5.24	4.70	6.86	4.46	4.54	2.20	2.20
AVG	5.00	6.25	6.26	4.44	5.35	5.38	6.12	6.21	6.86	5.17	5.18	2.99	5.38
SD	0.43	0.26	0.83	0.18	0.87	0.34	0.78	1.32	0.00	1.01	0.91	0.75	1.00
Wt	Jun -08	Jul -08	Aug -08	Sep -08	Oct -08	Nov -08	Dec -08	Jan -09	Feb -09	Mar -09	Apr -09	May -09	Total
Max	8.39	9.05	6.25	2.49	8.03	6.55	8.95	9.98	7.34	9.81	6.20	1.69	9.98
Min	3.36	8.28	2.27	1.88	1.75	3.15	3.72	3.15	7.34	3.06	2.97	1.21	1.21
AVG	5.10	8.70	4.63	2.18	4.43	5.06	7.10	6.82	7.34	4.68	4.58	1.40	4.90
SD	1.33	0.39	1.15	0.44	2.05	1.06	2.93	3.45	0.00	2.55	2.28	0.25	2.13

4.2.2 Growth parameters

Due to the limitation of sample size of *S. regularis*, the growth parameters were only calculated for *S. corneus* and *S. strictus*. The size distribution of *S. corneus* and *S. strictus* was classified in 0.5-cm interval. Length frequency distribution of 12 months was used to predict growth parameters. The maximum length (L_{∞}) and K value were derived from automatic search routine by using POWELL-WETHERALL PLOT and ELEFAN-1 in FiSAT program. The age at length zero (t_0) of *S. corneus* and *S. strictus* was estimated from experiment on breeding of Razor clam studied by Sriprathumwong *et al.* (2002) which was within 4 hrs or -0.0004566 year for Razor clam to develop from egg stage to become trochophore stage.

The results of growth parameters of *S. corneus* and *S. strictus* were estimated the von Bertalanffy's Growth Function (VBGF) (Figure 4.16-4.17) as follows.

$$S. \text{ corneus: } L(t) = 9.61 (1 - e^{-0.51(t+0.0004566)})$$

$$W(t) = 23.76 (1 - e^{-0.51(t+0.0004566)})$$

$$S. \text{ strictus: } L(t) = 9.57 (1 - e^{-0.52(t+0.0004566)})$$

$$W(t) = 17.61 (1 - e^{-0.52(t+0.0004566)})$$

From the growth equation, it was found that the maximum total length and growth constant (K value) of *S. corneus* were 9.61 cm and 0.51 per year respectively. The growth rate of this species was about 0.31 cm per month within the first year age and later on decreased to 0.18 cm per month in the second year age. *S. corneus* would reach the maximum total length in about six years. In case of *S. strictus*, its maximum length 9.57 cm was reached within six years whereas its growth rate was equal to *S. corneus* (0.31 cm per month in the first year) (Figure 4.18-4.19).

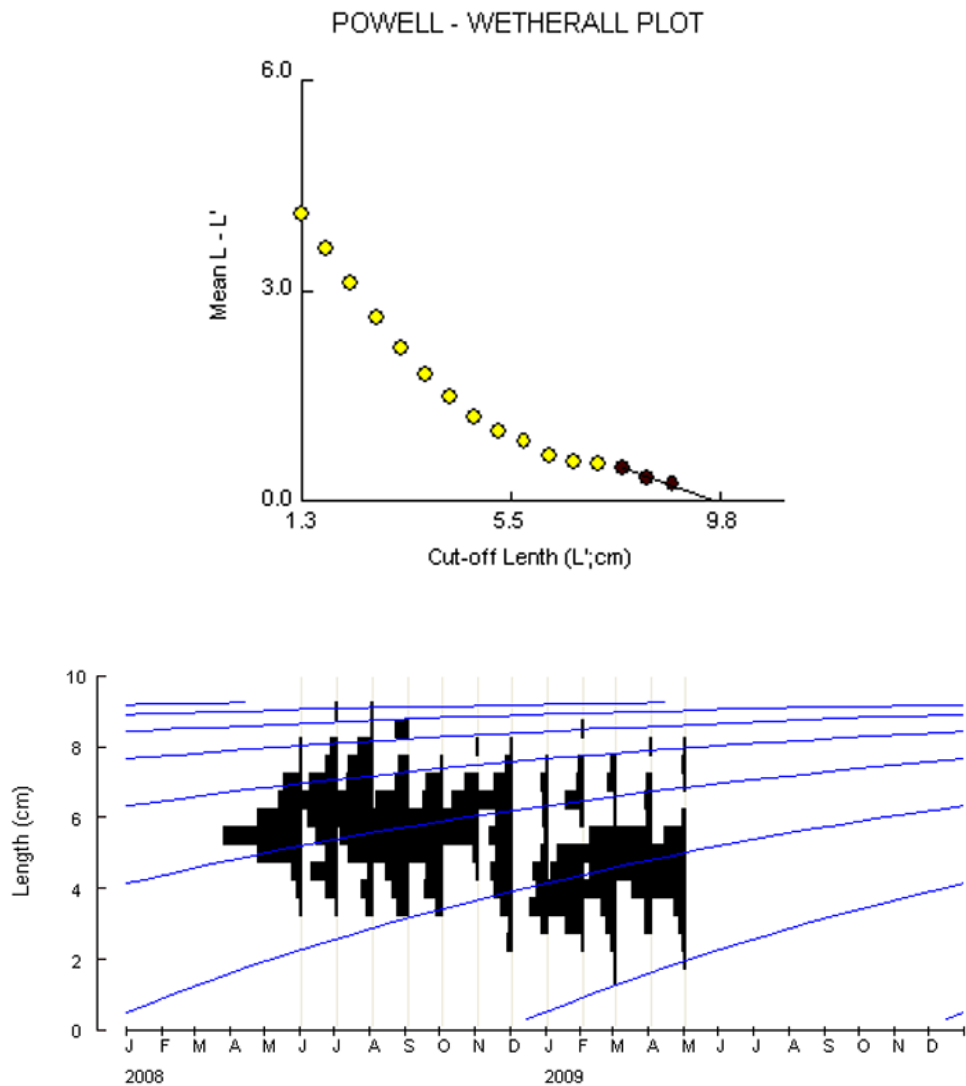


Figure 4.16: Estimation of maximum length by using POWELL-WETHERALL PLOT (above) and the VBGF of *S. corneus* in the Don Hoi Lot (below).

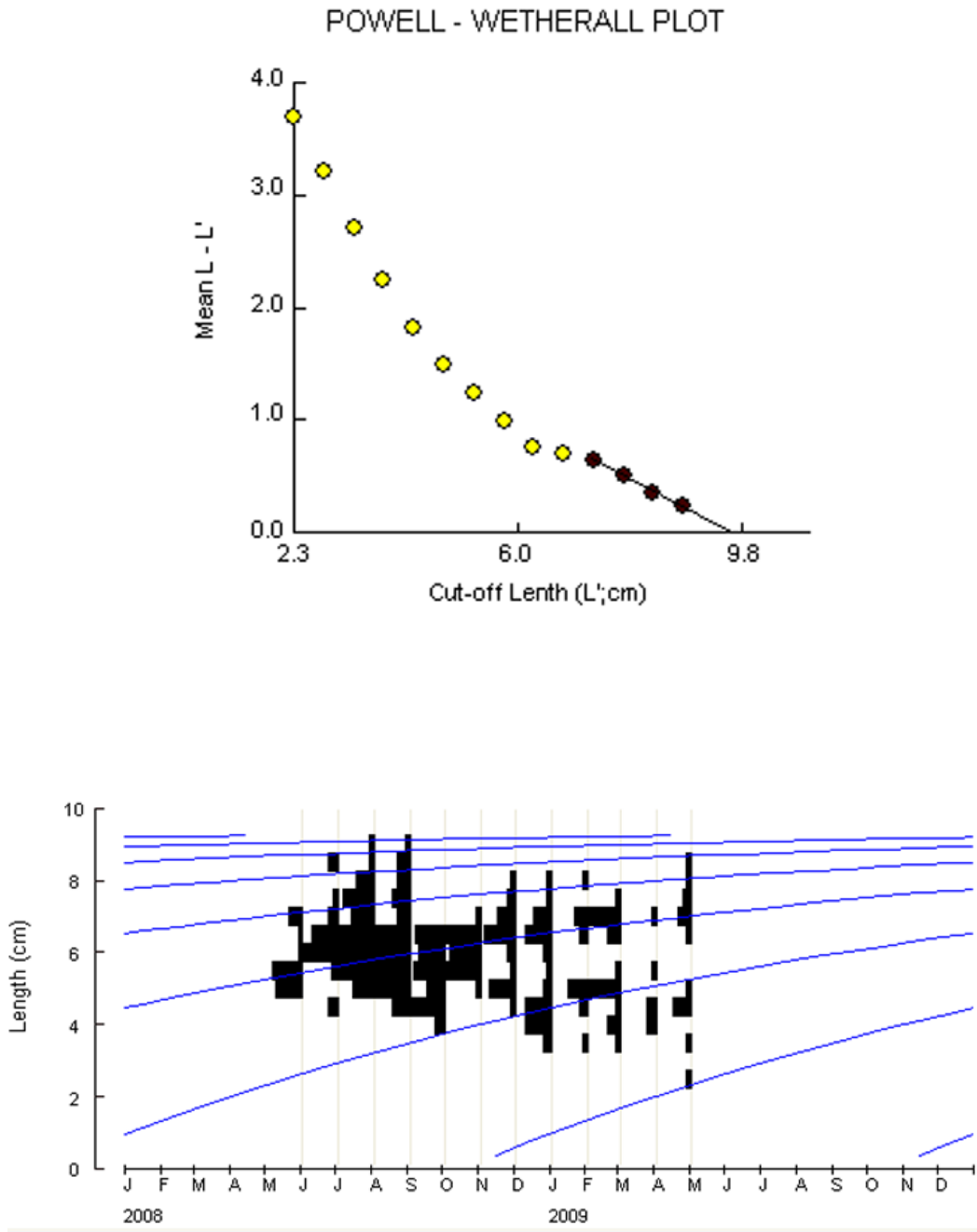


Figure 4.17: Estimation of maximum length by using POWELL-WETHERALL PLOT (above) and the VBGF of *S. strictus* in the Don Hoi Lot (below).

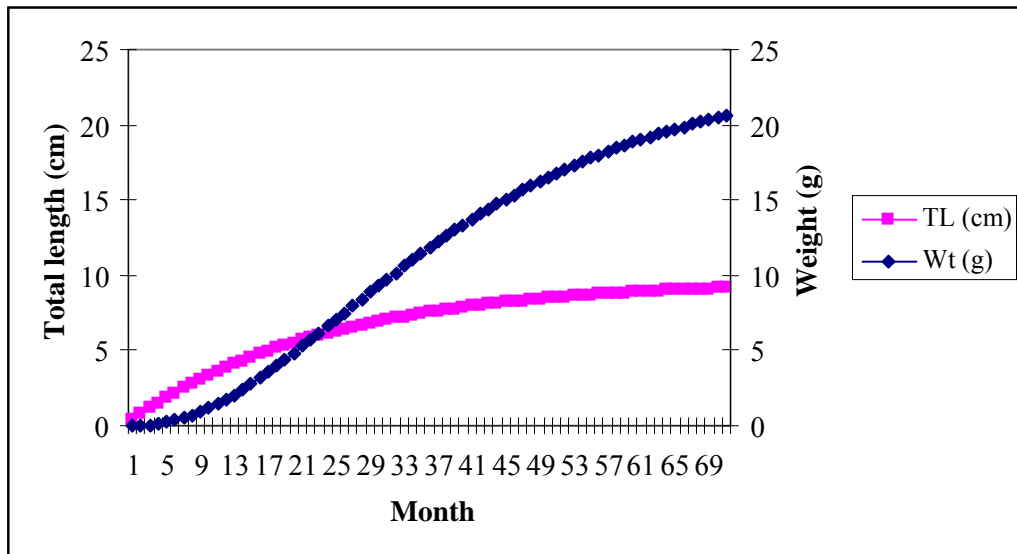


Figure 4.18: Growth model of total length and weight of *S. corneus* in Don Hoi Lot

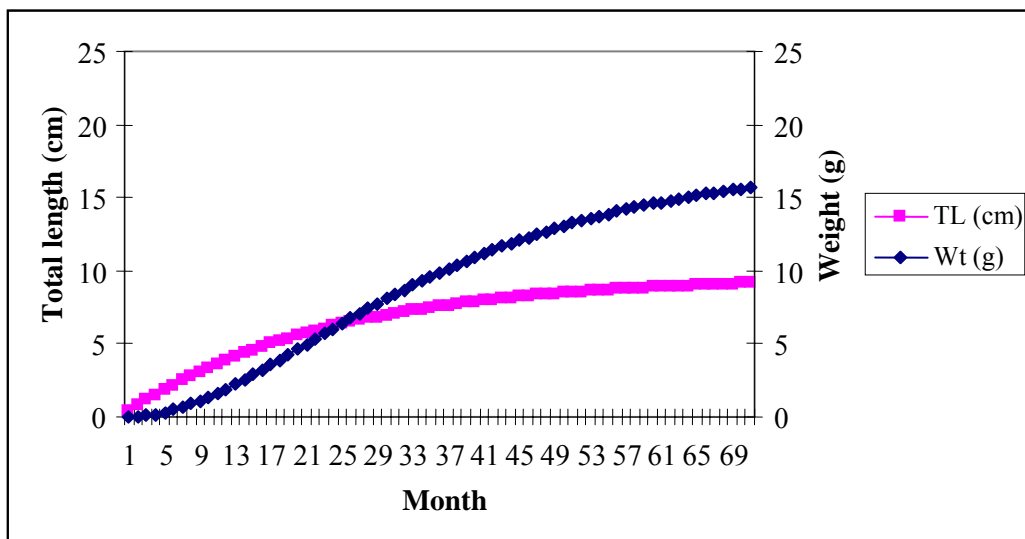


Figure 4.19: Growth model of total length and weight of *S. strictus* in Don Hoi Lot

4.2.3 Mortality coefficient (M) and exploitation rate (E)

The mortality coefficients of *S. corneus* and *S. strictus* were calculated by Pauly’s empirical formula (FAO, 1983) using L_{∞} and K value derived from growth parameters. The average annual water temperature during the study period (29.4 °C) was used in the equation as below:

$$\log (M) = - 0.0066 - 0.279 \log (L_{\infty}) + 0.6543 \log (K) + 0.463 \log (T)$$

Fishing mortality (F) could be estimated by the difference between the natural mortality coefficient (M) and the total mortality efficient (Z). Z values of *S. corneus* and *S. strictus* were calculated according to method of Jone and van Zalinge (1981) which were 3.678 and 2.945 respectively (Figure 4.20-4.21) whereas M were 1.613 and 1.717 respectively and Z were 2.065 and 1.228 respectively.

Exploitation rate of *S. corneus* and *S. strictus*, calculated by dividing F by Z, were 0.56 and 0.42 respectively (Table 4.8). The appropriate exploitation rate should be close or equal to 0.5 indicating that the utilization of that fish species was close to the maximum production. The results revealed that exploitation rate of *S. corneus* at Don Hoi Lot were over exploitation whereas utilization of *S. strictus* was still within the optimal use.

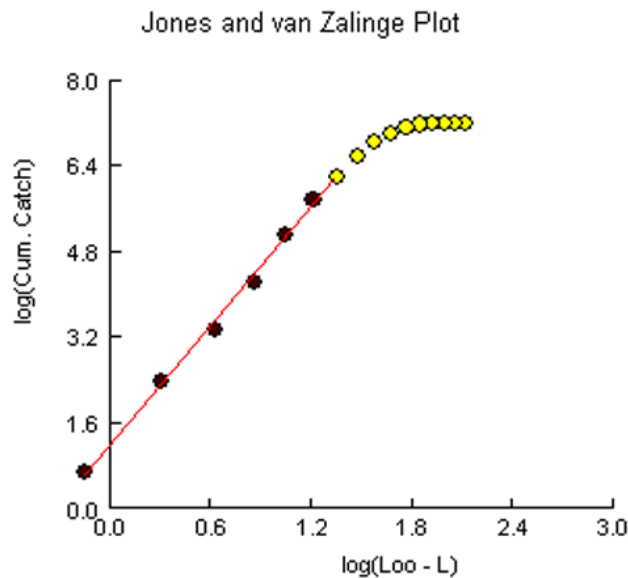


Figure 4.20: Estimation of Z value of *S. corneus* in Don Hoi Lot

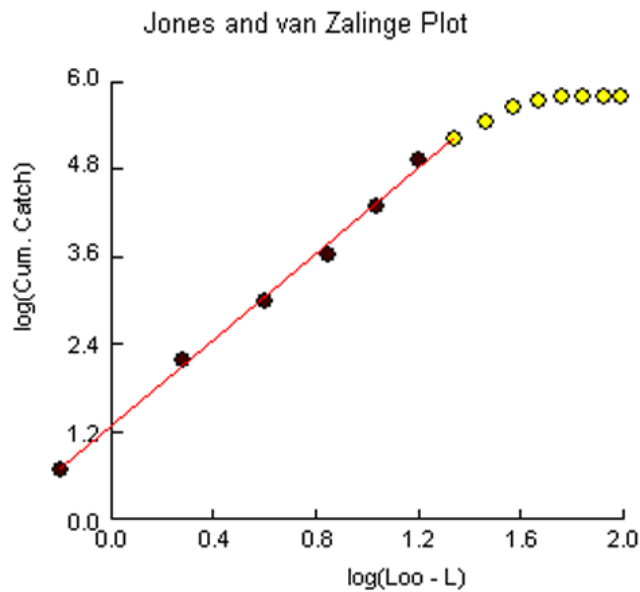


Figure 4.21: Estimation of Z value of *S. strictus* in Don Hoi Lot

Table 4.8: Fishing mortality coefficient (F), natural mortality coefficient (M), total mortality efficient (Z) and exploitation rate (E) of *S. corneus* and *S. strictus*.

Species	F (year ⁻¹)	M (year ⁻¹)	Z (year ⁻¹)	E
<i>S. corneus</i>	2.065	1.613	3.678	0.56
<i>S. strictus</i>	1.228	1.717	2.945	0.42

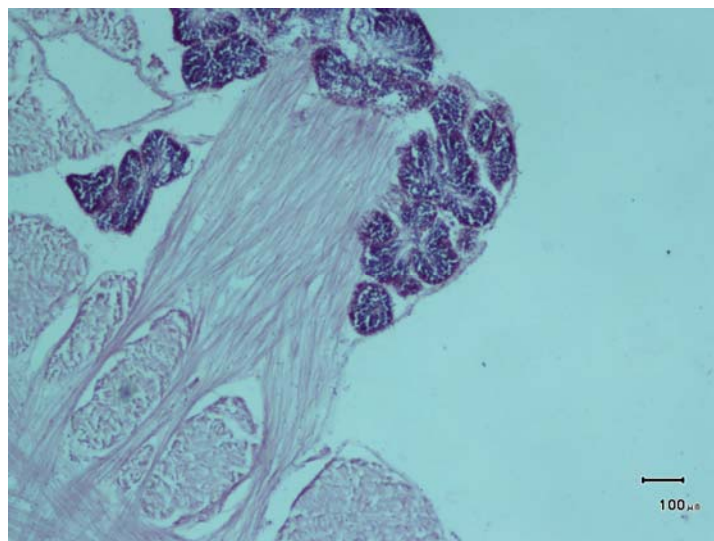
4.3 Reproductive biology

In this part, the only dominant species of Razor clams (*S. corneus*) was analyzed in term of its reproductive biology.

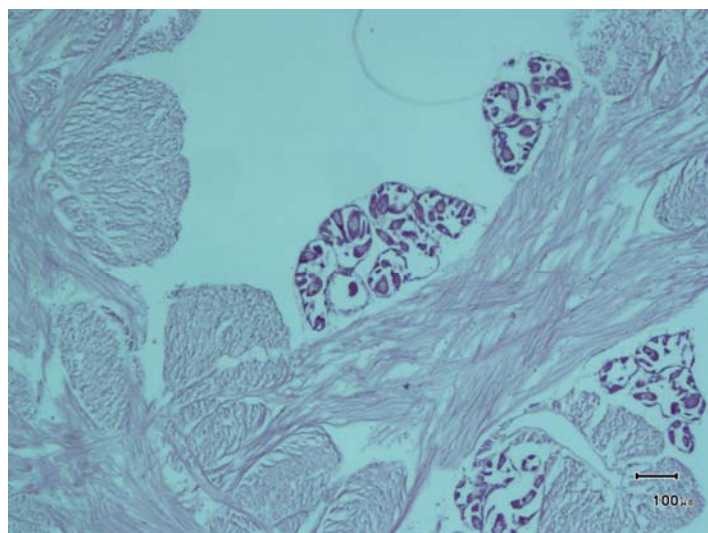
4.3.1 Sexual characteristics

It was difficult to identify sex organ from external observation, thus 301 specimens of *S. corneus* were examined by dissecting their reproductive organ to identify male and female during June 2008 to May 2009 (Figure 4.22). Average total length of male and female ranged from 3.97 to 7.58 cm and 4.00 to 7.76 cm respectively. The average total length of male and female in each month was shown in

Figure 4.23. A small part of the gonad was taken from the part covering the anterior adductor muscle, dissected by microtome in 5 μm -thick and fixed for internal sex organ study. The results indicated that 103 individuals (34 % of total specimens) were male whereas 60.13, 1.33 and 4.32 % were female, hermaphrodite and unidentified. The average sex ratio between male and female was 1: 1.76. It was observed that the percentage of male was always low comparing with female during June 2008 to February 2009 whereas it increased its proportion during March 2009 to May 2009 (Table 4.9 and Figure 4.24).



(A)



(B)

Figure 4.22: Photomicrographs showing male (A) and female (B) sex organ of *S. corneus*

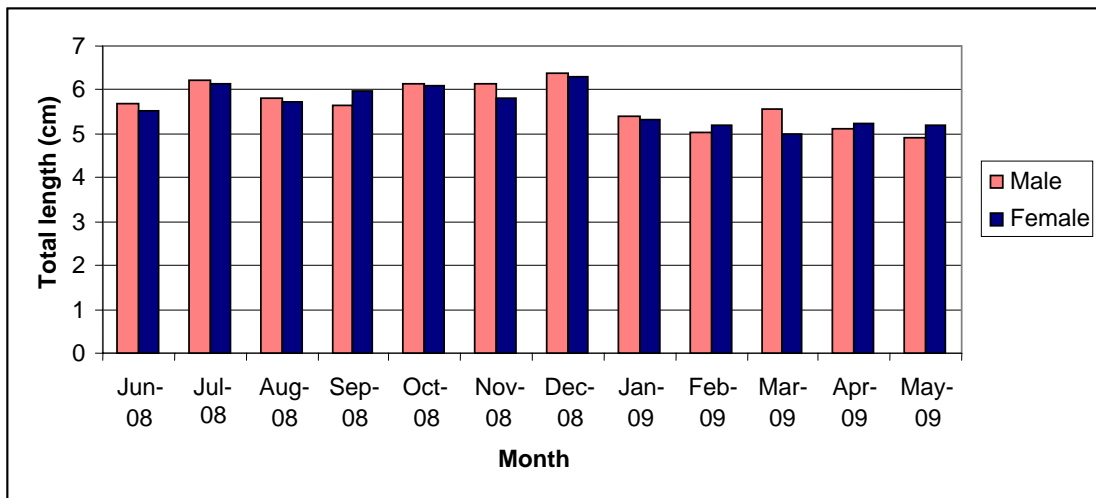


Figure 4.23: Average total length of male and female of *S. corneus* in each month in Don Hoi Lot during June 2008-May 2009

Table 4.9: Ratio of male, female and hermaphrodite of *S. corneus* in each month in Don Hoi Lot during June 2008-May 2009

Month	Total number	Male	Female	Hermaphrodite	Unidentified	Male: Female
Jun-08	31	9	22			1:2.44
Jul-08	30	12	18			1:1.50
Aug-08	26	8	14	2	2	1:1.75
Sep-08	28	9	18		1	1:2.00
Oct-08	29	10	17		2	1:1.70
Nov-08	30	9	21			1:2.33
Dec-08	31	7	22	2		1:3.14
Jan-09	17	3	12		2	1:4.00
Feb-09	21	6	13		2	1:2.17
Mar-09	19	11	8			1:0.73
Apr-09	18	10	8			1:0.80
May-09	21	9	8		4	1:0.89
Total (average)	301 (100)	103 (34.22)	181 (60.13)	4 (1.33)	13 (4.32)	(1:1.76)

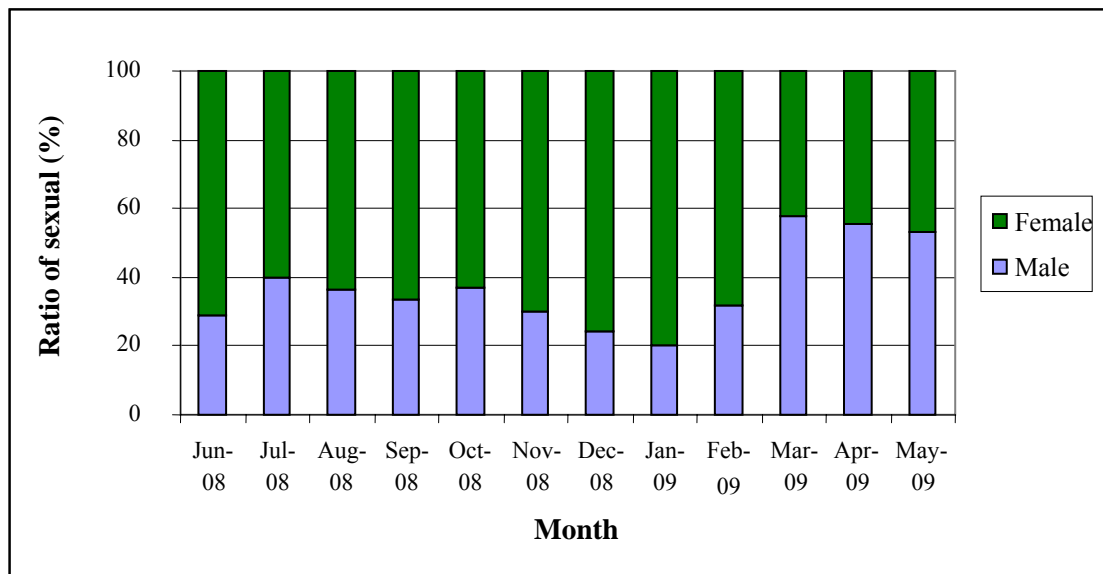


Figure 4.24: Ratio of male and female of *S. corneus* in each month in Don Hoi Lot during June 2008-May 2009

4.3.2 Spawning season

The monthly egg stages from 181 females of *S. corneus* were observed. Tuaychareon and Voraingtara (1991) separated egg development into six stages, therefore this study also established a six-stage gametogenic scale: (I) prefollicular stage, (II) initial development stage, (III) advance development stage, (IV) mature stage, (V) partially spawned stage and (VI) spent stage. This study concentrated on the spawning season which was mainly in stage IV and V (Tuaychareon and Voraingtara, 1991), therefore stage II and III were combined into the same stage (Figure 4.25). The results revealed that the lowest total length of female was the egg at stage IV (mature stage) was 4.00 cm in June 2008. In Table 4.10 and Figure 4.26-4.27, the maturation period of *S. corneus* (stage IV) occurred in two peaks which were June 2008 to July 2008 and May 2009 for the first peak (40-83.6 %) and September 2008 to November 2008 for second peak (22.7-30.0%) whereas spawning period (stage V) was found in almost every month except in April 2009. The high peak of spawning period was reached during July (25.3%) to December 2009 (63.2 %) and February 2009 (23.1 %) to March 2009 (25.0%). The highest spent time occurred in August 2008 (67.9 %) and followed by October 2008 (52.9 %) and February 2009 (32.3%). It was observed that, there was no spent stage of *S. corneus* during June 2008 to July 2008.

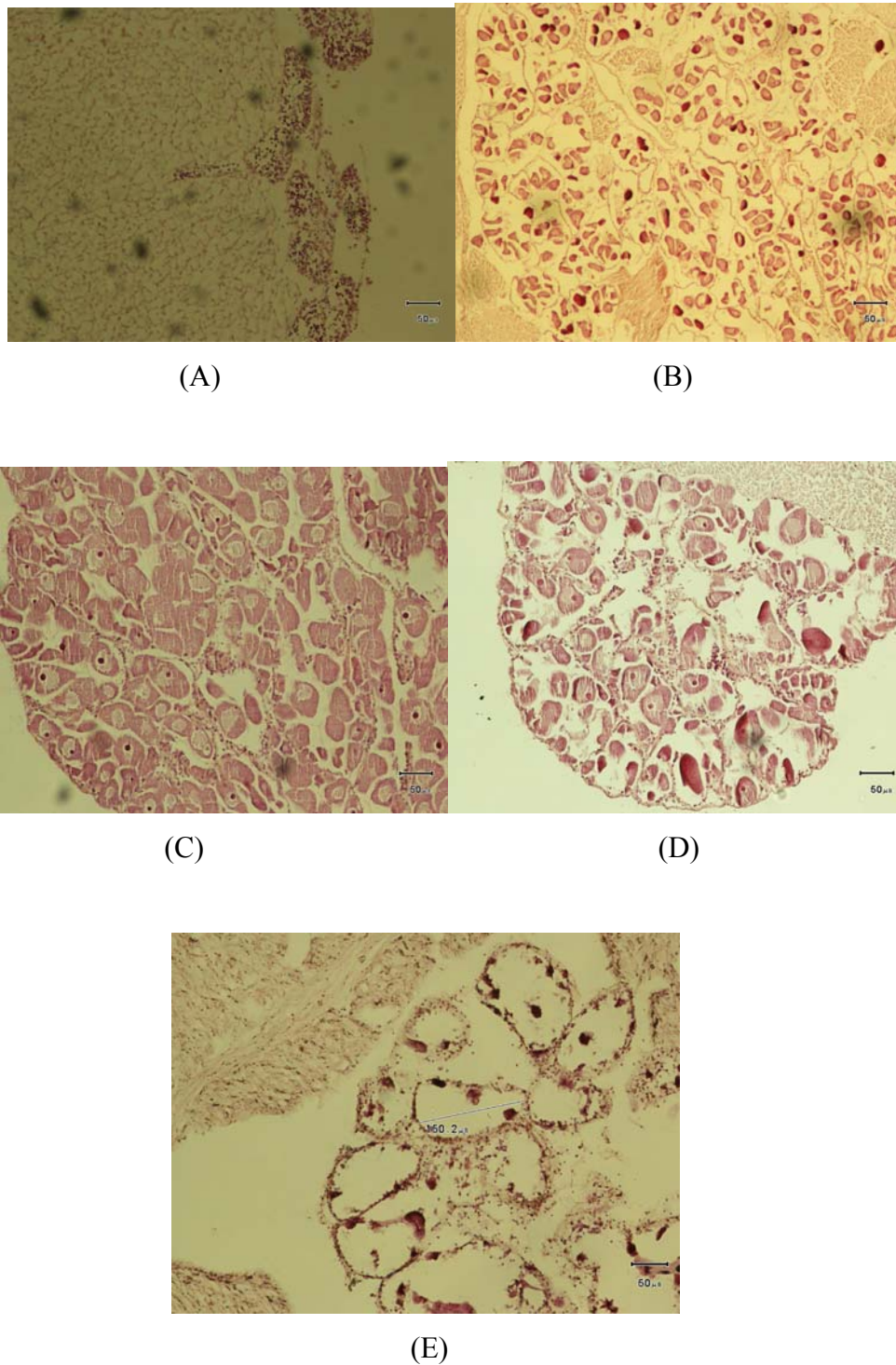


Figure 4.25: Development of six egg stages of *S. corneus* : prefollicular development-stage I (A), initial-stage II & development-stage III (B), mature egg-stage IV (C), partially spawning-stage V (D) and spent-stage VI (E)

Table 4.10: Total length and egg stage of *S. corneus* in each month in Don Hoi Lot

Month	Male (TL)				Female (TL)				Egg stage (%)				
	Max	Min	AVG	SD	Max	Min	AVG	SD	I	II&III	IV	V	VI
Jun-08	6.56	5.23	5.70	0.50	6.85	4.00	5.55	0.71	0.0	9.1	83.6	7.3	0.0
Jul-08	7.09	5.03	6.21	0.72	7.76	4.70	6.15	0.82	0.0	20.5	53.7	25.3	0.5
Aug-08	6.18	5.17	5.80	0.31	6.44	4.93	5.71	0.43	0.0	0.0	5.7	26.4	67.9
Sep-08	6.14	4.57	5.63	0.48	6.97	5.35	6.00	0.35	0.0	17.2	30.0	44.4	8.3
Oct-08	7.06	5.28	6.12	0.57	6.92	5.19	6.08	0.52	0.0	5.9	22.9	18.2	52.9
Nov-08	6.66	5.64	6.15	0.34	6.88	5.09	5.80	0.50	0.0	24.3	25.7	45.2	4.8
Dec-08	7.58	3.97	6.40	1.02	7.15	5.12	6.32	0.49	0.0	0.9	1.8	63.2	34.1
Jan-09	6.95	4.49	5.39	1.36	6.68	4.20	5.34	0.97	65.8	9.2	5.0	3.3	16.7
Feb-09	6.72	3.69	5.04	1.22	6.77	4.02	5.22	1.02	7.7	24.6	12.3	23.1	32.3
Mar-09	6.84	4.68	5.57	0.79	5.29	4.58	4.97	0.21	0.0	37.5	12.5	25.0	25.0
Apr-09	5.69	4.70	5.10	0.32	5.74	4.97	5.24	0.25	2.5	85.0	0.0	0.0	12.5
May-09	5.85	4.05	4.90	0.62	7.10	4.10	5.19	0.92	0.0	31.3	40.0	16.3	12.5

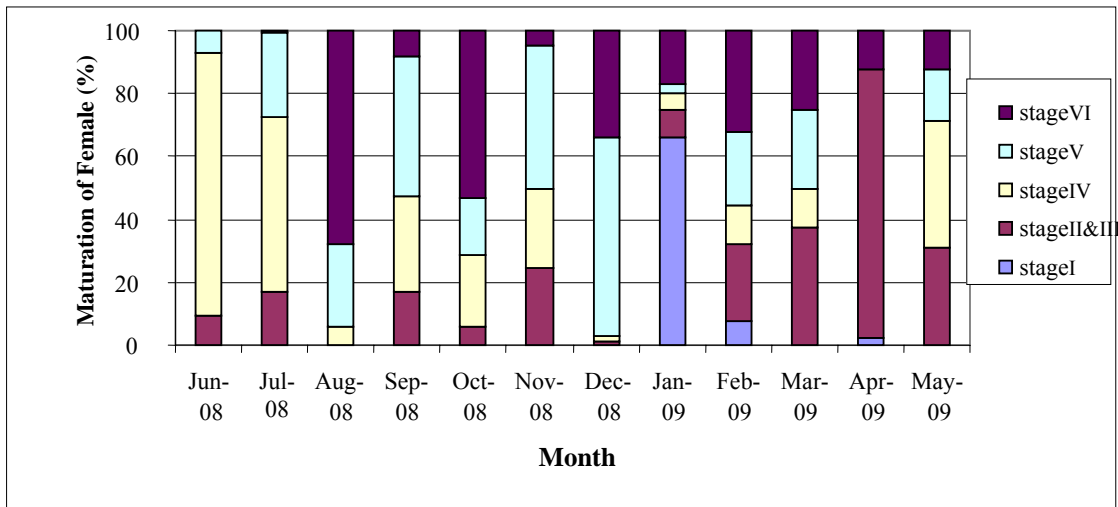


Figure 4.26: Egg stage of *S. corneus* in each month in Don Hoi Lot

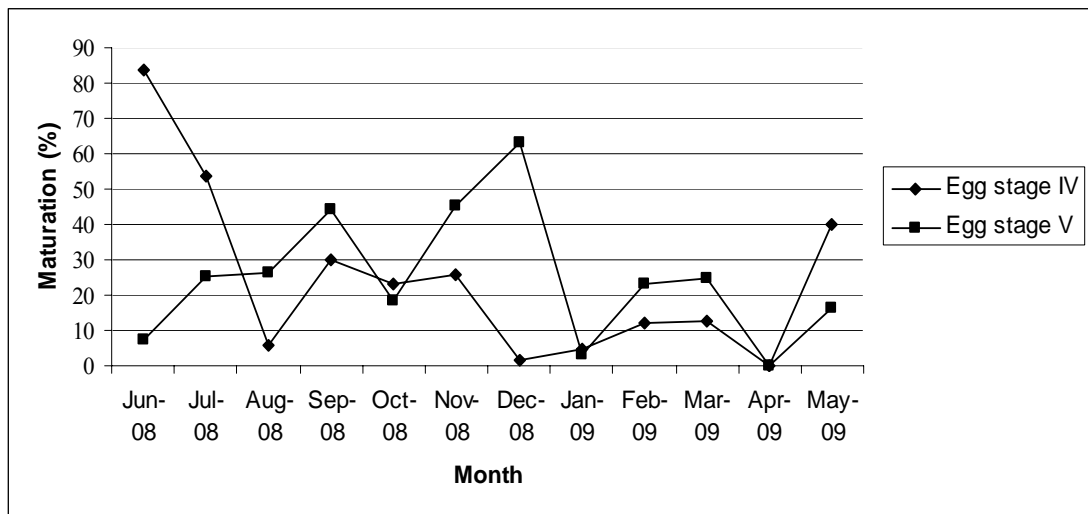


Figure 4.27: Annual variation of egg stage IV & V of *S. corneus* in Don Hoi Lot

4.4 Stomach content

Due to limitation of number of specimens therefore the study in this aspect was only conducted in dominant species (*S. corneus*). 68 specimens collected in each month were analyzed for their stomach content under the microscope. Total length of specimens ranged from 3.24 cm to 7.76 cm and averaging 6.12 ± 0.79 cm. All individuals of phytoplankton in the stomach were counted on monthly basis and classified based on each class size of Razor clams. In overall, there were five classes of phytoplankton found in stomach of *S. corneus* which were cyanophyceae, chlorophyceae, euglenophyceae, bacillariophyceae and dinophyceae. The majority of phytoplankton found in Razor clam stomach was diatoms (94.37%), followed by blue green algae (2.81%) and green algae (2.06%)(Figure 4.28). 25 genera of phytoplankton were recorded and the dominant species were *Thalassiosira spp.* (50.66%), followed by *Thalassionema frauenfeldii* (10.32%) and *Coscinodiscus spp* (9.01%). The abundance (percentage) and photos of phytoplankton genera found in the Razor clam stomach was presented in Figure 4.29-4.30.

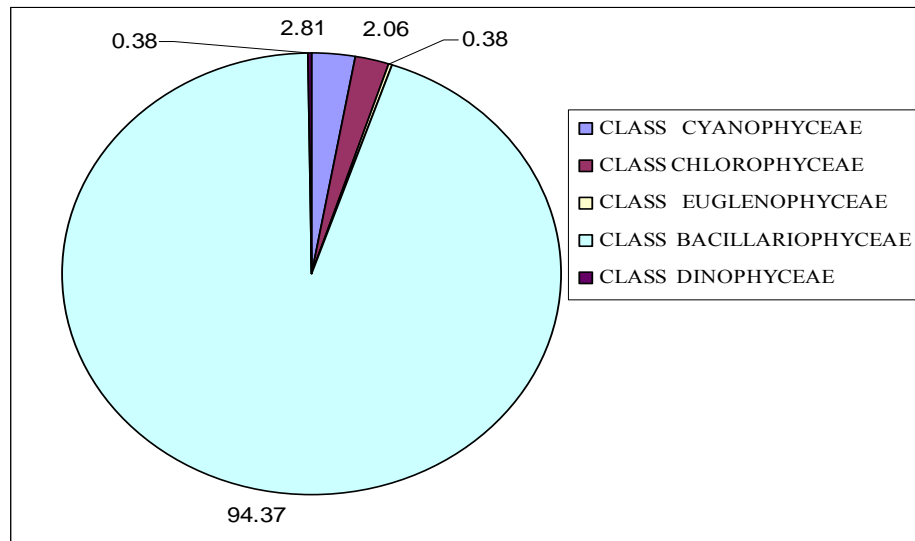


Figure 4.28: Species composition of Phytoplankton (classes) in stomach of *S. corneus* in Don Hoi Lot

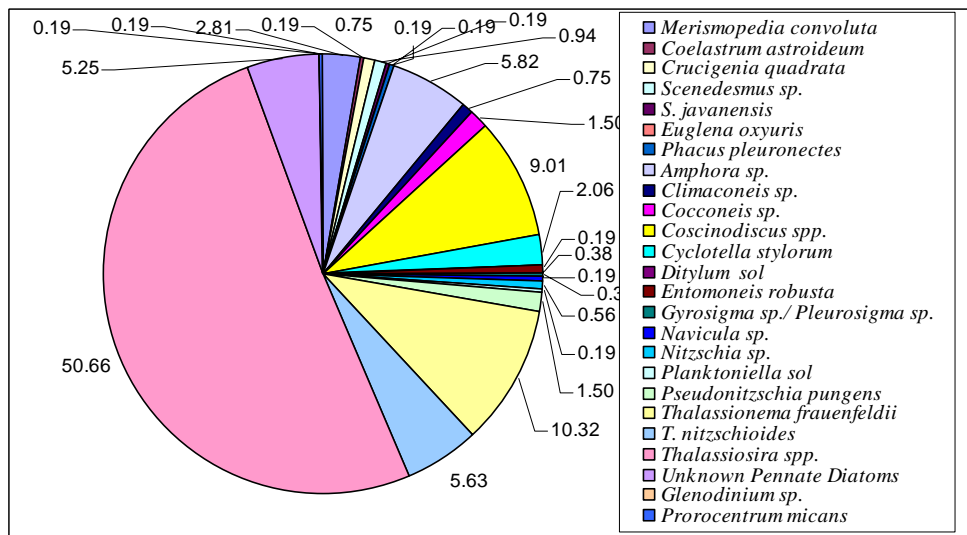


Figure 4.29: The abundance (percentage) of phytoplankton (genera) found in the stomach of *S. corneus* in Don Hoi Lot.

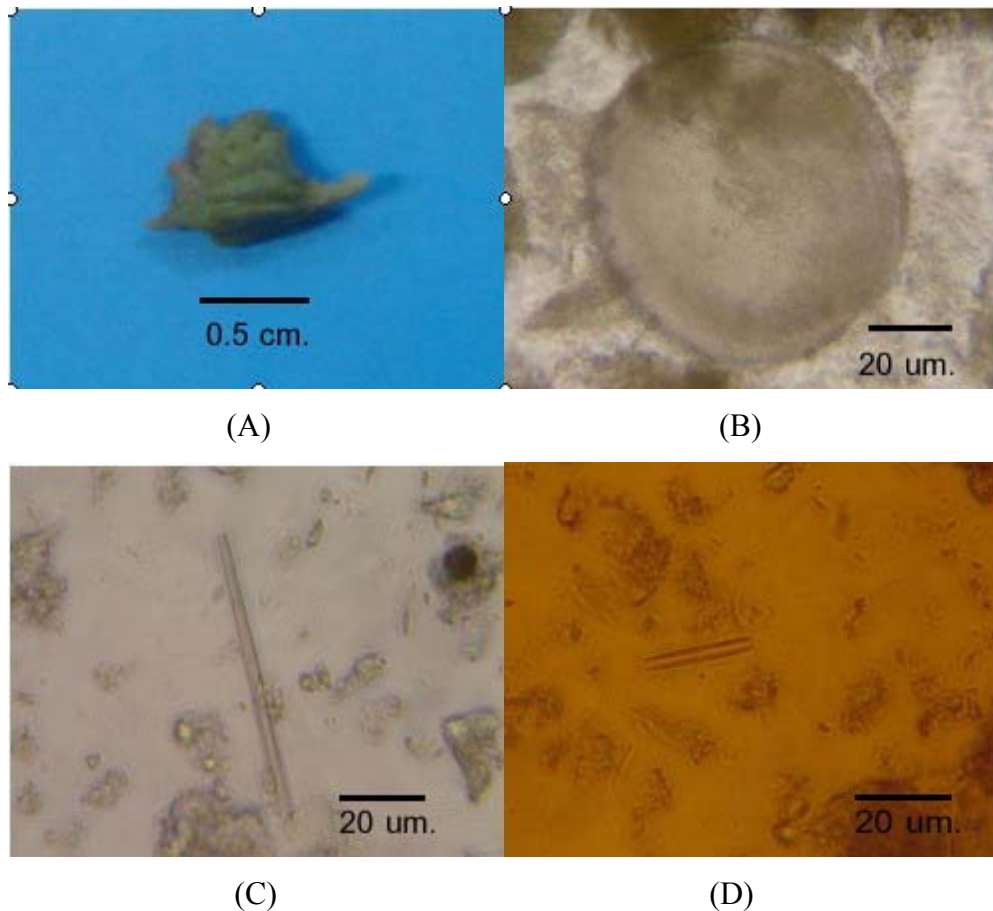


Figure 4.30: Phytoplankton's found in stomach of *S. corneus* (A) such as *Coscinodiscus* sp. (B), *Thalassionema frauenfeldii*(C) and *Thalassionema nitzschioides* (D).

In term of annual variation of phytoplankton (individuals) in the stomach in each month, the results showed that high density of phytoplankton found in October 2008 and November 2008 whereas *Thalassiosira* spp. was the dominant species found in every month in the stomach content (Figure 4.31). The species composition was 14 in October 2008, followed by June 2008 (11 species), and November 2008 (10 species) (Figure 4.32).

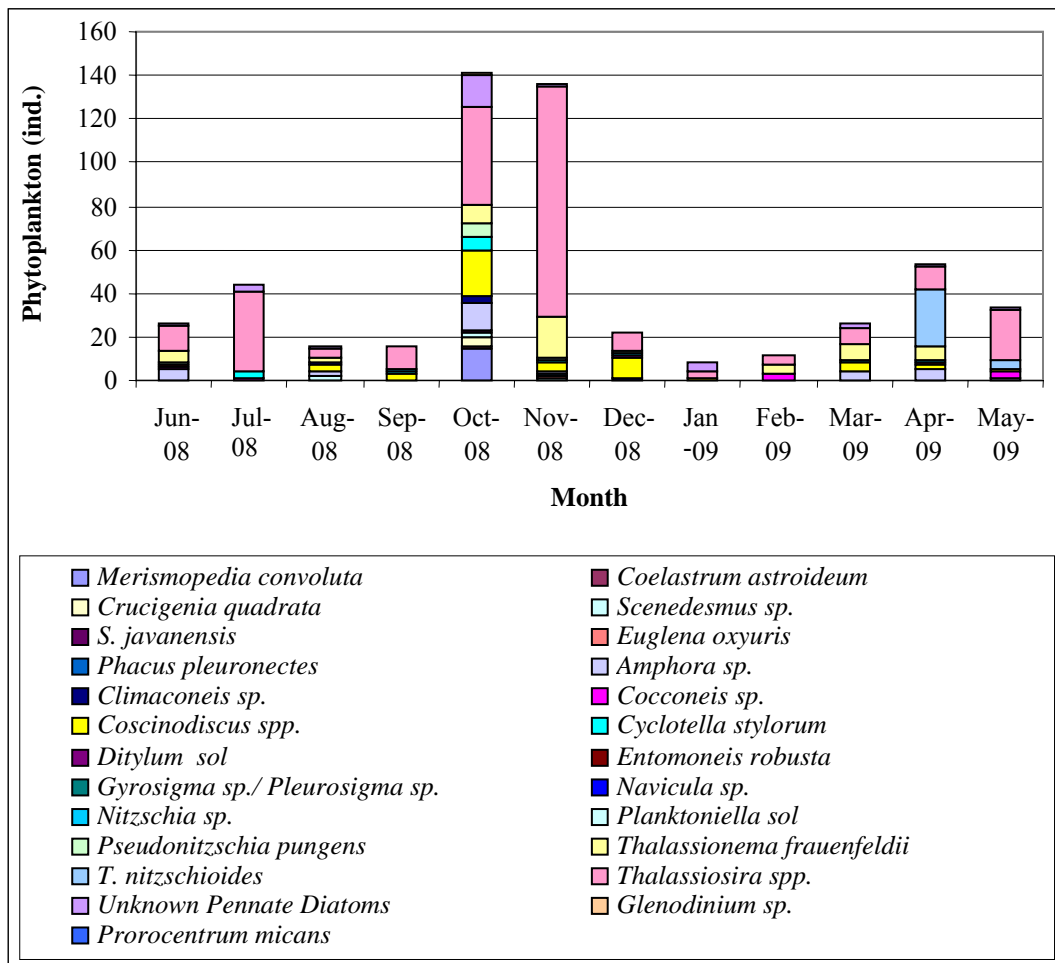


Figure 4.31: Annual variation of phytoplankton (individuals) in stomach of *S. corneus* in each month in Don Hoi Lot.

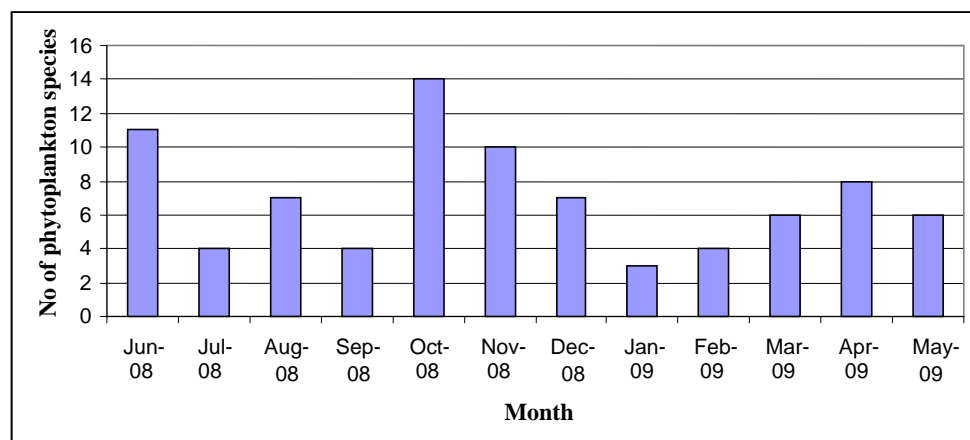


Figure 4.32: Annual variation of phytoplankton species composition in stomach of *S. corneus* in each month in Don Hoi Lot.

68 specimens of *S. corneus* were classified into five different sizes of total length (3-4, >4-5, >5-6, >6-7 and >7-8 cm). Dominant species of phytoplankton found in the stomach of all sizes of specimens were *Thalassiosira* spp. and *Thalassionema frauenfeldii* ranging from 33.3 to 81.8 % and 5.3 to 20 % respectively. There were 19 phytoplankton species found in the stomach of *S. corneus* at 6-7 cm size, followed by 13 species in 5-6 cm size. Only 3 species, *Thalassiosira* spp., *Thalassionema frauenfeldii* and *Cocconeis* sp., were found in the stomach of small size of clams (3-4 cm) (Table 4.11).

Table 4.11 Phytoplankton species composition in stomach content of *S. corneus* of five different sizes in Don Hoi Lot (values indicate percent of clams containing phytoplankton species)

NO.	Species composition (%)	Size of <i>S. corneus</i> (cm)				
		3-4	>4-5	>5-6	>6-7	>7-8
1	<i>Merismopedia convoluta</i>					26.3
2	<i>Coelastrum astroideum</i>			0.9		
3	<i>Crucigenia quadrata</i>					7.0
4	<i>Scenedesmus</i> sp.			0.9	1.2	
5	<i>S. javanensis</i>			0.9		
6	<i>Euglena oxyuris</i>				0.3	
7	<i>Phacus pleuronectes</i>				0.3	
8	<i>Amphora</i> sp.		8.6	9.3	5.6	
9	<i>Climaconeis</i> sp.				0.3	5.3
10	<i>Cocconeis</i> sp.	9.1	5.7	0.9	1.2	
11	<i>Coscinodiscus</i> spp.		8.6	4.6	12.1	1.8
12	<i>Cyclotella stylorum</i>			0.9	3.1	
13	<i>Ditylum sol</i>				0.3	
14	<i>Entomoneis robusta</i>			0.9	0.3	
15	<i>Gyrosigma</i> sp./ <i>Pleurosigma</i> sp.		2.9		0.3	
16	<i>Navicula</i> sp.				0.3	
17	<i>Nitzschia</i> sp.			1.9	0.3	

Table 4.11: Phytoplankton species composition in stomach content of *S. corneus* of five different sizes in Don Hoi Lot (values indicate percent of clams containing phytoplankton species) (cont.).

NO.	Species	Size of <i>S. corneus</i> (cm)				
		3-4	>4-5	>5-6	>6-7	>7-8
18	<i>Planktoniella sol</i>				0.3	
19	<i>Pseudonitzschia pungens</i>				2.5	
20	<i>Thalassionema frauenfeldii</i>	9.1	20.0	13.9	9.0	5.3
21	<i>T. nitzschioides</i>			27.8		
22	<i>Thalassiosira spp.</i>	81.8	48.6	33.3	55.9	49.1
23	<i>Unknown Pennate Diatoms</i>		5.7	3.7	5.9	5.3
24	<i>Glenodinium sp.</i>				0.3	
25	<i>Prorocentrum micans</i>				0.3	
Number of phytoplankton species		3	7	13	19	7
Number of observed Razor clams		2	3	21	39	3

4.5 Discussion and conclusion

4.5.1 Species composition

According to Tuaycharoen and Voraingtara (1991), in the past, many research related to Razor clams in Samut Songkhram Province identified Razor clam species in different scientific names, for instance *S. grandis* by Department of Fisheries in 1969 and Davison in 1977, *S. regularis* and *S. vitreus* by Pradatsundarasar in 1982, *S. strictus* by Tuaycharoen in 1991 and *S. regularis* by Worrapiumphong in 2005 (Worrapiumphong, 2005). The results of this study was the first record that identified species composition of Razor clams existing in Don Hoi Lot. Tuaycharoen and Kongrabeab (2005) reported that there were four species (*S. corneus*, *S. strictus*, *S. regularis* and *S. thailandicus*) found in Don Hoi Lot, whereas this study found only three species of Razor clams (*S. corneus*, *S. strictus* and *S. regularis*). In term of spatial distribution in three zones, this research findings indicated that the dominant species in all zones was *S. corneus* averaging 76 %, followed by *S. strictus* (20 %). It

was difficult to differentiate Razor clam species from one species to another by examining external characteristics when they were still alive or moveable. Difference of tentacle characteristics was quite useful to identify Razor clam species in this research. In term of annual variation, *S. corneus* was the majority species in all months. They were found year round while the ratio of *S. strictus* likely increased in January.

4.5.2 Abundance, distribution and assemblage structure of Razor clams

The results of this research revealed that at present the density of Razor clams in Don Hoi Lot was very low comparing with the past studies (less than 1 individual/ m²) in Don Na San. In 2007, Tantanasarit reported that the density of Razor clams was 3.02 individuals/ m² comparing to 37.3 individuals/ m² reported by Tuaycharoen and Voraingtara (1991). It meant that the population of this mollusk decreased very rapidly. In terms of spatial and temporal distribution, the majority species of Razor clams were *S. corneus*, followed by *S. strictus*. There were five stations that could not collect specimens, namely S2, S5, S6, S7 and S8. Most stations were occupied by *S. corneus* except S1, S12 and S24 where *S. strictus* were the dominant. There were two stations (S13 and S30) that only *S. corneus* was found (100 %). This supported the hypothesis and can be concluded that spatial and temporal distributions of Razor clam species in Don Hoi Lot are not homogeneous.

4.5.3 Population dynamics of Razor clams in Don Hoi Lot

Length-weight relationship of three Razor clams was calculated and it was found that their growth patterns were allometric. This result supported the study of Worrapiumphong (2005) and Tuaycharoen and Charoenporntip (1995). Razor clam was an invertebrate which b value was not equal to 3, which was similar to other mollusks such as *Perna viridis* (b value 2.78) and *Paphia undulate* (b value 2.76). It could be concluded that the growth patterns of mollusks along the coastline were allometric. K value in the growth equation of *S. corneus* and *S. strictus* were 0.51 and 0.52 per year comparing to 1.5 per year of *S. strictus* reported by Tuaycharoen and Charoenporntip in 1995. K value might vary depending on changing environment factors and sampling

site. If the K value was low, it meant that such aquatic animal would spend more time to reach the maximum length (L_{∞}), therefore an opportunity for them to become closer to extinct was higher (Chaidee, 2009). This research found that the growth rate of Razor clams was lower than the study of Tuaycharoen and Charoenporntip in 1995. In term of exploitation rate (E), E value of *S. corneus* (0.560) was similar to the study of Tuaycharoen and Charoenporntip (0.558). Both figures were over than 0.5, therefore utilization of Razor clams in Don Hoi Lot was over harvesting. In case of growth rate of *S. corneus* and *S. strictus*, this research revealed that they grew very slow comparing to the results studied by Ruffolo *et al.* (1999) and Tuaycharoen and Charoenporntip (1995). When comparing the result of this research and Sriprathumwong *et al.* (2002). Similar result was found that at aging of 54 days or 2 months, the size of Razor clam reached to 2,000 micron or 0.2 mm of total length.

4.5.4 Reproductive biology

Average sex ratio between male and female of *S. corneus* was 1:1.76. Number of male was less than female. This result supported by Tuaycharoen and Voraingtara (1991). In this research, average percentage of hermaphrodite (1.33 %) was found, similar to 1.3 % found by Tuaycharoen and Voraingtara in 1991. For development of egg stages, it was found that maturation of *S. corneus* appeared from May to July or the beginning of rainy season until November, whereas the high peak of maturity studied by Tuaycharoen and Voraingtara in 1991 occurred in September and November which was also similar result. Spawning season was peaked in September and December which was the same period, whereas Pradatsundarasar *et al.* (1989) suggested that the spawning season of Razor clam had two periods starting from March to April for the first time and July to August for the second time. In conclusion, the reproductive cycle of *S. corneus* was an annual cycle, comprising a rest phase (stage I) from January to February and followed by the beginning of development of gonad (stage II & III) starting in December and gradually increased and reached the highest peak in April. The mature egg (stage IV) developed into two peaks during May to July and September to November. In this research, *S. corneus* had a prolonged spawning period while two high peaks were found in September and December. Thus the reproductive cycle of this mollusk might be different from others

in the same genus due to diversified environmental conditions and habitats (Darriba *et al.*, 2004). For instance, the spawning season of Razor clam (*Sinonovacula constricta*) in China was closely related to water temperature variation therefore the same species in different localities tended to spawn at different times. In Fujian province, its spawning season occurred between September to January, while in Liaoning province starting at the end of June and one female could release eggs 3-4 time in spawning season at the interval of about two weeks (JiaXin, 1990).

4.5.5 Stomach content

There were five classes and 25 phytoplankton genera found in stomach content of *S. corneus*. Diatoms were dominant phytoplankton in particular *Thalassiosira* spp., followed by *Thalassionema frauenfeldii* and *Coscinodiscus* spp. This result was supported by Boutong (1997) that diatoms *Coscinodiscus*, *Planktoniella*, *Nitzcia* and *Heterothrix* were observed in the stomach content of *S. regularis* and *S. vitreus*. Diatoms were found in the stomach in every month and in the high proportion comparing to others especially in October and November due to intensive nutrients released from inlands (Boutong, 1997). In the small size of *S. corneus* (at 3-4 cm total length), there were only three species of phytoplankton found in the stomach. It was observed that number of phytoplankton species found in the stomach varied positively with the size of Razor clams. For instance at total length of 4-5, 5-6 and 6-7 cm, the number of phytoplankton were 7, 13 and 19 species, respectively. Therefore the size of phytoplankton might be one of several factors that affected Razor clam feeding habit. These observations were supported by Boutong (1997) reporting that phytoplankton found in the stomach content of *S. regularis* and *S. vitreus* were small size. Furthermore the shape of phytoplankton might impact feeding behavior of Razor clam as well. JiaXin (1990) studied on feeding habit in China and observed that even though Razor clams were filter feeders but they could mechanically select food particle and the major food organisms in their stomach were benthic diatoms such as *Nitzschia* sp and *Coscinodiscus* sp while there were only few spiny species found in the stomach content. This was also supported by Boutong (1997).

CHAPTER V

ENVIRONMENTAL CHARACTERISTICS AT DON HOI LOT

This chapter presents the results of environmental characteristics. It describes hydrological conditions, physical factors and soil characters, chemical factors and water quality, and biological factors and their interactions. General discussion and conclusion are at the end of the chapter. Spatial and temporal variation of these environmental factors was discussed. Spatial variation at Don Hoi Lot study site was investigated both in transverse and longitudinal dimension. Most of physical factors and soil characters were analyzed into six transverse transects (T1 to T6) and TA to TF representing six longitudinal transects. The study on these factors was conducted in four main parts: site characteristics, soil parameters, their interactions, conclusion and discussion. For chemical factors and water quality, transverse transects consisted of 6 lines, the same as physical study. Whereas longitudinal transects of chemical study consisted of only three lines which were TA, TC and TF. For biological part, the outcomes of the study included species and biomass of phytoplankton and other mollusks found in the area. Statistical analysis and interactions among factors were presented at the end of each part.

5.1 Hydrographic conditions

During the study period, rainfall data were obtained from the Meteorological Department, whereas amount of water discharged or runoff data from Mae Klong Dam locating in Kanchanaburi province were received from the Royal Irrigation Department. Rainfall and water discharge data were shown in Figure 5.1-5.2.

Amount of average rainfall ranged from 0-227 mm each month and the maximum rainfall was in October 2008 whereas there was no rain during November 2008-February 2009. Average amount of water discharged from Mae Klong Dam

ranged discharge ranged from 410-815 million m³ per month. The peak discharge was in June 2008 (815 million m³), followed by November 2009 (660 million m³).

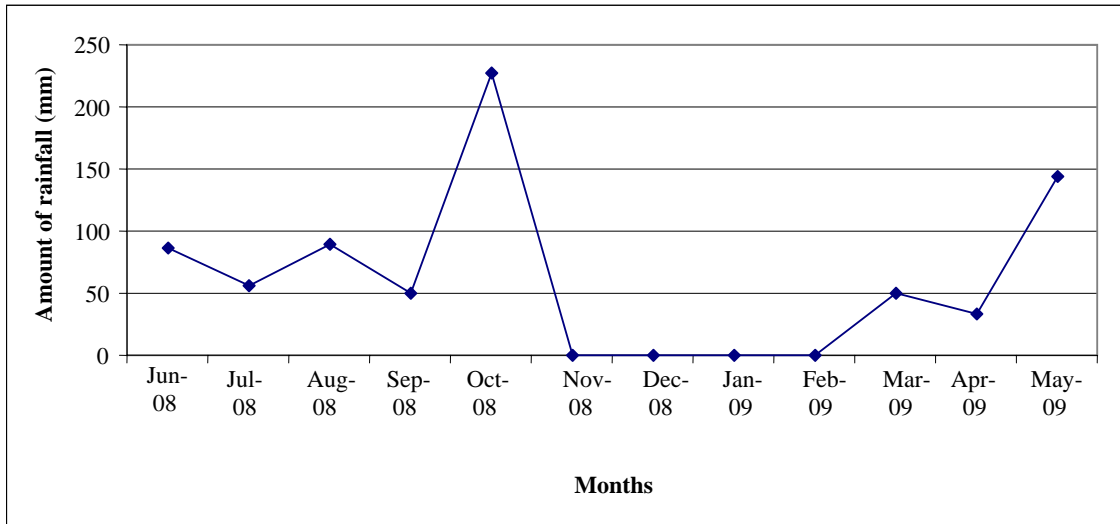


Figure 5.1: Annual variation of average amount of rain in Don Hot Lot

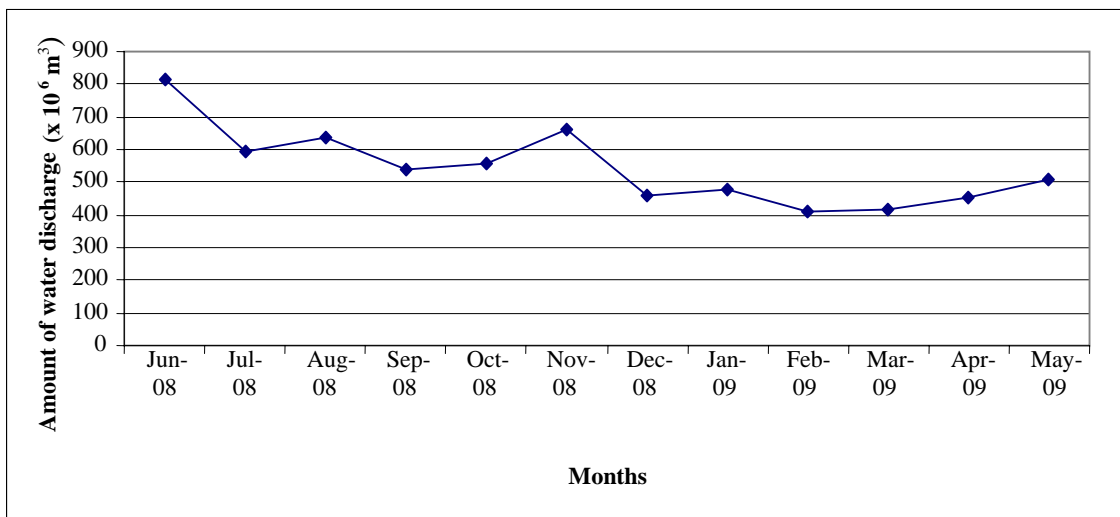


Figure 5.2: Amount of water discharge from Mae Klong Dam during June 2008- May 2009

5.2 Physical factors and soil characteristics

Physical factors and soil characteristics at Don Hoi Lot was analyzed during June 2008-May 2009. Eight parameters studied were temperature, pH, water content, total organic matter, sand composition in soil, median grain size of soil, redox-potential in soil and acid volatile sulfide in soil. Five out of eight parameters (pH, water content, total organic matter, sand composition and median grain size) were measured and analyzed in soil at two layers: the upper layer (1-15 cm deep from soil surface) and the lower layer (15-30 cm deep from soil surface). Detailed data on all physical factors and soil characteristics including statistical analysis are presented in Appendix B.

5.2.1 Soil temperature

Soil temperature was measured at the same time when Razor clams were collected. In term of spatial variation and transverse transect, the results showed that the average annual temperature was 29.43 ± 5.12 °C, ranging from 29.12 ± 5.21 to 29.76 ± 5.75 °C. The highest average soil temperature was found in the 6th transverse section (T6) and the lowest value was found in T2. For longitudinal transect, the results showed that average temperature ranged from 29.37 ± 5.10 to 29.51 ± 5.36 °C. The highest average soil temperature was found in the TC section which was located in middle of the study site, while the lowest value was found in TE transect. The results clearly showed that soil temperature varied between transverse transects (T1-T6) more than longitudinal transects (TA-TF). The ranges of average standard deviations were higher in T1-T6 than TA-TF in each month (0.26-2.23 °C and 0.12-0.41 °C, respectively).

Soil temperature changed in consistent with temporal variation. The annual variation of average temperature in the study site ranged 19.78-35.18 °C. Average soil temperature started getting low in October (26.72 °C) or at beginning of the winter season and the minimal average temperature was reached in January. The higher average soil temperatures recorded in April to September ranged from 32.21-35.18 °C and the maximal average temperature reached its peak in May or in the summer period (Figure 5.3-5.4).

The statistical analysis in transverse transect showed that the average temperatures were significantly different ($p < 0.01$) among transects, by months and its interaction. For longitudinal transect, the average temperature was only significantly different ($p < 0.05$) by months whereas there was no difference ($p < 0.01$) both in each transect and its interaction. It also confirmed that the average temperature varied based mainly on transverse distribution rather than longitudinal distribution.

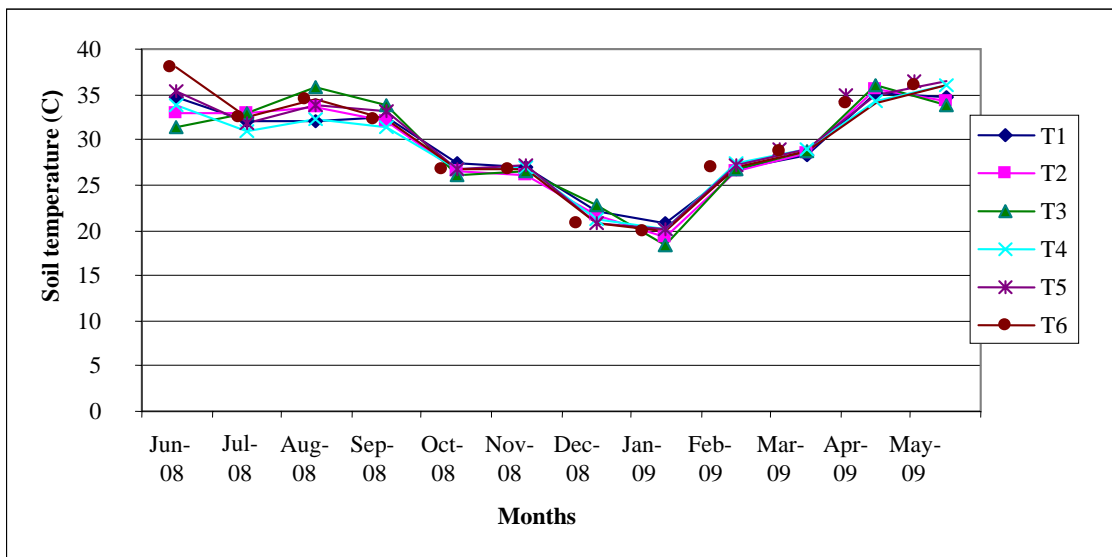


Figure 5.3: Annual variation of soil temperature in transverse transects during June 2008 to May 2009.

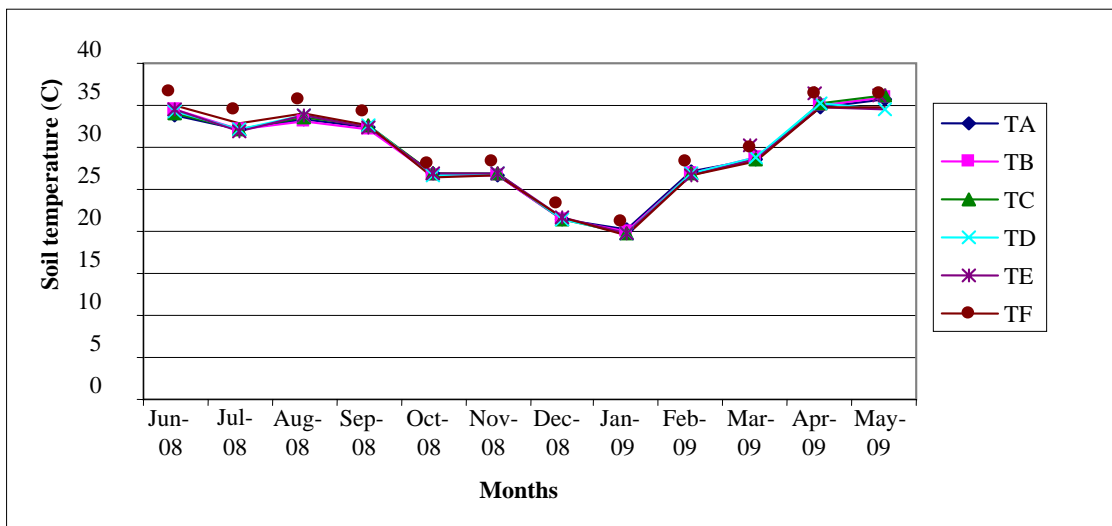


Figure 5.4: Annual variation of soil temperature in longitudinal transects during June 2008 to May 2009.

5.2.2 Soil pH

Soil pH was measured at two levels: upper layer (0-15 cm deep) and lower layer (15-30 cm deep). In term of spatial variation and transverse transect, the results showed that the average pH values of the upper and the lower soil layers were 7.45 ± 0.33 and 7.52 ± 0.35 , respectively. The value ranged from 7.41 ± 0.28 to 7.50 ± 0.44 and 7.46 ± 0.23 to 7.58 ± 0.44 , respectively. In longitudinal transect, average pH values of the upper and the lower soil layers ranged from 7.43 ± 0.29 to 7.47 ± 0.31 and 7.48 ± 0.31 to 7.55 ± 0.33 , respectively. It was also noted that the average pH found in the upper layer was higher than in the lower layer. In the upper and the lower soil layers, soil pH was likely influenced by transverse transects (T1-T6) more than longitudinal transects (TA-TF). Average standard deviations found in most of transverse transects were higher when compared with those of longitudinal transects in each month.

For temporal distribution, it was found that average pH values of the upper and the lower soil layers ranged from 7.03-8.10 and 7.11-8.27, respectively. Average pH was getting high in June (early rainy season) and reached the maximum value in July, whereas the minimum average was reached in May (late summer season) both in the upper and the lower layers (Figure 5.5-5.8).

The statistical analysis in transverse transect also showed that the average pH were significantly different ($p < 0.01$) among transects, by months and its interaction both in the upper and the lower layers. In term of longitudinal transect, the average pH was only significantly different ($p < 0.01$) by month whereas there was no difference ($p < 0.05$) both in each transect and its interaction in both layers. It was confirmed that the average pH variation was influenced by transverse rather than longitudinal distribution. Comparison of pH in both soil layers revealed that the value in the lower soil layer was significantly ($p < 0.01$) higher than that in the upper layer in each transect.

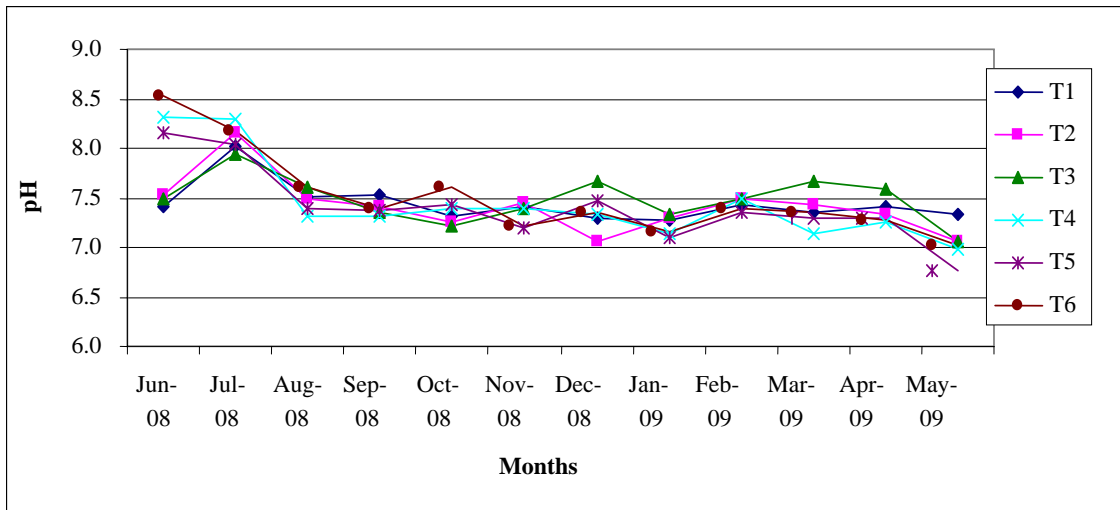


Figure 5.5: Annual variation of pH in upper soil layer in transverse transects during June 2008 to May 2009.

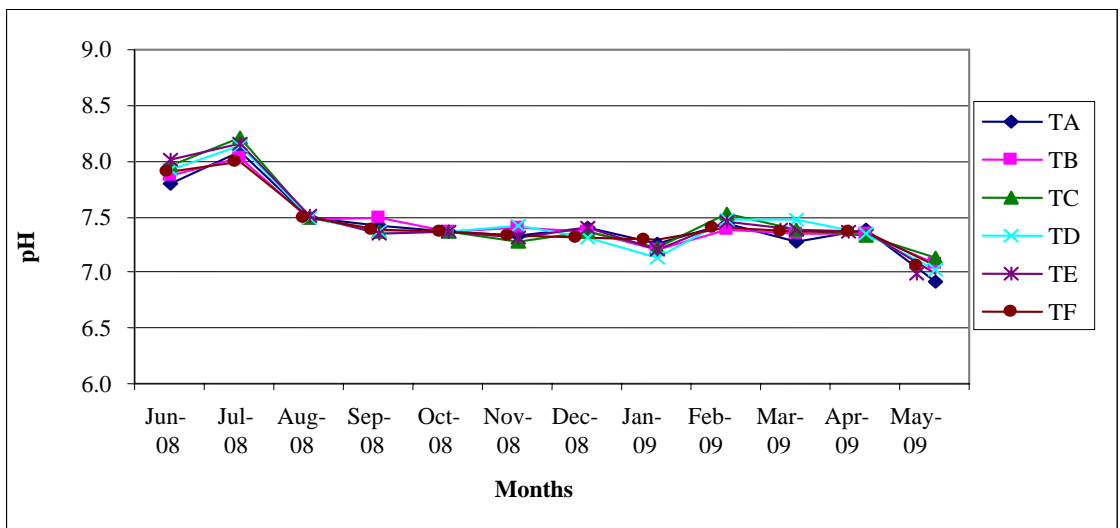


Figure 5.6: Annual variation of pH in upper soil layer in longitudinal transects during June 2008 to May 2009.

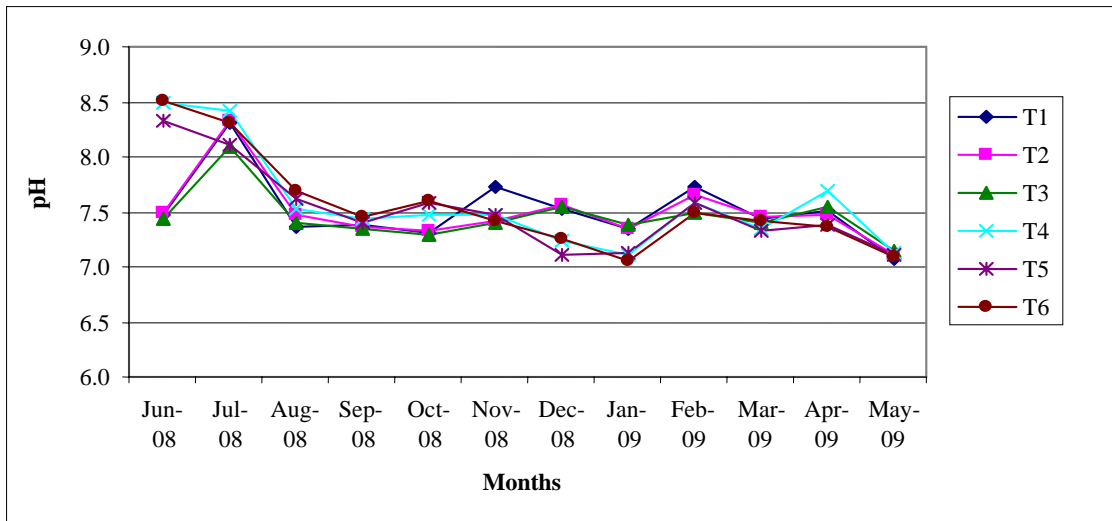


Figure 5.7: Annual variation of pH in lower soil layer in transverse transects during June 2008 to May 2009.

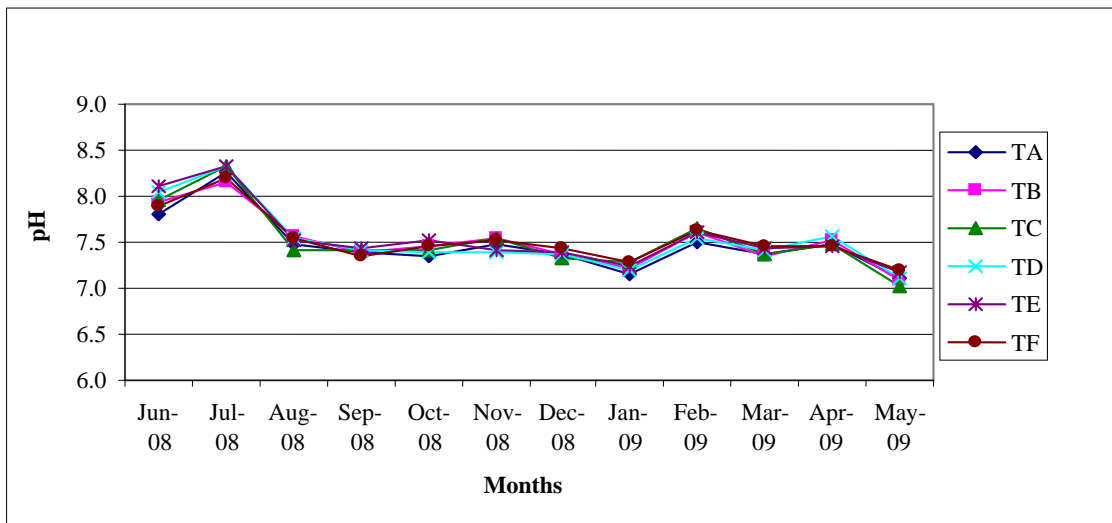


Figure 5.8: Annual variation of pH in lower soil layer in longitudinal transects during June 2008 to May 2009.

5.2.3 Water content in Soil

Water content in soil was analyzed in two layers, the same as temperature. In term of spatial distribution, the results showed that the average water content of soil layers was 25.18 % in the upper layer and 24.38 % in the lower layer. In the upper layer, the average water content in transverse transects was highest in T1 (27.31 ± 1.74 %) and lowest in T4 (23.63 ± 0.58 %), whereas in longitudinal transects , the highest

water content was found in TF (27.55 ± 1.16 %) and the lowest water content was found in TD (23.85 ± 0.73 %). In the lower layer, the average water content in transverse transects was highest in T1 (26.46 ± 1.39 %) and lowest in T5 (23.28 ± 0.79 %), whereas, in the longitudinal transects, the maximum water content was reached in TF (25.75 ± 1.38 %) and the lowest water content was found in TD (23.59 ± 0.80 %).

In term of temporal variation in the upper layer, average water content ranged from 24.41-26.55 % and the lowest value was in December 2008. In the lower layer, average water content ranged 23.02-25.58 % and the lowest value was in April 2009 (Figure 5.9-5.12).

The statistical analysis in transverse transect showed that average water content was significantly different ($p < 0.01$) in each transect and by months both in upper and lower soil layers. In term of longitudinal transect and in the lower soil layer, the average water content was significantly different ($p < 0.01$) both by months and in each transect. In the upper soil layer, it was found that there was significant difference ($p < 0.01$) by months whereas there was only difference ($p < 0.01$) in each transect. Comparing between average water content in both soil layers, values in the lower soil layer were lower than in upper layer in each transect and statistical analysis showed significant difference ($p < 0.01$).

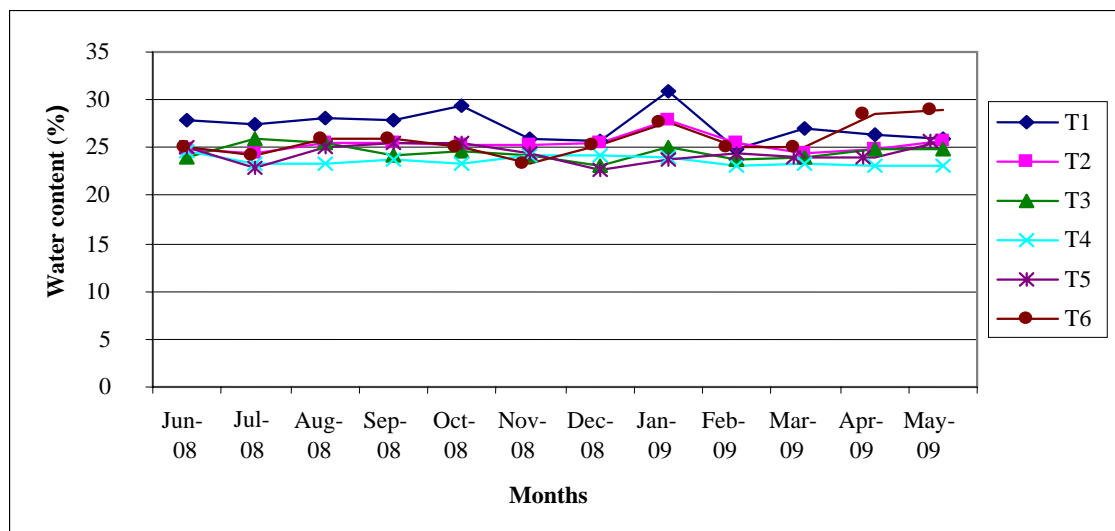


Figure 5.9: Annual variation of water content in upper soil layer in transverse transects during June 2008 to May 2009.

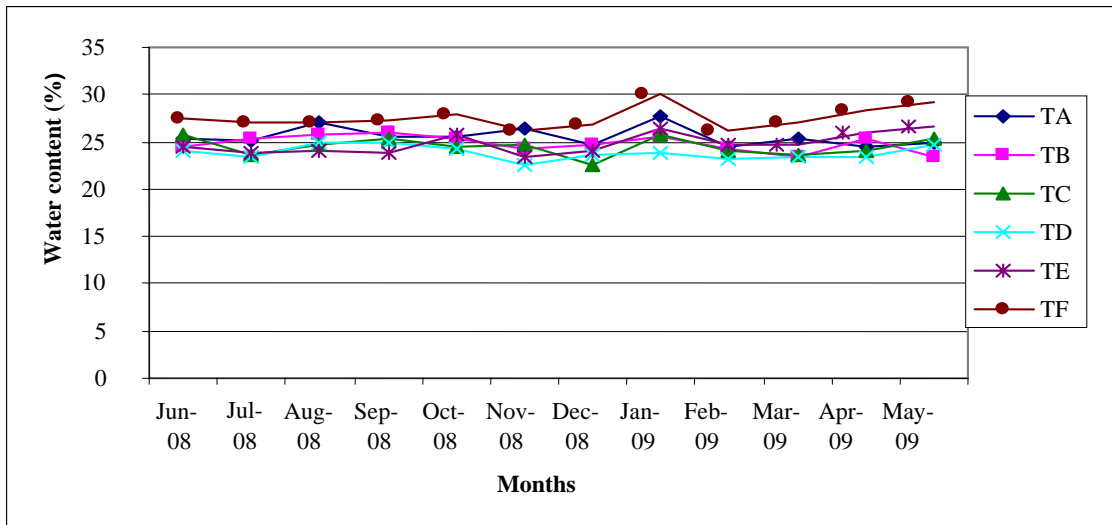


Figure 5.10: Annual variation of water content in upper soil layer in longitudinal transects during June 2008 to May 2009.

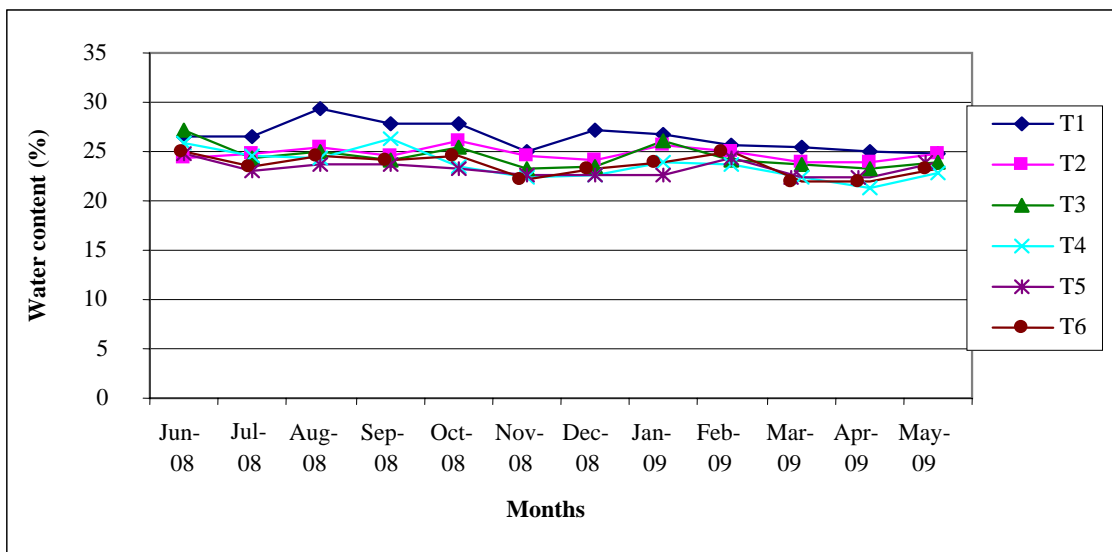


Figure 5.11: Annual variation of water content in lower soil layer in transverse transects during June 2008 to May 2009.

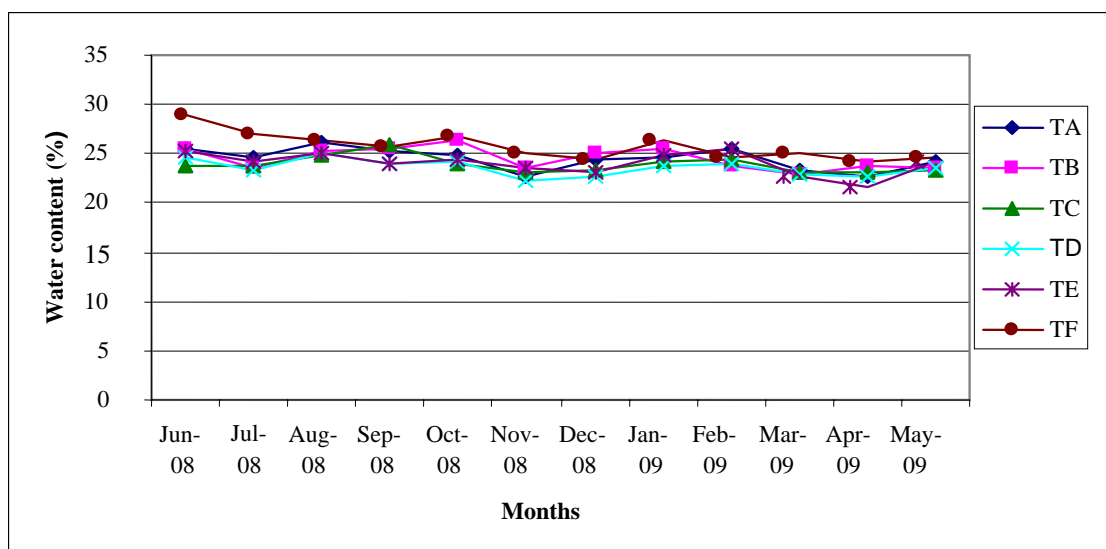


Figure 5.12: Annual variation of water content in lower soil layer in longitudinal transects during June 2008 to May 2009.

5.2.4 Total organic matter

Total organic matter in soil was measured at two levels. Spatial distribution results revealed that the average total organic matter of soil was 35.08 mg/g in the upper layer and 35.73 mg/g in the lower layer. In the upper layer, the average total organic matter in transverse transects was highest at T1 (40.62 ± 6.58 mg/g) and lowest at T3 (31.40 ± 3.22 mg/g), whereas in longitudinal transects, the highest total organic matter was found at TF (41.36 ± 7.98 mg/g) and the lowest total organic matter was at TD (30.41 ± 5.35 mg/g). In the lower layer, the average total organic matter in transverse transects was highest at T1 (40.88 ± 7.06 mg/g) and lowest at T5 (31.13 ± 6.54 mg/g), whereas in longitudinal transects, the highest total organic matter was found at TF (40.13 ± 6.36 mg/g) and the lowest total organic matter was at TC (33.86 ± 8.19 mg/g).

In term of temporal variation in the upper layer, average total organic matter ranged 24.97-46.68 mg/g. The lowest and the highest values were in July 2008 and April 2009, respectively. In the lower layer, average total organic matter ranged 26.45-49.97 mg/g, the lowest and the highest values were found in the same months as in the upper layer (Figure 5.13-5.16).

The statistical analysis in transverse transect showed that the average total organic matter was significantly different ($p < 0.01$) both in each transect and by

months both in the upper and the lower soil layer. In case of interaction of both factors, there was significant difference ($p < 0.01$) only in the lower soil layer. In term of longitudinal transect, the average total organic matter was significantly different ($p < 0.01$) both by months and in each transect. Comparing between average total organic matter in soil layers, statistical analysis showed no difference ($p < 0.05$).

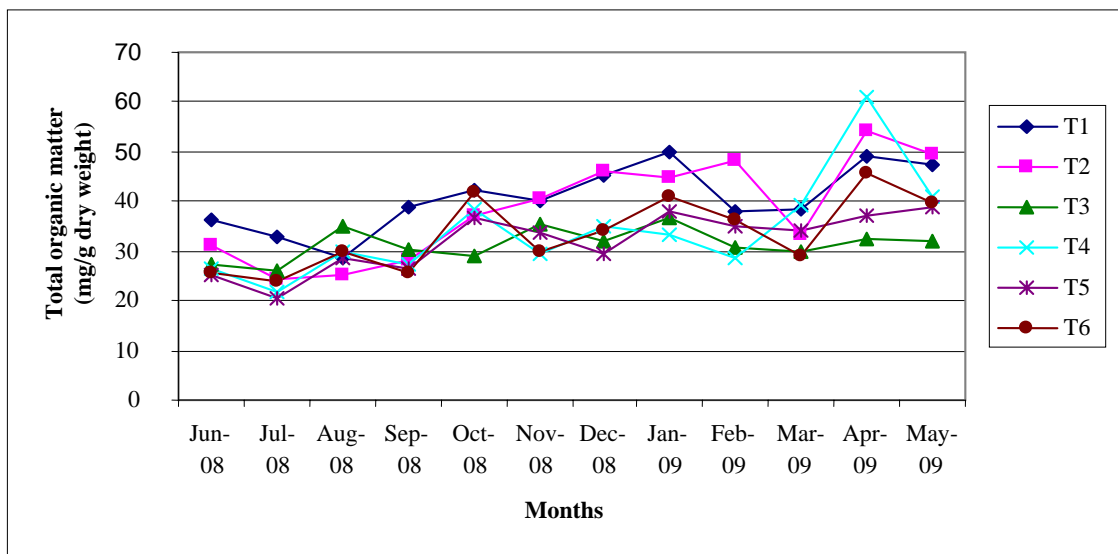


Figure 5.13: Annual variation of total organic matter in upper soil layer in transverse transects during June 2008 to May 2009.

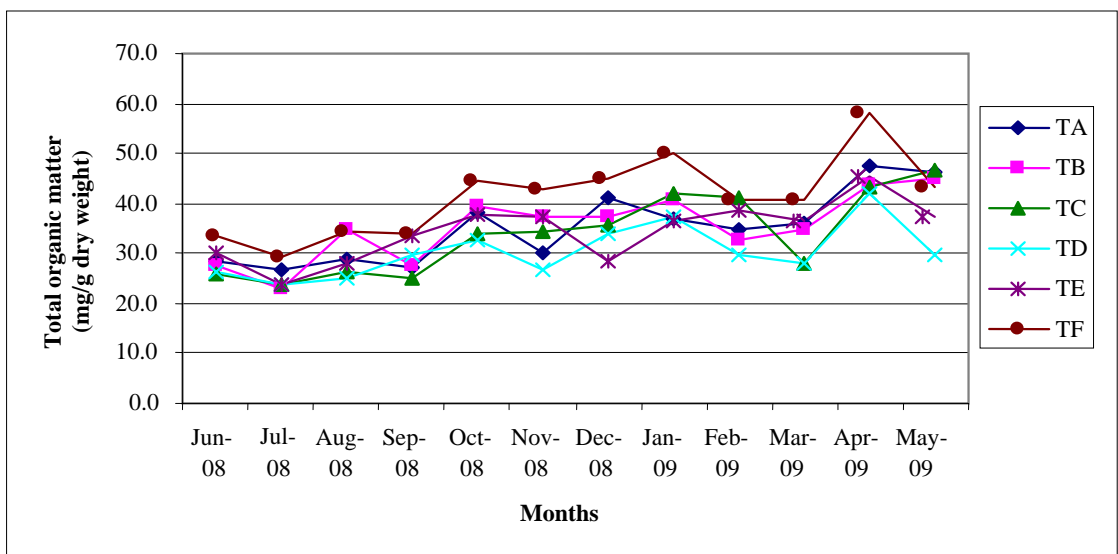


Figure 5.14: Annual variation of total organic matter in upper soil layer in longitudinal transects during June 2008 to May 2009.

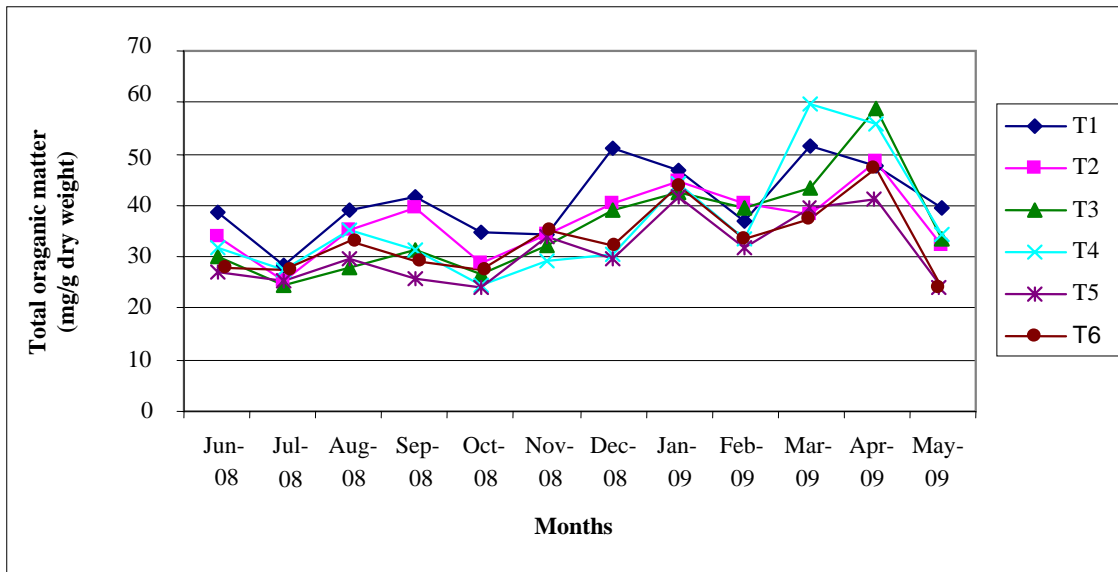


Figure 5.15: Annual variation of total organic matter in lower soil layer in transverse transects during June 2008 to May 2009.

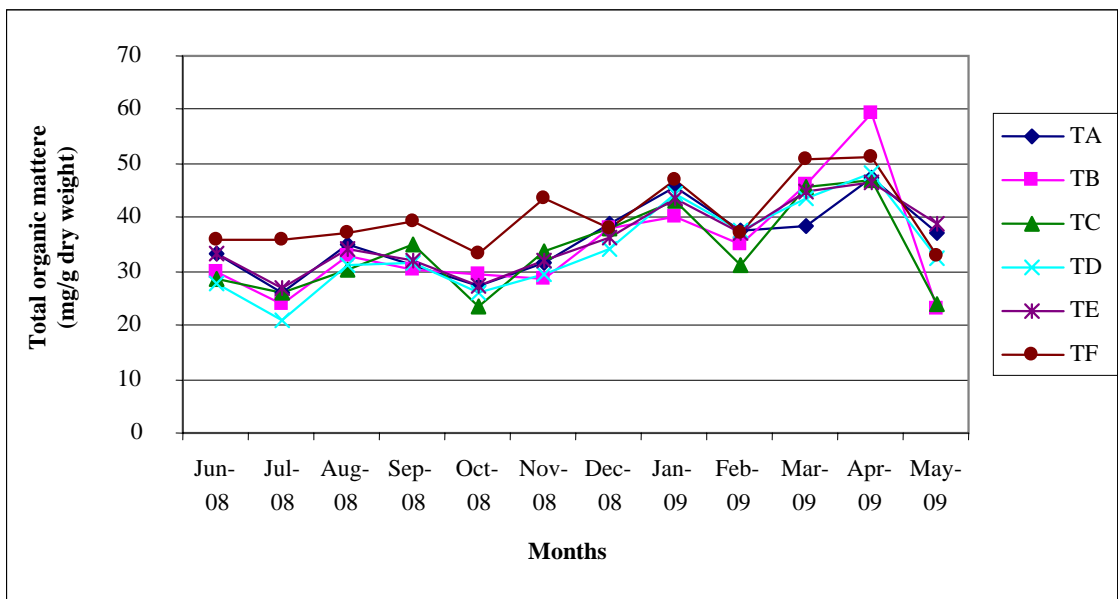


Figure 5.16: Annual variation of total organic matter in lower soil layer in longitudinal transects during June 2008 to May 2009.

5.2.5 Sand composition

Sand composition in soil was studied in two levels. The results showed that the average sand composition of soil layers was 75.8 % in the upper layer and 73.9 % in the lower layer. Sand composition varied along with transverse transects more than

longitudinal transects. The average standard deviations were higher at T1-T6 comparing to TA-TF in both layers. In the upper layer, the average sand composition in transverse transects was highest at T6 (85.0 ± 6.1 %) and lowest at T1 (58.5 ± 21.0 %), whereas in longitudinal transects, the highest sand composition was found in TE (79.4 ± 11.5 %) and the lowest sand composition was in TB (72.4 ± 13.8 %). In the lower layer, the average sand composition in transverse transects was highest in T6 (86.5 ± 6.0 %) and lowest in T1 (57.3 ± 23.0 %), whereas in longitudinal transects, the highest sand composition was found in TE (77.1 ± 14.2 %) and the lowest sand composition was found in TB (71.1 ± 14.9 %).

In term of temporal variation in the upper layer, the average sand composition ranged 54.1-85.5 % and the average lower values were 59.4, 59.6 and 54.1 % in July 2008, November 2008 and March 2009, respectively. The lowest value was always found in T1. In the lower layer, average sand composition ranged 45.0-63.7 % and the lower values were also found in the same time as reported in the upper layer (Figure 5.17-5.20).

The statistical analysis in transverse transect showed that average sand composition was significantly different ($p < 0.01$) among transects and by months and their interaction both in upper soil layer and lower soil layer. In term of longitudinal transect in the upper soil layer, the average sand composition was significantly different ($p < 0.01$) both by months and in each transect, whereas there was only significant difference ($p < 0.01$) in the lower soil layer. Comparing between average sand composition in soil layers, statistical analysis showed that there was significant difference ($p < 0.01$).

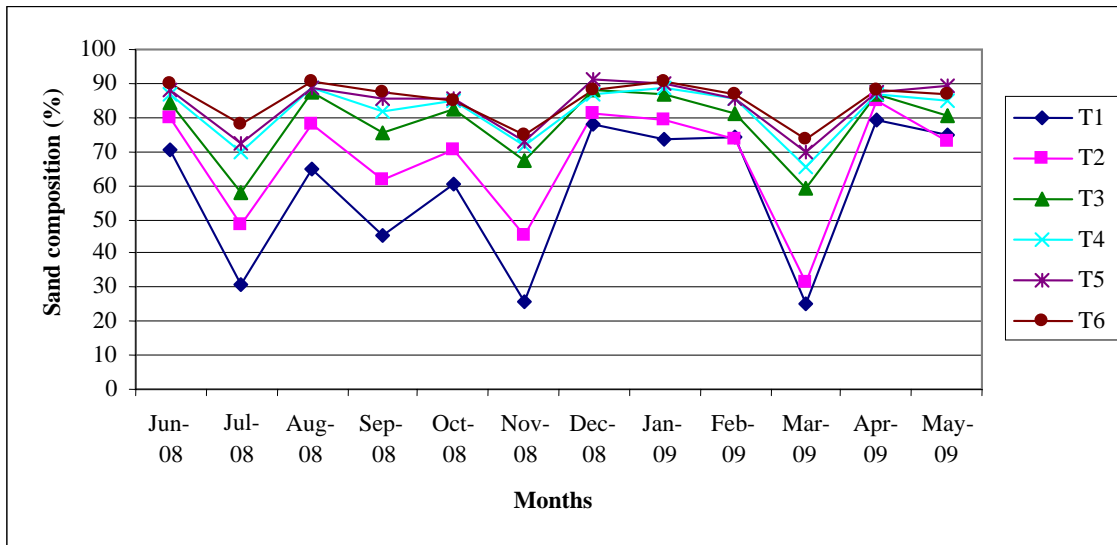


Figure 5.17: Annual variation of sand composition in upper soil layer in transverse transects during June 2008 to May 2009.

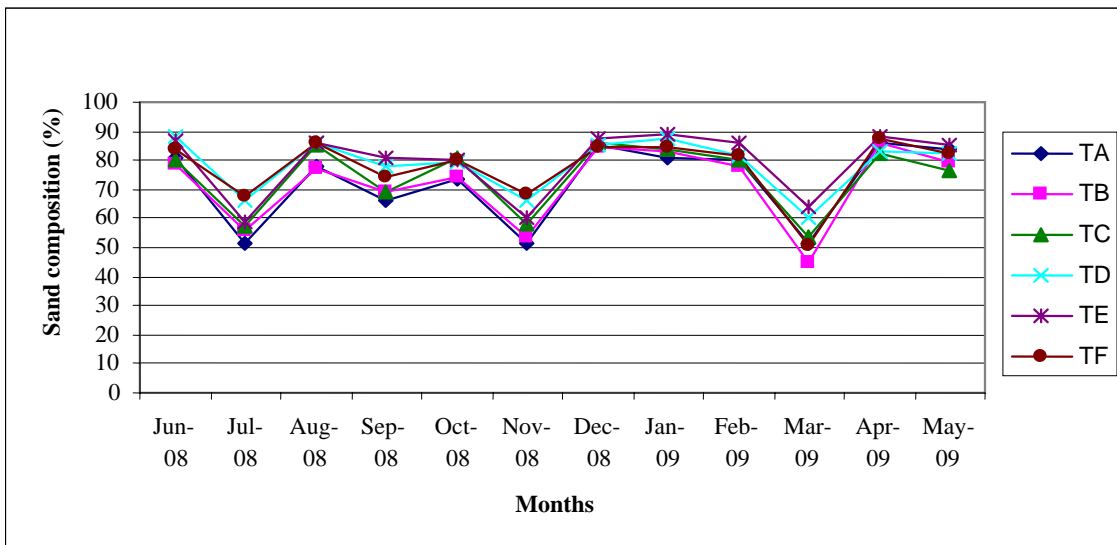


Figure 5.18: Annual variation of sand composition in upper soil layer in longitudinal transects during June 2008 to May 2009.

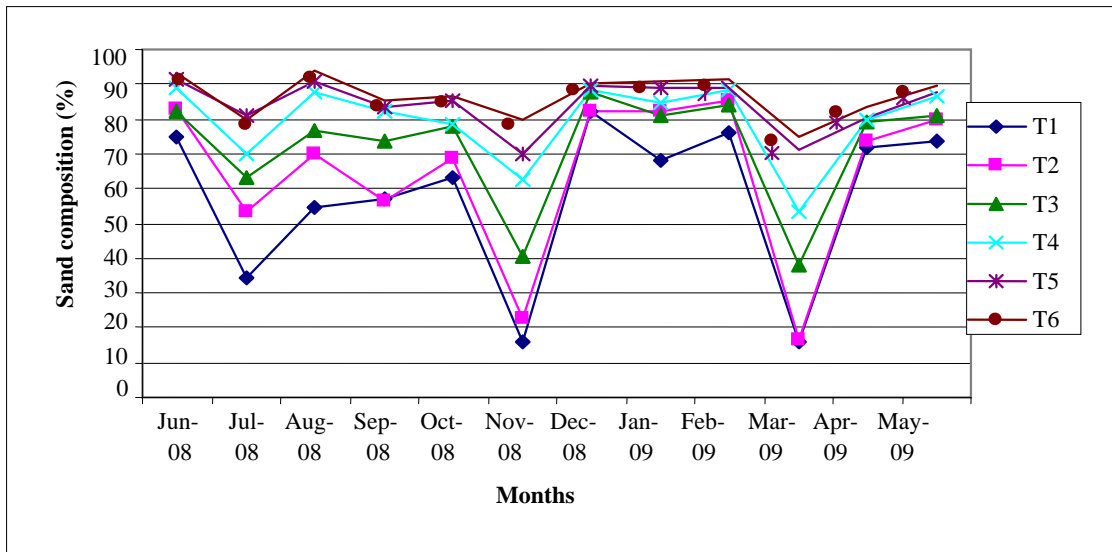


Figure 5.19: Annual variation of sand composition in lower soil layer in transverse transects during June 2008 to May 2009.

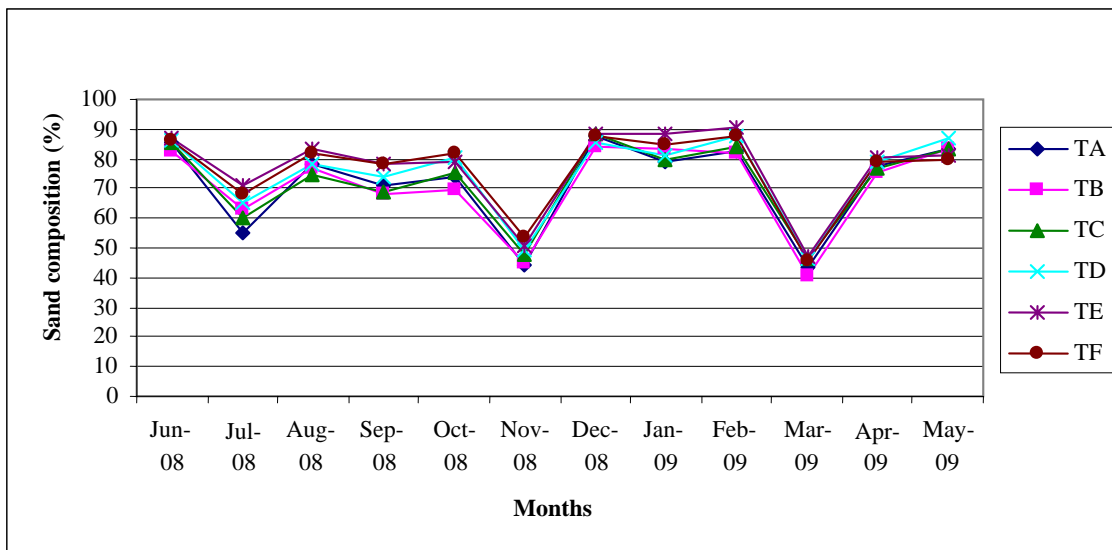


Figure 5.20: Annual variation of sand composition in lower soil layer in longitudinal transects during June 2008 to May 2009.

5.2.6 Median grain size

Median grain size in soil was studied in two levels. The results showed that average median grain size of soil layers was 74.8 μm in diameter in the upper layer and 74.1 μm in diameter in the lower layer. The results clearly showed that median grain size varied within transverse transects more than longitudinal transects. The

range of average standard deviations was higher in T1-T6 than in TA-TF in both layers at each month. In the upper layer, the average median grain size in transverse transects was highest in T6 (80.1 ± 3.3 μm in diameter) and lowest in T1 (64.0 ± 14.7 μm in diameter), whereas in longitudinal transects, the highest median grain size was found in TF (77 ± 6.7 μm in diameter) and the lowest median grain size was found in TB (71.9 ± 9.9 μm in diameter). In the lower layer, the average median grain size in transverse transects was highest in T6 (82 ± 2.8 μm in diameter) and lowest in T1 (62.8 ± 18.0 μm in diameter), whereas in longitudinal transects, the highest median grain size was found in TF (76 ± 9.0 μm in diameter) and the lowest median grain size was found in TB (71.9 ± 11.1 μm in diameter).

In term of temporal variation in the upper layer, average median grain size ranged from 59.4-81.0 μm in diameter and average lower values were 65.6, 65.4 and 59.4 μm in diameters in July 2008, November 2008 and March 2009 respectively. Especially the lowest value was found in T1. In the lower layer, average median grain size ranged from 54.5-81.9 μm in diameter and lower values were found in the same time as reported in the upper layer (Figure 5.21-5.24).

The statistical analysis in transverse transect showed that average median grain size was significantly different ($p < 0.01$) among transects and by months and their interaction both in upper soil layer and lower soil layer. In term of longitudinal transect in the upper soil layer, the average median grain size was significantly different ($p < 0.01$) both by months and in each transect whereas in the lower soil layer, there was only significant difference ($p < 0.01$) by months and was different ($p < 0.05$) in each transect. Comparing between average median grain size in soil layers, statistical analysis showed that there was no difference ($p < 0.05$).

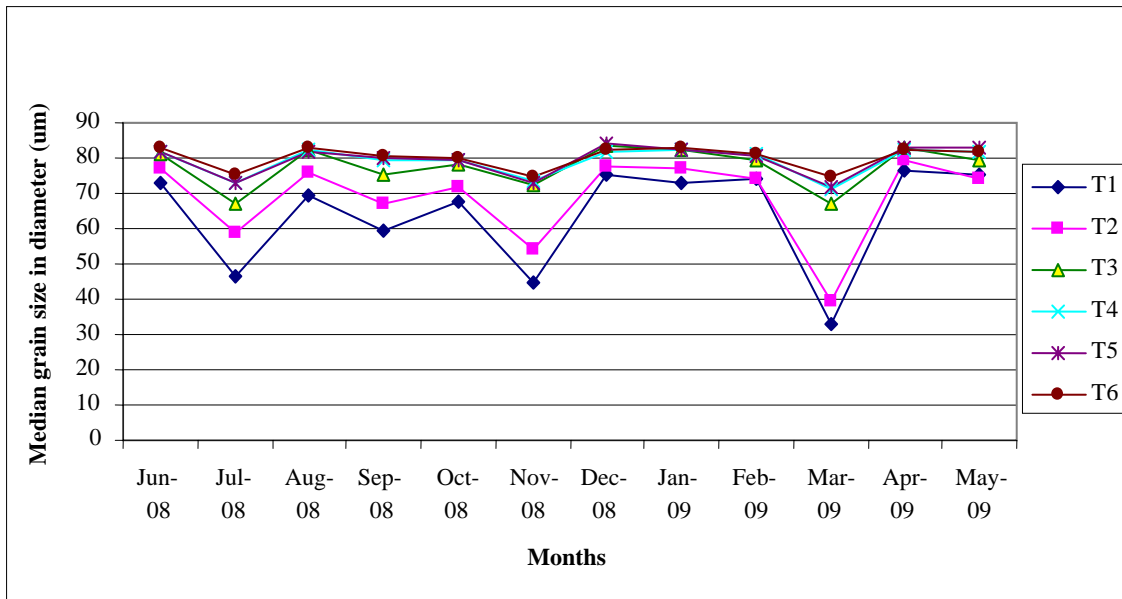


Figure 5.21: Annual variation of median grain size in upper soil layer in transverse transects during June 2008 to May 2009.

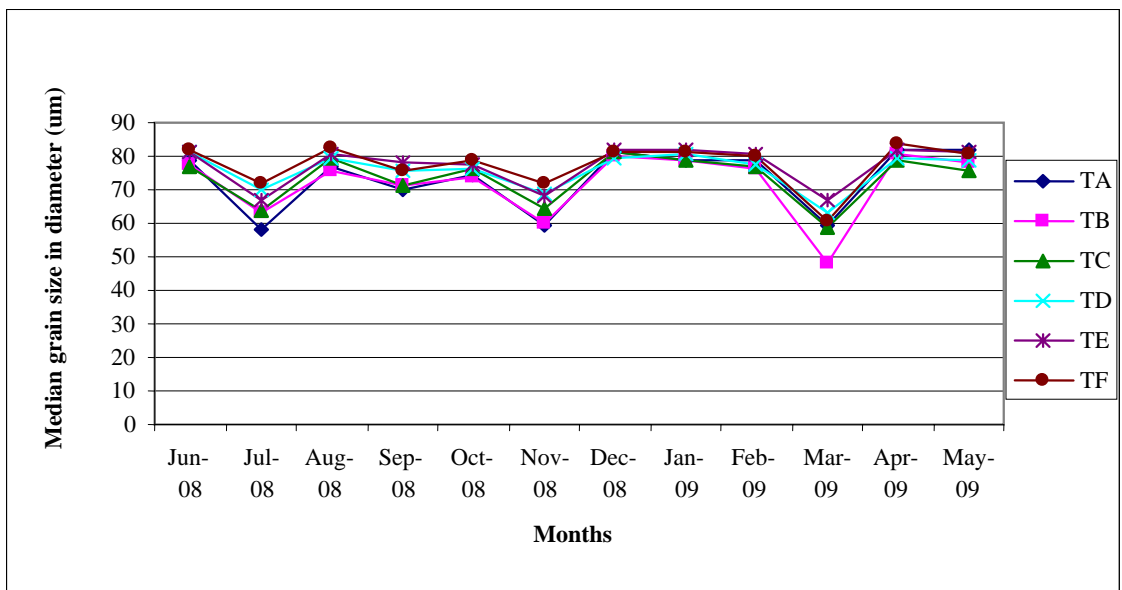


Figure 5.22: Annual variation of median grain size in upper soil layer in longitudinal transects during June 2008 to May 2009.

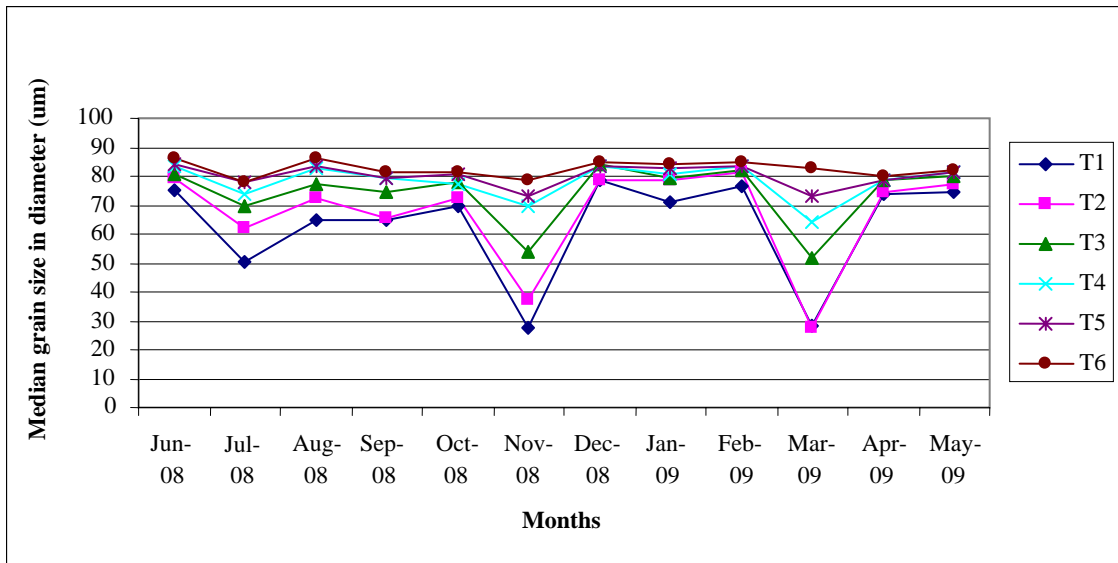


Figure 5.23: Annual variation of median grain size in lower soil layer in transect transects during June 2008 to May 2009.

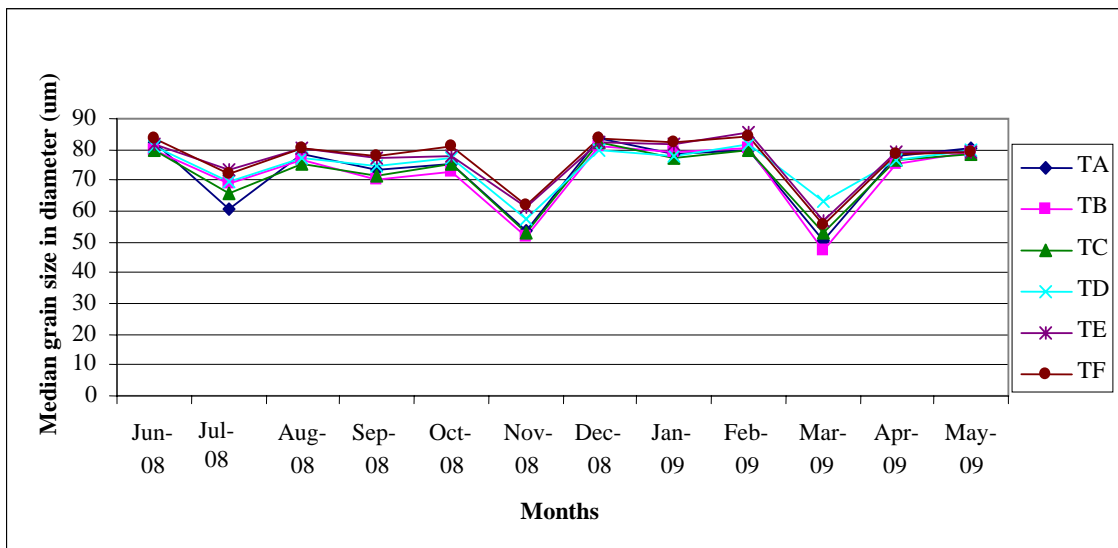


Figure 5.24: Annual variation of median grain size in lower soil layer in longitudinal transects during June 2008 to May 2009.

5.2.7 Redox potential in soil substrate

Redox potential was identified by observing soil depth that showed the difference of vertical soil color from brown to black. The results showed that the average depth of redox potential at 0 mV of soil layers was 3.91 cm. In term of spatial variation, average depth at redox potential 0 mV in transverse transect was highest in

T4 (5.10 ± 1.12 cm) and lowest in T1 (2.68 ± 1.12 cm), whereas in longitudinal transects, the highest average depth at redox potential 0 mV was found in TD (5.43 ± 1.38 cm) locating in the middle of the study site and the lowest value was found in TF (2.56 ± 0.77 cm).

In term of temporal variation, the annual variation of average depth at redox potential 0 mV ranged from 2.49 ± 0.84 to 5.10 ± 0.88 cm. The lowest and highest values were in March 2009 and August 2008 respectively (Figure 5.25-5.26).

The statistical analysis results showed that average depth at redox potential 0 mV were significantly different ($p < 0.01$) both in each transect and by months in transverse and longitudinal transects, whereas it was only different ($p < 0.05$) in their interaction in transverse transect.

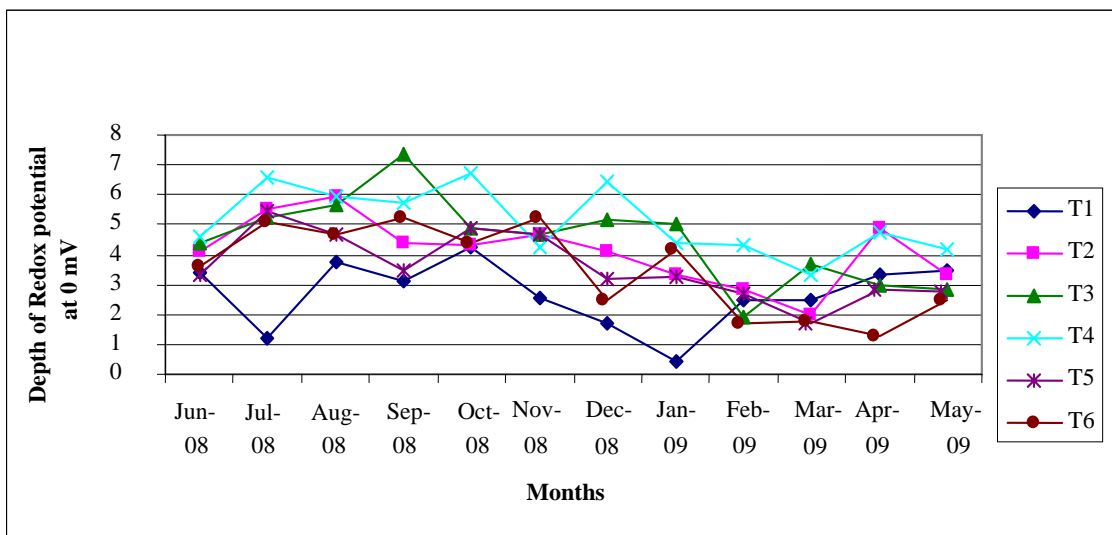


Figure 5.25: Annual variation of depth of redox-potential at 0 mV in transect transects during June 2008 to May 2009.

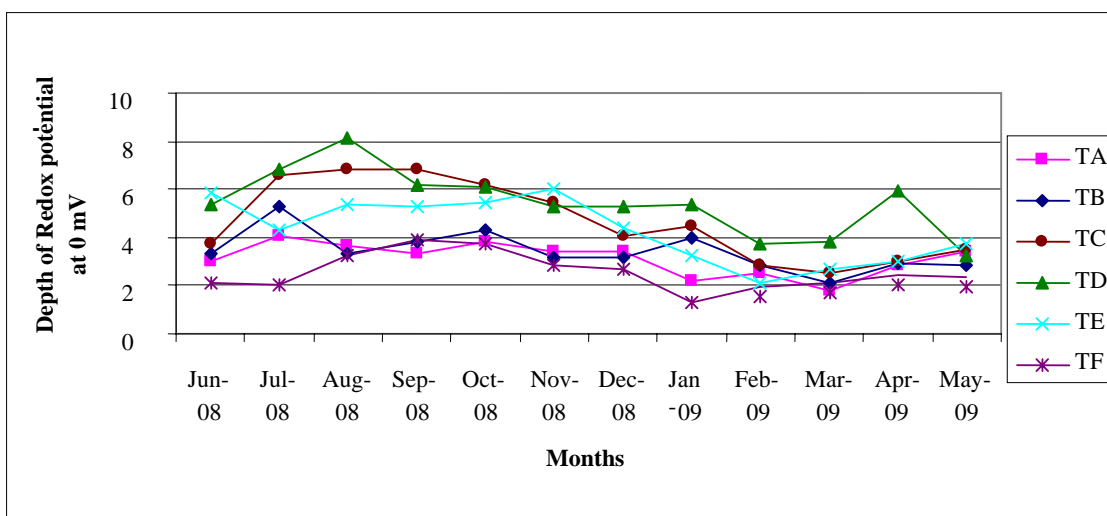


Figure 5.26: Annual variation of depth of redox-potential at 0 mV in longitudinal transects during June 2008 to May 2009.

5.2.8 Acid volatile sulfide in soil

Acid volatile sulfide in soil was analyzed in August 2008, December 2008 and April 2009, representing the rainy, winter and summer season, respectively. The results showed that the average acid volatile sulfide of soil layers was 0.007 mg/l. Average maximum acid volatile sulfide in transverse transect was in T1 (0.019 ± 0.020 mg/g) and minimum value was in T4 (0.002 ± 0.001 mg/g). Whereas in longitudinal transects, the highest acid volatile sulfide was found in TF (0.015 ± 0.008 mg/g) and the lowest acid volatile sulfide was in TD (0.002 ± 0.001 mg/g).

Temporal variation, the average acid volatile sulfide ranged 0.003-0.010 mg/g. The highest was in December 2008 and the lowest was in August 2008 (Figure 5.27-5.28).

The statistical analysis results showed that the average acid volatile sulfide was only different ($p < 0.05$) among transects, by months and its interaction in transverse transect, whereas there was no difference in longitudinal transect ($p < 0.05$).

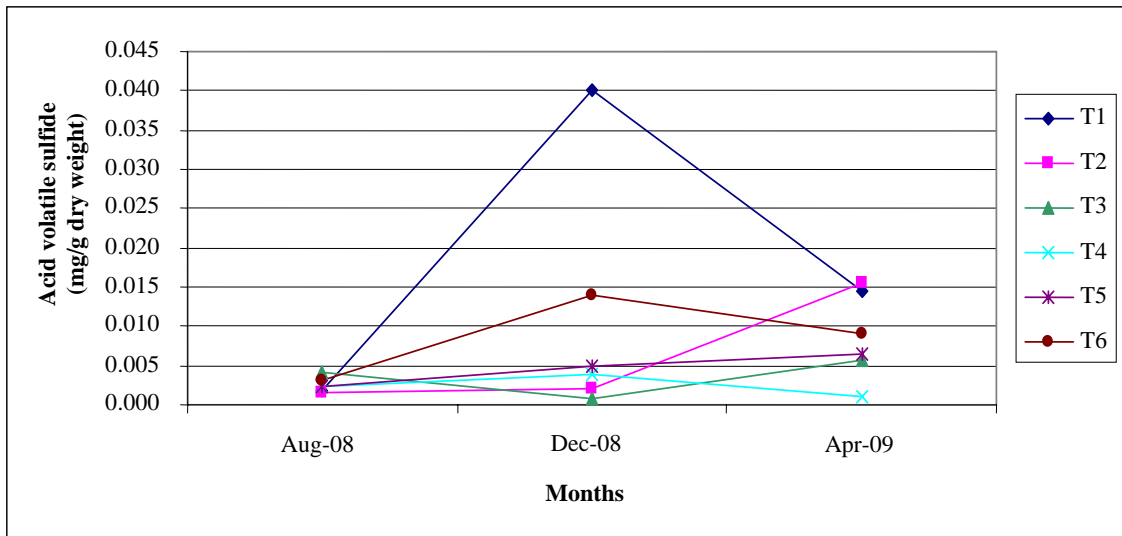


Figure 5.27: Annual variation of acid volatile sulfide in transect transects during June 2008 to May 2009.

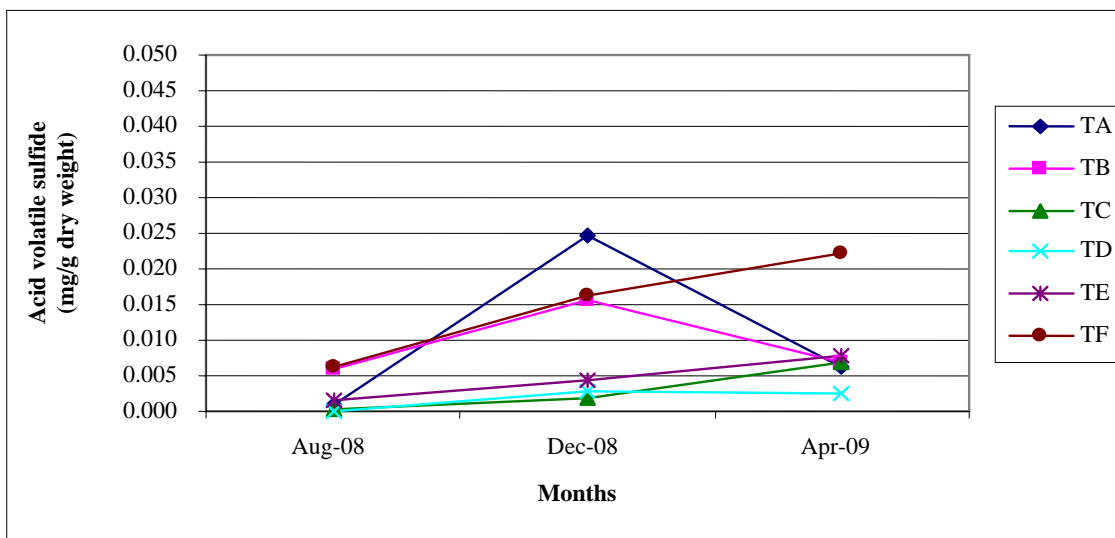


Figure 5.28: Annual variation of acid volatile sulfide in longitudinal transects during June 2008 to May 2009.

5.2.9 Relationship among physical parameters and soil characteristics

Soil parameters were analyzed by Pearson correlation to find out their relationship. The analytical results were presented as follows:

Soil temperature was measured while collecting soil samples. The correlation coefficient or (r) between soil temperature and soil pH (both in upper and lower layers) varied significantly in positive direction ($r= 0.236$ and 0.262

respectively). The similar relationship occurred with redox-potential. Whereas the relationship between soil temperature and total organic matter in both upper and lower soil layers were correlated significantly in negative direction ($r = - 0.133$ and -0.153 , respectively). Sand composition has correlation with pH in the same manner as the total organic matter both in the upper and lower soil layers.

Water content has negative correlation with sand composition, median grain size and redox potential. Whereas it positively correlated with total organic matter in both soil layers.

The relationship between total organic matter (in both upper and lower soil layers) and redox potential varied significantly in negative direction, $r = -0.234$ and -0.248 , respectively.

Sand composition has positive correlation with median grain size and redox potential in both soil layers. The details of relationship of soil parameters were shown in Table 5.1.

Table 5.1: Pearson correlation among soil parameters at Don Hoi Lot during June 2008-May 2009 (n=432)

Soil parameters	Temperature	pH ¹	pH ²	Water content ¹	Water content ²	Total organic matter ¹	Total organic matter ²	Sand composition ¹	Sand composition ²	Median grain size ¹	Median grain size ²
pH ¹	0.236**										
pH ²	0.262**	0.797**									
Water content ¹	0.018	-0.057	-0.065								
Water content ²	0.003	0.101*	0.056	0.423**							
Total organic matter ¹	-0.133**	-0.314**	-0.244**	0.311**	0.125**						
Total organic matter ²	-0.153**	-0.211**	-0.205**	0.202**	0.179**	0.327**					
Sand composition ¹	-0.007	-0.147**	-0.143**	-0.187**	-0.214**	-0.060	-0.066				
Sand composition ²	0.006	-0.066	-0.053	-0.112*	-0.148**	-0.056	-0.150**	0.829**			
Median grain size ¹	0.026	-0.098*	-0.116*	-0.146**	-0.160**	-0.049	-0.062	0.946**	0.802**		
Median grain size ²	0.024	-0.034	-0.030	-0.079	-0.126**	-0.024	-0.118*	0.800*	0.939**	0.801**	
Redox potential	0.095*	0.125**	0.121*	-0.372**	-0.215**	-0.234**	-0.248**	0.188**	0.102*	0.152**	0.086

Remark: * = Significant at 0.05 level ** = Significant at 0.01 level
 1 = upper soil layer 2 = lower soil layer

5.3 Chemical factors

The study of chemical parameters in Don Hoi Lot was conducted between June 2008 and May 2009. Thirteen parameters consisting water depth, water temperature, water pH, dissolved oxygen, transparency, turbidity, salinity, alkalinity, hardness, total ammonia nitrogen, nitrate nitrogen, phosphate phosphorus and chlorophyll-a were analyzed. All parameters were analyzed in two transects at 18 stations during high tide: six transverse transects and three longitudinal transects. One transverse transect consisted of 3 stations whereas one longitudinal transect had 6 stations.

Water quality was compared with marine water quality standard class III which is suitable for aquaculture purpose (Pollution Control Department, 2010). Detailed data on all chemical factors and water quality including statistical analysis at Don Hoi Lot are presented in Appendix B.

5.3.1 Water depth

Measurement of water depth was conducted during collecting water samples. The average water depth of spatial transect was 1.6 ± 0.4 m. In transverse transects, the average maximum water depth was in T6 (1.8 ± 0.4 m), the most far away from the Mae Klong River mouth. The lowest depth was in T1 and T2 with the same depth of 1.5 ± 0.4 m. In longitudinal transects, the lowest water depth was in TC (1.5 ± 0.3 m) at the middle of the study site. The average maximum water depth was found in TA and TF with the same depth of 1.7 ± 0.4 m.

For temporal variation, average water depth ranged 1.1-2.3 m. The average maximum depth was found in June 2008, whereas an average minimum depth was reached in September 2008 (Figure 5.29-5.30).

The statistical analysis in transverse transect, showed that average water depth was significantly different ($p < 0.01$) both in transects and by months, whereas in longitudinal transects, there was significant difference ($p < 0.01$) among transects, by months and interactions.

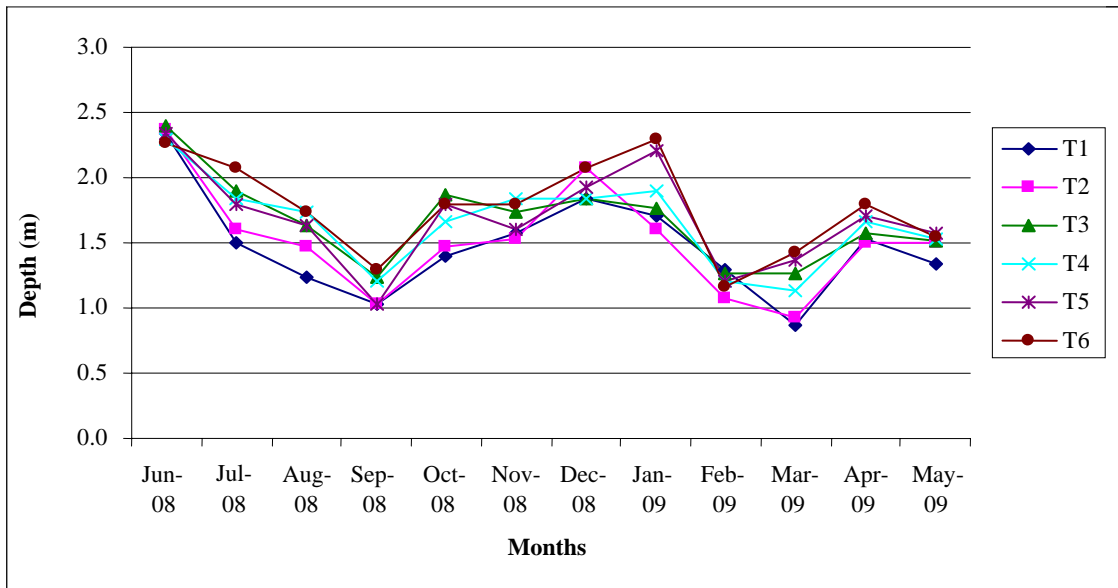


Figure 5.29: Annual variation of water depth in transverse transects during June 2008 to May 2009

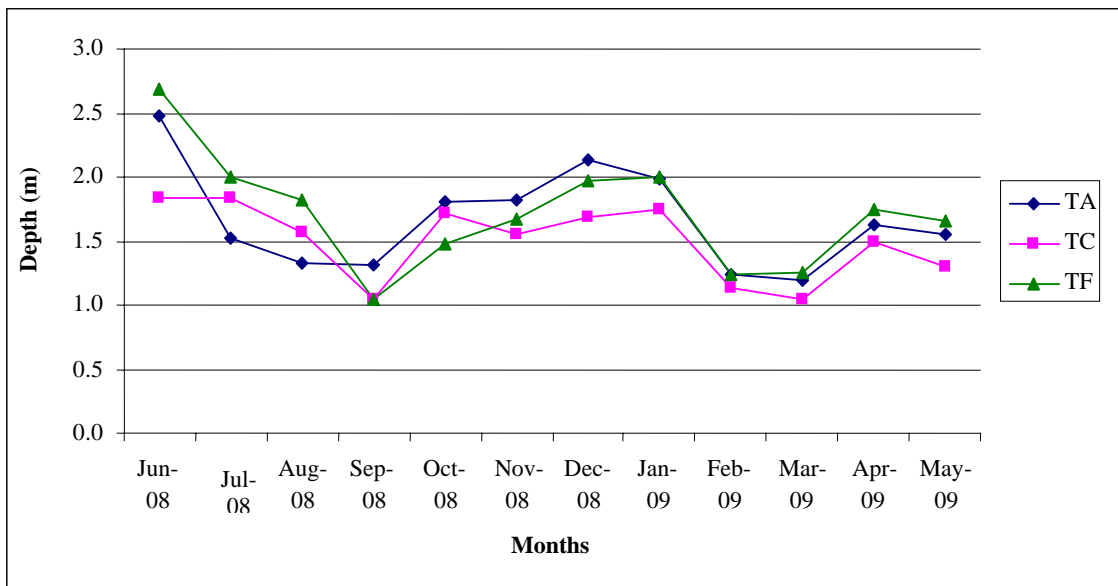


Figure 5.30: Annual variation of water depth in longitudinal transects during June 2008 to May 2009

5.3.2 Water temperature

Water temperature was measured in the middle of water column when collecting water samples in the field. The average water temperature was 29.4 °C. In term of spatial variation, the transverse transects had the average water temperature

ranging 29.3-29.5 °C, whereas the longitudinal transects ranged 29.4-29.5 °C. The average water temperature value in all transects was considerable constant.

Temporal average water temperature varied between 22.4-32.3 °C. The average water temperature declined in December 2008 and January 2009 during winter season (23.8 and 22.4 °C, respectively) (Figure 5.31-5.32).

The statistical analysis in transverse transects showed that the average water temperature was significantly different ($p < 0.01$) both by months and interactions. Whereas there was not difference in transects. In longitudinal transects, there was significant difference ($p < 0.01$) only by months. There was difference ($p < 0.05$) in interactions whereas there was no difference in each transect.

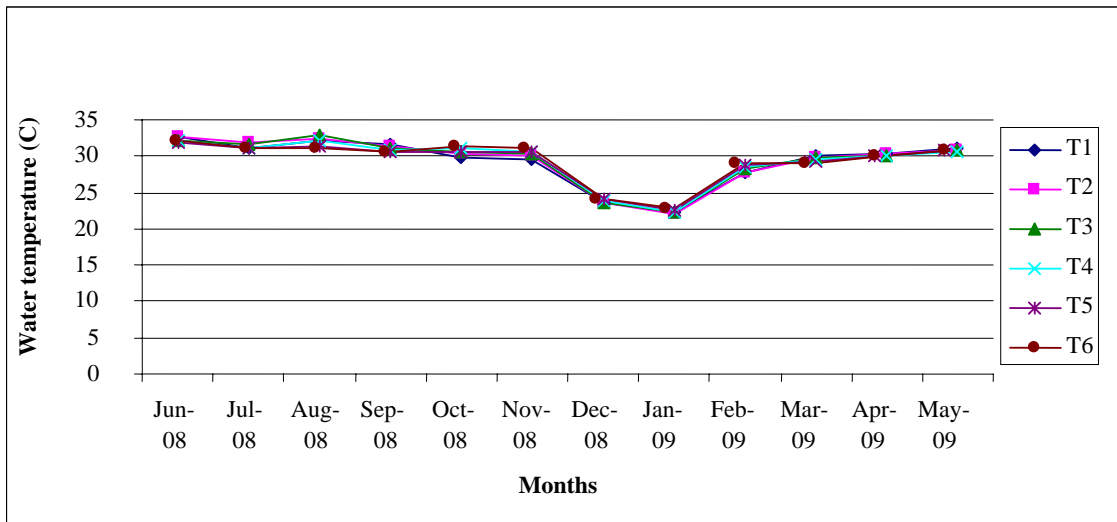


Figure 5.31: Annual variation of water temperature in transverse transects during June 2008 to May 2009

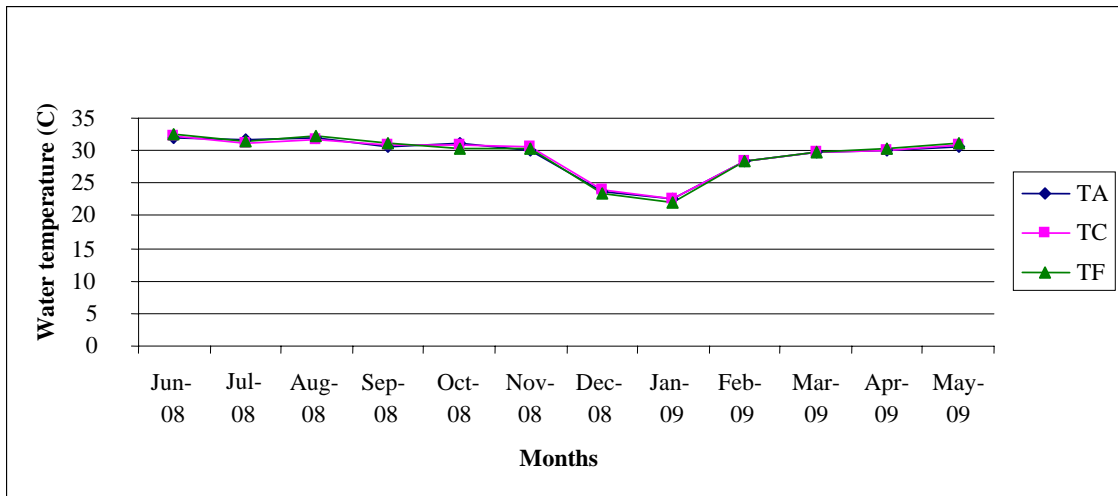


Figure 5.32: Annual variation of water temperature in longitudinal transects during June 2008 to May 2009

5.3.3 Water pH

Average water pH was measured when collecting water samples. The average pH was 8.2. In transverse transects, water pH values gradually increased from T1 to T6 (8.1 to 8.3) whereas in longitudinal transects, the maximum average pH value was in TC (8.3), the middle of the study site. In term of temporal variation, the lowest pH (7.6) was found in July 2008 and the highest pH (8.6) was in November 2008 and May 2009. The average pH in all transects ranged from 7.0-8.5 whereas the average temporal pH variation in November 2008 and May 2009 exceeded the value indicated by marine water quality standard (Figure 5.33-5.34).

The average transverse transect water pH was significantly different ($p < 0.01$) both in transects and by months, whereas there was no difference in interactions. There was significant difference ($p < 0.01$) among longitudinal transects, by months and interactions.

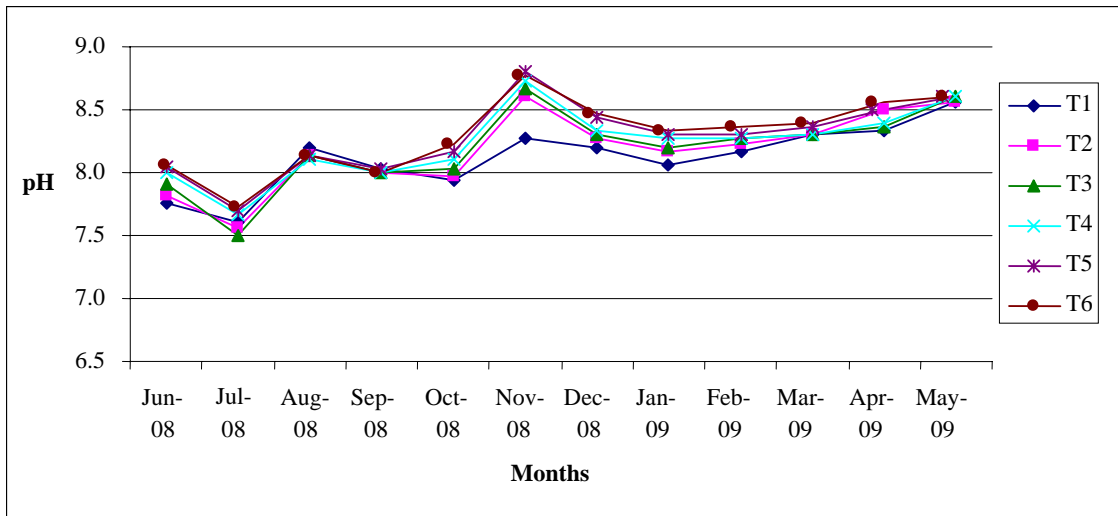


Figure 5.33: Annual variation of water pH in transverse transects during June 2008 to May 2009

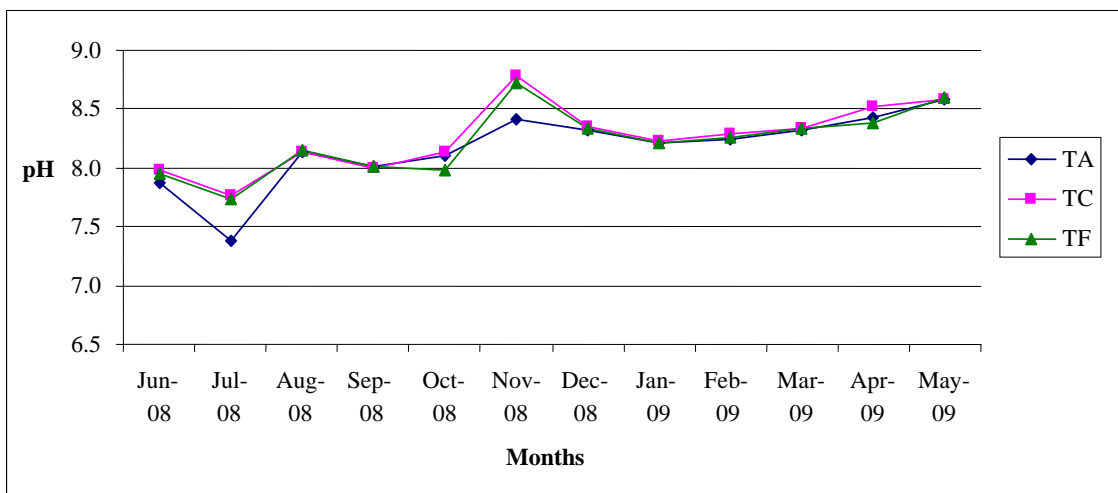


Figure 5.34: Annual variation of water pH in longitudinal transects during June 2008 to May 2009

5.3.4 Dissolved oxygen

Average DO was measured in the same time when collecting water samples. The results showed that the average DO value was 5.16 mg/l. In transverse transects, average DO values ranged from 5.00-5.41 mg/l and gradually increased from transect T1 and T2 to T6 whereas in each longitudinal transect, average DO value was rather constant (5.16 mg/l). All transects had DO higher than 4 mg/l which met the DO standard for marine water quality.

The annual variation of DO in the study site ranged from 3.2-10.32 mg/l. The lowest average DO value (3.2 mg/l) was found in September 2008 and the highest average DO value (10.32 mg/l) was in November 2008. Especially in T6, DO value was 12.09 mg/l (Figure 5.35-5.36).

The statistical analysis in transverse transects showed that average DO was significantly different ($p < 0.01$) among each transect, by months and interaction. In longitudinal transects, the average DO was only significantly different ($p < 0.05$) by months, whereas there was no difference ($p < 0.01$) both in each transect and its interaction. It was confirmed that average DO varied based on temporal variation rather than spatial variation and varied based on transverse distribution rather than longitudinal distribution.

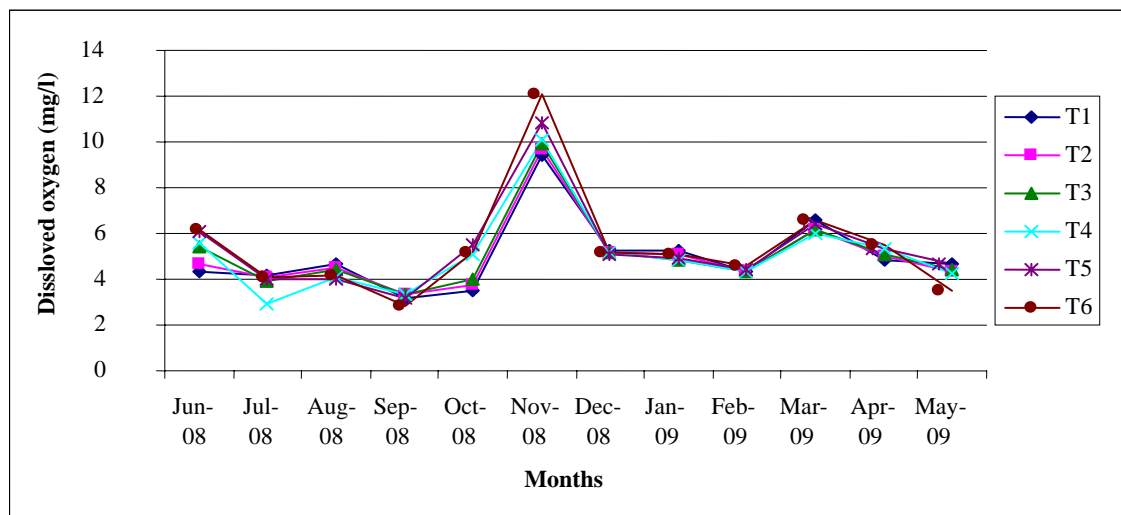


Figure 5.35: Annual variation of dissolved oxygen in transverse transects during June 2008 to May 2009

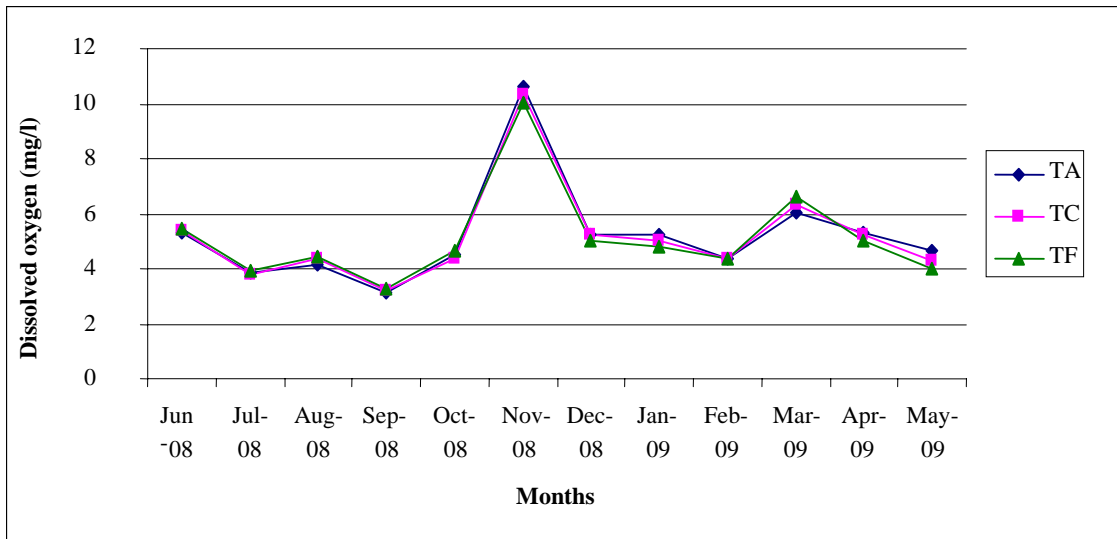


Figure 5.36: Annual variation of dissolved oxygen in longitudinal transects during June 2008 to May 2009

5.3.5 Transparency

The results showed that the average transparency value was 64.9 cm. In transverse transects, average transparency values ranged 54.0-74.7 cm and gradually increased from T1 to T6. In each longitudinal transect, average maximum transparency value was in TA (67.8 ± 27.4 cm) and average minimal value was in TF (62.2 ± 17.9 cm). The values declined from TA to TF. In term of temporal variation, the low average transparency values were found in August 2008, November 2008 and February 2009 (42.6, 44.3 and 36.5 cm respectively), whereas the highest average transparency value (97.9 cm) was found in December 2009 (Figure 5.37-5.38).

The statistical analysis in transverse transects showed that average transparency was significantly different ($p < 0.01$) both in each transect and by months and different ($p < 0.05$) in their interaction. In term of longitudinal transect, the average transparency was significantly different ($p < 0.01$) by months and their interactions, whereas there was no difference in each transect. It was confirmed that average transparency varied based on temporal variation rather than spatial variation and varied based on transverse distribution rather than longitudinal distribution.

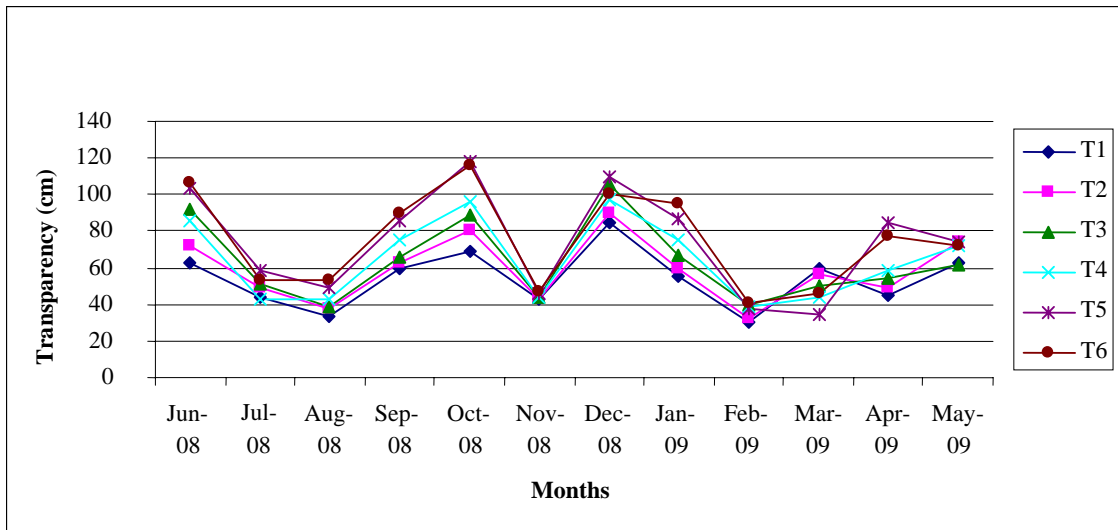


Figure 5.37: Annual variation of transparency in transverse transects during June 2008 to May 2009

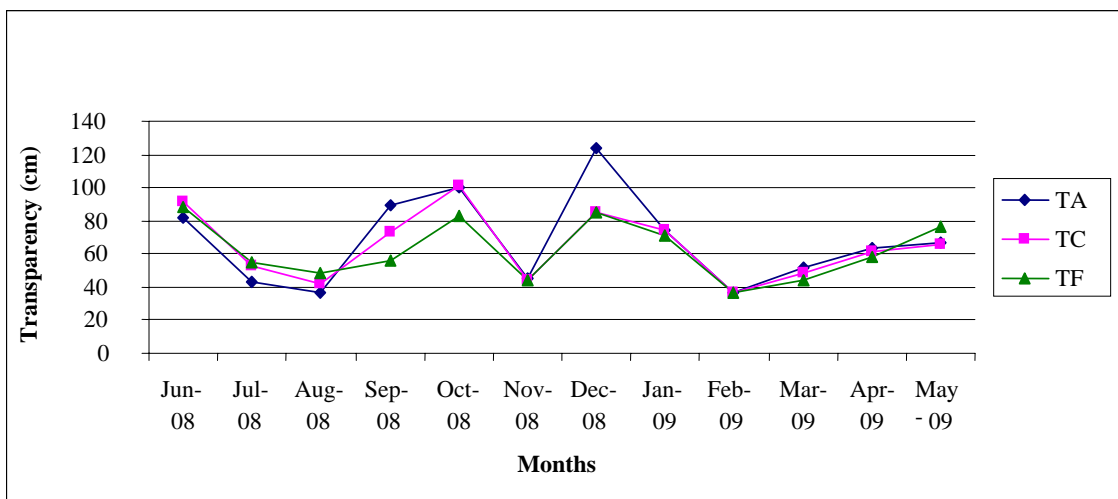


Figure 5.38: Annual variation of transparency in longitudinal transverse transects during June 2008 to May 2009

5.3.6 Turbidity

The results showed that the average turbidity was 18.1 NTU and varied with transverse transects (T1-T6) rather than longitudinal transects (TA-TF). The range of average standard deviations were higher in T1-T6 in each month (1.2-13.6 and 0.48-10.65 respectively). In transverse transects, average turbidity ranged from 16.0-20.3 NTU. The lowest value was found in T6 (16.0 ± 15.98 NTU) whereas in longitudinal transects, average highest turbidity was found in TC (19.0 ± 16.87 NTU)

and lowest value was in TA (17.2 ± 15.54 NTU). In term of temporal variation, the high average turbidity value was found in August 2008, February and March 2009 which was 37.1 , 44.1 and 43.9 NTU respectively and the lowest average turbidity was found in January 2009 (3.1 NTU) during winter season (Figure 5.39-5.40).

The statistical analysis in transverse transects showed that average turbidity was significantly different ($p < 0.01$) both in each transect and by months. In term of longitudinal transects, the average turbidity was significantly different ($p < 0.01$) by months, in each transect and interactions. It was demonstrated that average turbidity varied based on temporal variation rather than spatial variation and varied based on transverse distribution rather than longitudinal distribution.

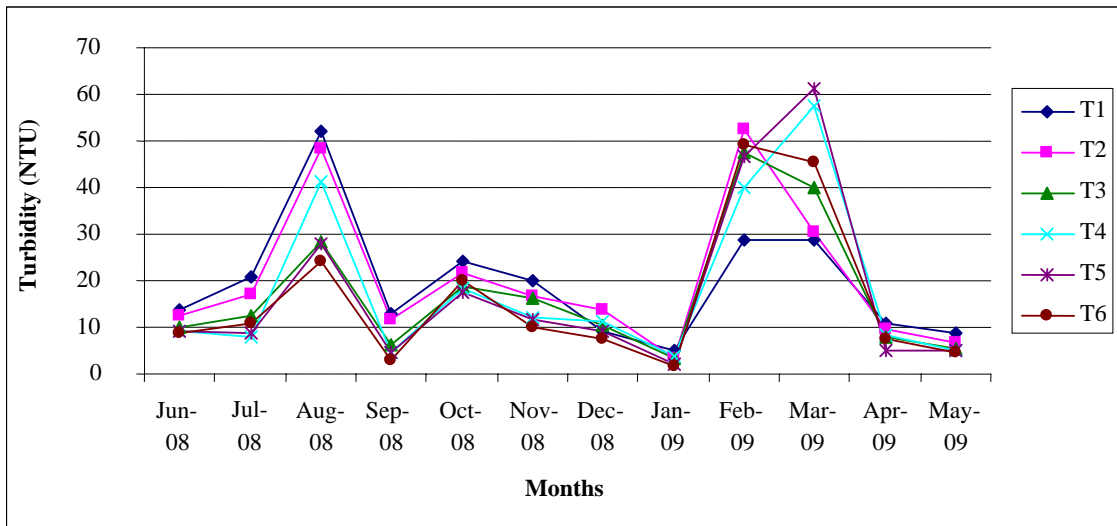


Figure 5.39: Annual variation of turbidity in transverse transects during June 2008 to May 2009

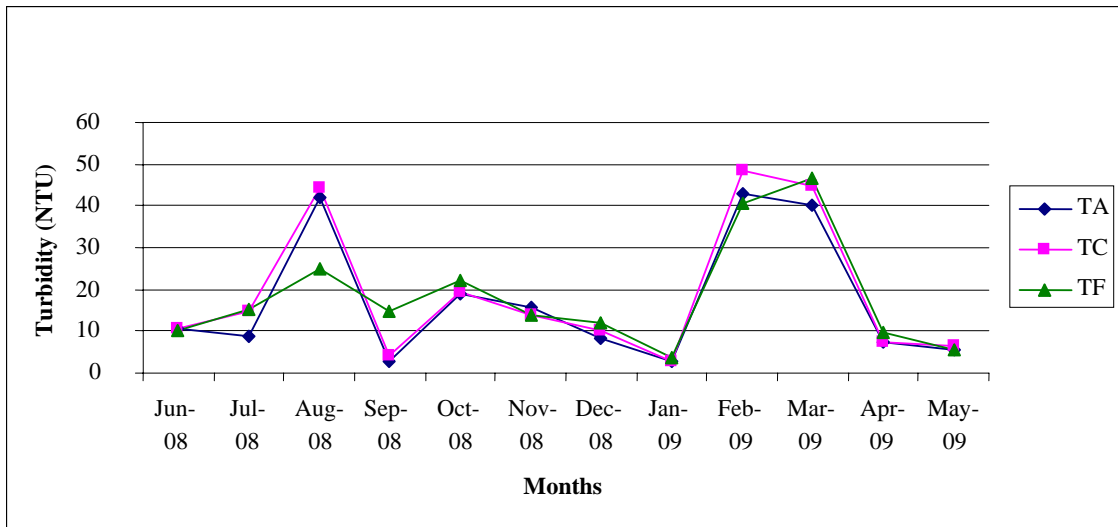


Figure 5.40: Annual variation of turbidity in longitudinal transects during June 2008 to May 2009

5.3.7 Salinity

The results showed that the average salinity was 21.8 PSU and likely varied with transverse transects (T1-T6) rather than longitudinal transects (TA-TF). The range of average standard deviations were higher in T1-T6 in each month (1.0-5.9 and 0.3-4.7 respectively). In transverse transects, average salinity ranged 19.2 ± 7.2 PSU to 24.2 ± 4.9 PSU and gradually increased from T1 to T6 whereas in longitudinal transects, average lowest salinity was found in TA (21.1 ± 5.7 PSU) and gradually increased from TA to TF. In term of temporal variation, average salinity ranged 11.0-33.7 PSU. Average highest salinity was found in January 2009 (33.7 PSU) and the lowest average salinity was found in October 2008 (11.0 PSU). Especially in T1, T2 and TF, average salinity were below 10 PSU due to their locations close to the coast line comparing to other transects (Figure 5.41-5.42).

The statistical analysis in transverse transects showed that average salinity was significantly different ($p < 0.01$) among in each transect, by months and by interaction. In longitudinal transects, the average salinity was significantly different ($p < 0.01$) both by months and interaction, whereas it was different ($p < 0.05$) in each transect. It was demonstrated that average salinity varied based on both temporal variation and spatial variation and varied based on both transverse distribution and longitudinal distribution.

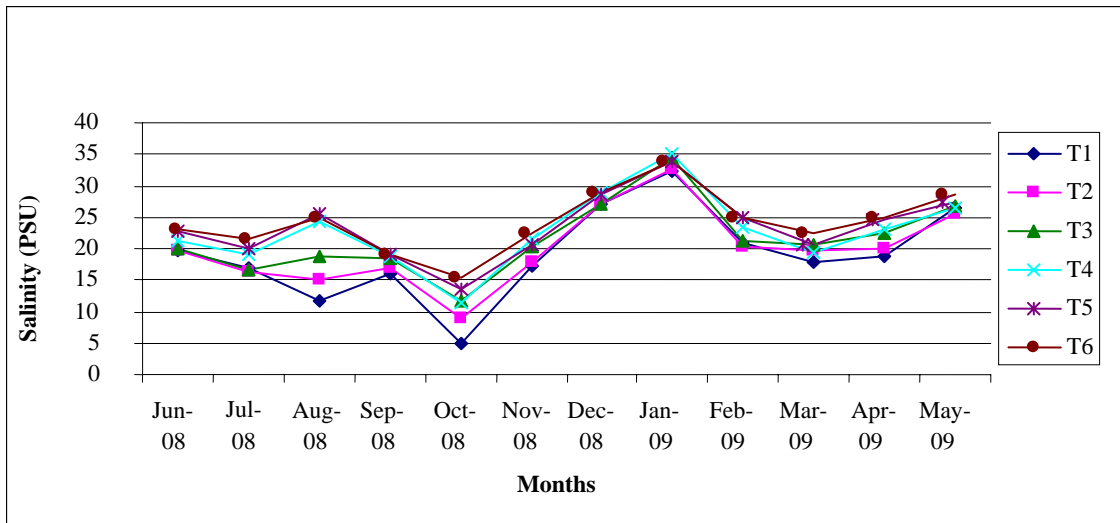


Figure 5.41: Annual variation of salinity in transverse transects during June 2008 to May 2009

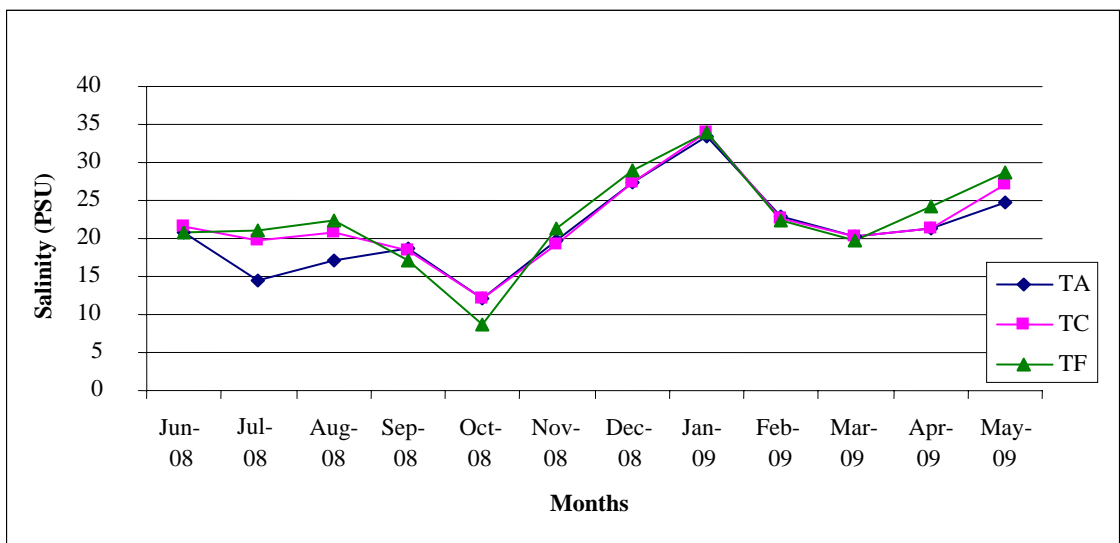


Figure 5.42: Annual variation of salinity in longitudinal transects during June 2008 to May 2009

5.3.8 Alkalinity

The results showed that the average alkalinity was 102.7 mg/l. Alkalinity values ranged from 101.4 mg/l to 103.6 mg/l and 102.5 mg/l to 103.1 mg/l in transverse transects and longitudinal transects respectively. Average alkalinity in transverse transects were rather constant as well as in longitudinal transects. In term of temporal variation, the low alkalinity values 95.1, 68.7 and 93 mg/l were found in

June 2008, July 2008 and May 2009 respectively or beginning of rainy season (Figure 5.43-5.44).

The statistical analysis in transverse transect showed that average alkalinity was significantly different ($p < 0.01$) both by months and interaction whereas there was no difference ($p < 0.05$) in each transect. In term of longitudinal transect, the average alkalinity was significantly different ($p < 0.01$) only by months and not different ($p < 0.05$) in each transect and its interaction. It was confirmed that average alkalinity varied only based on temporal variation.

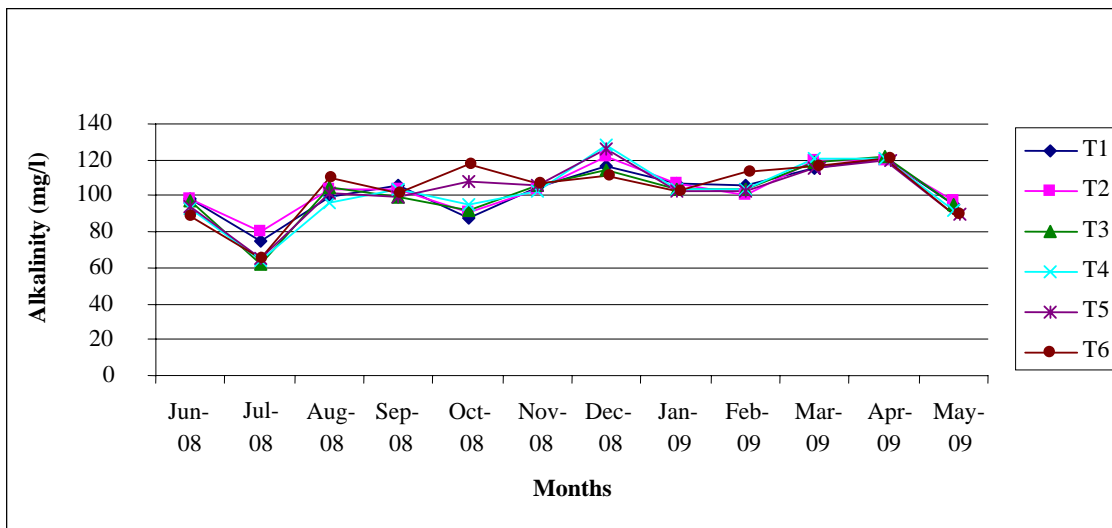


Figure 5.43: Annual variation of alkalinity in transverse transects during June 2008 to May 2009

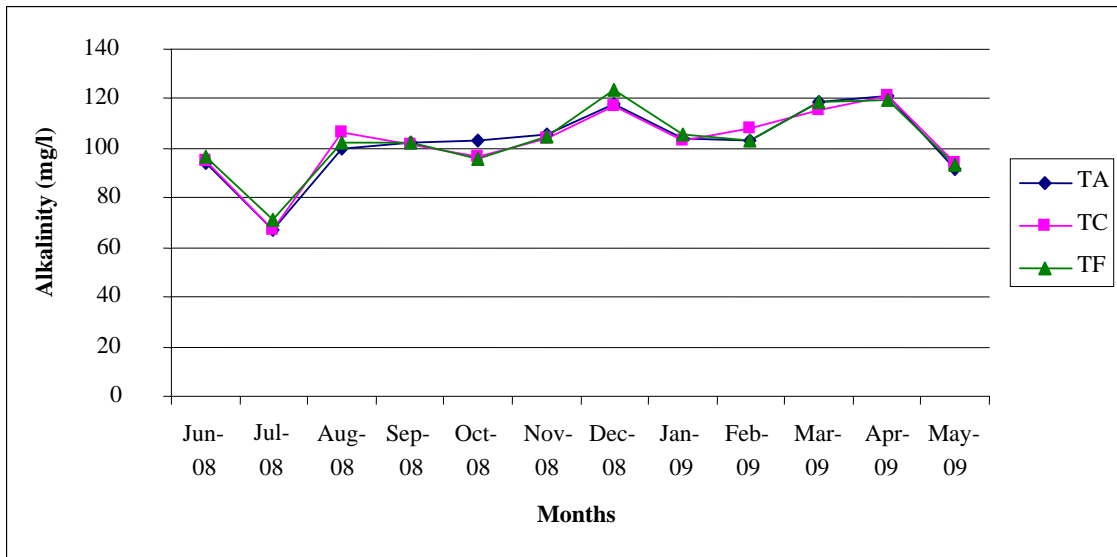


Figure 5.44: Annual variation of alkalinity in longitudinal transects during June 2008 to May 2009

5.3.9 Hardness

The results showed that the average hardness was 450.4 mg/l. In transverse transects, average hardness values ranged 377.8 ± 138.6 mg/l to 483.6 ± 99.23 mg/l and gradually increased from T1 to T5 and T6 whereas in longitudinal transects, average lowest and highest hardness values were found in TA (430.1 ± 96.7 mg/l) and TF (464.2 ± 108.2 mg/l) respectively. In term of temporal variation, average hardness ranged 250.6-535 mg/l. Average highest hardness was found in January 2009 (615 mg/l) and the lowest average hardness was found in October 2008 (250.6 mg/l) (Figure 5.45-5.46).

The statistical analysis in transverse transect showed that average hardness was significantly different ($p < 0.01$) in each transect and by months but different ($p < 0.05$) in its interaction. In longitudinal transect, the average hardness was significantly different ($p < 0.01$) only by months whereas there was no difference ($p < 0.05$) in each transect and its interaction. It showed that average hardness varied based on both temporal and spatial variation.

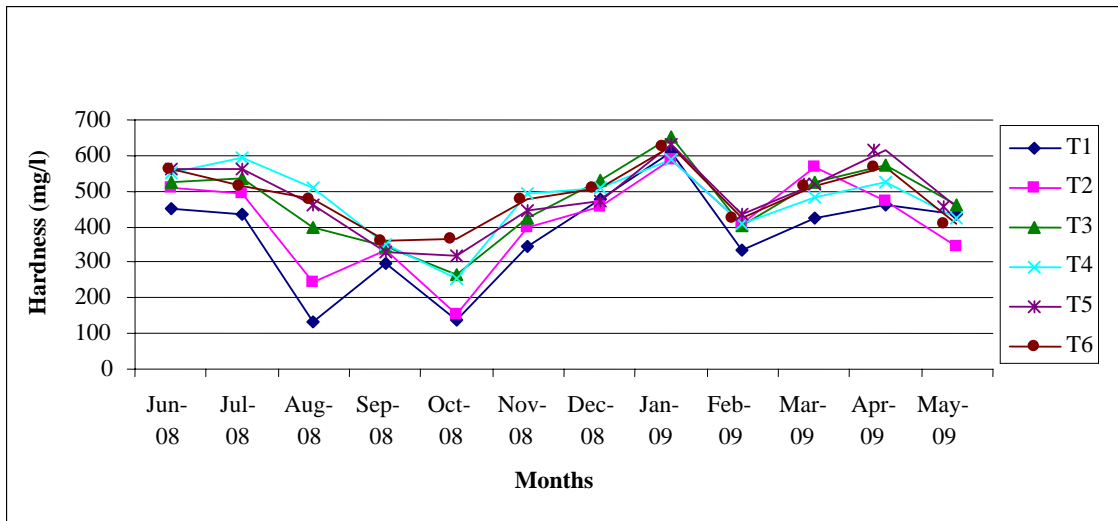


Figure 5.45: Annual variation of hardness in transverse transects during June 2008 to May 2009

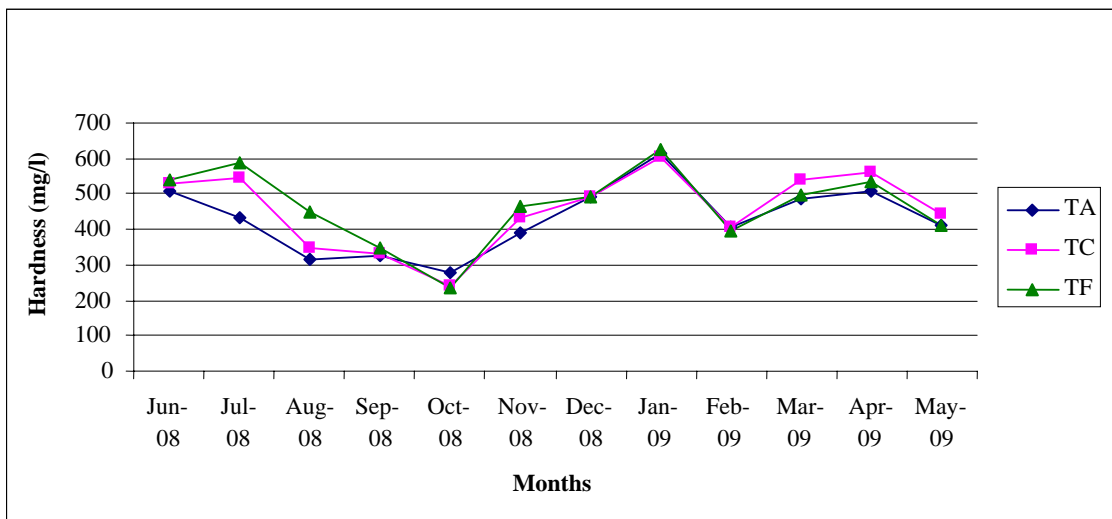


Figure 5.46: Annual variation of hardness in longitudinal transects during June 2008 to May 2009

5.3.10 Ammonia

The average ammonia was 0.074 mg/l. In transverse transects, average ammonia values ranged 0.059 ± 0.045 mg/l to 0.090 ± 0.052 mg/l and gradually declined from T1 to T5 and T6 whereas in longitudinal transects, average ammonia values ranged 0.07 ± 0.0485 mg/l to 0.077 ± 0.0467 mg/l and gradually increased from TA to TF. In term of temporal variation, average ammonia ranged 0.011-0.162 mg/l. Average highest ammonia was found in July 2008 and the low average ammonia

values 0.016 mg/l and 0.011 mg/l were found in October and November 2008, respectively (Figure 5.47-5.48).

The statistical analysis in transverse transect showed that average total ammonia was significantly different ($p < 0.01$) both in each transect and by months whereas there was no difference ($p < 0.05$) in its interaction. In longitudinal transect, the average total ammonia was significantly difference ($p < 0.01$) only by month whereas there was no different ($p < 0.05$) in each transect and its interaction. It showed that average total ammonia varied mainly based on temporal variation and on transverse transect in case of spatial variation.

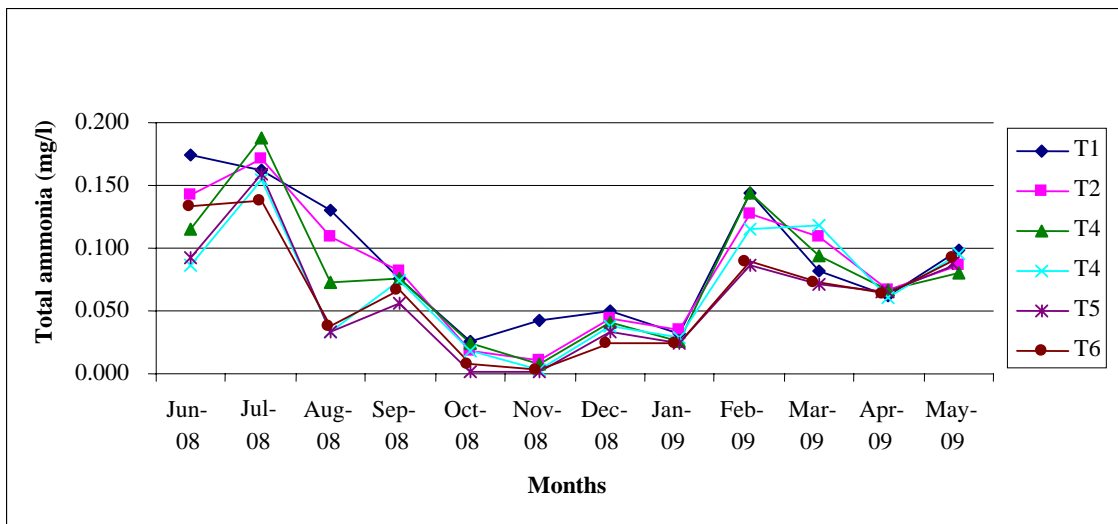


Figure 5.47: Annual variation of total ammonia in transverse transects during June 2008 to May 2009

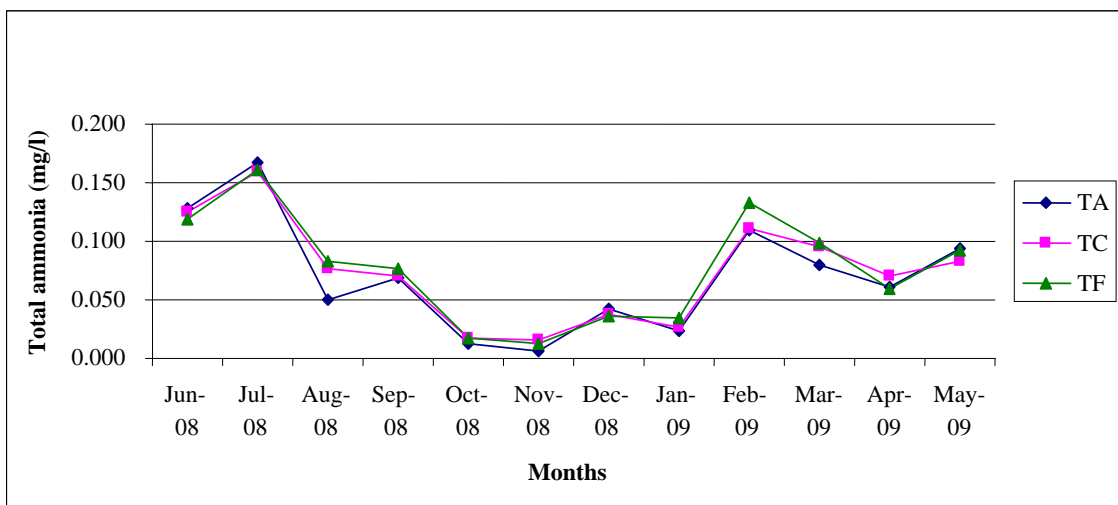


Figure 5.48: Annual variation of total ammonia in longitudinal transects during June 2008 to May 2009

5.3.11 Nitrate

Average quantity of nitrate in the samples of water collected at the middle depth in Don Hoi Lot was measured. The results showed that the average nitrate was 0.67 mg/l. For spatial variation, in transverse transects, average nitrate values ranged from 0.45 mg/l to 1.02 mg/l and the maximum average nitrate was found at T1 (0.45±0.24 mg/l) and values gradually declined to T6 (1.02±0.64 mg/l) whereas in longitudinal transect, average nitrate values ranged 0.60±0.32 mg/l to 0.74±0.39 mg/l and gradually declined from TA to TF. In term of temporal variation, average nitrate values ranged 0.17-1.16 mg/l. Average highest nitrate was found in February 2009 and the lowest average nitrate was found in November 2008. Comparing the average nitrate with the nitrate in marine water quality standard, it was found that all average nitrate values in all transects in each month exceeded the nitrate standard (0.06 mg/l) of the marine water quality (Figure 5.49-5.50).

The statistical analysis in transverse transect illustrated that average nitrate was significantly different ($p < 0.01$) among each transect, by months and interaction. In longitudinal transect, the average nitrate was significantly different ($p < 0.01$) only by month whereas there was no difference ($p < 0.05$) in each transect and interaction. It showed that average nitrate varied based on temporal variation. For spatial variation, average nitrate varied based on only in transverse transect.

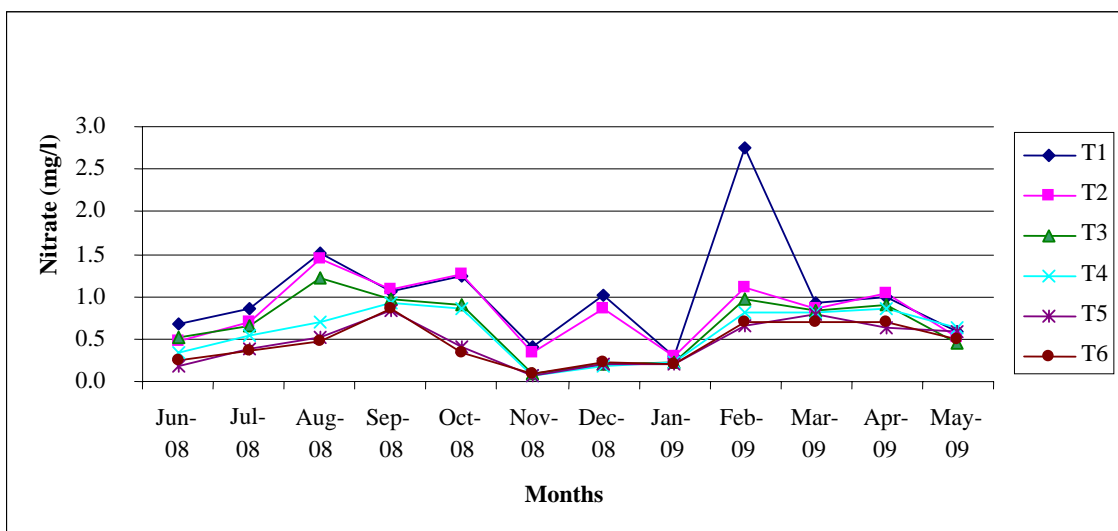


Figure 5.49: Annual variation of nitrate nitrogen in transverse transects during June 2008 to May 2009

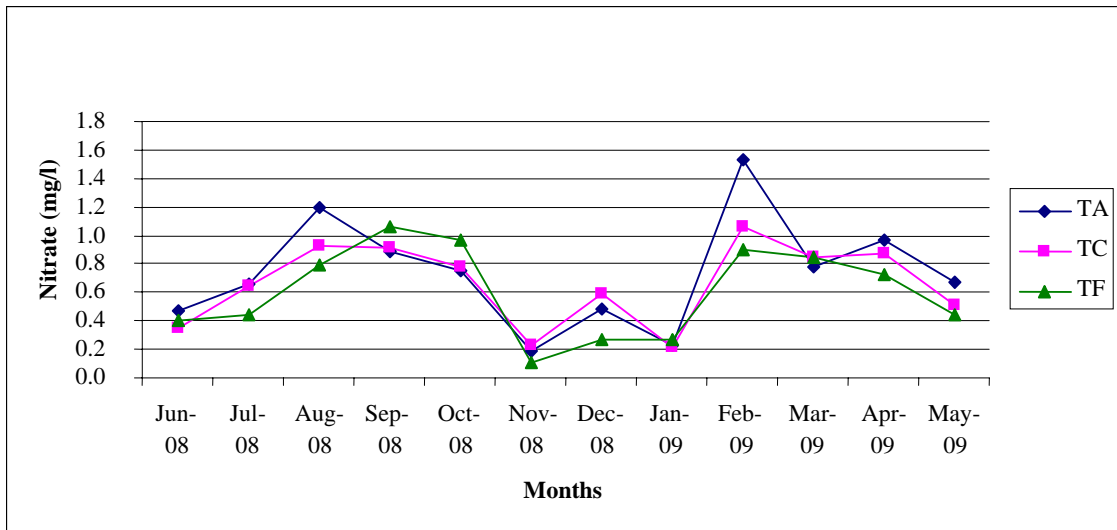


Figure 5.50: Annual variation of nitrate nitrogen in longitudinal transects during June 2008 to May 2009

5.3.12 Phosphorus

The quantity of phosphorus was determined in orthophosphate form and average orthophosphate was measured. The results revealed that the average orthophosphate was 0.046 mg/l. In spatial variation, average orthophosphate values ranged from 0.038 mg/l to 0.056 mg/l and 0.043 mg/l to 0.049 mg/l in transverse transects and longitudinal transects respectively. In temporal variation, average orthophosphate values ranged from 0.02-0.116 mg/l. The maximum average orthophosphate was found in January 2009 and minimum average orthophosphate value was found in November 2008. Comparing the average orthophosphate with the marine water quality standard, it was found that all average orthophosphate values in all transects and each month were rather constant and met with orthophosphate standard (0.045 mg/l) of marine water quality, except in January 2009 and February 2009 or late winter season when average orthophosphate exceeded than the standard (Figure 5.51-5.52).

The statistical analysis in transverse transect illustrated that average orthophosphate was significantly different ($p < 0.01$) by months whereas there was not difference ($p < 0.05$) in each transect and interaction. In longitudinal transect, the average orthophosphate was significantly different ($p < 0.01$) both by months and interaction whereas there was no difference ($p < 0.05$) in each transect. It showed that

average orthophosphate varied based on temporal variation rather than spatial variation in both transverse and longitudinal transects.

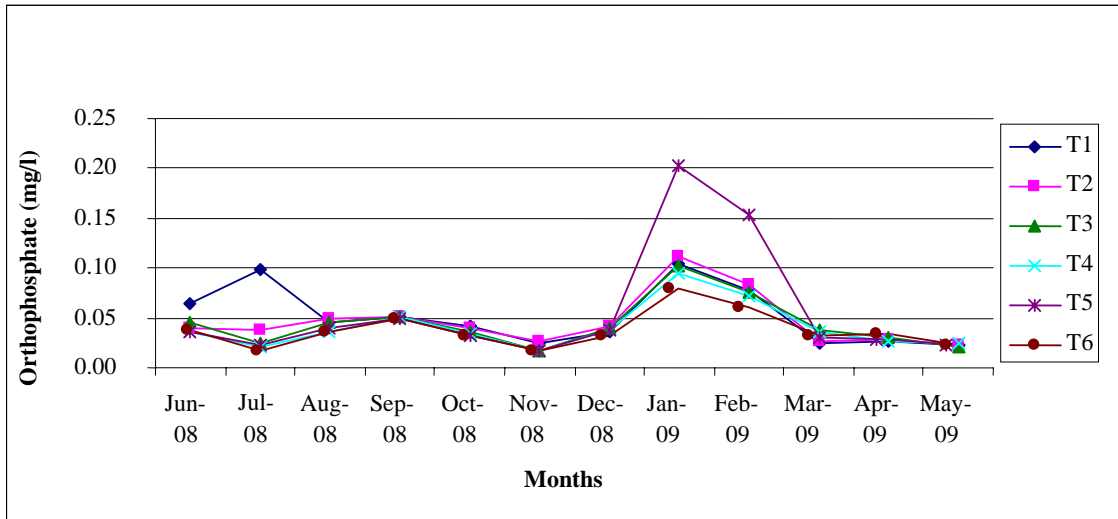


Figure 5.51: Annual variation of orthophosphate in transverse transects during June 2008 to May 2009

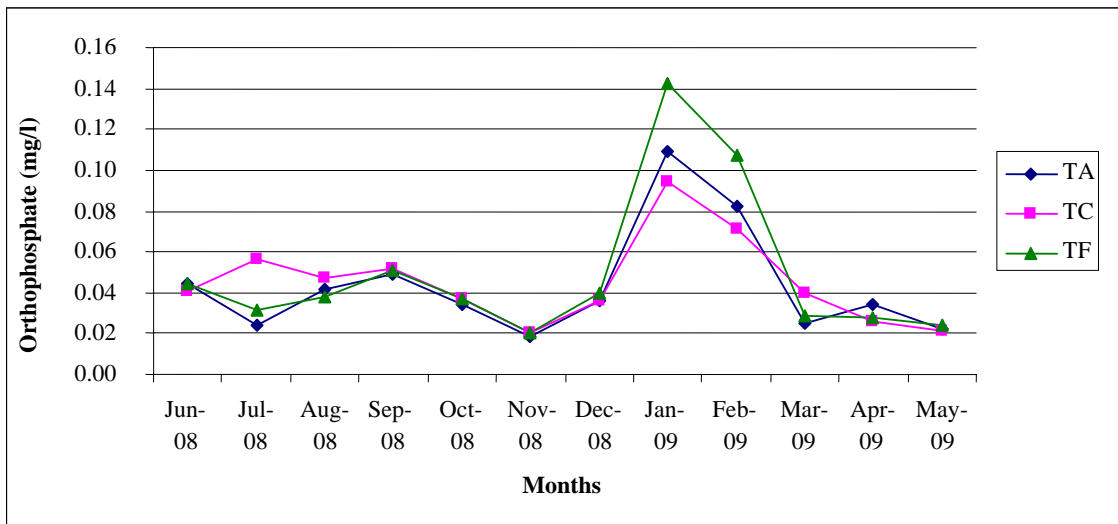


Figure 5.52: Annual variation of orthophosphate in longitudinal transects during June 2008 to May 2009

5.3.13 Chlorophyll-a

The chlorophyll-a content was analyzed from water samples collected. The results showed that the average chlorophyll-a content was 6.5 mg/m^3 . For spatial distribution, the average chlorophyll-a ranged from $5.3 \pm 7.7 \text{ mg/m}^3$ to $7.3 \pm 5.7 \text{ mg/m}^3$ and $6.2 \pm 6.2 \text{ mg/m}^3$ to $6.9 \pm 6.7 \text{ mg/m}^3$ in transverse transects and longitudinal transects, respectively. The considerable high chlorophyll-a content was found in T4-T6 in transverse transect and TF in longitudinal transect. In term of temporal variation, the average chlorophyll-a content ranged from 0.4 - 18.9 mg/m^3 . Maximum chlorophyll-a was found in two peaks in November 2008 and February 2009 or during the dry season whereas minimum chlorophyll-a was found in July 2008 (rainy season) (Figure 5.53-5.54).

The transverse transect analysis revealed that the average chlorophyll-a was significantly different ($p < 0.01$) only by months. There was no difference ($p < 0.05$) among transects and interaction as found in longitudinal transects. It showed that the average chlorophyll-a varied based on temporal variation.

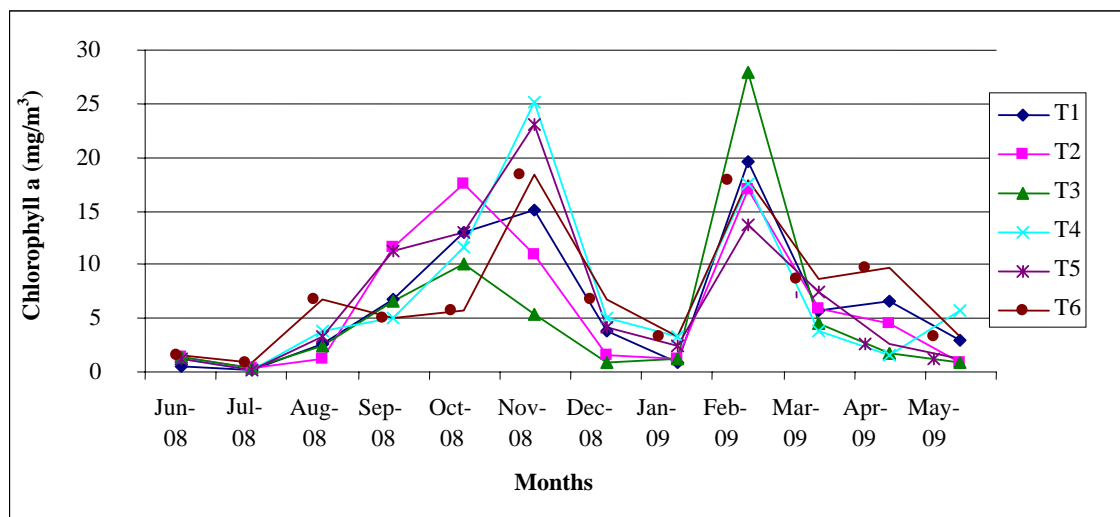


Figure 5.53: Annual variation of chlorophyll-a in transverse transects during June 2008 to May 2009

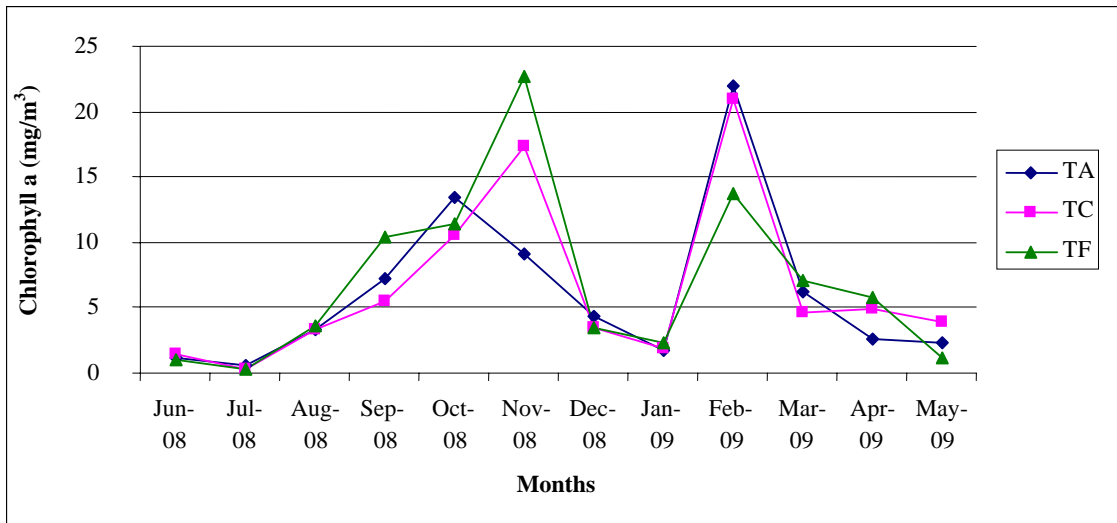


Figure 5.54: Annual variation of chlorophyll-a in longitudinal transects during June 2008 to May 2009

5.3.14 Relationship among chemical parameters

Water quality parameters were analyzed by using Pearson correlation in order to find out their relationship (Table 5.2). The results were as follows:

Water depth had significantly positive correlation with transparency ($r=0.434$), salinity ($r=0.285$), hardness ($r=0.355$), but had significantly negative correlation with turbidity ($r=-0.322$), nitrate ($r=-0.482$) and chlorophyll-a ($r=-0.362$).

Water temperature was significantly negatively correlated with water pH ($r=-0.187$), transparency ($r=-0.221$), salinity ($r=-0.551$), alkalinity ($r=-0.336$), hardness ($r=-0.346$) and orthophosphate ($r=-0.478$), but was significantly positively correlated with turbidity ($r=0.317$), ammonia ($r=0.282$) and nitrate ($r=0.282$).

The relationships between water pH and these factors (dissolved oxygen, salinity, alkalinity, and chlorophyll-a) were significantly positive with correlation coefficients 0.508, 0.375, 0.512 and 0.342 respectively. Their relationship with plant nutrients (total ammonia, nitrate and orthophosphate) was significantly reverse variation. These relationship patterns of water pH with mentioned parameters were the same as with dissolved oxygen.

Transparency was significantly positive correlated with salinity ($r=0.200$) but significantly negative varied with turbidity ($r=-0.560$), total ammonia ($r=-0.294$),

nitrate($r=-0.352$) and chlorophyll-a ($r=-0.199$). These relationship patterns of transparency with the mentioned parameters were in opposite direction with turbidity.

The relationships between salinity and alkalinity, hardness and phosphate were significantly positive variation with correlation coefficients 0.255, 0.705 and 0.235 respectively, whereas the relationships with nitrate and chlorophyll-a were significantly diverse variation.

The relationship between alkalinity and total ammonia was significantly negative correlated ($r= - 0.397$) whereas the relationship with chlorophyll-a ($r= 0.290$) was significantly positive. The results showed that the relationship between hardness and nitrate was negative, similar to what found in chlorophyll-a.

Total ammonia was significantly positive correlated with nitrate ($r= 0.348$) whereas the relationship was significantly negative with chlorophyll-a ($r=- 0.297$).

Table 5.2: Pearson correlation among water qualities and related parameters at Don Hoi Lot during June 2008-May 2009 (n=216)

Water parameters	Depth	Temperature	pH	Dissolved oxygen	Transparency	Turbidity	Salinity	Alkalinity	Hardness	Ammonia	Nitrate	Phosphate
Temperature	-0.142*											
pH	-0.140*	-0.187**										
Dissolved oxygen	0.155*	-0.081	0.518**									
Transparency	0.434**	-0.221**	0.010	-0.101								
Turbidity	-0.322**	0.317**	-0.033	0.135*	-0.560**							
Salinity	0.285**	-0.551**	0.375**	0.106	0.200**	-0.395**						
Alkalinity	-0.120	-0.336**	0.512**	0.334**	0.075	0.133	0.255**					
Hardness	0.355**	-0.346**	0.099	0.195**	0.138*	-0.304**	0.705**	0.087				
Ammonia	-0.064	0.348**	-0.464**	-0.353**	-0.294**	0.169*	-0.094	-0.397**	0.051			
Nitrate	-0.482**	0.282**	-0.254**	-0.435**	-0.352**	0.339**	-0.504**	0.005	-0.520**	0.348**		
Phosphate	-0.020	-0.478**	-0.152*	-0.239**	0.048	-0.074	0.235**	0.077	0.112	0.046	0.075	
Chlorophyll-a	-0.362**	0.021	0.342**	0.235**	-0.199**	0.304**	-0.185**	0.290**	-0.338**	-0.297**	0.152*	0.006

Remark: * = Significant at 0.05 level ** = Significant at 0.01 level

5.4 Biological factors

5.4.1 Phytoplankton in Don Hoi Lot

Phytoplankton taxa, their abundance, spatial and temporal distribution were analyzed from 18 water samples collected at Don Hoi Lot during June 2008-May 2009. The analysis was based on monthly basis, sampling stations, transverse and longitudinal variation.

5.4.1.1 Species composition

Phytoplankton samples were identified. There were 187 species under 3 divisions (Cyanophyta, Chlorophyta and Chromophyta), 9 classes (Cyanophyceae, Chlorophyceae, Euglenophyceae, Bacillariophyceae, Chrysophyceae, Xanthophyceae, Dictyochophyceae, Prymnesiophyceae and Dinophyceae), 20 orders, 52 families and 109 genera existed. The major diverse groups were class Bacillariophyceae or diatom composing 87 species or 46.52 % of total species, followed by class Chlorophyceae or green algae (44 species or 23.53 %), Dinophyceae or dinoflagellates (20 species or 10.70 %), Cyanophyceae or blue-green algae (18 species or 9.63 %), Euglenophyceae or euglenoid (13 species or 6.95 %), Dictyochophyceae or silicoflagellates (2 species or 1.07 %) and the remaining three classes (Chrysophyceae or chrysophytes, Xanthophyceae or Xanthophytes and Prymnesiophyceae or haptophytes) consisted of one species in each, respectively. The most diverse genera were *Chaetoceros* (15 species), followed by *Scenedesmus* (10 species) and *Rhizosolenia* (7 species) respectively (Figure 5.55 and Table 5.3). The list of phytoplankton species is presented in Table 5.4.

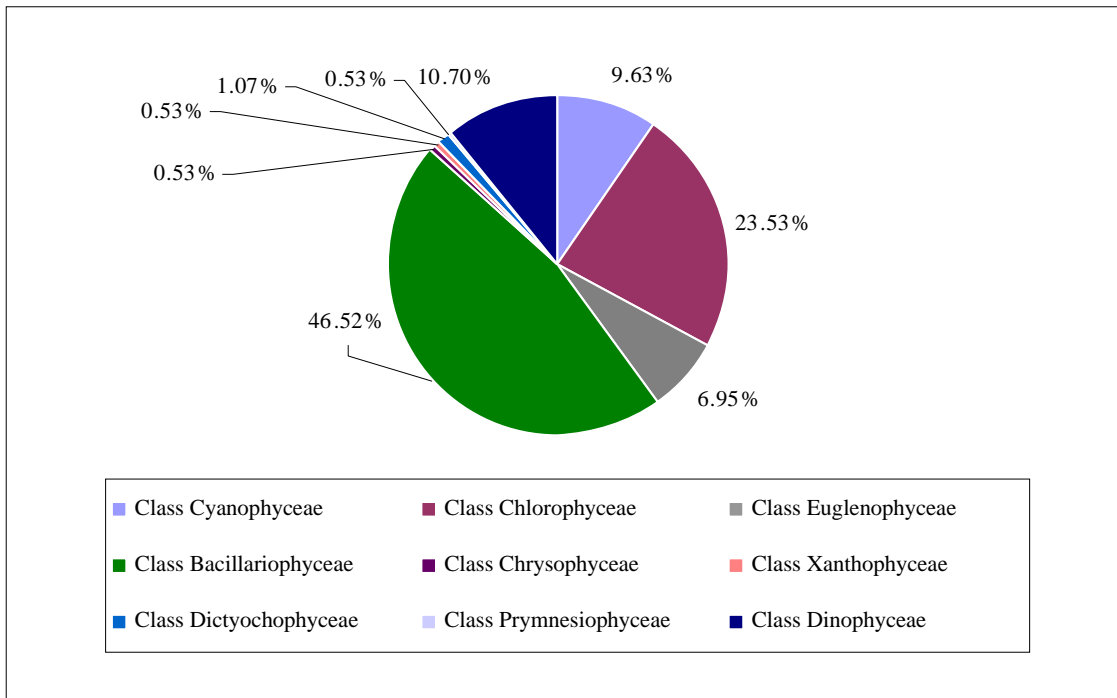


Figure 5.55: Species composition in percentage of phytoplankton in Don Hoi Lot during June 2008 -May 2009

In term of phytoplankton abundance, their quantity ranged from 1- 773,473 unit/l. The maximum number of phytoplankton was found in class Bacillariophyceae, 97.5257 % of all phytoplankton, followed by class Dinophyceae (2.0021 %). Number of phytoplankton of the remaining classes was less than 1% (Table 5.3).

Table 5.3: Species composition and average number of phytoplankton in each month in Don Hoi Lot during June 2008- May 2009, classified by classes

Class	No. of species	Percentage of total	No. of phytoplankton (unit/l)	Percentage of total
Cyanophyceae	18	9.63	3438	0.4335
Chlorophyceae	44	23.53	273	0.0344
Euglenophyceae	13	6.95	23	0.0029
Bacillariophyceae	87	46.52	773,473	97.5257
Chrysophyceae	1	0.53	1	0.0001
Xanthophyceae	1	0.53	2	0.0003
Dictyochophyceae	2	1.07	3	0.0004
Prymnesiophyceae	1	0.53	4	0.0005
Dinophyceae	20	10.70	15879	2.0021
Total	187	100	793,097	100

Table 5.4: List of phytoplankton species in Don Hot Lot during June 2008-May 2009

No. of species	TAXA
PHYTOPLANKTON	
DIVISION CYANOPHYTA	
CLASS CYANOPHYCEAE	
Order Chroococcales	
Family Chroococcaceae	
1	<i>Chroococcus turgidus</i> (Kützing) Naegeli
2	<i>Merismopedia convoluta</i> Brébisson
3	<i>M. minima</i> Beck
4	<i>M. tenuissima</i> Lemmermann
5	<i>Microcystis aeruginosa</i> Kützing
Order Nostocales	
Family Oscillatoriaceae	
6	<i>Oscillatoria</i> spp.
7	<i>Phormidium mucicola</i> Naumann & Huber - Pestalozzi
8	<i>Spirulina platensis</i> (Nordstedt) Geitler
9	<i>S. major</i> Kützing
Family Nostocaceae	
10	<i>Anabaena</i> sp.
11	<i>A. affinis</i> Lemmermann
12	<i>A. spiroides</i> Klebahn
13	<i>Anabaenopsis circularis</i> (G.S. West) Woloszynska & Miller
14	<i>Cylindrospermopsis raciborskii</i> (Woloszynska) Seenayya et Subba Raju
15	<i>C. philippinensis</i> (Taylor) Komárek
16	<i>Raphidiopsis curvata</i> Fritsch & Rich
17	<i>Raphidiopsis indica</i> Singh
18	<i>R. mediterranea</i> Skuja

Table 5.4: List of phytoplankton species in Don Hot Lot during June 2008-May 2009
(cont.)

No. of species	TAXA
	DIVISION CHLOROPHYTA
	CLASS CHLOROPHYCEAE
	Order Volvocales
	Family Volvocaceae
19	<i>Eudorina elegans</i> Ehrenberg
20	<i>Pandorina morum</i> (Müller) Bory
	Order Tetrasporales
	Family Palmellaceae
21	<i>Sphaerocystis</i> sp.
	Order Chlorococcales
	Family Hydrodictyaceae
22	<i>Pediastrum duplex</i> Meyen
23	<i>P. duplex</i> var. <i>clathratum</i> (A. Braun) Lagerheim
24	<i>P. duplex</i> var. <i>gracilimum</i> West & West
25	<i>P. simplex</i> (Meyen) Lemmermann
26	<i>P. simplex</i> var. <i>duodenarium</i> (Bailey) Rabenhorst
27	<i>P. tetras</i> (Ehrenberg) Ralfs
	Family Coelastraceae
28	<i>Coelastrum astroideum</i> De Notaris
29	<i>C. microporum</i> Naegeli
30	<i>C. reticulatum</i> (Dangeard) Senn
31	<i>C. sphaericum</i> Naegeli
	Family Oocystaceae
32	<i>Ankistrodesmus falcatus</i> (Corda) Ralfs
33	<i>Dictyosphaerium pulchellum</i> Wood
34	<i>Monoraphidium contortum</i> (Thuret) Komarkova - Legnerova

Table 5.4: List of phytoplankton species in Don Hot Lot during June 2008-May 2009
(cont.)

No. of species	TAXA
35	<i>M. caribeum</i> Hindak
36	<i>M. griffithii</i> (Berkeley) Komarkova – Legnerova
37	<i>M. irregulare</i> (Smith) Komarkova - Legnerova
38	<i>M. komarkovae</i> Nygaard
39	<i>Tetraedron arthrodesmiforme</i> (G. S. West) Woloszynska
40	<i>T. trigonum</i> (Naegeli) Hansgirg
Family Radiococcaceae	
41	<i>Coenochloris pyrenoidosa</i> Korschikoff
Family Scenedesmaceae	
42	<i>Actinastrum gracillimum</i> G.M.Smith
43	<i>A. hantzschii</i> Lagerheim
44	<i>Crucigenia crucifera</i> (Wolle) Collins
45	<i>C. neglecta</i> Fott & Ettl
46	<i>C. quadrata</i> Morren
47	<i>C. tetrapedia</i> (Kirchner) West & West
48	<i>Dicloster acuatus</i> Jao, Wei & Hu
49	<i>Scenedesmus</i> sp.
50	<i>S. acuminatus</i> (Lagerheim) Chodat
51	<i>S. acutus</i> Meyen
52	<i>S. bicaudatus</i> (Hansgirg) Chodat
53	<i>Scenedesmus javanensis</i> Chodat
54	<i>S. ovalternus</i> Chodat
55	<i>S. perforatus</i> Lemmermann
56	<i>S. protuberans</i> Fristch & Rich
57	<i>S. quadricauda</i> (Turpin) Brébisson
58	<i>S. spinulatus</i> Biswas

Table 5.4: List of phytoplankton species in Don Hot Lot during June 2008-May 2009
(cont.)

No. of species	TAXA
Order Ulotrichales	
Family Ulotrichaceae	
59	<i>Ulothrix</i> sp.
Family Desmidiaceae	
60	<i>Closterium</i> sp.
61	<i>Cosmarium contractum</i> Kirchner
62	<i>Staurastrum</i> spp.
CLASS EUGLENOPHYCEAE	
Order Euglenales	
Family Euglenaceae	
63	<i>Euglena acus</i> Ehrenberg
64	<i>E. oxyuris</i> schmarda var. <i>charkowiensis</i> (Swirenko) Chu
65	<i>Lepocinclis ovum</i> (Ehrenberg) Lemmermann
66	<i>L. salina</i> Fritsch
67	<i>Phacus hamatus</i> Pochmann
68	<i>P. longicauda</i> (Ehrenberg) Dujardin
69	<i>P. pleuronectes</i> (O.F.Müller) Dujardin
70	<i>P. ranula</i> Pochmann
71	<i>P. tortus</i> (Lemmermann) Skvortzov
72	<i>Strombomonas fluviatilis</i> (Lemmermann) Deflandre
73	<i>S. gibberosa</i> (Playfair) Deflandre
74	<i>Trachelomonas ovalis</i> Playfair var. <i>minor</i> Playfair
Order Heteronematales	
Family Paranemaceae	
75	<i>Entosiphon sulcatum</i> (Dujardin) Stein
DIVISION CHROMOPHYTA	

Table 5.4: List of phytoplankton species in Don Hot Lot during June 2008-May 2009
(cont.)

No. of species	TAXA
CLASS BACILLARIOPHYCEAE	
Order Biddulphiales	
Suborder Coscinodiscineae	
Family Thalassiosiraceae	
76	<i>Cyclotella meneghiniana</i> Kützing
77	<i>C. stylorum</i> Brightwell
78	<i>Lauderia annulata</i> Cleve
79	<i>Planktoniella sol</i> (Wallich) Schütt
80	<i>Skeletonema costatum</i> (Greville) Cleve
81	<i>Thalassiosira</i> spp.
Family Melosiraceae	
82	<i>Melosira varians</i> Agardh
83	<i>M. dubia</i> Kützing
84	<i>Paralia sulcata</i> (Ehrenberg) Cleve
Family Aulacoseiraceae	
85	<i>Aulacoseira granulata</i> (Ehrenberg) Simonsen
Family Leptocylindraceae	
86	<i>Leptocylindrus danicus</i> Cleve
Family Coscinodiscaceae	
87	<i>Coscinodiscus</i> spp.
88	<i>Palmeria hardmaniana</i> Greville
Family Hemidiscaceae	
89	<i>Actinocyclus</i> sp.
Family Asterolampraceae	
90	<i>Asteromphalus flabellatus</i> (Brébisson) Ralfs
Suborder Rhizosoleniineae	

Table 5.4: List of phytoplankton species in Don Hot Lot during June 2008-May 2009
(cont.)

No. of species	TAXA
Family Rhizosoleniaceae	
91	<i>Dactyliosolen phuketensis</i> (Sundström) Hasle
92	<i>Guinardia flaccida</i> (Castracane) H.Peragallo
93	<i>Proboscia alata</i> (Brightwell) Sundström
94	<i>Pseudosolenia calcaravis</i> (Schultze) Sundström
95	<i>Rhizosolenia bergonii</i> H.Peragallo
96	<i>R. hyalina</i> Ostenfeld
97	<i>R. longiseta</i> Zacharias
98	<i>R. pungens</i> Cleve–Euler
99	<i>R. setigera</i> Brightwell
100	<i>R. striata</i> Greville
101	<i>R. styliformis</i> Brightwell
Family Hemiaulaceae	
102	<i>Cerataulina pelagica</i> (Cleve) Hendey
103	<i>Climacodium</i> sp.
104	<i>Eucampia cornuta</i> (Cleve) Grunow
105	<i>E. zodiacus</i> Ehrenberg
106	<i>Hemiaulus indicus</i> Karsten
107	<i>H. membranaceus</i> Cleve
Family Biddulphiaceae	
108	<i>Biddulphia</i> sp.
109	<i>Hydrosera triquetra</i> Wallich
Family Chaetoceraceae	
110	<i>Bacteriastrum comosum</i> Pavillard
111	<i>B. delicatulum</i> Cleve
112	<i>B. furcatum</i> Shadbolt

Table 5.4: List of phytoplankton species in Don Hot Lot during June 2008-May 2009
(cont.)

No. of species	TAXA
113	<i>B. hyalinum</i> Lauder
114	<i>Chaetoceros affinis</i> Lauder
115	<i>C. borealis</i> Bailey
116	<i>C. compressus</i> Lauder
117	<i>C. curvisetus</i> Cleve
118	<i>C. danicus</i>
119	<i>C. denticulatum</i> Lauder
120	<i>C. diadema</i> (Ehrenberg) Gran
121	<i>C. didymus</i> Ehrenberg
122	<i>C. diversus</i> Cleve
123	<i>C. lacinosus</i> Scühttt
124	<i>C. lauderi</i> Ralfs
125	<i>C. lorenzianus</i> Grunow
126	<i>C. peruvianus</i> Brightwell
127	<i>C. pseudocurvisetus</i> Mangin
128	<i>C. subtilis</i> Cleve
	Family Lithodesmaceae
129	<i>Ditylum sol</i> Grunow
	Family Eupodiscaceae
130	<i>Odontella aurita</i> (Lyngbye) C.A.Agardh
131	<i>O. mobiliensis</i> (Bailey) Grunow
132	<i>O. sinensis</i> (Greville) Grunow
133	<i>Triceratium favus</i> Ehrenberg f. <i>quadrata</i> Grunow
	Order Bacillariales
	Suborder Fragilariineae
	Family Fragilariaceae

Table 5.4: List of phytoplankton species in Don Hot Lot during June 2008-May 2009
(cont.)

No. of species	TAXA
134	<i>Fragilaria</i> sp.
135	<i>Synedra</i> sp.
136	<i>Synedrosphenia</i> sp.
Family Thalassionemataceae	
137	<i>Lioloma</i> sp.
138	<i>Thalassionema frauenfeldii</i> (Grunow) Hallegraeff
139	<i>T. nitzschioides</i> (Grunow) Mereschkowsky
140	<i>Thalassiothrix</i> sp.
Family Striatellaceae	
141	<i>Grammatophora undulata</i> Ehrenberg
Suborder Bacillariineae	
Family Achnanthaceae	
142	<i>Cocconeis</i> sp.
Family Cymbellaceae	
143	<i>Cymbella</i> sp.
144	<i>Gomphonema</i> sp.
Family Naviculaceae	
145	<i>Amphora</i> sp.
146	<i>Climaconeis</i> sp.
147	<i>Diploneis</i> spp.
148	<i>Gyrosigma</i> spp.
149	<i>Meunier membranacea</i> (Cleve) P.C.Silva
150	<i>Navicula</i> spp.
151	<i>Pinnularia</i> sp.
152	<i>Pleurosigma</i> spp.
153	<i>Trachyneis</i> sp.

Table 5.4: List of phytoplankton species in Don Hot Lot during June 2008-May 2009
(cont.)

No. of species	TAXA
Family Bacillariaceae	
154	<i>Bacillaria paxillifer</i> (O.F. Müller) Hendey
155	<i>Cylindrotheca closterium</i> (Ehrenberg) Reimann et Lewin
156	<i>Nitzschia</i> spp.
157	<i>Pseudonitzschia pungens</i> (Grunow & Cleve) Hasle
158	<i>Tryblionella</i> sp.
Family Surirellaceae	
159	<i>Entomoneis robusta</i> (Mc Call) Reimer
160	<i>Surirella elegans</i> Ehrenberg
161	<i>S. ovata</i> Kützing
162	<i>S. robusta</i> Ehrenberg var. <i>splendida</i> Van Heurck
CLASS CHRYSOPHYCEAE	
Order Ochromonadaceae	
Family Dinobryaceae	
163	<i>Dinobryon sertularia</i> Ehrenberg
CLASS XANTHOPHYCEAE	
Order Mischococcales	
Family Pleurochloridaceae	
164	<i>Centrtractus belanophorus</i> Lemmermann
CLASS DICTYOPHYCEAE	
Order Dictyochales	
Family Dictyochophyceae	
165	<i>Dictyocha fibula</i> Ehrenberg var. <i>stapedia</i> (Haeckel) Lemmermann
166	<i>Distephanus speculum</i> (Ehrenberg) Haeckel
CLASS PRYMNESIOPHYCEAE	
Order Isochrysidales	

Table 5.4: List of phytoplankton species in Don Hot Lot during June 2008-May 2009
(cont.)

No. of species	TAXA
	Family Isochrysidaceae
167	<i>Isochrysis galbana</i> Parke
	CLASS DINOPHYCEAE
	Order Prorocentrales
	Family Prorocentraceae
168	<i>Prorocentrum micans</i> Ehrenberg
169	<i>P. sigmoides</i> Böhm
	Order Dinophysiales
	Family Dinophysiaceae
170	<i>Dinophysis caudata</i> Savilla–Kent
171	<i>Phalacroma rudgei</i> Murray & Whitting
	Order Gymnodiniales
	Family Gymnodiniaceae
172	<i>Gymnodinium</i> spp.
	Family Polykrikaceae
173	<i>Polykrikos</i> sp.
	Order Noctilucales
	Family Noctilucaeae
174	<i>Noctiluca scintillans</i> (Macartney) Kofoid & Swezy
	Order Gonyaulacales
	Family Ceratiaceae
175	<i>Ceratium furca</i> (Ehrenberg) Claparède & Lachmann
176	<i>C. fusus</i> (Ehrenberg) Dujardin
177	<i>C. massiliense</i> (Gourret) Jörgensen
178	<i>C. trichoceros</i> (Ehrenberg) Kofoid
179	<i>C. tripos</i> (O.F. Müller) Nitzsch var. <i>pulchellum</i> (Schröder) Lope

Table 5.4: List of phytoplankton species in Don Hot Lot during June 2008-May 2009
(cont.)

No. of species	TAXA
Family Gonyaulacaceae	
180	<i>Alexandium</i> sp.
181	<i>Gonyaulax</i> spp.
Family Pyrophacaceae	
182	<i>Pyrophacus horologium</i> Stein
Order Peridiniales	
Family Calciodinellaceae	
183	<i>Scrippsiella</i> sp.
Family Congruentidiaceae	
184	<i>Diplosalis</i> sp.
Family Peridiniaceae	
185	<i>Peridinium</i> spp.
Family Glenodiniaceae	
186	<i>Glenodinium</i> sp.
Family Protoperidiniaceae	
187	<i>Protoperidinium</i> spp.

Species composition found at each station ranged from 72-116 species. The maximum number of species was found at the 1st water sampling station whereas the minimum was found at the 33rd water sampling station. The most diverse group found in all stations was diatoms; ranging from 48-63 species, followed by green algae (3-25 species), dinoflagellates (8-17 species), blue-green algae (4-13 species), euglenoid (0-6 species), silicoflagellates, chrysophytes, xanthophytes and haptophytes (0-1 species each), respectively (Figure 5.56 and Appendix B).

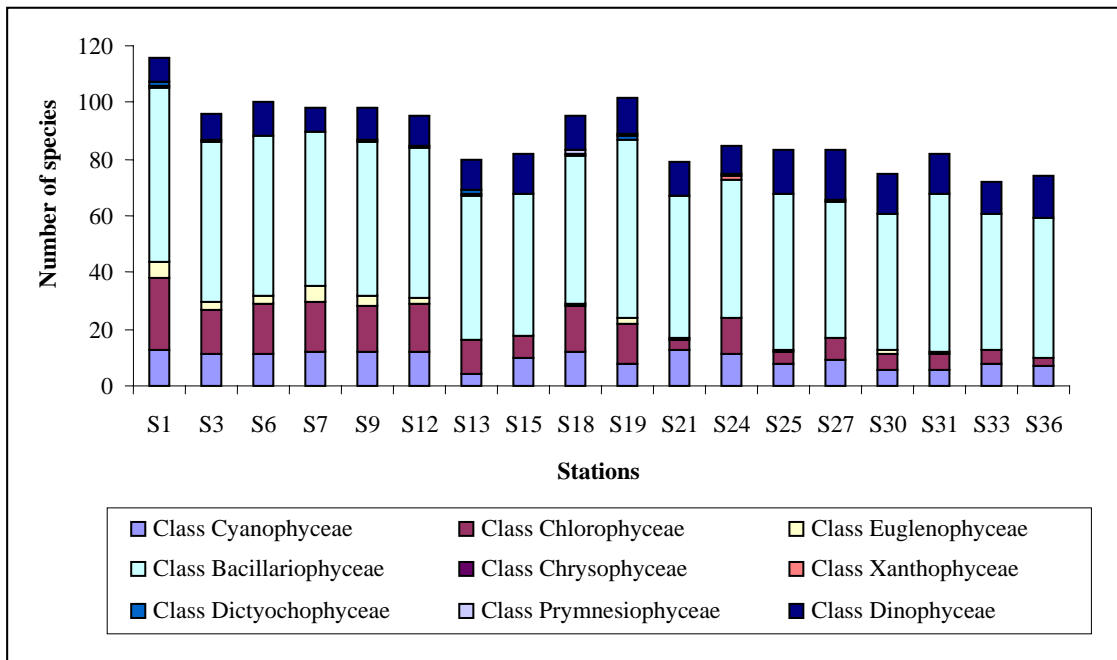


Figure 5.56: Species composition of phytoplankton at each station in Don Hot Lot during June 2008-May 2009

The annual variation of species composition found in each month ranged from 46-98 species. The maximum number of species was found in June 2008 whereas the minimum was found in January 2009. The most diverse group found in each month was diatoms, ranging from 30-58 species, followed by green algae (0-29 species), blue-green algae (1-16 species), dinoflagellates (4-16 species), euglenoid (0-8 species), silicoflagellates, chrysophytes, xanthophytes and haptophytes (0-1 species each) respectively (Figure 5.57).

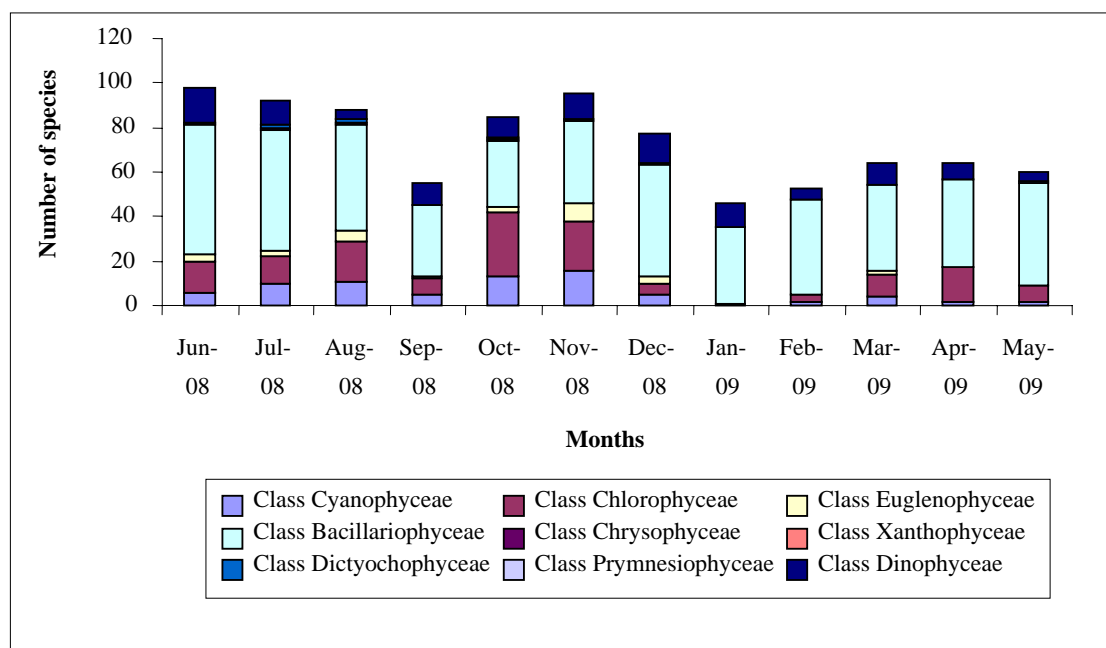


Figure 5.57: Species composition of phytoplankton in each month in Don Hot Lot during June 2008-May 2009

5.4.1.2 Abundance and distribution of phytoplankton

Number of phytoplankton at each station ranged from 817-1,299,875 unit/l, whereas the average number was 66,091unit/l. The maximum number of phytoplankton was at the 24th station whereas the lowest number was found at the 1st station. In term of annual variation, the number of phytoplankton was apparently high in November 2009 or the beginning of winter season, especially at the 24th station. The other months of the year, number of phytoplankton was low and fluctuated in the narrow range (Figure 5.58).

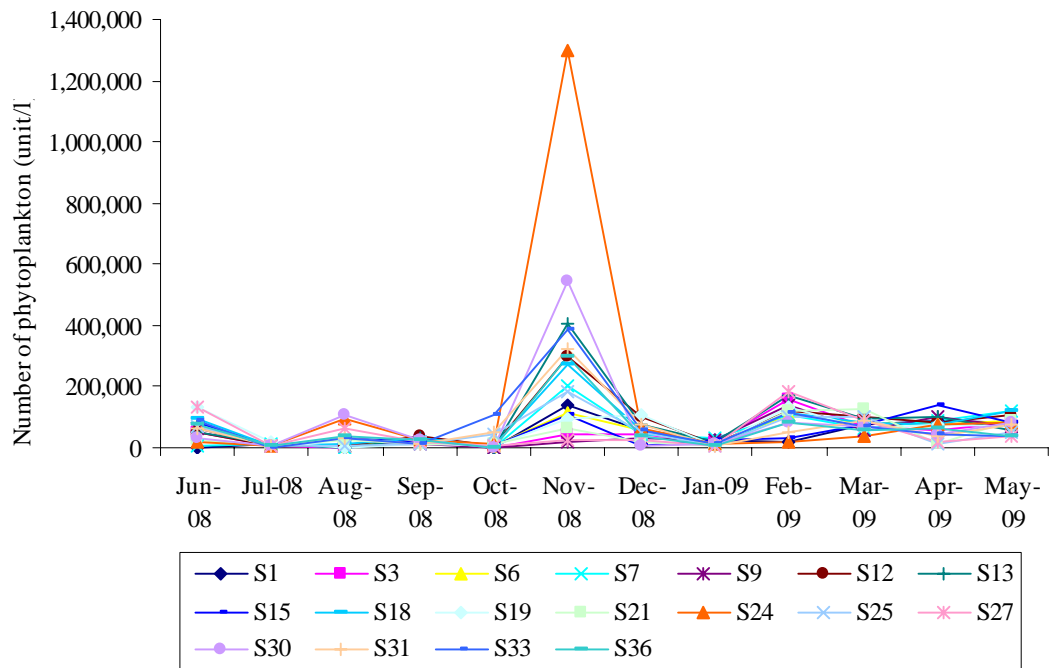


Figure 5.58: Annual variation of phytoplankton abundance at each station in Don Hot Lot during June 2008-May 2009

Comparing the ratio of species composition of phytoplankton at each station, the results showed that diatoms was the main group of phytoplankton found at all stations. The annual average number ranged from 95.36-99.68 % of the total phytoplankton (Figure 5.59). In term of species composition of phytoplankton by months, the results revealed that diatom was the major phytoplankton and the average number ranged from 75.12-99.94 %, followed by dinoflagellates (0.01-24.52 %) (Figure 5.60).

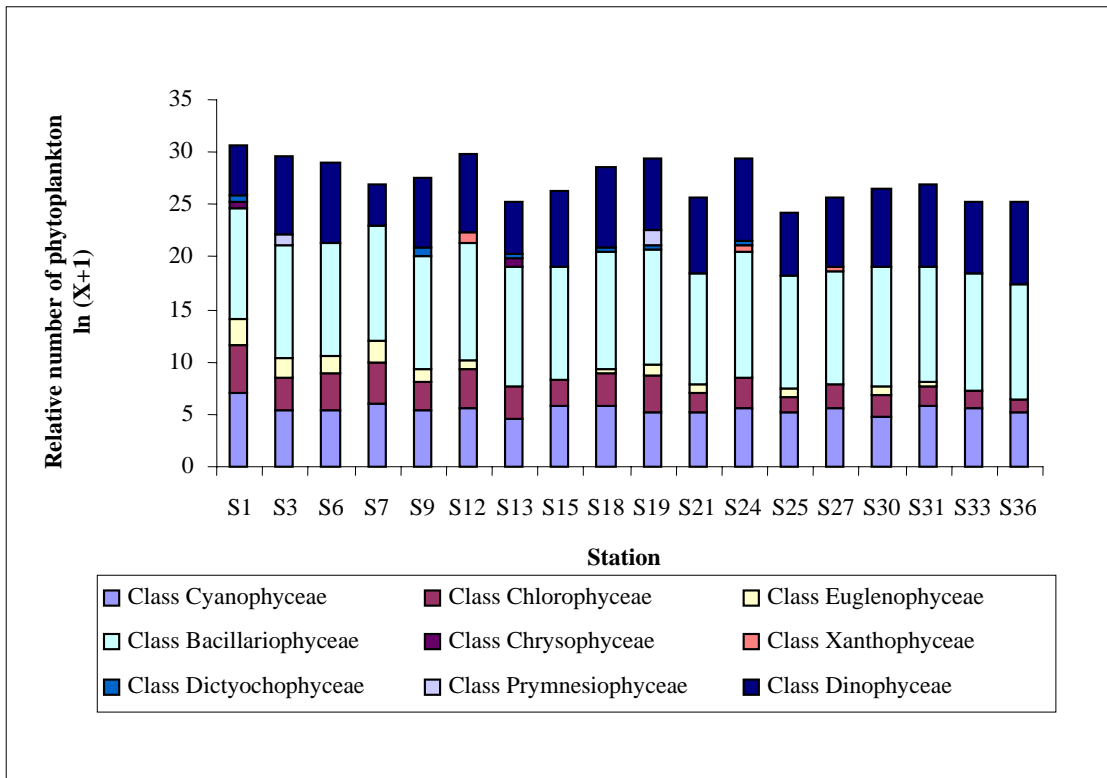


Figure 5.59: Relative number of phytoplankton found at each station in Don Hot Lot during June 2008-May 2009

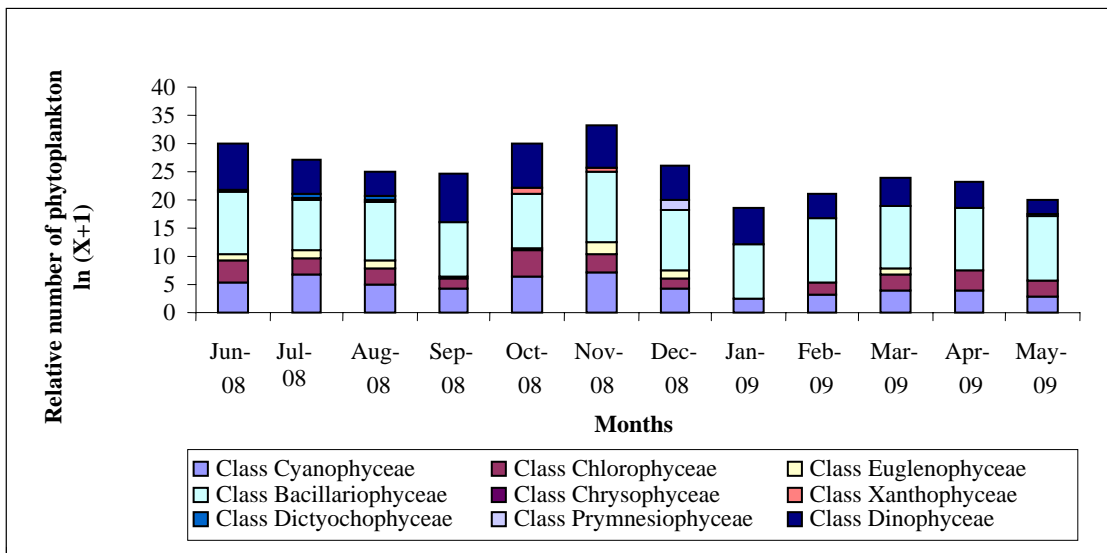


Figure 5.60: Relative number of phytoplankton found in each month in Don Hot Lot during June 2008-May 2009

Among transverse transects, the average low number of phytoplankton were found in T1 and T2 ($48,852 \pm 36,596$ and $59,917 \pm 53,701$ unit/l, respectively), whereas the average maximum number of phytoplankton was found in T4 ($83,461 \pm 130,370$ unit/l). Among longitudinal transects, the average maximum number of phytoplankton was in TF ($83,103 \pm 125,764$ unit/l). In term of temporal variation, the highest number of phytoplankton was found in November 2008 followed by in February 2009 ($269,136$ unit/l), ($102,259$ unit/l)(Figure 5.61 and 5.62). The statistical analysis in transverse transects showed that the average number of phytoplankton was significantly different ($p < 0.01$) by months whereas in longitudinal transects, there was significant difference ($p < 0.01$) both by months and interactions. There was no difference ($p < 0.05$) among transects, both transverse and longitudinal (Appendix B).

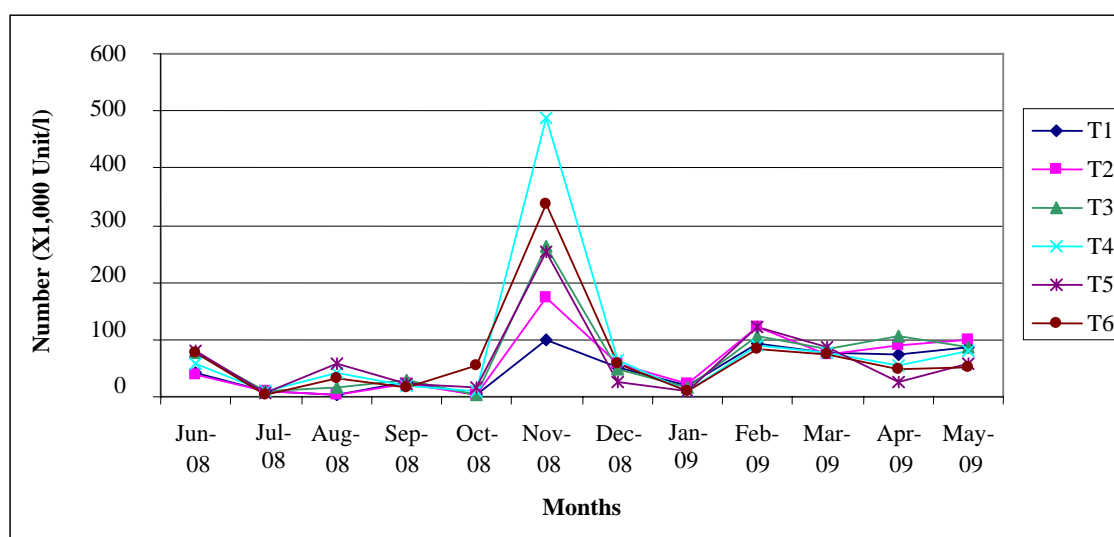


Figure 5.61: Annual variation of abundance of phytoplankton in transverse transects in Don Hot Lot during June 2008-May 2009

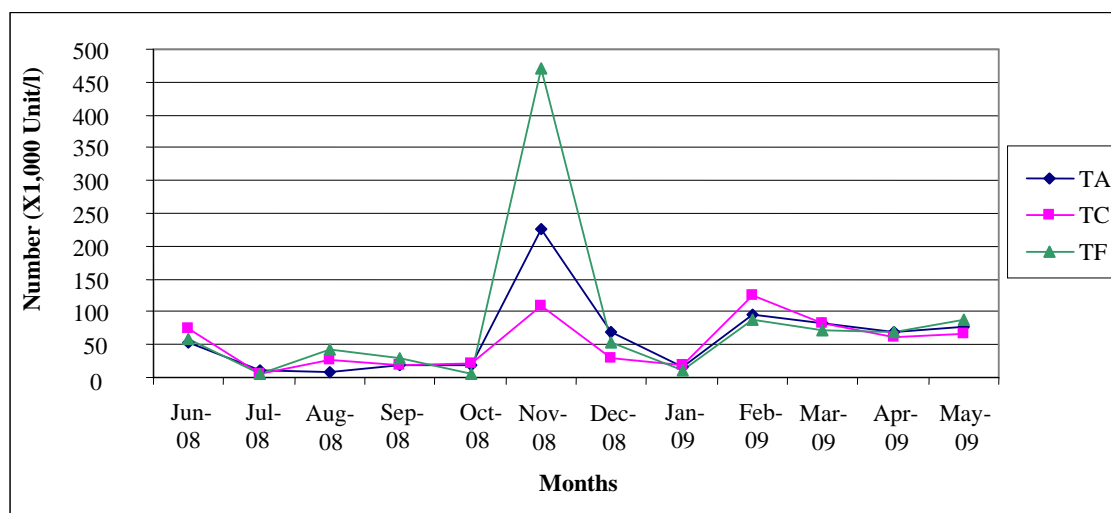


Figure 5.62: Annual variation of abundance of phytoplankton in longitudinal transects in Don Hot Lot during June 2008-May 2009

5.4.1.3 Diversity index and dominant species

Diversity index of phytoplankton was analyzed at each station during June 2008-May 2009 and the results showed that diversity index ranged from 0.53-0.82. The maximum value was found at the 1st station (0.82) and the minimum value was found at the 24th station (Table 5.5). Dominant species of phytoplankton found in each month were shown in Table 5.6. The majority of phytoplankton consisted of 6 species which were *Chaetoceros pseudocurvisetus*, *Pseudonitzschia pungens*, *Thalassiosira spp.*, *Cylindrotheca closterium*, *Skeletonema costatum* and *Thalassionema nitzschioides* (Figure 5.63). During the study period, *Chaetoceros pseudocurvisetus* dominated the study area in several months such as June 2008, September 2008, October 2008, November 2008, December 2008, February 2009 and March 2009. Especially in November 2008, number of this species increased rapidly and reached 209,229 unit/l or 77.74 % of total phytoplankton (Table 5.6).

Table 5.5: Diversity index of phytoplankton at each station in Don Hoi Lot during June 2008-May 2009.

Station No.	No of species	Average number of phytoplankton (unit/l)	Diversity index (log10)
1	116	43844	0.82
3	96	47309	0.75
6	100	55402	0.80
7	98	58387	0.68
9	98	44136	0.72
12	95	77229	0.74
13	80	85177	0.61
15	82	51400	0.75
18	94	73871	0.78
19	102	60721	0.72
21	79	43867	0.81
24	85	145794	0.53
25	83	54575	0.64
27	83	51429	0.70
30	75	85082	0.62
31	82	69499	0.72
33	72	80686	0.55
36	74	61239	0.76

Table 5.6: Dominant species of phytoplankton found in each month in Don Hoi Lot during June 2008-May 2009.

Month	Order of majority	Dominant species	Average number of phytoplankton (unit/l)	Percentage of total phytoplankton
Jun-08	1	<i>Chaetoceros pseudocurvisetus</i>	49,871	80.34
	2	<i>Ceratium furca</i>	2,570	4.14
Jul-08	1	<i>Pseudonitzschia pungens</i>	3,941	50.67
	2	<i>Oscillatoria spp.</i>	410	5.27
Aug-08	1	<i>Thalassiosira spp.</i>	12,090	47.05
	2	<i>Chaetoceros pseudocurvisetus</i>	7,766	30.22
Sep-08	1	<i>Chaetoceros pseudocurvisetus</i>	12,622	56.55
	2	<i>Ceratium furca</i>	5,172	23.17
Oct-08	1	<i>Chaetoceros pseudocurvisetus</i>	11,190	74.61
	2	<i>Peridinium spp.</i>	2,352	15.68
Nov-08	1	<i>Chaetoceros pseudocurvisetus</i>	209,229	77.74
	2	<i>Cylindrotheca closterium</i>	17,328	6.44
Dec-08	1	<i>Chaetoceros pseudocurvisetus</i>	25,543	50.05
	2	<i>Cylindrotheca closterium</i>	16,295	31.93
Jan-09	1	<i>Cylindrotheca closterium</i>	5,361	35.89
	2	<i>Chaetoceros pseudocurvisetus</i>	2,797	18.72
Feb-09	1	<i>Chaetoceros pseudocurvisetus</i>	78,870	77.13
	2	<i>Thalassiosira spp.</i>	15,570	15.23
Mar-09	1	<i>Chaetoceros pseudocurvisetus</i>	44,196	55.85
	2	<i>Skeletonema costatum</i>	19,838	25.07
Apr-09	1	<i>Skeletonema costatum</i>	38,588	57.71
	2	<i>Chaetoceros pseudocurvisetus</i>	23,204	34.70
May-	1	<i>Thalassionema nitzschioides</i>	56,719	73.80
	2	<i>Chaetoceros pseudocurvisetus</i>	14,207	18.49

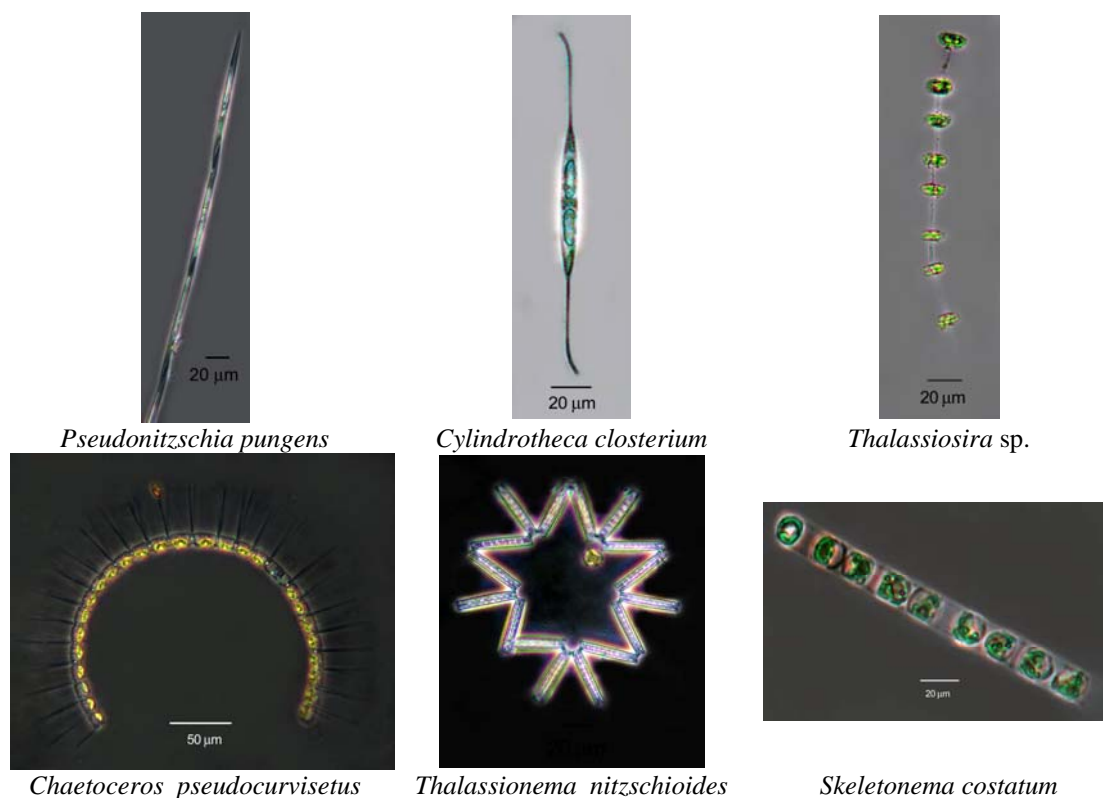


Figure 5.63: Dominant species of phytoplankton found in Don Hoi Lot during June 2008-May 2009.

5.4.2 Mollusks assemblage in Don Hoi Lot

5.4.2.1 Diversity of mollusk species

Two classes, ten families, eleven genera and fourteen species of mollusks were presented at the study site (Table 5.7). Seven species; *Natica tigrina* (Roding, 1798), *Meretrix lusoria* (Roding, 1798), *M. meretrix* (Linnaeus, 1758), *Anadara granosa* (Linnaeus, 1758), *S. corneus*, *S. strictus* and *S. regularis* are considered as economic important species. Out of 14 species, 6 species (*Nassarius distortus*, *A. granosa*, *S. corneus*, *S. strictus*, *M. lusoria* and *M. meretrix*) were found every month during the study period. Only one species (*N. distortus*) was found at all 36 stations, followed by *M. meretrix* (35 stations or 97%) and *S. corneus* (30 stations). *V. myristica* was found only in one month and at one station (Figure 5.64).

In term of abundance, *Musculus senhousia* (Benson in Cantor, 1842) or Horse mussel was the most abundance (12,976.81 individual/10 m² or 99.241 %), followed by *N. distortus* or Nassa mud snail (0.355 %) and *M. meretrix* (0.215 %). Abundance

of the remaining mollusk species accounted less than 0.1% of the total abundance (Table 5.8). Horse mussel was found in high density at several stations (no.12, 14, 16, 17, 18, 21-24, 27-36). Most of these stations located at edge of the study site. High density of *M. meretrix* was found at stations mostly located in the middle of the study site (Figure 5.65).

Table 5.7: Mollusk species found in Don Hoi Lot during June 2008 to May 2009

Class	Family	Scientific name	Common name	Thai name	
Gastropoda	Naticidae	<i>Natica tigrina</i> (Roding, 1798)	Tiger Moon snail	หอยตะกาย	
	Potamididae	<i>Cerithidea cingulata</i> (Gmelin, 1791)	Girdled horn snail	หอยขี้นก	
	Nassariidae	<i>Nassarius distortus</i> (Adams, 1852)	Nassa mud snail	หอยเจดีย์	
		<i>Niotha distorta</i> (Adams, 1852)	Nassa mud snail	หอยเจดีย์	
	Bullidae	<i>Bulla</i> sp.	Umbilical Egg Shell	หอยไข่	
	Melongenidae	<i>Volema myristica</i> (Roding, 1798)	Nutmeg melongena	หอยพญ	
	Bivalvia	Mytilidae	<i>Musculus senhousia</i> (Benson in Cantor, 1842)	Horse mussel	หอยกะพง
		Veneridae	<i>Meretrix lusoria</i> (Roding, 1798)	Enamel venus shell	หอยดลัษ
			<i>Meretrix meretrix</i> (Linnaeus, 1758)	Enamel venus shell	หอยดลัษ
Arcidae		<i>Anadara granosa</i> (Linnaeus, 1758),	Ark shell	หอยแครง	
Tellinidae		<i>Tellina capsoides</i> (Lamarck, 1818)	Senegambian tellin	หอยขาว	
Solenidae		<i>Solen corneus</i> (Lamarck, 1818)	Razor clam	หอยหลอด	
		<i>Solen strictus</i> (Gould, 1861)	Razor clam	หอยหลอด	
	<i>Solen regularis</i> (Dunker, 1861)	Razor clam	หอยหลอด		

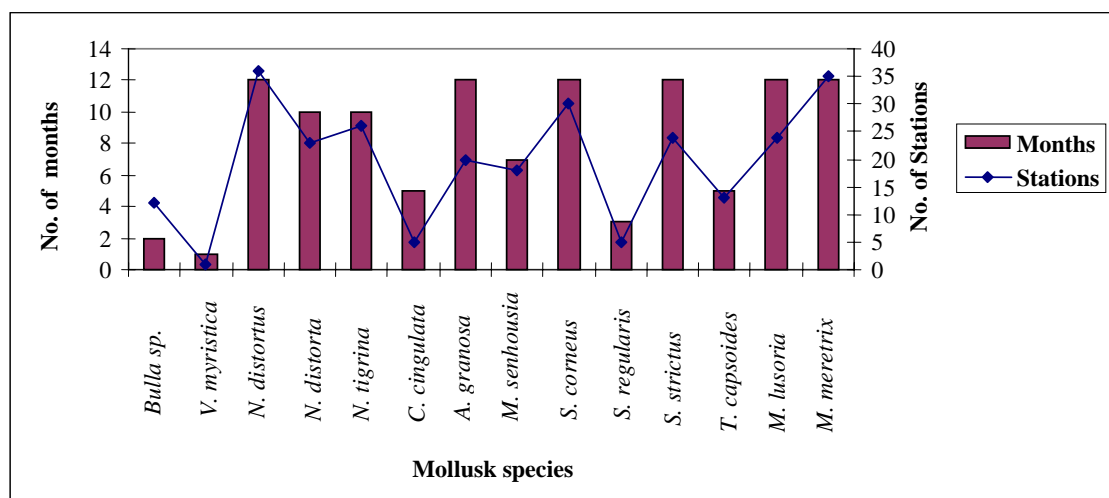


Figure 5.64: Variation of occurrence of mollusk species by months and stations in Don Hoi Lot during June 2008 to May 2009.

Table 5.8: Average abundance of mollusk species found in Don Hoi Lot during June 2008 to May 2009

Mollusk species	Average abundance (individuals/10 m ²)	% of Total abundance
<i>Bulla sp.</i>	7.41	0.057
<i>V. myristica</i>	0.02	0.000
<i>N. distortus</i>	46.39	0.355
<i>N. distorta</i>	3.06	0.023
<i>N. tigrina</i>	2.29	0.018
<i>C. cingulata</i>	0.21	0.002
<i>A. granosa</i>	4.10	0.031
<i>M. senhousia</i>	12,976.81	99.241
<i>S. corneus</i>	0.67	0.005
<i>S. regularis</i>	0.01	0.000
<i>S. strictus</i>	0.19	0.001
<i>T. capsoides</i>	0.56	0.004
<i>M. lusoria</i>	5.79	0.044
<i>M. meretrix</i>	28.10	0.215
	13,075.60	100.00

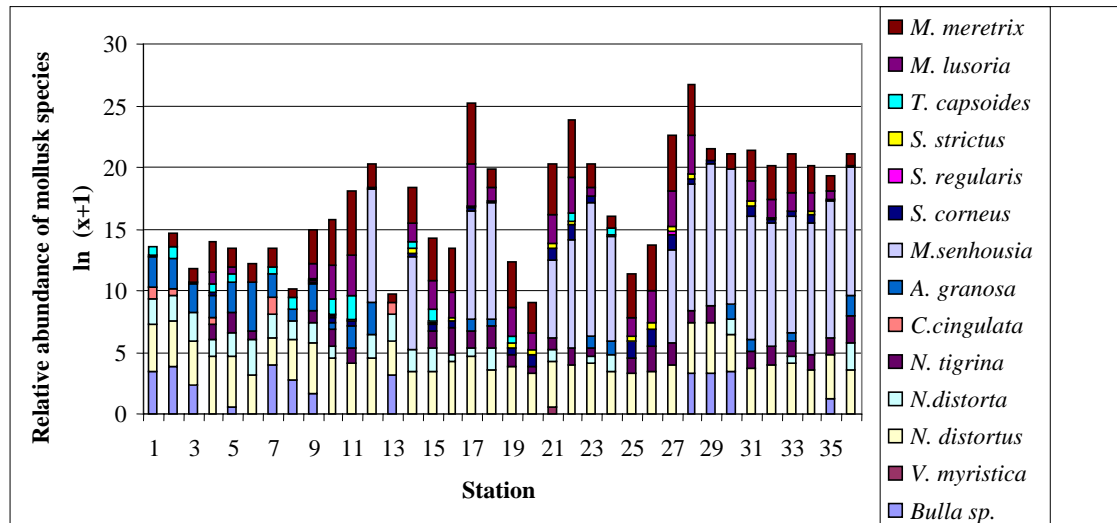


Figure 5.65: Relative abundance of mollusk species at each station found in Don Hoi Lot during June 2008 to May 2009

5.4.2.2 Abundance and distribution of Mollusks

5.4.2.2.1 Spatial distribution

In term of spatial distribution, the dominant species found in the study site were *M. senhousia* or horse mussel, followed by *N. distortus* and *M. meretrix*. When grouping them into two directions (transverse and longitudinal transects), the results were shown in Table 5.9-5.10 and Figure 5.66-5.67 and could be described as follows:

Bulla sp. was found in all transverse transects, except T4. Its high average abundance was recorded in three transects: T1, T5 and T2 (14.58 ± 19.56 , 13.75 ± 15.13 and 11.94 ± 20.70 individual/10 m², respectively). It was observed that the average abundance was quite low in the middle of the study site (T3 and T4) and T6. In longitudinal transects, the maximum average abundance occurred in TA (17.78 ± 21.77 individuals/10 m²), followed by TB (10.14 ± 18.49 individual/10 m²) locating closest to the right angle -nearest Mae Klong channel. The least abundance was TC (2.22 ± 3.79 individuals/10 m²) locating almost in the middle of the study area.

The average abundance of *V. myristica* was low and was only found in T4 (0.14 ± 0.34 individuals/10 m²) and TC (0.14 ± 0.34 individuals/10 m²) in transverse and longitudinal transects, respectively.

N. distortus was the most second abundant species. It was commonly found at all 36 stations and in every month. In term of transverse transect, it was a high abundant species with an average of 46.39 ± 6.31 individual/10 m² (40.56 ± 12.73 to 56.11 ± 34.13 individuals/10 m²). The maximum average abundance was recorded in T2, followed by T1. In term of longitudinal transect, the high average abundance of this species was found in TD, followed by TE (69.44 ± 28.75 and 61.25 ± 24.00 individuals/10 m², respectively).

In term of transverse transect, average abundance of *N. distorta* ranged from 0.42 ± 1.02 to 7.92 ± 4.79 individuals/10 m². The highest average abundance was recorded in T1 and the lowest was found in T5. In term of longitudinal transect, abundance of this mollusk ranged from 0.83 ± 1.05 to 6.94 ± 5.18 individuals/10 m². The highest average abundance was recorded in TF and the lowest was found in TD. It was observed that high abundance could be found in the rim of islets and low abundance was in the middle of islets.

Normally, horse mussel was found in small size comparing with other mollusks, therefore this caused the proportion of its density enormously high comparing with other species. In transverse transect, the average abundance was $12,976.81 \pm 14,647.65$ individuals/10 m². The species was not found in T1 (closest to the coastline). The abundance gradually increased outwards from T2 and reached the maximum average abundance in T6 ($32,354.17 \pm 17,279.69$ individuals/10 m²). Considering longitudinal transects, horse mussel abundance was found in all transects and the maximum values was in TE ($35,548.89 \pm 39,845.44$ individuals/10 m²), followed by TF ($19,063.06 \pm 21,000.24$ individuals/10 m²). These two transects were at the rim of the study area, opposite to the right angle -nearest to the coastline.

N. tigrina was an economically important mollusk species found in The study area. Average abundance was slightly low comparing with other species. Low average abundance of this species occurred in T2 (transverse transect) and TA (longitudinal transect), 1.11 ± 1.25 and 1.11 ± 1.25 individuals/10 m², respectively.

Average abundance of *C. cingulata* was slightly low and was only found in three transverse transects: T1, T2 and T3 (0.56 ± 0.68 , 0.42 ± 1.02 and 0.28 ± 0.68 individuals/10 m², respectively). The abundance found in TA, TB and TD were

97+1.11, 0.14+0.34 and 0.14+0.34 individuals/10 m², respectively in longitudinal transects.

A. granosa was an economically important mollusk species collected by local fisherman in The study area. Its average abundance ranged from 0.42±0.70 to 16.39±17.04 individuals/10 m² in transverse transects. The highest average abundance of this species occurred in T1 and the lowest average abundance was found in T3. In term of longitudinal transect, the maximum average abundance was in TF (12.22±19.46 individuals/10 m²), whereas the minimum average abundance was found in TD (0.97±2.00 individuals/10 m²).

Average abundance of *T. capsoides* was slightly low comparing with other mollusk species: 0.56±0.67 and 0.56±0.35 individuals/10 m² in transverse and longitudinal transects, respectively. The maximum average abundance was found in T2 (1.81±2.20 individuals/10 m²) and TE (1.11±2.34 individuals/10 m²) in transverse and longitudinal transects, respectively. This species was not found in T5 and T6 during the study period.

There were two species of enamel Venus shell found in the study area: *M. lusoria* and *M. meretrix*. In term of transverse transect, the average abundance of *M. meretrix* (28.10±16.64 individuals/10 m²) was higher than that of *M. lusoria* (5.79±3.54 individuals/10 m²). Low average abundance of both species was found in T1 and T6, while the higher average abundance occurred in T2 to T5. In term of longitudinal transect, the maximum average abundance of *M. lusoria* was recorded in TD (11.53±8.92 individuals/10 m²) and the minimum was found in TF (0.28±0.68 individuals/10 m²). The maximum average abundance of *M. meretrix* was recorded in TE (57.50±84.37 individuals/10 m²) and the minimum was found in TF (3.33±1.67 individuals/10 m²).

When comparing the average abundance of Razor clams with other mollusks found in Don Hoi Lot, the results showed that in term of transverse transect, their average abundance were slightly low, accounted for 0.67±0.57, 0.19±0.13 and 0.01±0.02 individuals/10 m² for *S. corneus*, *S. strictus* and *S. regularis*, respectively. The minimum average abundance of *S. corneus* and *S. strictus* were found in the same transverse transect (T1) and these two species were present in all transverse and longitudinal transects. In term of longitudinal transect, the minimum average

abundance of *S. corneus* and *S. strictus* were found in the same transect (TF). *S. regularis* was only found in some transects, namely T2, T3 and T5 transverse transects and TA, TC and TD longitudinal transects.

Table 5.9: Spatial distribution (transverse transects) of average abundance of mollusk species in Don Hoi Lot during June 2008- May 2009 (individuals/10m²)

No	Mollusk species	Transverse transects						Average
		T1	T2	T3	T4	T5	T6	
1	<i>Bulla</i> sp.	14.58±19.56	11.94±20.70	3.75±9.19	0.00±0.00	13.75±15.13	0.42±1.02	7.41±6.77
2	<i>V. myristica</i>	0.00±0.00	0.00±0.00	0.00±0.00	0.14±0.34	0.00±0.00	0.00±0.00	0.02±0.06
3	<i>N. distortus</i>	51.11±31.05	56.11±34.13	47.36±33.88	40.56±12.73	40.69±17.22	42.50±10.90	46.39±6.31
4	<i>N. distorta</i>	7.92±4.79	3.47±2.32	4.03±2.66	0.97±1.34	0.42±1.02	1.53±3.35	3.06±2.77
5	<i>N. tigrina</i>	1.25±1.73	1.11±1.25	3.19±2.91	1.39±1.14	3.19±2.38	3.61±1.95	2.29±1.15
6	<i>C. cingulata</i>	0.56±0.68	0.42±1.02	0.28±0.68	0.00±0.00	0.00±0.00	0.00±0.00	0.21±0.24
7	<i>A. granosa</i>	16.39±17.04	5.69±4.52	0.42±0.70	0.56±0.86	0.42±1.02	1.11±1.64	4.10±6.36
8	<i>M. senhousia</i>	0.00±0.00	1,574.03 +3,855.56	3,185.42 +4,689.92	10,535.69 +20,164.38	30,211.53 +39,023.99	32,354.17 +17,279.69	12,976.81 +14,647.65
9	<i>S. corneus</i>	0.08±0.11	0.24±0.26	0.42±0.25	1.18±0.90	1.53±1.35	0.60±0.42	0.67±0.57
10	<i>S. regularis</i>	0.00±0.00	0.03±0.04	0.01±0.03	0.00±0.00	0.04±0.07	0.00±0.00	0.01±0.02
11	<i>S. strictus</i>	0.03±0.04	0.08±0.07	0.17±0.19	0.32±0.20	0.38±0.30	0.17±0.17	0.19±0.13
12	<i>T. capsoides</i>	0.69±0.63	1.81±2.20	0.42±0.70	0.42±0.46	0.00±0.00	0.00±0.00	0.56±0.67
13	<i>M. lusoria</i>	0.42±0.70	7.08±10.54	8.61±11.08	6.81±7.14	9.31±9.70	2.50±1.67	5.79±3.54
14	<i>M. meretrix</i>	3.61±3.82	41.39±71.06	38.61±54.88	37.08±38.04	37.78±32.67	10.14±7.65	28.10±16.64

Table 5.10: Spatial distribution (longitudinal transects) of average abundance of mollusk species in Don Hoi Lot during June 2008- May 2009 (individuals/10 m²)

No	Mollusk species	Longitudinal transects								Average
		TA	TB	TC	TD	TE	TF			
1	<i>Bulla</i> sp.	17.78±21.77	10.14±18.49	2.22±3.79	4.44±10.89	4.86±10.32	5.00±12.25	7.41±5.71		
2	<i>V. myristica</i>	0.00±0.00	0.00±0.00	0.14±0.34	0.00±0.00	0.00±0.00	0.00±0.00	0.02±0.06		
3	<i>N. distortus</i>	29.72±15.83	34.03±10.60	45.97±12.41	69.44±28.75	61.25±24.00	37.92±25.86	46.39±15.84		
4	<i>N. distorta</i>	3.33±3.69	2.50±2.93	3.47±3.39	0.83±1.05	1.25±2.28	6.94±5.18	3.06±2.19		
5	<i>N. tigrina</i>	1.11±1.25	1.81±2.71	2.36±1.70	3.33±2.11	2.92±1.15	2.22±3.23	2.29±0.79		
6	<i>C. cingulata</i>	0.97±1.11	0.14±0.34	0.00±0.00	0.14±0.34	0.00±0.00	0.00±0.00	0.21±0.38		
7	<i>A. granosa</i>	3.06±4.43	2.08±4.34	2.92±4.24	0.97±2.00	3.33±4.47	12.22±19.46	4.10±4.07		
8	<i>M. senhousia</i>	4,016.81 ±9,839.12	3,813.33 ±8,512.23	2,422.78 ±4,867.80	12,995.97 ±18,547.18	35,548.89 ±39,845.44	19,063.06 ±21,000.24	12,976.81 ±12,823.26		
9	<i>S. corneus</i>	0.75±0.98	0.89±1.19	1.06±1.04	0.89±0.74	0.36±0.23	0.10±0.10	0.67±0.37		
10	<i>S. regularis</i>	0.01±0.03	0.00±0.00	0.06±0.07	0.01±0.03	0.00±0.00	0.00±0.00	0.01±0.02		
11	<i>S. strictus</i>	0.26±0.27	0.28±0.26	0.25±0.25	0.26±0.16	0.06±0.07	0.03±0.04	0.19±0.12		
12	<i>T. capsoides</i>	0.42±0.46	0.69±0.82	0.28±0.68	0.69±0.97	1.11±2.34	0.14±0.34	0.56±0.35		
13	<i>M. lusoria</i>	2.64±3.35	3.75±4.59	6.94±6.16	11.53±8.92	9.58±13.97	0.28±0.68	5.79±4.32		
14	<i>M. meretrix</i>	16.25±19.60	14.44±14.61	35.42±31.98	41.67±33.41	57.50±84.37	3.33±1.67	28.10±20.21		

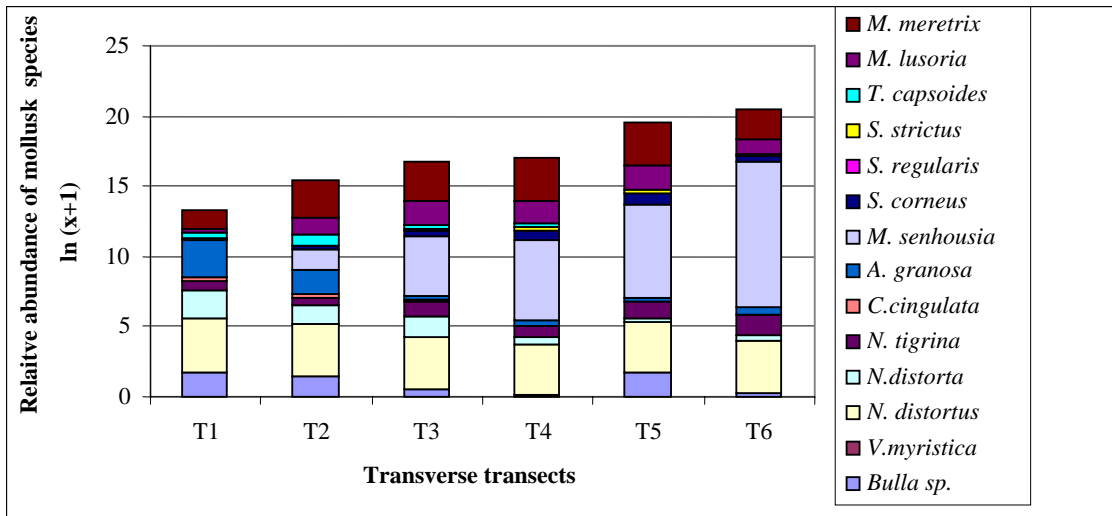


Figure 5.66: Spatial distribution (transverse transects) of relative abundance of each species in Don Hoi Lot during June 2008- May 2009

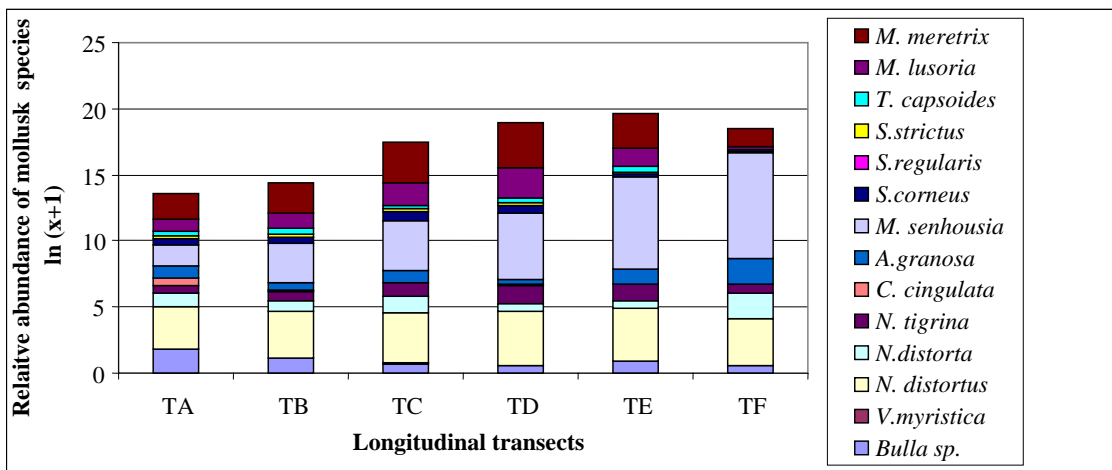


Figure 5.67: Spatial distribution (longitudinal transects) of relative abundance of each species in Don Hoi Lot during June 2008- May 2009

5.4.2.2.2 Temporal distribution

Annual variation of mollusk species in Don Hoi Lot during June 2008- May 2009 was demonstrated in Table 5.11 and Figure 5.68.

In June 2008 or the beginning of rainy season, there were 7 species found. The most abundant species was *M. meretrix* (80.00 individuals/10 m²), followed by *M. lusoria* (19.44 individuals/10 m²), *N. distortus* (19.17 individuals/10 m²), *A. granosa* (2.78 individuals/10 m²), and *T. capsoides* (1.67 individuals/10 m²), abundance of the remaining two species was lower than 1.00 individuals/10 m².

In July 2008, the number of mollusk species increased to 11 species. The majority of species found in this month were *N. distortus* (42.50 individuals/10 m²), followed by *M. meretrix* (33.33 individuals/10 m²), *M. lusoria* (6.11 individuals/10 m²), and *Bulla* sp. (1.94 individuals/10 m²), whereas average abundance of the rest species was less than 1.00 individuals/10 m².

During rainy season (August 2008 to October 2008), the most abundance of mollusk species was still *N. distortus*, followed by *M. meretrix* and *M. lusoria*. The number of mollusk species ranged from 8-10 species. It was observed that there was no remarkable population of *M. senhousia* occurred in the sampling area during June 2008 to October 2008 or rainy season.

In November 2009 or the beginning of winter season, there were 9 species found. The dominant mollusk species were *M. senhousia*, *N. distortus*, *M. meretrix*, *N. distorta* and *N. tigrina*, respectively from the highest to the lowest abundance. In this month, it was observed that abundance of *M. senhousia* was lowest comparing to other months. During the winter season (from December 2008 to February 2009), the ratio of species composition in terms of average abundance and dominant species occurred in the same pattern as already mentioned in the previous month, except the appearance of high abundance (86.94 individuals/10 m²) of *Bulla* sp. found in January 2009. The number of species ranged from 9 to 11 species in this period.

In March 2009 or starting of the summer period until the end of summer in May 2009, population of *M. senhousia* was still the outstanding dominant species. The structure and species composition were the same pattern as mentioned in winter time. It was observed that the size of *M. senhousia* increased continuously during this period and the population dropped in May 2009.

In term of annual variation of each species, it was found that *Bulla* sp. occurred in two months: July 2008 and January 2009 (its peak), whereas *V. myristica* was rare and only found in July 2008. There were six species recorded that were appeared for year round: *N. distortus*, *A. granosa*, *S. corneus*, *S. strictus*, *M. lusoria* and *M. meretrix*. Their abundance were peaked in October 2008, December 2008, August 2008, September 2008, June 2008 and June 2008, respectively. *M. senhousia* only occurred in seven months starting from November 2008 to May 2009 (during winter and summer season). *N. distorta* was found in ten months during July 2008 to

April 2009 whereas maximum abundance was recorded in February 2009. *N. tigrina* was found in ten months and its maximum abundance was recorded in January 2009. *C. cingulata* was found in two periods: during August 2008 to September 2008 (the 1st period) and during February 2009 to April 2009 (the 2nd period). *T. capsoides* was found during summer until the beginning of rainy season (during March to July).

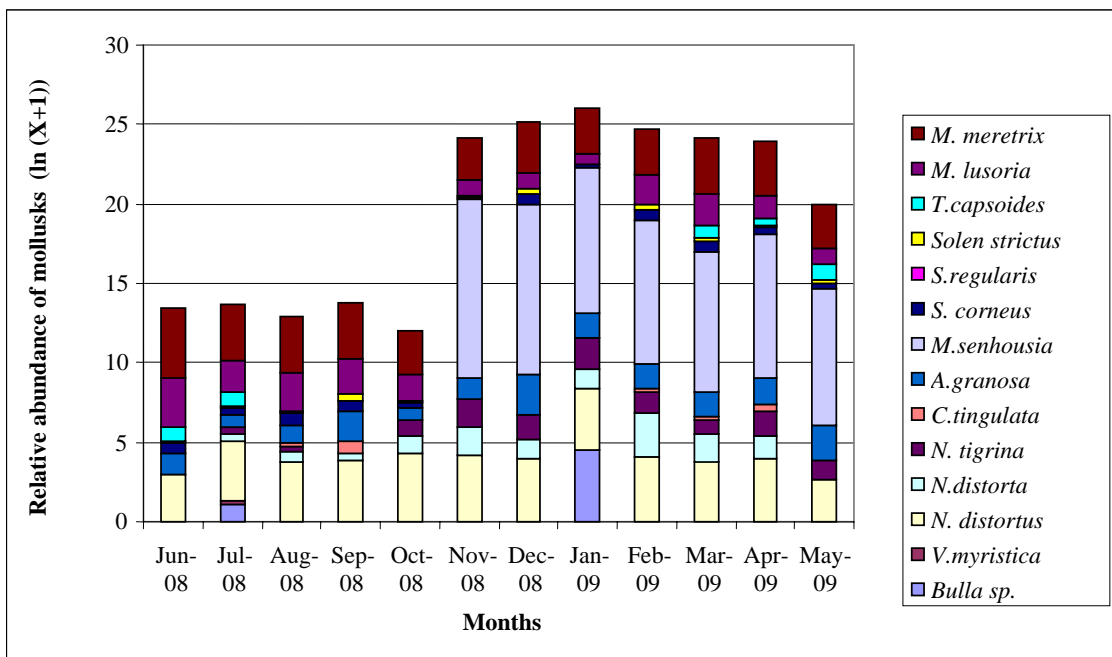


Figure 5.68: Annual distribution of relative abundance of each species in Don Hoi Lot during June 2008- May 2009

Table 5.11: Average abundance of mollusk species in Don Hoi Lot during June 2008- May 2009 (individuals /10m²)

No	Mollusk species	Month												Average		SD
		Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Average	SD	
1	<i>Bulla</i> sp.	0.00	1.94	0.00	0.00	0.00	0.00	0.00	86.94	0.00	0.00	0.00	0.00	0.00	7.41	25.05
2	<i>V. myristica</i>	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.08
3	<i>N. distortus</i>	19.17	42.50	39.72	48.33	74.17	65.56	54.44	46.94	57.50	43.61	51.67	13.06	46.39	17.26	17.26
4	<i>N. distorta</i>	0.00	0.56	1.11	0.56	1.94	4.72	2.22	2.50	15.00	4.72	3.33	0.00	3.06	4.11	4.11
5	<i>N. tigrina</i>	0.00	0.56	0.28	0.00	1.67	4.72	3.89	6.11	2.78	1.39	3.61	2.50	2.29	2.00	2.00
6	<i>C. cingulata</i>	0.00	0.00	0.28	1.11	0.00	0.00	0.00	0.00	0.28	0.28	0.56	0.00	0.21	0.34	0.34
7	<i>A. granosa</i>	2.78	1.11	2.22	5.28	1.11	3.06	10.83	3.89	3.61	3.33	4.44	7.50	4.10	2.76	2.76
8	<i>M. senhousia</i>	0.00	0.00	0.00	0.00	0.00	73,039.72	43,969.44	9,425.83	8,422.78	7,389.17	8,092.50	5,382.22	12,976.81	22,474.61	22,474.61
9	<i>S. corneus</i>	0.83	0.64	1.08	0.97	0.44	0.17	1.00	0.17	0.94	0.92	0.53	0.39	0.67	0.33	0.33
10	<i>S. regularis</i>	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.08	0.01	0.03	0.03
11	<i>S. strictus</i>	0.08	0.08	0.06	0.64	0.08	0.14	0.39	0.03	0.33	0.14	0.14	0.17	0.19	0.18	0.18
12	<i>T. capsoides</i>	1.67	1.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39	0.56	1.67	0.56	0.74	0.74
13	<i>M. lusoria</i>	19.44	6.11	10.56	8.06	4.44	1.67	1.67	0.83	5.56	6.11	3.06	1.94	5.79	5.20	5.20
14	<i>M. meretrix</i>	80.00	33.33	31.94	30.28	14.44	13.06	22.50	16.94	17.50	33.33	30.00	13.89	28.10	18.23	18.23

5.4.2.3 Diversity Indices and Assemblage Structure of Mollusks

5.4.2.3.1 Spatial variation

Diversity index including evenness and richness index were analyzed in each month in transverse transects, longitudinal transects and at each station during June 2008-May 2009.

In term of spatial variation and in transverse transects, the diversity index ranged from 0.016-1.404. The highest diversity index and evenness index were found in T1, followed by T2 to T6 according to distance from coastline (Table 5.12). Assemblage structure of mollusks was analyzed to define similarity between every pair of species in each transect by using a cluster analysis and non multidimensional scaling. The results were shown in Figure 5.69-5.70. Communities of mollusks in transverse transects in Don Hoi Lot could be divided into four groups at 65% of similarity (stress 0.01): T1 (group 1), T2 and T3 (group 2), T4 (group 3), and T5 and T6 (group 4).

Table 5.12: Diversity index of average abundance of mollusks in each transverse transect in Don Hot Lot during June 2008-May 2009

Transverse Transect	Species richness	Average abundance (individuals/10m ²)	Evenness index	Diversity index
T1	11	97	0.586	1.404
T2	13	1,703	0.149	0.381
T3	13	3,293	0.073	0.188
T4	11	10,625	0.024	0.059
T5	11	30,319	0.012	0.029
T6	10	32,417	0.007	0.016

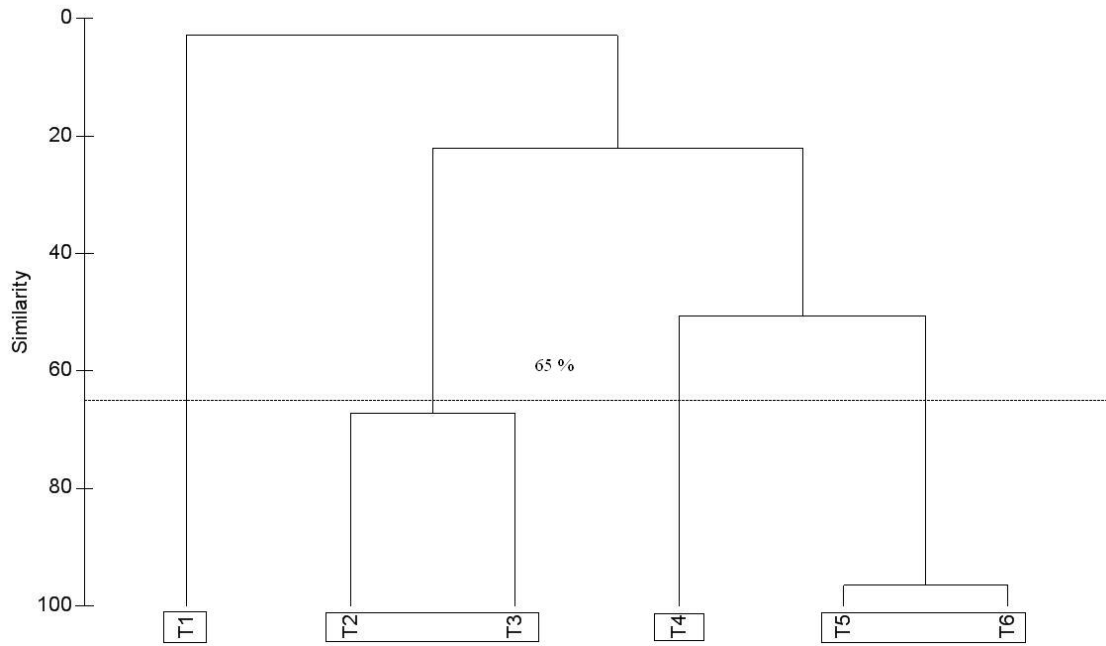


Figure 5.69: Dendrogram showing hierarchical clustering of mollusks in transverse transect

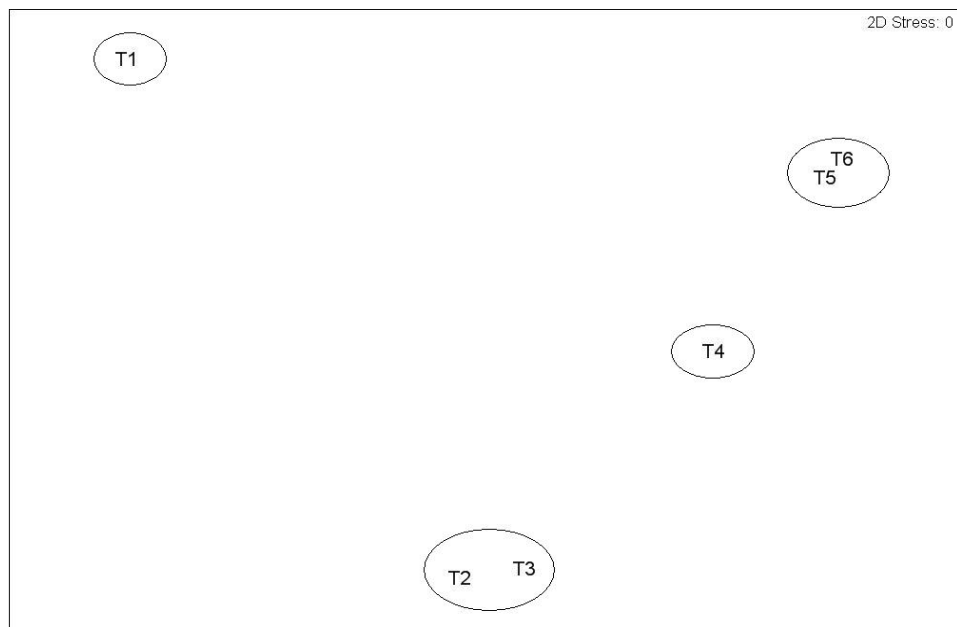


Figure 5.70: Non-MDS ordinations of mollusks in transverse transect, classified into four groups, stress value= 0.01

When grouping abundance of mollusks into longitudinal transects, it was found that the maximum diversity index and evenness index ranging from 0.029-0.224 and 0.012-0.087 respectively, were found in the middle of the study site (TC). The minimum values were found in TF, in the rim of the study site nearest to coastline (Table 5.13). When testing the similarity of abundance of mollusk based on longitudinal transect by a cluster analysis and non multidimensional scaling, it could be divided into 4 group at 75 % of similarity (stress 0.01): TA and TB (group1), TC (group 2), TD and TE (group 3) and TF (group 4) (Figure 5.71).

Table 5.13: Diversity index of average abundance of mollusks in each longitudinal transect in Don Hot Lot during June 2008-May 2009

Longitudinal Transect	Species richness	Average abundance (individuals/10m ²)	Evenness index	Diversity index
TA	13	4,093	0.047	0.123
TB	12	3,884	0.048	0.119
TC	13	2,524	0.087	0.224
TD	13	13,130	0.027	0.070
TE	11	35,691	0.013	0.031
TF	11	19,131	0.012	0.029

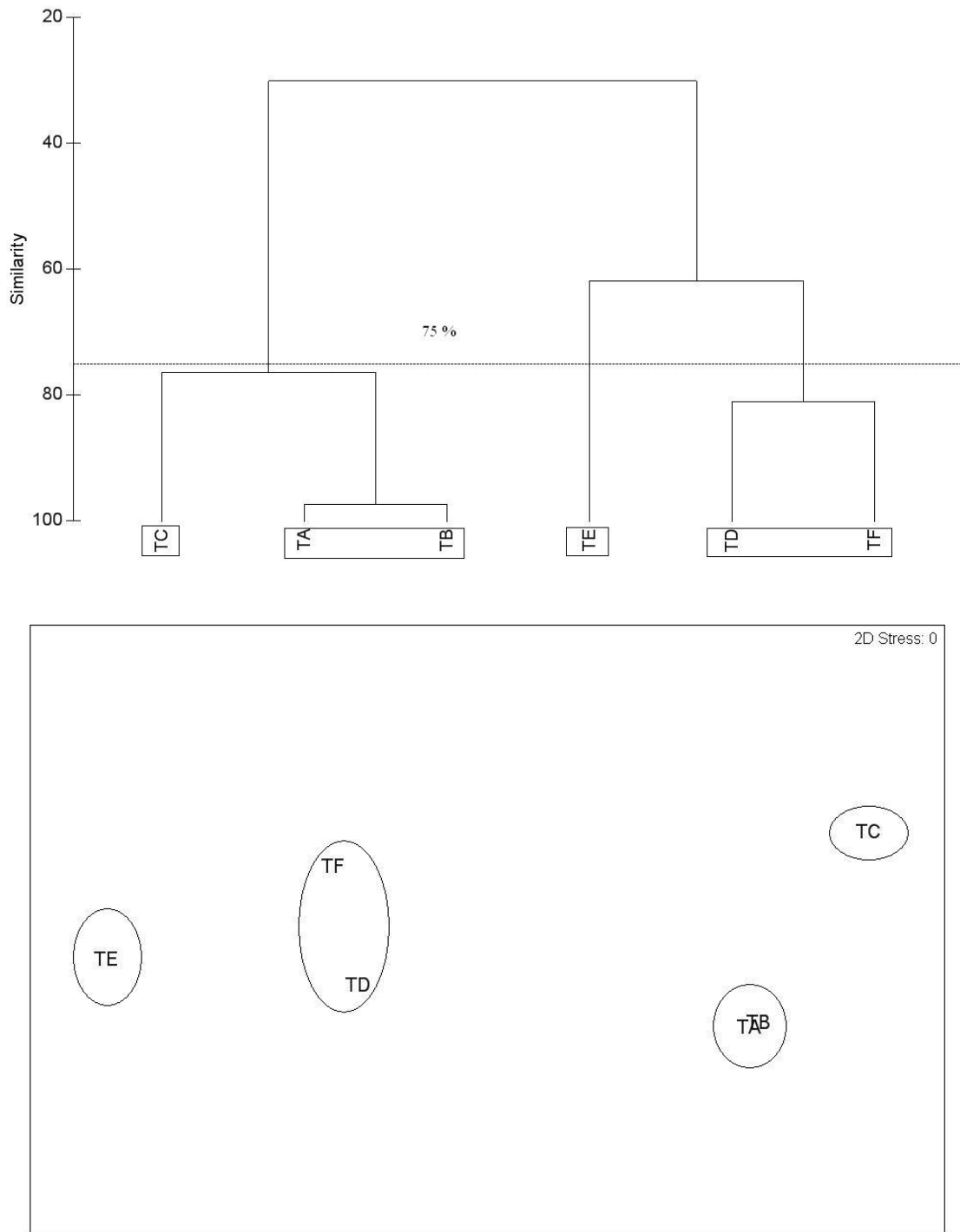


Figure 5.71: Dendrogram showing hierarchical clustering of mollusks in longitudinal transect (above) and non-MDS ordination of mollusks, classified into three groups, stress value= 0.01 (below)

Table 5.14 presented diversity index including evenness and richness index of mollusks at each station. The diversity index ranged from 0.006 to 1.440 and the highest value was found at the 15th station locating almost in the middle of study area whereas the lowest value was found at the 35th station locating in T6 which was far away from coastline. When computing the similarity of abundance of mollusks based on station variation by a cluster analysis and non multidimensional scaling (Figure 5.72), all stations could be divided into five groups at 38 % similarity (stress 0.04) as follows:

Group I: This group was consisted of S11, S5, S9, S4, S10, S16, S20, S 15, S19, S25 and S26. At average similarity 60.09 %, the majority of mollusk species of this group were *N. distortus* *M. meretrix* and *M. lusoria* (59.19, 28.38 and 5.94 % respectively).

Group II: This group was consisted of S6, S7, S3, S1, S2, S8 and S13. At average similarity 57.95 %, the majority of mollusk species of this group were *N. distortus*, *Bulla* sp, *N. distorta* and *A. granosa* (43.61, 31.07, 13.03 and 8.77 % respectively).

Group III: This group was consisted of S21, S14 and S27. At average similarity 63.20 %, the majority of mollusk species of this group was *M. senhousia* (91.66 %).

Group IV: This group was consisted of S24, S17, S22, S12, S18 and S33. At average similarity 77.45 %, the majority of mollusk species of this group was *M. senhousia* (99.04 %).

Group V: This group was consisted of S31, S32, S28, S36, S29, S34, S35, S23 and S30. At average similarity 72.29 %, the majority of mollusk species of this group was *M. senhousia* (99.85 %).

Table 5.14: Diversity index of average abundance of mollusks at each station in Don Hot Lot during June 2008-May 2009

Station	Species richness	Average abundance (individuals/10m ²)	Evenness index	Diversity index
1	8	94	0.621	1.291
2	7	106	0.672	1.307
3	6	66	0.702	1.258
4	10	135	0.333	0.768
5	8	83	0.551	1.146
6	5	96	0.722	1.162
7	7	79	0.608	1.184
8	6	48	0.661	1.185
9	10	95	0.543	1.249
10	10	159	0.484	1.113
11	8	281	0.495	1.030
12	7	9,558	0.038	0.074
13	6	47	0.675	1.209
14	8	1,807	0.086	0.180
15	9	80	0.655	1.440
16	7	119	0.560	1.089
17	9	6,050	0.111	0.243
18	8	11,653	0.016	0.033
19	7	102	0.561	1.092
20	6	42	0.617	1.106
21	9	613	0.315	0.691
22	8	6,406	0.074	0.155
23	9	51,384	0.005	0.011
24	7	5,203	0.024	0.047
25	7	73	0.577	1.123
26	6	95	0.738	1.322
27	8	1,942	0.186	0.386
28	8	28,264	0.021	0.045
29	6	96,255	0.005	0.008
30	7	55,284	0.005	0.009
31	8	24,164	0.010	0.021
32	7	21,206	0.014	0.027
33	9	12,347	0.022	0.049
34	7	43,697	0.005	0.010
35	7	60,094	0.003	0.006
36	7	32,993	0.008	0.015

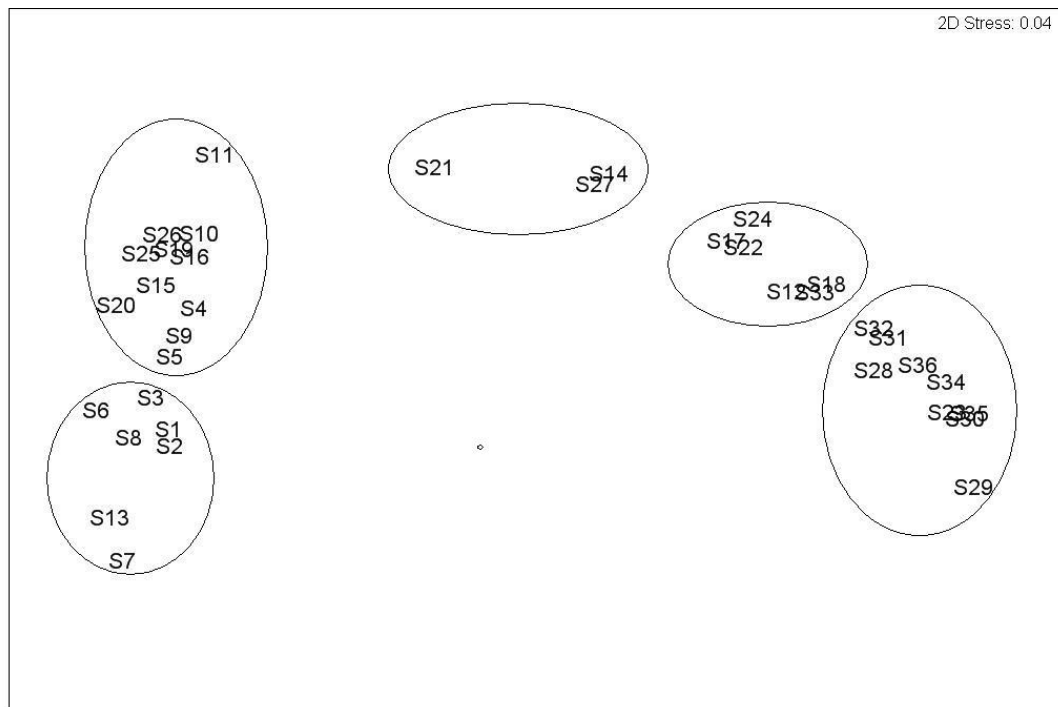
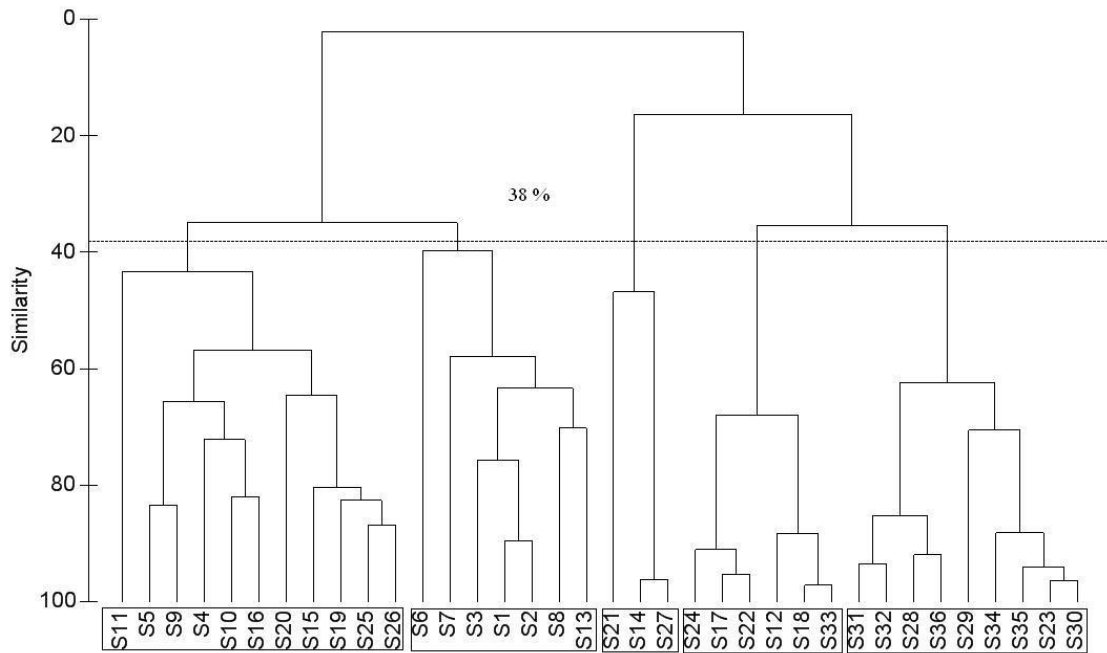


Figure 5.72: Dendrogram showing hierarchical clustering of mollusks at each station (above) and non-MDS ordination of mollusks, classified into five groups, stress value= 0 .04 (below)

5.4.2.3.2 Temporal variation

The temporal diversity index ranged from 0.011 to 1.043. The high diversity indices were recorded during rainy season from June 2008 to October 2009. The values drastically dropped in winter season by dropping to 0.011 in November and 0.018 in December 2009. It was found that the decrease in diversity index was matching with the high density of horse mussel population in the study area. During January 2009-May 2009, the diversity index increased slightly (Table 5.15). Assemblage structure of mollusks was analyzed to define similarity between every pair of species in each month by a cluster analysis and non multidimensional scaling. The results were in Table 5.15 and Figure 5.73. Communities of mollusks in Don Hoi Lot could be divided into three groups at 50% of similarity and stress 0.01 group I (from June 2008 to October 2008) , group II (from November 2008 to December 2008) and group III (from January 2009 to May 2009).

Table 5.15: Annual variation of diversity index of average abundance of mollusks in Don Hot Lot during June 2008-May 2009

Month	Species richness	Average abundance (individuals/10m ²)	Evenness index	Diversity index
Jun-08	7	124	0.536	1.043
Jul-08	11	89	0.514	1.233
Aug-08	10	87	0.534	1.230
Sep-08	8	95	0.597	1.240
Oct-08	8	98	0.414	0.862
Nov-08	9	73,133	0.005	0.011
Dec-08	9	44,066	0.008	0.018
Jan-09	11	9,590	0.045	0.108
Feb-09	10	8,526	0.036	0.082
Mar-09	11	7,484	0.036	0.086
Apr-09	11	8,190	0.033	0.080
May-09	10	5,423	0.025	0.057

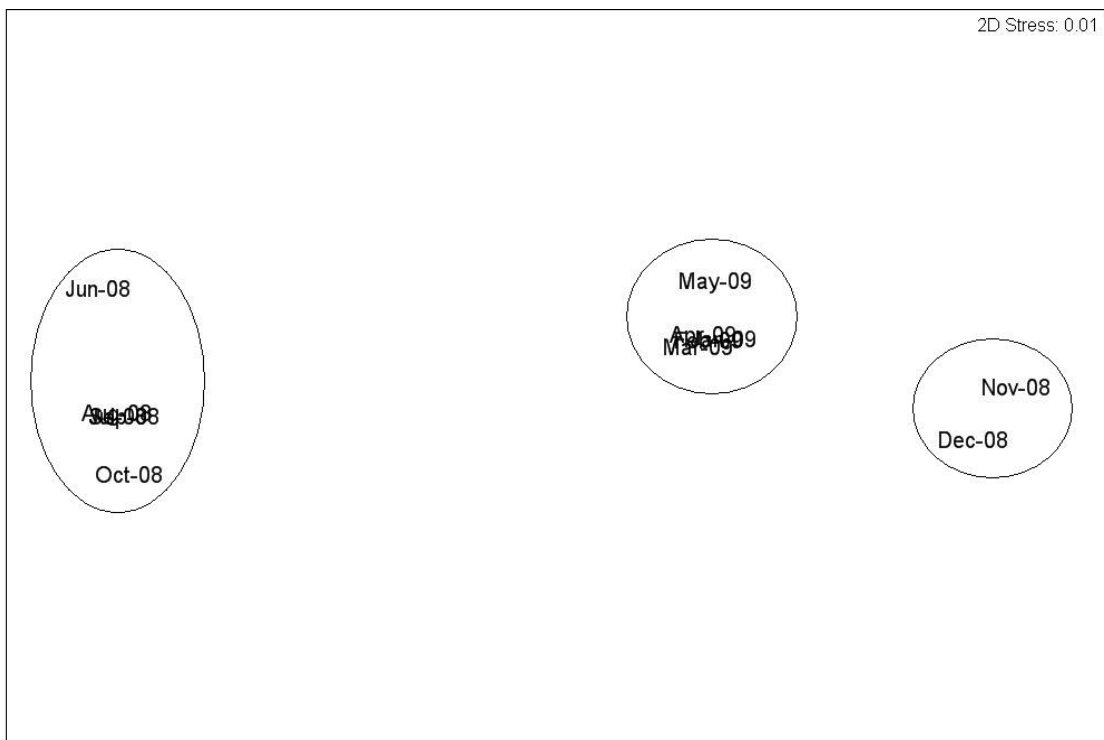
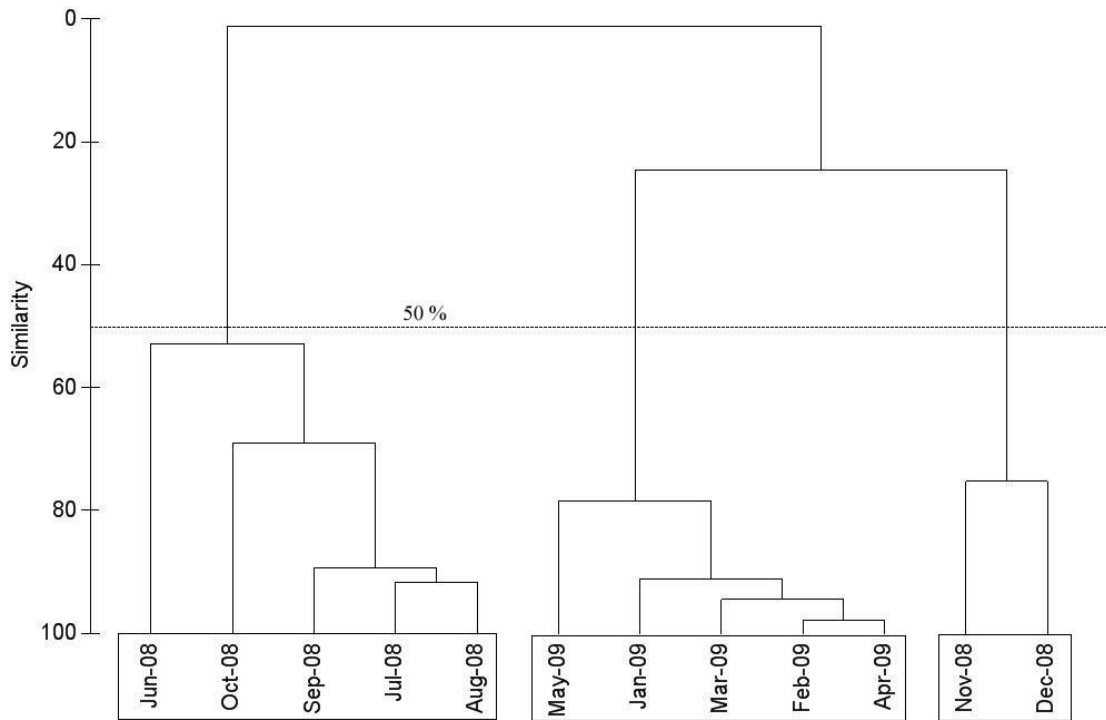


Figure 5.73: Dendrogram showing hierarchical clustering of mollusks in each month (above) and non-MDS ordination of mollusks, classified into three groups, stress value= 0 (below)

5.4.2.4 Relationship between mollusk species

During the study, there were 14 mollusk species found in Don Hoi Lot. The relationship among these mollusk species was analyzed by using Pearson correlation (Table 5.16). The results showed that abundance of *S. corneus* had positively significant correlation with of *V. myristica* ($r= 0.203$), *S. strictus* ($r= (0.266)$), *M. meretix* ($r=0.138$) and correlated with *M. lusoria* ($r=0.122$). The relationship between *S. corneus* and *N. distorta* was negatively correlated ($r=-0.098$).

M. senhousia was the most abundant species during the study period. It was positively significant correlated with *N. tigrina* ($r=0.204$). The relationships between *M. meretix* and *M. lusoria*, *M. meretix* and *T. capsoides*, and *M. lusoria* and *T. capsoides* were positively significant correlated ($r=0.798$, $r=0.304$ and $r=0.384$, respectively). *M. lusoria* was negatively correlated with *N. distorta* ($r=-0.108$).

Table 5.16: Pearson correlation among mollusk species in Don Hoi Lot during June 2008-May 2009 (n=432)

Mollusk species	<i>Bulla</i> sp.	<i>V. myristica</i>	<i>N. distortus</i>	<i>N. distorta</i>	<i>N. tigrina</i>	<i>C. cingulata</i>	<i>A. granosa</i>	<i>M. senhousia</i>	<i>S. corneus</i>	<i>S. regularis</i>	<i>S. strictus</i>	<i>T. capsoides</i>	<i>M. lusoria</i>
<i>V. myristica</i>	-0.007												
<i>N. distortus</i>	-0.091	-0.033											
<i>N. distorta</i>	-0.005	-0.015	0.037										
<i>N. tigrina</i>	-0.045	-0.017	0.087	-0.020									
<i>C. cingulata</i>	-0.018	-0.006	0.023	0.019	-0.047								
<i>A. granosa</i>	-0.029	-0.010	-0.043	0.061	-0.064	0.032							
<i>M. senhousia</i>	-0.001	-0.024	0.062	-0.053	0.204**	-0.066	-0.057						
<i>S. corneus</i>	-0.062	0.203**	-0.009	-0.098*	0.059	-0.049	-0.066	-0.038					
<i>S. regularis</i>	-0.016	-0.006	-0.047	-0.038	0.050	-0.016	-0.025	-0.060	0.052				
<i>S. strictus</i>	-0.040	-0.014	-0.035	-0.070	-0.004	-0.016	-0.050	-0.037	0.266**	0.057			
<i>T. capsoides</i>	-0.023	-0.008	-0.029	-0.045	-0.059	-0.022	0.001	-0.067	-0.061	-0.020	-0.048		
<i>M. lusoria</i>	-0.056	0.022	0.007	-0.108*	-0.007	-0.045	-0.052	-0.040	0.122*	-0.011	0.038	0.384**	
<i>M. meretrix</i>	-0.045	-0.016	0.002	-0.087	-0.044	-0.043	-0.053	-0.066	0.138**	-0.039	0.051	0.304**	0.798**

Remark: * = Significant at 0.05 level ** = Significant at 0.01 level

5.5 Interactions among environmental factors

5.5.1 Physical and chemical factors

The relationships between physical and chemical factors were analyzed by using Pearson Correlation. The analytical results were presented in Table 5.17. Soil temperature was positively significant correlated with water temperature ($r=0.833$), total ammonia ($r=0.448$) and nitrate nitrogen ($r=0.293$). Whereas it was negatively significant correlated with dissolved oxygen ($r=-0.261$), salinity ($r=-0.259$), alkalinity ($r=-0.285$), orthophosphate ($r=-0.412$) and chlorophyll-a ($r=-0.199$).

pH in the upper and the lower soil layers were positively significantly correlated with water temperature and total ammonia. Whereas it has negatively significant correlation with water pH, salinity, alkalinity, total ammonia and chlorophyll-a.

Water content in the upper soil layer was negatively correlated with hardness ($r=-0.148$). Water content in the lower soil layer was negatively significant correlated with water pH ($r=-0.318$), salinity ($r=-0.253$) and hardness ($r=-0.239$). Water content in the lower soil layer was positively significant correlated with nitrate nitrogen ($r=-0.274$).

Total organic matter in the upper soil layer was positively significant correlated with water pH ($r=0.295$) and alkalinity ($r=0.295$), but had negative correlation with water temperature ($r=-0.262$) and total ammonia ($r=-0.188$). Total organic matter in the lower soil layer had the same correlation with parameters as in the upper soil layer. Total organic matter in lower soil layer was positively significant correlated with dissolved oxygen and hardness.

Sand composition and median grain size in the upper and the lower soil layers had positive correlation with water depth, water pH, transparency, salinity, hardness and orthophosphate, but had negatively correlation with water temperature, dissolved oxygen, turbidity, total ammonia and nitrate nitrogen.

Redox-potential and water temperature had significantly positive correlation ($r=0.211$), whereas relationship between redox-potential and orthophosphate had negatively significant correlation ($r=-0.213$).

Table 5.17: Pearson correlation among physical factors, chemical factors and related parameters at Don Hoi Lot during June 2008-May 2009 (n=216)

Soil parameters	Water quality and related parameters												
	Depth	Temperature	pH	Dissolved oxygen	Transparency	Turbidity	Salinity	Alkalinity	Hardness	Ammonia	Nitrate	Phosphate	Chlorophyll-a
Temperature	-0.080	0.833**	-0.133	-0.261**	-0.137	0.053	-0.259**	-0.285**	-0.115	0.448**	0.293**	-0.412**	-0.199**
pH ¹	0.186**	0.259**	-0.534**	-0.114	-0.037	0.104	-0.188**	-0.397**	0.158*	0.376**	-0.025	-0.085	-0.277**
pH ²	0.161*	0.281**	-0.496**	-0.029	-0.114	0.138*	-0.190**	-0.440**	0.161*	0.371**	-0.053	-0.138*	-0.240**
Water content ¹	0.045	-0.040	-0.076	-0.032	-0.068	-0.016	-0.116	-0.030	-0.148*	-0.011	0.064	0.093	-0.067
Water content ²	0.067	0.069	-0.318**	-0.170	-0.074	0.059	-0.253**	-0.143*	-0.239**	0.157*	0.274**	0.112	-0.084
Total organic matter ¹	0.002	-0.262**	0.295**	0.113	0.021	-0.042	0.116	0.295**	-0.015	-0.188**	0.042	0.074	0.054
Total organic matter ²	-0.046	-0.294**	0.184**	0.193**	-0.163*	-0.037	0.154*	0.360**	0.186**	-0.057	0.136*	0.123	0.037
Sand composition ¹	0.329**	-0.180**	0.215**	-0.166*	0.321**	-0.195**	0.405**	0.120	0.230**	-0.206**	-0.232**	0.116	-0.041
Sand composition ²	0.328**	-0.194**	0.076	-0.308**	0.342**	-0.229**	0.381**	0.019	0.193**	-0.102	-0.160*	0.168*	-0.060
Median grain size ¹	0.327**	-0.173*	0.207**	-0.170*	0.291**	-0.201**	0.387**	0.124	0.216**	-0.163*	-0.216**	0.102	-0.039
Median grain size ²	0.316**	-0.154	0.057	-0.321**	0.293**	-0.198**	0.309**	0.015	0.158*	-0.101	-0.115	0.170*	-0.067
Redox potential	-0.011	0.211**	-0.018	-0.134*	0.118	-0.023	-0.139*	-0.160*	-0.166*	-0.101	-0.050	-0.213**	0.043

Remark; * = Significant at 0.05 level ** = Significant at 0.01 level

1 = upper soil layer

2 = lower soil layer

5.5.2 Relationship between phytoplankton abundance and physical and chemical factors

The relationships between phytoplankton abundance and all physical and chemical factors were analyzed by using Pearson correlation. The detailed results were shown in Table 5.18. During the study period, phytoplankton abundance was significantly positively correlated with dissolved oxygen ($p<0.01$), water pH ($p<0.01$), hardness ($p<0.01$), alkalinity ($p<0.01$), and chlorophyll-a ($p<0.01$), but was negatively correlated with soil pH in upper soil layer ($p<0.01$), water content in upper soil layer ($p<0.01$) and nitrate nitrogen ($p<0.01$). Total organic matter in both soil layers were positively correlated ($p<0.05$) with phytoplankton abundance, whereas the correlation between phytoplankton abundance and salinity ($p<0.01$), redox-potential ($p<0.05$) and phosphate phosphorus ($p<0.05$) was negative.

Table 5.18: Pearson correlation between phytoplankton and physical and chemical factors in Don Hoi Lot during June 2008-May 2009 (n=216)

Total organic matter ¹	Total organic matter ²	Salinity	Dissolved oxygen	Water pH	Hardness	Alkalinity
0.135*	0.170*	0.361**	0.497**	0.530**	0.259**	0.384**

Chlorophyll-a	Water content	Soil pH ¹	Redox potential	Nitrate nitrogen	Phosphate
0.246**	-0.197**	-0.191**	-0.157*	-0.246**	-0.173**

Remark; * = Significant at 0.05 level ** = Significant at 0.01 level
 1 = upper soil layer 2 = lower soil layer

5.5.3 Relationship between mollusks and physical factors

The relationships between mollusks and physical factors were analyzed by using Pearson Correlation. The analytical results were presented in Table 5.19. The results indicated that mollusk species would be in an assemblage depending on each physical factor. Soil temperature was positively significantly correlated with *M. meretrix* ($r=0.133$), but was negatively significantly correlated with other mollusks,

such as *Bulla* sp. ($r=-0.247$), *N. distortus* ($r=-0.176$), *N. distorta* ($r=-0.132$), *N. tigrina* ($r=-0.193$), and *M. senhousia* ($r=-0.124$).

Soil pH in the upper and the lower layers had positively significant correlation with three species: *V. myristica*, *M. lusoria*, and *M. meretrix*, but had negative correlation with *N. tigrina* and *M. senhousia*.

Water content in the upper soil layer was positively significantly correlated with *Bulla* sp. ($r=-0.159$), *N. distorta* ($r=0.162$), and *A. granosa* ($r=0.149$), but was negatively significantly correlated with *S. corneus* ($r=-0.248$), *S. strictus* ($r=-0.135$), *M. lusoria* ($r=-0.188$), and *M. meretrix* ($r=-0.130$). It was found that several mollusk species (*N. distorta*, *C. cingulata* and *A. granosa*) had positive significantly correlation with water content in the lower soil layer, but *N. tigrina*, *M. senhousia*, *S. corneus*, and *M. lusoria* had negative correlation.

Total organic matter in the upper soil layer was positively significantly correlated with *N. distorta* ($r=0.197$) and *A. granosa* ($r=0.217$), but was negatively significantly correlated with *M. lusoria*, ($r=-0.182$), and *M. meretrix* ($r=-0.157$). Total organic matter in the lower soil layer was almost correlated with species mentioned in upper soil layer. Total organic matter in lower soil layer was positively significantly correlated with *Bulla* sp. ($r=-0.132$) and *M. senhousia* ($r=0.148$).

Sand composition and median grain size in upper and lower soil layers, had positive correlation with *M. senhousia* and *S. corneus*, but had negative correlation with *N. distorta* and *T. capsoides*.

Finally redox-potential was positively significantly correlated with *S. corneus* ($r=0.178$), *M. lusoria* ($r=0.265$) and *M. meretrix* ($r=0.215$), but was negatively significantly correlated with *Bulla* sp. ($r=-0.229$), *N. distorta* ($r=-0.182$) and *M. senhousia* ($r=-0.207$).

Table 5.19: Pearson correlation between mollusk species and physical factors at Don Hoi Lot during June 2008-May 2009 (n=432)

Mollusk species	Temperature	pH ¹	pH ²	Water content ¹	Water content ²	Total organic matter ¹	Total organic matter ²
<i>Bulla</i> sp.	-0.247**	-0.096*	-0.118*	0.159**	0.058	0.105*	0.132**
<i>V. myristica</i>	0.005	0.150**	0.135**	-0.051	-0.043	-0.042	-0.031
<i>N. distortus</i>	-0.176**	-0.037	-0.052	-0.110*	-0.008	-0.081	-0.030
<i>N. distorta</i>	-0.132**	-0.013	0.039	0.162**	0.130**	0.197**	0.200**
<i>N. tigrina</i>	-0.193**	-0.149**	-0.133**	0.007	-0.125**	0.066	0.100*
<i>C. cingulata</i>	0.070	0.005	-0.021	0.066	0.153**	0.004	0.083
<i>A. granosa</i>	-0.034	-0.073	-0.024	0.149**	0.143**	0.217**	0.140**
<i>M. senhousia</i>	-0.124**	-0.240**	-0.260**	0.026	-0.248**	0.053	0.148**
<i>S. corneus</i>	0.028	0.061	0.059	-0.248**	-0.212**	-0.117*	-0.122*
<i>S. regularis</i>	0.019	-0.098*	-0.100*	-0.056	-0.043	0.098*	0.093
<i>S. strictus</i>	-0.010	-0.026	-0.064	-0.135**	-0.105*	-0.107*	-0.094
<i>T. capsoides</i>	0.097*	0.089	0.063	-0.043	0.025	-0.057	0.022
<i>M. lusoria</i>	0.081	0.184**	0.194**	-0.188**	-0.151**	-0.182**	-0.133**
<i>M. meretrix</i>	0.133**	0.207**	0.219**	-0.130**	-0.104*	-0.157**	-0.167**

Remark; * = Significant at 0.05 level ** = Significant at 0.01 level

1 = upper soil layer 2 = lower soil layer

Table 5.19: Pearson correlation between mollusk species and physical factors at Don Hoi Lot during June 2008-May 2009 (n=432) (cont.).

Mollusk species	Sand composition ¹	Sand composition ²	Median Grain size ¹	Median Grain size ²	Redox potential
<i>Bulla</i> sp.	0.019	0.018	0.033	0.019	-0.229**
<i>V. myristica</i>	-0.031	-0.024	-0.019	-0.016	0.117*
<i>N. distortus</i>	0.037	-0.047	0.032	-0.050	0.116*
<i>N. distorta</i>	-0.152**	-0.117*	-0.126**	-0.119*	-0.182**
<i>N. tigrina</i>	0.103*	0.053	0.076	0.017	0.091
<i>C. cingulata</i>	-0.107*	-0.112*	-0.076	-0.094	-0.026
<i>A. granosa</i>	-0.060	-0.040	-0.029	-0.019	-0.117*
<i>M. senhousia</i>	0.190**	0.216**	0.177**	0.199**	-0.207**
<i>S. corneus</i>	0.164**	0.164**	0.139**	0.122*	0.178**
<i>S. regularis</i>	0.044	0.068	0.033	0.031	0.005
<i>S. strictus</i>	0.087	0.106*	0.069	0.086	0.070
<i>T. capsoides</i>	-0.145**	-0.112*	-0.150**	-0.097*	0.080
<i>M. lusoria</i>	0.063	0.051	0.018	0.021	0.265**
<i>M. meretrix</i>	0.075	0.057	0.041	0.020	0.215**

Remark; * = Significant at 0.05 level ** = Significant at 0.01 level
 1 = upper soil layer 2 = lower soil layer

5.5.4 Relationship between mollusk species and chemical factors and phytoplankton abundance

The relationships between mollusk species and chemical factors were analyzed by using Pearson correlation (Table 5.20). During the study period, water depth had positively significantly correlation with *T. capsoides* ($r=0.172$) and was significantly correlated in diverse direction with *N. distorta* ($r=-0.201$).

Water temperature had positively significant correlation with three mollusk species, namely *Bulla* sp. ($r=0.208$), *N. tigrina* ($r=0.179$), and *M. senhousia* ($r=0.307$). Water pH was only significantly correlated in negative direction with *N. distorta* ($r=-0.269$).

Concentration of dissolved oxygen was negatively significantly correlated with four mollusk species, namely *Bulla* sp. ($r=-0.325$), *N. distortus* ($r=-0.196$), *N. tigrina* ($r=-0.186$), and *M. senhousia* ($r=-0.198$). The relationship between transparency and *V. myristica* was negatively significantly correlated ($r=-0.226$).

Turbidity was positively correlated with *N. tigrina* ($r=0.180$) and *M. senhousia* ($r=0.333$), but was negatively correlated with *M. lusoria* ($r=-0.180$). Salinity was negatively significantly correlated with *Bulla* sp. ($r=-0.190$) but was positively significantly correlated with *N. distorta* ($r=0.228$).

Alkalinity was positively significantly correlated with *Bulla* sp. ($r=0.193$) and *M. senhousia* ($r=0.191$). The relationship between hardness and *M. senhousia* ($r=0.207$) was positively significantly correlated. Hardness was negatively significantly correlated with *M. lusoria* ($r=-0.198$) and *M. meretrix* ($r=-0.194$).

For relationship between plant nutrients and abundance of each mollusk species, it was found that total ammonia was correlated significantly and positively with *T. capsoides* ($r=0.200$). Nitrate nitrogen was correlated significantly and positively with *N. distorta* ($r=0.228$) but was correlated significantly and negatively with *N. tigrina* ($r=-0.177$). The relationship between concentration of orthophosphate and abundance of *Bulla* sp. was correlated significantly in positive direction ($r=0.341$).

Finally chlorophyll-a was positively significantly correlated with *N. distorta* ($r=0.181$). Abundance of phytoplankton was significantly correlated with *M. senhousia* ($r=0.208$) and *N. distorta* ($r=0.144$).

Table 5.20: Pearson correlation between mollusk species and chemical and related factors at Don Hoi Lot during June 2008-May 2009 (n=216).

Mollusk species	Water quality and related parameters						
	Depth	Temperature	pH	Dissolved oxygen	Transparency	Turbidity	Salinity
<i>Bulla</i> sp.	0.079	0.208**	0.019	-0.325**	0.022	-0.020	-0.190**
<i>V. myristica</i>	0.028	-0.002	-0.126	0.016	-0.226**	-0.094	0.005
<i>N. distortus</i>	-0.057	0.014	-0.066	-0.196**	0.081	0.059	0.155*
<i>N. distorta</i>	-0.201**	-0.051	-0.269**	-0.086	0.045	0.078	0.228**
<i>N. tigrina</i>	0.069	0.179**	0.082	-0.186**	0.118	0.180**	-0.169*
<i>C. cingulata</i>	-0.094	-0.063	0.022	0.043	-0.106	-0.052	-0.146*
<i>A. granosa</i>	-0.041	0.059	-0.048	-0.136*	0.001	0.025	0.000
<i>M. senhousia</i>	0.070	0.307**	0.026	-0.198**	0.142*	0.333**	-0.093
<i>S. corneus</i>	-0.078	0.124	0.005	-0.016	-0.159*	0.022	0.026
<i>S. regularis</i>	-0.038	0.137*	0.043	-0.006	-0.099	0.101	-0.097
<i>S. strictus</i>	-0.132	0.070	0.009	-0.025	0.017	0.107	0.034
<i>T. capsoides</i>	0.172*	0.024	0.077	0.108	-0.050	-0.067	-0.071
<i>M. lusoria</i>	-0.021	0.026	0.144*	0.164*	-0.137*	-0.180**	-0.117
<i>M. meretrix</i>	-0.062	-0.038	0.066	0.163*	-0.105	-0.163*	-0.062

Remark: * = Significant at 0.05 level ** = Significant at 0.01 level

Table 5.20: Pearson correlation between mollusk species and chemical and related factors at Don Hoi Lot during June 2008-May 2009 (n=216). (cont.).

Mollusk species	Water quality and related parameters							
	Alkalinity	Hardness	Ammonia	Nitrate	Phosphate	Chlorophyll-a	Abundance of Phytoplankton	
<i>Bulla</i> sp.	0.193**	0.031	-0.131	-0.147*	0.341**	-0.131	-0.040	
<i>V. myristica</i>	0.054	-0.167*	0.073	-0.004	-0.064	-0.094	-0.109	
<i>N. distortus</i>	-0.023	0.067	-0.120	0.043	0.026	0.113	-0.030	
<i>N. distorta</i>	-0.112	0.058	0.115	0.246**	0.132	0.181**	0.144*	
<i>N. tigrina</i>	0.137*	0.046	-0.142*	-0.177**	0.046	0.114	0.040	
<i>C. cingulata</i>	-0.102	0.059	0.031	0.131	0.017	0.103	0.031	
<i>A. granosa</i>	-0.025	0.110	0.004	0.026	0.014	-0.008	0.058	
<i>M. senhousia</i>	0.191**	0.207**	-0.099	-0.162*	0.040	0.083	0.208*	
<i>S. corneus</i>	0.091	-0.010	0.006	-0.066	-0.085	0.000	0.050	
<i>S. regularis</i>	0.034	-0.051	-0.056	-0.070	-0.057	-0.107	-0.024	
<i>S. strictus</i>	-0.025	0.028	-0.036	-0.085	-0.054	0.136	0.131	
<i>T.capsoides</i>	0.008	-0.167*	0.200**	-0.014	-0.046	-0.175	0.017	
<i>M. lusoria</i>	0.078	-0.198**	0.080	-0.111	-0.067	-0.153	-0.070	
<i>M. meretrix</i>	0.023	-0.194**	0.122	-0.040	-0.043	-0.051	-0.005	

Remark; * = Significant at 0.05 level ** = Significant at 0.01 level

5.6 Discussion and conclusion

5.6.1 Physical and chemical characteristics in Don Hoi Lot

Physical and chemical factors including soil characters and water quality were analyzed for the period of June 2008-May 2010. All physical factors varied based on transverse variation. Most factors varied based on longitudinal variation, except soil temperature, soil pH, sand composition in lower soil layer and acid volatile sulfide. For annual variation, all physical factors changed according to several factors, namely seasonal variation, amount of rainfall, discharge of Mae Klong dam, altitude and distance from shoreline, and locations of sampling stations. Conclusion of variation of each physical and chemical factor in terms of spatial and temporal distribution was presented in Table 5.21. Effects of physical and chemical factors on razor clams were discussed.

Table 5.21: Spatial and temporal variation of physical and chemical factors in Don Hoi Lot during June 2008-May 2009.

Environmental factors	Spatial distribution		Temporal distribution		
	Transverse	Longitudinal	Monthly	High values	Low values
Soil temperature	+	-	+	Apr-Sep	Oct-Jan
Soil pH ¹	+	-	+	Jun-Jul	May
Soil pH ²	+	-	+	Jun-Jul	May
Water content ¹	+	+	+	-	Dec
Water content ²	+	+	+	-	Apr
Total organic matter ¹	+	+	+	Apr	Jul
Total organic matter ²	+	+	+	Apr	Jul
Sand composition ¹	+	+	+	-	Jul, Nov, Mar
Sand composition ²	+	-	+	-	Jul, Nov, Mar

Table 5.21: Spatial and temporal variation of physical and chemical factors in Don Hoi Lot during June 2008-May 2009 (cont.).

Environmental factors	Spatial distribution		Temporal distribution		
	Transverse	Longitudinal	Monthly	High values	Low values
Median grain size ¹	+	+	+	-	Jul, Nov, Mar
Median grain size ²	+	+	+	-	Jul, Nov, Mar
Redox-potential	+	+	+	Aug	Mar
Acid volatile sulfide	+	-	+	Dec	Aug
Depth	+	+	+	-	-
Water temperature	-	-	+	-	Dec, Jan
Water pH	+	-	+	Nov	Jul
Dissolved oxygen	+	-	+	Nov	Sep
Transparency	+	-	+	Dec	Feb
Turbidity	+	+	+	Aug, Feb, Mar	Jan
Salinity	+	+	+	Jan	Oct
Alkalinity	-	-	+	-	Jul
Hardness	+	+	+	Jan	Oct
Ammonia nitrogen	+	-	+	Jul	Oct, Nov
Nitrate nitrogen	+	-	+	Feb	Nov
Phosphate phosphorus	-	-	+	Jan	Nov
Chlorophyll-a	-	-	+	Nov, Feb	Jul

Remark: 1 = upper soil layer, 2 = lower soil layer
 + = impact variation, - = no impact or not clearly determined

5.6.1.1 Soil and water temperature

During the study period, soil temperature was measured during nighttime for six months (October 2008-March 2009) and during daytime for the remaining six months. Soil temperature ranged from 19.78-35.18 °C. The main factor affecting the variation of soil temperature was seasonal change (low temperature during October 2008 to January 2009 or winter season). Water temperature varied in the same trend. There was difference in soil temperature between transverse and longitudinal transects. There was positively significant ($p < 0.01$) correlation between soil temperature and soil pH in both layers and between soil temperature and total ammonia and nitrate nitrogen. Soil temperature was negatively significantly ($p < 0.01$) correlated with the amount of total organic matter (both soil layers) and phosphate phosphorus. Water temperature ranged from 22.4 to 32.3 °C which was similar to 25.05 to 31.05 °C of Phuwapanich *et al.* (2003). Average water temperature was 29.4 °C which was proximal with average water temperature in the inner Gulf of Thailand, 29.7 °C (Mongkulmann, 2001). Water temperature was significantly ($p < 0.01$) correlated in positive direction with turbidity, ammonia and nitrate, but in negative direction with water pH, transparency, salinity, alkalinity, hardness and orthophosphate. The change of water temperature would affect and cause the variation of other environmental factors. It could be concluded that soil and water temperature were almost constant comparing with other previous studies and water temperature in Don Hoi Lot was still suitable for living aquatic organisms according to the standard of the Pollution Control Department (ranging from 23-32 °C) (Pollution Control Department, 2010).

5.6.1.2 Soil pH and water pH

Soil pH in Don Hoi Lot in upper and lower soil layers ranged from 7.03-8.10 and 7.11-8.27 respectively. According to the Department of Fisheries (1995), Razor clams could be found in soil pH ranging from 7.6-8.1. It was found that the range of soil pH was wider than soil pH previously recorded by Department of Fisheries in both lower and upper layers. Soil pH in Don Hoi Lot had more acidity due to high amount of total organic matter found in the area, in particular in the first transverse transect (T1). This might be one of several causes that stimulated reduction of density of Razor clams continuously in the area. For spatial variation, it was found

that soil pH (both layers) varied based on transverse transects rather than longitudinal transects. Soil pH had significant annual variation, was high in July 2008 (starting of rainy season) and was low in May 2009 (at the end of summer season). Average soil pH in lower and upper layer was different significantly ($p < 0.01$). Soil pH of both layers were negatively correlated with total organic matter ($p < 0.01$), sand composition in upper layer ($p < 0.01$), median grain size in upper layer ($p < 0.05$), but redox-potential was positively correlated with soil pH in upper layer ($p < 0.01$) and soil pH in lower layer ($p < 0.05$).

Water pH varied significantly based on transverse and longitudinal transects and varied monthly. Water pH was positively significantly correlated with dissolved oxygen, salinity, alkalinity, and chlorophyll-a concentration. Water pH was negatively correlated with nitrate nitrogen ($p < 0.01$), total ammonia ($p < 0.01$) and orthophosphate phosphorus ($p < 0.05$). At the end of rainy season and the beginning of winter season (in November), water pH was peaked as well as dissolved oxygen and chlorophyll-a concentration. Phytoplankton abundance was also high, while amount of plant nutrients (nitrate nitrogen, total ammonia, and orthophosphate phosphorus) were low. During the increase of phytoplankton or the occurrence of eutrophication, phytoplankton would uptake nutrient substances, therefore plant nutrients would decline in the same period. This incident was supported by Boondao's study in Mae Klong River estuary in 2005 (Boondao, 2006). This finding demonstrated that water pH fluctuation would impact more or less the chemical factors in Don Hoi Lot.

5.6.1.3 Water content and total organic matter

Average water content was 25.18 and 24.38 % in upper and lower soil layer respectively which was similar to Tantanarit 's report in 2007 that the water content in Don Hoi Lot ranging from 25 to 35 % whereas water content in zone I locating 2 km far from Mae Klong River mouth was 27.70 %. The results indicated that average water content in upper soil layer was significantly different from in lower soil layer. The high average water content was found in T1 and T2, and TA, TB, and TF in transverse and longitudinal transects respectively due to their locations and soil composition. They were situated nearest to coast line with high sedimentation.

Total organic matter was measured in two soil layers and there was no difference between them. The average total organic matter was 35.08 and 35.73 mg/g dry weight in upper and lower soil layer respectively which was between 19.26-44.61 mg/g dry weight previously recorded by Tantanasarit in 2007. In 2004-2005, Dongdee reported that average total organic matter in Don Hoi Lot was 2.53-2.62 %, similar to Tuaycharoen and Voraingtara in 1991 reported that average total organic matter was 2.5 %. Therefore there was a trend of increment of amount of total organic matter in Don Hoi Lot.

The present study clearly indicated that amount of total organic matter was varied significantly based on transverse and longitudinal transects and had monthly variation. The high average total organic matter was found in T1 and T2, and TF in transverse and longitudinal transect respectively. Total organic matter had significantly positive correlation with water content in both soil layers ($p < 0.01$), water pH and alkalinity ($p < 0.01$), but was negatively correlated with redox potential ($p < 0.01$), soil pH in both layers ($p < 0.01$), soil temperature ($p < 0.01$) and water temperature ($p < 0.05$). It could be concluded that the amount of total organic matter in Don Hoi Lot was in the category as high to highest level according to the standard of soil chemistry issued by Land Development Department (Vichitworkun, 2001).

5.6.1.4 Soil composition

Average sand composition in soil was 75.8 and 73.9 % in upper and lower soil layer respectively. Sand composition was lowest in T1 and gradually increased offshore and reached the maximum in T6. Several researches for instance, Tuaycharoen and Charoenpornthip (1997) studied the soil composition in Ban Bang Kunsai to Laem Panoen, Phetchaburi Province and found that the average percentage of sand was 59.30. In 1996-1998, Tuaycharoen studied the habitat of Razor clams at the mouth of the Chao Phraya River, Samut Prakarn Province and reported that the average percentage of sand in Phra Samut Jadee, Maung and Bang Bo Districts, Samut Prakarn Province were 60.12, 69.27 and 73.03 respectively (Tuaycharoen *et al.*, 2002). Average sand composition found in the present study was similar and supported by Pradatsundarasar (1982). The results also indicated that amount of sand composition was positively significantly correlated with median grain size in both soil layers ($p < 0.01$), water depth ($p < 0.01$), transparency $p < 0.01$), salinity

$p < 0.01$) and hardness ($p < 0.01$), but was negatively correlated with water content in lower soil layers ($p < 0.01$), turbidity ($p < 0.01$), and nitrate nitrogen ($p < 0.05$).

Pradatsundarasar (1982) reported that the distribution of *S. regularis* was limited within the sandbar of the estuary where the average sediment grain size was 0.125 mm or 125 μm . In this study, the average median grain size was 74.8 and 74.1 μm in upper and lower soil layers respectively. Therefore there was a trend that the percentage of sand composition in Don Hoi Lot would decrease gradually and this would be one of several causes affecting the reduction of population of Razor clams in Don Hoi Lot.

5.6.1.5 Dissolved oxygen and plant nutrients

Dissolved oxygen concentration varied significantly based on transverse transect and had monthly variation. The low concentration was found in T1 and T2 transverse transects and gradually increased offshore and reached the maximum in T6. In general, dissolved oxygen concentration was higher than 4 mg/l, except in September 2008. The maximum concentration was in November 2009 during the phytoplankton bloom. The study also indicated that dissolved oxygen concentration was positively significantly ($p < 0.01$) correlated with several parameters, namely water pH, alkalinity, hardness and chlorophyll-a, but was negatively significantly correlated with plant nutrients (total ammonia, nitrate nitrogen and phosphate phosphorus). This was supported by Boondao in 2006 that the phytoplankton bloomed in October 2005 (the end of rainy season) due to availability of plant nutrients released from agricultural land through Don Hoi Lot via Mae Klong River. During the daytime in November 2009, phytoplankton produced incredible amount of dissolved oxygen therefore super saturation occurred whereas dissolved oxygen decreased and aquatic organisms could not survive during night time. It was observed that a number of fishes died that time in Don Hoi Lot. Therefore dissolved oxygen concentration, normally was above than 4 mg/l and was suitable for living aquatic organisms except in the beginning of winter season (October) to December when its concentration was low during nighttime.

5.6.2 Biological characteristic in Don Hoi Lot

5.6.2.1 Phytoplankton in Don Hoi Lot

A total of 187 phytoplankton species was recorded during June 2008 to May 2009. The majority group was diatoms, followed by green algae. Dominant species were *Chaetoceros pseudocurvisetus*, *Pseudonitzschia pungens*, *Thalassiosira* spp., *Cylindrotheca closterium*, *Skeletonema costatum* and *Thalassionema nitzschioides*. Number of phytoplankton was maximum in November 2009 at the same peak with chlorophyll-a and dissolved oxygen. *Chaetoceros pseudocurvisetus* was the most common phytoplankton found in this study in term of spatial and temporal distribution. This species was a common species in coastal areas in Thailand The lowest diversity index was found at the 24th station locating nearest to Prince Chumporn Khedudomsak Memorial whereas the highest was found at the 1st station locating nearest to Mae Klong River mouth.

The results indicated that phytoplankton abundance was positively significantly correlated with total organic matter in both soil layers ($p < 0.05$), salinity ($p < 0.01$), dissolved oxygen ($p < 0.01$), water pH ($p < 0.01$), hardness ($p < 0.01$), alkalinity and chlorophyll-a, but was negatively correlated with soil pH in upper soil layer ($p < 0.01$), water content in upper soil layer ($p < 0.01$), redox-potential ($p < 0.05$), nitrate nitrogen ($p < 0.01$) and phosphate phosphorus ($p < 0.05$).

5.6.2.2 Mollusks in Don Hoi Lot

There were 14 mollusk species including three species of Razor clams found in Don Hoi Lot during June 2008 to May 2009 and seven of them were economic mollusks. *N. distortus* was found at all 36 stations and all year round. *M. senhousia* or Horse mussel had the most abundance and was found on the edge of sand dune and the area connecting to gully. *A. granosa* was one of economic mollusk species and the maximum average abundance occurred in T1 and TF locating in the sandy mud substrate, whereas the minimum average abundance was found in T3 and TD locating in the muddy sand area. Low average abundance of *M. lusoria* and *M. meretrix* were found in T1, T6 and TF, whereas the higher average abundance occurred in T2 to T5 and TD. Comparing the average abundance of Razor clams (*S. corneus*, *S. strictus* and *S. regularis*) with other mollusks found in Don Hoi Lot during the study period, the results indicated that their average abundance was low.

Annual variation of mollusk species in Don Hoi Lot was found. In June 2008 or the beginning of rainy season, there were 7 species and the most abundant species was *M. meretrix*. In July 2008, the number of mollusk species shifted to 11 species and the majority of species found in this month were *N. distortus*. During rainy season (August 2008 to October 2008), the most average abundance of mollusk species was still *N. distortus*, followed by *M. meretrix*. In November 2008 or the beginning of winter season, the dominant mollusk species was *M. senhousia*. During the winter season (from December 2008 to May 2009), population of *M. senhousia* were still outstanding. It was observed that the size of *M. senhousia* increased continuously during this period and their population dropped in May 2009.

In term of spatial variation, the maximum diversity index was found in T1 and TC, whereas the minimum was found in T6 and TF. In case of annual variation, the high diversity index was recorded in September 2008 and low value was found in November 2008.

The relationship between mollusk species in Don Hoi Lot and other environmental factors could be concluded as follows. *M. senhousia* had significantly positive correlation with *N. tigrina*, total organic matter (lower soil layer), sand composition (both soil layers), median grain size (both soil layers), water temperature, turbidity, alkalinity, hardness and phytoplankton abundance, but had significantly negative correlation with soil temperature, soil pH (both soil layers), redox potential and dissolved oxygen. *M. meretrix* and *M. lusoria* had significantly positive correlation with each other, with soil pH (in both soil layers), redox potential, and dissolved oxygen, but had significantly negative correlation with water content (in both soil layers), total organic matter (in both soil layers), hardness and turbidity. *N. distortus* was significantly negatively correlated with dissolved oxygen and soil temperature. *A. granosa* was significantly positively correlated with water content (in both soil layers) and total organic matter (in both soil layers), but was negatively correlated with dissolved oxygen and redox- potential.

CHAPTER VI

ASSESSMENT OF HARVESTING RATE AND TOTAL CATCH

This chapter presented the results of socioeconomic analysis of local fishermen who harvested Razor clams as main activity. The purpose was to analyze the implication of change of *Solen* sp on socioeconomic and social aspects. Results of this study were compared with other previous research on Razor clam harvesting.

6.1 General characteristics of Razor clam fishers

A total of 20 Razor clam fishers were interviewed. The ratio of male: female was 1:1. Average age of female collectors was 46.62, ranging from 37-60, whereas average age of man collectors was 35 ranging from 17-53.

Most interviewed Razor clam collectors have lived in the study area for average of 38.5 years. Most collectors (90 %) had the education at secondary school level. Family size was 4.5 on average. Most collectors (85%) were local inhabitants.

The main income of Razor clam fishers was derived from several activities such as Razor clam harvesting, other mollusk collecting (ark shell and tiger moon snail), working as employees etc. Most collectors had experience in Razor clam harvesting from 5-40 years with an average of 22.5 years. The detailed of this information was shown in Table 6.1.

Table 6.1: Socio-economic data of Razor clam harvesters in Don Hoi Lot

Total number of respondents = 20			
Gender	Respondent		%
Male	10		50
Female	10		50
Origin			
local	17		85
Unidentified	3		15
Education			
Uneducated	2		10
Primary school	18		90
Age (years)	min	max	average
Male	17	53	35
Female	37	60	46.62
Residence time (years)	17	60	38.5
Family size (members/family)	2	10	4.5
Experience in harvesting Razor clam (years)	5	40	22.5

6.2 Fishery activities

Most collectors harvested not only Razor clam but also Ark shell and Tiger moon snail throughout the year but harvesting period of Razor clams lasted for 18-31 days or average 23 days per month. Intensive Razor clam harvesting took place at Don Na San (in front of Prince Chumporn Khedudomsak Memorial), Don Laem and others at percentage of 60, 20 and 20 %, respectively.

Selling price of fresh *Solen* spp ranged from 60-220 baht/kg or average 140 baht/kg, whereas of Ark shell and Tiger moon shell were 13 and 32.5 baht/kg, respectively. Fishers transported the harvested Razor clams to sell directly at market, sold to middle man and household consumption at percentage of 15, 75 and 10 %, respectively (Table 6.2).

Table 6.2: Fishery activities of Razor clam harvesters

Total number of respondents = 20			
Fishing ground	Respondent	%	
Don Na San	12	60	
Don Laem	4	20	
Other islets	4	20	
Type of fishers			
Razor clams only	17	85	
Razor clams and other mollusks	3	15	
Type of utilization			
Sell directly at market	3	15	
Sell to middle man	15	75	
Household consumption	2	10	
	min	max	average
Fishing effort (day/month)	18	31	23
Selling price (baht/kg)			
Razor clam	60	220	140
Ark shell	-	-	13
Tiger moon snail	30	35	32.5
Harvesting period	Duration		
Razor clam	All year round especially during June to September		
Ark shell	All year round		
Tiger moon snail	All year round		

6.3 Harvesting rate and total catch of Razor clam

A total number of fishers harvesting Razor clam harvesters in Don Hoi Lot were 20. The annual production of Razor clams was about 11,222 kg or average 935 kg/month, peak in August 1,364 kg and lowest harvest in February 653.5 kg. The high total catch was recorded during June to September. Total time used to harvest Razor

clams was estimated 2,846 hours or average 237.2 hours/month. Maximum harvesting time was in July accounted for 388 hours and lowest in February for only 146 hours. In term of CPUE, it was revealed that the maximum was found in October (0.30 kg/fisher/hour) while the lowest was occurred in May (0.16 kg/fisher/hour) and averaging 0.23 kg/fisher/hour (Table 6.3 and Figure 6.1).

Table 6.3: Fishing effort and total catch of Razor clams in Don Hoi Lot

Month	Total catch (kg)	Fishing effort (hrs)	Total catch/hrs (kg)	Fisherman (person)	CPUE (kg/fisher/hr)	Harvesting period
Jun_08	1,191.5	336	3.55	18	0.20	Day time
Jul_08	1,320	388	3.40	18	0.19	Day time
Aug_08	1,364	358	3.81	18	0.21	Day time
Sep_08	1,101	248	4.44	18	0.25	Night time
Oct_08	792	148	5.35	18	0.30	Night time
Nov_08	825.5	176	4.69	18	0.26	Night time
Dec_08	858	192	4.47	18	0.25	Night time
Jan_09	760	192	3.96	18	0.22	Night time
Feb_09	653.5	146	4.48	18	0.25	Night time
Mar_09	760	174	4.37	18	0.24	Day time
Apr_09	784	206	3.81	20	0.19	Day time
May_09	812.5	282	2.88	18	0.16	Day time
AVG	935	237	4.10	18.17	0.23	
SD	320	84	0.66	0.58	0.04	
MAX	1,364	388	5.35	20	0.30	
MIN	654	146	2.88	18	0.16	

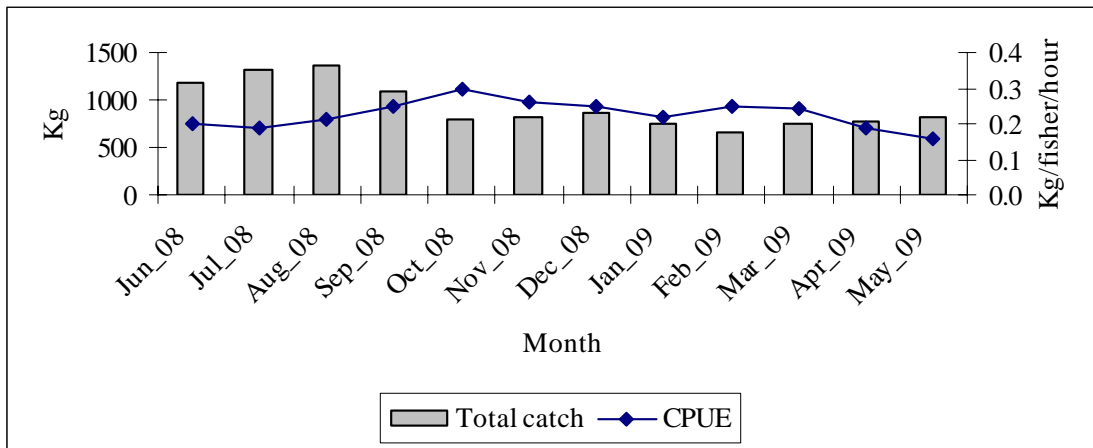


Figure 6.1: Total catch and CPUE of Razor clams in Don Hoi Lot

Total catch of Razor clams in Don Hoi Lot was estimated to 11,222 kg or 11.2 tons/year. Comparing this figure to average production of Razor clams in the past which were mostly recorded by Department of Fisheries in 1983-1988 and 1998-2004 were 548.5 and 152.3 tons/year respectively (Department of Fisheries, 1989; 2000; 2001; 2002; 2003; 2004; 2005; 2006) (Table 6.4).

Table 6.4: Average total catch of Razor clams between 1983-2009

Year	Average total catch (tons/year)
1983-1988	548.5
1998-2004	152.3
2008-2009 (the study period)	11.2

Modified from Department of Fisheries 1983-1988 and 1998-2004

The trend of total catch of Razor clams decreased continuously since the year of 1998 (74 tons) due to high demand consumption and high selling price compared to other mollusks. Relationship between yield of Razor clams (recorded by Department of Fisheries, by other researches, and by this study since 1983 to 2009) and time series was analyzed Figure 6.2).

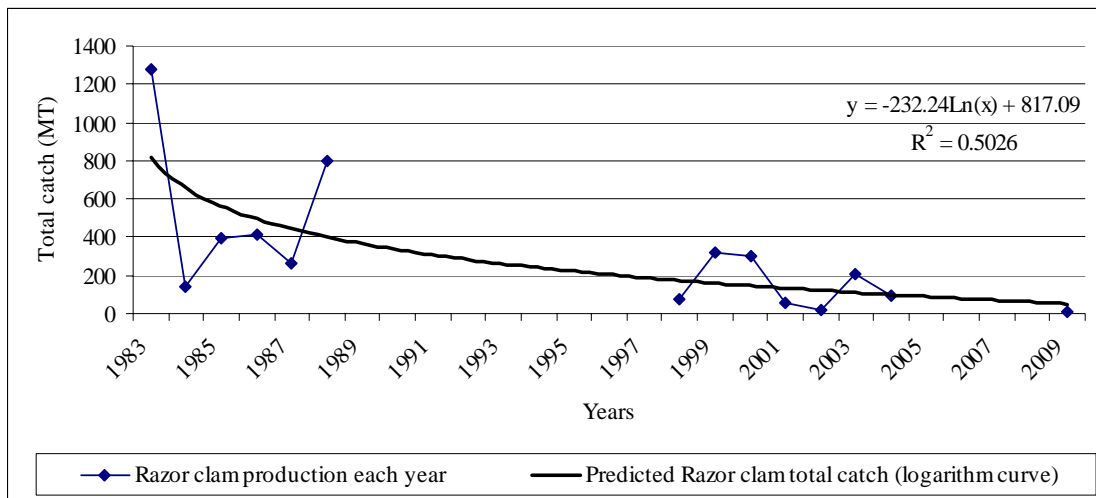


Figure 6.2: Predicted equation of total catch of Razor clams from 1983 to 2009

6.4 Threats to Razor clam's habitat

About 73 % of total respondents expressed their concern about the impact of local communities on Don Hoi Lot. Only 20% argued that present threats were polluted water, mud deposits, more Horse mussel, harvesting of Venus shell, no water circulation, and use of sodium hydroxide for harvesting Razor clam.

Widespread of invasive exotic fauna and flora such as Horse mussel impacted Razor clam's habitat because Horse mussel would cover holes of Razor clams during their population growth. Other mollusks for instance Lamp shell and Venus shell had impact on Razor clam population. Local fishermen stated that some mollusk species especially Razor clam and Wedge shell (*Donax faba* Gmelin) would disappear or have low population within the net 5-10 years.

There was no clear response on regulations and measures for Don Hoi Lot conservation such as closure of fishing season and rotation of harvesting areas. Respondents recommended that wastewater from nearby areas through Mae Klong River mouth to Don Hoi Lot should be intensively controlled.

6.5 Discussion and conclusion

In 2005, Worrapiumphong reported that an average number of Razor clams harvesters were 82 persons/day and their number fluctuated each month due to Razor clam abundance, season and opportunity of other jobs. The results from this study indicated that number of Razor clam harvesters decreased due to the reduction of Razor clam population. Most collectors were local people living in this area averaging 38.5 years.

Razor clam fishers harvested different kind of mollusk species throughout a year, but the harvesting period lasted for 18-31 days or average 23 days per month. Intensive Razor clms harvesting took place at Don Na San due to easy access in particular in the period when sand dune exposed in the night time during September 2008 to February 2009.

Selling price of *Solen* spp ranged from 60-220 baht/kg or average 140 baht/kg (total fresh weight including shell) compared to 9-140 baht/kg during 1983-2005 (Jarinrattanakorn, 2001 and Worrapiumphong, 2005). The price of Razor clams increased continually since 1983 until now. This might be one of several pressures causing reduction of Razor clam population.

From this research, total catch of Razor clams in Don Hoi Lot was estimated at 11,222 kg or 11.22 tons/year. Comparing to previous their production, therefore the trend of total catch of Razor clams decreased continuously despite of high demand consumption and high price.

Razor clam collectors stated that major threats to Don Hoi Lot were water pollution from inland, increase of exotic mollusk species e.g. Horse mussel, Venus shell collecting methods, use of caustic soda or sodium hydroxide mixing with lime for catching Razor clams during nighttime. Even though, local authority (Samut Songkhram Province) issued several measures to protect the reduction of Razor clam population and their habitat since 1986, problems still remained.

CHAPTER VII

INTERACTIONS BETWEEN RAZOR CLAMS AND ENVIRONMENTAL FACTORS

This chapter presents the results of interactions between three main biological aspects of Razor clams and key environmental factors, followed by discussion and conclusion.

7.1 Interaction between abundance of Razor clams and key environmental variables

7.1.1 Relationships between Razor clams and environmental variables

The analysis of the relationship between Razor clams and each environmental variable using Pearson correlation coefficient indicated that *S. corneus* had positive correlation with other four species of mollusks, namely *S. strictus*, *V. myristica*, *M. meretrix* and *M. lusoria*. Only one species (*N. distorta*) had negative correlation with *S. corneus* (Table 7.1). However their interactions were quite low according to Permprasert (2004) classifying degree of correlation coefficient into 3 levels: 0-50, 51-80, 81-100 % at low, moderate and high relationship, respectively. The analysis of interactions between *S. corneus* and nine physical variables revealed that five variables (redox potential, sand composition in upper and lower soil layer and median grain size in both soil layers) had positive correlation with *S. corneus*, but four variables (water content and total organic matter in both soil layers) had negative correlation. The degree of correlation was very low. For chemical parameters, it was revealed that there was only negative correlation between *S. corneus* and transparency (Table 7.1).

For *S. strictus*, sand composition in lower soil layer, water content in both soil layers and total organic matter in upper soil layer were correlated with their

abundance (Table 7.2). There were only few environmental parameters (soil pH, total organic matter and water temperature) that had low level of correlation with *S. regularis* (Table 7.3).

Table 7.1: Pearson correlation between density of *S. corneus* and key environmental variables at Don Hoi Lot during June 2008-May 2009

<i>S. strictus</i>	<i>V. myristica</i>	<i>M. meretrix</i>	<i>M. lusoria</i>	<i>N. distorta</i>
0.266**	0.203**	0.138**	0.122*	-0.098*

Redox potential	Sand composition ¹	Sand composition ²	Median grain size ¹	Median grain size ²
0.178**	0.164**	0.164**	0.139**	0.122*

Water content ¹	Water content ²	Total organic matter ¹	Total organic matter ²	Transparency
-0.248**	-0.212**	-0.117*	-0.122*	-0.159*

Remark; * = Significant at 0.05 level, 1 = upper soil layer, 2 = lower soil layer

** = Significant at 0.01 level, n = 432 except n = 216 for transparency

Table 7.2: Pearson correlation between density of *S. strictus* and key environmental variables at Don Hoi Lot during June 2008-May 2009 (n = 432)

<i>S. corneus</i>	Sand composition ²	Water content ¹	Water content ²	Total organic matter ¹
0.266**	0.106*	-0.135**	-0.105*	-0.107*

Remark; * = Significant at 0.05 level, 1 = upper soil layer

** = Significant at 0.01 level, 2 = lower soil layer

Table 7.3: Pearson correlation between density of *S. regularis* and key environmental variables at Don Hoi Lot during June 2008-May 2009

Soil pH ¹	Soil pH ²	Total organic matter ¹	Water temperature
-0.098*	-0.100*	0.098*	0.137*

Remark; * = Significant at 0.05 level, 1 = upper soil layer

** = Significant at 0.01 level, 2 = lower soil layer

n = 432 except n =216 for water temperature

7.1.2 Relationship between *S. corneus* and environmental variables

The dominant species of Razor clams in this area was *S. corneus* and their high abundance comparing to others was analyzed in details. When grouping abundance of *S. corneus* at 36 sampling stations by a cluster analysis, this species could be divided into four groups (at 80 % of similarity) as follows.

Group I: abundance at stations 20, 21, 22, 25, 26 and 27

Group II: abundance at stations 1, 12, 13 and 30

Group III: abundance at stations 3, 4, 9, 18, 35 and 36

Group IV: abundance at stations 10, 11, 14, 15, 16, 17, 19, 23, 28, 29, 31, 32, 33 and 34

Remaining stations which *S. corneus* was not found during the study period were stations 2, 5, 6, 7, 8 and 24. These stations located in the rim of Don Na San or were close to coastline (Figure 7.1).

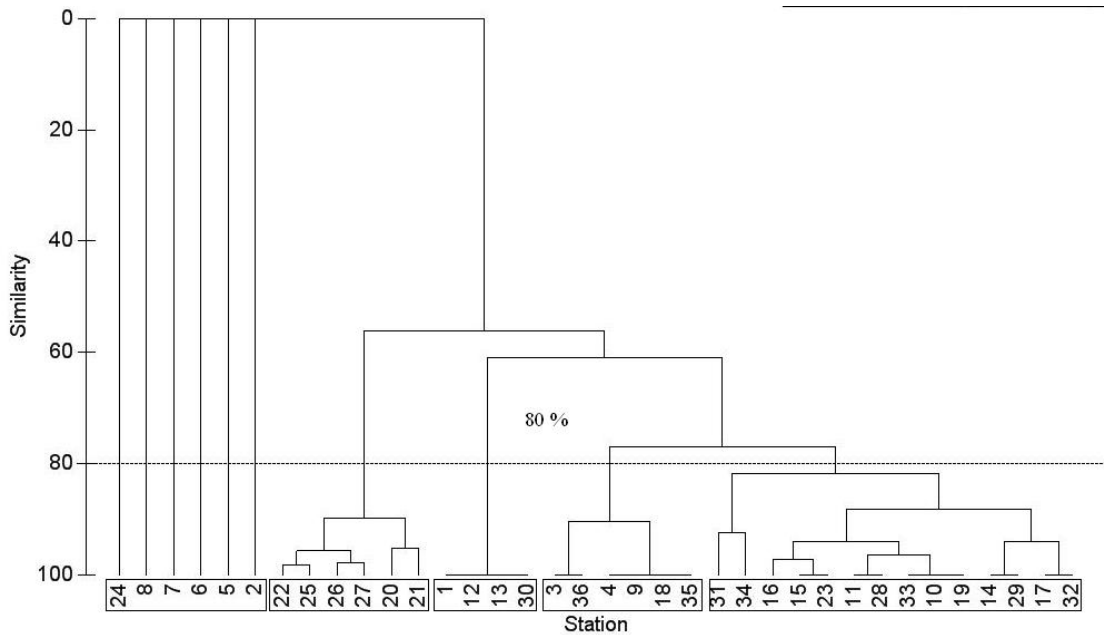


Figure 7.1: Dendrogram showing hierarchical clustering of *S. corneus* at each station at Don Hoi Lot

The selected 9 physical environmental variables at 36 stations were analyzed by using cluster analysis (Euclidean distances) and non-MDS at similarity of average squared distance of 3.1 (Figure 7.2). The majority of variables contributing to each group were further analyzed by using SIMPER. Principal Component Analysis (PCA) was carried out to find the linkage between physical variables and each station (Figure 7.3). Therefore all sampling stations could be divided into six groups based on physical variables as follows.

Group I: stations 4 and 9. At average squared distance 0.78, the first two majorities of variables contributing to this group were water content in the lower soil layer (38.02 %) and the total organic matter in the upper soil layer (20.58 %).

Group II: stations 1, 2, 3, 6, 7 and 8. At average squared distance 2.87, the first two majorities of variables contributing to this group were total organic matter in the upper soil layer (28.50 %) and the water content in the upper soil layer (19.44 %).

Group III: stations 5, 12, 18, 24 and 36. At average squared distance 3.35, the first two majorities of variables contributing to this group were water content in the upper soil layer (19.90%) and the lower soil layer (16.54 %).

Group IV: stations 13, 14, 15, 19, 20, 23, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34 and 35. At average squared distance 2.18, the first two majorities of variables contributing to this group were total organic matter in the lower soil layer (22.77 %) and water content in the upper soil layer (15.17 %).

Group V: stations 10, 11, 16, 21 and 36. At average squared distance 2.21, the first two majorities of variables contributing to this group were sand composition in the lower soil layer (19.73 %) and median grain size in the lower soil layer (18.92 %).

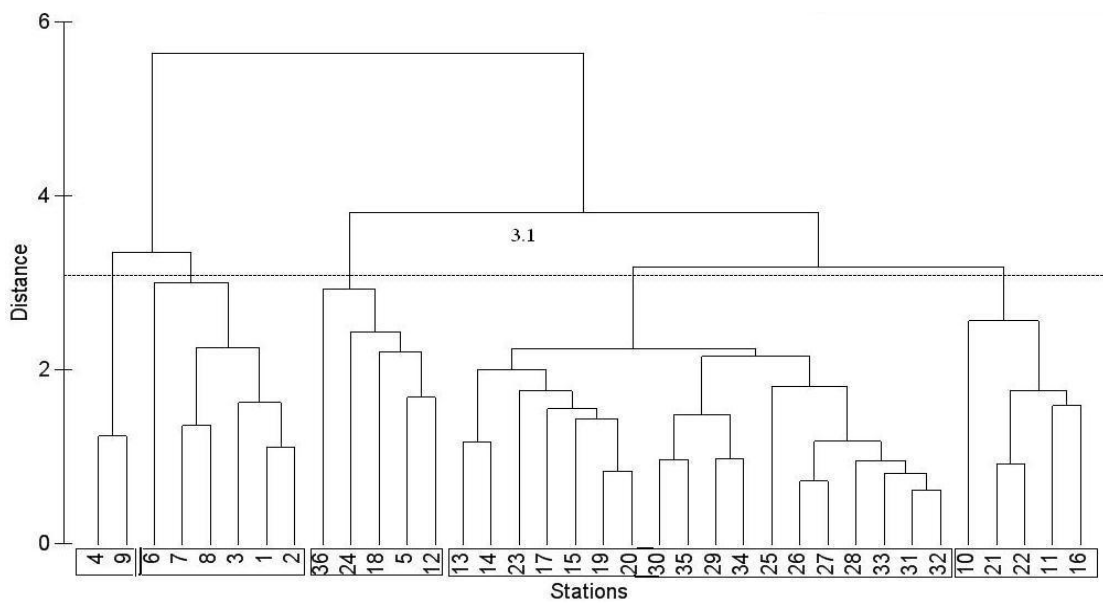


Figure 7.2: Dendrogram showing hierarchical clustering of physical variables at each station in Don Hoi Lot

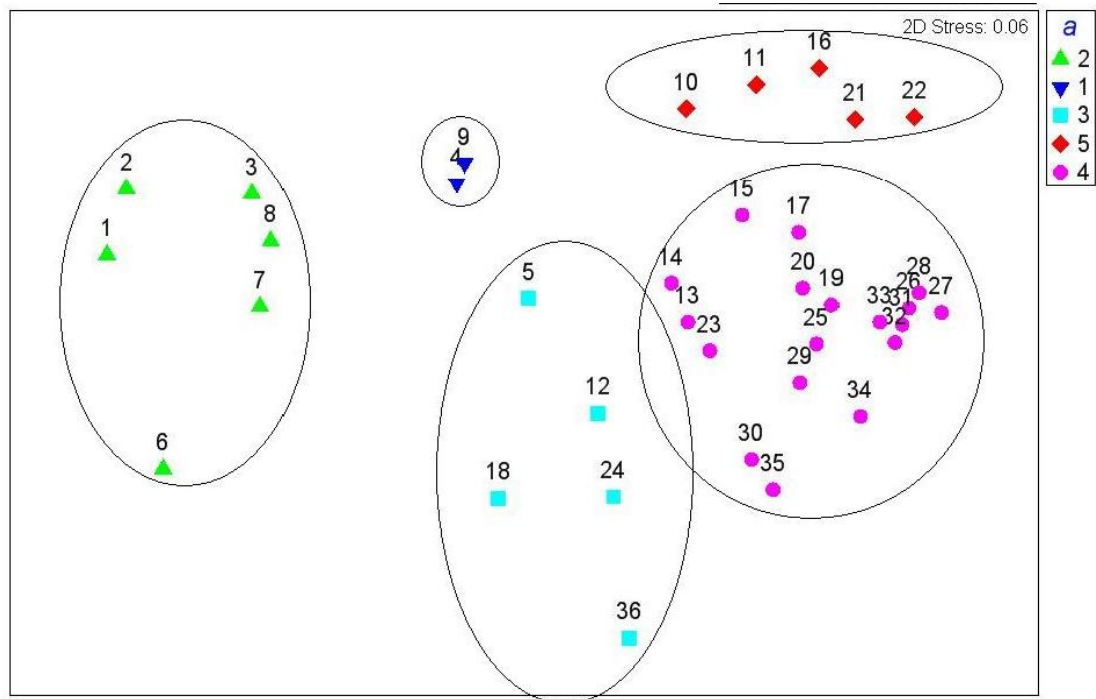


Figure 7.3: Dendrogram showing non-MDS ordination of physical variables at each station, classified into five groups, stress value= 0.06

In Figure 7.4, PCA was conducted to find out the linkage between key physical variables and stations. The result indicated that stations in group 2 (most stations in this group situated near the coastline and sandy mud substrate) had little linkage with other groups. The direction of Redox-potential was positively correlated with stations in group 5 which located in the middle of Don Na Sarn. Sand composition and median grain size had high linkage with stations in group 4 in particular stations 13, 23, 29 and 34. For group 3, stations 4 and 9 had little linkage with physical factors even though they were located in the circle.

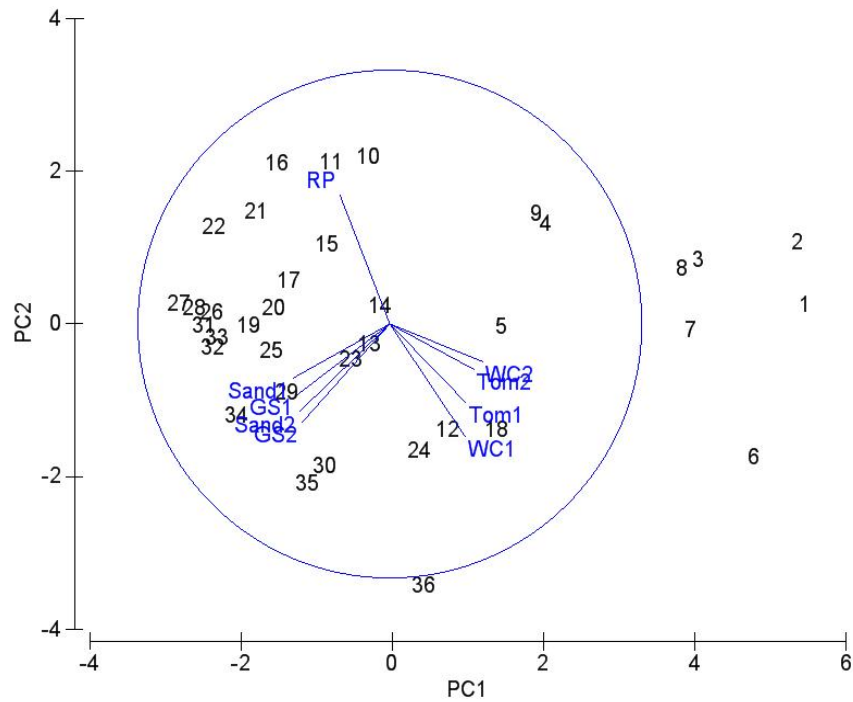


Figure 7.4: Principal Component Analysis of physical variables at each station in Don Hoi Lot (RP=Redox –Potential, WC=Water content, GS = Median grain size, Tom= Total organic matter, 1= upper soil layer and 2= lower soil layer)

Finally, relationship between *S. corneus* structure and multivariate of environment was examined using BIO-ENV procedure (Clarke and Waewick, 1994). Nine physical environmental variables were analyzed as single representative of environmental data on BIO-ENV analysis. The best correlation (0.563) occurred with the combination of three variables: total organic matter, water content, and percentage of sand composition, all in the upper soil layer (Table 7.4).

Table 7.4: Summary of results of combination of variables from BIO-ENV analysis

No. of Variable	Correlation coefficient	Variable 1	Variable 2	Variable 3	Variable 4	Variable 5
3	0.563	TOM ¹	WC ¹	%Sand ¹		
3	0.555	TOM ¹	WC ¹	WC ²		
4	0.554	TOM ¹	WC ¹	%Sand ¹	TOM ²	
3	0.553	TOM ¹	WC ¹	MGS ¹		
4	0.553	TOM ¹	WC ¹	%Sand ¹	WC ²	
2	0.552	TOM ¹	WC ¹			
4	0.550	TOM ¹	WC ¹	MGS ¹	TOM ²	
5	0.547	TOM ¹	WC ¹	%Sand ¹	WC ²	TOM ²
4	0.547	TOM ¹	WC ¹	WC ²	MGS ¹	
4	0.546	TOM ¹	WC ¹	%Sand ¹	MGS ¹	

Remark: TOM = Total organic matter, WC = Water content,

MGS = Median grain size, 1= upper soil layer 2= lower soil layer

7.1.3 Relationship between *S. corneus* and other mollusk species and environmental variables

The relationships among environmental parameters and mollusk assemblages including Razor clam species were analyzed by using a Canonical Correspondence Analysis (CCA) which was a direct gradient technique. The rank of each station was related to the values of environmental factors (Guerra-Garcia and Garcia-Gomez, 2004). Figure 7.5 showed the relationship between physical parameters, abundance of mollusk species, and stations. The results could be summarized as follows.

In quarter I, Razor clams, Venus shell and Tiger moon snail were found in the same area or habitat and had directly positive correlation with Redox-potential. Sand composition and median grain size in upper soil layer were positively correlated with this mollusk group. This quarter consisted of stations 5, 10, 11, 15, 16, 22, 26, 27, 17 and 25. The graph also showed that this mollusk group had negative relationship with water content in the upper soil layer and other variables, namely acid volatile sulfide, water content in the lower soil layer, and total organic matter in both soil

layers which could be observed in quarter IV. In quarter IV, having high amount of total organic matter and water content, some mollusks such as *Bulla* sp, *A. granosa* and *N. distortus* could be found. This quarter consisted of stations 1, 2, 3, 6 and 7.

Figure 7.6 demonstrated the relationship among Razor clams, chemical variables, other mollusk species and stations. The graph showed clearly that high concentration of total ammonia and nitrate nitrogen could be found in the same areas of stations 1, 2, 3 and 4 with *Bulla* sp, *A. granosa* and *N. distortus*. Water temperature and turbidity showed positive relationship with Razor clams whereas water depth showed negative correlation.

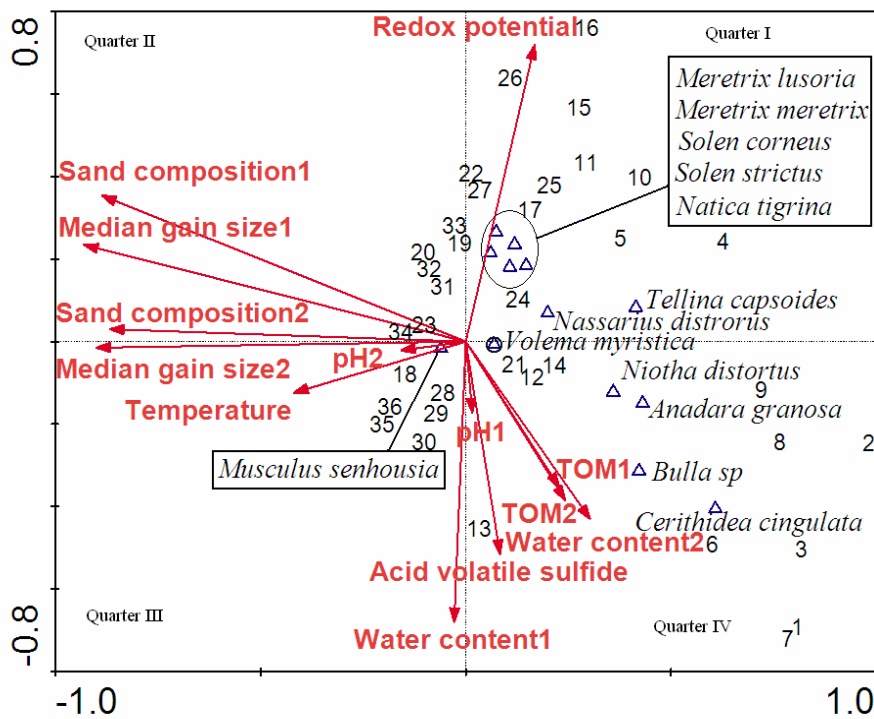


Figure 7.5: Graph representation showing the relationship between stations, mollusk species, and physical variations at Don Hoi Lot

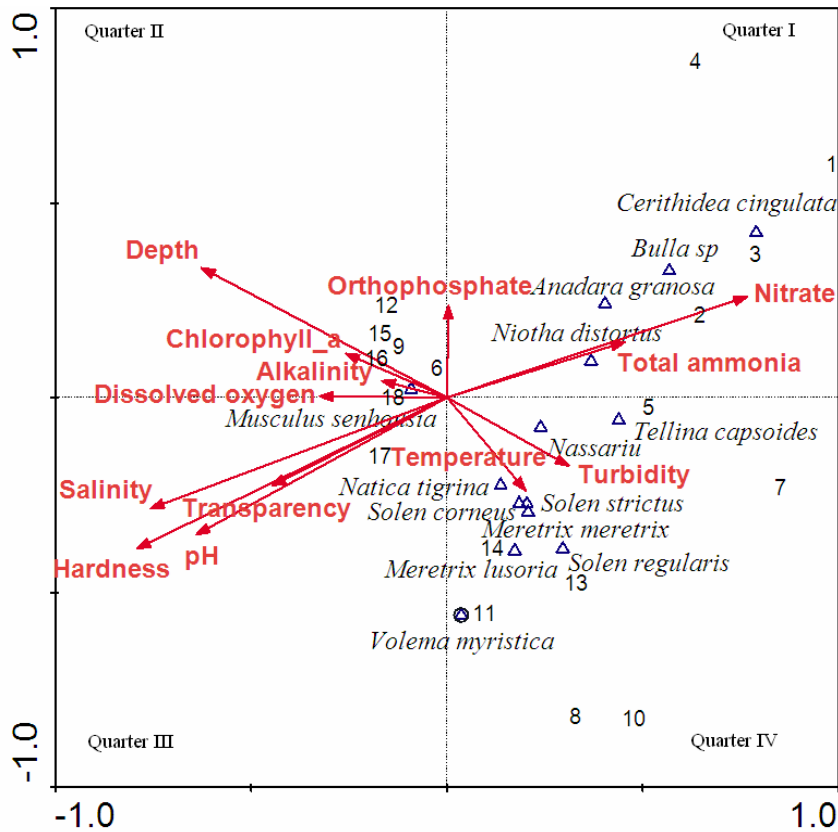


Figure 7.6: Graph representation showing the relationship between stations, mollusk species, and chemical variations at Don Hoi Lot

7.2 Interactions between reproductive parameters and environmental factors

The analysis was carried out on some selected environmental parameters which had potential impacts on reproductive activities of Razor clams. The study examined how these variables (water and soil temperature, amount of rainfall and amount of water discharged from Mae Klong Dam, concentration of chlorophyll-a and phytoplankton abundance) were correlated with development of egg stage in particular egg stage IV (mature stage) and egg stage V (spawned stage).

The analysis of interaction between *S. corneus* and each environmental variable using Pearson correlation coefficient (despite very low R- value) indicated that average amount of water discharged from Mae Klong dam had highly positive

correlation with egg stage IV of *S. corneus*, followed by water temperature, soil temperature and amount of rainfall. *S. corneus* had negative correlation with chlorophyll-a. In egg stage V, two variables (soil temperature and amount of rainfall) had negative correlation with amount of eggs. Abundance of phytoplankton and concentration of chlorophyll-a were positively correlated with this mollusk (Table 7.5). It was also observed that the relationship between variables and the clams in stage V was different from stage IV.

Annual fluctuations of water and soil temperature were positively correlated with maturity of egg (stage IV) of Razor clam especially when the temperature dropped in December and January (during winter season). At that time, the percentage of ripe egg was reduced when soil temperature declined. This incident might stimulate female to release the egg into the water. It was observed that Razor clam would reach the peak of spawning period (egg stage V) in December (Figure 7.7-7.8).

The analysis results showed the sign of phytoplankton abundance and concentration of chlorophyll-a which were significant factors affecting the development of egg stage in particular stage IV (negative correlation) and spawning period of Razor clams (positive correlation). Phytoplankton abundance was relevant to Razor clams as a source of food. In Figure 7.9, it was discovered that low concentration of chlorophyll-a occurred during summer (from April to July), whereas the high proportion of ripe eggs was found in this period. Comparing these parameters with the spawning period of Razor clams, the results clearly showed that phytoplankton abundance was one of key factors that stimulated eggs laying of this mollusk in nature. In Figure 7.10-7.11, the highest concentration of chlorophyll-a and phytoplankton abundance was recorded in November, whereas the high peak of spawning time of Razor clams occurred in the following month (December). It could be implied that when source of food was ready and available for their larvae, the clams would lay the eggs. The relationship between development of egg stage and annual rainfall and water discharge from Mae Klong dam was also analyzed. The amount of water discharged from the dam was calculated to amount of water directly flowed to Mae Klong River mouth. The increasing rainfall possibly stimulated the female to develop egg stage to become mature during April to July, while spawning period reached the highest peak in December when there was no rainfall (Figure 7.12-7.13). Amount of water discharged from Mae Klong dam had

highly positive correlation with the development of egg stage IV of Razor clam. The plant nutrients increased when amount of water discharge from dam increased , and thus might stimulate this mollusk to develop their egg stage at Don Hoi Lot (Figure 7.14). The equation showing the relationship between amount of water discharged from dam and development of egg stage IV of Razor clam was shown in Figure 7.15.

Table 7.5: Pearson correlation between development of *S. corneus* and key environmental variables at Don Hoi Lot during June 2008-May 2009

Egg stage	Discharge from Dam	Water temperature	Soil temperature	Rain-fall	Phyto-plankton abundance	Chloro-phyll-a	Level of relationship ¹
IV	0.74	0.54					Moderate
IV			0.47	0.31	-0.01	-0.32	Low
V	-0.06	-0.15	-0.31	-0.28	0.27	0.38	Low

Remark; 1 = according to Permprasert (2004).

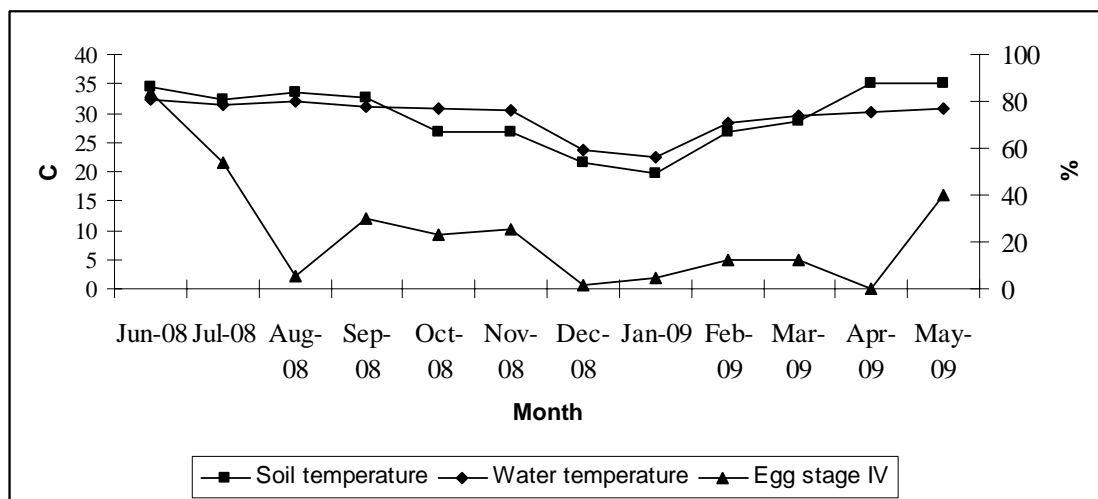


Figure 7.7: Relationship between percentage of egg stage IV and water temperature and soil temperature at Don Hoi Lot

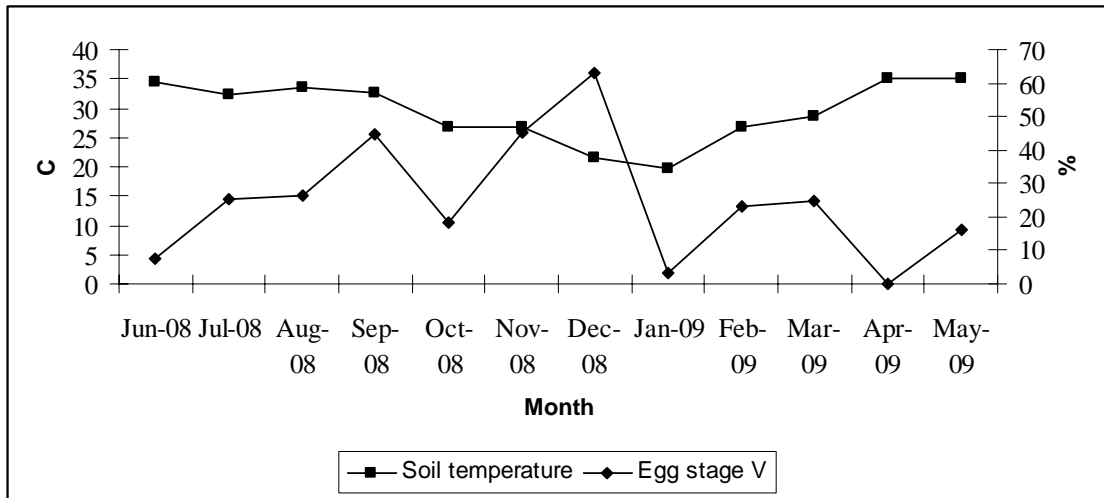


Figure 7.8: Relationship between percentage of egg stage V and soil temperature at Don Hoi Lot

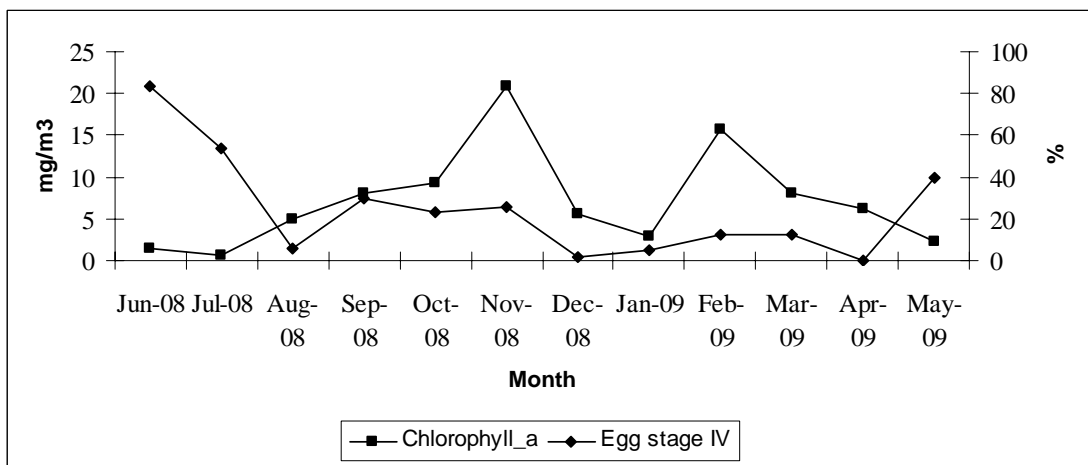


Figure 7.9: Relationship between percentage of egg stage IV and concentration of chlorophyll-a at Don Hoi Lot

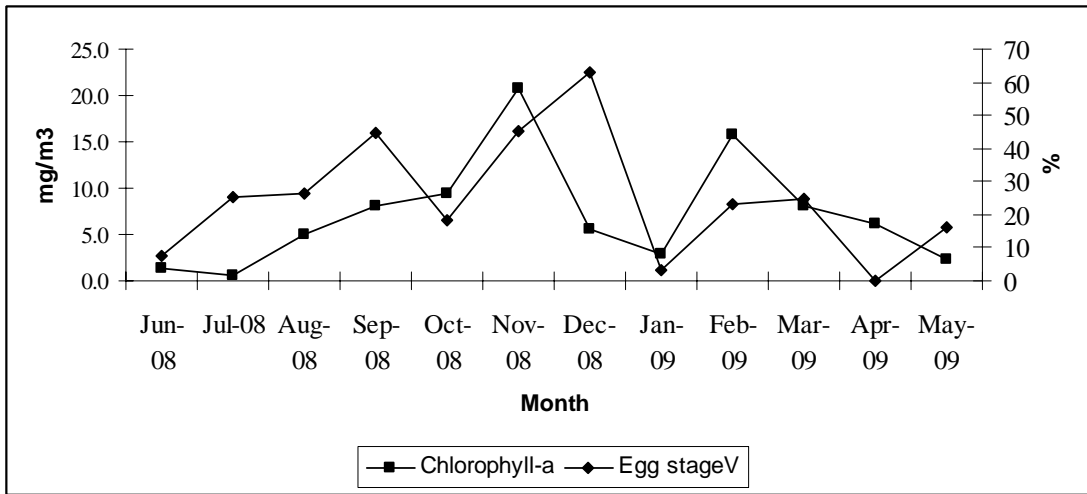


Figure 7.10: Relationship between percentage of egg stage V and concentration of chlorophyll-a at Don Hoi Lot

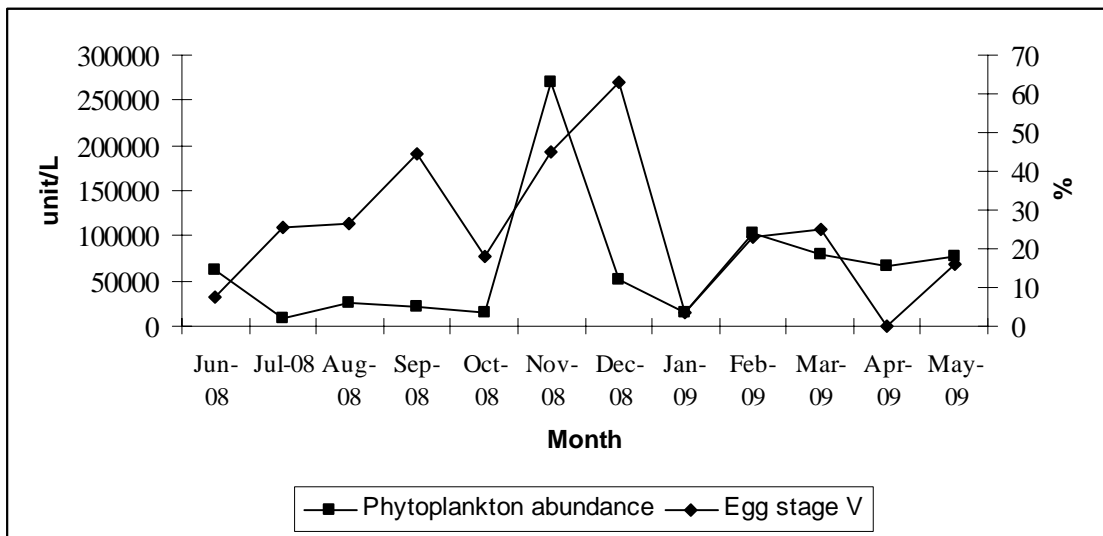


Figure 7.11: Relationship between percentage of egg stage V and phytoplankton abundance at Don Hoi Lot

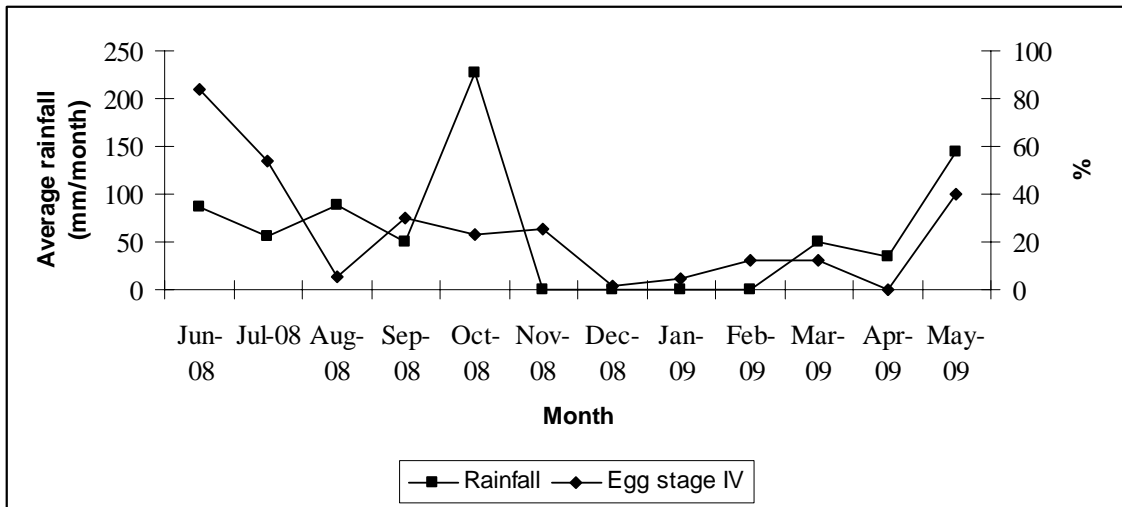


Figure 7.12: Relationship between percentage of egg stage IV and amount of rainfall at Don Hoi Lot

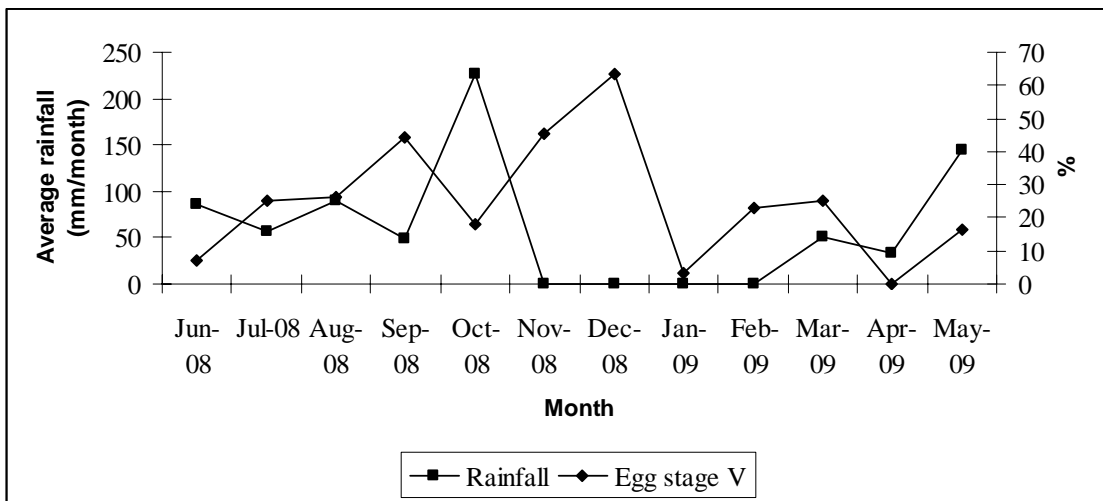


Figure 7.13: Relationship between percentage of egg stage V and amount of rainfall at Don Hoi Lot

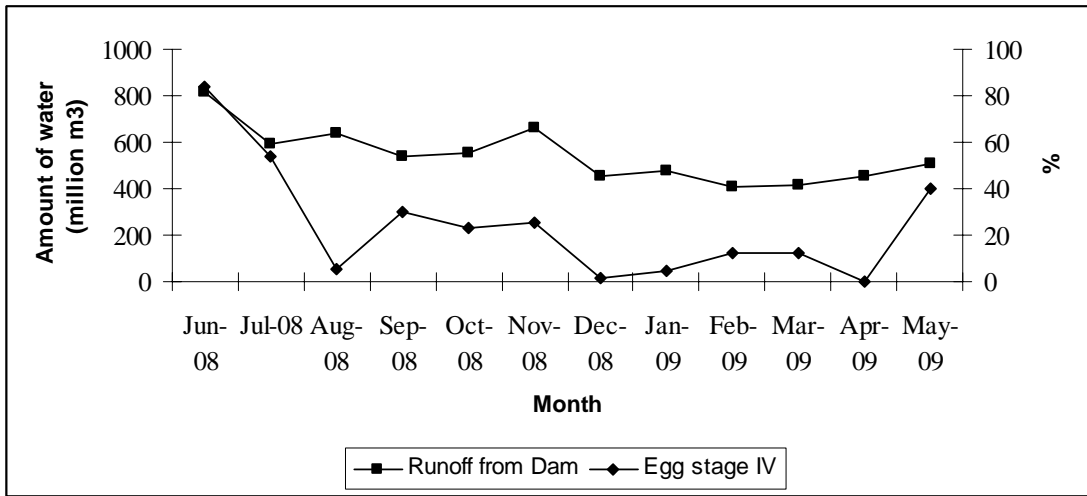


Figure 7.14: Relationship between percentage of egg stage IV and amount of water discharge from Mae Klong at Don Hoi Lot

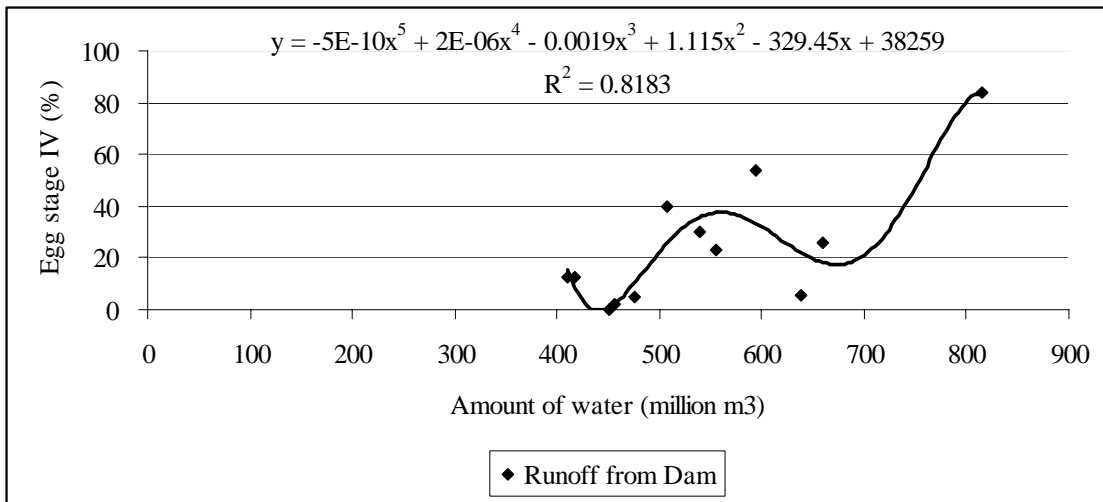


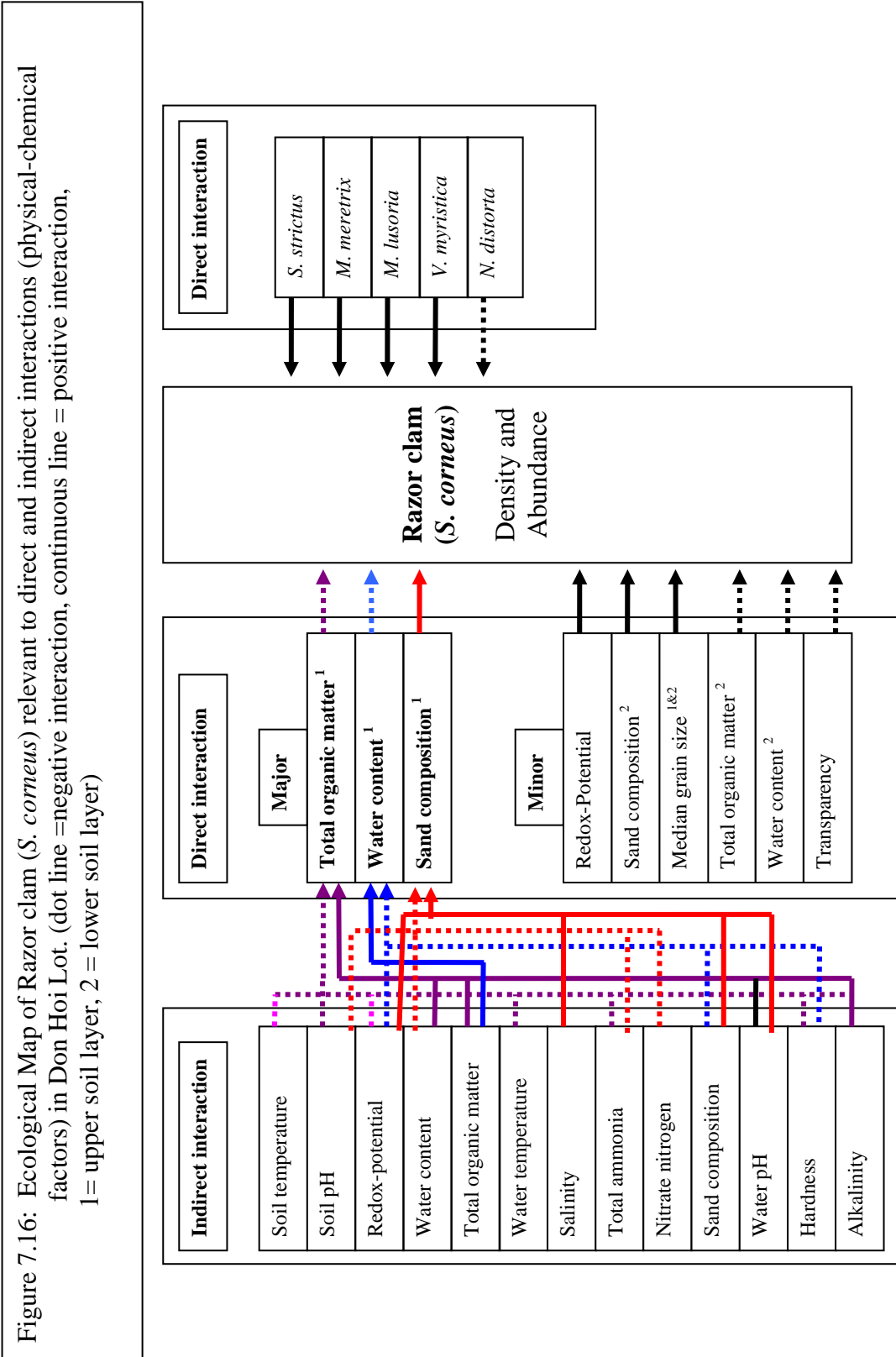
Figure 7.15: Predicted equation of percentage of egg stage IV and amount of water runoff from Mae Klong at Don Hoi Lot

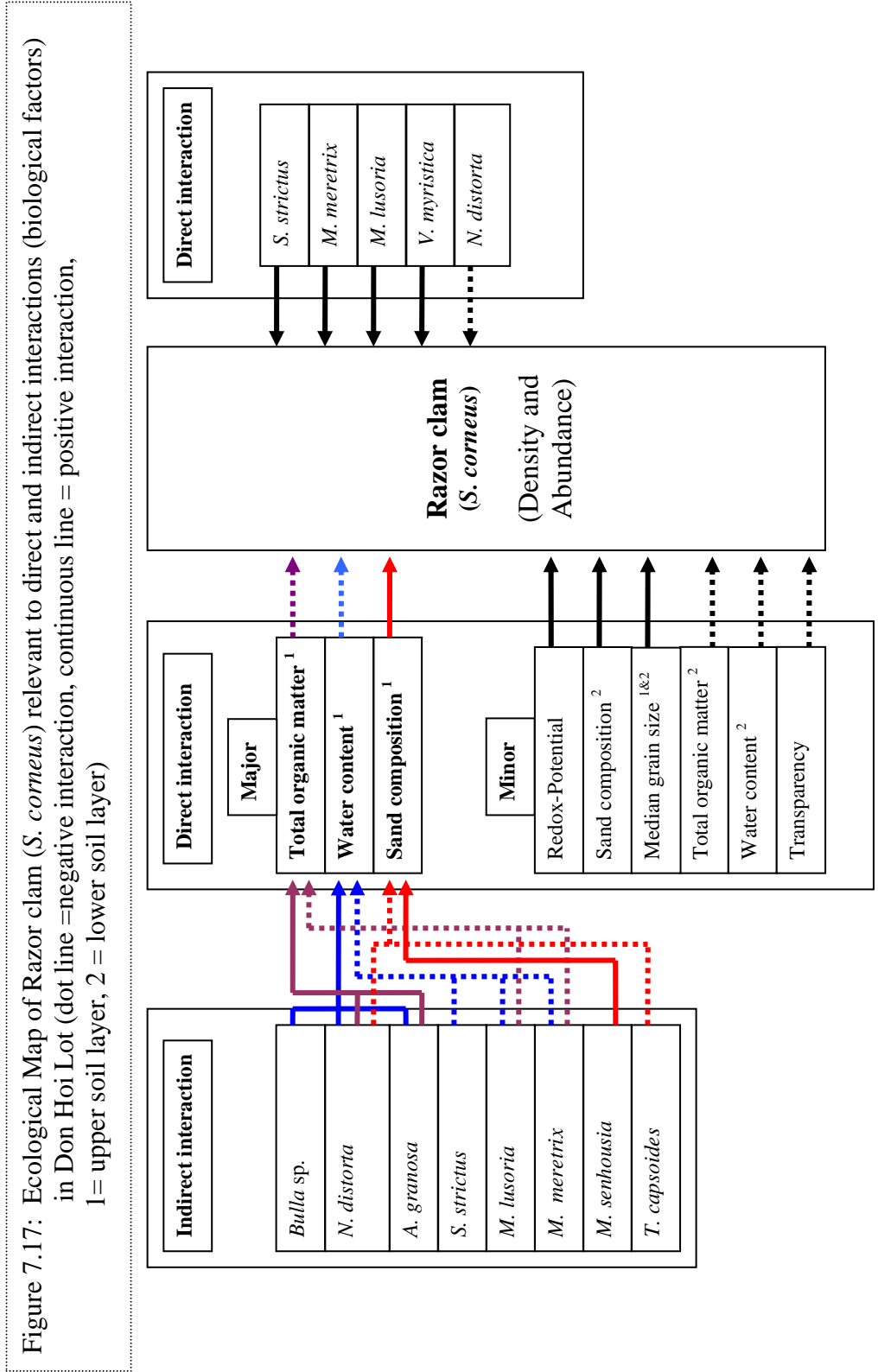
7.3 Discussion and conclusion

7.3.1 Interaction between abundance of Razor clams and environmental variables

Many physical, chemical and biological variables related to Razor clams in terms of their biology, habitats and abundance were analyzed at Don Hoi Lot during June 2008 to May 2009. Several techniques and software programs were applied for data analysis. This research attempted to develop ecological map of interactions between Razor clams and environmental factors. As a result of low correlation coefficient and no relationship between some parameters, only variables with high correlation coefficient were selected to be analyzed by software programs namely BIO-ENV and CCA. The multivariate analysis or techniques based on MDS and BIO-ENV procedure were much more useful to understand their interactions. The results demonstrated that soil characteristics in particular combination of three variables: proportion of sand in the soil (positive variation), organic matter (negative variation), and water content in the surface soil layer (negative variation), had high relationship with abundance of Razor clam (*S. corneus*). All variables could be classified into four groups according to R-value in correlation function and BIO-ENV analysis. All information derived from correlation coefficient, BIO-ENV, CCA of variables were used to develop the linkage among them and finally to draw ecological map of dominant species of Razor clams (*S. corneus*) (Figure 7.16). In the ecological map, all relevant variables to *S. corneus* were described into three groups. The first group was the majority which had little or no relationship directly to Razor clams which were not shown in the diagram. In the second group, the R-value showed significant correlation with Razor clams even though, they were low, these variables were identified as having minor direct impact on Razor clams. These variables were median grain size in both layers, redox-potential, sand composition (in lower layer), total organic matter (in lower layer) and water content (in lower layer). Third group consisted of sand composition, total organic matter and water content, which all of them were of the upper soil layer. This last group had indirect interaction, having a significant correlation with three variables in the third group.

In case of the relationship of *S. corneus* with other mollusks, it was found that *S. strictus* had direct and indirect interaction based on R-value. These findings were supported by the result from CCA. According to ecological map (Figure 7.17), mollusks found in Don Hoi Lot could be grouped into two major types based on soil composition. The first group consisting of *S. corneus*, *S. strictus*, *M. meretrix*, *M. lusoria*, *V. myristica* and *M. senhousia* preferred to live in the muddy sand (high percentage of sand composition in the soil and low percentage of total organic matter and water content). The second group preferred living in the sandy mud or mud (low percentage of sand composition in the soil, high percentage of total organic matter and water content). Mollusks within this group were *N. distorta*, *Bulla* sp., *A. granosa* and *T. capsoides*. Therefore, availability of each species of mollusk varied with the soil characteristics. Mollusk species could be used as biological indicator of soil in Don Hoi Lot and other tidal flats. In this research, it was found that the density of *M. senhousia* was massive and this species was positively correlated with sand composition in the soil, which was similar to *Solen* spp. Therefore they lived in the similar substrate. *M. senhousia* settled in dense patches and their threads from neighboring nests entangled to form mat over the sediment surface. Crooks (2002) reported density of 5,000-10,000 mussels/m² of mats in Mission Bay, with peak density of over 150,000 mussels/m². Therefore this species might affect and caused the depletion of Razor clams population. This reason was supported by local fishermen in Don Hoi Lot.





7.3.2 Biological aspects of Razor clams at Don Hoi Lot

Major variable affecting the development of mature eggs (stage IV) of Razor clams was amount of water flowing to Mae Klong Estuary and Don Hoi Lot including amount of rainfall and water discharge from dam. Both of them had positive correlation with development of mature eggs, but had no direct relationship with abundance of phytoplankton and concentration of chlorophyll-a. Water and soil temperature showed positive correlation with development of mature eggs as referred by Thapanand (2006) that water quality, especially temperature, rainfall and turbidity were related to reproduction activities in tropical freshwater fishes. In case of Razor clams, rainfall and amount of water discharge from Mae Klong dam stimulated *S. corneus* to develop their eggs to mature. Development of egg stage V (spawning period) of Razor clams was positively correlated with abundance of phytoplankton and concentration of chlorophyll-a. Razor clams might lay the eggs when their food or phytoplankton were available in nature. However, many factors that might affect Razor clam and their ripe egg development, such as condition factor of female, food sources and predators (Thapanand, 2006).

CHAPTER VIII

CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion

8.1.1 Razor clam communities in Don Hoi Lot

The Razor clam communities in Don Hoi Lot were dominated by *S. corneus* (76.7 %), followed by *S. strictus* (19.5 %) and *S. regularis* (3.8 %).

In the study area, high population occurred in the 5th transverse transect (T5) and the 3rd longitudinal transect (TC) located in the middle of Study area. Low population occurred at stations with low percentage of sand, the 1st transverse transect (T1) and the 6th longitudinal transect (TF) in located in the rim of the islet and muddy substrate. High density of Razor clams occurred in September and December. The analysis results confirmed two the hypotheses that the distribution pattern of Razor clams (all species) was not homogeneous in terms of space (transverse and longitudinal transects) and time at Don Hoi Lot.

The length-weight relations were analyzed and their growth patterns were allometric. The growth rate of *S. corneus* and *S. strictus* was quite similar, equaled to 3 mm of total length per month in the first year, comparing to 1 cm per month recorded by Rufflo *et al.* (1999). The maximum growth (9.61 and 9.57 cm of *S. corneus* and *S. strictus* respectively) was reached within 6 years old. Exploitation rate (E values) of *S. corneus* and *S. strictus* were 0.56 and 0.42 respectively. The appropriate exploitation rate should not be more than 0.5. It could be concluded that *S. corneus* was over exploited, whereas utilization of *S. strictus* still did not reach the optimal use. The results confirmed the hypothesis that the biology in case of growth patterns of all species were similar (allometric) and the growth parameters (growth rate, maximum growth) of *S. corneus* and *S. strictus* were also similar.

The average sex ratio between male and female were 1: 1.76. The percentage of male was always low comparing with female during June 2008 to

February 2009, whereas it increased its proportion during March 2009 to May 2009. The maturation period of *S. corneus* (stage IV) occurred in two periods: from May to June and September to November. Razor clams spawned (stage V) almost year round. The high peak of spawning period was during July to December and February to March. In term of feeding habit, the major phytoplankton found in Razor clam stomach was diatoms (94.37 %). 25 genera of phytoplankton were recorded and the dominant species were *Thalassiosira* spp., followed by *Thalassionema frauenfeldii* and *Coscinodiscus* spp.

Major variable that affecting the development of mature eggs (stage IV) was amount of water discharge from Mae Klong dam. Water and soil temperature showed positive correlation with development of mature eggs, therefore impact of temperature variation and climate change on the biology of Razor clams should be further analyzed.

8.1.2. Environmental situation at Don Hoi Lot

Most physical and chemical factors varied with transverse rather than longitudinal transect. In term of annual variation, all physical factors changed relevant to several factors including seasonal variation, amount of rainfall, discharge of Mae Klong dam, altitude and distance from shoreline to sampling stations.

Water temperature was significantly correlated with several variables i.e. positively correlated with turbidity, ammonia and nitrate, but negatively correlated with water pH, transparency, salinity, alkalinity, hardness and orthophosphate. Soil and water temperature in Don Hoi Lot was constant and suitable for living aquatic organisms according to the Marine Water Quality standard class III provided by the Pollution Control Department.

Soil pH in upper and lower soil layer ranged from 7.03-8.10 and 7.11-8.27 respectively. Comparing to the values of Department of Fisheries (1995), the range of soil pH was wider and soil pH in Don Hoi Lot tended to be more acidity due to increasing of amount of total organic matter in the area.

Water pH varied significantly based on transverse and longitudinal transects and had monthly variation. Water pH was significantly correlated with several variables, namely dissolved oxygen, salinity, alkalinity, chlorophyll-a, nitrate

nitrogen, total ammonia and orthophosphate phosphorus. Average highest water pH occurred at the end of rainy season and the beginning of winter (in November 2009). Dissolved oxygen and chlorophyll-a including phytoplankton were high, whereas amount of plant nutrients (nitrate nitrogen, total ammonia, and orthophosphate phosphorus) were low. This finding demonstrated that water pH fluctuation would impact chemical factors in Don Hoi Lot.

Average water content was 25.18 and 24.38 % in upper and lower soil layer respectively, similar to Tantanasarit's report in 2007. Average water content in upper soil layer was significantly different from lower soil layer. High average water content was found in the areas close to shoreline. High sedimentation was gradually low towards the offshore. This result was supported by Chatanathawej's study in Kung Krabea Bay (Chatanathawej, 2001).

The amount of total organic matter varied significantly based on transverse and longitudinal transects and had monthly variation. The average total organic matter was 35.08 and 35.73 mg/g dry weight in upper and lower soil layers respectively. Comparing to the past studies, there was a trend of increasing total organic matter in the study area. The amount of total organic matter could be classified as high to highest level regarding to the standard of soil chemistry issued by Land Development Department (Vichitworkun, 2001). Thus this incidence should be monitored continuously in order to avoid unexpected situation in the future.

Average sand composition in soil was 75.8 and 73.9 % in upper and lower soil layer respectively. Sand composition was lowest in T1 and gradually increased offshore and reached the maximum in T6. Average sand composition was similar and supported by many previous researchers. Pradatsundarasar (1982) reported that the distribution of *S. regularis* was limited within the sandbar of the estuary where the average sediment grain size was 0.125 mm or 125 μm , whereas average median grain size was 74.8 and 74.1 μm in this study. Therefore there was a trend that percentage of sand in the soil composition would decrease gradually and should cause the reduction of Razor clam population in the future.

Dissolved oxygen concentration varied significantly based on transverse transect and had monthly variation. The low concentration in transverse transect was found in T1 and T2 and gradually increased offshore and reached the maximum in T6.

In general, dissolved oxygen concentration was higher than 4 mg/l, except in September 2008. The maximum concentration was in November 2009 during the phytoplankton bloom.

A total of 187 phytoplankton species was recorded during June 2008 to May 2009. The majority group was diatoms, followed by green algae. Dominant species were *Chaetoceros pseudocurvisetus*, *Pseudonitzschia pungens*, *Thalassiosira spp.*, *Cylindrotheca closterium*, *Skeletonema costatum* and *Thalassionema nitzschioides*. Number of phytoplankton was highest in November 2009 at the same peak of chlorophyll-a and dissolved oxygen. *Chaetoceros pseudocurvisetus* was the most common phytoplankton found in this study in terms of spatial and temporal distribution. This species was a common species that occurred in coastal areas

There were 14 mollusk species found in Don Hoi Lot during June 2008 to May 2009. *N. distortus* was found at 36 stations and all year round, while *M. senhousia* was the most abundantly which was found on the edge of sand dune and the area connecting with gully. Comparing the average abundance of Razor clams (*S. corneus*, *S. strictus* and *S. regularis*) with other mollusks found in the study site during the study period, the results revealed that their average abundance were very low. Each mollusk was correlated differently with environmental factors. *M. senhousia* was significantly positively correlated with total organic matter in the lower soil layer, sand composition in both soil layers, median grain size in both soil layers, water temperature, turbidity, alkalinity, hardness and phytoplankton abundance, but was significantly negatively correlated with soil temperature, soil pH (both soil layers), redox potential and dissolved oxygen. *M. meretrix* and *M. lusoria* had significantly positive correlation with each other, with soil pH (in both soil layers), redox potential, and dissolved oxygen, but had significantly negative correlation with water content (in both soil layers), total organic matter (in both soil layers), hardness and turbidity. *N. distortus* had significantly negative correlation with dissolved oxygen and soil temperature. *A. granosa* was significantly positively correlated with water content (in both soil layers) and total organic matter (in both soil layers), but was negatively correlated with dissolved oxygen and redox- potential.

Finally, all variables investigated in this study were analyzed by BIO-ENV and ecological map. The results demonstrated that soil properties in the upper layer, in

particular the combination of percentage of sand in the soil composition, organic matter and water content in the surface soil layer, showed the high relationship with abundance of Razor clam (*S. corneus*) in Don Hoi Lot. Therefore, monitoring program relevant to these parameters should be conducted continuously in order to avoid the reduction of Razor clam population in the future.

8.1.3. Total catch and social impact in Don Hoi Lot

The number of Razor clam fishers during this study was equal to 20 persons which was smaller than the research conducted by Oiamsomboon in 2000 (27 persons). Most fishers were local people living in this area averaging 38.5 years. Razor clams fishers harvested *Solen* spp throughout the year. During this study, the price of *Solen* spp ranged from 60-220 baht/kg or average 140 baht/kg. The total catch in Don Hoi Lot was 11,222 kg or 11.22 ton/year. Therefore the total catch of Razor clams was low comparing to the past. This caused the over exploitation of Razor clams in Don Hoi Lot regarding the high demand for consumption and high price.

Comparing the ecological data and the socioeconomic data, it could be concluded that one of major threats to Don Hoi Lot tidal flat was water pollution from inland. High deposit of total organic matter, the increase of Horse mussel population (exotic mollusk species), harvesting practices to collect Venus shell, using sodium hydroxide mixing with lime for catching Razor clams during nighttime would affect the Razor clam population.

8.2 Recommendations

8.2.1 Proposed potential management regime for Razor clam conservation

1. The research results illustrated that major factors affecting Razor clam population were sand composition, total organic matter and water content in upper soil layer. Human activities having impacts on soil composition e.g. pier construction at Doi Hoi Lot could block the water flow and cause sedimentation. Therefore any

human activity that would increase sedimentation and changensand composition in the area, needed to be considered vigilantly by involving stakeholders.

2. Amount of total organic matter had negative correlation with abundance of Razor clams, and thus should be measured regularly, e.g. at least twice a year. Total organic matter would increase following high concentration of plant nutrients (nitrogen and phosphorus) released to the water column. If loading of nutrients from inland was increased continuously, nutrient would be uptaken by phytoplankton for their growth. The research indicated that the concentration of chlorophyll-a was classified at eutrophic level especially in November, therefore water treatment program to manage organic waste should be considered and established in the area. Water monitoring project conducted by local stakeholders should be encouraged.

3. At present, catching Razor clam by spreading lime over the substrate is not allowed. However, during this research local fisherman stated that such practice is still used during nighttime. Therefore, law enforcement and local conservative network should be promoted in the area.

4. Razor clams and Venus shell lived in similar soil substrate. Harvesting methods to catch one species would disturb another species. Local fishermen and stakeholders should agree to set up accepted conservation zone for each species.

5. Soil and water pH and temperature, which more or less relevant to climate changes, were correlated with density of Razor clams in the area. Thus the study on impacts of changes in soil and water temperature on biology of Razor clams should be conducted in details.

6. Conservation zones for protecting the spawning grounds of Razor clams should be established in certain period. The research results indicated that high population of Razor clams was found in the middle of Don Na San (at stations 20-22 and 25-27) and the spawning period occurred all year round and peaked during July to December and February to March. Therefore, these certain areas and times should be declared as closure areas and periods, not allowed for Razor clams harvesting, to make sure that Razor clams would not be extinct in the future.

7. A monitoring program to monitor significant parameters such as sand composition, total organic matter, water content in upper soil layer and chlorophyll-a

in a certain period should exist in order to assess environmental situation in Don Hoi Lot.

8. A public awareness program to promote the understanding and disseminate information about the Razor clams habitats, values, importance and problems of Razor clams should be initiated, promoted and supported. Environmental database should be established and information should be widely distributed via local schools and educational programs.

8.2.2 Further studies

1. Biology and interactions of mollusks (including *S. strictus* and *S. regularis*) and other aquatic species in Don Hoi Lot should be further studied in order to provide the better understanding and baseline data for strategic management planning for the whole ecosystems and their sustainable use.

2. Impacts of soil and water temperature changes on biology of Razor clams, in particular at stage of egg development should be studied in details in order to avoid Razor clams population depletion.

3. Abundance of phytoplankton especially dominant species such as *Chaetoceros pseudocurvisetus*, *Pseudonitzschia pungens*, and *Thalassiosira* spp., their biology and distribution should be further studied in order to assess and monitor their positive and negative impacts on aquatic species and environment in the area.

4. Biological aspects of other mollusk species in Don Hoi Lot such as their reproductive system and spawning period should be further studied to provide baseline data for establishing mollusk conservation zones and for sustainable use of mollusks.

5. Socio-economic aspects of local people and mollusk harvesters, as well as present and planned development projects should be paid attention to, Environmental Impact Assessment (EIA) and Cumulative Environmental Impact Assessment (CEIA) must be effectly undertaken, improved and strengthened.

6. Status of Don Hoi Lot in terms of environment and socio-economic aspects before and after Ramsar site declaration under the Ramsar Convention, including impacts of local and governmental policies on the environment situation, natural resources and biodiversity, as well as benefits to local people, especially mollusk harvestors, should be further studied.

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APPENDICES

APPENDIX A

Table 1 Length and weight data of *S. corneous* in Don Hoi Lot

Month	Wt	TL	Wt	TL	Wt	TL
Jun-08	2.93	6.68	12.45	6.85	2.31	4.91
Jun-08	1.94	5.60	10.48	6.45	2.04	5.50
Jun-08	5.51	6.66	11.40	6.37	1.65	4.62
Jun-08	2.22	5.66	9.04	6.42	1.95	5.24
Jun-08	4.98	6.32	7.44	6.08	0.47	3.16
Jun-08	4.55	6.10	8.33	6.34	12.42	6.65
Jun-08	4.84	6.68	8.34	6.07	11.05	6.56
Jun-08	4.60	6.56	8.57	5.83	9.08	6.05
Jun-08	1.16	4.20	7.20	5.72	7.98	5.73
Jun-08	3.26	5.20	8.08	5.52	7.04	5.63
Jun-08	4.03	6.10	7.17	5.18	9.33	6.00
Jun-08	3.60	6.20	8.72	5.98	8.39	5.86
Jun-08	1.18	4.15	6.78	5.68	7.15	5.34
Jun-08	1.14	4.14	7.66	5.78	8.03	5.86
Jun-08	6.62	7.50	6.67	5.59	7.51	5.10
Jun-08	1.46	3.98	8.87	5.74	6.53	5.38
Jun-08	9.05	5.44	5.69	5.24	6.89	5.58
Jun-08	7.28	5.58	7.19	5.50	7.43	5.60
Jun-08	5.44	5.12	7.47	5.64	7.08	5.23
Jun-08	6.74	5.30	6.76	5.58	6.59	5.54
Jun-08	6.66	5.38	5.53	5.68	7.44	5.50
Jun-08	7.84	5.36	7.80	5.62	5.68	5.16
Jun-08	8.02	5.38	6.81	5.24	7.11	5.45
Jun-08	6.38	5.31	6.25	5.28	5.66	5.21
Jun-08	6.75	5.24	5.42	5.17	6.33	5.16
Jun-08	7.81	5.30	4.32	4.78	5.28	5.02
Jun-08	4.91	4.99	5.09	5.14	4.82	4.88
Jun-08	5.35	5.06	5.52	5.00	6.66	5.30
Jun-08	5.37	5.24	6.85	5.62	6.45	5.69
Jun-08	6.27	5.29	6.77	5.72	5.57	5.23
Jun-08	5.78	5.01	6.26	5.28	4.19	4.64
Jun-08	6.53	5.30	4.96	4.76	5.07	5.06
Jun-08	7.12	5.22	4.91	4.76	5.28	5.34
Jun-08	5.42	5.02	5.39	4.94	6.13	5.00
Jun-08	4.80	4.64	5.98	5.48	4.96	4.89
Jun-08	4.96	5.06	5.05	4.98	6.71	4.00
Jun-08	6.28	4.90	5.08	4.92	6.00	4.41
Jun-08	6.28	5.08	4.61	4.78	4.99	5.00
Jun-08	4.97	4.74	2.43	3.92	4.70	4.82
Jun-08	4.84	4.59	4.50	6.53	4.93	4.74
Jun-08	5.16	4.67	5.52	6.70	6.08	5.14
Jun-08	5.26	4.88	0.99	4.20	6.86	5.21

Table 1: Length and weight data of *S. corneous* in Don Hoi Lot (cont.)

Month	Wt	TL	Wt	TL	Wt	TL
Jun-08	4.88	4.97	3.88	6.95	6.11	5.02
Jun-08	4.10	4.70	2.14	5.90	4.52	4.86
Jun-08	3.36	4.47	3.56	7.00	4.31	6.24
Jun-08	6.52	7.98	4.65	6.43	4.78	6.26

Table 1: Length and weight data of *S. corneous* in Don Hoi Lot (cont.)

Month	Wt	TL	Wt	TL	Wt	TL
Jul-08	2.87	5.64	3.12	4.80	9.82	6.74
Jul-08	2.58	5.98	2.62	4.22	12.68	6.75
Jul-08	2.90	5.32	2.58	4.20	10.87	6.62
Jul-08	3.21	5.90	3.02	4.38	12.01	7.09
Jul-08	0.88	3.55	2.54	4.20	8.93	6.28
Jul-08	1.87	5.34	3.07	4.50	9.13	6.44
Jul-08	3.62	7.07	2.96	4.26	8.13	6.70
Jul-08	3.21	5.96	2.68	4.08	7.85	6.33
Jul-08	0.88	3.55	2.65	4.30	7.94	6.23
Jul-08	11.75	6.91	2.52	4.28	6.85	6.05
Jul-08	10.50	6.94	2.41	4.15	7.54	7.48
Jul-08	11.14	6.70	2.33	4.40	1.20	3.95
Jul-08	9.73	6.80	2.57	4.25	7.10	7.58
Jul-08	9.08	6.31	2.42	3.95	3.95	5.60
Jul-08	10.45	6.72	1.69	3.60	2.72	5.80
Jul-08	8.48	6.56	2.71	4.30	8.01	7.86
Jul-08	9.04	6.40	1.43	3.42	3.69	6.18
Jul-08	8.53	6.60	8.26	7.72	3.64	6.34
Jul-08	7.83	5.90	7.85	8.58	1.00	3.85
Jul-08	7.98	6.15	7.85	6.13	3.40	5.98
Jul-08	10.07	6.55	9.71	6.50	5.66	6.62
Jul-08	8.28	6.30	9.52	6.36	1.15	4.46
Jul-08	7.24	5.93	10.99	7.07	3.29	4.50
Jul-08	8.53	5.88	9.28	6.44	7.29	6.18
Jul-08	6.78	5.90	8.03	6.22		
Jul-08	6.92	5.84	10.18	6.42		
Jul-08	7.31	6.05	9.24	6.43		
Jul-08	6.18	5.36	11.04	6.40		
Jul-08	7.99	6.01	9.10	6.70		
Jul-08	4.48	5.10	8.98	6.22		
Jul-08	4.53	4.90	8.99	6.00		
Jul-08	4.73	5.05	9.91	6.46		
Jul-08	4.30	4.70	8.30	6.31		
Jul-08	3.50	4.84	6.57	6.05		
Jul-08	5.13	5.24	6.30	5.90		
Jul-08	4.76	5.25	7.23	5.66		
Jul-08	4.50	5.15	2.31	3.94		
Jul-08	5.09	4.75	11.06	6.42		
Jul-08	3.68	4.84	12.30	7.15		
Jul-08	5.35	5.57	15.46	7.76		
Jul-08	5.13	5.25	10.86	6.38		
Jul-08	5.34	5.54	9.82	6.50		
Jul-08	4.76	5.30	11.74	7.05		
Jul-08	4.75	5.04	11.40	7.00		
Jul-08	4.03	5.03	10.26	6.70		
Jul-08	3.66	4.70	14.64	7.38		

Table 1: Length and weight data of *S. corneous* in Don Hoi Lot (cont.)

Month	Wt	TL	Wt	TL	Wt	TL
Aug-08	3.96	6.62	10.25	8.87	4.95	6.80
Aug-08	3.83	6.00	8.85	7.52	0.99	4.23
Aug-08	7.15	7.00	7.80	6.44	0.93	3.38
Aug-08	1.09	3.88	7.56	6.03	8.59	7.90
Aug-08	2.71	5.12	3.30	6.34	5.64	7.23
Aug-08	3.39	6.41	4.78	5.96	4.77	7.10
Aug-08	2.59	4.71	6.25	5.90	5.47	7.03
Aug-08	6.25	7.10	4.09	5.17	5.73	7.50
Aug-08	1.81	4.56	3.31	4.55	6.12	7.50
Aug-08	5.47	5.92	1.23	3.60	3.76	5.93
Aug-08	6.07	5.65	10.43	8.44	5.27	7.70
Aug-08	5.07	5.44	5.20	6.52	4.62	6.31
Aug-08	6.40	5.79	7.05	7.06	3.51	5.90
Aug-08	7.78	6.27	7.84	6.70	4.36	7.16
Aug-08	4.67	5.80	4.70	6.40	3.40	6.20
Aug-08	6.63	6.00	6.86	6.54	5.15	6.78
Aug-08	4.43	5.70	2.61	5.50	4.33	6.37
Aug-08	6.77	6.13	9.52	7.80	6.83	7.06
Aug-08	7.44	6.23	6.06	7.00	4.05	6.74
Aug-08	6.62	5.83	4.36	6.00	6.04	6.51
Aug-08	5.58	6.10	4.87	6.19	3.12	5.91
Aug-08	6.72	5.97	6.86	6.54	3.14	6.09
Aug-08	6.47	6.28	9.52	7.80	5.23	6.80
Aug-08	6.23	5.88	4.43	7.25	4.73	6.49
Aug-08	7.42	6.42	2.61	4.70	7.88	7.39
Aug-08	6.46	5.87	0.84	3.20	6.90	7.08
Aug-08	4.09	5.50	3.30	5.82	6.25	5.69
Aug-08	5.72	5.26	6.61	7.53	6.21	5.58
Aug-08	4.92	5.74	7.22	6.70	5.54	5.60
Aug-08	5.21	5.42	0.97	3.49	5.09	5.55
Aug-08	5.87	5.90	1.53	3.72	5.76	5.65
Aug-08	5.49	5.63	0.97	3.70	7.56	5.84
Aug-08	5.12	5.50	8.09	7.62	7.00	6.15
Aug-08	3.82	5.30	0.93	3.22	7.91	6.30
Aug-08	4.67	5.76	0.94	3.70	5.53	5.89
Aug-08	5.12	5.60	5.53	6.06	5.36	5.72
Aug-08	6.07	6.18	7.01	7.22	5.14	5.49
Aug-08	4.29	5.55	8.52	6.83	5.83	5.89
Aug-08	4.78	5.39	1.27	4.44	5.17	5.50
Aug-08	5.63	5.60	3.00	5.45	4.63	5.54
Aug-08	4.25	5.39	6.48	6.42	4.83	5.65
Aug-08	4.67	5.44	4.97	5.90	3.34	4.48
Aug-08	3.65	5.50	5.61	6.52	3.75	4.93
Aug-08	3.73	5.35	5.37	7.23	4.20	5.04
Aug-08	3.90	5.17	4.26	6.21	1.00	3.82
Aug-08	9.13	7.74	3.49	6.36	3.62	5.62

Table 1: Length and weight data of *S. corneous* in Don Hoi Lot (cont.)

Month	Wt	TL	Wt	TL	Wt	TL	Wt	TL
Sep-08	0.85	3.40	3.21	4.80	2.84	4.68	3.30	4.75
Sep-08	2.22	4.48	1.79	4.19	2.86	4.51	3.24	5.04
Sep-08	3.20	5.80	2.23	4.82	3.58	5.44	2.89	5.22
Sep-08	2.33	5.33	2.65	4.55	3.65	5.23	4.52	5.62
Sep-08	4.79	7.10	2.32	4.52	3.10	4.19	3.65	4.88
Sep-08	2.95	5.78	2.31	4.33	2.70	4.47	3.50	4.70
Sep-08	4.54	6.22	2.61	4.95	3.04	4.14	2.58	4.70
Sep-08	5.31	6.78	3.13	4.73	1.55	4.15	2.70	4.64
Sep-08	3.04	5.72	1.83	4.44	0.86	3.39	3.44	4.82
Sep-08	5.68	6.76	2.32	4.50	5.88	7.24	3.85	4.96
Sep-08	5.26	6.46	1.78	4.28	8.49	8.14	2.90	4.74
Sep-08	3.80	6.73	2.07	4.46	7.41	7.42	2.52	4.56
Sep-08	0.96	3.64	0.86	3.50	6.35	7.12	2.87	4.58
Sep-08	3.00	6.04	1.01	3.62	0.96	3.73	1.85	4.32
Sep-08	2.60	5.48	0.75	3.54	4.97	6.48	1.68	4.50
Sep-08	2.67	5.22	0.75	3.50	1.11	3.66	0.67	3.34
Sep-08	2.15	4.86	0.37	3.56	4.62	6.33	2.83	4.75
Sep-08	5.49	6.75	8.79	8.08	6.52	6.58	3.82	5.10
Sep-08	2.55	5.46	0.99	3.60	8.93	8.28	3.69	5.00
Sep-08	0.96	3.40	1.30	3.78	9.83	8.10		
Sep-08	8.80	6.97	8.88	8.38	8.26	8.14		
Sep-08	6.36	6.37	8.19	8.31	6.11	7.11		
Sep-08	5.32	5.64	0.84	3.56	8.03	6.30		
Sep-08	6.03	5.92	6.08	6.06	7.36	6.14		
Sep-08	5.81	6.00	5.58	6.03	7.27	5.83		
Sep-08	4.82	5.68	6.30	6.17	5.73	5.88		
Sep-08	4.56	5.82	5.91	6.04	5.52	5.92		
Sep-08	4.46	5.63	8.03	6.00	5.49	5.79		
Sep-08	3.57	4.82	6.18	6.03	6.24	5.66		
Sep-08	4.31	5.27	7.94	6.40	5.78	5.50		
Sep-08	3.59	5.05	6.21	5.88	5.35	4.57		
Sep-08	3.93	5.00	6.70	6.08	5.82	5.76		
Sep-08	3.55	4.94	6.78	6.19	6.09	6.00		
Sep-08	3.21	5.90	6.26	6.09	5.21	5.64		
Sep-08	4.08	5.41	7.51	6.04	4.59	5.48		
Sep-08	3.82	5.38	4.86	5.35	5.10	5.91		
Sep-08	3.98	6.78	4.21	5.27	5.19	6.05		
Sep-08	3.70	5.00	5.49	5.52	4.70	5.67		
Sep-08	3.39	4.92	4.82	5.73	3.83	5.14		
Sep-08	3.45	5.04	4.40	5.18	4.03	5.56		
Sep-08	2.83	4.70	4.49	5.83	4.51	5.44		
Sep-08	3.85	5.23	5.72	6.00	3.76	5.15		
Sep-08	3.65	4.95	4.86	5.44	3.51	5.00		
Sep-08	3.58	5.17	4.42	5.31	2.99	4.60		
Sep-08	2.74	4.78	4.15	5.14	3.93	4.95		
Sep-08	3.16	4.86	3.17	4.80	3.24	4.92		

Table 1: Length and weight data of *S. corneous* in Don Hoi Lot (cont.)

Month	Wt	TL	Wt	TL	Wt	TL
Oct-08	1.59	3.90	6.70	6.14	8.05	6.56
Oct-08	5.05	5.20	7.39	6.60	5.17	5.83
Oct-08	5.27	5.10	7.79	6.87	6.68	6.42
Oct-08	4.44	5.08	6.27	6.28	5.59	6.16
Oct-08	6.45	5.88	6.53	6.19	6.40	6.13
Oct-08	4.89	5.70	5.17	5.92	5.92	5.73
Oct-08	3.79	5.00	6.01	5.79	4.69	5.32
Oct-08	4.68	5.40	5.84	6.03	6.09	5.69
Oct-08	4.15	4.70	5.88	5.76	4.91	5.50
Oct-08	1.11	3.62	4.67	5.46	5.63	5.68
Oct-08	1.09	3.40	4.70	5.58	5.66	5.82
Oct-08	1.18	3.38	4.22	5.67	5.10	5.80
Oct-08	1.34	3.54	5.06	5.36	5.11	5.64
Oct-08	7.90	6.55	4.30	5.41	5.82	5.66
Oct-08	6.94	5.94	4.14	5.06	4.86	5.41
Oct-08	5.25	5.76	4.59	5.64	4.18	5.17
Oct-08	6.36	6.16	2.78	4.89	4.51	5.31
Oct-08	5.72	5.68	3.13	4.82	3.60	5.04
Oct-08	5.91	5.84	3.34	4.74	3.27	4.76
Oct-08	4.05	5.06	3.80	4.96	3.29	4.79
Oct-08	4.12	5.19	3.76	5.08	3.92	5.01
Oct-08	5.72	5.72	3.21	4.87	3.15	4.86
Oct-08	3.45	4.77	3.25	5.04	3.40	5.09
Oct-08	4.17	5.49	2.95	4.66	3.18	4.75
Oct-08	4.90	5.28	2.96	5.16	2.02	4.45
Oct-08	4.82	5.40	3.00	4.60	2.43	4.77
Oct-08	4.43	5.78	3.38	5.07	2.54	4.82
Oct-08	3.70	4.99	2.54	4.47	2.17	4.20
Oct-08	4.85	4.98	3.08	4.67	2.19	4.84
Oct-08	3.31	4.60	3.59	4.98	1.01	3.55
Oct-08	2.59	4.42	2.46	4.43	1.18	3.88
Oct-08	3.11	4.67	1.06	3.62	1.05	3.72
Oct-08	3.29	4.89	1.01	3.37		
Oct-08	3.78	4.86	1.14	3.76		
Oct-08	3.20	4.76	1.16	3.55		
Oct-08	3.32	4.63	3.97	5.03		
Oct-08	1.99	4.34	8.62	6.40		
Oct-08	2.32	4.48	0.89	3.52		
Oct-08	2.39	4.23	8.49	6.51		
Oct-08	2.78	4.37	9.34	6.73		
Oct-08	2.83	4.62	6.35	6.68		
Oct-08	2.62	4.10	6.70	6.23		
Oct-08	1.42	3.38	7.27	6.37		
Oct-08	1.27	3.80	7.73	6.85		
Oct-08	9.66	6.92	7.45	6.72		
Oct-08	8.49	7.06	7.69	6.34		

Table 1: Length and weight data of *S. corneous* in Don Hoi Lot (cont.)

Month	Wt	TL	Wt	TL
Nov-08	8.26	6.64	7.56	6.32
Nov-08	4.85	5.55	6.08	5.90
Nov-08	9.36	6.43	5.30	5.74
Nov-08	7.59	6.45	4.71	5.18
Nov-08	7.07	6.12	4.89	5.69
Nov-08	6.73	6.13	6.17	5.88
Nov-08	7.24	6.20	4.68	5.62
Nov-08	5.97	5.78	4.76	5.28
Nov-08	6.02	5.98	5.53	5.25
Nov-08	6.00	5.67	5.20	5.58
Nov-08	5.99	5.76	4.82	5.40
Nov-08	5.40	5.55	3.52	5.00
Nov-08	5.04	5.37	4.69	5.18
Nov-08	6.70	5.75	4.86	5.30
Nov-08	5.21	5.37	4.82	5.45
Nov-08	5.21	5.38	4.99	5.26
Nov-08	5.25	5.47	5.01	5.38
Nov-08	4.58	5.19	4.34	5.49
Nov-08	4.19	5.15	4.69	5.32
Nov-08	9.88	7.54	5.22	5.57
Nov-08	9.62	6.86	5.16	5.44
Nov-08	6.11	6.70	5.92	5.68
Nov-08	8.77	6.27	5.46	5.43
Nov-08	10.99	6.54	4.63	5.09
Nov-08	8.10	6.66	4.42	5.14
Nov-08	9.42	6.49	4.49	5.09
Nov-08	7.24	6.05	4.41	5.24
Nov-08	8.54	6.43	3.76	5.76
Nov-08	5.68	5.97	3.92	4.92
Nov-08	5.57	5.84	4.30	5.12
Nov-08	8.03	6.34		
Nov-08	7.40	6.12		
Nov-08	7.69	6.50		
Nov-08	8.65	5.72		
Nov-08	4.48	5.64		
Nov-08	3.95	5.12		
Nov-08	5.19	5.26		
Nov-08	4.45	5.24		
Nov-08	3.55	5.04		
Nov-08	1.78	4.04		
Nov-08	9.12	7.00		
Nov-08	9.84	6.95		
Nov-08	3.25	4.74		
Nov-08	9.02	6.88		
Nov-08	6.13	6.36		
Nov-08	7.91	6.50		

Table 1: Length and weight data of *S. corneous* in Don Hoi Lot (cont.)

Month	Wt	TL	Wt	TL	Wt	TL
Dec-08	8.45	6.33	2.52	4.67	7.27	6.49
Dec-08	8.85	6.43	3.08	4.62	6.22	6.37
Dec-08	7.89	6.22	1.58	4.13	7.36	5.91
Dec-08	1.01	4.00	2.05	4.04	6.58	6.08
Dec-08	0.72	3.44	1.96	4.11	7.81	6.15
Dec-08	8.65	6.32	2.62	4.24	7.89	6.66
Dec-08	1.12	3.24	2.04	4.10	7.39	6.09
Dec-08	1.97	4.22	1.90	4.11	4.94	5.88
Dec-08	1.39	3.64	1.71	3.62	3.98	5.63
Dec-08	0.85	3.34	1.51	3.65	4.40	6.01
Dec-08	0.36	2.20	1.54	3.81	4.10	5.21
Dec-08	0.76	3.76	0.57	3.25	4.00	5.07
Dec-08	0.42	2.80	0.99	3.68	4.40	5.86
Dec-08	7.25	5.46	0.41	3.00	4.47	5.34
Dec-08	1.52	3.72	2.27	4.16	4.55	5.36
Dec-08	4.32	5.58	1.09	3.37	3.87	5.20
Dec-08	6.11	5.52	16.42	7.58	2.56	4.86
Dec-08	2.13	4.00	11.07	6.99	2.47	4.54
Dec-08	3.74	4.89	9.53	6.94	1.41	3.98
Dec-08	7.01	6.00	8.58	6.98	1.74	4.04
Dec-08	2.88	4.67	8.68	6.58	1.47	4.78
Dec-08	6.70	6.24	9.41	6.43	1.02	3.42
Dec-08	1.86	4.24	7.11	6.31		
Dec-08	8.87	7.00	6.57	6.27		
Dec-08	7.50	6.66	4.03	5.12		
Dec-08	10.18	6.86	1.78	3.97		
Dec-08	9.04	6.74	1.39	4.48		
Dec-08	8.09	6.38	0.14	2.20		
Dec-08	9.97	6.42	10.58	7.06		
Dec-08	6.81	6.12	3.80	4.70		
Dec-08	8.04	6.31	6.25	6.46		
Dec-08	7.75	6.31	11.49	7.50		
Dec-08	6.70	6.21	10.58	7.06		
Dec-08	6.21	5.74	3.80	4.70		
Dec-08	7.16	6.01	9.05	6.28		
Dec-08	6.85	5.89	0.97	2.26		
Dec-08	5.99	5.42	1.54	3.48		
Dec-08	5.30	5.23	8.89	6.45		
Dec-08	5.33	5.47	8.55	6.85		
Dec-08	5.02	5.38	6.38	6.42		
Dec-08	5.95	5.14	7.51	6.22		
Dec-08	4.69	5.17	8.35	6.45		
Dec-08	5.07	5.32	8.88	6.89		
Dec-08	2.83	4.01	8.80	7.15		
Dec-08	3.08	4.66	6.12	5.97		
Dec-08	2.58	4.32	7.35	6.37		

Table 1: Length and weight data of *S. corneous* in Don Hoi Lot (cont.)

Month	Wt	TL
Jan-09	6.81	6.09
Jan-09	5.64	5.44
Jan-09	6.12	5.93
Jan-09	4.70	5.52
Jan-09	6.55	6.68
Jan-09	3.03	4.76
Jan-09	2.27	4.22
Jan-09	2.23	4.52
Jan-09	2.42	4.62
Jan-09	1.94	4.20
Jan-09	2.52	4.49
Jan-09	2.29	4.30
Jan-09	1.84	4.21
Jan-09	1.91	4.23
Jan-09	1.60	3.93
Jan-09	1.84	4.09
Jan-09	1.49	3.89
Jan-09	1.15	3.60
Jan-09	1.10	3.60
Jan-09	0.89	3.23
Jan-09	1.07	3.37
Jan-09	0.75	2.96
Jan-09	0.86	3.22
Jan-09	0.70	3.18
Jan-09	0.73	2.84
Jan-09	0.44	2.70
Jan-09	1.00	3.36
Jan-09	0.37	2.60
Jan-09	8.84	7.26
Jan-09	2.28	4.39
Jan-09	7.95	6.43
Jan-09	5.98	6.06
Jan-09	8.19	7.00
Jan-09	2.39	4.20
Jan-09	8.72	6.95
Jan-09	8.11	6.55
Jan-09	5.87	5.86
Jan-09	4.30	5.18
Jan-09	2.63	4.73

Table 1: Length and weight data of *S. corneous* in Don Hoi Lot (cont.)

Month	Wt	TL	Wt	TL	Wt	TL
Feb-09	2.07	4.14	1.03	3.40	2.46	4.58
Feb-09	3.41	4.62	1.16	3.68	2.31	4.58
Feb-09	2.27	4.34	0.85	3.43	1.76	4.08
Feb-09	1.07	3.16	0.54	3.18	1.32	3.58
Feb-09	2.68	4.28	0.81	3.24	2.02	4.36
Feb-09	1.33	3.52	0.45	3.15	1.59	3.98
Feb-09	1.67	3.80	0.57	3.24	1.81	4.46
Feb-09	1.22	3.02	0.64	3.22	1.30	3.80
Feb-09	2.85	4.46	0.78	3.28	1.59	3.98
Feb-09	1.34	3.58	0.48	3.08	1.39	3.74
Feb-09	1.43	3.90	10.02	7.32	1.07	3.36
Feb-09	0.78	3.47	8.73	7.17	1.30	3.76
Feb-09	0.64	2.60	4.37	5.82	1.38	3.70
Feb-09	1.12	3.60	1.74	4.02	1.37	3.61
Feb-09	1.33	4.12	1.54	4.01	1.58	3.84
Feb-09	1.09	3.96	0.51	2.81	1.06	3.54
Feb-09	1.49	3.90	16.68	8.02	0.95	3.28
Feb-09	2.01	4.14	0.53	2.64	1.05	3.36
Feb-09	0.41	2.57	0.26	2.35	0.80	3.20
Feb-09	0.41	2.74	1.99	4.10	0.88	3.22
Feb-09	0.73	3.02	1.74	3.96	0.85	3.24
Feb-09	0.58	2.82	13.31	7.07	0.54	2.68
Feb-09	7.68	6.77	3.29	4.53	0.58	2.86
Feb-09	6.41	6.29	0.68	3.15	0.83	3.54
Feb-09	5.62	6.21	0.86	3.05	0.73	3.28
Feb-09	6.38	6.38	2.02	3.96	5.03	3.98
Feb-09	6.48	6.46	1.05	3.36	1.07	3.54
Feb-09	6.59	6.72	6.51	6.14	0.96	3.22
Feb-09	4.40	5.86	6.76	6.99	0.84	3.32
Feb-09	2.44	4.76	9.02	6.70	1.06	3.60
Feb-09	2.19	4.28	5.84	6.22	0.64	3.15
Feb-09	1.98	4.26	7.66	6.48	0.44	2.88
Feb-09	2.57	4.84	7.02	6.18	0.57	2.74
Feb-09	2.46	4.64	7.97	6.44	0.74	3.14
Feb-09	2.26	4.36	6.56	6.04	0.85	2.80
Feb-09	1.84	4.09	5.67	6.24	0.63	3.39
Feb-09	1.48	3.92	2.80	4.62		
Feb-09	2.40	4.51	2.76	4.49		
Feb-09	2.47	4.53	3.80	4.80		
Feb-09	1.18	3.69	3.20	4.78		
Feb-09	1.71	3.96	3.16	4.88		
Feb-09	1.32	3.66	2.32	4.60		
Feb-09	0.91	3.31	2.38	4.24		
Feb-09	1.05	3.46	3.15	4.86		
Feb-09	0.96	3.37	2.43	4.42		
Feb-09	0.81	3.30	2.42	4.63		

Table 1: Length and weight data of *S. corneous* in Don Hoi Lot (cont.)

Month	Wt	TL	Wt	TL	Wt	TL
Mar-09	9.96	6.62	1.34	3.70	1.43	4.00
Mar-09	1.48	3.98	1.22	3.59	0.96	3.34
Mar-09	0.76	3.30	0.83	3.10	1.38	3.74
Mar-09	0.97	3.33	1.20	2.80	1.16	3.62
Mar-09	0.97	3.32	1.81	2.20	1.11	3.66
Mar-09	4.21	5.14	1.23	1.86	0.97	3.54
Mar-09	1.99	3.90	0.32	1.24	0.67	3.19
Mar-09	2.31	4.18	3.65	5.30	0.69	3.10
Mar-09	0.62	2.80	8.54	7.15	0.84	3.66
Mar-09	1.48	3.58	1.00	3.60		
Mar-09	1.22	3.48	7.99	6.82		
Mar-09	0.49	2.62	8.59	6.84		
Mar-09	0.49	2.58	8.84	6.52		
Mar-09	8.38	6.82	3.91	5.25		
Mar-09	0.42	2.56	3.96	5.05		
Mar-09	0.67	2.80	4.00	5.18		
Mar-09	0.38	2.32	4.19	5.15		
Mar-09	6.75	6.19	3.10	4.68		
Mar-09	3.18	4.81	2.91	4.58		
Mar-09	1.65	3.85	3.38	4.90		
Mar-09	1.33	3.74	3.66	5.01		
Mar-09	0.51	2.29	3.89	5.01		
Mar-09	5.42	5.79	3.87	5.11		
Mar-09	4.35	4.88	3.15	4.82		
Mar-09	4.79	5.01	2.41	4.54		
Mar-09	5.12	5.22	3.33	5.00		
Mar-09	5.04	5.29	3.22	4.86		
Mar-09	3.88	4.92	2.25	4.46		
Mar-09	4.39	5.10	3.04	4.95		
Mar-09	5.05	5.24	1.95	4.40		
Mar-09	4.58	4.92	2.65	4.38		
Mar-09	4.02	4.92	2.01	4.24		
Mar-09	4.57	4.96	1.57	3.90		
Mar-09	4.19	4.88	1.91	4.18		
Mar-09	3.33	4.60	1.43	3.76		
Mar-09	3.73	4.84	2.17	4.54		
Mar-09	4.96	4.80	1.63	4.41		
Mar-09	3.45	4.92	1.89	4.46		
Mar-09	4.28	5.01	1.71	4.02		
Mar-09	3.80	4.89	1.81	4.18		
Mar-09	3.11	4.34	1.92	4.26		
Mar-09	2.87	4.27	1.20	4.00		
Mar-09	8.19	7.15	1.63	3.91		
Mar-09	12.92	7.42	1.70	4.27		
Mar-09	2.02	4.18	1.33	3.74		
Mar-09	1.47	3.71	0.78	3.18		

Table 1: Length and weight data of *S. corneous* in Don Hoi Lot (cont.)

Month	Wt	TL	Wt	TL	Wt	TL
Apr-09	0.75	3.42	3.54	5.24	1.41	3.68
Apr-09	0.84	3.12	3.42	4.85	1.55	4.24
Apr-09	1.10	3.82	2.72	5.12	1.22	3.94
Apr-09	2.32	4.52	4.26	5.38	1.21	3.92
Apr-09	0.69	3.00	3.33	4.91	1.14	3.52
Apr-09	6.92	6.18	3.02	4.70	1.14	3.67
Apr-09	3.91	4.84	3.24	4.87	1.25	3.78
Apr-09	1.23	3.46	3.36	4.78	1.01	3.78
Apr-09	5.51	5.45	2.76	4.70	0.68	3.26
Apr-09	3.69	5.24	2.02	4.36		
Apr-09	3.85	5.13	2.95	4.72		
Apr-09	3.74	4.97	3.46	5.02		
Apr-09	3.94	5.34	2.05	4.43		
Apr-09	3.25	4.91	1.59	4.19		
Apr-09	3.26	4.86	1.36	4.19		
Apr-09	3.71	5.34	6.73	6.82		
Apr-09	3.91	5.38	6.56	6.92		
Apr-09	3.62	5.00	7.95	6.80		
Apr-09	3.92	5.22	7.14	6.41		
Apr-09	3.98	5.16	5.27	6.08		
Apr-09	2.88	4.74	4.51	5.46		
Apr-09	2.83	4.46	4.39	5.36		
Apr-09	3.69	5.50	3.17	4.86		
Apr-09	2.54	4.46	2.59	4.98		
Apr-09	2.20	4.46	4.09	5.23		
Apr-09	2.41	4.57	3.56	5.10		
Apr-09	3.51	4.98	3.71	5.12		
Apr-09	3.41	4.84	4.59	5.34		
Apr-09	2.16	4.36	3.81	5.34		
Apr-09	2.17	4.46	2.73	4.72		
Apr-09	2.38	4.62	2.91	4.84		
Apr-09	15.61	7.78	2.74	4.64		
Apr-09	2.44	5.32	2.77	4.74		
Apr-09	0.38	2.70	3.13	4.82		
Apr-09	0.64	2.72	3.96	5.15		
Apr-09	9.08	6.30	3.27	4.78		
Apr-09	3.21	5.78	2.34	4.58		
Apr-09	1.58	4.36	2.58	4.74		
Apr-09	0.53	2.76	2.95	5.00		
Apr-09	0.89	3.62	2.74	4.80		
Apr-09	3.02	4.96	2.25	4.51		
Apr-09	1.11	4.08	2.47	4.56		
Apr-09	4.51	5.69	2.44	4.79		
Apr-09	5.02	5.74	1.76	3.90		
Apr-09	4.04	5.36	1.16	3.66		
Apr-09	3.88	5.05	1.42	4.04		

Table 1: Length and weight data of *S. corneous* in Don Hoi Lot (cont.)

Month	Wt	TL	Wt	TL	Wt	TL
May-09	2.23	4.24	1.71	3.93	2.54	4.32
May-09	3.67	5.12	2.10	3.96	3.26	4.72
May-09	3.71	5.08	1.90	3.98	2.29	4.47
May-09	2.28	4.48	1.81	4.50	2.23	4.32
May-09	2.11	4.12	1.43	3.96	2.98	4.86
May-09	0.94	3.32	1.92	3.90	2.91	4.47
May-09	7.34	6.70	1.62	3.70	3.02	4.65
May-09	9.30	7.30	0.91	3.30	2.18	4.21
May-09	3.13	4.10	1.55	3.73	1.96	4.08
May-09	3.48	4.40	0.99	3.22	2.00	4.24
May-09	2.62	4.00	0.74	2.90	1.83	4.13
May-09	1.33	4.00	1.59	4.38	2.75	4.56
May-09	3.77	5.17	2.23	4.69	2.72	4.62
May-09	4.46	4.98	1.26	3.84	2.65	4.35
May-09	4.23	4.90	1.04	3.50	1.75	3.89
May-09	4.33	5.23	0.88	3.00	1.76	3.98
May-09	4.78	5.49	0.74	2.76	1.97	4.10
May-09	4.06	5.00	1.85	4.05	1.75	4.09
May-09	3.49	4.84	0.93	3.24	1.32	3.53
May-09	2.53	4.20	2.91	3.10	1.65	3.90
May-09	2.85	4.34	1.50	2.20	1.64	3.98
May-09	2.91	4.48	0.92	1.60	1.69	3.76
May-09	2.57	4.39	2.59	4.64	1.54	4.68
May-09	3.40	4.64	1.54	4.00	0.78	3.15
May-09	3.13	4.84	7.51	7.68	0.58	2.83
May-09	3.60	4.87	1.44	3.74	0.27	2.30
May-09	2.46	4.35	12.25	7.10		
May-09	2.54	4.33	5.62	5.85		
May-09	2.34	4.16	5.45	5.49		
May-09	2.02	3.94	5.61	5.84		
May-09	2.73	4.35	5.14	5.34		
May-09	2.05	3.95	4.60	5.12		
May-09	2.47	4.49	5.04	5.40		
May-09	2.16	4.22	4.79	5.04		
May-09	2.44	4.14	4.26	5.30		
May-09	1.90	4.24	4.14	4.99		
May-09	2.71	4.58	3.56	4.80		
May-09	1.88	4.07	3.44	4.78		
May-09	2.28	4.43	4.06	5.06		
May-09	2.41	4.23	4.23	5.06		
May-09	2.42	4.29	2.86	4.39		
May-09	2.21	4.27	2.78	4.54		
May-09	2.36	4.03	2.87	4.45		
May-09	1.86	3.76	2.83	4.43		
May-09	1.47	3.84	2.26	4.09		
May-09	2.38	4.42	3.01	4.97		

Table 2: Length and weight data of *S. strictus* in Don Hoi Lot.

Month	Wt	TL	Month	Wt	TL
Jun-08	10.84	6.80	Aug-08	7.14	5.96
Jun-08	3.78	5.00	Aug-08	5.29	5.65
Jun-08	4.36	5.09	Aug-08	5.83	6.00
Jun-08	4.30	5.06	Aug-08	6.15	5.98
Jun-08	4.06	4.87	Aug-08	5.91	7.20
Jun-08	3.95	4.76	Aug-08	3.27	6.18
Jun-08	3.89	4.80	Aug-08	6.38	6.32
Jun-08	3.49	6.54	Aug-08	6.12	7.28
Jun-08	1.64	4.90	Aug-08	7.11	7.20
Jun-08	4.87	6.98	Aug-08	5.62	7.38
Jun-08	9.09	6.22	Aug-08	4.34	6.74
Jun-08	6.03	5.17	Aug-08	3.80	5.74
Jun-08	5.84	5.48	Aug-08	6.90	8.00
Jun-08	6.11	5.49	Aug-08	8.84	8.32
Jun-08	5.20	5.13	Aug-08	5.29	6.71
Jun-08	5.31	5.20	Aug-08	4.49	6.96
Jun-08	5.73	5.23	Aug-08	8.45	8.70
Jun-08	4.81	4.60	Aug-08	6.43	7.61
Jul-08	5.64	7.16	Aug-08	6.23	6.60
Jul-08	10.70	6.26	Aug-08	6.47	6.96
Jul-08	3.75	4.46	Aug-08	6.90	7.49
Jul-08	2.44	4.24	Aug-08	6.36	7.40
Jul-08	7.56	8.06	Aug-08	3.49	5.65
Jul-08	8.74	8.12	Aug-08	7.54	7.60
Jul-08	9.91	6.75	Aug-08	3.03	5.80
Jul-08	8.19	6.17	Aug-08	5.96	7.12
Jul-08	10.79	6.60	Aug-08	6.85	7.82
Jul-08	10.22	6.85	Aug-08	5.69	5.49
Aug-08	5.22	6.20	Aug-08	8.42	6.50
Aug-08	7.68	5.90	Aug-08	5.92	5.99
Aug-08	7.05	6.28	Aug-08	5.49	5.60
Aug-08	8.16	6.20	Aug-08	8.47	6.15
Aug-08	7.09	6.44	Aug-08	6.47	6.14
Aug-08	7.52	6.36	Aug-08	9.24	8.40
Aug-08	6.47	6.06	Aug-08	5.67	5.74
Aug-08	4.90	5.55	Aug-08	5.41	6.07
Aug-08	6.89	6.20	Aug-08	4.40	5.97
Aug-08	6.23	5.90	Aug-08	5.02	5.70
Aug-08	6.15	5.90	Sep-08	2.69	5.02
Aug-08	6.82	6.19	Sep-08	3.67	6.40
Aug-08	4.71	5.50	Sep-08	3.79	6.06
Aug-08	5.91	5.94	Sep-08	5.35	7.04

Table 2: Length and weight data of *S. strictus* in Don Hoi Lot (cont.)

Month	Wt	TL	Month	Wt	TL
Sep-08	5.55	6.92	Sep-08	4.30	5.40
Sep-08	3.38	6.20	Sep-08	5.96	6.07
Sep-08	4.69	6.62	Sep-08	5.02	5.60
Sep-08	2.33	5.06	Sep-08	3.43	5.35
Sep-08	2.47	5.06	Sep-08	3.39	5.06
Sep-08	5.20	5.80	Sep-08	2.59	4.77
Sep-08	4.41	6.27	Sep-08	4.28	4.99
Sep-08	2.58	6.14	Sep-08	2.64	4.40
Sep-08	6.76	6.22	Sep-08	9.25	6.36
Sep-08	5.79	5.67	Sep-08	3.00	5.50
Sep-08	5.13	5.73	Sep-08	2.28	5.20
Sep-08	4.71	5.49	Sep-08	8.88	8.38
Sep-08	5.06	5.64	Sep-08	4.74	6.62
Sep-08	3.71	4.89	Sep-08	7.69	6.30
Sep-08	3.65	5.20	Sep-08	5.78	5.94
Sep-08	3.39	5.00	Sep-08	4.99	5.64
Sep-08	2.85	4.43	Sep-08	4.92	5.62
Sep-08	2.83	4.57	Sep-08	4.32	5.12
Sep-08	2.25	4.20	Sep-08	4.54	5.10
Sep-08	6.37	7.10	Sep-08	4.05	4.98
Sep-08	7.95	8.66	Sep-08	3.32	4.69
Sep-08	2.91	5.02	Sep-08	3.80	4.93
Sep-08	9.44	7.76	Sep-08	3.61	5.05
Sep-08	6.47	7.34	Sep-08	2.18	4.34
Sep-08	8.14	7.19	Sep-08	3.07	4.76
Sep-08	4.14	5.75	Sep-08	2.78	4.86
Sep-08	7.28	7.76	Sep-08	2.57	4.52
Sep-08	8.94	8.26	Sep-08	2.98	4.80
Sep-08	8.33	8.22	Sep-08	3.41	5.03
Sep-08	3.37	5.06	Sep-08	2.22	4.63
Sep-08	7.95	7.54	Oct-08	4.47	5.46
Sep-08	6.46	6.31	Oct-08	6.04	5.80
Sep-08	6.25	6.36	Oct-08	6.20	5.84
Sep-08	6.30	6.22	Oct-08	4.73	5.21
Sep-08	5.54	5.62	Oct-08	3.77	5.04
Sep-08	5.86	6.08	Oct-08	3.61	4.96
Sep-08	6.42	5.88	Oct-08	3.26	4.66
Sep-08	4.02	5.34	Oct-08	4.87	4.92
Sep-08	5.61	5.75	Oct-08	2.22	4.40
Sep-08	5.39	5.79	Oct-08	2.91	4.52
Sep-08	4.59	5.37	Oct-08	2.32	4.06
Sep-08	5.53	5.58	Oct-08	2.02	4.45

Table 2: Length and weight data of *S. strictus* in Don Hoi Lot (cont.)

Month	Wt	TL	Month	Wt	TL
Oct-08	2.46	4.29	Nov-08	10.41	6.73
Oct-08	2.99	4.39	Nov-08	8.24	6.24
Oct-08	2.29	4.24	Nov-08	8.79	6.33
Oct-08	1.65	3.65	Nov-08	7.27	6.24
Oct-08	2.22	4.19	Nov-08	7.42	6.28
Oct-08	1.39	3.91	Nov-08	7.99	6.44
Oct-08	2.33	4.36	Nov-08	6.12	6.17
Oct-08	7.52	6.39	Nov-08	9.76	6.20
Oct-08	5.49	5.93	Nov-08	6.36	6.26
Oct-08	8.44	6.19	Nov-08	7.10	6.12
Oct-08	5.41	5.78	Nov-08	5.48	5.63
Oct-08	5.22	5.68	Dec-08	8.70	6.24
Oct-08	5.15	5.74	Dec-08	8.05	6.74
Oct-08	4.52	5.46	Dec-08	10.48	7.02
Oct-08	3.92	5.12	Dec-08	7.94	6.36
Oct-08	3.91	5.17	Dec-08	3.57	4.80
Oct-08	3.60	5.27	Dec-08	9.88	7.54
Oct-08	13.44	7.55	Dec-08	7.71	6.58
Nov-08	5.34	5.43	Dec-08	3.22	4.71
Nov-08	6.62	6.40	Dec-08	2.96	4.76
Nov-08	3.71	5.68	Dec-08	2.55	4.52
Nov-08	5.88	6.40	Dec-08	2.22	4.10
Nov-08	6.30	5.80	Dec-08	7.90	6.34
Nov-08	7.59	6.30	Dec-08	5.27	5.72
Nov-08	7.32	6.19	Dec-08	5.91	6.14
Nov-08	6.31	6.05	Dec-08	10.22	6.96
Nov-08	7.06	6.06	Dec-08	13.22	7.46
Nov-08	5.59	5.26	Dec-08	6.47	6.00
Nov-08	4.38	5.35	Dec-08	10.11	6.26
Nov-08	4.39	5.32	Dec-08	8.50	6.39
Nov-08	4.22	5.64	Dec-08	6.42	6.49
Nov-08	7.46	6.72	Dec-08	8.14	6.67
Nov-08	6.71	5.76	Dec-08	4.43	5.31
Nov-08	7.05	5.79	Dec-08	3.08	4.86
Nov-08	5.15	5.54	Dec-08	3.05	4.97
Nov-08	4.62	5.33	Dec-08	7.61	6.64
Nov-08	4.59	5.48	Jan-09	4.95	5.86
Nov-08	5.40	5.48	Jan-09	2.06	4.24
Nov-08	4.15	5.05	Jan-09	1.28	3.62
Nov-08	4.54	5.10	Jan-09	15.31	7.64
Nov-08	4.72	5.19	Jan-09	10.15	7.09
Nov-08	4.37	4.98	Jan-09	7.99	6.89

Table 2: Length and weight data of *S. strictus* in Don Hoi Lot (cont.)

Month	Wt	TL	Month	Wt	TL	Month	Wt	TL
Jan-09	6.36	6.34	Mar-09	3.47	4.66	May-09	2.31	4.49
Jan-09	8.49	6.83	Mar-09	3.27	4.70	May-09	1.64	4.24
Jan-09	7.50	6.60	Mar-09	3.39	4.61	May-09	1.76	4.04
Jan-09	7.35	6.86	Mar-09	3.55	4.66	May-09	1.86	4.10
Jan-09	6.72	6.19	Mar-09	3.65	4.81	May-09	15.76	6.60
Jan-09	5.83	6.30	Mar-09	3.66	4.68	May-09	9.86	7.08
Jan-09	7.36	6.40	Mar-09	3.49	4.64	May-09	12.13	7.18
Jan-09	7.46	6.31	Mar-09	3.21	4.72	May-09	9.81	6.27
Jan-09	5.98	6.10	Mar-09	3.55	4.72			
Jan-09	5.49	5.76	Mar-09	3.48	4.56			
Jan-09	3.97	5.38	Mar-09	8.18	6.84			
Jan-09	2.78	4.53	Mar-09	1.10	3.41			
Jan-09	2.42	4.32	Mar-09	1.80	4.66			
Jan-09	1.83	4.14	Mar-09	3.28	5.12			
Jan-09	2.27	4.58	Mar-09	2.28	4.44			
Jan-09	2.32	4.22	Mar-09	7.36	6.89			
Jan-09	1.84	4.15	Mar-09	7.95	6.72			
Jan-09	1.32	3.60	Mar-09	7.29	6.58			
Jan-09	1.22	3.90	Mar-09	1.53	3.72			
Jan-09	1.63	4.03	Mar-09	1.76	4.00			
Jan-09	1.48	4.00	Mar-09	1.16	3.56			
Jan-09	0.94	3.62	Mar-09	2.54	4.37			
Jan-09	0.90	3.23	Mar-09	8.50	6.89			
Jan-09	1.12	3.54	Mar-09	8.99	6.98			
Jan-09	0.88	3.16	Mar-09	6.33	6.02			
Jan-09	8.83	6.82	Mar-09	8.24	6.14			
Feb-09	9.64	6.57	Mar-09	8.06	6.39			
Feb-09	2.92	4.40	Apr-09	1.22	3.64			
Feb-09	10.36	6.50	Apr-09	1.28	3.98			
Feb-09	3.83	4.74	Apr-09	1.63	4.07			
Feb-09	5.38	6.02	Apr-09	1.23	4.02			
Feb-09	2.57	4.70	Apr-09	4.34	5.44			
Feb-09	1.02	3.42	Apr-09	9.08	6.30			
Feb-09	12.06	6.96	Apr-09	8.70	6.80			
Feb-09	2.47	4.01	May-09	0.96	3.38			
Feb-09	14.66	7.80	May-09	1.52	2.10			
Feb-09	10.50	4.93	May-09	11.55	7.68			
Feb-09	8.26	6.72	May-09	7.86	6.90			
Feb-09	7.59	6.54	May-09	13.83	8.20			
Mar-09	12.85	7.37	May-09	8.57	6.94			
Mar-09	8.29	6.77	May-09	8.67	6.52			
Mar-09	3.70	4.66	May-09	3.14	4.99			

Table 3: Length and weight data of *S. regularis* in Don Hoi Lot

Month	Wt	TL	Month	Wt	TL
Jun-08	3.90	4.49	Nov-08	5.37	5.34
Jun-08	5.22	5.54	Nov-08	5.01	5.62
Jun-08	4.99	5.10	Nov-08	5.92	5.72
Jun-08	6.21	5.09	Nov-08	4.03	4.85
Jun-08	5.24	5.09	Nov-08	5.45	5.25
Jun-08	5.49	5.04	Nov-08	6.55	5.80
Jun-08	4.39	4.70	Nov-08	5.00	5.45
Jun-08	4.02	4.62	Nov-08	3.15	5.00
Jun-08	8.39	5.86	Dec-08	8.62	6.74
Jun-08	6.41	5.36	Dec-08	8.95	6.39
Jun-08	4.32	4.95	Dec-08	3.72	5.24
Jun-08	4.36	4.86	Jan-09	3.15	4.70
Jun-08	3.36	4.27	Jan-09	9.98	7.08
Jul-08	8.28	6.03	Feb-09	7.34	6.86
Jul-08	9.05	6.54	Mar-09	9.81	7.20
Jul-08	8.78	6.17	Mar-09	3.37	4.71
Aug-08	5.51	6.32	Mar-09	3.50	4.78
Aug-08	6.25	6.00	Mar-09	3.97	4.98
Aug-08	5.12	7.50	Mar-09	4.37	4.88
Aug-08	2.27	5.86	Mar-09	3.06	4.46
Aug-08	4.49	7.23	Apr-09	6.20	5.82
Aug-08	5.52	7.44	Apr-09	2.97	4.54
Aug-08	3.93	5.70	May-09	1.32	3.10
Aug-08	5.29	5.52	May-09	1.69	2.20
Aug-08	4.10	5.74	May-09	1.21	3.68
Aug-08	3.81	5.30			
Sep-08	2.49	4.57			
Sep-08	1.88	4.31			
Oct-08	8.03	7.18			
Oct-08	7.86	6.58			
Oct-08	6.70	6.24			
Oct-08	6.85	6.17			
Oct-08	4.46	5.62			
Oct-08	4.00	4.97			
Oct-08	2.98	5.14			
Oct-08	5.22	5.09			
Oct-08	3.42	5.20			
Oct-08	2.68	4.73			
Oct-08	2.60	5.10			
Oct-08	1.75	4.29			
Oct-08	4.05	5.08			
Oct-08	3.56	4.92			
Oct-08	2.22	3.90			

Table 4: Prediction of age, total length and weight of *S. corneus* in Don Hoi Lot

Month	TL	GR(cm/mth)	Wt	GR(g/mth)
1	0.40	0.38	0.00	0.02
2	0.79	0.37	0.02	0.04
3	1.15	0.35	0.05	0.06
4	1.50	0.34	0.12	0.09
5	1.84	0.32	0.21	0.12
6	2.16	0.31	0.33	0.16
7	2.47	0.30	0.49	0.19
8	2.77	0.28	0.68	0.22
9	3.06	0.27	0.89	0.25
10	3.33	0.26	1.14	0.28
11	3.59	0.25	1.42	0.30
12	3.84	0.24	1.72	0.33
13	4.08	0.23	2.05	0.35
14	4.31	0.22	2.39	0.37
15	4.53	0.21	2.76	0.38
16	4.74	0.20	3.15	0.40
17	4.95	0.19	3.55	0.41
18	5.14	0.19	3.96	0.42
19	5.33	0.18	4.38	0.43
20	5.50	0.17	4.82	0.44
21	5.67	0.16	5.26	0.45
22	5.84	0.16	5.70	0.45
23	6.00	0.15	6.15	0.45
24	6.15	0.14	6.61	0.45
25	6.29	0.14	7.06	0.45
26	6.43	0.13	7.51	0.45
27	6.56	0.13	7.96	0.45
28	6.69	0.12	8.41	0.45
29	6.81	0.12	8.86	0.44
30	6.93	0.11	9.30	0.44
31	7.04	0.11	9.74	0.43
32	7.14	0.10	10.17	0.42
33	7.25	0.10	10.59	0.42
34	7.35	0.09	11.01	0.41
35	7.44	0.09	11.41	0.40

Table 4: Prediction of age, total length and weight of *S. corneus* in Don Hoi Lot(cont.)

Month	TL	GR(cm/mth)	Wt	GR(g/mth)
36	7.53	0.09	11.82	0.39
37	7.62	0.08	12.21	0.38
38	7.70	0.08	12.59	0.38
39	7.78	0.08	12.97	0.37
40	7.85	0.07	13.34	0.36
41	7.93	0.07	13.69	0.35
42	8.00	0.07	14.04	0.34
43	8.06	0.06	14.38	0.33
44	8.13	0.06	14.71	0.32
45	8.19	0.06	15.04	0.31
46	8.25	0.06	15.35	0.30
47	8.31	0.05	15.65	0.29
48	8.36	0.05	15.95	0.29
49	8.41	0.05	16.23	0.28
50	8.46	0.05	16.51	0.27
51	8.51	0.05	16.78	0.26
52	8.56	0.04	17.03	0.25
53	8.60	0.04	17.29	0.24
54	8.64	0.04	17.53	0.23
55	8.68	0.04	17.76	0.23
56	8.72	0.04	17.99	0.22
57	8.76	0.04	18.21	0.21
58	8.79	0.03	18.42	0.20
59	8.83	0.03	18.63	0.20
60	8.86	0.03	18.82	0.19
61	8.89	0.03	19.01	0.18
62	8.92	0.03	19.20	0.18
63	8.95	0.03	19.38	0.17
64	8.98	0.03	19.55	0.16
65	9.00	0.03	19.71	0.16
66	9.03	0.02	19.87	0.15
67	9.05	0.02	20.02	0.15
68	9.08	0.02	20.17	0.14
69	9.10	0.02	20.31	0.14
70	9.12	0.02	20.45	0.13

Remark: GR = Growth rate

Table 5: Prediction of age, total length and weight of *S. strictus* in Don Hoi Lot.

Month	TL	GR(cm/mth)	Wt	GR(g/mth)
1	0.41	0.39	0.01	0.03
2	0.80	0.37	0.04	0.06
3	1.17	0.36	0.10	0.09
4	1.52	0.34	0.19	0.12
5	1.87	0.33	0.32	0.15
6	2.19	0.31	0.47	0.18
7	2.51	0.30	0.66	0.21
8	2.81	0.29	0.87	0.23
9	3.09	0.27	1.10	0.26
10	3.37	0.26	1.36	0.27
11	3.63	0.25	1.63	0.29
12	3.88	0.24	1.92	0.31
13	4.12	0.23	2.23	0.32
14	4.35	0.22	2.55	0.33
15	4.58	0.21	2.88	0.34
16	4.79	0.20	3.22	0.34
17	4.99	0.19	3.56	0.35
18	5.18	0.19	3.91	0.35
19	5.37	0.18	4.26	0.36
20	5.55	0.17	4.62	0.36
21	5.72	0.16	4.98	0.36
22	5.88	0.16	5.33	0.35
23	6.04	0.15	5.69	0.35
24	6.19	0.14	6.04	0.35
25	6.33	0.14	6.39	0.35
26	6.47	0.13	6.73	0.34
27	6.60	0.13	7.07	0.34
28	6.73	0.12	7.41	0.33
29	6.85	0.12	7.74	0.32
30	6.96	0.11	8.07	0.32
31	7.07	0.11	8.38	0.31
32	7.18	0.10	8.69	0.30
33	7.28	0.10	9.00	0.30
34	7.38	0.09	9.30	0.29
35	7.47	0.09	9.59	0.28

Table 5: Prediction of age, total length and weight of *S. strictus* in Don Hoi Lot(cont.)

Month	TL	GR(cm/mth)	Wt	GR(g/mth)
36	7.56	0.09	9.87	0.28
37	7.64	0.08	10.15	0.27
38	7.73	0.08	10.41	0.26
39	7.80	0.07	10.67	0.25
40	7.88	0.07	10.93	0.25
41	7.95	0.07	11.17	0.24
42	8.02	0.07	11.41	0.23
43	8.09	0.06	11.64	0.22
44	8.15	0.06	11.87	0.22
45	8.21	0.06	12.08	0.21
46	8.27	0.06	12.29	0.20
47	8.32	0.05	12.49	0.20
48	8.37	0.05	12.69	0.19
49	8.43	0.05	12.88	0.18
50	8.47	0.05	13.06	0.18
51	8.52	0.04	13.24	0.17
52	8.56	0.04	13.41	0.16
53	8.61	0.04	13.57	0.16
54	8.65	0.04	13.73	0.15
55	8.69	0.04	13.88	0.15
56	8.72	0.04	14.03	0.14
57	8.76	0.03	14.17	0.14
58	8.80	0.03	14.31	0.13
59	8.83	0.03	14.44	0.13
60	8.86	0.03	14.57	0.12
61	8.89	0.03	14.69	0.12
62	8.92	0.03	14.81	0.11
63	8.95	0.03	14.92	0.11
64	8.97	0.03	15.03	0.10
65	9.00	0.02	15.13	0.10
66	9.02	0.02	15.23	0.10
67	9.05	0.02	15.33	0.09
68	9.07	0.02	15.42	0.09
69	9.09	0.02	15.51	0.09
70	9.11	0.02	15.60	0.08

Remark: GR = Growth rate

Table 6: Number of phytoplankton in the stomach content of *S. corneous* in each month during June 2008 to May 2009

NO.	Species	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Total	%
1	<i>Merismopedtia convoluta</i>	0	0	0	0	15	0	0	0	0	0	0	0	15	2.81
2	<i>Coelastrum astroideum</i>	0	0	0	0	1	0	0	0	0	0	0	0	1	0.19
3	<i>Crucigenia quadrata</i>	0	0	0	0	4	0	0	0	0	0	0	0	4	0.75
4	<i>Scenedesmus</i> sp.	0	0	2	0	2	1	0	0	0	0	0	0	5	0.94
5	<i>S. javanensis</i>	0	0	0	0	1	0	0	0	0	0	0	0	1	0.19
6	<i>Euglena oxyuris</i>	0	0	0	0	0	1	0	0	0	0	0	0	1	0.19
7	<i>Phacus pleuronectes</i>	0	0	0	0	0	1	0	0	0	0	0	0	1	0.19
8	<i>Amphora</i> sp.	5	0	2	0	13	1	0	0	0	4	5	1	31	5.82
9	<i>Glumaconeis</i> sp.	0	0	0	0	3	0	1	0	0	0	0	0	4	0.75
10	<i>Cocconeis</i> sp.	1	1	0	0	0	0	0	0	3	0	0	3	8	1.50
11	<i>Coccinodiscus</i> spp.	0	0	3	3	21	4	9	1	0	4	2	1	48	9.01
12	<i>Cyclotella stylonum</i>	0	3	0	1	6	1	0	0	0	0	0	0	11	2.06
13	<i>Ditylum sol</i>	0	0	0	0	0	0	1	0	0	0	0	0	1	0.19
14	<i>Entomoneis robusta</i>	1	0	0	0	0	0	0	0	0	0	1	0	2	0.38
15	<i>Gyrosigma</i> sp./ <i>Pleurosigma</i> sp.	0	0	0	0	0	0	1	0	0	1	0	0	2	0.38
16	<i>Navicula</i> sp.	0	0	1	0	0	0	0	0	0	0	0	0	1	0.19
17	<i>Nitzschia</i> sp.	0	0	0	1	0	0	1	0	0	0	1	0	3	0.56
18	<i>Planktoniella sol</i>	0	0	0	0	0	1	0	0	0	0	0	0	1	0.19
19	<i>Pseudonitzschia pungens</i>	1	0	0	0	6	0	1	0	0	0	0	0	8	1.50
20	<i>Thalassionema frauenfeldii</i>	6	0	2	0	9	19	0	0	4	8	7	0	55	10.32
21	<i>T. nitzschoides</i>	0	0	0	0	0	0	0	0	0	0	26	4	30	5.63
22	<i>Thalassiosira</i> spp.	11	37	5	11	45	106	8	3	4	7	10	23	270	50.66
23	Unknown Pennate Diatoms	1	3	1	0	14	1	0	4	0	2	1	1	28	5.25
24	<i>Glenodinium</i> sp.	0	0	0	0	1	0	0	0	0	0	0	0	1	0.19
25	<i>Prorocentrum micans</i>	0	0	0	0	0	0	0	0	1	0	0	0	1	0.19
Total		26	44	16	16	141	136	22	8	12	26	53	33	533	
%		4.88	8.26	3.00	3.00	26.45	25.52	4.13	1.50	2.25	4.88	9.94	6.19	100	

Table 7: List of phytoplankton species found in the stomach content of *S. corneous* in each month during June 2008 to May 2009

NO.	Species	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	No of months
1	<i>Merismopedia convoluta</i>	-	-	-	-	+	-	-	-	-	-	-	-	1
2	<i>Coelastrum astroideum</i>	-	-	-	-	+	-	-	-	-	-	-	-	1
3	<i>Crucigenia quadrata</i>	-	-	-	-	+	-	-	-	-	-	-	-	1
4	<i>Scenedesmus</i> sp.	-	-	+	-	+	+	-	-	-	-	-	-	3
5	<i>S. javanensis</i>	-	-	-	-	+	-	-	-	-	-	-	-	1
6	<i>Euglena oxyuris</i>	-	-	-	-	-	+	-	-	-	-	-	-	1
7	<i>Phacus pleuronectes</i>	-	-	-	-	-	+	-	-	-	-	-	-	1
8	<i>Amphora</i> sp.	+	-	+	-	+	+	-	-	-	+	+	+	7
9	<i>Climaconeis</i> sp.	-	-	-	-	+	-	+	-	-	-	-	-	2
10	<i>Cocconeis</i> sp.	+	+	-	-	-	-	-	-	+	-	-	+	4
11	<i>Coccinodiscus</i> spp.	-	-	+	+	+	+	+	+	-	+	+	+	9
12	<i>Cyclotella stylorum</i>	-	+	-	+	+	+	-	-	-	-	-	-	4
13	<i>Ditylum sol</i>	-	-	-	-	-	-	+	-	-	-	-	-	1
14	<i>Entomoneis robusta</i>	+	-	-	-	-	-	-	-	-	-	+	-	2
15	<i>Gyrosigma</i> sp./ <i>Pleurosigma</i> sp.	-	-	-	-	-	-	+	-	-	+	-	-	2
16	<i>Navicula</i> sp.	-	-	+	-	-	-	-	-	-	-	-	-	1
17	<i>Nitzschia</i> sp.	-	-	-	+	-	-	+	-	-	-	+	-	3
18	<i>Planktoniella sol</i>	-	-	-	-	-	+	-	-	-	-	-	-	1
19	<i>Pseudonitzschia pungens</i>	+	-	-	-	+	-	+	-	-	-	-	-	3
20	<i>Thalassionema frauenfeldii</i>	+	-	+	-	+	+	-	-	+	+	+	-	7
21	<i>T. nitzschioides</i>	-	-	-	-	-	-	-	-	-	-	+	+	2
22	<i>Thalassiosira</i> spp.	+	+	+	+	+	+	+	+	+	+	+	+	12
23	Unknown Pennate Diatoms	+	+	+	-	+	+	-	+	-	+	+	+	9
24	<i>Glenodinium</i> sp.	-	-	-	-	+	-	-	-	-	-	-	-	1
25	<i>Prorocentrum micans</i>	-	-	-	-	-	-	-	-	+	-	-	-	1
	No of spp	7	4	7	4	14	10	7	3	4	6	8	6	

APPENDIX B

Table 1: Comparison of physical factors of spatial scale (transverse transects) in Don Hoi Lot during June 2008- May 2009

Parameters	Average values in Transverse transects						Grand average
	T1	T2	T3	T4	T5	T6	
Soil temperature (°C)	29.42±4.88	29.12±5.21	29.42±5.51	29.18±4.95	29.67±5.49	29.76±5.75	29.43±5.12
Soil pH ¹	7.44±0.20	7.41±0.28	7.48±0.23	7.45±0.43	7.41±0.38	7.50±0.44	7.45±0.33
Soil pH ²	7.52±0.31	7.50±0.30	7.46±0.23	7.58±0.44	7.52±0.38	7.55±0.44	7.52±0.35
Water content ¹ (%)	27.31±1.74	25.38±0.90	24.53±0.76	23.63±0.58	24.39±0.99	25.86±1.70	25.18±1.66
Water content ² (%)	26.46±1.39	24.78±0.68	24.50±1.18	23.64±1.45	23.28±0.79	23.61±1.12	24.38±1.54
Total organic matter (mg/g dry wt) ¹	40.62±6.58	38.57±10.09	31.40±3.22	34.36±10.21	32.00±5.83	33.54±7.32	35.08±8.09
Total organic matter(mg/g dry wt) ²	40.88±7.06	36.77±6.61	35.82±9.53	36.52±11.02	31.13±6.54	33.24±6.9	35.73±8.41
Sand composition ¹ (%)	58.5±21.0	67.2±17.0	78.1±10.9	81.7±8.0	83.9±7.5	85.0±6.1	75.8±15.9
Sand composition ² (%)	57.3±23.0	64.4±23.3	72.1±16.6	79.2±11.5	84.1±7.4	86.5±6.0	73.9±18.8
Median grain size ¹ (µm in diameter)	64.0±14.7	68.8±12.2	77.6±6.0	79.2±4.2	79.4±4.4	80.1±3.3	74.8±10.4
Median grain size ² (µm in diameter)	62.8±18.0	67.2±17.4	74.2±10.7	78.1±6.2	80.1±4.0	82.4±2.8	74.1±13.2
Depth of Redox-potential at 0 mV (cm)	2.68±1.12	4.12±1.12	4.48±1.45	5.1±1.12	3.57±1.11	3.51±1.50	3.91±1.43
Acid volatile sulfide (mg/g dry wt) ³	0.019±0.020	0.006±0.008	0.004±0.003	0.002±0.001	0.005±0.002	0.009±0.005	0.007±0.009

Remark: 1 = upper soil layer, 2 = lower soil layer, 3 = data were measured in August 2008, December 2008 and April 2009

Table 2: Comparison of physical factors of spatial scale (longitudinal transects) in Don Hoi Lot during June 2008- May 2009

Parameters	Average values in Longitudinal transects							Grand average
	TA	TB	TC	TD	TE	TF	TF	
Soil temperature (°C)	29.41±5.11	29.44±5.26	29.51±5.36	29.40±5.24	29.37±5.10	29.44±5.34	29.44±5.34	29.43±5.05
Soil pH ¹	7.43±0.29	7.45±0.26	7.47±0.31	7.45±0.30	7.46±0.32	7.44±0.26	7.44±0.26	7.45±0.28
Soil pH ²	7.48±0.31	7.52±0.29	7.52±0.34	7.53±0.34	7.55±0.33	7.53±0.27	7.53±0.27	7.52±0.30
Water content ¹ (%)	25.57±1.01	24.78±0.83	24.48±0.96	23.85±0.73	24.86±1.09	27.55±1.16	27.55±1.16	25.18±1.51
Water content ² (%)	24.47±1.08	24.53±1.13	23.93±0.86	23.59±0.80	24.01±1.18	25.75±1.38	25.75±1.38	24.38±1.27
Total organic matter (mg/g dry wt) ¹	35.16±7.19	35.30±6.71	33.85±8.09	30.41±5.35	34.41±5.93	41.36±7.98	41.36±7.98	35.08±7.46
Total organic matter(mg/g dry wt) ²	35.81±6.57	34.67±10.16	33.86±8.19	33.87±8.15	36.03±6.48	40.13±6.36	40.13±6.36	35.73±7.80
Sand composition ¹ (%)	72.4±13.8	72.1±13.4	74.4±11.8	78.6±9.5	79.4±11.5	77.6±10.8	77.6±10.8	75.8±11.8
Sand composition ² (%)	71.7±15.5	71.1±14.9	72.6±14.1	74.8±14.0	77.1±14.2	76.2±13.7	76.2±13.7	73.9±14.1
Median grain size ¹ (µm in diameter)	73.2±9.3	71.9±9.9	73.5±7.3	75.8±5.5	77.2±6.1	77.4±6.7	77.4±6.7	74.8±7.7
Median grain size ² (µm in diameter)	72.9±11.4	71.9±11.1	72.3±10.0	74.7±7.5	76.3±8.7	76.7±9.0	76.7±9.0	74.1±9.6
Depth of Redox-potential at 0 mV (cm)	3.12±0.69	3.42±0.83	4.67±1.63	5.43±1.38	4.28±1.32	2.56±0.77	2.56±0.77	3.91±1.49
Acid volatile sulfide ³	0.011±0.012	0.010±0.005	0.003±0.003	0.002±0.001	0.005±0.003	0.015±0.008	0.015±0.008	0.007±0.007

Remark: 1 = upper soil layer, 2 = lower soil layer, 3 = data were measured in August 2008, December 2008 and April 2009

Table 3: Comparison of physical factors of temporal scale (transverse transects) in Don Hoi Lot during June 2008-May 2009

Parameters	Average values in Transverse transects					
	June	July	August	September	October	November
Soil temperature (°C)	34.33±2.23	32.21±0.75	33.64±1.46	32.50±0.85	26.72±0.39	26.75±0.39
Soil pH ¹	7.91±0.48	8.10±0.13	7.49±0.12	7.39±0.08	7.37±0.14	7.35±0.11
Soil pH ²	7.95±0.54	8.27±0.13	7.51±0.12	7.40±0.04	7.43±0.14	7.48±0.13
Water content ¹ (%)	25.29±1.36	24.72±1.7	25.58±1.56	25.47±1.47	25.53±2.05	24.61±0.90
Water content ² (%)	25.58±1.05	24.42±1.17	25.42±2.05	25.09±1.57	25.13±1.70	23.35±1.17
Total organic matter (mg/g dry wt) ¹	28.62±4.22	24.97±4.34	29.54±3.19	29.48±4.91	37.67±4.85	34.77±4.84
Total organic matter(mg/g dry wt) ²	31.47±4.36	26.45±1.60	33.41±4.11	33.21±6.07	27.81±3.92	33.19±2.18
Sand composition ¹ (%)	83.3±7.3	59.4±17.7	83.1±10.0	72.8±16.5	78.1±10.5	59.6±19.9
Sand composition ² (%)	85.5±6.9	63.7±17.7	78.9±14.9	73.0±13.2	76.6±9.1	48.5±26.2
Median grain size ¹ (µm in diameter)	79.6±3.9	65.6±11.1	79.1±5.4	73.7±8.8	76.1±5.1	65.4±12.6
Median grain size ² (µm in diameter)	81.4±4.0	68.5±10.7	77.9±8.1	74.1±7.2	76.6±4.6	56.5±20.7
Depth of Redox-potential at 0 mV (cm)	3.89±0.52	4.85±1.86	5.10±0.88	4.89±1.57	4.93±0.94	4.35±0.92
Acid volatile sulfide ³	ND	ND	0.003±0.001	ND	ND	ND

Remark: 1 = upper soil layer, 2 = lower soil layer, 3 = data were measured in August 2008, December 2008 and April 2009, ND = no data

Table 3: Comparison of physical factors of temporal scale (transverse transects) in Don Hoi Lot during June 2008-May 2009 (cont.)

Parameters	Average values in Transverse transects										Grand average
	December	January	February	March	April	May					
Soil temperature (°C)	21.47±0.79	19.78±0.81	26.92±0.34	28.65±0.26	34.99±0.72	35.18±1.06	29.43±5.12				
Soil pH ¹	7.36±0.20	7.22±0.10	7.44±0.06	7.37±0.18	7.36±0.13	7.03±0.18	7.45±0.33				
Soil pH ²	7.38±0.20	7.23±0.15	7.59±0.09	7.40±0.05	7.49±0.12	7.11±0.03	7.52±0.35				
Water content ¹ (%)	24.41±1.27	26.55±2.83	24.44±0.90	23.59±1.30	25.28±1.95	25.70±1.90	25.18±1.66				
Water content ² (%)	23.82±1.68	24.84±1.59	24.62±0.74	23.32±1.27	23.02±1.42	23.92±0.76	24.38±1.54				
Total organic matter (mg/g dry wt) ¹	36.94±7.08	40.62±6.05	36.27±6.84	33.99±4.15	46.68±10.6	41.42±6.25	35.08±8.09				
Total organic matter(mg/g dry wt) ²	37.17±8.11	43.90±1.78	35.93±3.49	44.88±8.88	49.97±6.35	31.34±6.16	35.73±8.41				
Sand composition ¹ (%)	85.5±4.9	84.8±6.9	81.2±5.9	54.1±20.8	85.5±3.2	81.5±6.7	75.8±15.9				
Sand composition ² (%)	86.7±3.7	82.6±8.1	85.6±5.4	45.0±25.8	77.9±4.3	83.1±5.9	73.9±18.8				
Median grain size ¹ (µm in diameter)	80.8±3.6	80.0±4.1	78.4±3.4	59.4±18.3	81.0±2.6	79.2±3.7	74.8±10.4				
Median grain size ² (µm in diameter)	72.1±2.7	79.4±4.5	81.9±2.9	54.5±23.1	77.3±2.7	79.4±3.2	71.1±13.2				
Depth of Redox-potential at 0 mV (cm)	3.83±1.76	3.43±1.62	2.65±0.94	2.49±0.84	3.35±1.36	3.18±0.61	3.91±1.43				
Acid volatile sulfide ³	0.011±0.015	ND	ND	ND	0.009±0.006	ND	0.007±0.009				

Remark: 1 = upper soil layer, 2 = lower soil layer, 3 = data were measured in August 2008, December 2008 and April 2009, ND = no data

Table 4: Comparison of physical factors of temporal scale (longitudinal transects) in Don Hoi Lot during June 2008- May 2009

Parameters	Average values in Longitudinal transects									
	June	July	August	September	October	November				
Soil temperature (°C)	34.33±0.41	32.21±0.29	33.64±0.34	32.50±0.17	26.72±0.14	26.75±0.17				
Soil pH ¹	7.91±0.08	8.10±0.08	7.49±0.02	7.39±0.05	7.37±0.00	7.35±0.05				
Soil pH ²	7.95±0.11	8.27±0.08	7.51±0.05	7.40±0.03	7.43±0.06	7.48±0.07				
Water content ¹ (%)	25.29±1.24	24.72±1.42	25.58±1.23	25.47±1.15	25.53±1.27	24.61±1.48				
Water content ² (%)	25.58±1.76	24.42±1.39	25.42±0.61	25.09±0.9	25.13±1.17	23.35±0.97				
Total organic matter (mg/g dry wt) ¹	28.62±2.9	24.97±2.39	29.54±4.14	29.48±3.59	37.67±4.27	34.77±5.67				
Total organic matter(mg/g dry wt) ²	31.47±3.14	26.45±5.01	33.41±2.43	33.21±3.47	27.81±3.41	33.19±5.43				
Sand composition ¹ (%)	83.3±3.9	59.4±6.1	83.1±4.3	72.8±5.9	78.1±3.3	59.6±6.6				
Sand composition ² (%)	85.5±1.4	63.7±5.7	78.9±3.4	73.0±4.5	76.6±4.6	48.5±3.5				
Median grain size ¹ (µm in diameter)	79.6±2.1	65.6±5.1	79.1±2.5	73.7±3.3	76.1±1.9	65.4±5.2				
Median grain size ² (µm in diameter)	81.4±1.5	68.5±4.6	77.9±2.1	74.1±3.1	76.6±2.8	56.5±4.4				
Depth of Redox-potential at 0 mV (cm)	3.89±1.43	4.85±1.78	5.10±2.05	4.89±1.42	4.93±1.10	4.35±1.36				
Acid volatile sulfide ³	ND	ND	0.003±0.003	ND	ND	ND				

Remark: 1 = upper soil layer, 2 = lower soil layer, 3 = data were measured in August 2008, December 2008 and April 2009, ND = no data

Table 4: Comparison of physical factors of temporal scale (longitudinal transects) in Don Hoi Lot during June 2008- May 2009 (cont.)

Parameters	Average values in Longitudinal transects										Grand average
	December	January	February	March	April	May					
Soil temperature (°C)	21.47±0.16	19.78±0.27	26.92±0.14	28.65±0.12	34.99±0.28	35.18±0.76	29.43± 5.05				
Soil pH ¹	7.36±0.04	7.22±0.06	7.44±0.05	7.37±0.06	7.36±0.02	7.03±0.08	7.45±0.28				
Soil pH ²	7.38±0.04	7.23±0.05	7.59±0.06	7.40±0.04	7.49±0.04	7.11±0.06	7.52±0.30				
Water content ¹ (%)	24.41±1.43	26.55±2.16	24.44±0.99	24.59±1.46	25.28±1.76	25.70±1.96	25.18±1.51				
Water content ² (%)	23.84±0.97	24.84±0.91	24.62±0.74	23.32±0.87	23.02±0.95	23.92±0.48	24.38±1.27				
Total organic matter (mg/g dry wt) ¹	36.94±5.73	40.62±5.15	36.27±4.71	33.99±5.04	46.68±5.90	41.42±6.62	35.08±7.46				
Total organic matter(mg/g dry wt) ²	37.17±1.83	43.90±2.39	35.93±2.52	44.88±3.91	49.97±4.86	31.34±6.57	35.73±7.80				
Sand composition ¹ (%)	85.5±1.2	84.8±2.9	81.2±2.6	54.1±6.9	85.5±2.3	81.5±3.3	75.8±11.8				
Sand composition ² (%)	86.7±1.8	82.6±3.5	85.6±3.4	45.0±2.6	77.9±1.9	83.1±2.4	73.9±14.1				
Median grain size ¹ (µm in diameter)	80.8±1.0	80.0±1.4	79.4±1.7	59.4±6.3	81.0±1.9	79.2±2.2	74.8±7.7				
Median grain size ² (µm in diameter)	82.1±1.4	79.4±2.2	81.9±2.4	54.5±5.5	77.3±1.3	79.4±0.7	74.1±9.6				
Depth of Redox-potential at 0 mV (cm)	3.83±0.94	3.43±1.49	2.65±0.66	2.49±0.74	3.35±1.28	3.18±0.51	3.91±1.49				
Acid volatile sulfide ³	0.011±0.009	ND	ND	ND	0.009±0.007	ND	0.007±0.007				

Remark: 1 = upper soil layer, 2 = lower soil layer, 3 = data were measured in August 2008, December 2008 and April 2009, ND = no data

Table 5: Statistical analysis of physical factors for comparison between spatial and temporal variation in transverse and longitudinal transects in each month

Parameters	Transverse transect					Longitudinal transect						
	F-ratio (Transect)	Sig. Level	F-ratio (Month)	Sig. Level	F-ratio (Inter-action)	Sig. Level	F-ratio (Transect)	Sig. Level	F-ratio (Month)	Sig. Level	F-ratio (Inter-action)	Sig. Level
Soil temperature	9.289	.000**	1,911.663	.000**	11.654	.000**	.126	.986	705.415	.000**	.470	1.000
Soil pH ¹	4.629	.000**	122.986	.000**	9.394	.000**	.247	.941	51.761	.000**	.318	1.000
Soil pH ²	4.341	.001**	141.031	.000**	9.300	.000**	.844	.519	60.763	.000**	.357	1.000
Water content ¹	19.780	.000**	2.294	.010**	1.104	.296	17.448	.000**	2.113	.019*	.570	.994
Water content ²	27.481	.000**	7.880	.000**	.986	.507	9.374	.000**	6.294	.000**	.615	.986
Total organic matter ¹	8.590	.000**	12.682	.000**	1.012	.457	8.286	.000**	11.988	.000**	.584	.992
Total organic matter ²	13.088	.000**	28.796	.000**	1.657	.004**	6.511	.000**	25.029	.000**	1.026	.430
Sand composition ¹	86.610	.000**	50.562	.000**	2.783	.000**	3.263	.007**	20.942	.000**	.283	1.000
Sand composition ²	173.259	.000**	133.197	.000**	7.711	.000**	1.866	.100	30.498	.000**	.156	1.000
Median grain size ¹	56.577	.000**	36.017	.000**	3.199	.000**	3.221	.007**	17.576	.000**	.427	1.000
Median grain size ²	97.961	.000**	72.170	.000**	7.076	.000**	2.525	.029*	22.523	.000**	.255	1.000
Redox-potential	9.541	.000**	6.774	.000**	1.417	.034*	13.452	.000**	6.380	.000**	.549	.996
Acid volatile sulfide ³	2.968	.016*	3.093	.50*	2.042	.038*	1.782	.124	2.624	.078	.736	.689

Remark: * = Significant at 0.05 level ** = Significant at 0.01 level

1 = upper soil layer, 2 = lower soil layer, 3 = data were measured in August 2008, December 2008 and April 2009

Table 6. Statistical analysis of physical factors for comparison between different of upper and lower soil layers.

Parameters	Mean		Standard deviation		n	Different between mean	t-value	Significant level
	Upper layer	Lower layer	Upper layer	Lower layer				
Soil pH	7.4498	7.5204	0.35534	0.37336	432	-0.0706	-6.484	.000**
Water content (%)	25.1811	24.3793	2.83916	2.36744	432	0.8017	5.817	.000**
Total organic matter (mg/g dry wt)	35.0804	35.7275	12.86562	11.08169	432	-0.6471	-0.953	.341
Sand composition (%)	75.7523	73.9259	18.10542	19.89623	432	1.8264	3.376	.001**
Median grain size (µm in diameter)	74.8	74.1	12.03	14.23	432	0.7	1.855	.64

Remark; * = Significant at 0.05 level ** = Significant at 0.01 level

Table 7: Soil parameters measured at Don Hoi Lot during June 2008 to May 2009 (June 2008).

Station	Date	Time	Temp. °C	Soil pH		TOM (mg/g dry wt)		Water content (%)		Sand composition (%)		RP (cm)	Medium grain size(uM)	
				upper	lower	upper	lower	upper	lower	upper	lower		upper	lower
1	4	11.50	34.0	7.10	7.10	38.55	41.56	30.06	30.30	59	76	2.5	67	74
2	4	12.10	34.0	7.20	7.10	34.01	41.81	24.90	27.93	65	66	4.5	70	72
3	4	12.20	35.0	7.80	7.90	33.02	33.05	37.00	24.76	67	76	3.5	72	76
4	4	12.30	35.0	7.50	7.80	33.16	33.52	24.87	25.07	77	74	4.0	75	74
5	4	12.40	35.0	7.30	7.50	35.28	49.26	22.55	25.46	81	80	5.0	77	77
6	4	12.50	35.0	7.60	7.40	42.59	32.93	28.36	25.02	72	77	1.0	75	77
7	4	10.15	33.0	7.50	7.20	32.30	39.52	29.23	23.30	80	87	2.0	80	85
8	4	10.25	33.0	7.70	7.80	36.15	39.50	23.33	24.53	63	78	2.8	69	76
9	4	10.35	33.0	7.30	7.40	30.86	31.64	24.61	24.35	82	81	4.5	77	77
10	4	10.45	33.0	7.40	7.50	29.84	32.58	24.31	23.99	86	81	2.2	78	78
11	4	11.18	33.0	7.70	7.50	27.11	29.71	23.97	24.15	90	84	10.0	80	78
12	4	11.30	32.5	7.60	7.60	29.88	29.39	24.17	26.30	80	85	3.0	79	81
13	4	10.05	32.0	7.20	7.40	24.41	31.08	21.46	24.54	84	83	2.5	83	84
14	4	9.15	32.0	7.40	7.30	24.09	27.11	24.81	25.67	79	80	3.5	79	80
15	4	9.00	31.5	7.90	7.40	24.83	32.81	20.60	23.98	85	84	3.0	78	79
16	4	8.50	31.0	7.70	7.60	23.14	27.16	23.37	24.59	89	86	9.0	81	82
17	4	8.40	31.0	7.80	7.80	35.07	23.64	26.37	22.86	89	83	7.0	84	79
18	4	8.30	31.0	7.00	7.10	32.39	37.98	27.85	40.96	81	78	1.2	82	79
19	5	10.24	33.5	8.60	8.40	22.87	28.42	22.76	25.86	91	86	3.0	84	83
20	5	10.15	33.5	8.20	8.50	27.50	24.34	24.87	27.18	84	90	2.0	79	83
21	5	9.55	32.8	8.40	8.30	24.66	28.65	23.64	22.57	82	91	5.0	78	83
22	5	9.38	32.0	8.40	9.00	18.52	26.71	22.19	23.12	89	88	9.5	82	82
23	5	9.30	32.5	8.10	8.60	30.09	37.13	23.39	28.12	84	88	5.0	81	84
24	5	13.00	38.0	8.20	8.10	36.17	45.81	31.44	28.10	91	91	3.0	87	86
25	5	10.38	33.0	8.00	8.30	24.61	30.93	23.98	24.30	84	90	5.0	79	84
26	5	10.52	35.0	8.30	8.60	18.02	20.91	24.93	23.72	93	90	2.0	86	82
27	5	11.02	34.5	7.80	8.10	19.18	21.79	23.87	23.37	82	88	2.5	78	82
28	5	11.22	36.5	7.90	8.10	26.71	23.57	24.77	23.91	95	94	4.0	85	84
29	5	11.30	36.5	8.60	8.60	29.78	30.35	25.87	25.66	82	93	5.0	78	86
30	5	11.44	36.5	8.40	8.30	32.59	33.53	26.41	27.67	91	92	1.5	85	88
31	5	12.44	37.0	8.40	8.40	27.62	28.88	24.60	24.77	86	93	3.0	80	85
32	5	12.33	39.0	8.40	8.30	24.91	24.58	24.39	23.52	89	93	5.0	81	85
33	5	12.28	38.0	8.60	8.60	22.83	24.23	24.30	23.87	85	91	4.0	79	83
34	5	12.18	38.0	8.60	8.30	26.23	23.89	25.15	26.81	95	94	3.5	85	87
35	5	12.07	38.5	8.60	8.60	23.14	29.86	24.97	24.97	96	93	3.0	87	86
36	5	12.03	37.0	8.60	8.80	28.37	35.00	26.97	25.46	90	95	3.0	84	90

Remark: Rp = Depth of Redox-potential at 0 mV

Table 7: Soil parameters measured at Don Hoi Lot during June 2008 to May 2009 (July 2008) (cont.)

Station	Date	Time	Temp. °C	Soil pH		TOM (mg/g dry wt)		Water content (%)		Sand composition (%)		RP (cm)	Medium grain size(µM)	
				upper	lower	upper	lower	upper	lower	upper	lower		upper	lower
1	2	9.30	32	8.20	8.30	44.97	34.93	30.38	29.21	16	20	1.5	34	38
2	2	9.43	32	7.80	8.10	26.70	24.42	28.88	24.45	16	23	1.5	33	42
3	2	9.54	32	7.90	8.10	31.73	24.58	25.25	24.90	20	18	1.0	35	35
4	2	10.05	32	8.00	8.20	21.41	18.56	23.05	22.74	40	47	1.0	57	61
5	2	10.19	32.5	8.00	8.90	26.49	24.06	26.47	25.95	44	54	1.5	59	65
6	2	10.30	32	8.20	8.30	46.12	44.43	31.15	31.24	48	45	0.8	61	60
7	2	12.00	33	8.10	8.40	26.94	25.01	25.78	26.51	22	24	0.8	32	34
8	2	11.45	33	8.30	8.50	23.16	31.64	25.67	25.95	46	55	4.0	61	70
9	2	11.35	33	8.40	8.60	23.65	23.99	23.71	24.90	47	52	5.0	61	63
10	2	11.20	33	8.40	8.60	23.00	21.62	24.32	24.53	59	45	11.0	67	60
11	2	11.08	32	8.20	8.30	23.56	13.64	23.21	21.90	48	74	10.0	61	73
12	2	12.15	33	7.50	7.60	26.92	35.67	23.74	24.81	68	70	2.5	71	73
13	2	12.30	33	7.90	8.10	26.89	19.51	24.87	24.17	46	54	1.0	60	65
14	2	12.42	33	7.80	7.70	29.05	19.77	29.39	24.74	45	69	2.0	59	74
15	2	13.00	33	8.00	8.00	23.48	28.57	24.16	23.78	59	61	10.0	67	68
16	2	13.10	33	7.80	8.20	26.15	26.05	24.33	22.65	69	55	9.0	73	65
17	2	13.20	33	8.10	8.20	24.13	23.53	24.52	22.69	60	73	6.5	69	74
18	2	13.30	33.0	8.00	8.40	26.02	29.93	27.78	27.78	68	68	3.0	73	73
19	3	8.50	31.0	8.30	8.50	19.08	21.82	23.74	23.17	80	72	7.0	77	74
20	3	8.40	31.0	8.30	8.50	19.83	24.81	23.88	22.78	71	76	9.0	73	78
21	3	8.27	30.0	8.60	8.60	24.66	28.46	22.34	22.37	64	64	12.0	70	72
22	3	8.20	30.0	8.50	8.60	25.65	16.08	22.16	24.04	73	78	7.5	74	76
23	3	8.16	30.0	8.20	8.10	18.65	36.28	21.74	25.12	63	67	3.0	70	73
24	3	11.25	34.0	7.90	8.20	22.47	37.94	26.51	29.69	67	63	1.0	72	69
25	3	9.10	31.0	7.90	7.90	20.71	24.97	23.46	22.87	68	84	5.0	71	79
26	3	9.18	32.0	7.70	7.80	16.71	25.17	22.49	21.62	78	83	9.0	75	77
27	3	9.28	32.0	7.90	8.10	19.16	19.98	23.37	22.49	73	82	5.0	73	77
28	3	9.39	31.5	8.10	8.20	25.12	19.00	22.79	22.75	78	81	7.5	75	78
29	3	9.48	32.0	8.30	8.30	21.98	31.31	23.00	25.06	59	77	3.0	67	76
30	3	10.02	32.0	8.30	8.40	20.14	31.63	22.42	23.97	78	80	3.0	77	79
31	3	11.00	33.0	8.10	8.40	21.45	29.35	22.94	22.14	77	75	9.0	74	75
32	3	10.55	32.5	8.30	8.30	22.58	16.56	21.32	22.08	80	73	6.0	76	74
33	3	10.47	32.5	8.50	8.50	19.32	30.02	22.31	23.79	81	86	6.5	76	79
34	3	10.35	33.0	8.00	8.20	20.93	23.30	23.20	23.19	76	84	5.0	75	79
35	3	10.28	32.0	8.10	8.20	27.17	31.26	24.70	24.09	77	81	2.0	76	79
36	3	10.17	32.5	8.10	8.30	32.78	34.52	30.84	25.07	76	81	2.0	76	80

Table 7: Soil parameters measured at Don Hoi Lot during June 2008 to May 2009 (August 2008) (cont.)

Station	Date	Time	Temp. °C	Soil pH		TOM (mg/g dry wt)		Water content (%)		Sand composition (%)		RP (cm)	Medium grain size (uM)		AVS (mg/g dry wt)
				upper	lower	upper	lower	upper	lower	upper	lower		upper	lower	
1	15	8:57	31.0	7.3	7.4	32.45	39.93	33.32	30.70	51	61	4.0	63	67	0.0031
2	15	9:05	31.0	7.5	7.5	25.03	48.45	28.37	29.79	50	46	4.0	62	60	0.0013
3	15	9:17	31.0	7.6	7.3	25.00	35.38	29.19	29.50	67	44	5.0	71	59	0.0018
4	15	9:30	33.0	7.5	7.3	22.98	34.78	27.48	34.62	80	50	4.0	77	63	0.0001
5	15	9:38	33.0	7.6	7.4	20.67	36.53	24.65	26.50	74	68	3.0	73	71	0.0027
6	15	9:45	33.0	7.6	7.3	44.83	40.58	25.92	25.37	66	59	2.5	71	68	0.0015
7	15	10:55	33.0	7.5	7.5	27.41	45.17	30.05	25.79	67	63	2.5	72	71	0.0000
8	15	10:45	33.0	7.4	7.5	26.12	32.29	23.83	24.56	68	66	3.0	71	70	0.0088
9	15	10:36	34.0	7.5	7.3	30.53	29.13	24.35	23.99	77	64	4.0	74	69	0.0000
10	15	10:27	34.0	7.6	7.4	21.21	31.03	24.05	23.80	79	65	13.0	75	71	0.0000
11	15	10:15	34.0	7.5	7.6	19.63	34.76	23.50	25.66	88	76	10.0	79	74	0.0000
12	15	10:04	33.0	7.5	7.5	26.96	38.00	27.00	28.70	90	86	3.0	84	81	0.0010
13	15	11:15	35.0	7.7	7.3	22.99	29.61	26.52	24.64	81	76	2.5	80	81	0.0000
14	15	11:23	34.0	7.7	7.6	78.88	26.97	26.54	25.31	82	75	2.5	80	78	0.0217
15	15	11:32	36.5	7.6	7.2	25.62	27.03	23.73	24.66	92	76	8.0	83	75	0.0000
16	15	11:45	37.0	7.6	7.6	18.56	27.09	23.08	22.63	90	73	10.0	81	74	0.0000
17	15	11:52	36.5	7.6	7.3	31.14	22.05	28.18	25.93	91	82	8.0	85	79	0.0000
18	15	12:00	36.0	7.5	7.4	33.26	35.97	24.92	27.24	90	78	3.0	86	78	0.0035
19	16	9:15	32.0	7.4	7.3	28.11	34.11	23.52	24.97	91	89	4.0	84	85	0.0011
20	16	9:00	32.0	7.3	7.5	23.35	31.82	24.52	24.76	84	90	2.5	79	83	0.0047
21	16	8:55	32.0	7.3	7.6	30.36	33.02	24.27	22.50	91	81	12.0	83	79	0.0000
22	16	8:46	31.0	7.2	7.6	30.26	34.70	22.36	22.18	89	92	9.0	81	85	0.0000
23	16	8:24	30.0	7.3	7.5	33.80	43.76	22.19	26.25	86	87	3.0	83	84	0.0058
24	16	11:40	36.0	7.4	7.7	34.55	35.08	22.93	25.57	90	86	5.0	84	82	0.0016
25	16	9:30	33.0	7.5	7.7	33.11	32.18	24.79	23.65	86	89	4.0	80	82	0.0010
26	16	9:40	34.0	7.3	7.5	29.60	26.01	25.84	23.53	91	89	4.0	81	82	0.0000
27	16	9:50	33.5	7.4	7.6	24.78	28.00	23.64	23.47	91	92	5.0	82	85	0.0004
28	16	10:00	34.0	7.4	7.7	26.17	28.88	24.52	23.58	87	92	9.0	80	82	0.0000
29	16	10:10	35.0	7.4	7.6	28.19	30.43	22.74	22.75	89	93	3.0	82	85	0.0008
30	16	10:20	33.0	7.3	7.6	29.44	31.48	29.44	24.83	89	90	3.0	84	85	0.0122
31	16	11:10	36.0	7.6	7.7	27.95	28.14	24.33	26.81	90	92	5.0	82	85	0.0000
32	16	11:00	35.0	7.6	7.8	26.09	31.85	24.91	23.63	90	93	4.0	81	86	0.0000
33	16	10:55	35.0	7.5	7.5	21.51	29.95	23.26	24.71	94	92	7.0	84	84	0.0003
34	16	10:52	34.0	7.6	7.7	31.42	30.95	27.87	22.94	90	96	4.0	82	87	0.0008
35	16	10:45	34.0	7.7	7.7	33.97	36.50	23.35	23.76	90	96	5.0	82	88	0.0000
36	16	10:35	33.5	7.6	7.7	37.43	41.00	31.58	25.93	90	94	3.0	85	88	0.0173

Remark: AVS= Acid volatile sulfide

Table 7: Soil parameters measured at Don Hoi Lot during June 2008 to May 2009 (September 2008) (cont.)

Station	Date	Time	Temp. °C	Soil pH		TOM (mg/g dry wt)		Water content (%)		Sand composition (%)		RP (cm)	Medium grain size(µM)	
				upper	lower	upper	lower	upper	lower	upper	lower		upper	lower
1	1	12.03	32	7.5	7.4	42.30	39.41	30.07	29.42	44	56	4	60	66
2	1	12.10	32	7.8	7.3	29.20	40.08	29.85	29.41	33	29	2.5	53	44
3	1	12.24	33	7.6	7.5	28.33	39.36	27.24	28.66	45	51	3	59	63
4	1	12.40	33	7.4	7.4	34.53	45.19	25.79	26.35	52	58	3	64	67
5	1	12.50	33	7.4	7.3	42.82	31.72	25.68	24.33	66	85	3	70	80
6	1	12.53	32	7.5	7.4	56.90	53.23	29.11	28.30	32	62	3	50	70
7	1	14.00	32	7.4	7.3	31.17	38.69	23.74	26.42	40	40	3	55	55
8	1	13.48	32	7.5	7.3	39.74	31.72	27.84	26.45	56	55	4	65	65
9	1	13.40	32	7.4	7.4	25.93	33.22	26.29	23.21	44	54	4	59	65
10	1	13.30	32	7.4	7.4	24.38	42.86	24.03	22.89	67	53	4	70	64
11	1	13.20	32	7.4	7.3	21.33	41.22	22.51	23.42	82	67	9	76	71
12	1	13.10	32	7.4	7.5	25.24	50.20	28.34	25.40	79	71	2.5	76	73
13	1	14.18	33	7.5	7.5	29.05	34.48	26.07	25.01	64	78	3	71	79
14	1	14.26	33	7.4	7.3	21.86	33.16	23.23	24.85	65	75	4	71	76
15	1	14.36	34	7.2	7.3	25.00	26.76	23.93	23.76	75	72	10	73	72
16	1	14.52	35	7.3	7.2	36.59	29.24	24.32	21.82	84	70	9	78	73
17	1	14.51	34	7.3	7.5	39.82	30.47	23.46	23.13	84	70	10	81	72
18	1	14.47	34	7.4	7.3	28.68	34.17	24.51	25.80	79	76	8	79	75
19	2	11.28	32	7.2	7.4	21.33	24.25	23.89	23.79	84	88	2	80	82
20	2	11.17	31	7.4	7.6	29.53	21.19	24.82	23.50	80	81	3	77	79
21	2	11.03	31.5	7.3	7.5	22.03	58.25	23.61	36.67	76	74	12	77	73
22	2	10.50	31	7.3	7.5	32.20	20.62	23.08	25.53	87	83	10	81	80
23	2	10.43	31	7.3	7.3	31.18	29.76	22.45	23.05	79	74	2.5	81	76
24	2	14.09	32	7.4	7.3	28.78	34.51	24.73	24.67	86	92	5	82	87
25	2	11.43	33	7.4	7.3	22.58	22.23	24.31	23.87	77	84	3	74	80
26	2	11.51	33.5	7.3	7.4	22.30	24.80	24.11	23.02	88	88	4	79	80
27	2	12.00	33	7.4	7.4	25.61	27.37	24.93	22.18	83	82	4	79	77
28	2	12.12	33	7.5	7.5	28.93	24.62	25.76	23.47	89	89	4	81	82
29	2	12.19	33	7.3	7.5	32.44	27.33	25.48	25.22	89	79	3	82	77
30	2	12.32	33	7.3	7.3	27.74	29.19	28.14	24.51	86	79	3	85	78
31	2	13.37	32	7.5	7.4	17.70	26.82	25.43	22.84	86	78	5	79	77
32	2	13.29	32	7.5	7.4	23.06	30.85	25.46	26.30	91	80	5.5	83	77
33	2	13.07	32	7.3	7.4	22.28	26.12	25.46	21.64	91	82	8	82	79
34	2	13.03	32	7.3	7.5	22.01	26.18	26.58	24.24	89	89	7	81	83
35	2	13.00	32	7.4	7.7	32.91	31.21	23.52	24.24	86	95	4	80	87
36	2	12.45	33	7.3	7.3	35.95	35.08	29.20	25.79	83	89	2	80	85

Table 7: Soil parameters measured at Don Hoi Lot during June 2008 to May 2009 (October 2008) (cont.)

Station	Date	Time	Temp. °C	Soil pH		TOM (mg/g dry wt)		Water content (%)		Sand composition (%)		RP (cm)	Medium grain size(uM)	
				upper	lower	upper	lower	upper	lower	upper	lower		upper	lower
1	5	2:57	27	7.5	7.2	31.56	36.48	29.92	26.64	43	47	3	59	61
2	5	2:46	28	7.3	7.3	51.00	41.36	30.73	30.15	47	62	7	61	69
3	5	2:34	28	7.4	7.3	43.40	27.49	27.74	27.03	68	54	5	72	65
4	5	2:20	27	7.3	7.3	41.07	30.99	24.78	25.58	73	71	4	73	73
5	5	3:23	27	7.2	7.4	36.63	29.07	29.78	28.12	67	71	4.5	71	74
6	5	3:30	27	7.2	7.4	51.13	44.36	33.51	29.02	63	75	2	69	77
7	5	4:56	27	7.2	7.2	49.41	30.08	26.91	27.38	59	69	1.5	68	74
8	5	4:43	26	7.3	7.4	32.72	27.84	24.15	28.84	60	49	2	67	62
9	5	2:14	27	7.2	7.4	35.60	27.81	24.67	24.71	72	72	6	72	74
10	5	4:28	26	7.2	7.2	27.48	23.75	25.29	26.65	65	70	5	69	72
11	5	4:11	27	7.3	7.5	40.70	31.67	24.12	23.26	84	73	8	78	74
12	5	3:57	26	7.3	7.3	38.01	31.38	26.83	26.24	82	78	3.5	78	77
13	5	5:42	26	7.3	7.3	32.35	29.11	26.79	25.35	77	75	3	73	79
14	5	5:30	26	7.3	7.3	30.99	27.32	23.23	26.11	76	70	3	77	75
15	5	5:11	26	7.2	7.3	28.00	24.62	24.36	23.77	87	80	4	77	76
16	5	1:59	27	7.2	7.3	21.78	23.06	22.98	24.65	88	80	8	80	77
17	5	5:55	26	7.1	7.3	27.95	24.38	23.69	25.33	87	83	7	82	80
18	5	6:05	26	7.2	7.3	32.66	31.38	26.96	27.51	79	79	4.5	80	81
19	6	1:43	27	7.3	7.2	35.53	17.40	22.26	22.59	87	81	6	80	79
20	6	1:29	27	7.3	7.5	39.64	24.07	22.96	24.36	81	74	5	77	75
21	6	1:15	27	7.4	7.4	30.16	18.35	23.80	21.44	89	78	9	80	77
22	6	1:04	27	7.5	7.6	36.98	26.30	23.05	23.54	89	82	8	81	78
23	6	1:05	27	7.5	7.6	35.38	27.74	22.42	22.77	77	76	7	77	76
24	6	4:46	26	7.3	7.5	53.69	33.49	25.34	26.65	85	82	5.5	81	80
25	6	1:59	27	7.4	7.6	41.34	24.60	22.83	24.49	90	85	6	82	80
26	6	2:14	26	7.4	7.6	38.99	29.22	24.97	21.53	90	78	3	80	76
27	6	2:29	27	7.4	7.5	30.30	19.83	23.37	22.82	86	86	6	78	80
28	6	2:40	26	7.4	7.5	28.01	21.59	25.30	23.60	81	87	5.5	76	79
29	6	2:51	27	7.5	7.6	34.12	20.45	27.65	22.99	81	85	5	77	83
30	6	3:03	27	7.5	7.7	48.45	29.74	28.69	23.85	87	89	4	83	86
31	6	4:24	27	7.5	7.6	37.83	25.39	24.64	22.36	87	85	3.5	83	80
32	6	4:11	27	7.6	7.6	42.19	27.45	25.48	27.80	90	84	6	81	79
33	6	4:00	26	7.6	7.6	35.53	22.67	23.42	24.76	82	84	7	77	80
34	6	3:45	27	7.6	7.5	40.18	29.57	24.04	21.67	82	91	6	78	83
35	6	3:35	27	7.6	7.7	51.64	30.74	26.65	23.84	85	85	1	80	81
36	6	3:23	27	7.7	7.6	43.61	30.32	25.72	27.27	85	89	3	81	84

Table 7: Soil parameters measured at Don Hoi Lot during June 2008 to May 2009 (November 2008) (cont.)

Station	Date	Time	Temp. °C	Soil pH		TOM (mg/g dry wt)		Water content (%)		Sand composition (%)		RP (cm)	Medium grain size(µM)	
				upper	lower	upper	lower	upper	lower	upper	lower		upper	lower
1	4	1.39	27	7.3	7.8	37.31	34.48	26.01	24.90	18	10	1	39	20
2	4	1.33	26.5	7.6	7.7	50.55	35.07	24.34	26.81	11	9	3	28	15
3	4	1.21	27	7.3	7.8	34.57	38.65	26.54	25.85	27	11	3	46	11
4	4	1.45	27	7.5	7.6	31.25	19.63	23.14	21.33	27	18	3.5	49	37
5	4	1.54	27	7.4	7.7	30.41	26.37	25.35	24.12	33	17	3	53	33
6	4	2.10	27	7.4	7.8	56.08	51.50	30.64	26.71	38	31	2	54	48
7	4	3.15	26.5	7.4	7.7	30.99	33.20	28.20	22.90	21	19	3	33	30
8	4	3.07	26	7.5	7.5	57.23	33.30	28.63	24.84	14	12	1	33	26
9	4	0.54	26	7.6	7.5	54.08	38.39	25.43	24.29	22	14	5	43	28
10	4	2.20	26	7.3	7.3	25.97	30.92	22.48	21.90	75	12	5	73	27
11	4	2.30	26	7.4	7.1	46.17	31.92	22.79	26.28	64	31	11	69	50
12	4	2.50	26	7.5	7.4	29.22	37.45	24.30	27.27	75	47	3	75	61
13	4	4.02	26	7.3	7.3	29.34	33.36	26.72	24.04	50	44	2	62	58
14	4	3.48	26	7.5	7.4	33.56	26.03	23.01	21.94	63	41	3	71	55
15	4	0.34	27	7.3	7.5	42.71	35.50	23.57	23.78	60	38	4.5	70	55
16	4	0.21	27	7.7	7.3	27.79	21.70	22.64	22.04	77	41	6	75	56
17	4	4.29	26	7.4	7.4	25.00	28.45	22.63	22.86	71	55	8	74	65
18	4	4.43	27	7.2	7.5	53.01	48.23	27.21	25.48	84	23	4.5	82	35
19	5	0.41	27	7.6	7.2	24.25	18.95	31.03	21.48	70	53	3	73	64
20	5	0.24	27	7.5	7.6	21.41	22.72	22.22	21.02	79	67	2	76	71
21	5	0.12	27	7.3	7.5	22.09	26.02	21.47	20.06	68	65	10	71	70
22	5	23.58	27	7.4	7.6	33.02	30.84	22.58	23.44	69	67	4	71	72
23	5	23.40	28	7.3	7.4	40.58	28.81	23.46	23.34	71	56	6	74	67
24	5	4.06	26	7.3	7.5	35.82	48.07	25.05	25.40	73	67	0.5	75	72
25	5	0.59	27	7.2	7.5	38.32	35.20	23.16	22.54	72	60	4	73	68
26	5	1.11	27	7.2	7.6	35.81	32.59	23.55	23.84	72	59	5	72	67
27	5	1.25	27	7	7.4	33.21	26.87	26.63	21.67	89	79	3	80	76
28	5	1.43	27	7.4	7.3	17.39	42.60	22.89	23.30	79	75	6.5	75	74
29	5	1.58	28	7.2	7.5	43.01	32.90	24.83	22.28	55	68	5	65	73
30	5	2.13	27	7.2	7.5	33.40	33.42	25.01	21.94	72	78	4.5	74	79
31	5	3.38	26	7.2	7.4	20.79	35.50	23.26	20.40	76	80	7.5	75	80
32	5	3.26	27	7.1	7.5	25.45	22.86	24.01	22.60	85	83	5	79	78
33	5	3.13	27	7.2	7.6	20.79	35.91	24.75	22.55	82	80	7	77	77
34	5	3.03	27	7.2	7.2	24.87	30.16	22.00	21.63	68	83	6.5	71	79
35	5	2.48	27	7.2	7.4	37.63	44.21	21.80	22.06	69	78	3	72	78
36		2.33	27	7.4	7.4	48.49	43.23	24.80	23.75	68	76	2.5	73	78

Table 7: Soil parameters measured at Don Hoi Lot during June 2008 to May 2009 (December 2008) (cont.)

Station	Date	Time	Temp. °C	Soil pH		TOM (mg/g dry wt)		Water content (%)		Sand composition (%)		RP (cm)	Medium grain size (uM)		AVS (mg/g dry wt)
				upper	lower	upper	lower	upper	lower	upper	lower		upper	lower	
1	3	2:55	22	7.5	7.6	35.29	63.34	25.83	28.06	70	74	0.5	71	75	0.1313
2	3	2:47	22	7.4	7.6	37.47	43.89	29.27	29.71	74	76	0.5	74	76	0.0770
3	3	2:35	22	7.3	7.4	32.21	63.00	25.14	27.19	78	85	0.5	76	80	0.0011
4	3	1:56	22	7.3	7.4	45.84	36.22	24.08	23.62	80	89	5	75	81	0.0017
5	3	2:10	22	7.3	7.6	41.58	51.31	24.85	27.09	87	84	2.5	80	79	0.0108
6	3	2:19	22	7	7.6	79.94	47.89	25.20	26.83	79	84	1	76	80	0.0187
7	3	3:32	22	7.1	7.6	74.64	38.81	29.16	24.91	82	82	4	79	81	0.0036
8	3	3:17	22	7.1	7.6	76.16	54.27	24.59	24.85	73	67	4	73	71	0.0016
9	3	1:31	22	6.9	7.4	33.42	37.43	24.62	24.77	74	87	3	74	80	0.0000
10	3	3:49	21	6.8	7.6	26.07	34.01	24.35	23.59	87	76	3.5	80	75	0.0000
11	3	4:10	21	7.2	7.6	26.08	36.65	22.75	23.05	86	90	8	79	81	0.0000
12	3	4:21	22	7.2	7.6	39.84	41.56	27.04	23.15	85	91	2	80	84	0.0073
13	3	1:21	23	7.6	7.6	29.86	39.55	26.11	23.71	89	90	4	86	88	0.0008
14	3	0:56	22	7.6	7.6	31.95	31.17	21.44	23.85	87	88	3.5	84	87	0.0006
15	3	0:43	22	7.6	7.5	32.20	39.57	21.39	23.36	86	89	3	80	81	0.0000
16	3	0:28	23	7.5	7.6	29.18	49.75	24.24	23.41	91	81	10	83	78	0.0000
17	3	0:14	23	7.9	7.5	32.30	34.63	21.72	22.21	91	90	7.5	86	84	0.0000
18	3	0:00	23	7.8	7.5	35.76	40.28	23.64	24.17	83	88	3	83	87	0.0027
19	2	1:03	21	7.4	7.1	47.93	34.86	20.96	23.26	90	93	3.5	85	87	0.0016
20	2	0:44	21	7.8	7.2	26.62	37.51	24.09	24.46	88	94	4	82	88	0.0113
21	2	0:26	21	7.5	7.2	45.63	25.75	23.02	21.00	88	82	10.5	83	79	0.0000
22	2	0:06	21	7.2	7.3	39.29	26.26	22.98	20.95	88	87	9	81	79	0.0000
23	2	23:45	22	6.8	7.3	11.90	28.36	25.56	22.19	86	85	3.5	81	83	0.0023
24	2	4:13	21	7.3	7.3	38.64	30.56	29.20	23.76	80	88	8	79	84	0.0079
25	2	1:25	21	7.4	7.1	42.39	29.70	23.16	23.15	93	93	4.5	85	85	0.0000
26	2	1:44	21	7.1	7.2	33.98	29.12	23.65	22.84	94	90	3	84	82	0.0007
27	2	1:59	20	7.6	7.2	22.24	32.17	18.52	21.12	96	92	4.5	89	86	0.0000
28	2	2:10	20	7.6	7	22.03	26.40	22.36	22.64	86	93	3	79	84	0.0006
29	2	2:28	21	7.8	7	28.20	33.60	24.05	21.35	88	87	3	82	81	0.0093
30	2	2:40	21	7.3	7.2	26.85	27.08	24.49	24.46	90	84	1	86	81	0.0183
31	2	3:48	20	7.4	7.2	17.79	27.84	22.45	22.93	88	92	4	83	84	0.0105
32	2	3:37	20	7.2	7	19.04	30.89	24.82	25.13	90	88	4	82	82	0.0018
33	2	3:25	21	7.3	7.2	48.03	30.38	22.96	22.66	94	94	3	85	87	0.0098
34	2	3:15	21	7.5	7.3	40.15	31.14	23.93	21.59	81	85	1	77	82	0.0139
35	2	3:07	21	7.4	7.4	31.34	32.16	25.31	22.47	88	94	2	82	86	0.0047
36	2	3:01	21	7.3	7.4	48.11	40.91	31.85	24.65	89	89	1	84	86	0.0429

Table 7 Soil parameters measured at Don Hoi Lot during June 2008 to May 2009 (January 2009) (cont.)

Station	Date	Time	Temp. °C	Soil pH		TOM (mg/g dry wt)		Water content (%)		Sand composition (%)		RP (cm)	Medium grain size(uM)	
				upper	lower	upper	lower	upper	lower	upper	lower		upper	lower
1	16	0.33	21	7	7.2	47.73	47.28	31.92	27.11	63	44	0	69	59
2	16	0.43	21	7.1	7.2	47.81	43.08	31.10	26.34	81	70	0	76	72
3	16	0.50	21	7.2	7.4	43.94	43.50	30.58	28.42	73	73	0	73	74
4	16	0.55	20	7.3	7.4	42.23	39.15	24.03	27.86	74	71	1	73	72
5	16	1.02	20	7.5	7.5	51.26	48.02	27.26	24.98	81	85	1.5	76	79
6	16	1.10	21	7.6	7.4	67.52	58.68	41.02	26.36	68	64	0	72	71
7	16	2.09	19	7.5	7.2	46.13	58.12	33.58	26.67	72	82	2	75	81
8	16	2.00	19	7.3	7.3	39.80	43.24	25.68	27.18	66	77	1	70	75
9	16	1.49	19	7.3	7.4	50.58	60.53	31.17	24.94	78	69	4	76	73
10	15	23.58	20	7.2	7.3	46.87	36.86	23.05	22.70	87	87	5	80	81
11	16	1.25	19	7.2	7.5	34.74	32.95	23.58	25.10	92	88	6	82	81
12	16	1.39	19.5	7.3	7.4	50.05	37.26	30.35	27.06	82	88	2	78	81
13	16	2.36	19	7.3	7.3	37.09	36.06	26.21	24.62	83	79	0	82	81
14	16	2.24	19	7.3	7.4	41.15	39.39	24.58	29.47	81	84	5	80	82
15	16	2.47	18	7.4	7.4	34.56	34.01	23.40	23.72	84	77	4	78	75
16	16	2.56	18	7.2	7.3	31.21	57.74	23.78	23.54	95	71	11	85	72
17	16	3.05	18.5	7.3	7.3	34.16	39.38	24.13	25.27	89	88	8	83	82
18	16	3.16	18	7.5	7.6	41.63	48.88	27.85	29.71	90	88	2	86	85
19	15	0.50	21	7.2	7.1	31.94	43.42	24.36	23.38	88	87	3	83	82
20	15	0.39	21	7.2	7.1	38.18	37.97	22.11	23.73	87	88	5	81	82
21	15	0.22	20	7.2	7.1	29.27	41.60	22.32	21.96	87	84	5	81	79
22	15	0.05	20	7	7.1	30.59	48.60	21.22	22.91	91	77	10	83	77
23	14	23.50	21	7	7.1	24.47	45.98	29.23	26.55	89	84	1.5	83	81
24	14	23.45	18	7.2	7.2	45.08	47.42	24.95	25.49	89	88	2	84	84
25	15	1.07	21	7.2	7.1	27.41	41.84	23.62	22.25	90	91	4	82	84
26	15	1.25	20	7.2	7.2	39.23	38.93	23.75	22.69	95	88	5	84	81
27	15	1.38	20	7.1	7.3	43.05	37.24	23.47	22.78	86	87	5	80	80
28	15	1.45	20	7	7.1	39.75	41.32	23.29	22.64	88	89	4	81	82
29	15	1.56	20	7	7	36.44	45.40	23.12	22.50	89	91	0.5	82	84
30	15	2.07	20	7.1	7.1	42.15	44.33	24.70	22.68	90	89	1	84	85
31	15	3.16	20	7.3	7	31.57	48.03	26.54	23.90	89	89	4	81	83
32	15	3.03	20	7.1	7.1	37.65	36.96	26.04	23.01	90	91	8	81	82
33	15	2.48	20	7.1	7.1	51.06	42.17	23.19	22.73	93	89	9	85	82
34	15	2.40	20	7.1	7	33.70	42.04	27.34	23.01	91	90	1	83	83
35	15	2.30	20	7.2	7.1	38.09	48.91	31.64	24.68	92	92	2	84	85
36	15	2.20	20	7.1	7	54.29	44.21	31.75	26.44	90	92	1	84	88

Table 7 Soil parameters measured at Don Hoi Lot during June 2008 to May 2009 (February 2009) (cont.)

Station	Date	Time	Temp. °C	Soil pH		TOM (mg/g dry wt)		Water content (%)		Sand composition (%)		RP (cm)	Medium grain size(uM)	
				upper	lower	upper	lower	upper	lower	upper	lower		upper	lower
1	25	0.18	27	7.6	7.5	42.66	38.30	24.80	30.47	58	82	3	66	80
2	25	0.09	27	7	7.7	37.07	44.26	26.14	24.28	67	55	3	71	68
3	25	0.00	27	7.7	7.7	33.68	34.70	23.94	26.98	73	75	3	74	75
4	25	0.32	26.5	7.5	7.8	29.76	31.52	22.34	23.32	87	84	2.5	79	81
5	25	0.41	26.5	7.4	7.8	43.39	34.23	25.73	24.57	83	77	3	78	76
6	25	0.48	26.5	7.4	7.9	42.35	39.06	25.63	24.07	78	82	0.5	77	79
7	24	23.42	27	7.6	7.5	40.21	48.40	23.93	25.74	72	69	3.5	74	73
8	24	23.34	27	7.5	7.8	36.62	39.68	27.73	23.18	64	84	2.5	69	80
9	24	23.25	27	7.5	7.7	34.28	30.87	24.18	25.15	68	82	2	71	78
10	25	1.19	26	7.5	7.6	31.94	46.95	23.49	23.75	64	88	3	71	84
11	25	1.11	26	7.4	7.7	35.15	40.05	24.34	27.82	91	98	3	81	88
12	25	1.02	26	7.4	7.6	43.89	35.62	29.25	24.81	82	90	3	78	85
13	24	23.08	27	7.3	7.3	33.94	47.62	28.18	22.67	80	87	2	82	80
14	24	22.57	27	7.5	7.4	29.04	31.43	22.26	23.49	79	80	2.5	79	82
15	24	22.48	27	7.7	7.7	24.44	36.41	23.19	25.25	89	82	2	80	80
16	24	22.30	27	7.5	7.6	29.99	43.06	23.05	23.25	70	78	2	73	77
17	25	1.39	26	7.6	7.5	38.82	42.25	22.68	25.15	89	93	1	83	90
18	25	1.51	26	7.4	7.5	29.08	35.68	23.67	24.89	81	86	2	81	83
19	23	22.11	27.5	7.5	7.4	30.92	27.57	23.01	25.21	92	88	2	86	83
20	23	22.00	27	7.5	7.6	26.78	33.27	22.64	24.38	89	88	3	82	83
21	23	21.50	27	7.6	7.6	26.91	28.39	25.52	21.12	80	88	4	79	81
22	23	21.40	27	7.5	7.7	28.97	33.38	22.03	20.90	91	90	11	82	82
23	23	21.28	28	7.5	7.7	25.45	36.94	22.42	26.76	90	89	2	83	86
24	23	21.23	28	7.4	7.5	33.47	42.41	22.60	23.26	71	86	4	75	85
25	23	22.22	27	7.3	7.6	27.65	30.68	23.26	23.31	91	82	1.5	83	81
26	23	22.34	27	7.4	7.6	29.60	26.76	22.92	22.32	82	88	4	76	82
27	23	22.47	27	7.4	7.5	29.99	28.77	22.06	24.27	89	85	4	81	79
28	23	22.59	28	7.4	7.6	27.54	39.16	23.43	26.38	90	97	4	81	87
29	23	23.08	27	7.3	7.5	46.30	31.79	28.70	25.38	76	94	1.5	77	87
30	23	23.10	27	7.3	7.7	49.68	33.01	25.73	24.35	87	89	1	84	85
31	23	24.00	27	7.3	7.7	33.06	33.65	23.58	25.27	89	88	3	82	83
32	23	23.57	27	7.4	7.6	35.85	34.47	23.25	24.75	87	95	2	80	86
33	23	23.54	27	7.3	7.7	30.28	28.06	25.05	24.28	82	91	2	78	85
34	23	23.43	27	7.4	7	29.93	31.46	24.65	26.26	86	87	0	80	80
35	23	23.36	27	7.5	7.4	42.57	37.52	24.39	23.57	86	91	2	82	85
36	23	23.30	27	7.5	7.6	46.86	36.13	30.03	25.89	90	95	1	85	88

Table 7: Soil parameters measured at Don Hoi Lot during June 2008 to May 2009 (March 2009) (cont.)

Station	Date	Time	Temp. °C	Soil pH		TOM (mg/g dry wt)		Water content (%)		Sand composition (%)		RP (cm)	Medium grain size(µM)	
				upper	lower	upper	lower	upper	lower	upper	lower		upper	lower
1	8	19:56	28.5	7.4	7.5	42.64	48.09	29.41	25.22	14	12	3	31	22
2	8	19:43	29	7.4	7.4	45.25	51.38	27.81	25.04	9	11	2	7	16
3	8	19:39	28	7.5	7.4	39.52	48.14	27.12	28.76	20	12	3	31	20
4	8	20:06	28	7.5	7.4	19.49	58.86	23.02	23.97	6	15	2	15	33
5	8	20:18	28	7.1	7.5	32.27	48.12	24.64	23.42	86	28	3	84	47
6	8	20:27	28	7.2	7.4	50.13	54.72	29.58	25.55	16	18	2	30	31
7	8	19:21	29	7.4	7.4	34.39	48.99	27.68	24.76	25	18	2	35	19
8	8	19:10	29	7.3	7.5	32.61	46.09	24.77	24.75	6	8	1	12	13
9	8	19:00	29	7.4	7.4	26.74	33.73	23.39	21.98	17	12	2	28	25
10	8	20:42	28	7.5	7.5	26.68	32.10	23.54	23.81	74	13	3	73	25
11	8	20:53	28	7.6	7.5	35.70	30.60	22.88	23.04	8	17	4	21	37
12	8	21:08	28	7.4	7.4	44.69	37.33	23.78	25.45	57	33	0	66	46
13	8	21:58	28	7.5	7.5	23.99	28.50	21.47	23.79	60	49	2	71	61
14	8	21:47	28	7.6	7.4	29.56	29.44	22.75	22.78	39	44	2	50	57
15	8	18:47	29	7.5	7.3	26.62	35.52	23.83	22.74	67	45	3	70	58
16	8	18:35	30	7.9	7.5	33.23	31.98	22.96	22.36	65	35	9	73	52
17	8	21:23	29	7.7	7.4	32.16	59.90	23.47	22.55	71	23	4	73	35
18	8	21:33	28	7.8	7.3	33.96	75.38	29.18	28.27	53	32	2	64	46
19	9	21:33	29	6.9	7.2	29.37	52.46	22.40	22.36	77	40	2	77	55
20	9	21:30	29	7.3	7.3	23.88	73.58	21.67	22.20	67	39	3.5	72	54
21	9	21:07	29	7.2	7.3	25.91	75.11	22.26	21.63	60	61	4	68	68
22	9	20:55	29	7.1	7.2	40.63	60.49	22.48	22.63	63	69	4	69	73
23	9	20:43	29	7.2	7.4	58.28	57.32	23.13	22.51	58	56	0	68	67
24	9	0:11	28.5	7.1	7.7	56.66	38.10	27.44	23.63	68	54	6.5	74	66
25	9	21:50	29	7.2	7.3	64.90	33.86	23.60	22.11	62	67	1	68	71
26	9	22:02	29	7.2	7.3	53.25	39.27	21.76	21.10	70	69	3	72	72
27	9	22:15	28.5	7.3	7.2	21.35	40.65	22.90	22.84	87	73	2	80	74
28	9	22:27	29	7.4	7.3	17.19	35.19	22.83	23.54	78	73	1	75	73
29	9	22:39	29	7.5	7.4	24.56	32.69	25.98	20.98	85	79	2	80	76
30	9	22:48	29	7.2	7.5	23.97	54.45	26.84	24.23	38	65	1	54	72
31	9	23:45	28.5	7.3	7.3	20.32	19.48	27.54	22.33	72	77	0.5	74	75
32	9	23:38	28.5	7.3	7.2	24.57	35.92	21.54	21.29	77	71	1	76	72
33	9	23:29	28.5	7.4	7.6	28.16	40.72	21.60	21.01	72	74	1	74	74
34	9	23:18	28.5	7.4	7.6	30.59	42.64	25.88	20.80	74	75	4	74	123
35	9	23:10	29	7.2	7.4	35.56	41.20	28.48	23.22	76	81	3	76	79
36	9	23:06	29	7.5	7.4	34.79	43.77	25.62	22.85	72	71	1	74	74

Table 7: Soil parameters measured at Don Hoi Lot during June 2008 to May 2009 (April 2009) (cont.)

Station	Date	Time	Temp. °C		Soil pH		TOM (mg/g dry wt)		Water content (%)		Sand composition (%)		RP (%)		Medium grain size (µM)		AVS (mg/g dry wt)
			upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	
1	2	14.25	35	7.3	7.5	42.50	50.20	28.24	25.08	82	63	2	69	0.0033			
2	2	14.17	35.5	7.4	7.7	34.84	50.57	25.03	28.42	79	61	3	77	0.0149			
3	2	14.08	36	7.3	7.4	60.05	51.49	27.35	25.18	77	73	4	76	0.0056			
4	2	14.38	36	7.5	7.5	65.43	37.82	23.38	26.42	68	78	4	70	0.0015			
5	2	14.49	35	7.5	7.5	32.37	44.77	24.87	20.58	83	84	2	78	0.0286			
6	2	14.57	33.5	7.5	7.5	60.33	50.46	29.47	24.95	87	73	5	81	0.0330			
7	2	13.32	34	7.3	7.4	68.59	47.34	27.23	24.61	79	87	3	79	0.0279			
8	2	13.20	35	7.4	7.4	65.79	87.67	25.05	25.26	87	67	3	79	0.0062			
9	2	13.47	36.5	7.3	7.5	45.72	45.33	23.12	25.86	81	61	3	76	0.0280			
10	2	15.17	36	7.3	7.6	25.34	34.63	23.71	23.58	84	77	10	78	0.0009			
11	2	15.29	35.5	7.3	7.4	71.07	39.09	22.32	22.21	91	75	9.5	81	0.0000			
12	2	15.39	36	7.4	7.5	47.83	38.30	27.90	22.36	88	73	1	83	0.0299			
13	2	16.30	36	7.8	7.4	39.42	41.80	24.62	23.03	87	79	2	85	0.0006			
14	2	16.19	36	7.6	7.5	28.61	71.38	23.46	24.04	88	79	1.5	85	0.0189			
15	2	16.10	36	7.6	7.6	31.02	77.83	22.67	23.71	88	81	3	81	0.0015			
16	2	16.00	36	7.6	7.6	24.73	70.00	23.45	23.62	84	69	8	79	0.0000			
17	2	16.45	36	7.5	7.6	25.26	42.00	26.67	20.82	90	82	2	85	0.0008			
18	2	16.55	35.5	7.4	7.6	46.04	49.98	28.34	24.92	84	84	1.5	83	0.0122			
19	1	13.10	35	7.3	7.8	32.39	58.45	21.80	21.57	89	79	5	85	0.0000			
20	1	12.55	34	7.2	7.9	49.69	58.79	23.16	22.71	83	84	4	80	0.0000			
21	1	12.47	34	7.2	7.6	51.34	36.62	22.83	21.23	83	81	4	80	0.0000			
22	1	12.32	34	7.2	7.8	72.32	64.02	21.74	18.75	90	80	9.5	83	0.0000			
23	1	12.23	34	7.3	7.6	64.20	61.14	26.02	20.83	88	75	2	84	0.0029			
24	1	15.40	35	7.3	7.4	97.46	56.50	22.88	22.11	86	78	4	82	0.0028			
25	1	13.20	35	7.3	7.3	61.62	45.80	21.57	21.95	93	83	3	84	0.0018			
26	1	13.27	36	7.3	7.4	37.92	41.50	22.92	22.37	92	74	4	82	0.0000			
27	1	13.44	35	7.3	7.5	22.97	33.31	22.66	21.61	78	79	3	77	0.0009			
28	1	13.47	36	7.3	7.4	24.92	32.97	19.97	23.04	82	87	3	82	0.0022			
29	1	13.59	34	7.3	7.3	35.92	43.83	28.31	22.73	90	80	2	83	0.0120			
30	1	14.08	34	7.3	7.4	40.50	51.01	28.18	23.00	90	78	2	88	0.0225			
31	1	15.07	34	7.3	7.5	40.59	40.58	24.05	19.93	87	73	2	81	0.0031			
32	1	14.58	34	7.2	7.2	44.78	46.19	32.07	19.59	88	86	2	81	0.0015			
33	1	14.49	34	7.3	7.3	48.65	38.04	26.02	21.58	88	84	1	82	0.0060			
34	1	14.43	34	7.2	7.5	40.36	50.33	27.81	21.00	89	83	1	83	0.0099			
35	1	14.33	34	7.3	7.4	43.60	48.90	28.17	21.90	86	87	0.5	82	0.0026			
36	1	14.30	34	7.3	7.3	56.46	60.19	33.20	28.06	90	86	1	85	0.0320			

Table 7: Soil parameters measured at Don Hoi Lot during June 2008 to May 2009 (May 2009) (cont.).

Station	Date	Time	Temp. °C	Soil pH		TOM (mg/g dry wt)		Water content (%)		Sand composition (%)		RP (cm)	Medium grain size(µM)	
				upper	lower	upper	lower	upper	lower	upper	lower		upper	lower
1	2	15:30	35	8.3	7	38.32	65.30	25.82	24.36	91	84	4	86	78
2	2	15:22	35	8.8	7	65.46	35.13	27.72	26.15	74	81	3	75	77
3	2	15:13	35	8.6	7	39.76	23.40	28.22	22.96	61	74	4	68	76
4	2	15:42	35	8.2	7.1	34.51	40.94	23.75	25.85	74	75	2	74	74
5	2	15:52	34	8	7.1	72.37	38.62	23.81	25.84	73	64	5	73	69
6	2	15:59	34	8.1	7.2	33.33	34.50	26.00	23.86	76	65	3	77	71
7	2	14:54	34	7	7.3	75.23	40.06	29.02	26.47	64	75	2	72	78
8	2	14:45	35	7	7	75.10	29.45	22.48	26.31	65	68	3	70	71
9	2	14:28	35	7.1	7	71.75	11.74	25.06	25.11	71	76	3	72	74
10	2	14:20	34	7.1	7	21.04	27.51	23.05	23.77	67	88	3	71	80
11	2	16:22	34	7	7.1	11.99	41.55	23.80	22.75	86	90	8	80	81
12	2	16:13	33	7.1	7.2	42.07	42.95	30.71	23.77	84	81	1	79	78
13	2	14:12	34	6.9	7.5	36.06	39.69	22.08	23.59	82	78	2	83	81
14	2	13:55	35	7	7	31.81	22.75	22.82	23.55	75	81	3	78	81
15	2	13:47	35.5	7.4	7	24.80	37.55	23.10	23.79	77	84	2	75	78
16	2	13:35	33	7	7.3	24.65	25.58	24.03	24.15	83	92	6.5	80	83
17	2	17:07	33	6.9	7.1	37.69	44.77	28.28	22.59	83	77	1.5	79	80
18	2	17:15	33	7.1	7	38.29	31.02	29.36	25.69	83	75	2	82	78
19	1	14:16	37	6.9	7	36.53	29.42	23.41	24.32	84	87	3	83	83
20	1	14:06	37	6.9	6.9	26.06	31.15	21.15	21.81	86	89	3	80	82
21	1	13:56	37	6.9	7.1	50.58	33.44	23.02	22.11	86	91	8	82	82
22	1	13:44	34	7	7.1	31.34	34.00	22.50	22.07	85	89	5	80	82
23	1	13:30	35	7	7.3	36.06	41.93	23.56	22.41	85	83	4	84	80
24	1	16:43	36	7.2	7.4	65.32	36.77	24.77	24.47	82	79	2	81	79
25	1	14:33	37.5	6.7	7	61.44	33.67	24.44	23.25	89	84	6.5	82	80
26	1	14:42	37	6.8	7.6	40.54	5.23	22.06	21.62	84	92	2	80	82
27	1	14:49	38	6.7	7	58.37	14.57	23.45	22.88	88	89	3	82	81
28	1	15:00	35	6.8	7	23.35	31.58	24.89	23.16	90	85	1	82	78
29	1	15:08	35	6.8	7	11.97	33.03	27.15	27.20	91	84	1	84	82
30	1	15:16	36	6.8	7.1	36.47	26.42	32.03	25.39	95	94	3	89	87
31	1	16:40	36.5	6.7	6.8	29.20	14.66	24.76	22.63	93	91	3	84	83
32	1	16:02	36	7	7	30.65	14.66	24.76	22.35	91	91	3	85	82
33	1	16:00	36	7.1	7	35.54	22.44	29.60	23.16	75	87	1	75	81
34	1	15:51	35.5	7	7.1	43.66	33.94	29.62	22.58	93	92	2	85	83
35	1	15:44	35.5	7.2	7.4	54.78	32.29	33.13	24.67	94	89	3	86	82
36	1	15:35	36	7.1	7.3	44.94	26.49	31.79	24.49	74	86	3	74	82

Table 8: Statistic analysis for Soil parametersAnalysis of Variance for soil temperature (°C) ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	23.910	5	4.782	9.289	.000
-Months	10,825.676	11	984.152	1,911.663	.000
2-Factor Interaction	329.968	55	5.999	11.654	.000
Residual	185.333	360	.515		
Total (Corrected)	11,364.887	431			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	.881	5	.176	.126	.986
-Months	10,825.676	11	984.152	705.415	.000
2-Factor Interaction	36.081	55	.656	.470	1.000
Residual	502.250	360	1.395		
Total (Corrected)	11,364.887	431			

Table 8: Statistic analysis for Soil parameters (cont.).Analysis of Variance for pH in the upper soil layer ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	.010	5	.002	4.629	.000
-Months	.561	11	.051	122.986	.000
2-Factor Interaction	.214	55	.004	9.394	.000
Residual	.149	360	.000		
Total (Corrected)	.934	431			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	.001	5	.000	.247	.941
-Months	.561	11	.051	51.761	.000
2-Factor Interaction	.017	55	.000	.318	1.000
Residual	.355	360	.001		
Total (Corrected)	.934	431			

Table 8: Statistic analysis for Soil parameters (cont.).

Analysis of Variance for pH in the lower soil layer ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	.009	5	.002	4.341	.001
-Months	.635	11	.058	141.031	.000
2-Factor Interaction	.210	55	.004	9.300	.000
Residual	.147	360	.000		
Total (Corrected)	1.001	431			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	.004	5	.001	.844	.519
-Months	.635	11	.058	60.763	.000
2-Factor Interaction	.020	55	.000	.375	1.000
Residual	.342	360	.001		
Total (Corrected)	1.001	431			

Table 8: Statistic analysis for Soil parameters (cont.).

Analysis of Variance for water content (%) in the upper soil layer ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Transverse transect	.169	5	.034	19.780	.000
-Months	.043	11	.004	2.294	.010
2-Factor Interaction	.104	55	.002	1.104	.296
Residual	.614	360	.002		
Total (Corrected)	.930	431			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	.162	5	.032	17.448	.000
-Months	.043	11	.004	2.113	.019
2-Factor Interaction	.058	55	.001	.570	.994
Residual	.667	360	.002		
Total (Corrected)	.930	431			

Table 8: Statistic analysis for Soil parameters (cont.).Analysis of Variance for water content (%) in the lower soil layer ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	.148	5	.030	27.481	.000
-Months	.093	11	.008	7.880	.000
2-Factor Interaction	.058	55	.001	.986	.507
Residual	.388	360	.001		
Total (Corrected)	.687	431			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	.063	5	.013	9.374	.000
-Months	.093	11	.008	6.294	.000
2-Factor Interaction	.046	55	.001	.615	.986
Residual	.485	360	.001		
Total (Corrected)	.687	431			

Table 8: Statistic analysis for Soil parameters (cont.).Analysis of Variance for total organic matter (mg/g dry wt) in the upper soil layer ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	.654	5	.131	8.590	.000
-Months	2.124	11	.193	12.682	.000
2-Factor Interaction	.847	55	.015	1.012	.457
Residual	5.481	360	.015		
Total (Corrected)	9.106	431			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	.667	5	.133	8.286	.000
-Months	2.124	11	.193	11.988	.000
2-Factor Interaction	.517	55	.009	.584	.992
Residual	5.798	360	.016		
Total (Corrected)	9.106	431			

Table 8: Statistic analysis for Soil parameters (cont.).

Analysis of Variance for Total organic matter ((mg/g dry wt) in the lower soil layer (p< 0.01)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	27.670	5	5.534	13.088	.000
-Months	133.929	11	12.175	28.796	.000
2-Factor Interaction	38.534	55	.701	1.657	.004
Residual	152.212	360	.423		
Total (Corrected)	352.344	431			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	15.836	5	3.167	6.511	.000
-Months	133.930	11	12.175	25.029	.000
2-Factor Interaction	27.458	55	.499	1.026	.430
Residual	175.121	360	.486		
Total (Corrected)	352.345	431			

Table 8: Statistic analysis for Soil parameters (cont.).

Analysis of Variance for Sand composition (%) in the upper soil layer (p< 0.01)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	40,726.678	5	8,145.336	86.610	.000
-Months	52,306.414	11	4,755.129	50.562	.000
2-Factor Interaction	14,394.905	55	261.726	2.783	.000
Residual	33,856.500	360	94.046		
Total (Corrected)	141,284.498	431			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	3,704.456	5	740.891	3.263	.007
-Months	52,306.414	11	4,755.129	20.942	.000
2-Factor Interaction	3,533.127	55	64.239	.283	1.000
Residual	81,740.500	360	227.057		
Total (Corrected)	141,284.498	431			

Table 8: Statistic analysis for Soil parameters (cont.).Analysis of Variance for Sand composition (%) in the lower soil layer ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	47,439.963	5	9,487.993	173.259	.000
-Months	80,235.407	11	7,294.128	133.197	.000
2-Factor Interaction	23,225.926	55	422.290	7.711	.000
Residual	19,714.333	360	54.762		
Total (Corrected)	170,615.630	431			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	2,230.907	5	446.181	1.866	.100
-Months	80,235.407	11	7,294.128	30.498	.000
2-Factor Interaction	2,049.648	55	37.266	.156	1.000
Residual	86,099.667	360	239.166		
Total (Corrected)	170,615.630	431			

Table 8: Statistic analysis for Soil parameters (cont.).Analysis of Variance for median grain size (μm) in the upper soil layer ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	.015	5	.003	56.577	.000
-Months	.021	11	.002	36.017	.000
2-Factor Interaction	.009	55	.000	3.199	.000
Residual	.019	360	5.366E-05		
Total (Corrected)	.065	431			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	.002	5	.000	3.221	.007
-Months	.021	11	.002	17.576	.000
2-Factor Interaction	.003	55	4.695E-05	.427	1.000
Residual	.040	360	.000		
Total (Corrected)	.065	431			

Table 8: Statistic analysis for Soil parameters (cont.).

Analysis of Variance for median grain size (μm) in the lower soil layer ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	.021	5	.004	97.961	.000
-Months	.034	11	.003	72.170	.000
2-Factor Interaction	.017	55	.000	7.076	.000
Residual	.015	360	4.306E-05		
Total (Corrected)	.088	431			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	.002	5	.000	2.525	.029
-Months	.034	11	.003	22.523	.000
2-Factor Interaction	.002	55	3.520E-05	.255	1.000
Residual	.050	360	.000		
Total (Corrected)	.088	431			

Table 8: Statistic analysis for Soil parameters (cont.).

Analysis of Variance for acid volatile sulfide (mg/g dry wt) in soil ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	.003	5	.001	2.968	.016
-Months	.001	2	.001	3.093	.050
2-Factor Interaction	.004	10	.000	2.042	.038
Residual	.020	90	.000		
Total (Corrected)	.029	107			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	.002	5	.000	1.782	.124
-Months	.001	2	.001	2.624	.078
2-Factor Interaction	.002	10	.000	.736	.689
Residual	.023	90	.000		
Total (Corrected)	.029	107			

Table 8: Statistic analysis for Soil parameters (cont.).Analysis of Variance for Redox-Potential in soil ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	15.843	5	3.169	9.541	.000
-Months	24.745	11	2.250	6.774	.000
2-Factor Interaction	25.887	55	.471	1.417	.034
Residual	119.557	360	.332		
Total (Corrected)	186.031	431			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	23.713	5	4.743	13.452	.000
-Months	24.745	11	2.250	6.380	.000
2-Factor Interaction	10.648	55	.194	.549	.996
Residual	126.923	360	.353		
Total (Corrected)	186.029	431			

Table 8 Statistic analysis for Soil parameters (cont.).Student's t-test between mean water content (%) of upper and lower soil layers ($p < 0.01$)

Water content	Mean	Standard deviation	n	Difference between means	t-value	Significant level
Upper layer	25.1811	2.83916	432	0.8017	5.817	.000
Lower layer	24.3793	2.36744	432			

Student's t-test between average median grain size (μm in diameter) of upper and lower soil layers ($p < 0.01$).

Median grain size	Mean	Standard deviation	n	Difference between mean	t-value	Significant level
Upper layer	74.8	12.03	432	0.7	1.855	.064
Lower layer	74.1	14.23	432			

Student's t-test between mean total organic matter (mg/g dry wt) of upper and lower soil layers ($p < 0.01$).

Total organic matter	Mean	Standard deviation	n	Difference between mean	t-value	Significant level
Upper layer	35.0804	12.86562	432	-0.6471	-0.953	.341
Lower layer	35.7275	11.08169	432	11.08169		

Table 8: Statistic analysis for Soil parameters (cont.).Student's t-test between mean soil pH of upper and lower soil layers ($p < 0.01$).

Total organic matter	Mean	Standard deviation	n	Difference between mean	t-value	Significant level
Upper layer	7.4498	0.35534	432	-0.0706	-6.484	.000
Lower layer	7.5204	0.37336	432			

Student's t-test between mean sand composition (%) of upper and lower soil layers ($p < 0.01$).

Water content	Mean	Standard deviation	n	Difference between mean	t-value	Significant level
Upper layer	75.7523	18.10542	432	1.8264	3.376	.001
Lower layer	73.9259	19.89623	432			

Table 9: Comparison of chemical factors of Transverse transects in Don Hoi Lot during July 2008- May 2009 with Marine water quality standard and the decree was issued by the National Environmental Board.

Parameters	Average water quality						Grand average	Marine water class III (Aquaculture)
	T1	T2	T3	T4	T5	T6		
Depth (m)	1.5±0.4	1.5±0.4	1.7±0.3	1.7±0.3	1.7±0.4	1.8±0.4	1.6 ±0.4	N ³
Water temperature (°C)	29.3±3.2	29.5±3.4	29.5±3.3	29.4±3.1	29.3±3.0	29.4±3.0	29.4±3.1	N ¹
Water pH	8.1±0.26*	8.2±0.31*	8.2±0.31*	8.2±0.29*	8.3±0.29*	8.3±0.29*	8.2±0.29*	7.0-8.5
Dissolved oxygen (mg/l)	5.01±1.63*	5.00±1.64*	5.07±1.71*	5.09±1.81*	5.38±1.94*	5.41±2.36*	5.16±1.81*	Not less than 4
Transparency (cm)	54.0±15.6	58.9±17.9	63.3±21.8	64.4±21.9	74.1±28.7	74.7±26.5	64.9±23.0	N ²
Turbidity (NTU)	19.5±12.93	20.3±15.73	17.2±14.16	18.3±17.84	17.4±18.71	16.0±15.98	18.1±15.51	N ³
Salinity (PSU)	19.2±7.2	20.0±6.1	21.5±5.8	22.7±5.9	23.5±5.3	24.2±4.9	21.8±6.0	N ⁴
Alkalinity (mgCaCO ₃ /l)	102.5±12.78	103.9±12.02	101.4±15.56	102.1±16.70	102.6±15.70	103.6±15.72	102.7±14.34	N ³
Hardness (mg CaCO ₃ /l)	377.8±138.6	413.9±129.0	469.7±107.3	474.2±99.4	483.6±99.2	483.3±82.0	450.4±114.4	N ³
Total ammonia (mg/l)	0.090±0.052	0.083±0.051	0.078±0.052	0.069±0.046	0.059±0.045	0.063±0.045	0.074±0.048	Not exceed 0.07 ^a
Nitrate nitrogen (mg/l)	1.02±0.64	0.83±0.37	0.66±0.36	0.58±0.30	0.46±0.26	0.45±0.24	0.67±0.43	Not exceed 0.06
Phosphate phosphorus (mg/l)	0.051±0.029*	0.046±0.026*	0.044±0.024*	0.040±0.022*	0.056±0.059*	0.038±0.018*	0.046±0.032*	Not exceed 0.045
Chlorophyll a (mg/m ³)	6.5±6.3	6.1±6.4	5.3±7.7	7.0±7.5	7.7±7.7	7.3±5.7	6.5±6.6	N ³

Remark: N¹= an increase shall not exceed 1 °C from the natural temperature

N²= a decrease shall not be exceed than 10% of the minimum transparency governed by natural condition

N³= no standard determined

N⁴= any change shall not exceed 10% of the minimum salinity

a= determined in an unionized form, * = more/less than standard with Marine water class III

Table 10: Comparison of chemical factors of Longitudinal transects in Don Hoi Lot during July 2008- May 2009 with Marine water quality standard and the decree issued by the National Environmental Board.

Parameters	Average water quality				Marine water class III (Aquaculture)
	TA	TC	TF	Grand average	
Depth (m)	1.7±0.4	1.5±0.3	1.7±0.4	1.6±0.4	N ³
Water temperature (°C)	29.4±3.1	29.5±3	29.4±3.3	29.4±3.1	N ¹
Water pH	8.2±0.32 *	8.3±0.28*	8.2±0.28*	8.2±0.29 *	7.0-8.5
Dissolved oxygen (mg/l)	5.16±1.88*	5.16±1.81 *	5.16±1.76*	5.16±1.77*	Not less than 4
Transparency (cm)	67.8±27.4	64.7±20.8	62.2±17.9	64.9±21.9	N ²
Turbidity (NTU)	17.2±15.54	19.0±16.87	18.3±13.38	18.1±14.90	N ³
Salinity (PSU)	21.1±5.7	22.0±5.4	22.4±6.4	21.8±5.7	N ⁴
Alkalinity (mgCaCO ₃ /l)	102.5±14.38	102.5±14.03	103.1±14.08	102.7±13.75	N ³
Hardness (mg CaCO ₃ /l)	430.1±96.7	456.9±109.1	464.2±108.2	450.4±102.9	N ³
Total ammonia (mg/l)	0.070±0.049	0.074±0.045	0.077±0.047	0.074±0.045	Not exceed 0.07 ^a
Nitrate nitrogen (mg/l)	0.74±0.39	0.66±0.28	0.60±0.32	0.67±0.33	Not exceed 0.06
Phosphate phosphorus (mg/l)	0.043±0.027*	0.045±0.021 *	0.049±0.037*	0.046±0.028*	Not exceed 0.045
Chlorophyll a (mg/m ³)	6.2±6.2	6.5±6.5	6.9±6.7	6.5±6.3	N ³

Remark: N¹ = an increase shall not exceed 1 °C from the natural temperature

N² = a decrease shall not be exceed than 10% of the minimum transparency governed by natural condition

N³ = no standard determined

N⁴ = any change shall not exceed 10% of the minimum salinity

a= determined in an unionized form, * = more/less than standard with Marine water class III

Table 11: Comparison of chemical factors of Transverse transects in Don Hoi Lot (in each month) during June 2008- May 2009 with Marine water quality standard and the decree issued by the National Environmental Board.

Parameters	Average water quality												Marine water class III (Aquaculture)
	June	July	August	September	October	November	December						
Depth (m)	2.3±0.0	1.8±0.2	1.6±0.2	1.1±0.1	1.7±0.2	1.7±0.1	1.9±0.1						N ³
Water temperature (°C)	32.3±0.3	31.4±0.3	32±0.7	31±0.4	30.7±0.5	30.4±0.5	23.8±0.3						N ¹
Water pH	7.9±0.12*	7.6±0.09*	8.1±0.03*	8.0±0.02*	8.1±0.12*	8.6±0.02	8.3±0.1*						7.0-8.5
Dissolved oxygen (mg/l)	5.38±0.75*	3.86±0.48	4.31±0.24*	3.2±0.20	4.5±0.85*	10.32±0.99*	5.16±0.05*						Not less than 4
Transparency (cm)	87.2±17.23	49.9±5.88	42.6±7.48	72.9±12.44	94.7±19.55	44.3±1.74	97.9±9.50						N ²
Turbidity (NTU)	10.6±2.0	13.0±5.0	37.1±11.7	7.2±4.1	20.1±2.4	14.5±3.7	10.2±2.1						N ³
Salinity (PSU)	21.1±1.5	18.4±2.1	20.1±5.9	18.0±12	11.0±3.6	20.1±2.0	27.9±1.0						N ⁴
Alkalinity (mgCaCO ₃ /l)	95.1±3.83	68.7±7.41	102.7±4.60	101.9±2.52	98.7±11.57	104.9±1.60	119.6±6.78						N ³
Hardness (mg CaCO ₃ /l)	526.1±42.8	521.7±55.7	370.0±151.0	335.6±22.2	250.6±89.8	429.4±54.8	492.2±28.5						N ³
Total ammonia (mg/l)	0.124±0.033	0.162±0.016	0.070±0.042	0.072±0.009	0.016±0.009	0.011±0.015	0.038±0.009						Not exceed 0.07 ^a
Nitrate nitrogen (mg/l)	0.41±0.19	0.58±0.19	0.97±0.47	0.95±0.10	0.83±0.39	0.17±0.15	0.45±0.39						Not exceed 0.06
Phosphate phosphorus (mg/l)	0.043±0.011*	0.037±0.031*	0.042±0.005*	0.050±0.000*	0.036±0.034*	0.020±0.005*	0.037±0.003*						Not exceed 0.045
Chlorophyll a (mg/m ³)	1.2±0.4	0.4±0.3	3.4±1.9	7.7±3.0	11.8±3.9	16.4±7.5	3.7±2.2						N ³

Remark: N¹= an increase shall not exceed 1 °C from the natural temperature

N²= a decrease shall not be exceed than 10% of the minimum transparency governed by natural condition

N³= no standard determined

N⁴= any change shall not exceed 10% of the minimum salinity

a= determined in an unionized form, * = more/less than standard with Marine water class III

Table 11: Comparison of chemical factors of Transverse transects in Don Hoi Lot (in each month) during June 2008- May 2009 with Marine water quality standard and the decree issued by the National Environmental Board (cont.).

Parameters	Average water quality						Marine water class III (Aquaculture)
	January	February	March	April	May	Grand average	
Depth (m)	1.9±0.3	1.2±0.1	1.2±0.2	1.6±0.1	1.5±0.1	1.6±0.4	N ³
Water temperature (°C)	22.4±0.2	28.4±0.5	29.7±0.4	30.2±0.2	30.9±0.1	29.4±3.1	N ¹
Water pH	8.2±0.1*	8.3±0.07*	8.3±0.04*	8.4±0.09*	8.6±0.02	8.2±0.29*	7.0-8.5
Dissolved oxygen (mg/l)	5.01±0.18*	4.37±0.1*	6.32±0.24*	5.17±0.26*	4.33±0.44*	5.16±1.81*	Not less than 4
Transparency (cm)	73.4±15.47	36.5±4.24	48.4±9.02	61.4±16.16	96.4±6.01	64.9±23.0	N ²
Turbidity (NTU)	3.1±1.2	44.1±8.6	43.9±13.6	8.2±2.0	5.8±1.5	18.1±15.51	N ³
Salinity (PSU)	33.7±1.0	22.7±2.1	20.1±1.5	22.3±2.5	26.8±1.0	21.8±6.0	N ⁴
Alkalinity (mgCaCO ₃ /l)	104.5±2.16	104.8±4.59	117.7±2.24	120.6±1.06	93.0±3.21	102.7±14.34	N ³
Hardness (mg CaCO ₃ /l)	615.0±24.4	402.2±34.6	506.1±49.2	535.0±61.3	421.1±43.5	450.4±114.4	N ³
Total ammonia (mg/l)	0.028±0.005	0.118±0.026	0.091±0.019	0.064±0.002	0.090±0.006	0.074±0.048	Not exceed 0.07 ^a
Nitrate nitrogen (mg/l)	0.24±0.04	1.16±0.79	0.82±0.07	0.86±0.16	0.54±0.07	0.67±0.43	Not exceed 0.06
Phosphate phosphorus (mg/l)	0.116±0.044	0.087±0.033	0.031±0.005*	0.029±0.003*	0.023±0.002*	0.046±0.032*	Not exceed 0.045
Chlorophyll a (mg/m ³)	2.0±1.1	18.9±4.8	6.0±1.8	4.5±3.2	2.5±1.9	6.5±6.6	N ³

Remark: N¹= an increase shall not exceed 1 °C from the natural temperature

N²= a decrease shall not be exceed than 10% of the minimum transparency governed by natural condition

N³= no standard determined ; N⁴= any change shall not exceed 10% of the minimum salinity

a= determined in an unionized form, * = more/less than standard with Marine water class III

Table 12: Comparison of chemical factors of Longitudinal transects in Don Hoi Lot (in each month) during June 2008- May 2009 with Marine water quality standard and the decree issued by the National Environmental Board.

Parameters	Average water quality										Marine water class III (Aquaculture)
	June	July	August	September	October	November	December				
Depth (m)	2.3±0.4	1.8±0.2	1.6±0.2	1.1±0.2	1.7±0.2	1.7±0.1	1.9±0.2	N ³			
Water temperature (°C)	32.3±0.3	31.4±0.3	32.0±0.3	31.0±0.2	30.7±0.5	30.4±0.3	23.8±0.3	N ¹			
Water pH	7.9±0.06*	7.6±0.21*	8.1±0.01*	8.0±0.01*	8.1±0.08*	8.6±0.20	8.3±0.02*	7.0-8.5			
Dissolved oxygen (mg/l)	5.38±0.05*	3.86±0.08*	4.31±0.14*	3.20±0.05	4.50±0.11*	10.32±0.28*	5.16±0.11*	Not less than 4			
Transparency (cm)	87.2±5.0	49.9±6.4	42.6±5.8	72.9±16.9	94.7±10.4	44.3±0.8	97.9±22.6	N ²			
Turbidity (NTU)	10.6±0.48	13.0±3.61	37.1±10.65	7.2±6.77	20.1±1.70	14.5±1.03	10.2±1.76	N ³			
Salinity (PSU)	21.1±0.5	18.4±3.5	20.1±2.6	18.0±0.9	11.0±2.0	20.1±1.1	27.9±0.8	N ⁴			
Alkalinity (mgCaCO ₃ /l)	95.1±1.23	68.7±2.12	102.7±3.15	101.9±0.63	98.7±4.25	104.9±1.02	119.6±3.71	N ³			
Hardness (mg CaCO ₃ /l)	526.1±17.3	521.7±80.5	370.0±68.9	335.6±8.6	250.6±23.0	429.4±37.0	492.2±1.9	N ³			
Total ammonia (mg/l)	0.124±0.005	0.162±0.004	0.070±0.017	0.072±0.004	0.016±0.003	0.011±0.005	0.038±0.004	Not exceed 0.07 ^a			
Nitrate nitrogen (mg/l)	0.41±0.06	0.58±0.12	0.97±0.21	0.95±0.09	0.83±0.12	0.17±0.06	0.45±0.17	Not exceed 0.06			
Phosphate phosphorus (mg/l)	0.043±0.002*	0.037±0.017*	0.042±0.004*	0.050±0.002	0.036±0.002*	0.020±0.001*	0.037±0.002*	Not exceed 0.045			
Chlorophyll a (mg/m ³)	1.2±0.2	0.4±0.1	3.4±0.2	7.7±2.5	11.8±1.5	16.4±6.9	3.7±0.5	N ³			

Remark: N¹= an increase shall not exceed 1 °C from the natural temperature

N²= a decrease shall not be exceed than 10% of the minimum transparency governed by natural condition

N³= no standard determined

N⁴= any change shall not exceed 10% of the minimum salinity with Marine water class III

a= determined in an unionized form, * = more/less than standard

Table 12: Comparison of chemical factors of Longitudinal transects in Don Hoi Lot (in each month) during June 2008- May 2009 with Marine water quality standard and the decree issued by the National Environmental Board (cont.).

Parameters	Average water quality							Marine water class III (Aquaculture)
	January	February	March	April	May	Grand average		
Depth (m)	1.9±0.1	1.2±0.1	1.2±0.1	1.6±0.1	1.5±0.2	1.6±0.4	N ³	
Water temperature (°C)	22.4±0.3	28.4±0.0	29.7±0.1	30.2±0.0	30.9±0.2	29.4±3.1	N ¹	
Water pH	8.2±0.01*	8.3±0.02*	8.3±0.01*	8.4±0.07*	8.6±0.01	8.2±0.29*	7.0-8.5	
Dissolved oxygen (mg/l)	5.01±0.22*	4.37±0.02*	6.32±0.26*	5.17±0.27*	4.33±0.22*	5.16±1.77*	Not less than 4	
Transparency (cm)	73.4±2.2	36.5±0.3	48.4±3.5	61.4±2.6	69.4±5.7	64.9±21.9	N ²	
Turbidity (NTU)	3.1±0.55	44.1±3.98	43.9±3.24	8.2±1.32	5.8±0.63	18.1±14.90	N ³	
Salinity (PSU)	33.7±0.3	22.7±0.3	20.1±0.3	22.3±1.6	26.8±1.9	21.8±5.7	N ⁴	
Alkalinity (mgCaCO ₃ /l)	104.5±1.20	104.8±2.75	117.7±1.74	120.6±0.69	93.0±1.26	102.7±13.75	N ³	
Hardness (mg CaCO ₃ /l)	615.0±10.0	402.2±6.3	506.1±28.3	535.0±26.7	421.1±17.8	450.4±102.9	N ³	
Total ammonia (mg/l)	0.028±0.006	0.118±0.013	0.091±0.010	0.064±0.006	0.090±0.006	0.074±0.045	Not exceed 0.07 ^a	
Nitrate nitrogen (mg/l)	0.24±0.02	1.16±0.33	0.82±0.04	0.86±0.12	0.54±0.11	0.67±0.33	Not exceed 0.06	
Phosphate phosphorus (mg/l)	0.116±0.025	0.087±0.019	0.031±0.007*	0.029±0.004*	0.023±0.001*	0.046±0.028*	Not exceed 0.045	
Chlorophyll a (mg/m ³)	2.0±0.3	18.9±4.4	6.0±1.3	4.5±1.6	2.5±1.3	6.5±6.3	N ³	

Remark: N¹ = an increase shall not exceed 1 °C from the natural temperature
 N² = a decrease shall not be exceed than 10% of the minimum transparency governed by natural condition
 N³ = no standard determined
 N⁴ = any change shall not exceed 10% of the minimum salinity
 a= determined in an unionized form, * = more/less than standard with Marine water class III

Table 13: Statistical analysis of chemical factors for comparison between spatial and temporal variation in transverse and longitudinal transects in each month.

Physical factors	Transverse transect					Longitudinal transect						
	F-ratio (Transect)	Sig. Level	F-ratio (Month)	Sig. Level	F-ratio (Inter-action)	Sig. Level	F-ratio (Transect)	Sig. Level	F-ratio (Month)	Sig. Level	F-ratio (Inter-action)	Sig. Level
Depth	5.926	.000**	28.224	.000**	.583	.988	17.264	.000**	40.453	.000**	3.651	.000**
Water temperature	.823	.535	831.647	.000**	2.206	.000**	.382	.683	672.114	.000**	1.681	.035*
Water pH	10.244	.000**	83.375	.000**	.861	.734	9.212	.000**	88.238	.000**	2.649	.000**
Dissolved oxygen	3.226	.009**	175.407	.000**	3.351	.000**	.045	.956	97.317	.000**	.501	.971
Transparency	15.473	.000**	59.287	.000**	1.541	.022*	.861	.424	44.444	.000**	2.171	.003**
Turbidity	4.579	.001**	59.940	.000**	1.088	.341	5.798	.004**	69.553	.000**	3.064	.000**
Salinity	25.755	.000**	93.355	.000**	1.823	.002**	4.507	.012*	39.001	.000**	2.167	.003**
Alkalinity	.636	.672	71.505	.000**	1.713	.006**	.147	.863	56.931	.000**	.541	.954
Hardness	15.271	.000**	40.339	.000**	1.582	.016*	3.401	.035*	27.203	.000**	.931	.555
Ammonia nitrogen	7.343	.000**	54.028	.000**	1.117	.298	.857	.426	42.189	.000**	.335	.998
Nitrate nitrogen	35.285	.000**	54.007	.000**	2.247	.000**	2.044	.132	18.909	.000**	.675	.860
Phosphate phosphorus	2.042	0.076	35.328	.000**	1.330	.092	1.315	.271	34.335	.000**	2.054	.005**
Chlorophyll a	1.565	.174	30.425	.000**	1.111	.307	.200	.819	29.165	.000**	1.077	.375

Remark; * Significant at 0.05 level, ** Significant at 0.01 level

Table 14: Water quality and related parameters at Don Hoi Lot during June 2008 to May 2009 (5 June 2008).

Station	Time	Depth (m)	Salinity (psu)	Transparency (cm)	Temp. (°C)	DO (mg/l)	pH	Turbidity (NTU))	Hardness (mg/l)	Alkalinity (mg/l)	Ammonia (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Chlorophyll-a (mg/m3)
3	6.30	1.8	20	83	33.1	3.85	7.8	12	500	110	0.089	0.686	0.044	0.50
6	6.40	2.1	23	69	33.0	4.60	7.8	16	550	95	0.195	0.451	0.067	0.89
7	5.15	2.7	18	65	32.5	4.27	7.7	12	500	90	0.180	0.529	0.034	2.47
9	6.24	1.9	20	80	32.5	5.03	7.9	13	510	96	0.096	0.361	0.039	0.63
12	6.50	2.5	21	72	32.9	4.74	7.9	12	520	110	0.150	0.544	0.045	0.91
13	5.20	2.6	19	76	32.0	4.87	7.8	12	550	97	0.138	0.650	0.042	1.84
15	6.15	1.8	21	103	32.3	5.57	8.0	8	520	96	0.084	0.369	0.044	1.38
18	6.55	2.8	20	98	32.5	5.87	7.9	10	500	99	0.123	0.521	0.048	0.71
19	5.23	2.1	23	80	32.0	5.58	7.9	12	550	94	0.078	0.312	0.029	0.85
21	6.05	1.8	20	95	32.2	5.40	8.1	10	550	92	0.090	0.289	0.041	0.64
24	7.00	3.0	21	84	32.5	5.83	8.0	6	550	94	0.091	0.395	0.036	2.12
25	5.30	2.2	24	117	31.8	6.23	8.1	8	570	95	0.067	0.201	0.044	1.00
27	5.55	1.7	24	93	31.8	6.20	8.1	12	550	89	0.134	0.165	0.030	2.39
30	7.05	3.1	20	100	32.4	5.80	8.0	8	570	99	0.076	0.193	0.034	0.50
31	5.38	2.2	24	116	31.9	6.64	8.1	8	570	99	0.068	0.193	0.034	0.87
33	5.45	2.0	25	93	32.1	6.15	8.1	10	560	85	0.255	0.237	0.044	2.82
36	7.15	2.6	20	110	32.3	5.74	8.1	8	550	82	0.076	0.335	0.038	0.81

Table 14: Water quality and related parameters at Don Hoi Lot during June 2008 to May 2009 (2 July 2008) (cont.).

Station	Time	Depth (m)	Salinity (psu)	Transparency (cm)	Temp. (°C)	DO		pH	Turbidity (NTU)	Hardness (mg/l)	Alkalinity (mg/l)	Ammonia (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Chlorophyll-a (mg/m ³)
						(mg/l)	(mg/l)								
1	15.48	1.2	13	37	30.4	4.40	4.40	7.5	13	290	65	0.077	0.910	0.023	0.14
3	17.28	1.6	18	50	31.3	4.23	4.23	7.7	18	550	80	0.218	0.970	0.241	0.26
6	18.36	1.7	20	45	31.7	3.91	3.91	7.6	31	460	80	0.192	0.665	0.033	0.16
7	15.58	1.3	11	42	32.8	4.59	4.59	7.3	7	280	70	0.235	0.761	0.029	0.28
9	17.35	1.7	18	52	31.4	3.85	3.85	7.7	20	500	80	0.112	0.774	0.023	0.32
12	18.28	1.8	20	53	31.6	3.70	3.70	7.7	24	700	92	0.167	0.547	0.062	0.28
13	16.05	1.7	10	36	31.8	4.00	4.00	7.0	9	440	65	0.163	0.804	0.025	0.14
15	17.41	2.0	20	67	31.4	3.84	3.84	7.8	9	520	55	0.230	0.704	0.019	0.83
18	18.23	2.0	20	51	31.5	3.80	3.80	7.7	20	650	65	0.170	0.472	0.028	0.22
19	16.13	1.4	14	41	32.1	3.11	3.11	7.4	5	600	65	0.185	0.686	0.024	0.15
21	17.47	1.8	21	30	30.1	1.80	1.80	7.8	13	550	65	0.130	0.593	0.018	0.29
24	18.16	2.3	22	59	31.5	3.82	3.82	7.8	6	630	63	0.150	0.346	0.023	0.27
25	16.19	1.7	19	49	31.5	3.51	3.51	7.5	11	540	70	0.165	0.369	0.024	0.26
27	17.54	1.8	19	65	31.1	4.50	4.50	7.8	12	560	70	0.152	0.449	0.024	0.15
30	18.12	1.9	22	62	31.0	4.10	4.10	7.8	3	580	55	0.162	0.358	0.022	0.21
31	16.24	1.8	20	51	31.5	3.67	3.67	7.6	8	440	70	0.177	0.410	0.018	2.09
33	18.00	2.1	23	50	31.0	4.40	4.40	7.8	18	600	55	0.110	0.400	0.012	0.23
36	18.05	2.3	22	60	31.1	4.24	4.24	7.8	7	500	72	0.128	0.291	0.021	0.29

Table 14: Water quality and related parameters at Don Hoi Lot during June 2008 to May 2009(15 August 2008) (cont.)

Station	Time	Depth (m)	Salinity (psu)	Transparency (cm)	Temp. (°C)	DO (mg/l)	pH	Turbidity (NTU))	Hardness (mg/l)	Alkalinity (mg/l)	Ammonia (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Chlorophyll-a (mg/m3)
3	17.19	1.5	12	37	32.2	4.95	8.2	70	120	107	0.102	1.331	0.038	0.89
6	17.25	1.3	12	34	33.7	4.26	8.1	41	150	101	0.234	1.735	0.051	4.45
7	15.35	1.0	9	30	32.6	4.60	8.2	66	160	90	0.081	1.911	0.054	0.89
9	17.27	1.5	15	31	32.5	4.55	8.1	43	220	110	0.148	1.532	0.053	0.89
12	17.42	1.9	21	52	32.3	4.37	8.1	36	350	112	0.100	0.872	0.038	1.78
13	15.55	1.3	11	28	33.6	4.40	8.1	45	220	100	0.058	1.800	0.048	3.56
15	17.37	1.6	20	52	32.2	4.22	8.1	23	350	114	0.120	1.204	0.049	0.89
18	17.48	2.0	25	37	33.3	4.58	8.2	17	620	99	0.039	0.619	0.039	2.67
19	16.24	1.6	21	31	32.3	3.48	8.0	48	440	110	0.042	1.055	0.035	1.78
21	17.22	1.7	26	40	31.5	3.95	8.1	63	470	95	0.024	0.560	0.047	6.23
24	17.39	1.9	26	59	32.4	4.78	8.2	13	620	85	0.036	0.462	0.029	3.56
25	16.47	1.5	26	53	31.5	3.70	8.1	26	460	100	0.025	0.536	0.028	2.67
27	17.25	1.6	26	40	31.2	4.15	8.2	36	470	101	0.034	0.482	0.051	3.56
30	17.15	1.8	25	54	31.1	4.27	8.1	22	460	105	0.040	0.508	0.040	3.56
31	16.50	1.7	25	51	31.2	4.03	8.1	22	480	110	0.041	0.456	0.035	8.01
33	17.00	1.5	25	53	30.9	4.20	8.1	31	470	110	0.030	0.431	0.043	7.12
36	17.10	2.0	25	56	31.2	4.32	8.2	20	480	110	0.044	0.534	0.032	5.34

Table 14: Water quality and related parameters at Don Hoi Lot during June 2008 to May 2009 (1 September 2008) (cont.).

Station	Time	Depth (m)	Salinity (psu)	Transparency (cm)	Temp. (°C)	DO (mg/l)	pH	Turbidity (NTU)	Hardness (mg/l)	Alkalinity (mg/l)	Ammonia (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Chlorophyll-a (mg/m ³)
1	7.01	1.3	16	75	31.7	3.35	8.1	8	270	102	0.068	0.779	0.048	8.01
3	8.08	0.9	16	56	31.5	3.11	8.0	9	300	104	0.082	1.155	0.053	3.56
6	8.14	0.9	16	49	31.6	3.08	8.0	22	320	110	0.076	1.235	0.050	8.90
7	7.08	1.3	18	79	31.1	3.54	8.0	1	310	102	0.072	1.057	0.050	9.79
9	8.02	1.0	17	56	31.4	3.26	8.0	6	340	105	0.084	1.013	0.051	11.57
12	8.20	0.8	16	52	31.3	3.22	8.0	28	360	103	0.089	1.153	0.052	13.35
13	7.14	1.4	19	88	30.5	3.33	8.0	1	350	104	0.084	1.000	0.050	7.12
15	7.58	1.0	18	57	31.3	3.36	8.0	2	350	99	0.066	0.939	0.049	2.67
18	8.24	1.3	18	52	31.3	3.25	8.0	16	330	95	0.076	0.980	0.052	9.79
19	7.19	1.2	19	88	30.4	3.35	8.0	1	350	105	0.075	0.892	0.047	6.23
21	7.50	1.1	19	78	30.9	3.40	8.0	4	330	100	0.081	0.897	0.053	4.45
24	8.28	1.3	18	59	30.9	3.27	8.0	9	370	105	0.068	1.008	0.050	4.45
25	7.24	1.2	20	103	30.3	3.01	8.0	2	330	99	0.057	0.792	0.048	8.90
27	7.43	1.0	20	89	30.5	3.27	8.0	3	330	98	0.046	0.722	0.050	9.79
30	8.37	0.9	17	64	31.1	3.31	8.1	9	320	100	0.064	1.003	0.051	15.13
31	7.30	1.5	20	105	30.3	2.38	8.0	3	360	102	0.052	0.817	0.048	3.56
33	7.36	1.3	20	104	30.3	2.67	8.0	1	350	101	0.067	0.779	0.050	0.89
36	8.42	1.1	17	60	30.8	3.37	8.0	6	370	100	0.082	0.959	0.051	10.68

Table 14: Water quality and related parameters at Don Hoi Lot during June 2008 to May 2009 (6 October 2008) (cont.).

Station	Time	Depth (m)	Salinity (psu)	Transparency (cm)	Temp. (°C)	DO (mg/l)	pH	Turbidity (NTU))	Hardness (mg/l)	Alkalinity (mg/l)	Ammonia (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Chlorophyll-a (mg/m3)
3	12.31	1.6	5	69	30.1	3.82	8.0	25	110	93	0.027	1.496	0.044	3.56
6	12.44	1.0	5	68	29.9	3.31	7.9	24	130	67	0.027	1.496	0.041	6.23
7	10.58	1.8	11	74	30.9	3.80	8.0	22	180	112	0.011	1.055	0.037	18.69
9	12.24	1.3	10	91	30.3	3.77	8.0	17	160	64	0.021	1.181	0.044	16.91
12	12.46	1.3	6	77	30.1	3.64	7.9	26	120	98	0.021	1.529	0.038	16.91
13	11.05	2.1	12	103	31.3	4.21	8.1	14	240	91	0.021	0.980	0.033	14.24
15	12.22	1.7	12	95	30.6	4.13	8.1	19	330	102	0.021	0.957	0.035	14.24
18	12.56	1.8	11	67	30.0	3.55	7.9	23	230	82	0.031	0.794	0.040	1.78
19	11.12	1.6	11	100	31.8	5.60	8.1	18	270	89	0.019	0.890	0.034	12.46
21	12.10	1.8	14	94	30.9	4.30	8.2	15	210	93	0.020	0.763	0.035	3.56
24	13.04	1.6	9	94	30.7	5.40	8.0	22	290	104	0.015	0.939	0.036	18.69
25	11.22	1.7	16	124	31.8	5.02	8.2	20	360	112	0.002	0.462	0.031	0.89
27	12.00	2.1	15	124	31.7	5.16	8.2	14	320	108	0.003	0.134	0.032	15.13
30	13.13	1.6	10	107	28.6	6.31	8.1	19	280	105	0.001	0.609	0.036	23.14
31	11.35	2.0	18	132	31.2	4.88	8.3	16	430	113	0.002	0.446	0.031	5.34
33	11.55	1.8	17	133	31.1	5.18	8.3	26	320	122	0.011	0.126	0.032	9.79
36	13.18	1.6	11	83	31.9	5.50	8.1	18	350	117	0.012	0.441	0.032	1.78

Table 14: Water quality and related parameters at Don Hoi Lot during June 2008 to May 2009 (4 November 2008) (cont.).

Station	Time	Depth (m)	Salinity (psu)	Transparency (cm)	Temp. (°C)	DO (mg/l)	pH	Turbidity (NTU)	Hardness (mg/l)	Alkalinity (mg/l)	Ammonia (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Chlorophyll-a (mg/m ³)
1	10.20	1.9	15	41	29.2	9.80	7.5	24	270	103	0.010	0.660	0.023	8.01
3	11.57	1.3	17	45	29.9	9.18	8.7	15	340	105	0.076	0.374	0.027	18.69
6	12.04	1.5	20	41	29.4	9.19	8.6	20	420	105	0.040	0.155	0.024	18.69
7	10.27	1.6	17	43	29.5	9.30	8.3	17	380	105	0.015	0.168	0.026	10.68
9	11.49	1.5	17	43	30.5	10.05	8.8	16	340	102	0.005	0.678	0.026	9.79
12	12.11	1.5	20	43	30.5	9.57	8.7	17	470	103	0.013	0.157	0.029	12.46
13	10.35	1.8	19	48	30.4	9.62	8.5	17	420	108	0.002	0.093	0.017	4.45
15	11.42	1.6	20	40	30.7	9.98	8.8	14	420	107	0.007	0.085	0.017	2.67
18	12.18	1.8	22	44	30.2	10.22	8.7	17	430	103	0.013	0.064	0.014	8.90
19	10.45	2.2	23	49	30.3	10.90	8.6	16	500	102	0.002	0.057	0.015	2.67
21	11.34	1.5	21	42	30.8	10.25	8.8	11	530	103	0.003	0.083	0.018	28.48
24	12.25	1.8	21	40	30.7	9.06	8.8	10	450	104	0.006	0.083	0.018	44.50
25	10.53	1.6	22	44	30.0	11.40	8.8	10	420	108	0.002	0.064	0.016	24.03
27	11.26	1.6	19	45	31.1	10.05	8.8	15	450	104	0.001	0.080	0.017	29.37
30	12.33	1.6	21	48	30.7	11.00	8.8	11	460	107	0.001	0.080	0.018	16.02
31	11.01	1.8	22	46	31.1	12.71	8.8	9	350	109	0.004	0.093	0.013	4.45
33	11.18	1.8	21	47	31.1	12.26	8.8	12	530	102	0.003	0.083	0.017	15.13
36	12.41	1.8	24	48	30.8	11.30	8.7	8	550	109	0.003	0.080	0.020	35.60

Table 14: Water quality and related parameters at Don Hoi Lot during June 2008 to May 2009 (2 December 2008) (cont.).

Station	Time	Depth (m)	Salinity (psu)	Transparency (cm)	Temp. (°C)	DO (mg/l)	pH	Turbidity (NTU))	Hardness (mg/l)	Alkalinity (mg/l)	Ammonia (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Chlorophyll-a (mg/m3)
3	12.10	1.6	27	66	24.7	5.71	8.3	13	500	112	0.037	0.441	0.032	8.90
6	12.05	1.8	29	64	22.7	5.03	8.2	13	480	127	0.052	0.503	0.040	1.78
7	10.09	2.8	26	128	23.3	4.98	8.2	10	480	122	0.052	0.482	0.044	0.89
9	11.51	1.5	26	81	24.2	5.39	8.4	13	430	118	0.035	0.423	0.034	2.67
12	11.58	1.9	29	61	23.0	5.03	8.2	18	460	126	0.045	0.384	0.048	0.89
13	10.16	2.0	27	122	23.8	5.38	8.3	9	510	108	0.047	0.428	0.037	0.89
15	11.43	1.6	27	90	23.7	5.13	8.3	10	540	111	0.040	0.240	0.044	0.89
18	11.36	1.9	27	105	23.2	4.91	8.3	12	540	123	0.035	0.186	0.039	0.89
19	10.23	1.9	30	129	24.2	5.58	8.4	11	550	123	0.033	0.222	0.032	6.23
21	11.20	1.6	27	83	23.9	4.99	8.3	11	460	118	0.042	0.222	0.039	2.67
24	11.29	2.0	30	79	23.7	5.00	8.3	12	520	143	0.037	0.165	0.040	6.23
25	10.36	2.0	28	140	24.0	5.18	8.4	10	480	134	0.040	0.178	0.038	3.56
27	11.13	1.8	29	94	24.0	5.01	8.4	7	510	128	0.036	0.175	0.038	4.45
30	11.05	2.0	29	96	24.0	5.03	8.5	10	420	116	0.025	0.162	0.035	4.45
31	10.44	2.0	29	101	24.0	5.13	8.5	10	470	109	0.021	0.113	0.030	13.35
33	10.51	2.0	29	95	24.1	5.18	8.4	6	520	117	0.031	0.160	0.029	0.89
36	10.57	2.2	29	105	24.1	5.17	8.5	7	540	108	0.022	0.155	0.037	6.23

Table 14: Water quality and related parameters at Don Hoi Lot during June 2008 to May 2009 (14 January 2009) (cont.).

Station	Time	Depth (m)	Salinity (psu)	Transparency (cm)	Temp. (°C)	DO		pH	Turbidity (NTU)	Hardness (mg/l)	Alkalinity (mg/l)	Ammonia (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Chlorophyll-a (mg/m ³)
						(mg/l)	(mg/l)								
1	12.24	1.9	31	65	22.7	5.32	8.0	5	620	105	0.027	0.206	0.093	0.89	
3	12.19	1.7	33	52	22.5	5.36	8.1	4	580	109	0.028	0.320	0.095	0.89	
6	12.13	1.5	33	50	22.0	5.16	8.1	6	630	108	0.041	0.325	0.124	0.89	
7	11.49	1.7	33	61	22.5	5.26	8.2	3	590	108	0.021	0.278	0.095	0.89	
9	11.59	1.3	32	67	22.5	5.25	8.2	3	600	103	0.032	0.263	0.103	0.89	
12	12.05	1.8	33	51	21.4	4.77	8.1	4	570	110	0.052	0.307	0.134	1.78	
13	11.42	1.8	33	61	22.5	5.28	8.2	3	680	107	0.021	0.217	0.098	1.78	
15	11.32	1.6	35	59	22.5	4.71	8.2	5	600	102	0.021	0.219	0.093	0.89	
18	11.24	1.9	35	82	22.1	4.51	8.2	2	670	103	0.033	0.245	0.113	0.89	
19	10.59	2.0	35	86	22.5	5.08	8.3	2	560	100	0.018	0.193	0.083	0.89	
21	11.06	1.5	35	79	22.6	4.73	8.3	3	630	105	0.029	0.160	0.129	0.89	
24	11.16	2.2	35	62	21.8	4.67	8.2	6	580	106	0.038	0.333	0.072	8.01	
25	10.49	2.1	34	91	22.6	5.06	8.3	2	620	103	0.022	0.222	0.204	3.56	
27	10.40	2.2	34	97	22.5	5.13	8.3	2	620	101	0.026	0.157	0.072	2.67	
30	10.34	2.3	34	73	22.2	4.60	8.3	3	650	104	0.026	0.201	0.333	0.89	
31	10.07	2.4	34	83	22.5	5.22	8.3	1	620	102	0.027	0.237	0.085	2.67	
33	10.16	2.2	34	95	22.9	5.08	8.3	1	600	101	0.024	0.180	0.075	5.34	
36	10.24	2.3	34	107	22.8	4.95	8.4	2	650	104	0.020	0.170	0.080	1.78	

Table 14: Water quality and related parameters at Don Hoi Lot during June 2008 to May 2009 (23 February 2008) (cont.).

Station	Time	Depth (m)	Salinity (psu)	Transparency (cm)	Temp. (°C)	DO (mg/l)	pH	Turbidity (NTU))	Hardness (mg/l)	Alkalinity (mg/l)	Ammonia (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Chlorophyll-a (mg/m3)
3	9.45	1.4	21	34	27.7	4.40	8.2	24	360	107	0.118	2.274	0.033	24.03
6	9.52	1.2	20	27	27.5	4.25	8.2	30	350	103	0.177	1.186	0.041	12.46
7	10.16	1.3	20	31	27.8	4.28	8.1	35	400	101	0.095	1.129	0.036	16.91
9	10.08	1.1	21	34	27.9	4.26	8.3	80	420	100	0.144	1.008	0.036	14.24
12	10.00	0.8	20	31	27.9	4.35	8.3	43	400	101	0.144	1.153	0.041	19.58
13	10.22	1.3	24	40	28.4	4.30	8.3	44	470	102	0.134	0.928	0.036	24.03
15	10.26	1.1	21	39	28.3	4.31	8.3	55	380	105	0.099	0.902	0.040	38.27
18	10.32	1.4	19	40	28.0	4.29	8.2	43	360	103	0.200	1.083	0.048	21.36
19	10.54	1.1	22	38	28.5	4.26	8.3	46	400	105	0.122	0.964	0.041	8.01
21	10.47	1.1	24	39	28.5	4.39	8.3	33	420	100	0.113	0.774	0.041	19.58
24	10.38	1.4	24	39	28.6	4.36	8.2	41	400	106	0.109	0.673	0.059	24.92
25	11.02	1.2	25	39	28.7	4.46	8.3	61	450	100	0.085	0.660	0.036	25.81
27	11.08	1.1	24	34	28.7	4.34	8.3	43	430	104	0.082	0.691	0.043	11.57
30	11.15	1.3	26	41	28.9	4.35	8.3	36	430	103	0.094	0.645	0.044	3.56
31	11.36	1.2	25	42	29.0	4.62	8.4	39	420	104	0.084	0.748	0.034	34.71
33	11.30	1.0	25	40	29.0	4.57	8.3	56	420	132	0.112	0.691	0.037	17.80
36	11.22	1.3	25	39	29.0	4.47	8.4	52	430	105	0.071	0.658	0.039	0.89

Table 14 Water quality and related parameters at Don Hoi Lot during June 2008 to May 2009 (8 March 2009) (cont.).

Station	Time	Depth (m)	Salinity (psu)	Transparency (cm)	Temp. (°C)	DO		Turbidity (NTU)	Hardness (mg/l)	Alkalinity (mg/l)	Ammonia (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Chlorophyll-a (mg/m ³)
						(mg/l)	pH							
1	12.43	1.0	18	65	30.2	6.49	8.3	26	360	120	0.066	0.890	0.023	6.23
3	12.51	0.8	18	66	30.3	6.52	8.3	26	470	113	0.093	0.951	0.024	5.34
6	12.57	0.8	18	47	30.1	6.77	8.3	34	440	114	0.085	0.921	0.027	5.34
7	12.36	1.1	18	60	29.6	5.79	8.3	26	530	123	0.116	0.859	0.027	2.67
9	12.28	1.0	20	63	30.0	6.28	8.3	17	580	120	0.104	0.985	0.028	5.34
12	12.18	0.7	21	47	30.2	6.44	8.3	48	600	115	0.108	0.745	0.026	9.79
13	11.51	1.2	21	49	29.6	5.70	8.3	46	500	112	0.060	0.856	0.031	5.34
15	12.00	1.1	21	53	30.0	6.30	8.3	33	610	113	0.109	0.655	0.052	0.89
18	12.08	1.5	20	49	30.0	6.44	8.3	41	470	130	0.112	0.985	0.031	7.12
19	11.43	1.1	20	56	29.6	5.64	8.3	40	510	125	0.120	0.694	0.028	2.67
21	11.33	0.9	20	35	29.8	6.05	8.3	75	500	117	0.115	0.993	0.050	4.45
24	11.25	1.4	18	41	29.6	6.36	8.3	58	440	121	0.118	0.766	0.029	4.45
25	10.35	1.4	21	36	29.5	6.27	8.3	56	510	117	0.055	0.851	0.023	8.01
27	10.27	1.2	20	34	29.2	6.42	8.4	72	500	117	0.093	0.681	0.039	10.68
30	10.18	1.5	21	34	29.0	6.59	8.4	56	550	113	0.066	0.869	0.029	3.56
31	9.54	1.4	23	44	29.3	6.45	8.4	48	500	116	0.061	0.549	0.020	12.46
33	10.03	1.3	23	43	29.2	6.29	8.4	45	570	114	0.057	0.776	0.044	0.89
36	10.09	1.6	21	50	29.0	6.90	8.4	43	470	118	0.098	0.794	0.030	12.46

Table 14: Water quality and related parameters at Don Hoi Lot during June 2008 to May 2009 (1 April 2009) (cont.).

Station	Time	Depth (m)	Salinity (psu)	Transparency (cm)	Temp. (°C)	DO (mg/l)	pH	Turbidity (NTU)	Hardness (mg/l)	Alkalinity (mg/l)	Ammonia (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Chlorophyll-a (mg/m ³)
3	8.28	1.5	14	41	30.6	4.92	8.4	10	430	121	0.064	0.967	0.032	5.34
6	8.22	1.3	22	45	30.6	4.32	8.3	11	570	120	0.058	1.006	0.029	6.23
7	8.06	1.5	19	48	30.4	5.02	8.4	9	410	120	0.055	0.910	0.032	0.89
9	8.11	1.2	18	47	30.4	5.04	8.8	9	490	123	0.078	1.276	0.028	5.34
12	8.16	1.8	23	51	30.4	4.82	8.3	10	510	115	0.065	0.933	0.028	7.12
13	8.00	1.6	20	52	30.4	5.02	8.4	8	570	120	0.064	1.011	0.042	2.67
15	7.53	1.5	22	48	30.1	5.19	8.4	7	520	121	0.075	0.954	0.023	1.78
18	7.48	1.6	25	62	30.0	5.10	8.3	10	630	126	0.062	0.761	0.028	0.89
19	7.19	1.6	20	59	29.9	5.47	8.4	7	480	124	0.071	1.251	0.034	0.89
21	7.26	1.3	24	64	29.9	5.26	8.4	6	630	120	0.070	0.676	0.019	1.78
24	7.33	2.1	25	52	30.1	5.24	8.4	13	460	118	0.042	0.658	0.024	1.78
25	7.13	1.5	24	89	30.0	5.44	8.5	4	640	119	0.061	0.817	0.033	2.67
27	7.07	1.6	25	91	30.0	5.34	8.5	4	680	120	0.076	0.565	0.023	1.78
30	7.01	2.0	25	75	30.0	5.30	8.5	7	520	120	0.058	0.513	0.027	3.56
31	6.38	1.8	25	86	30.0	5.50	8.6	5	570	122	0.056	0.792	0.043	0.89
33	6.48	1.9	25	79	29.9	5.52	8.6	10	620	120	0.061	0.817	0.029	13.35
36	6.55	1.7	25	67	30.1	5.41	8.5	7	520	120	0.073	0.456	0.029	15.13

Table 14: Water quality and related parameters at Don Hoi Lot during June 2008 to May 2009 (1 May 2009) (cont.).

Station	Time	Depth (m)	Salinity (psu)	Transparency (cm)	Temp. (°C)	DO (mg/l)	pH	Turbidity (NTU)	Hardness (mg/l)	Alkalinity (mg/l)	Ammonia (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Chlorophyll-a (mg/m ³)
1	6.42	1.4	25	66	30.5	5.21	8.5	7	480	89	0.113	0.872	0.021	5.34
3	6.47	1.1	27	54	31.2	4.45	8.6	11	580	94	0.102	0.462	0.018	1.78
6	6.56	1.5	27	67	31.3	4.46	8.6	8	240	101	0.079	0.395	0.026	1.78
7	7.21	1.6	23	76	30.3	5.18	8.6	5	350	98	0.112	0.740	0.024	0.89
9	7.16	1.3	27	65	31.0	4.46	8.5	10	410	99	0.071	0.387	0.018	0.89
12	7.01	1.6	27	82	31.4	3.46	8.6	5	270	96	0.074	0.433	0.023	0.89
13	7.26	1.6	23	60	31.1	4.50	8.6	5	390	94	0.077	0.511	0.022	0.89
15	7.31	1.3	27	56	30.6	4.93	8.6	5	520	98	0.067	0.405	0.020	0.89
18	7.35	1.7	30	68	31.2	3.83	8.6	7	480	92	0.099	0.415	0.020	0.89
19	7.52	1.5	24	62	30.6	5.07	8.6	6	300	97	0.102	0.864	0.023	0.89
21	7.47	1.3	26	64	31.0	2.99	8.6	4	470	86	0.089	0.505	0.023	15.13
24	7.41	1.8	29	91	30.5	4.81	8.6	5	500	92	0.094	0.523	0.030	0.89
25	7.58	1.7	27	76	30.6	4.68	8.6	5	490	84	0.082	0.552	0.023	1.78
27	8.02	1.3	26	73	31.0	4.73	8.6	5	380	90	0.073	0.753	0.025	0.89
30	8.09	1.7	29	75	30.8	4.66	8.6	5	500	96	0.108	0.444	0.020	0.89
31	8.30	1.6	27	60	30.7	3.48	8.6	5	450	88	0.081	0.462	0.022	4.45
33	8.13	1.4	29	82	30.5	4.19	8.6	4	290	98	0.093	0.578	0.026	3.56
36	8.20	1.6	30	73	31.1	2.82	8.6	4	480	82	0.101	0.456	0.023	1.78

Table 15 Statistic analysis for Water quality and related parameters

Analysis of Variance for Water depth (m) (p< 0.01)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	2.320	5	.464	5.926	.000
-Months	24.305	11	2.210	28.224	.000
2-Factor Interaction	2.512	55	.046	.583	.988
Residual	11.273	144	.078		
Total (Corrected)	40.410	215			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	1.886	2	.943	17.264	.000
-Months	24.305	11	2.210	40.453	.000
2-Factor Interaction	4.387	22	.199	3.651	.000
Residual	9.832	180	.055		
Total (Corrected)	40.410	215			

Table 15: Statistic analysis for Water quality and related parameters (cont.).

Analysis of Variance for Water temperature (°C) (p< 0.01)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	.008	5	.002	.823	.535
-Months	18.097	11	1.645	831.647	.000
2-Factor Interaction	.240	55	.004	2.206	.000
Residual	.285	144	.002		
Total (Corrected)	18.630	215			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level.
Main effects					
-Longitudinal transect	.002	2	.001	.382	.683
-Months	18.097	11	1.645	672.114	.000
2-Factor Interaction	.091	22	.004	1.681	.035
Residual	.441	180	.002		
Total (Corrected)	18.630	215			

Table 15: Statistic analysis for Water quality and related parameters (cont.).Analysis of Variance for Water pH ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	.003	5	.001	10.244	.000
-Months	.045	11	.004	83.375	.000
2-Factor Interaction	.002	55	4.252E-05	.861	.734
Residual	.007	144	4.940E-05		
Total (Corrected)	.057	215			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	.001	2	.000	9.212	.000
-Months	.045	11	.004	88.238	.000
2-Factor Interaction	.003	22	.000	2.649	.000
Residual	.008	180	4.668E-05		
Total (Corrected)	.057	215			

Table 15: Statistic analysis for Water quality and related parameters (cont.).Analysis of Variance for Dissolved oxygen (mg/l) ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	.141	5	.028	3.226	.009
-Months	16.868	11	1.533	175.407	.000
2-Factor Interaction	1.611	55	.029	3.351	.000
Residual	1.259	144	.009		
Total (Corrected)	19.879	215			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	.001	2	.001	.045	.956
-Months	16.867	11	1.533	97.317	.000
2-Factor Interaction	.173	22	.008	.501	.971
Residual	2.836	180	.016		
Total (Corrected)	19.878	215			

Table 15: Statistic analysis for Water quality and related parameters (cont.).

Analysis of Variance for Transparency (cm) ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Transverse transect	.474	5	.095	15.473	.000
-Months	3.997	11	.363	59.287	.000
2-Factor Interaction	.519	55	.009	1.541	.022
Residual	.883	144	.006		
Total (Corrected)	5.873	215			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level.
Main effects					
-Longitudinal transect	.014	2	.007	.861	.424
-Months	3.997	11	.363	44.444	.000
2-Factor Interaction	.390	22	.018	2.171	.003
Residual	1.472	180	.008		
Total (Corrected)	5.873	215			

Table 15: Statistic analysis for Water quality and related parameters (cont.).

Analysis of Variance for Turbidity (NTU) ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	.993	5	.199	4.579	.001
-Months	28.602	11	2.600	59.940	.000
2-Factor Interaction	2.595	55	.047	1.088	.341
Residual	6.247	144	.043		
Total (Corrected)	38.437	215			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	.423	2	.211	5.798	.004
-Months	27.883	11	2.535	69.553	.000
2-Factor Interaction	2.456	22	.112	3.064	.000
Residual	6.524	179	.036		
Total (Corrected)	37.268	214			

Table 15: Statistic analysis for Water quality and related parameters (cont.).Analysis of Variance for Salinity (psu) ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	9.911	5	1.982	25.755	.000
-Months	79.035	11	7.185	93.355	.000
2-Factor Interaction	7.718	55	.140	1.823	.002
Residual	11.083	144	.077		
Total (Corrected)	107.748	215			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level.
Main effects					
-Longitudinal transect	1.709	2	.855	4.507	.012
-Months	81.347	11	7.395	39.001	.000
2-Factor Interaction	9.038	22	.411	2.167	.003
Residual	34.130	180	.190		
Total (Corrected)	126.224	215			

Table 15: Statistic analysis for Water quality and related parameters (cont.).Analysis of Variance for Alkalinity (mgCaCO₃/l) ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	157.648	5	31.530	.636	.672
-Months	38967.148	11	3542.468	71.505	.000
2-Factor Interaction	4667.796	55	84.869	1.713	.006
Residual	7134.000	144	49.542		
Total (Corrected)	50926.593	215			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level.
Main effects					
-Longitudinal transect	18.343	2	9.171	.147	.863
-Months	38967.148	11	3542.468	56.931	.000
2-Factor Interaction	740.769	22	33.671	.541	.954
Residual	11200.333	180	62.224		
Total (Corrected)	50926.593	215			

Table 15: Statistic analysis for Water quality and related parameters (cont.).

Analysis of Variance for Hardness (mgCaCO₃/l) (p< 0.01)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	350381.944	5	70076.389	15.271	.000
-Months	2036223.611	11	185111.237	40.339	.000
2-Factor Interaction	399256.944	55	7259.217	1.582	.016
Residual	660800.000	144	4588.889		
Total (Corrected)	3446662.500	215			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	46286.111	2	23143.056	3.401	.035
-Months	2036223.611	11	185111.237	27.203	.000
2-Factor Interaction	139302.778	22	6331.944	.931	.555
Residual	1224850.000	180	6804.722		
Total (Corrected)	3446662.500	215			

Table 15: Statistic analysis for Water quality and related parameters (cont.).

Analysis of Variance for Ammonia nitrogen (mg/l) (p< 0.01)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	.004	5	.001	7.343	.000
-Months	.068	11	.006	54.028	.000
2-Factor Interaction	.007	55	.000	1.117	.298
Residual	.017	144	.000		
Total (Corrected)	.096	215			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	.000	2	.000	.857	.426
-Months	.068	11	.006	42.189	.000
2-Factor Interaction	.001	22	4.948E-05	.335	.998
Residual	.027	180	.000		
Total (Corrected)	.096	215			

Table 15: Statistic analysis for Water quality and related parameters (cont.).Analysis of Variance for Nitrate nitrogen (mg/l) ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	2.231	5	.446	35.285	.000
-Months	7.514	11	.683	54.007	.000
2-Factor Interaction	1.563	55	.028	2.247	.000
Residual	1.821	144	.013		
Total (Corrected)	13.129	215			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	.137	2	.069	2.044	.132
-Months	6.979	11	.634	18.909	.000
2-Factor Interaction	.498	22	.023	.675	.860
Residual	6.040	180	.034		
Total (Corrected)	13.654	215			

Table 15: Statistic analysis for Water quality and related parameters (cont.).Analysis of Variance for Phosphate phosphorus (mg/l) in the lower soil layer ($p < 0.01$)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	.012	5	.002	2.042	.076
-Months	.471	11	.043	35.328	.000
2-Factor Interaction	.089	55	.002	1.330	.092
Residual	.175	144	.001		
Total (Corrected)	.747	215			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	.004	2	.002	1.239	.292
-Months	.605	11	.055	31.453	.000
2-Factor Interaction	.027	22	.001	.700	.836
Residual	.315	180	.002		
Total (Corrected)	.952	215			

Table 15: Statistic analysis for Water quality and related parameters (cont.).

Analysis of Variance for Chlorophyll a (mg/m³) (p< 0.01)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	2.756	5	.551	1.565	.174
-Months	117.892	11	10.717	30.425	.000
2-Factor Interaction	21.520	55	.391	1.111	.307
Residual	50.725	144	.352		
Total (Corrected)	192.893	215			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	.147	2	.073	.200	.819
-Months	117.892	11	10.717	29.165	.000
2-Factor Interaction	8.708	22	.396	1.077	.375
Residual	66.147	180	.367		
Total (Corrected)	192.893	215			

Table 15: Statistic analysis for Water quality and related parameters (cont.).

Analysis of Variance for Density of Phytoplankton (unit/l) (p< 0.01)

Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
- Transverse transect	.576	5	.115	.973	.437
-Months	45.062	11	4.097	34.608	.000
2-Factor Interaction	9.560	55	.174	1.468	.037
Residual	17.045	144	.118		
Total (Corrected)	72.242	215			
Source of variation	Type III Sum of Squares	Degree of freedom	Mean Square	F-ratio	Significant level
Main effects					
-Longitudinal transect	.314	2	.157	1.315	.271
-Months	45.062	11	4.097	34.335	.000
2-Factor Interaction	5.391	22	.245	2.054	.005
Residual	21.476	180	.119		
Total (Corrected)	72.242	215			

Table 16: Species composition of phytoplankton found in each month during June 2008 to May 2009

NO.	TAXA	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09
DIVISION CYANOPHYTA													
CLASS CYANOPHYCEAE													
1	<i>Anabaena</i> sp.	+	+	-	-	+	+	-	-	-	-	-	+
2	<i>A. affinis</i>	+	-	+	-	+	+	+	-	-	-	-	-
3	<i>A. spiroides</i>	-	-	+	+	+	+	-	-	-	-	-	-
4	<i>Anabaenopsis circularis</i>	+	+	+	+	+	+	-	-	-	-	-	-
5	<i>Chroococcus turgidus</i>	-	+	-	-	-	-	-	-	-	-	-	-
6	<i>Cylindrospermopsis raciborskii</i>	-	-	+	-	+	+	-	-	-	-	-	-
7	<i>C. philippinensis</i>	-	-	-	-	+	+	-	-	-	-	-	-
8	<i>Merismopedia convoluta</i>	-	+	+	-	-	-	-	-	-	-	-	-
9	<i>M. minima</i>	-	+	+	-	+	+	-	-	-	+	-	-
10	<i>M. tenuissima</i>	-	+	-	+	-	+	-	-	+	-	-	-
11	<i>Microcystis aeruginosa</i>	+	+	+	-	+	+	-	-	-	-	-	-
12	<i>Oscillatoria</i> spp.	+	+	+	+	+	+	+	+	+	+	+	+
13	<i>Phormidium mucicola</i>	-	-	-	-	-	+	+	-	-	-	-	-
14	<i>Raphidiopsis curvata</i>	-	-	-	-	+	+	-	-	-	-	-	-
15	<i>R. indica</i>	-	-	+	-	+	+	-	-	-	-	-	-
16	<i>R. mediterranea</i>	-	-	+	-	+	+	-	-	-	-	+	-
17	<i>Spirulina platensis</i>	+	+	+	+	+	+	+	-	-	+	-	-
18	<i>S. major</i>	-	+	-	-	-	+	+	-	-	+	-	-
	Subtotal Class Cyanophyceae	6	10	11	5	13	16	5	1	2	4	2	2
DIVISION CHLOROPHYTA													
CLASS CHLOROPHYCEAE													
19	<i>Actinastrum gracillimum</i>	-	-	-	-	+	-	-	-	-	-	+	-
20	<i>A. hantzschii</i>	-	-	-	-	+	+	-	-	-	-	-	-

Table 16: Species composition of phytoplankton found in each month during June 2008 to May 2009 (cont.)

NO.	TAXA	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09
21	<i>Ankistrodesmus falcatus</i>	+	-	-	-	+	-	-	-	-	-	-	-
22	<i>Closterium</i> sp.	-	-	-	+	-	-	-	-	-	-	-	-
23	<i>Coelastrum astroideum</i>	+	+	+	+	+	+	+	-	-	-	+	+
24	<i>C. microporum</i>	-	+	-	-	+	+	-	-	+	+	+	+
25	<i>C. reticulatum</i>	+	+	+	+	+	+	-	-	-	+	-	+
26	<i>C. sphaericum</i>	-	-	-	-	+	-	-	-	-	-	-	-
27	<i>Coenochloris pyrenoidosa</i>	+	+	-	-	+	-	-	-	-	-	+	-
28	<i>Cosmarium contractum</i>	-	-	+	-	-	-	+	-	-	-	-	-
29	<i>Crucigenia crucifera</i>	-	-	-	-	+	-	-	-	-	-	-	-
30	<i>C. negrecta</i>	-	-	-	-	+	-	-	-	-	-	-	-
31	<i>C. quadrata</i>	-	-	-	-	+	-	-	-	-	-	-	-
32	<i>C. tetrapedia</i>	+	-	+	-	+	-	-	-	+	+	-	+
33	<i>Dicloster acutatus</i>	-	-	-	-	+	-	-	-	-	-	-	-
34	<i>Dietyosphaerium pulchellum</i>	-	-	+	-	-	-	-	-	-	-	-	-
35	<i>Eudorina elegans</i>	-	+	+	-	-	+	-	-	-	-	-	-
36	<i>Monoraphidium contortum</i>	-	-	-	-	+	+	-	-	-	+	-	-
37	<i>M. caribeum</i>	-	-	-	-	+	+	-	-	-	-	+	-
38	<i>M. griffithii</i>	-	-	-	-	-	+	-	-	-	-	-	-
39	<i>M. irregulare</i>	-	-	-	-	+	+	-	-	-	-	-	-
40	<i>M. komarkovae</i>	-	-	-	-	+	+	-	-	-	-	-	-
41	<i>Pandorina morum</i>	+	+	+	-	-	+	-	-	-	+	-	-
42	<i>Pediastrum duplex</i>	-	-	+	-	-	+	-	-	-	-	+	-
43	<i>P. duplex</i> var. <i>clathratum</i>	-	-	-	-	-	+	-	-	-	-	-	-
44	<i>P. duplex</i> var. <i>gracilimum</i>	+	-	+	-	-	+	-	-	-	-	-	-
45	<i>P. simplex</i>	+	-	+	-	+	+	+	-	-	+	+	-

Table 16: Species composition of phytoplankton found in each month during June 2008 to May 2009 (cont.)

NO.	TAXA	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09
91	<i>C. danicus</i>	-	-	-	-	-	-	-	-	-	-	-	+
92	<i>C. denticulatum</i>	-	+	-	-	+	-	-	-	-	-	-	-
93	<i>C. diadema</i>	-	-	-	-	-	-	-	-	-	-	-	+
94	<i>C. dichymus</i>	+	+	+	-	-	-	+	+	+	+	+	+
95	<i>C. diversus</i>	-	-	-	-	-	-	-	-	-	-	-	+
96	<i>C. lacinosus</i>	+	-	-	-	-	+	+	-	+	+	+	+
97	<i>C. lauderi</i>	-	-	-	-	-	-	-	-	+	-	-	-
98	<i>C. lorenzianus</i>	+	+	-	+	+	+	+	+	+	+	+	+
99	<i>C. peruvianus</i>	+	-	-	-	+	-	-	-	-	-	-	+
100	<i>C. pseudocurvisetus</i>	+	+	+	+	+	+	+	+	+	+	+	+
101	<i>C. subtilis</i>	-	-	-	-	-	+	-	-	-	-	-	-
102	<i>Climacodium</i> sp.	-	-	-	-	-	-	-	-	-	-	-	+
103	<i>Climaconeis</i> sp.	+	+	+	+	-	-	-	-	-	-	-	-
104	<i>Cocconeis</i> sp.	+	+	+	+	-	+	-	+	+	+	+	+
105	<i>Coscinodiscus</i> spp.	+	+	+	+	+	+	+	+	+	+	+	+
106	<i>Cyclotella meneghiniana</i>	-	-	-	-	-	-	-	-	-	-	-	-
107	<i>C. stylorum</i>	-	-	-	-	-	-	-	+	+	+	+	+
108	<i>Cymbella</i> sp.	-	+	+	-	-	+	+	-	-	+	-	-
109	<i>Cylindrotheca closterium</i>	+	+	+	+	+	+	+	+	+	+	+	+
110	<i>Dactyliosolen phuketensis</i>	+	-	-	-	-	-	+	-	-	-	-	-
111	<i>Diploneis</i> spp.	+	+	+	+	-	-	-	+	+	+	-	+
112	<i>Ditylum sol</i>	+	+	-	-	-	+	+	-	-	-	-	-
113	<i>Eutomoneis robusta</i>	+	+	+	+	-	-	+	+	+	+	+	+
114	<i>Eucampia cornuta</i>	-	-	-	-	+	-	-	-	-	-	-	-
115	<i>E. zodiacus</i>	+	+	+	-	+	-	+	+	+	-	+	-

Table 16: Species composition of phytoplankton found in each month during June 2008 to May 2009 (cont.)

NO.	TAXA	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09
116	<i>Fragilaria</i> sp.	+	+	+	+	+	+	-	-	+	-	+	-
117	<i>Gomphonema</i> sp.	-	+	+	-	-	+	-	-	-	-	+	-
118	<i>Grammatophora undulata</i>	+	-	-	-	-	+	+	-	-	-	-	-
119	<i>Guinardia flaccida</i>	+	+	+	-	-	+	+	-	+	-	+	-
120	<i>Gyrosigma</i> spp.	+	+	+	+	+	+	+	+	+	+	+	+
121	<i>Hemiaulus indicus</i>	-	-	-	-	-	-	+	-	-	-	-	-
122	<i>H. membranaceus</i>	-	-	-	-	-	-	+	-	-	-	-	+
123	<i>Hydrosera triquetra</i>	-	+	+	-	-	-	-	-	-	-	-	-
124	<i>Lauderia annulata</i>	+	+	+	-	-	+	+	-	-	-	+	-
125	<i>Leptocylindrus danicus</i>	+	-	+	-	+	+	-	-	+	+	+	+
126	<i>Lioloma</i> sp.	+	-	-	-	-	-	+	-	-	-	-	-
127	<i>Melosira varians</i>	-	-	+	-	-	-	-	-	-	-	-	-
128	<i>M. dubia</i> Kützing	-	-	-	-	-	-	-	-	-	+	-	-
129	<i>Meunier membranacea</i>	+	-	-	-	-	+	+	-	+	-	+	+
130	<i>Navicula</i> spp.	+	+	+	+	+	+	+	+	+	+	+	-
131	<i>Nitzschia</i> spp.	+	+	+	+	+	+	+	+	+	+	+	+
132	<i>Odontella aurita</i>	-	-	-	-	-	-	-	-	-	-	-	+
133	<i>O. mobiliensis</i>	-	-	-	-	-	-	-	-	-	+	-	+
134	<i>O. sinensis</i>	+	+	+	+	+	+	+	+	+	+	+	+
135	<i>Palmeria hardmaniana</i>	+	-	-	-	-	-	-	-	-	-	-	-
136	<i>Paralia sulcata</i>	+	+	+	+	-	-	-	+	+	+	-	+
137	<i>Pinnularia</i> sp.	-	+	+	-	-	-	-	-	+	-	-	-
138	<i>Planktoniella sol</i>	+	+	-	+	-	+	-	-	+	+	+	-
139	<i>Pleurosigma</i> spp.	+	+	+	+	-	+	+	+	+	-	-	-
140	<i>Proboscia alata</i>	+	+	+	-	-	-	+	+	-	-	-	+

Table 16: Species composition of phytoplankton found in each month during June 2008 to May 2009 (cont.).

NO.	TAXA	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09
141	<i>Pseudonitzschia pungens</i>	+	+	+	+	+	+	+	+	+	+	+	+
142	<i>Pseudosolenia calcar avis</i>	+	+	+	+	-	+	+	+	+	+	+	-
143	<i>Rhizosolenia bergonii</i>	-	+	-	-	+	-	-	-	-	-	-	-
144	<i>R. hyalina</i>	-	-	-	-	-	-	+	-	-	-	-	-
145	<i>R. longiseta</i>	-	-	-	-	-	-	+	-	-	-	-	-
146	<i>R. pungens</i>	+	+	+	+	+	+	+	+	+	-	+	+
147	<i>R. setigera</i>	+	+	-	-	+	+	+	+	+	+	+	+
148	<i>R. striata</i>	-	+	+	-	-	-	+	+	-	-	+	+
149	<i>R. styliformis</i>	+	+	-	-	+	-	+	-	+	-	-	+
150	<i>Skeletonema costatum</i>	+	-	-	+	+	+	+	-	+	+	+	+
151	<i>Surirella ovata</i>	+	+	+	-	-	+	-	+	+	+	+	+
152	<i>S. elegans</i>	+	+	+	-	-	-	-	-	-	-	-	-
153	<i>S. robusta var. splendida</i>	+	+	+	-	-	-	-	-	-	-	-	+
154	<i>Synedra</i> sp.	+	+	+	+	+	-	-	-	-	+	-	+
155	<i>Synedrosphenia</i> sp.	+	-	+	-	+	-	-	-	-	-	-	-
156	<i>Thalassionema frauenfeldii</i>	+	+	+	+	+	+	+	+	+	+	+	+
157	<i>T. nitzschoides</i>	+	+	+	-	-	+	+	-	-	-	+	+
158	<i>Thalassiosira</i> spp.	+	+	+	+	+	+	+	+	+	+	+	+
159	<i>Thalassiothrix</i> sp.	-	-	-	-	-	-	+	-	-	-	-	-
160	<i>Trachyneis</i> sp.	-	-	-	+	-	-	-	-	-	-	-	-
161	<i>Triceratium favus f. quadrata</i>	+	+	+	-	-	-	-	-	-	-	-	+
162	<i>Tryblionella</i> sp.	+	+	+	-	+	+	+	-	+	-	+	+
Subtotal Class Bacillariophyceae		58	54	47	32	30	37	50	34	43	38	40	46

Table 16: Species composition of phytoplankton found in each month during June 2008 to May 2009 (cont.).

NO.	TAXA	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09
CLASS CHRYSOPHYCEAE													
163	<i>Dinobryon sertularia</i>	-	+	+	-	+	-	-	-	-	-	-	-
	Subtotal Class Chrysophyceae	0	1	1	0	1	0	0	0	0	0	0	0
CLASS XANTHOPHYCEAE													
164	<i>Centrtractus belanophorus</i>	-	-	-	-	+	+	-	-	-	-	-	-
	Subtotal Class Xanthophyceae	0	0	0	0	1	1	0	0	0	0	0	0
CLASS DICTYOCOPHYCEAE													
165	<i>Dictyocha fibula</i> var. <i>stapedia</i>	+	+	+	-	-	-	-	-	-	-	-	+
166	<i>Distephanus speculum</i>	-	-	+	-	-	-	-	-	-	-	-	-
	Subtotal Class Dictyochophyceae	1	1	2	0	0	0	0	0	0	0	0	1
CLASS PRYMNESIOPHYCEAE													
167	<i>Isochrysis galbana</i>	-	-	-	-	-	-	+	-	-	-	-	-
	Subtotal Class Prymnesiophyceae	0	0	0	0	0	0	1	0	0	0	0	0
CLASS DINOPHYCEAE													
168	<i>Alexandrium</i> sp.	-	-	-	+	-	-	-	-	-	-	-	-
169	<i>Ceratium furca</i>	+	+	-	+	+	+	+	+	+	+	+	-
170	<i>C. fusus</i>	+	+	-	-	-	-	-	-	-	-	-	-
171	<i>C. massiliense</i>	-	-	-	-	-	-	+	-	-	-	-	-
172	<i>C. trichoceros</i>	+	+	-	-	-	-	+	-	-	-	-	-
173	<i>C. Tripos</i> var. <i>pulchellum</i>	+	-	-	-	-	-	-	-	-	-	-	-
174	<i>Dinophysis caudata</i>	+	+	+	+	+	+	+	+	+	+	+	-
175	<i>Diplosalis</i> sp.	+	+	-	+	-	+	+	-	-	+	+	-
176	<i>Glenodinium</i> sp.	+	-	-	-	+	+	+	+	-	+	-	-
177	<i>Gonyaulax</i> spp.	+	+	-	+	+	+	+	+	-	+	+	+
178	<i>Gymnodinium</i> spp.	+	-	-	-	+	+	+	+	-	-	+	-

Table 16: Species composition of phytoplankton found in each month during June 2008 to May 2009 (cont.).

NO.	TAXA	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09
179	<i>Noctiluca scintillans</i>	+	+	+	+	+	-	+	+	+	-	+	-
180	<i>Peridinium</i> spp.	+	+	+	+	+	+	+	+	+	+	+	+
181	<i>Phalacoma rudgei</i>	+	-	-	-	-	-	-	-	-	-	-	-
182	<i>Polykrikos</i> sp.	-	-	-	-	-	+	-	-	-	-	-	-
183	<i>Prorocentrum micans</i>	+	+	-	+	+	+	+	+	+	+	-	+
184	<i>P. sigmoides</i>	-	-	-	+	-	-	-	+	-	+	-	-
185	<i>Protoperidinium</i> spp.	+	+	+	+	+	+	+	+	+	+	+	+
186	<i>Pyrophacus horologium</i>	+	-	-	-	-	-	+	-	-	-	-	-
187	<i>Scrippsiella</i> sp.	+	+	-	-	-	+	-	+	-	+	-	-
Subtotal Class Dinophyceae		16	11	4	10	9	11	13	11	5	10	7	4
Total Phytoplankton		98	92	88	55	85	95	77	46	53	64	64	60

Table 17: Species composition of phytoplankton found in each station during June 2008 to May 2009 (cont.)

No.	Taxa	Station																													
		1	3	6	7	9	12	12	12	4	13	15	18	19	21	24	25	27	30	31	33	36									
	Subtotal Class Cyanophyceae	13	11	11	11	12	12	12	12	4	13	15	18	19	21	24	25	27	30	31	33	36									
	DIVISION CHLOROPHYTA																														
	CLASS CHLOROPHYCEAE																														
19	<i>Actinastrum gracillimum</i>	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-									
20	<i>A. hantzschii</i>	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-									
21	<i>Ankistrodesmus falcatus</i>	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-									
22	<i>Closterium</i> sp.	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-									
23	<i>Coelastrum astroideum</i>	+	+	+	+	-	+	+	+	+	+	+	+	+	-	+	+	+	-	-	-	-									
24	<i>C. microporum</i>	+	+	+	+	+	+	+	+	+	+	+	+	-	-	+	+	-	-	+	-	-									
25	<i>C. reticulatum</i>	+	+	+	+	+	+	+	+	-	+	+	+	+	-	+	+	+	-	-	-	-									
26	<i>C. sphaericum</i>	+	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-									
27	<i>Coenochloris pyrenoidosa</i>	+	+	+	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-									
28	<i>Cosmarium contractum</i>	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-									
29	<i>Crucigenia crucifera</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-									
30	<i>C. neglecta</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-									
31	<i>C. quadrata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-									
32	<i>C. tetrapedia</i>	+	+	+	+	-	+	-	+	+	+	-	+	+	-	+	-	-	-	-	-	-									
33	<i>Diclostera acutatus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-									
34	<i>Dityosphaerium pulchellum</i>	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-									
35	<i>Eudorina elegans</i>	+	+	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-									
36	<i>Monoraphidium contortum</i>	+	-	+	-	-	-	+	+	+	+	-	+	+	-	-	-	+	+	-	-	-									

Table 18: Average abundance of phytoplankton found in each month during June 2008 to May 2009 in Don Hoi Lot, Samut Songkram Province (individual/l)

NO.	TAXA	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09
DIVISION CYANOPHYTA													
CLASS CYANOPHYCEAE													
1	<i>Anabaena</i> sp.	1.13	15.00	0.00	0.00	16.50	18.38	0.00	0.00	0.00	0.00	0.00	0.75
2	<i>A. affinis</i>	4.13	0.00	1.13	0.00	1.50	1.88	0.75	0.00	0.00	0.00	0.00	0.00
3	<i>A. spiroides</i>	0.00	0.00	1.13	0.38	0.38	0.75	0.00	0.00	0.00	0.00	0.00	0.00
4	<i>Anabaenopsis circularis</i>	9.00	0.38	0.75	0.38	5.63	0.38	0.00	0.00	0.00	0.00	0.00	0.00
5	<i>Chroococcus turgidus</i>	0.00	35.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	<i>Cylindropspermopsis raciborskii</i>	0.00	0.00	0.38	0.00	0.75	4.50	0.00	0.00	0.00	0.00	0.00	0.00
7	<i>C. philippinensis</i>	0.00	0.00	0.00	0.00	0.75	6.38	0.00	0.00	0.00	0.00	0.00	0.00
8	<i>Merismopedia convoluta</i>	0.00	15.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	<i>M. minima</i>	0.00	3.00	1.50	0.00	36.00	3.00	0.00	0.00	0.00	6.00	0.00	0.00
10	<i>M. tenuissima</i>	0.00	1.88	0.00	5.25	0.00	3.75	0.00	0.00	24.00	0.00	0.00	0.00
11	<i>Microcystis aeruginosa</i>	33.75	18.75	11.63	0.00	45.75	89.25	0.00	0.00	0.00	0.00	0.00	0.00
12	<i>Oscillatoria</i> spp.	182.25	409.88	135.38	67.13	526.88	934.88	39.75	12.00	3.00	42.75	53.25	16.50
13	<i>Phormidium mucicola</i>	0.00	0.00	0.00	0.00	0.00	35.63	19.50	0.00	0.00	0.00	0.00	0.00
14	<i>Raphidtopsis curvata</i>	0.00	0.00	0.00	0.00	1.13	1.88	0.00	0.00	0.00	0.00	0.00	0.00
15	<i>R. indica</i>	0.00	0.00	0.75	0.00	5.25	8.63	0.00	0.00	0.00	0.00	0.00	0.00
16	<i>R. mediterranea</i>	0.00	0.00	1.50	0.00	21.75	4.88	0.00	0.00	0.00	0.00	4.50	0.00
17	<i>Spirulina platensis</i>	11.25	0.38	5.25	1.50	17.25	101.25	6.75	0.00	0.00	0.75	0.00	0.00
18	<i>S. major</i>	0.00	334.88	0.00	0.00	0.00	0.38	0.75	0.00	0.00	0.75	0.00	0.00

Table 18: Average abundance of phytoplankton found in each month during June 2008 to May 2009 in Don Hoi Lot, Samut Songkram Province (individual/l) (cont.)

NO.	TAXA	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09
Subtotal Class Cyanophyceae		241.50	834.38	160.88	74.63	679.50	1215.75	67.50	12.00	27.00	50.25	57.75	17.25
DIVISION CHLOROPHYTA													
CLASS CHLOROPHYCEAE													
19	<i>Actinastrum gracillimum</i>	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.75	0.00
20	<i>A. hantzschii</i>	0.00	0.00	0.00	0.00	0.38	1.13	0.00	0.00	0.00	0.00	0.00	0.00
21	<i>Ankistrodesmus falcatus</i>	0.75	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	<i>Closterium</i> sp.	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	<i>Coelastrum astroideum</i>	29.25	0.38	0.38	0.75	6.38	1.13	0.75	0.00	0.00	0.00	6.75	1.50
24	<i>C. microporum</i>	0.00	0.38	0.00	0.00	2.25	1.50	0.00	0.00	2.25	2.25	1.50	1.50
25	<i>C. reticulatum</i>	0.38	0.38	0.38	0.38	5.63	0.38	0.00	0.00	0.00	0.75	0.00	9.75
26	<i>C. sphaericum</i>	0.00	0.00	0.00	0.00	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	<i>Coenochloris pyrenoidosa</i>	0.38	0.38	0.00	0.00	2.25	0.00	0.00	0.00	0.00	0.00	9.00	0.00
28	<i>Cosmarium contractum</i>	0.00	0.00	0.38	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00
29	<i>Crucigenia crucifera</i>	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	<i>C. neglecta</i>	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	<i>C. quadrata</i>	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	<i>C. tetrapedia</i>	1.88	0.00	0.38	0.00	9.00	0.00	0.00	0.00	3.00	3.75	0.00	3.00
33	<i>Diclostera acutatus</i>	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	<i>Dictyosphaerium pulchellum</i>	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	<i>Eudorina elegans</i>	0.00	3.75	0.38	0.00	0.00	1.13	0.00	0.00	0.00	0.00	0.00	0.00
36	<i>Monoraphidium contortum</i>	0.00	0.00	0.00	0.00	3.00	1.88	0.00	0.00	0.00	1.50	0.00	0.00

Table 18: Average abundance of phytoplankton found in each month during June 2008 to May 2009 in Don Hoi Lot, Samut Songkram Province (individual/l) (cont.)

NO.	TAXA	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09
58	<i>Sphaerocystis</i> sp.	0.75	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59	<i>Staurastrum</i> spp.	0.00	0.38	7.50	0.00	11.63	2.63	0.75	0.00	0.75	4.50	0.75	0.75
60	<i>Tetraedron arthrodesmiforme</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00
61	<i>T. trigonum</i>	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00
62	<i>Ulothrix</i> sp.	0.00	0.00	0.00	0.00	2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subtotal Class Chlorophyceae		46.50	15.38	15.38	4.50	86.25	28.50	6.00	0.00	6.00	16.50	30.00	18.00
CLASS EULENOPHYCEAE													
63	<i>Euglena acus</i>	1.13	0.00	1.13	0.00	0.00	1.50	0.00	0.00	0.00	0.75	0.00	0.00
64	<i>E. oxyuris</i>	0.00	0.38	0.00	0.38	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00
65	<i>Lepocinclis ovum</i>	0.00	0.00	0.75	0.00	0.38	2.25	0.00	0.00	0.00	0.00	0.00	0.00
66	<i>L. salina</i>	0.00	0.00	0.00	0.00	0.00	0.75	0.75	0.00	0.00	0.00	0.00	0.00
67	<i>Phacus hamatus</i>	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00
68	<i>P. longicauda</i>	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
69	<i>P. pleuronectes</i>	0.00	3.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70	<i>P. ranula</i>	0.00	0.00	0.75	0.00	0.00	0.75	0.00	0.00	0.00	0.75	0.00	0.00
71	<i>P. tortus</i>	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
72	<i>Strombomonas fluviatilis</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00
73	<i>S. gibberosa</i>	0.00	0.38	0.75	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00
74	<i>Trachelomonas ovalis</i> var. <i>mimor</i>	0.38	0.00	0.00	0.00	0.38	0.38	0.00	0.00	0.00	0.00	0.00	0.00
75	<i>Entosiphon sulcatum</i>	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00
Subtotal Class Euglenophyceae		1.88	4.50	3.75	0.38	0.75	7.50	3.00	0.00	0.00	1.50	0.00	0.00

Table 18: Average abundance of phytoplankton found in each month during June 2008 to May 2009 in Don Hoi Lot, Samut Songkram Province (individual/l) (cont.)

NO.	TAXA	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09
DIVISION CHROMOPHYTA													
CLASS BACILLARIOPHYCEAE													
76	<i>Actinocyclus</i> sp.	0.38	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.75
77	<i>Amphora</i> sp.	27.75	364.13	102.38	5.25	1.13	1.50	5.25	123.75	69.00	18.00	6.00	6.00
78	<i>Asteromphalus flabellatus</i>	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.75
79	<i>Aulacoseira granulata</i>	0.38	51.00	1.13	0.38	121.50	13.88	19.50	0.00	6.00	0.00	0.00	0.00
80	<i>Bacillaria paxillifer</i>	43.88	19.88	1.50	0.38	0.75	0.00	0.75	220.50	1.50	9.75	0.00	0.00
81	<i>Bacteriasstrum comosum</i>	0.38	0.00	0.00	0.00	0.00	0.00	14.25	0.00	0.00	0.00	0.00	0.00
82	<i>B. delicatulum</i>	3.75	4.88	0.00	0.00	0.00	0.00	0.75	0.75	0.00	0.00	0.00	0.00
83	<i>B. furcatum</i>	36.75	31.88	2.25	0.75	0.00	9.75	267.00	23.25	5.25	6.00	8.25	1.50
84	<i>B. hyalinum</i>	226.88	29.25	2.63	1.50	0.00	1309.50	486.75	39.75	1.50	0.75	26.25	0.75
85	<i>Biddulphia</i> sp.	12.75	129.38	51.75	4.50	0.00	0.00	0.75	2.25	15.75	4.50	0.75	0.00
86	<i>Cerataulina pelagica</i>	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	6.00	1.50	0.00	1.50
87	<i>Chaetoceros affinis</i>	83.25	0.00	0.00	327.00	0.00	0.00	214.13	0.00	718.50	474.75	122.63	0.00
88	<i>C. borealis</i>	3.75	0.00	0.00	0.00	0.00	0.00	15.38	6.00	0.00	0.00	0.00	0.00
89	<i>C. compressus</i>	127.50	3.00	0.00	0.00	1.50	0.00	236.25	100.13	0.00	60.00	68.63	0.00
90	<i>C. curvisetus</i>	542.63	4.50	144.00	961.13	1.88	2847.00	397.50	290.25	1074.75	688.50	444.38	358.13
91	<i>C. danicus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25
92	<i>C. denticulatum</i>	0.00	0.38	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00
93	<i>C. diadema</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00
94	<i>C. didymus</i>	22.50	89.63	1.50	0.00	0.00	0.00	59.25	27.38	63.75	45.38	55.13	3.00

Table 18: Average abundance of phytoplankton found in each month during June 2008 to May 2009 in Don Hoi Lot, Samut Songkram Province (individual/l) (cont.)

NO.	TAXA	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09
95	<i>C. diversus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.50
96	<i>C. lacinosus</i>	415.13	0.00	0.00	0.00	0.00	1821.75	363.00	0.00	175.13	102.75	118.88	49.50
97	<i>C. lauderi</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00
98	<i>C. lorentzianus</i>	1207.13	26.25	0.00	2269.13	5.63	4222.50	1027.50	456.75	272.25	220.13	138.75	70.88
99	<i>C. peruvianus</i>	2.63	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	7.50
100	<i>C. pseudocurvisetus</i>	49867.88	112.88	7765.50	12622.13	11190.00	209229.00	25528.13	2796.75	78870.38	44196.00	23203.88	14206.50
101	<i>C. subtilis</i>	0.00	0.00	0.00	0.00	0.00	46.88	0.00	0.00	0.00	0.00	0.00	0.00
102	<i>Climacodium</i> sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50
103	<i>Climaconeis</i> sp.	0.38	105.00	0.75	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
104	<i>Cocconeis</i> sp.	73.88	159.00	69.00	1.88	0.00	6.75	0.00	16.50	40.50	28.50	4.50	3.75
105	<i>Coccinodiscus</i> spp.	79.88	41.25	56.25	9.00	0.38	72.75	27.00	239.63	39.75	90.75	12.75	71.25
106	<i>Cyclotella meneghiniana</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.00
107	<i>C. stylonum</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.25	31.50	14.25	3.75	11.25
108	<i>Cymbella</i> sp.	0.00	1.13	0.38	0.00	0.00	0.38	10.50	0.00	0.00	0.75	0.00	0.00
109	<i>Cylindrotheca closterium</i>	871.13	24.75	4704.00	37.88	39.75	17328.00	16294.50	5361.00	2316.00	3206.25	412.50	87.75
110	<i>Dacyliosolen phuketensis</i>	12.00	0.00	0.00	0.00	0.00	0.00	11.25	0.00	0.00	0.00	0.00	0.00
111	<i>Diploneis</i> spp.	31.88	34.50	1.13	0.38	0.00	0.00	0.00	3.75	0.75	3.00	0.00	1.50
112	<i>Ditylum sol</i>	27.75	1.50	0.00	0.00	0.00	6.75	0.75	0.00	0.00	0.00	0.00	0.00
113	<i>Entomoneis robusta</i>	9.00	9.38	2.63	1.50	0.00	0.00	0.75	36.00	10.50	198.00	48.00	41.25
114	<i>Eucampia cornuta</i>	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
115	<i>E. zodiacus</i>	244.13	5.25	0.75	0.00	3.75	0.00	16.50	2.25	0.75	0.00	18.00	0.00

Table 18: Average abundance of phytoplankton found in each month during June 2008 to May 2009 in Don Hoi Lot, Samut Songkram Province (individual/l) (cont.)

NO.	TAXA	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09
116	<i>Fragilaria</i> sp.	11.25	0.38	1.13	0.38	7.50	1.13	0.00	0.00	0.75	0.00	0.75	0.00
117	<i>Gomphonema</i> sp.	0.00	0.75	0.75	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.75	0.00
118	<i>Grammatophora undulata</i>	0.38	0.00	0.00	0.00	0.00	0.75	0.75	0.00	0.00	0.00	0.00	0.00
119	<i>Guinardia flaccida</i>	7.50	0.75	0.38	0.00	0.00	0.75	36.00	0.00	0.75	0.00	1.50	0.00
120	<i>Gyrosigma</i> spp.	128.63	178.13	96.00	17.63	8.63	6.75	33.75	2793.38	497.25	267.75	57.00	22.50
121	<i>Hemiaulus indicus</i>	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00
122	<i>H. membranaceus</i>	0.00	0.00	0.00	0.00	0.00	0.00	10.50	0.00	0.00	0.00	0.00	1.50
123	<i>Hydrosera triquetra</i>	0.00	0.38	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
124	<i>Lauderia annulata</i>	16.88	1.13	0.38	0.00	0.00	15331.50	122.25	0.00	0.00	0.00	5.25	0.00
125	<i>Leptocylindrus danicus</i>	684.00	0.00	6.38	0.00	46.13	4.88	0.00	0.00	156.75	12.75	21.00	20.25
126	<i>Lioloma</i> sp.	2.63	0.00	0.00	0.00	0.00	0.00	49.88	0.00	0.00	0.00	0.00	0.00
127	<i>Melosira varians</i>	0.00	0.00	1.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
128	<i>M. dubia</i> Kützting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00
129	<i>Meunier membranacea</i>	7.88	0.00	0.00	0.00	0.00	0.75	25.50	0.00	0.75	0.00	2.25	2.25
130	<i>Navicula</i> spp.	79.50	73.50	18.38	2.63	3.75	12.75	15.00	61.50	10.50	2.25	3.00	0.00
131	<i>Nitzschia</i> spp.	400.13	282.00	135.75	25.50	3.38	9.00	8.25	1017.00	609.75	167.63	48.75	6.75
132	<i>Odontella aurita</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.50
133	<i>O. mobiliensis</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00	21.75
134	<i>O. sinensis</i>	40.50	2.63	0.75	1.13	6.75	2841.75	8.25	11.25	19.50	13.50	3.00	5.25
135	<i>Palmeria hardmaniana</i>	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
136	<i>Paralia sulcata</i>	1.13	3.38	6.00	1.50	0.00	0.00	0.00	0.75	6.00	4.50	0.00	1.50

Table 18: Average abundance of phytoplankton found in each month during June 2008 to May 2009 in Don Hoi Lot, Samut Songkram Province (individual/l) (cont.)

NO.	TAXA	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09
137	<i>Pinnularia</i> sp.	0.00	4.88	1.13	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00
138	<i>Planktoniella sol</i>	0.75	2.25	0.00	7.50	0.00	0.75	0.00	0.00	0.75	1.50	2.25	0.00
139	<i>Pleurosigma</i> spp.	6.38	0.38	1.13	1.13	0.00	1.13	3.00	96.75	2.25	0.00	0.00	0.00
140	<i>Proboscia alata</i>	100.88	40.13	0.75	0.00	0.00	0.00	0.75	15.00	0.00	0.00	0.00	1.50
141	<i>Pseudonitzschia pungens</i>	52.50	3941.25	114.38	7.50	4.88	915.75	982.88	141.75	90.00	3.75	264.00	20.25
142	<i>Pseudosolenia calcar avis</i>	18.75	7.88	1.50	2.63	0.00	0.38	2733.00	29.25	6.00	2.25	2.25	0.00
143	<i>Rhizosolenia bergonii</i>	0.00	0.38	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00
144	<i>R. hyalina</i>	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.00	0.00	0.00	0.00	0.00
145	<i>R. longiseta</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00
146	<i>R. pungens</i>	25.88	29.25	1.50	0.38	9.38	4.88	13.50	2.25	2.25	0.00	0.75	1.50
147	<i>R. setigera</i>	94.50	28.13	0.00	0.00	51.00	4.13	22.50	9.00	387.00	8.25	3.00	4.50
148	<i>R. striata</i>	0.00	2.25	1.50	0.00	0.00	0.00	1.50	0.75	0.00	0.00	0.75	6.75
149	<i>R. styliformis</i>	0.38	0.38	0.00	0.00	0.38	0.00	26.25	0.00	0.75	0.00	0.00	7.50
150	<i>Skeletonema costatum</i>	0.38	0.00	0.00	7.13	153.75	67.50	7.50	0.00	979.50	19837.50	38587.50	474.75
151	<i>Surirella ovata</i>	1.13	69.38	11.25	0.00	0.00	0.38	0.00	11.25	13.50	8.25	0.75	25.50
152	<i>S. elegans</i>	4.13	0.38	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
153	<i>S. robusta</i> var. <i>splendida</i>	1.13	1.13	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75
154	<i>Synedra</i> sp.	17.63	0.38	24.75	0.38	12.38	0.00	0.00	0.00	0.00	0.75	0.00	2.25
155	<i>Synedrosphenia</i> sp.	0.38	0.00	0.38	0.00	18.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
156	<i>Thalassionema frauenfeldii</i>	204.38	196.13	23.25	2.63	7.13	4307.63	143.25	124.50	66.00	87.00	528.75	434.25
157	<i>T. nitzschoides</i>	0.75	1.13	0.38	0.00	0.00	22.50	18.75	0.00	0.00	0.00	8.25	56718.75

Table 18: Average abundance of phytoplankton found in each month during June 2008 to May 2009 in Don Hoi Lot, Samut Songkram Province (individual/l) (cont.)

NO.	TAXA	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09
169	<i>Ceratium furca</i>	2569.50	181.88	0.00	5171.63	1.13	602.25	88.50	0.75	0.75	1.50	4.50	0.00
170	<i>C. fuscus</i>	30.75	4.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
171	<i>C. massiliense</i>	0.00	0.00	0.00	0.00	0.00	0.00	3.75	0.00	0.00	0.00	0.00	0.00
172	<i>C. trichoceros</i>	9.38	13.13	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00
173	<i>C. Tripos var. pulchellum</i>	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
174	<i>Dinophysis caudata</i>	48.00	76.88	17.63	36.75	3.75	196.50	17.25	16.50	0.00	0.75	0.00	0.00
175	<i>Diplosalis sp.</i>	13.13	0.38	0.00	17.25	0.00	12.00	1.50	0.00	0.00	0.75	2.25	0.00
176	<i>Glenodinium sp.</i>	4.13	0.00	0.00	0.00	3.00	6.38	1.50	1.50	0.00	0.75	0.00	0.00
177	<i>Gonyaulax spp.</i>	117.00	2.25	0.00	2.63	0.75	635.25	3.75	12.75	0.00	2.25	2.25	0.75
178	<i>Gymnodinium spp.</i>	526.13	0.00	0.00	0.00	0.38	1.13	0.75	0.75	0.00	0.00	0.75	0.00
179	<i>Noctiluca scintillans</i>	58.50	128.63	34.88	13.88	15.75	0.00	139.50	97.13	4.50	0.00	1.50	0.00
180	<i>Peridinium spp.</i>	187.88	11.63	12.00	15.38	2351.63	233.25	121.50	347.63	66.75	92.25	57.75	6.00
181	<i>Phalacoma rudgei</i>	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
182	<i>Polykrikos sp.</i>	0.00	0.00	0.00	0.00	0.00	2.63	0.00	0.00	0.00	0.00	0.00	0.00
183	<i>Prorocentrum micans</i>	9.00	3.38	0.00	15.38	7.50	60.38	15.00	22.50	3.75	33.75	0.00	0.75
184	<i>P. sigmoides</i>	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.75	0.00	0.75	0.00	0.00
185	<i>Protoperidinium spp.</i>	361.50	80.63	0.38	200.63	9.00	373.50	69.75	40.13	3.75	5.25	15.75	0.75
186	<i>Pyrophacus horologium</i>	8.63	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00
187	<i>Scrippsiella sp.</i>	34.50	0.38	0.00	0.00	0.00	1.13	0.00	21.75	0.00	0.75	0.00	0.00
Subtotal Class Dinophyceae		3979.13	503.25	64.88	5474.25	2392.88	2124.38	466.50	562.13	79.50	138.75	84.75	8.25
Total Phytoplankton		62073.75	7779.00	25696.50	22321.50	14997.00	269135.63	51039.75	14938.50	102258.75	79137.75	66867.00	76851.75

Table 19: Average abundance of phytoplankton found in each station during June 2008 to May 2009

No.	Taxa	Station															
		1	3	6	7	9	12	13	15	18							
DIVISION CYANOPHYTA																	
CLASS CYANOPHYCEAE																	
1	<i>Anabaena</i> sp.	27.00	0.00	2.81	1.13	0.56	1.13	0.56	5.63	0.00	5.63	0.00	5.63	7.88			
2	<i>A. affinis</i>	1.69	0.56	0.56	1.69	1.13	1.69	1.13	0.00	0.00	0.00	0.00	0.00	0.56			
3	<i>A. spiroides</i>	0.00	0.56	0.00	0.00	0.56	0.00	0.56	1.13	0.00	0.00	0.00	0.00	0.56			
4	<i>Anabaenopsis circularis</i>	0.00	0.56	0.00	0.56	1.69	0.56	1.69	3.94	0.56	0.00	0.56	0.00	7.88			
5	<i>Chroococcus turgidus</i>	11.25	0.56	0.56	11.25	0.56	11.25	0.56	0.56	0.56	11.25	0.56	11.25	0.56			
6	<i>Cylindrospermopsis raciborskii</i>	0.00	0.00	0.56	0.00	1.13	0.00	1.13	0.00	0.00	2.25	0.00	2.25	0.00			
7	<i>C. philippinensis</i>	0.56	0.00	0.56	1.13	0.56	1.13	0.56	0.00	0.00	3.38	0.00	3.38	0.00			
8	<i>Merismopedia convoluta</i>	0.00	0.00	0.00	0.00	7.88	0.00	7.88	2.25	0.00	0.00	0.00	0.00	0.00			
9	<i>M. minima</i>	37.13	2.25	19.13	0.00	0.00	0.00	0.00	6.75	0.00	0.00	0.00	0.00	6.75			
10	<i>M. tenuissima</i>	2.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	41.63	0.00	41.63	0.00			
11	<i>Microcystis aeruginosa</i>	28.13	0.00	27.56	135.00	0.00	135.00	0.00	21.38	0.00	0.00	0.00	0.00	0.00			
12	<i>Oscillatoria</i> spp.	540.56	169.88	149.06	196.31	209.25	196.31	209.25	193.50	83.25	234.00	83.25	234.00	258.19			
13	<i>Phormidium mucicola</i>	1.13	28.13	0.00	18.00	0.00	18.00	0.00	0.00	0.00	7.31	0.00	7.31	0.00			
14	<i>Raphidiopsis curvata</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.00	2.25	1.69			
15	<i>R. indica</i>	1.13	0.56	0.00	0.00	1.13	0.00	1.13	1.13	0.00	0.00	0.00	0.00	2.25			
16	<i>R. mediterranea</i>	5.06	2.81	7.88	1.13	3.94	1.13	3.94	10.69	0.00	1.13	0.00	1.13	7.31			
17	<i>Spirulina platensis</i>	25.88	6.75	9.56	5.06	7.31	5.06	7.31	16.31	12.94	12.38	12.94	12.38	12.94			
18	<i>S. major</i>	484.88	0.56	0.56	16.88	0.56	16.88	0.56	1.13	0.00	0.00	0.00	0.00	0.56			

Table 19: Average abundance of phytoplankton found in each station during June 2008 to May 2009 (cont.)

No.	Taxa	Station															
		1	3	6	7	9	12	13	15	18							
Subtotal Class Cyanophyceae		1167.19	213.19	218.81	396.00	228.38	264.38	97.31	321.19	307.13							
DIVISION CHLOROPHYTA																	
CLASS CHLOROPHYCEAE																	
19	<i>Actinastrum gracillimum</i>	0.56	0.00	0.00	0.00	0.00	0.00	1.13	0.00	0.00							
20	<i>A. hantzschii</i>	0.00	1.69	0.00	0.00	0.00	0.00	0.00	0.00	0.56							
21	<i>Ankistrodesmus falcatus</i>	0.56	0.56	0.00	0.56	0.00	0.00	0.00	0.00	0.00							
22	<i>Closterium</i> sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
23	<i>Coelastrum astroideum</i>	39.94	1.69	1.69	8.44	0.00	2.81	4.50	2.25	4.50							
24	<i>C. microporum</i>	2.25	0.56	3.38	2.25	1.69	0.00	1.13	2.25	0.56							
25	<i>C. reticulatum</i>	0.56	0.56	2.25	1.13	0.56	0.56	0.00	1.13	3.38							
26	<i>C. sphaericum</i>	0.56	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.56							
27	<i>Coenochloris pyrenoidosa</i>	0.56	1.13	1.13	0.56	0.00	14.06	0.00	0.00	0.00							
28	<i>Cosmarium contractum</i>	0.56	0.00	0.00	0.00	1.13	0.00	0.00	0.00	0.00							
29	<i>Crucigenia crucifera</i>	0.00	0.00	0.00	2.25	0.00	0.00	0.00	0.00	0.00							
30	<i>C. neglecta</i>	0.00	0.00	0.00	0.00	0.00	1.13	0.00	0.00	0.00							
31	<i>C. quadrata</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
32	<i>C. tetrapedia</i>	0.56	2.25	8.44	2.25	0.00	4.50	5.06	0.00	2.81							
33	<i>Diclostera acutatus</i>	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00							
34	<i>Dictyosphaerium pulchellum</i>	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00							
35	<i>Eudorina elegans</i>	5.63	0.56	0.00	0.00	0.56	0.00	0.00	0.00	0.56							
36	<i>Monoraphidium contortum</i>	1.13	0.00	2.25	0.00	1.13	1.13	1.13	0.00	1.13							

Table 19: Average abundance of phytoplankton found in each station during June 2008 to May 2009 (cont.)

No.	Taxa	Station															
		1	3	6	7	9	12	13	15	18							
DIVISION CHROMOPHYTA																	
CLASS BACILLARIOPHYCEAE																	
76	<i>Actinocyclus</i> sp.	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	1.13	0.00			
77	<i>Amphora</i> sp.	14.06	26.44	50.06	96.19	48.38	54.00	68.06	14.06	97.31							
78	<i>Asteromphalus flabellatus</i>	0.00	1.13	0.00	1.13	0.00	0.00	0.00	1.13	1.13							
79	<i>Aulacoseira granulata</i>	143.44	0.00	66.38	2.81	1.13	28.13	1.13	4.50	33.75							
80	<i>Bacillaria paxillifer</i>	9.56	0.00	3.94	14.06	42.75	0.56	17.44	14.06	0.00							
81	<i>Bacteriastrium comosum</i>	0.00	9.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00							
82	<i>B. delicatulum</i>	0.00	0.00	1.13	0.00	0.56	0.00	5.63	0.00	0.00							
83	<i>B. furcatum</i>	18.00	12.38	26.44	20.81	18.00	5.63	17.44	2.25	3.94							
84	<i>B. hyalinum</i>	11.81	25.31	233.44	71.44	142.31	122.06	351.00	34.88	312.75							
85	<i>Biddulphia</i> sp.	1.69	8.44	0.56	19.13	7.88	1.69	7.88	14.06	3.38							
86	<i>Cerataulina pelagica</i>	0.00	1.13	0.00	0.00	0.00	0.00	2.25	0.00	2.81							
87	<i>Chaetoceros affinis</i>	118.13	212.63	206.44	201.94	198.00	179.44	240.19	114.19	162.56							
88	<i>C. borealis</i>	7.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
89	<i>C. compressus</i>	50.63	49.50	43.31	53.44	45.56	26.44	38.81	73.69	58.50							
90	<i>C. curvisetus</i>	453.94	522.00	589.50	664.88	422.44	641.81	863.44	584.44	732.94							
91	<i>C. danicus</i>	2.25	0.00	0.00	0.00	0.00	1.13	0.00	0.00	0.00							
92	<i>C. denticulatum</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
93	<i>C. diadema</i>	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00							
94	<i>C. didymus</i>	17.44	61.88	56.81	80.44	38.25	16.88	33.75	33.19	32.06							

Table 19: Average abundance of phytoplankton found in each station during June 2008 to May 2009 (cont.)

No.	Taxa	Station															
		1	3	6	7	9	12	13	15	18							
95	<i>C. diversus</i>	3.38	3.38	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
96	<i>C. lacinosus</i>	232.31	71.44	231.19	0.00	138.38	309.94	345.38	244.13	274.50							
97	<i>C. lauderi</i>	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00							
98	<i>C. lorenzianus</i>	491.06	414.00	595.69	767.81	387.00	916.88	1046.81	649.69	783.56							
99	<i>C. peruvianus</i>	1.69	1.13	1.13	0.00	1.13	1.13	0.00	0.00	1.13							
100	<i>C. pseudocurvisetus</i>	19021.50	25813.69	30665.25	35470.13	25259.63	39119.63	57296.81	26856.00	38181.94							
101	<i>C. subtilis</i>	28.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
102	<i>Climacodium</i> sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
103	<i>Climaconeis</i> sp.	0.00	0.00	0.00	61.88	22.50	0.56	56.81	0.56	1.13							
104	<i>Cocconeis</i> sp.	4.50	21.94	36.00	81.56	20.81	24.75	57.38	47.25	28.13							
105	<i>Coscinodiscus</i> spp.	50.63	69.75	42.19	56.81	50.63	91.13	77.63	64.69	52.31							
106	<i>Cyclotella meneghiniana</i>	1.13	0.00	1.13	0.00	0.00	1.13	0.00	0.00	0.00							
107	<i>C. stylonum</i>	5.63	2.25	7.88	5.63	3.38	7.88	5.63	10.13	9.00							
108	<i>Cymbella</i> sp.	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
109	<i>Cylindrotheca closterium</i>	4523.06	3282.75	2693.81	2461.50	2036.25	11473.88	4516.88	1872.00	9672.19							
110	<i>Dactyliosolen phuketensis</i>	0.00	0.00	0.00	0.00	0.00	0.00	16.88	0.00	0.00							
111	<i>Diploneis</i> spp.	6.19	12.38	11.81	6.19	5.63	6.75	11.25	7.31	3.38							
112	<i>Ditylum sol</i>	0.00	12.38	6.75	2.25	0.00	1.13	0.00	0.56	1.13							
113	<i>Entomoneis robusta</i>	48.94	61.88	30.94	8.44	41.06	10.13	46.13	51.75	35.44							
114	<i>Eucampia cornuta</i>	0.00	0.00	1.69	0.00	0.00	0.00	0.00	0.00	0.00							
115	<i>E. zodiacus</i>	2.81	7.88	5.63	29.25	3.38	5.63	29.81	6.19	6.75							

Table 19: Average abundance of phytoplankton found in each station during June 2008 to May 2009 (cont.)

No.	Taxa	Station															
		1	3	6	7	9	12	13	15	18							
116	<i>Fragilaria</i> sp.	2.81	1.13	3.94	1.69	0.00	1.69	19.13	0.56	1.13							
117	<i>Gomphonema</i> sp.	0.00	0.00	0.00	0.56	0.56	0.56	1.69	0.00	0.00							
118	<i>Grammatophora undulata</i>	0.00	0.00	0.00	0.00	0.00	1.13	0.00	0.00	0.00							
119	<i>Guinardia flaccida</i>	1.13	2.25	5.63	0.56	5.63	0.00	7.88	0.56	2.25							
120	<i>Gyrosigma</i> spp.	253.69	214.88	189.56	254.25	167.63	186.75	208.69	203.63	294.75							
121	<i>Hemitaulus indicus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
122	<i>H. membranaceus</i>	0.00	12.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
123	<i>Hydrosera triquetra</i>	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56							
124	<i>Lauderia annulata</i>	519.75	65.25	1479.38	1607.06	303.75	1773.00	2842.31	253.69	1659.94							
125	<i>Leptocylindrus danicus</i>	16.31	8.44	203.63	23.06	54.00	93.38	92.25	56.25	109.13							
126	<i>Lioloma</i> sp.	0.00	13.50	2.25	3.94	3.38	1.13	0.00	0.00	0.00							
127	<i>Melosira varians</i>	0.56	1.13	0.00	0.00	0.56	0.00	0.00	0.00	0.00							
128	<i>M. dubia</i> Kützing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
129	<i>Meunier membranacea</i>	1.13	13.50	5.63	0.00	3.38	2.25	2.25	0.00	1.13							
130	<i>Navicula</i> spp.	92.81	15.75	33.75	23.06	5.63	9.00	43.31	9.56	10.69							
131	<i>Nitzschia</i> spp.	131.06	146.25	230.06	118.69	144.56	129.38	142.31	194.63	196.88							
132	<i>Odontella aurita</i>	0.00	0.00	0.00	0.00	1.13	0.00	0.00	0.00	1.13							
133	<i>O. mobilensis</i>	1.13	3.38	0.00	1.13	1.13	0.00	0.00	2.25	5.63							
134	<i>O. sinensis</i>	34.31	127.69	315.56	63.00	6.19	455.06	486.00	13.50	659.25							
135	<i>Palmeria hardmaniana</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
136	<i>Paralia sulcata</i>	0.56	1.13	1.13	2.81	1.13	0.56	7.31	1.13	0.56							

Table 19 Average abundance of phytoplankton found in each station during June 2008 to May 2009 (cont.)

No.	Taxa	Station															
		1	3	6	7	9	12	13	15	18							
137	<i>Pinnularia</i> sp.	1.13	0.56	0.56	7.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.69	0.00			
138	<i>Planktoniella</i> sol	0.00	1.13	0.56	1.69	0.00	0.56	1.13	0.56	1.13	0.56	1.69	0.56	1.69			
139	<i>Pleurosigma</i> spp.	6.19	18.56	5.63	33.75	5.63	25.88	1.69	3.94	13.50	3.38	21.38	3.94	13.50			
140	<i>Proboscia</i> alata	29.81	2.25	5.63	20.81	7.31	0.56	29.25	21.38	3.38	788.06	411.19	21.38	3.38			
141	<i>Pseudonitzschia</i> pungens	211.50	892.69	1148.06	831.38	532.69	483.75	669.38	411.19	788.06	88.31	20.81	0.00	0.00			
142	<i>Pseudosolenia</i> calcar avis	4.50	256.50	199.13	15.19	272.25	14.63	7.31	20.81	88.31	0.00	0.00	0.00	0.00			
143	<i>Rhizosolenia</i> bergonii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
144	<i>R. hyalina</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
145	<i>R. longiseta</i>	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
146	<i>R. pungens</i>	2.25	6.19	2.25	9.00	10.13	4.50	11.81	6.75	3.38	44.44	50.63	0.56	0.56			
147	<i>R. setigera</i>	37.69	47.25	87.75	56.81	28.13	64.69	81.00	50.63	44.44	0.00	0.00	0.00	0.00			
148	<i>R. striata</i>	3.38	1.13	2.25	0.56	0.00	0.00	0.00	0.56	0.56	0.00	0.00	0.56	0.56			
149	<i>R. styliformis</i>	1.13	5.63	13.50	4.50	0.56	5.63	1.13	0.00	0.00	0.00	0.00	0.00	0.00			
150	<i>Skeletonema</i> costatum	7824.94	3980.25	5960.25	5415.19	5404.50	10729.13	5337.00	7759.13	5230.13	17.44	4.50	0.00	0.00			
151	<i>Surirella</i> ovata	0.56	7.31	2.81	27.56	12.94	4.50	20.81	4.50	17.44	0.00	0.00	0.00	0.00			
152	<i>S. elegans</i>	6.19	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
153	<i>S. robusta</i> var. <i>splendida</i>	1.69	0.56	0.00	2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
154	<i>Synedra</i> sp.	52.31	6.75	2.25	6.19	0.56	4.50	0.00	0.00	3.94	0.00	0.00	0.00	0.00			
155	<i>Synedrosphenia</i> sp.	0.56	0.00	0.00	0.56	8.44	0.00	0.00	19.69	0.00	0.00	0.00	0.00	0.00			
156	<i>Thalassionema</i> frauenfeldii	172.69	108.56	846.56	221.63	258.19	274.50	1068.75	205.88	429.75	0.00	0.00	0.00	0.00			
157	<i>T. nitzschoides</i>	5344.31	4848.75	4408.31	6159.94	4443.75	5994.00	2700.00	6078.38	7542.00	0.00	0.00	0.00	0.00			

Table 19: Average abundance of phytoplankton found in each station during June 2008 to May 2009 (cont.)

No.	Taxa	Station															
		1	3	6	7	9	12	13	15	18							
158	<i>Thalassiosira</i> spp.	2431.13	3961.13	2057.63	2782.69	2587.50	1956.38	5946.75	3479.06	3976.31							
159	<i>Thalassiothrix</i> sp.	0.00	0.00	0.00	0.00	0.00	0.00	1.13	0.00	0.00							
160	<i>Trachyneis</i> sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
161	<i>Triceratium favus f. quadrata</i>	0.00	0.00	0.56	0.56	1.69	0.00	0.00	0.00	0.00							
162	<i>Tryblionella</i> sp.	2.81	0.56	0.56	1.13	0.56	4.50	11.25	1.13	1.13							
	Subtotal Class Bacillariophyceae	42462.00	45477.00	52828.88	57877.31	43209.00	75278.81	84900.38	49502.81	71578.69							
	CLASS CHRYSOPHYCEAE																
163	<i>Dinobryon sertularia</i>	0.56	0.00	0.00	0.00	0.00	0.00	1.13	0.00	0.00							
	Subtotal Class Chrysoephyceae	0.56	0.00	0.00	0.00	0.00	0.00	1.13	0.00	0.00							
	CLASS XANTHOPHYCEAE																
164	<i>Centractus belanophorus</i>	0.00	0.00	0.00	0.00	0.00	1.69	0.00	0.00	0.00							
	Subtotal Class Xanthophyceae	0.00	0.00	0.00	0.00	0.00	1.69	0.00	0.00	0.00							
	CLASS DICTYOCOPHYCEAE																
165	<i>Dictyocha fibula</i> var. <i>stapedia</i>	1.13	0.00	0.00	0.00	1.69	0.00	0.00	0.00	0.56							
166	<i>Distephanus speculum</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00							
	Subtotal Class Dictyochophyceae	1.13	0.00	0.00	0.00	1.69	0.00	0.56	0.00	0.56							
	CLASS PRYMNESIOPHYCEAE																
167	<i>Isochrysis galbana</i>	0.00	2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
	Subtotal Class Prymnesiophyceae	0.00	2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
	CLASS DINOPHYCEAE																
168	<i>Alexandrium</i> sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00							

Table 19: Average abundance of phytoplankton found in each station during June 2008 to May 2009 (cont.)

No.	Taxa	Station															
		1	3	6	7	9	12	13	15	18							
169	<i>Ceratium furca</i>	8.44	1353.38	1390.50	7.88	359.44	1164.94	40.50	871.88	1257.75							
170	<i>C. fusus</i>	0.00	0.00	0.00	0.00	5.63	0.00	0.00	0.00	0.00							
171	<i>C. massiliense</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
172	<i>C. trichoceros</i>	0.00	0.00	1.13	0.00	0.00	0.56	0.00	6.19	0.00							
173	<i>C. Tripos var. pulchellum</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
174	<i>Dinophysis caudata</i>	5.06	7.88	239.06	1.13	4.50	25.88	4.50	36.56	15.75							
175	<i>Diplosalis sp.</i>	0.00	6.19	7.31	0.00	0.56	17.44	1.13	1.13	6.75							
176	<i>Glenodinium sp.</i>	3.38	0.00	1.69	0.00	0.00	0.00	1.69	1.13	2.25							
177	<i>Gonyaulax spp.</i>	2.25	6.75	92.25	4.50	11.25	185.63	8.44	28.69	150.19							
178	<i>Gymnodinium spp.</i>	0.00	0.56	0.00	0.00	0.56	0.56	0.56	67.50	18.00							
179	<i>Noctiluca scintillans</i>	7.88	0.00	5.06	5.06	4.50	4.50	3.38	23.63	86.63							
180	<i>Peridinium spp.</i>	67.50	128.81	324.56	21.94	205.88	150.75	61.31	375.75	106.31							
181	<i>Phalacoma rudgei</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
182	<i>Polykrikos sp.</i>	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.00	1.69							
183	<i>Prorocentrum micans</i>	3.94	12.94	94.50	1.69	14.63	14.06	9.00	2.25	14.06							
184	<i>P. sigmoides</i>	0.00	0.00	1.13	0.00	0.00	0.00	0.00	0.00	0.00							
185	<i>Protoperidinium spp.</i>	3.94	69.75	157.50	10.13	68.06	74.81	23.06	145.69	300.94							
186	<i>Pyrophacus horologium</i>	0.00	0.00	0.00	0.00	5.63	0.00	0.00	0.56	0.00							
187	<i>Scrippsiella sp.</i>	1.13	1.69	1.13	1.13	0.00	0.00	0.00	3.38	2.25							
Subtotal Class Dinophyceae		103.50	1587.94	2315.81	53.44	680.63	1639.13	155.81	1564.88	1962.56							
Total Phytoplankton		43844.06	47308.50	55402.31	58386.94	44136.00	77229.00	85176.56	51399.56	73870.88							

Table 19: Average abundance of phytoplankton found in each station during June 2008 to May 2009 (cont.)

No.	Taxa	Station														
		19	21	24	25	27	30	31	33	36						
DIVISION CYANOPHYTA																
CLASS CYANOPHYCEAE																
1	<i>Anabaena</i> sp.	2.81	5.63	3.38	3.94	2.25	1.13	0.00	7.88	0.00						
2	<i>A. affinis</i>	0.00	1.13	1.13	0.00	0.00	0.00	0.00	0.00	0.00	5.63					
3	<i>A. spiroides</i>	0.00	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					
4	<i>Anabaenopsis circularis</i>	0.00	0.56	1.69	0.00	0.56	0.00	0.56	0.56	0.56	0.56					
5	<i>Chroococcus turgidus</i>	11.25	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56					
6	<i>Cylindrospermopsis raciborskii</i>	0.56	1.69	0.00	0.00	1.13	0.00	0.00	1.13	0.00	0.00					
7	<i>C. philippinensis</i>	0.00	3.38	0.00	0.00	0.56	0.56	0.00	0.00	0.00	0.00					
8	<i>Merismopedia convoluta</i>	14.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					
9	<i>M. minima</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.00	0.00					
10	<i>M. tenuissima</i>	0.00	0.00	7.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00					
11	<i>Microcystis aeruginosa</i>	0.00	27.00	37.13	22.50	0.00	0.00	0.00	0.00	0.00	0.00					
12	<i>Oscillatoria</i> spp.	138.94	96.19	168.75	116.44	255.94	114.75	343.69	221.63	145.13						
13	<i>Phormidium mucicola</i>	0.00	15.75	0.00	11.25	0.00	0.00	0.00	1.13	0.00	0.00					
14	<i>Raphidiopsis curvata</i>	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00					
15	<i>R. indica</i>	0.56	2.25	3.94	3.38	2.25	0.56	0.56	1.13	1.13						
16	<i>R. mediterranea</i>	0.56	0.56	4.50	1.13	1.69	0.00	0.00	0.00	0.56						
17	<i>Spirulina platensis</i>	10.13	11.25	19.13	9.56	22.50	1.69	1.13	15.19	16.88						
18	<i>S. major</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					
Subtotal Class Cyanophyceae		179.44	167.06	248.63	168.75	287.44	119.25	353.81	249.19	170.44						

Table 19: Average abundance of phytoplankton found in each station during June 2008 to May 2009 (cont.)

No.	Taxa	Station										
		19	21	24	25	27	30	31	33	36		
59	<i>Staurastrum</i> spp.	2.25	0.00	0.00	0.56	0.00	2.81	1.13	1.13	0.00		
60	<i>Tetraedron arthrodesmiforme</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
61	<i>T. trigonum</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00		
62	<i>Ulothrix</i> sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	Subtotal Class Chlorophyceae	32.06	5.63	19.69	3.38	7.31	6.19	4.50	4.50	2.81		
	CLASS EUGLENOPHYCEAE											
63	<i>Euglena acus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
64	<i>E. oxyuris</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
65	<i>Lepocinclis ovum</i>	0.00	1.13	0.00	0.00	0.00	0.56	0.00	0.00	0.00		
66	<i>L. salina</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
67	<i>Phacus hamatus</i>	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
68	<i>P. longicauda</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
69	<i>P. pleuronectes</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
70	<i>P. ranula</i>	0.00	0.00	0.00	0.00	0.00	1.13	0.56	0.00	0.00		
71	<i>P. tortus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
72	<i>Strombomonas fluviatilis</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
73	<i>S. gibberosa</i>	0.00	0.00	0.00	1.13	0.00	0.00	0.00	0.00	0.00		
74	<i>Trachelomonas ovalis</i> var. <i>minor</i>	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
75	<i>Entosiphon sulcatum</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	Subtotal Class Euglenophyceae	1.69	1.13	0.00	1.13	0.00	1.69	0.56	0.00	0.00		

Table 19: Average abundance of phytoplankton found in each station during June 2008 to May 2009 (cont.)

No.	Taxa	Station														
		19	21	24	25	27	30	31	33	36						
DIVISION CHROMOPHYTA																
CLASS BACILLARIOPHYCEAE																
76	<i>Actinocyclus</i> sp.	0.56	1.13	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
77	<i>Amphora</i> sp.	76.50	43.31	74.25	121.50	64.13	65.25	74.25	74.25	45.00	62.44					
78	<i>Asteromphalus flabellatus</i>	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13					
79	<i>Aulacoseira granulata</i>	11.25	6.75	13.50	7.88	0.00	0.00	0.00	0.00	0.00	0.00					
80	<i>Bacillaria paxillifer</i>	38.25	40.50	9.00	72.00	18.56	30.38	59.06	51.19	27.00						
81	<i>Bacteriastrium comosum</i>	6.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.63	0.00					
82	<i>B. delicatulum</i>	5.63	0.00	0.00	1.13	0.56	0.00	0.56	0.00	0.00	0.00					
83	<i>B. furcatum</i>	74.81	7.31	3.38	56.25	10.13	29.25	272.81	2.81	7.31						
84	<i>B. hyalinum</i>	133.88	34.31	303.19	122.63	80.44	155.81	403.31	531.56	118.13						
85	<i>Biddulphia</i> sp.	40.50	29.25	3.94	60.19	22.50	19.13	74.25	1.69	17.44						
86	<i>Cerataulina pelagica</i>	1.13	0.00	0.00	0.00	0.00	0.00	1.13	0.00	5.63						
87	<i>Chaetoceros affinis</i>	185.06	175.50	0.00	0.00	358.88	149.63	230.63	154.69	0.00						
88	<i>C. borealis</i>	0.00	0.00	0.00	7.88	0.00	0.00	16.31	5.63	0.00						
89	<i>C. compressus</i>	73.69	28.13	47.81	46.13	53.44	32.06	51.75	39.38	83.25						
90	<i>C. curvisetus</i>	712.69	451.69	996.19	598.50	578.81	780.19	613.13	900.00	525.38						
91	<i>C. danicus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
92	<i>C. denticulatum</i>	0.56	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00						
93	<i>C. diadema</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
94	<i>C. didymus</i>	18.56	15.19	16.31	21.94	38.81	20.81	29.25	0.00	19.69						
95	<i>C. diversus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						

Table 19: Average abundance of phytoplankton found in each station during June 2008 to May 2009 (cont.)

No.	Taxa	Station														
		19	21	24	25	27	30	31	33	36						
96	<i>C. lacinosus</i>	299.81	0.00	450.00	420.75	218.81	422.44	294.75	291.94	318.94						
97	<i>C. lauderi</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
98	<i>C. lorenzianus</i>	664.88	592.92	1606.50	950.63	856.13	1193.63	1080.00	1023.19	855.00						
99	<i>C. peruvianus</i>	2.25	0.00	0.00	0.00	0.00	2.25	0.00	0.00	0.00						
100	<i>C. pseudocurvisetus</i>	37539.00	18725.60	105243.19	36686.25	30183.75	55561.50	42834.38	59653.13	35303.06						
101	<i>C. subtilis</i>	0.00	0.00	0.00	0.00	0.00	42.19	0.00	0.00	0.00						
102	<i>Climacodium</i> sp.	0.00	0.00	0.00	2.25	0.00	0.00	0.00	0.00	0.00						
103	<i>Climaconeis</i> sp.	2.81	0.56	0.56	5.63	0.00	0.56	6.19	0.00	0.00						
104	<i>Cocconeis</i> sp.	56.25	72.00	21.94	19.13	23.06	29.25	27.56	20.25	14.63						
105	<i>Coccinodiscus</i> spp.	49.50	64.13	60.19	70.31	78.19	52.31	59.63	74.25	46.69						
106	<i>Cyclotella meneghiniana</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
107	<i>C. stylum</i>	5.63	5.63	14.63	4.50	3.38	3.38	5.63	5.63	6.75						
108	<i>Cymbella</i> sp.	2.25	0.00	0.00	2.25	2.81	5.06	0.56	4.50	1.69						
109	<i>Cylindrotheca closterium</i>	1878.75	2398.50	13930.31	1206.56	1815.19	3546.00	2459.81	2419.31	3838.50						
110	<i>Dacyliosolen phuketensis</i>	3.38	0.00	2.25	7.31	0.00	0.00	5.06	0.00	0.00						
111	<i>Diploneis</i> spp.	7.88	2.81	5.63	2.25	13.50	0.00	12.38	0.00	0.00						
112	<i>Ditylum sol</i>	0.56	0.00	0.00	0.00	1.13	0.56	17.44	0.00	11.25						
113	<i>Entomoneis robusta</i>	35.44	10.13	22.50	25.88	12.94	23.63	36.56	18.00	15.75						
114	<i>Eucampia cornuta</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00						
115	<i>E. zodiacus</i>	90.56	1.69	19.69	182.25	12.38	0.00	27.00	6.19	0.00						
116	<i>Fragilaria</i> sp.	0.56	0.00	0.56	1.69	0.00	0.00	0.00	0.00	0.00						

Table 19: Average abundance of phytoplankton found in each station during June 2008 to May 2009 (cont.)

No.	Taxa	Station														
		19	21	24	25	27	30	31	33	36						
138	<i>Planktoniella sol</i>	1.13	2.25	1.69	0.56	0.56	8.44	0.00	0.56	1.13						
139	<i>Pleurosigma</i> spp.	1.69	2.81	5.63	0.00	34.31	2.25	2.25	1.69	2.81						
140	<i>Proboscia alata</i>	46.13	11.81	1.13	17.44	6.75	10.13	11.81	6.75	6.19						
141	<i>Pseudonitzschia pungens</i>	1265.06	225.00	536.06	392.06	225.56	379.13	443.25	245.81	127.69						
142	<i>Pseudosolenia calcar avis</i>	1246.50	23.06	65.25	655.31	168.75	123.75	69.19	374.63	600.75						
143	<i>Rhizosolenia bergonii</i>	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00						
144	<i>R. hyalina</i>	0.00	0.00	0.00	0.00	0.00	0.00	3.38	0.00	0.00						
145	<i>R. longiseta</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
146	<i>R. pungens</i>	9.56	7.31	11.81	8.44	19.13	2.81	3.94	16.31	1.69						
147	<i>R. setigera</i>	47.25	40.50	93.94	78.19	65.25	16.31	9.56	48.94	19.69						
148	<i>R. striata</i>	0.56	1.69	0.56	0.00	1.69	0.56	3.94	1.13	1.69						
149	<i>R. styliformis</i>	9.56	1.13	0.56	0.00	0.00	3.38	0.00	2.25	4.50						
150	<i>Skeletonema costatum</i>	5274.00	7976.25	3578.63	2643.75	1473.75	1015.88	3109.50	1443.38	6017.63						
151	<i>Surirella ovata</i>	20.81	8.44	3.38	24.75	7.88	16.31	18.56	11.81	1.69						
152	<i>S. elegans</i>	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
153	<i>S. robusta</i> var. <i>splendida</i>	0.56	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
154	<i>Synedra</i> sp.	0.00	0.56	2.25	0.56	0.00	5.63	1.13	0.56	0.56						
155	<i>Synedrosphenia</i> sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
156	<i>Thalassionema frauenfeldii</i>	471.94	282.94	585.56	237.38	160.31	622.69	2127.94	720.56	391.50						
157	<i>T. nitzschoides</i>	3155.63	6729.75	4978.13	4162.50	2840.63	4246.88	5576.06	2896.88	3049.88						
158	<i>Thalassiosira</i> spp.	3854.25	3056.63	4457.25	3650.63	9115.88	11544.75	5090.06	5093.44	4221.56						

Table 19: Average abundance of phytoplankton found in each station during June 2008 to May 2009 (cont.)

No.	Taxa	Station										
		19	21	24	25	27	30	31	33	36		
159	<i>Thalassiothrix</i> sp.	0.00	0.00	0.00	0.00	0.00	0.00	12.38	1.69	0.00		
160	<i>Trachyneis</i> sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56		
161	<i>Triceratium favius f. quadrata</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
162	<i>Tryblionella</i> sp.	28.13	1.13	4.50	7.31	3.38	0.56	57.38	4.50	28.13		
	Subtotal Class Bacillariophyceae	59554.69	42255.00	143220.94	53997.19	50309.44	83243.25	66476.81	79500.94	58536.56		
	CLASS CHRYSOPHYCEAE											
163	<i>Dinobryon sertularia</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	Subtotal Class Chrysophyceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	CLASS XANTHOPHYCEAE											
164	<i>Centrtractus belanophorus</i>	0.00	0.00	1.13	0.00	0.56	0.00	0.00	0.00	0.00		
	Subtotal Class Xanthophyceae	0.00	0.00	1.13	0.00	0.56	0.00	0.00	0.00	0.00		
	CLASS DICTYOCOPHYCEAE											
165	<i>Dityocha fibula</i> var. <i>stapedia</i>	0.56	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00		
166	<i>Distephanus speculum</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	Subtotal Class Dictyochophyceae	0.56	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00		
	CLASS PRYMNESIOPHYCEAE											
167	<i>Isochrysis galbana</i>	3.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	Subtotal Class Prymnesiophyceae	3.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	CLASS DINOPHYCEAE											
168	<i>Alexandrium</i> sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
169	<i>Ceratium furca</i>	217.13	234.00	945.56	143.44	337.50	921.94	2112.75	421.31	1145.25		

Table 19: Average abundance of phytoplankton found in each station during June 2008 to May 2009 (cont.)

No.	Taxa	Station											
		19	21	24	25	27	30	31	33	36			
170	<i>C. fusus</i>	5.63	5.63	0.00	5.63	0.56	5.63	16.88	6.19	0.56			
171	<i>C. massiliense</i>	0.00	0.00	1.13	1.13	2.25	1.13	0.00	0.00	0.00			
172	<i>C. trichoceros</i>	2.25	0.00	0.56	1.13	0.56	6.19	2.25	11.25	6.19			
173	<i>C. Tripos var. pulchellum</i>	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00			
174	<i>Dinophysis caudata</i>	6.75	11.81	23.06	5.06	26.44	21.94	82.13	40.50	63.00			
175	<i>Diplosalis sp.</i>	0.56	0.56	4.50	0.56	2.25	0.56	2.25	1.13	18.00			
176	<i>Glenodinium sp.</i>	2.81	1.13	0.00	1.13	4.50	5.63	0.56	0.00	0.00			
177	<i>Gonyaulax</i> spp.	1.13	17.44	213.19	10.69	6.75	214.31	10.13	24.19	181.69			
178	<i>Gymnodinium</i> spp.	11.25	56.25	0.00	22.50	28.13	86.63	61.88	45.56	394.88			
179	<i>Noctiluca scintillans</i>	26.44	40.50	39.94	36.00	54.00	51.75	131.63	103.50	117.00			
180	<i>Peridinium</i> spp.	604.69	1028.25	936.00	118.69	285.75	280.69	102.38	179.44	276.75			
181	<i>Phalacoma rudgei</i>	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.56			
182	<i>Polykrikos</i> sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
183	<i>Prorocentrum micans</i>	2.81	4.50	21.94	5.06	5.63	17.44	5.06	8.44	19.13			
184	<i>P. sigmoides</i>	0.00	0.00	0.00	0.00	1.13	0.00	0.00	0.00	0.56			
185	<i>Protoperidinium</i> spp.	34.88	35.44	117.00	52.31	64.69	88.31	126.56	89.44	279.00			
186	<i>Pyrophacus horologium</i>	0.00	0.00	0.00	0.00	0.56	0.00	6.75	0.00	0.56			
187	<i>Scrippsiella</i> sp.	33.19	2.25	0.00	1.13	3.38	9.00	1.69	0.00	26.44			
Subtotal Class Dinophyceae		949.50	1437.75	2302.88	405.00	824.63	1711.13	2662.88	930.94	2529.56			
Total Phytoplankton		60721.31	43866.56	145793.81	54575.44	51429.38	85081.50	69498.56	80685.56	61239.38			

BIOGRAPHY

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