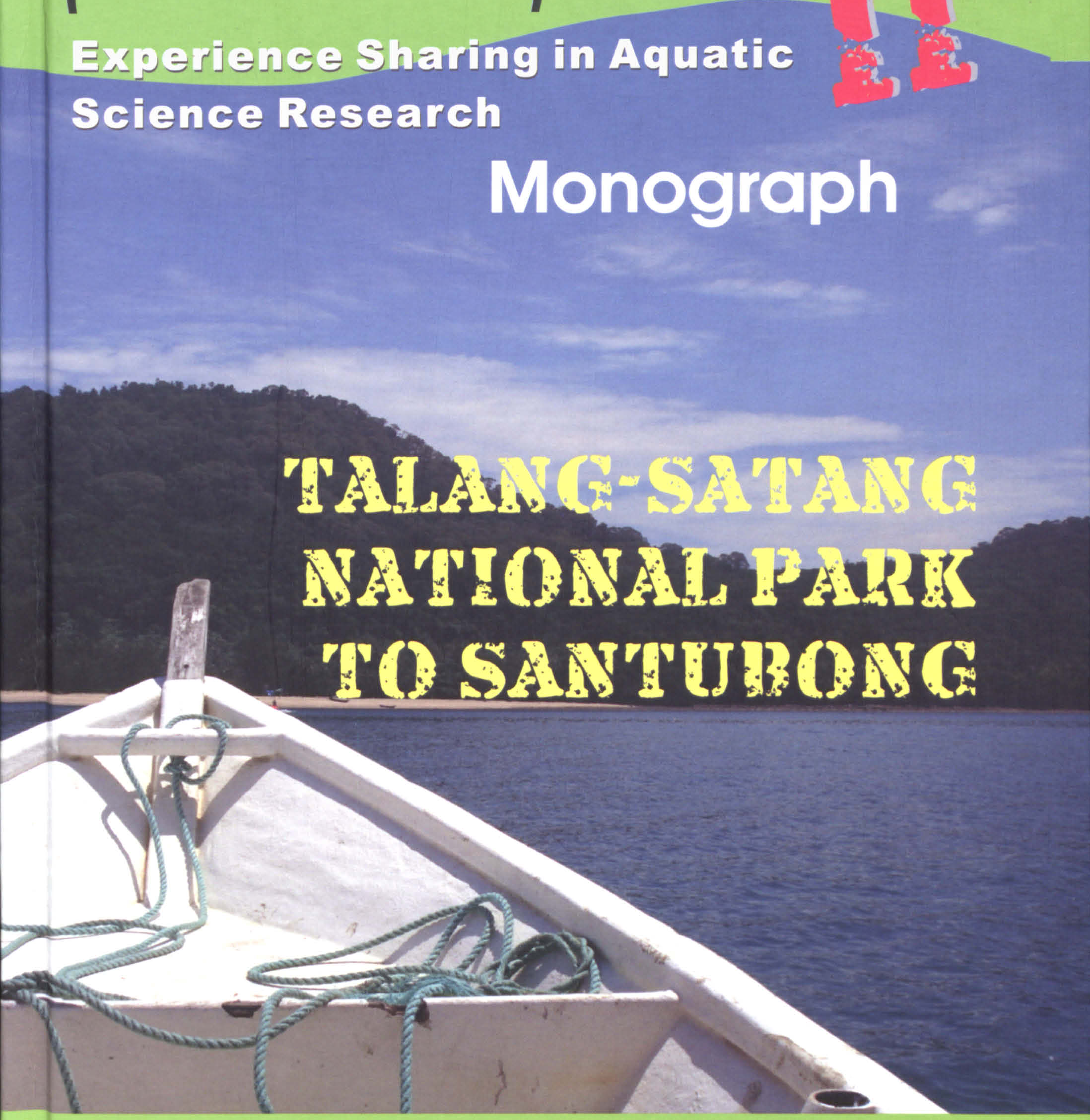
Aquatic Science Colloquium 2012 (AQUAColl 2012)

II

Experience Sharing in Aquatic Science Research

Monograph



TALANG-SATANG NATIONAL PARK TO SANTUBONG

UNIVERSITI MALAYSIA SARAWAK · UNIMAS

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Department of Aquatic Science
Faculty of Resource Science and Technology

MONOGRAPH

AQUATIC SCIENCE COLLOQUIUM 2012:

Experience Sharing in Aquatic Science Research II, Talang-Satang National Park to Santubong

Editorial Group: Lee Nyanti, Norhadi Ismail, Ruhana Hassan, Samsur Mohamad and Siti Akmar Khadijah Ab Rahim

Department of Aquatic Science
Faculty of Resource Science and Technology
Universiti Malaysia Sarawak
94300 Kota Samarahan
Sarawak, Malaysia
Tel: +6082-581000
Fax: +6082-583160

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MESSAGE FROM THE ADVISOR

Assalamu'alaikum WBT and Salam Sejahtera

Firstly, I would like to take this opportunity to congratulate the organizing committee and all members of the Department of Aquatic Science for successfully organized the second series of Aquatic Science Colloquium 2012 (AQUAColl 2012). Secondly, I would like to express my gratitude and thanks to the Scientific and Technical Committee for the preparation of the second monograph.

Following the success of the first colloquium (AQUAColl 2010) and the compilation of 14 research papers for the first monograph, the faculty has given full support to the Department of Aquatic Science to organize the second one, AQUAColl 2012 in September 2012. I am very glad indeed to support such an important academic event where students, lectures and researchers from other agencies can share their knowledge and research findings. The product of AQUAColl 2012 is the publication of the second monograph that consists of 15 selected research papers.

In line with our vision and mission, the faculty always supports any knowledge and research sharing activities as well as encouraging research collaboration with other researchers from both government and private agencies. We do believe that the consolidation of expertise in the field of aquatic science from all research institutions will enable us to explore and manage our natural aquatic resources more effectively.

I believed that the colloquium was an excellent platform for our young and enthusiastic researchers to motivate, facilitate and develop themselves as a productive and quality researcher. To other participants, I hope the meeting provided a golden opportunity to enhance and strengthen research collaboration between the university and other agencies.

Finally, I would like to thank all AQUAColl 2012 participants for their contribution in making the meeting a success. My appreciation and thanks also goes to all researchers who have contributed research papers for the second monograph. I hope the monograph will be a major source of reference for future research activities in Talang-Satang National Parks and Santubong waters.

Thank you.

PROF. DR. SHABDIN MOHD LONG
Advisor

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Assessment of Water Quality of Sibu Laut River, Telaga Air, Matang, Sarawak

Lee Nyanti[1], Chen-Lin Soo[2] and Teck-Yee Ling[2]

[1]*Department of Aquatic Science*
[2]*Department of Chemistry*
Faculty of Resource Science and Technology, Universiti Malaysia Sarawak
94300 Kota Samarahan, Sarawak

Corresponding author: lnyanti@frst.unimas.my

Abstract

The Sibu Laut River is located at the western boundary of the Kuching Wetland National Park and therefore it is important that the water quality be preserved for the health of aquatic life. A study was conducted in August 2011 to determine the water quality at five selected stations during high tide and low tide. Results of the study showed that temperature ranged from 29.0 – 30.8 °C. Salinity ranged from 28.3 – 33.3 PSU and 23.0 – 31.3 PSU during high tide and low tide, respectively. During high tide, salinity was generally higher than low tide and salinity at the bottom was higher than the surface. During low tide, transparency was the lowest near a shrimp farm. pH values during high tide and low tide ranged from 7.32 – 8.81 and 7.48 – 8.44, respectively with the station nearest to the coast showing the highest pH value during both tide levels. DO during high tide (4.80 – 8.08 mg/L) was higher than that during low tide (3.26 – 5.83 mg/L) in all stations. Lower DO values were observed during low tide than high tide and 80 % of DO readings were above 4.00 mg/L. TSS values were below 46 mg/L except for the station near to shrimp farm discharge. Chl-a was the highest at bottom water near a shrimp farm discharge station during low tide. BOD_5 ranged from 0.38 – 3.29 mg/L and the highest occurred during low tide at surface water near the shrimp farm. Ninety five percent of the BOD_5 and 95 % of TSS values complied with Class II of NWQS.

Keywords: estuarine water quality, tidal influence, Kuching Wetland National Park, physicochemical parameters

Introduction

Estuaries are important spawning and nursery ground for aquatic species (Nyanti *et al.*, 2012). Therefore, protection of water quality is important for the survival and health of the aquatic organisms. Many estuaries in the world face problems due to anthropogenic activities. For example, water enrichment from land use activities due tocommercial agriculture in the upstream as observed in the Gulf of Mexico where dead zone is a serious problem (Turner *et al.*, 2012). Pearl River estuary has also been reported to be enriched with nitrogen and phosphorus from sewage effluent (Yin *et al.*, 2008). Similar case was reported in Neuse River

Estuary where pulses of riverine nitrogen had significant effects on phytoplankton community structure (Piehler *et al.*, 2004).

Estuaries are also commonly found in the eastern part of Sarawak. The Sibu Laut River is one of the two major rivers that drain Kuching Wetland National Park which was declared a Ramsar site. Due to this reason, it is important that to monitor the water quality for the health aquatic life. In the watershed of this river, there are some settlements, agricultural activities and shrimp farming which may impact the water quality of the river. Previous studies of nearby rivers such as Semariang Batu River (Ling, 2009), Santubong River (Ling *et al.*, 2010b) and Sampadi River (Ling *et al.*, 2011) indicated that nutrients and organic matter in sediment or water are higher near human settlements and shrimp farm discharge areas. With the exception of the water and sediment study at Selang Sibu River (Ling *et al.*, 2012b) which is one of the tributaries of Sibu Laut River, there is no published literature on the water quality of the Sibu Laut River. Therefore, a study was conducted to assess the water quality during high tide and low tide.

Materials and Methods

The Sibu Laut River is located in the northwest region of Kuching, Sarawak. The area experiences a humid tropical climate with an annual rainfall of 3,600 - 4,000 mm. This region is not directly exposed to the northeast monsoon. Generally, rainfall is lowest during June and July, and reaches a peak in December and January. According to Malaysian Metrological Service (2007), mean temperature ranges from 19 to 36 °C. The locations of five sampling stations are shown in Figure 1.

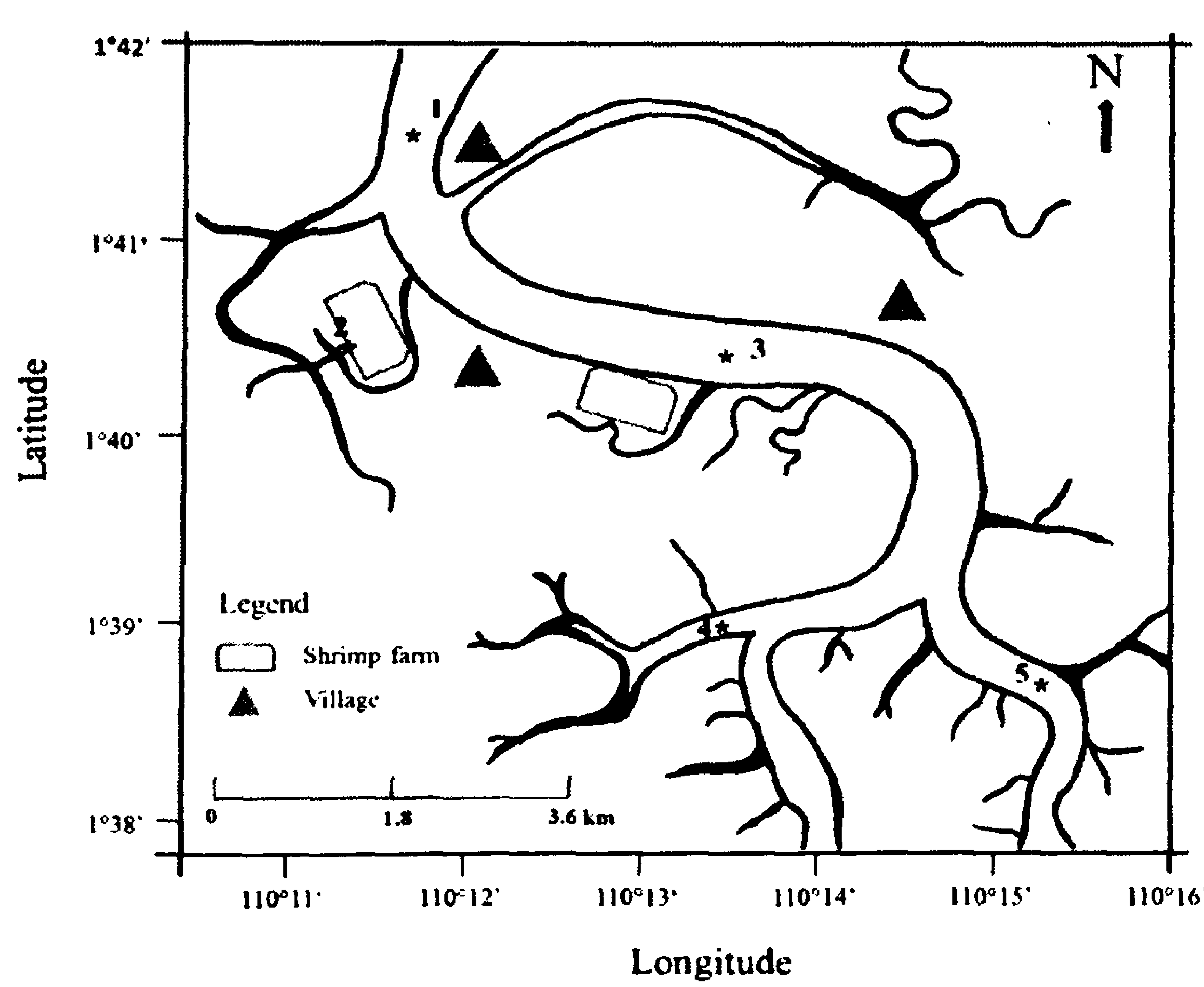

Figure 1: Study area and sampling stations.

Station 1 was located downstream of the river nearest to the sea while Station 2 was located at a tributary of Sibu Laut River. Station 3 was located half way downstream of Sibu Laut River. Stations 2 and 3 were situated near to shrimp farms. Lastly, Stations 4 and 5 were located at the upper reaches of the river.

Analyses of Total Suspended Solids (TSS), Biological Oxygen Demand (BOD_5) and chl-*a* followed Standard Methods (APHA, 2005). TSS was determined by filtration of an adequate sample volume through 0.7 μm pore size glass microfiber filter (Whatman GF/F) and drying at 105 °C. BOD_5 values were taken as the difference between the initial and final dissolved oxygen contents, after incubation of a sample in the dark for 5 days at 25 °C. For the analysis of chl-a, one litre of sample was filtered through a 0.7 μm pore size glass microfiber filter (Whatman GF/F). The filter paper and the residue were crushed using a pestle and mortar before extraction using 90 % (v/v) aqueous acetone for 24 hours. After centrifuging the mixture at 3,000 rpm, the optical density of the supernatant was determined by using a spectrophotometer (Hach DR2800) and readings were taken at wavelengths of 750, 664, 647 and 630 nm and the concentrations determined (Parsons *et al.*, 1984). All analyses were conducted in triplicate.

Water quality parameters (except transparency) among stations and between depths at a particular tide level were compared using two-way ANOVA. For multiple comparisons, Tukey's test was used. Overall comparisons were made using three-way ANOVA. All the analyses were conducted using SPSS 19.0.

Results and Discussion

Results of the study showed that temperature ranged from 29.0 – 30.8 °C with high tide water showing higher temperature than that of low tide (Figure 2). This temperature range is typical for estuarine water in the tropics. The temperature range observed in this study is within the range of 29.1 – 31.2 °C as reported by Ling *et al.* (2010b) in the lower part of Santubong River which is located nearby. During high tide, there was no significant difference between surface and bottom water temperature ($p = 0.543$) and among the stations ($p = 0.281$). However, during low tide, there was a significant difference in temperature between surface and bottom water ($p < 0.0005$) and there was a significant difference among stations where the mean temperatures were in decreasing order of Station 1 (30.00 °C) > Station 3 (29.80 °C) > Station 4 (29.35 °C) = Station 5 (29.43 °C) > Station 2 29.15 °C) ($p \leq 0.003$). The rank of temperature observed corresponds with the distance of the station from the mouth of the river except for Station 2 which was located at Selang Sibu River. During low tide there is more influence of inflow from the watershed which is cooler than the seawater. This showed that the temperature is affected by the distance of study sites from the sea.

Salinity ranged from 28.3 – 33.3 PSU and 23.0 – 31.3 PSU during high tide and low tide, respectively (Figure 3). At all stations, salinity values were higher at the surface than the bottom during high tide. This may be due to the small input of freshwater from the surrounding tributaries. Mean salinity at high tide (31.13 PSU) was significantly higher than during low tide (27.60 PSU) ($P < 0.0005$). The difference in salinity between surface and bottom water and among the stations depends on the location of the station and the tide level at the time the readings were taken. The lower salinity values at Stations 2 and 3 during low tide were most likely due to the freshwater inflow from tributaries located nearby these stations. As the salinity of seawater varies from 33 – 37 PSU with a mean of 34 PSU (Lawson, 1995), the readings obtained in the present study are generally lower due to the mixing with freshwater.

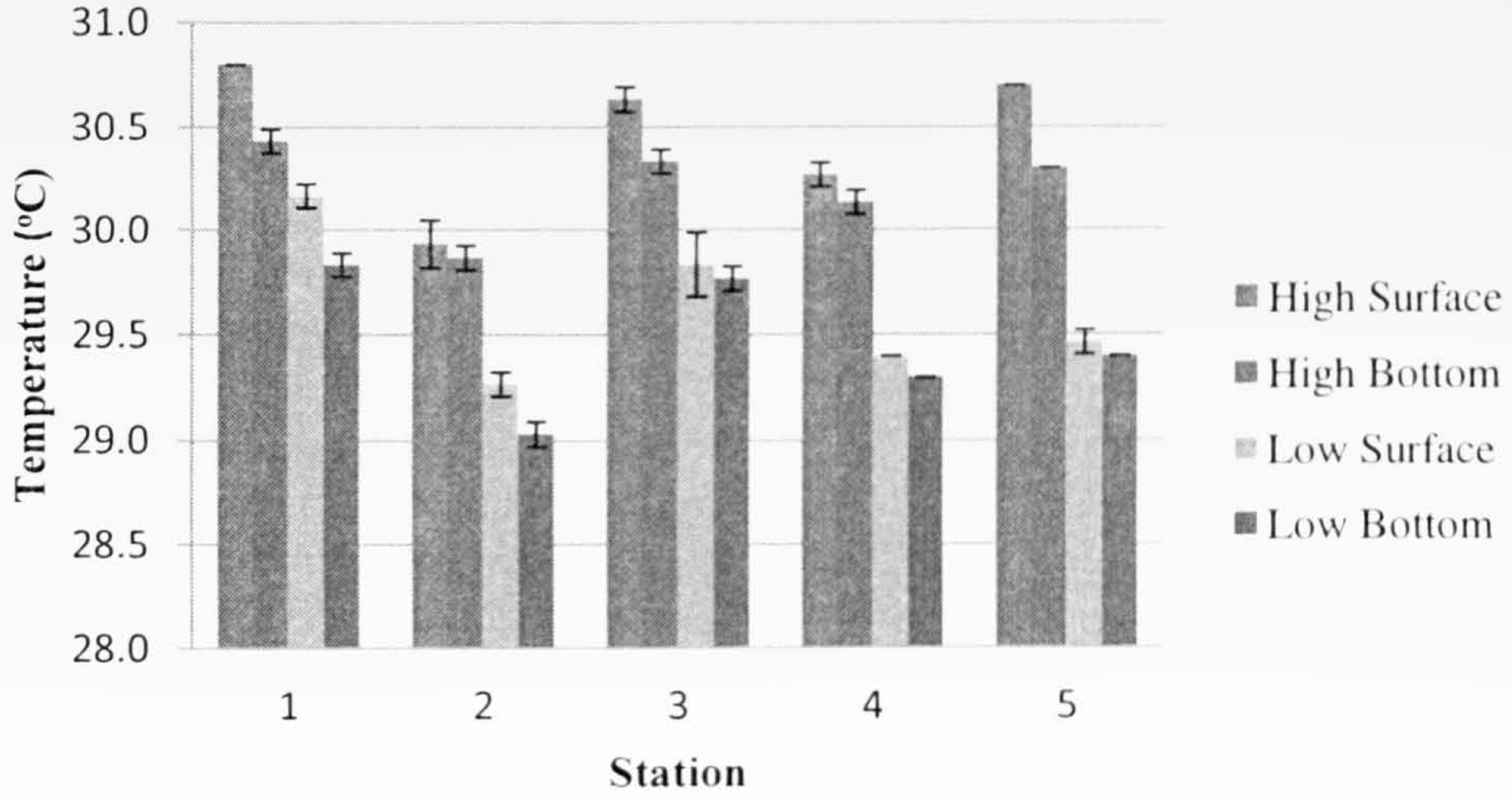

Figure 2: Temperature of the surface and bottom water at the five stations during high tide and low tide (High refers to high tide; Low refers to low tide).

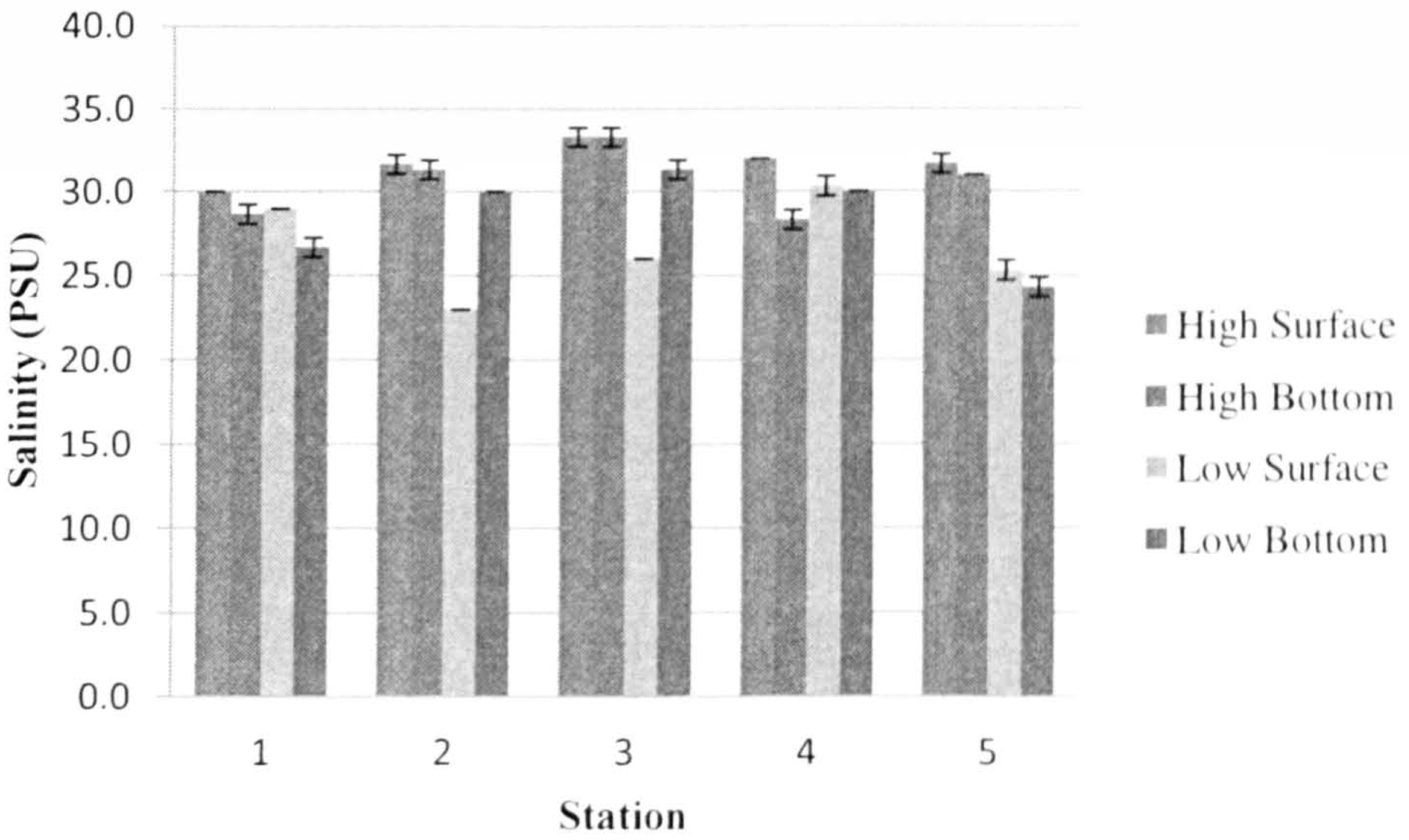

Figure 3: Salinity of the surface and bottom water at the five stations during high tide and low tide (High refers to high tide; Low refers to low tide).

The transparency value indicates the clarity of the water and this study showed that all the values were more than a metre except during low tide at Station 2 (Figure 4). There is no significant difference in transparency values between low tide and high tide at Stations 4 and 5 ($p > 0.05$). During high tide, transparency values were in decreasing order of Station 3 > Station 2 > Station 1 > Station 4 > Station 5. However, the trend was different during low tide with values in decreasing order of Station 4 > Station 5 > Station 3 > Station 1 > Station 2. The low transparency at Station 2 during low tide corresponds to the highest TSS observed among all stations at both surface and bottom water (Figure 5) and the highest chl-*a* (Figure 6) observed at the bottom water. The lower transparency at Station 3 during low tide when compared to high tide level corresponds to the highest BOD_5 at the surface during low tide (Figure 7). The lower transparency values near shrimp farms agreed with the observation reported by Ling *et al.* (2012b) that water transparency was lower near the shrimp farm discharge station when compared with other stations further away.

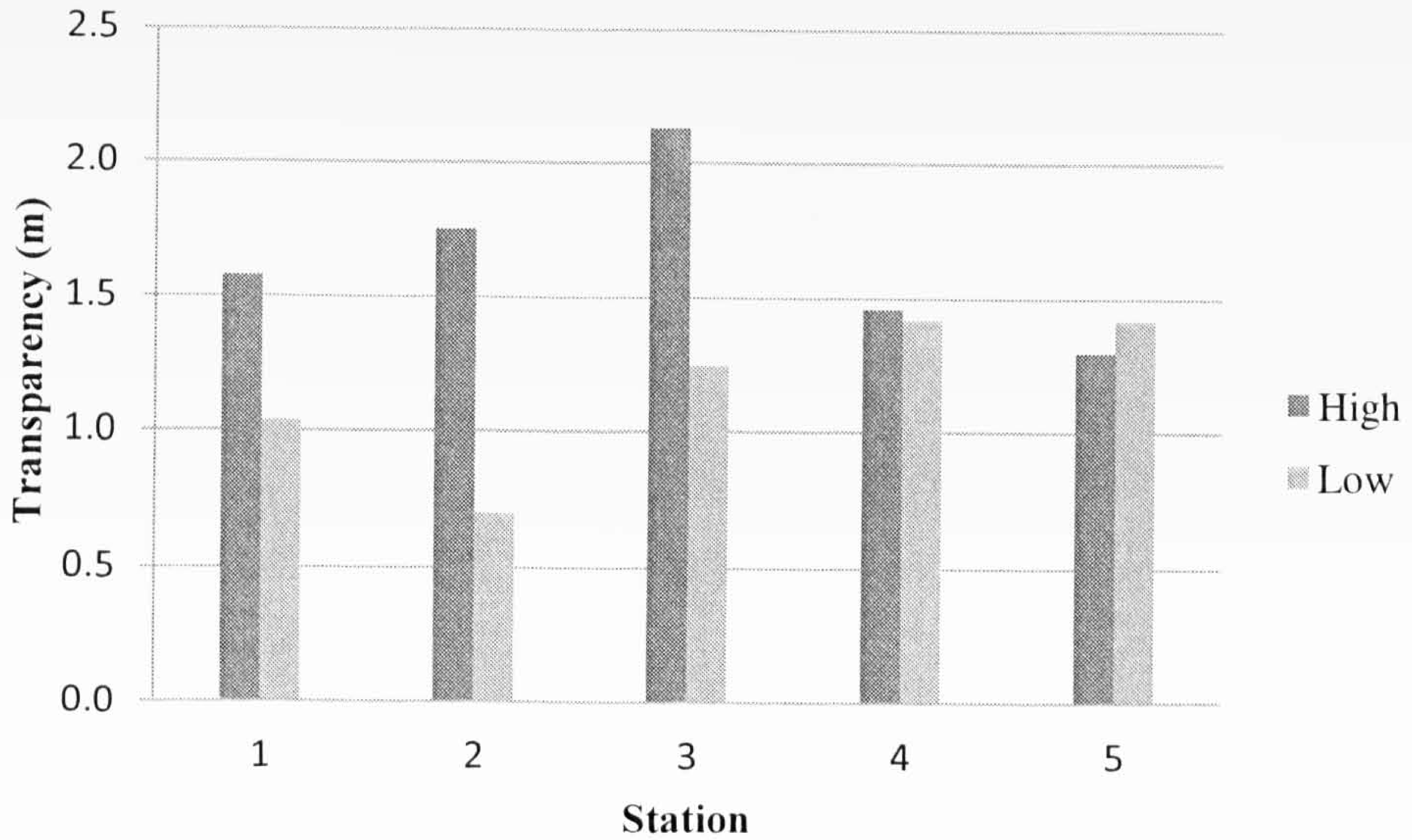

Figure 4: Transparency of the water at the five stations during high tide and low tide.

TSS values were higher during high tide (30.2 – 114.4 mg/L) when compared with low tide (21.6 – 45.9 mg/L) as shown in Figure 5. All the TSS values were below 46 mg/L except at Station 2 which is near the shrimp farm discharge where the value exceeded 110 mg/L near the bottom during high tide. At both tide levels and at both depths, Station 2 showed the highest TSS values and analysis shows that TSS was significantly higher at that station when compared with other stations ($P < 0.0005$). The high TSS (Figure 5) and low transparency (Figure 4) at Station 2 during low tide were likely related to shrimp farm discharge which was reported to contain high TSS. This observation was similar to that at Santubong River where it was reported that TSS ranged from 16.3 – 254.4 mg/L and stations near the shrimp farming areas recorded high values of TSS (Ling *et al.*, 2010b). A study of shrimp pond water quality during harvesting showed that TSS ranged from 98.3 – 436.7 mg/L (Ling *et al.*, 2010a). Nyanti *et al.* (2011) reported that TSS of shrimp pond effluent ranged from 33.7 – 175 mg/L during harvesting. The source of TSS is the pond bottom sludge which is disturbed during harvesting or flushed out after harvesting to clean the pond. Comparing with NWQS (DOE, 1994), 15 % and 80 % of the observed TSS values fall in Class I (< 25 mg/L) and Class II (25 – 50 mg/L), respectively. In this study, TSS value exceeded Class II limit only at the bottom water of Station 2.

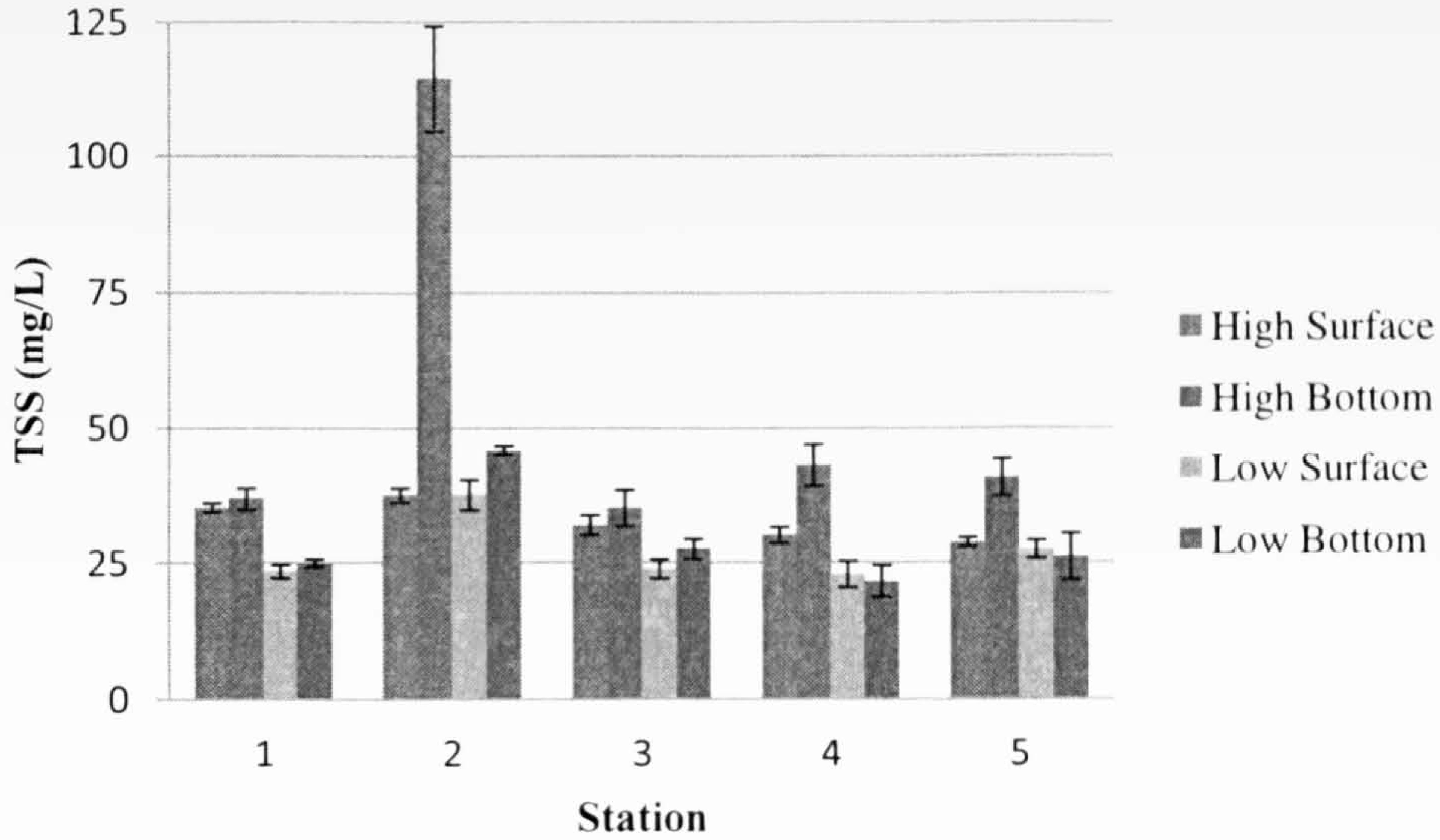

Figure 5: Total suspended solids (TSS) of the surface and bottom water at the five stations during high tide and low tide.

The values of chl-*a* during high tide ranged from 0.83 – 2.00 mg/m^3 whereas during low tide, the values ranged from 0.74 – 4.30 mg/m^3 (Figure 6). Only one value exceeded 2 mg/m^3 (low tide, bottom water at Station 2). During high tide, chl-*a* increased from downstream to upstream as nutrients is likely to increase due to inflow from human activities in the watershed. At low tide, all stations showed higher chl-*a* than Station 5, particularly at Station 2 bottom water where chl-*a* reached 4 mg/m^3. The source of chl-*a* at stations near shrimp farm could be from the pond effluent and/or algal growth stimulated by nutrients rich pond discharge. Nyanti *et al.* (2011b) and Ling *et al.* (2010a) both reported that shrimp farm harvest water showed high chl-*a* concentrations of 61.4 – 111.7 mg/m^3 and 169.2 – 388.4 mg/m^3, respectively. In addition, Nyanti *et al.* (2011a) reported that pond water during harvesting showed high total phosphorus (0.19 – 0.26 mg/L) and Ling *et al.* (2009; 2012b) reported that sediment near shrimp farm discharge point had elevated phosphorus and nitrogen and thus they could provide nutrients for algal growth. Correlation analysis showed that chl-*a* was negatively and significantly correlated with transparency ($r = 0.574$, $P = 0.008$). At Santubong River, it was also reported that stations near shrimp farming areas showed the highest chl-*a*. However, all the values obtained in this study except Station 2 (bottom water during low tide) were lower than those reported by Ling *et al.* (2010b).

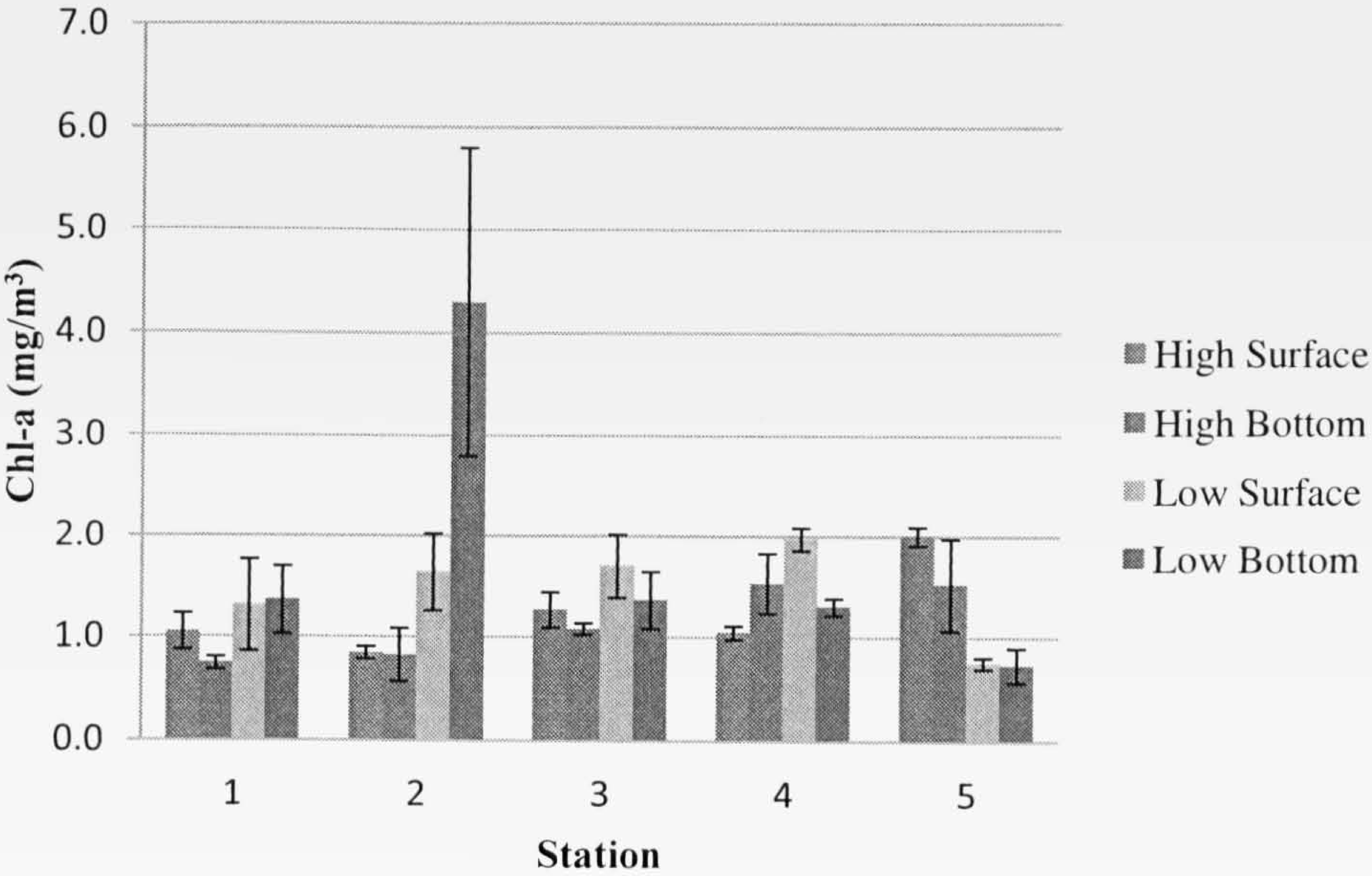

Figure 6: Chlorophyll-*a* of the surface and bottom water at the five stations during high tide and low tide.

At Stations 1, 2, and 3, BOD at surface water show higher values than bottom water and low tide higher than high tide (Figure 7). At Station 1, low tide BOD_5 was about three times higher than high tide values likely due to wastewater discharge from the village. BOD_5 at Station 3 was the highest at surface and bottom water during high tide and also at the surface water during low tide. BOD_5 at Station 3 was significantly higher than Stations 4 and 5 ($P = 0.027, 0.025$) but not significantly different from stations 1 and 2 ($P = 0.076$). Station 3 was located near a shrimp farm and the high BOD_5 is likely related to the shrimp effluent and also household wastewater from the settlement. Station 4 showed the highest BOD_5 at the bottom water during low tide whereas Station 5 has the second highest BOD_5 at surface water during high tide. This is likely due to contributions of the wastewater from the settlements located upstream of those stations. BOD_5 during low tide was significantly higher than high tide ($P = 0.003$) because of dilution of nutrients from land based activities during high tide. Land based activities of human settlement and shrimp farming contribute organic matter which exerted oxygen demand. Previous study on BOD_5 of wastewater from housing areas reported values ranging from 67 – 189 mg/L (Ling *et al.*, 2010c; 2012a) and BOD_5 of shrimp farm effluents ranging from 8.4 – 34.2 mg/L (Ling *et al.*, 2010a) and 6 – 18 mg/L (Nyanti *et al.*, 2011). In Sibu Laut River, BOD_5 values were generally lower than Santubong River (Ling *et al.*, 2010b) because villages in the immediate vicinity of the study area are low in population density. However, stations nearer to residential, construction and near shrimp farms areas showed similar values. Overall, the values of BOD_5 complied with Class I (< 1 mg/L) and II (1 – 3 mg/L) of the National Water Quality Standard (NWQS) of Malaysia except for the surface water at Station 3 during low tide which falls in Class III (3 – 6 mg/L).

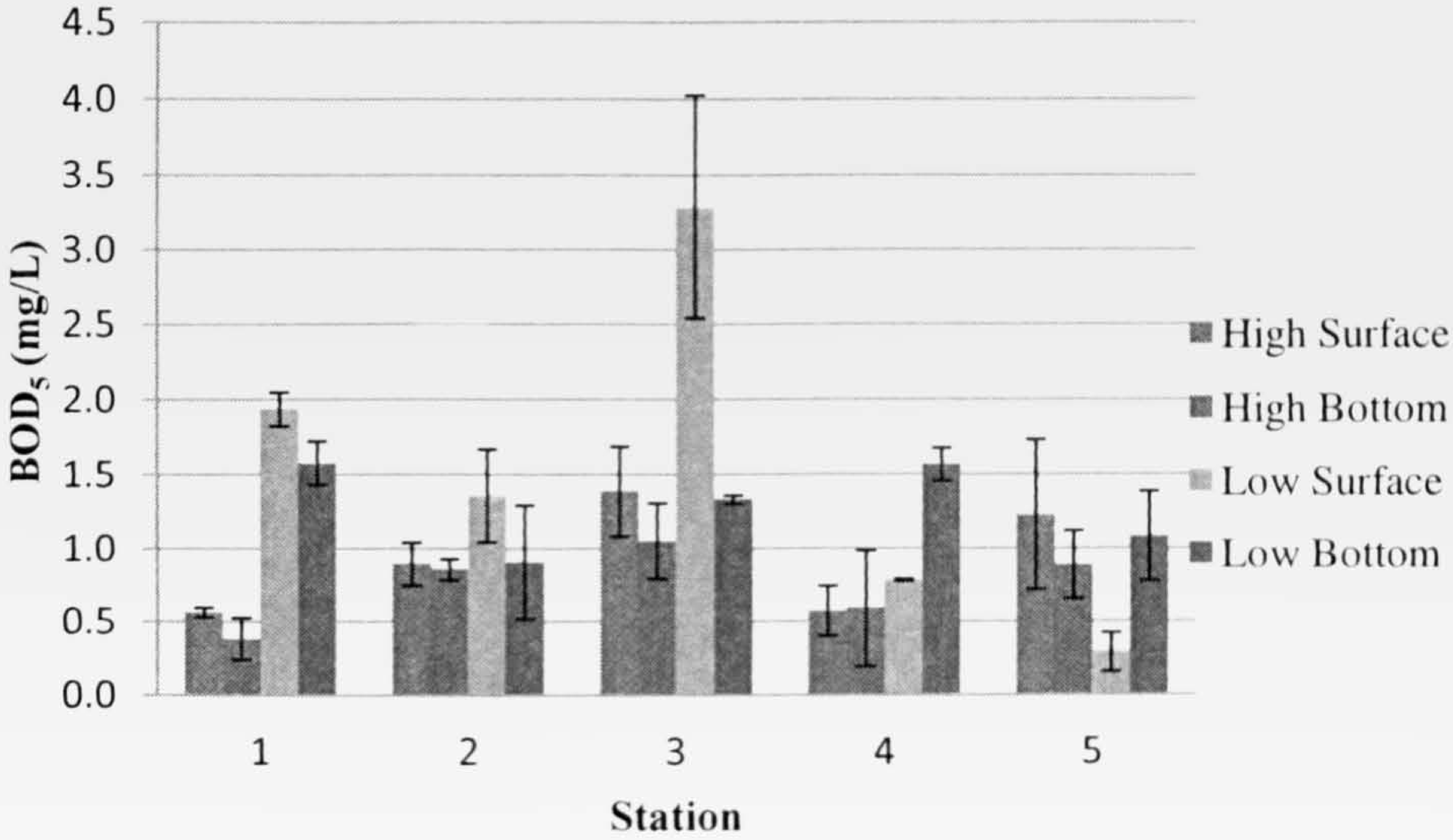

Figure 7: Biochemical oxygen demand (BOD_5) of the surface and bottom water at the five stations during high tide and low tide.

pH during high tide and low tide ranged from 7.32 – 8.81 and 7.48 – 8.44, respectively (Figure 8). Mean pH values during low tide were significantly lower than during high tide ($P < 0.0005$). In addition, bottom water showed higher mean pH value (8.08) than surface water (7.99) ($P = 0.04$) as salt water is denser than freshwater. Station 1 was observed to have the highest pH value during both tide levels as it is located nearest to the coast. As the mean pH of ocean surface water is about 8.3 (Lawson, 1995), pH at stations further upstream (Stations 4 and 5) have lower pH values due to higher proportion of freshwater. Tukey's Multiple Comparisons show that mean pH values of all stations were significantly different ($P \leq 0.046$). This is because the study stations are located at different distances from the coast.

At all stations, DO during high tide (4.80 - 8.08 mg/L) were significantly higher than low tide (3.26 – 5.83 mg/L) ($P < 0.0005$) as shown in Figure 9. There was no significant difference in DO between surface and bottom water ($P = 0.264$). Comparing among stations, Stations 4 and 5 which were the most upstream stations showed the lowest mean DO values at 4.33 and 4.39 mg/L, respectively, and they were significantly lower than all the other stations ($P < 0.0005$). During high tide, only Station 5 has DO value of less than 5 mg/L. However, during low tide, all stations except Station 1 showed DO of less than 5 mg/L.

The lower DO values at Station 4 when compared to other stations corresponded to the high BOD_5 at bottom water during low tide (Figure 7). This is likely due to the presence of some organic matters in the inflow from the settlement to the west of the sampling station. Although Station 5 is not particularly near to any settlement, there is a possibility of organic matter input from other nearby settlement due to tidal influence as reflected in the higher BOD_5 values during high tide and also bottom water of low tide (Figure 7). Lower DO values at Station 2 compared to Station 1 and 3 could have been due to shrimp farm discharge during harvesting (Nyanti *et al.*, 2011b). In this study, most of the

DO values complied Class E of the Interim Marine Water Quality Criteria and Standard of Malaysia (IMWQS), with the minimum of 4 mg/L except Station 2 (surface), Station 4 (surface and bottom) and Station 5 (surface) during low tide.

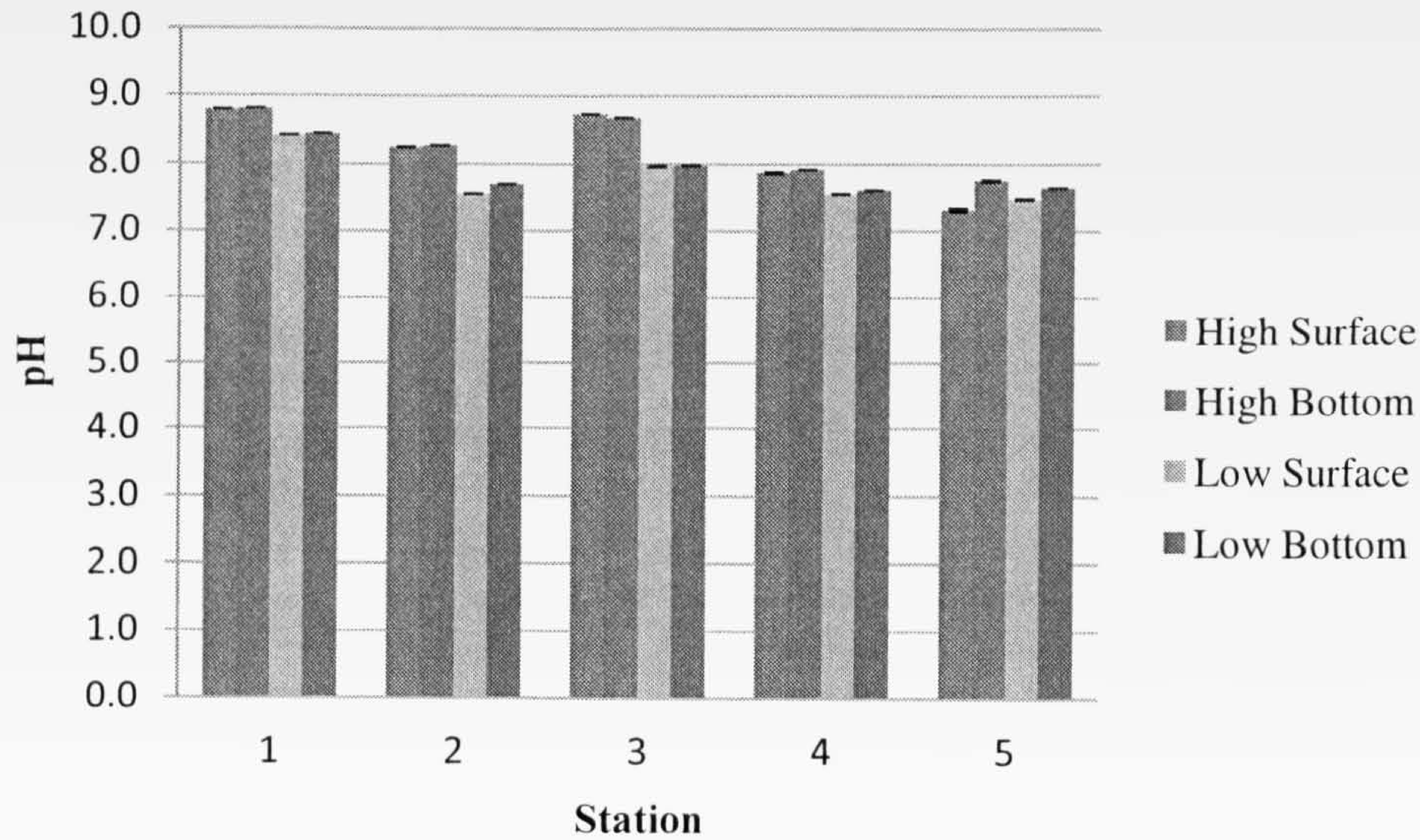

Figure 8: pH of the surface and bottom water at the five stations during high tide and low tide.

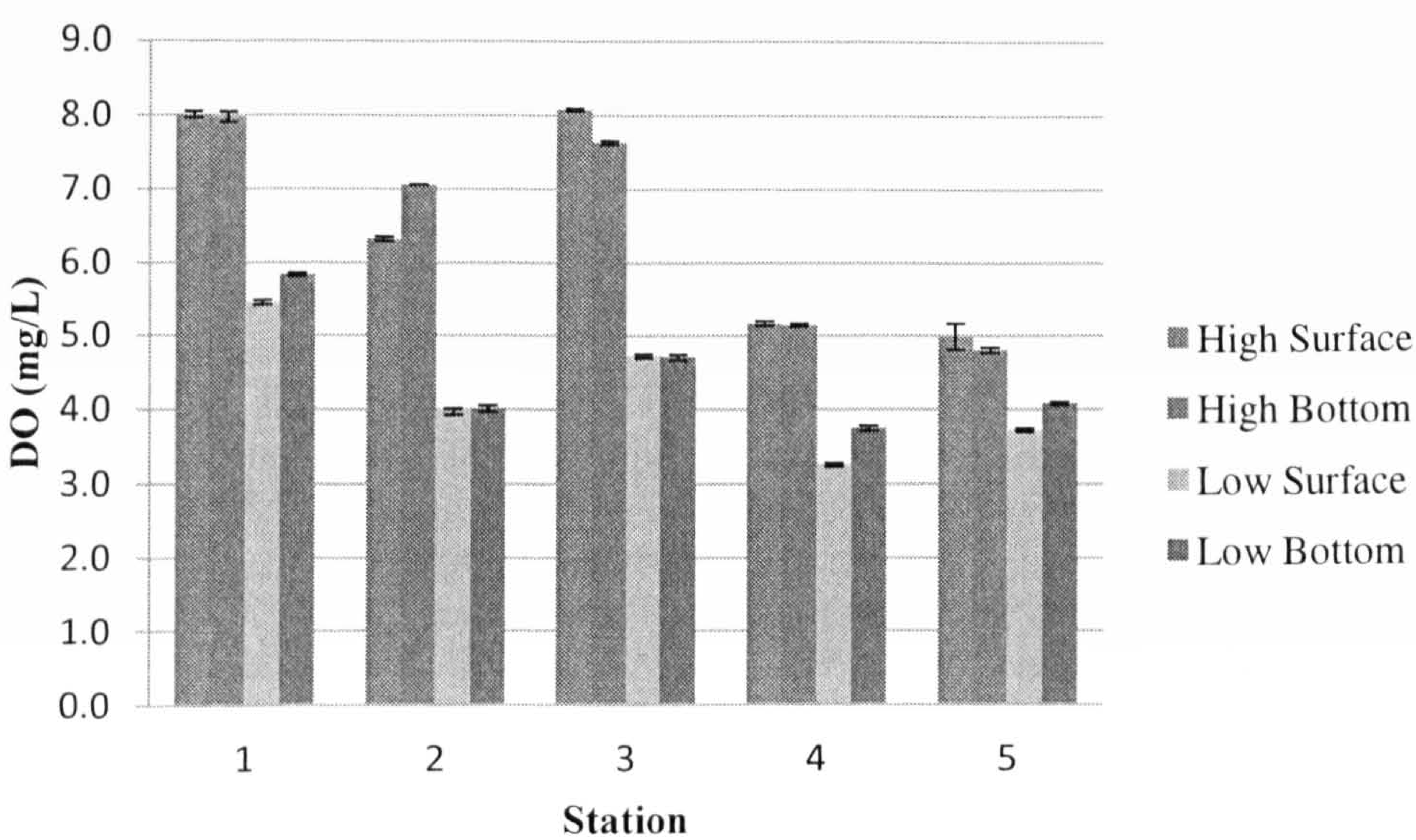

Figure 9: Dissolved oxygen of the surface and bottom water at the five stations during high tide and low tide.

Summary

In this study, only 5 % of BOD_5 values and 5 % of TSS values exceeded Class II limit of the NWQS. For DO values, 80 % were above 4 mg/L and all high tide values exceeded the limit of 4 mg/L set by IMWQS. Values of TSS and BOD_5 were highest near the shrimp farm discharge point. Continuous monitoring of development around this area is recommended to ensure the wetland water quality is conserved for healthy aquatic life.

Acknowledgements

The authors appreciate the facilities provided by Universiti Malaysia Sarawak and the financial support from the Faculty of Resource Science and Technology, Universiti Malaysia Sarawak and the Malaysian Ministry of Higher Education (FRGS No. 07(02)/749/2010(35)).

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Crocodiles of Sungai Sibu Laut, Sarawak.

Mohd Izwan Zulaini Abdul Gani and Ruhana Hassan

Department of Aquatic Science
Faculty of Resource Science and Technology, Universiti Malaysia Sarawak
94300 Kota Samarahan, Sarawak

Corresponding author: wans_zul88@yahoo.com

Abstract

Located in Kuching wetland area and also act as boundary to the protected area Kuching Wetland National Park, Sungai Sibu Laut is an important river especially for local communities from Sibu Laut villages, Telaga Air and few other villages. With increasing number of activities occur along this river, there is a possibility that saltwater crocodile's populations living alongside the river will be affected. Hence, this study was carried out to assess the density of crocodiles in Sungai Sibu Laut and also to study the possible human-crocodile conflict in the area. For crocodiles density study, night spotting techniques were used which involved direct counting of crocodiles at night using either torch (flashlight) or spotlight. Census involved recording the number of hatchlings, yearlings, sub-adults and adults (including eyeshines) along the 14.4 km linear distance of the river. A total of 29 crocodiles were spotted during two days of survey in Sungai Sibu Laut with a mean relative density of 1.04 non-hatchling/km. This paper also reports the viewsof local communities on crocodiles and other related matters.

Keywords: Saltwater crocodiles, human-crocodiles conflict, night spotting techniques, mean relative density

Introduction

Belonging to the Class Reptilia, the Order Crocodylia consists of 24 species including alligators, caiman, crocodiles, false crocodiles and gharials, which are then divided into three families namely Crocodylidae, Alligatoridae and Gavialidae. Each of them can be found in specific zoogeographical regions. In Sarawak there are only two species of crocodile, the most abundant species is *Crocodylus porosus*, which can be found in most of the major rivers and swamps in the state. The other species is *Tomistoma schlegelii*, which is less common and reported to inhibit swampy area of Batang Lupar and Batang Sadong (Cox and Gombek, 1985).

Saltwater crocodiles *C. porosus* in Sarawak are locally known as "Buaya Katak". In local culture and beliefs, the legend of "Bujang Senang" is referring to the huge crocodile that lived in Batang Lupar which had killed many people and was hard to catch (Ritchie and Jong, 2002). In addition, some local people believe that this living legend is in fact the elder leader of crocodiles in Batang Lupar and cannot be captured or killed due to semi-mythical nature (Ritchie and Jong, 2002). The species *T. schlegelii* is called by the name of "Buaya Jejulong".

In late 80s, *C. porosus* in Malaysia especially in Sarawak was in the brink of extinctions due to extensive hunting by local people. This species was hunted primarily for their skin and meat, while farm owner aims for their eggs and hatchlings. Both *C. porosus* and *T. schlegelii* are currently listed under Appendix I in Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES). Nationally, *C. porosus* is under Protection of Wildlife Act 1972 and listed as protected animals in the Sarawak Wild Life Protection Ordinance, 1998. Hence, any hunting, killing or selling activities of wild crocodiles in the state are prohibited.

However after a few decades protected by law, the crocodiles population in Sarawak is on the road to recovery. In addition, increasing cases of crocodile attack on human lately had caused concern to the communities which bring the assumption that the population of this species is on the rise. Field survey by Sarawak Forestry Corporation (SFC) reported that there have been marked increased in the density of this species (Tisen and Ahmad, 2010). With the recent efforts by SFC to down listingthis species from CITES Appendix I to Appendix II, substantial data on the crocodile's population in Sarawak is needed. Downlisting of the *C. porosus* is important so that this resource can be utilised more openly by the local communities, which can also contribute to the state economy.

This paper describes results of our survey on the density of crocodiles in Sungai Sibu Laut as well as the challenges face during the survey. Besides, local communities' views on matters related to crocodiles based on face-to-face interviews were also included in this paper.

Materials and Methods

Crocodile surveys in Sungai Sibu Laut were conducted in 14th and 15thAugust 2011. Night spotting technique modified from Cox and Gombek (1985), Games & Severre (1999) and Sullivan *et al.* (2010) was used in the survey. This technique involves direct counting of crocodiles at night using either torch (flashlight) or spotlight. On the boat, spotters scans shorelines or middle of the river for eye shines, while paying close attention ahead for snags, rubbish and other hazards. Spotlight surveys were conducted during low tide as the crocodiles are more concentrated in river and tributaries (Cox and Gombek, 1985).

When the spotlight was directed to the crocodiles, the retinal tapetum of a crocodile's eye will reflect distinctive orange or red colour (depending on the angle and intensity of lights). The light beam directed to the glowing eyes often mesmerises the animal, allowing a close approach for capture or at least the spotter can approximate the size or age of the crocodiles. When approaching the crocodiles, all survey team members remained silent and the boat moved slowly to ensure that the crocodile did not submerge into the water.

During the survey, the location where each individual was sighted was marked using Global Positioning System (GPS) (Garmin GPSMAP 62s). All crocodiles were categorised according to size class (hatchling, yearling, sub-adult and adult). If observers were unable to accurately estimate size class, the sightings were recorded as eyes only (EO). The commencement location and end point of a survey were also recorded using GPS as a waypoint for the calculation of linear survey distance.

For the survey on human-crocodile conflict, Telaga Air village was selected as a location for oral interviews. Correspondents were selected randomly and subjected to standard questionnaires. The questionnaires were divided into 5 sections which are identification details, profile of residents, dependency on water body, crocodile awareness and human crocodile conflict. The results of the interviews were analysed and plotted in pie charts.

Results and Discussion

A total of 19 individuals within a distance of 14.4 km of waterways were spotted (Figure 1). The highest numbers of crocodiles recorded were yearlings with 42 % of the total number spotted. Almost 21 % were hatchlings and sub-adults while none of the adult *C. porosus* was spotted.

The 'Eyes Only' recorded about 16 % of the total sightings during the surveys in Sungai Sibu Laut.

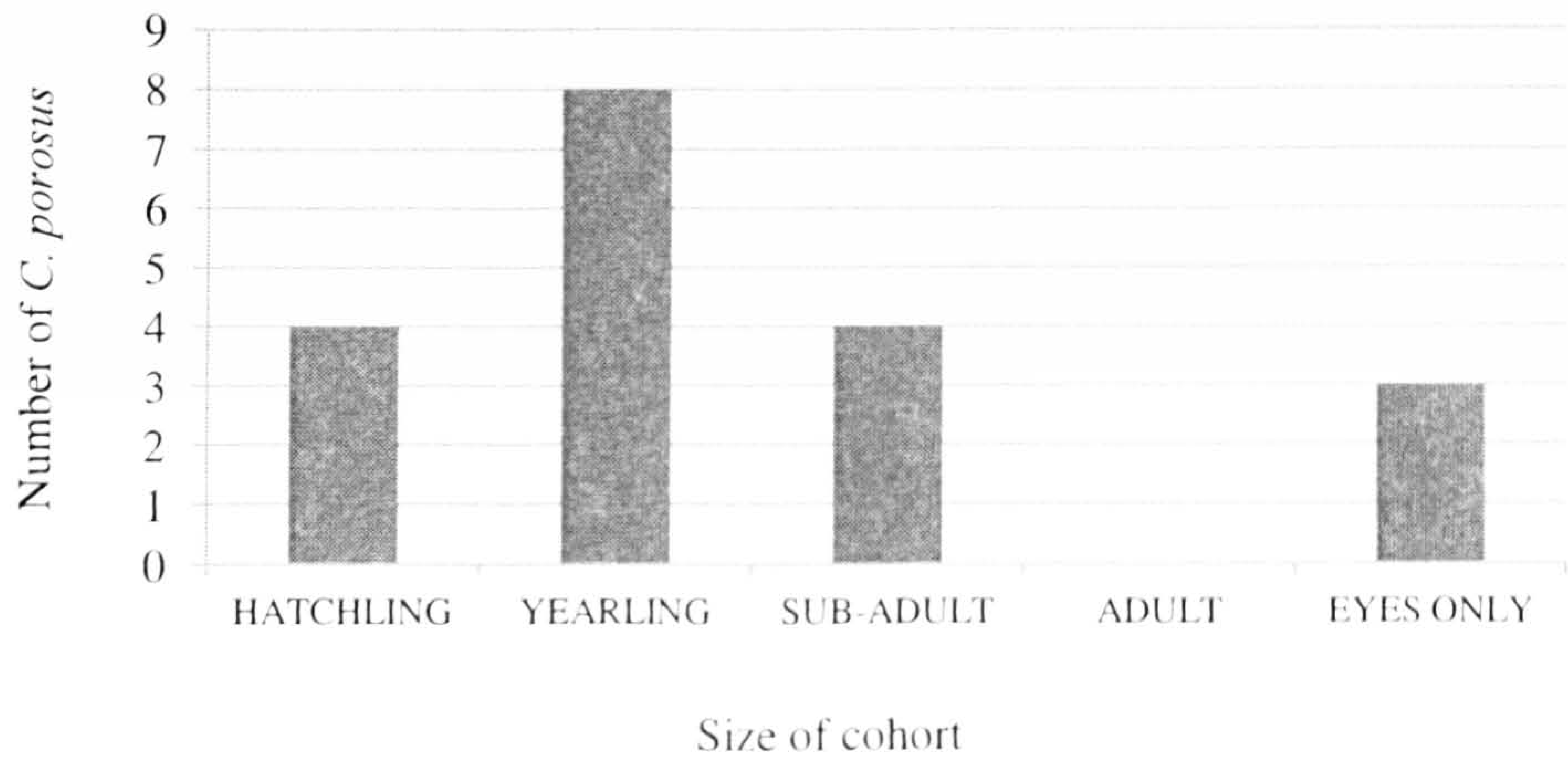

Figure 1: Number of *C. porosus* according to size of cohort recorded in Sungai Sibu Laut.

The mean relative density for *C. porosus* in Sungai Sibu Laut was 1.04 non-hatchling/km. This figure was a decreased of almost 40 % compare to the survey in 2003 (Tisen and Ahmad, 2010) where they reported that the mean relative density were 1.73 non-hatchling/km. Few reasons that could have contributed to the decrease in number of crocodiles sighted in the river are increasing fishing activities, expanding human settlement and populations as well as some river bank development that may have destroyed crocodile habitat.

The locations of the crocodile spotted during the surveys were marked with different colours according to the size cohort of the crocodile as shown in Figure 2. Most of the mature crocodile (sub-adults) spotted during the survey were found in the main river. Each of them was located at about 2 km distance from each other and was distributed along the main river (Figure 2). Most of crocodilian species are known for their territorial nature including saltwater crocodile, *C. porosus*. On the other hand, juvenile crocodiles were more concentrated in small rivers or tributaries, which are suitable for the younger animals as these areas were further from human disturbance (Cox and Gombek, 1985).

During the survey a few obstacles were faced. One of the main problems was tidal cycle in the river. Counting during high tide periods resulted in significantly lower number of sightings as crocodiles, especially small ones (hatchling and yearling) retires amongst flooded nipah and mangroves which make them difficult to spot. Hence, the survey was carried out prior to early low tide and the census of crocodiles (spot and count) was done slowly. However, due to the length and width of the rivers coupled with fast coming of the flooding, the surveys became relatively faster towards the end. Therefore, some parts of the counting exercise were done during high tide and this may have resulted in some crocodiles missed out during the counting.

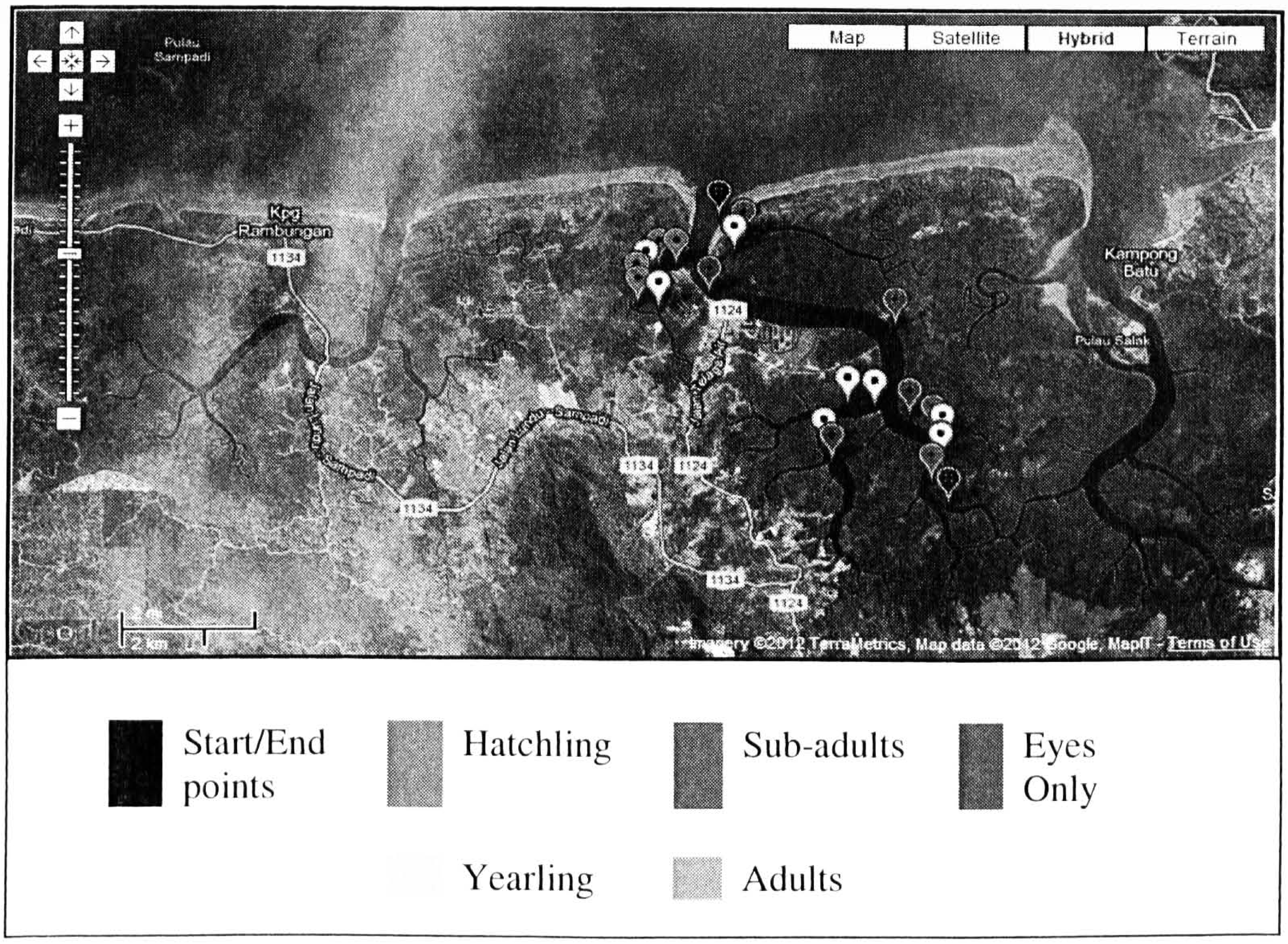

Figure 2: Maps showed location of crocodiles spotted during survey in Sungai Sibu Laut (maps adapted from Google Maps).

The other problem faced during this survey was obstruction of light from bright moon or people's house which may interfere with counting exercise especially near to the Telaga Air village. In addition, there are many villages located along Sungai Sibu Laut. These may have contributed many snags, rubbish and other hazards to the river which make it difficult for the spotters to differentiate between light reflect between crocodile's eye and rubbish. Cox and

Gombek (1985) reported that conditions such as calm water, no rain or fog and no obstructing light from bright moon or others could increased the possibility to spot crocodile.

A total of 21 individuals (villagers) from Telaga Air were interviewed on the human–crocodile's conflict. Most of the correspondents were between 40 to 60 years old (52 %) and only 5 % was more than 60 years old Most of the correspondents work as fishermen (52 %). A total of 48 % of the correspondents has their education until primary school.

Rapid physical infrastructure development has been brought to this village for the last few decades. As a result, all of the correspondents stated that tap water is their main source of water for daily use. A total of 48 % of the correspondents used Sungai Sibu Laut to travel to other villages or places, therefore the time to utilize the water body mostly depends on the tide. A total of 86 % of the correspondents are full and part-time fishermen using fishing rod and net. Generally, people in Telaga Air village still depend on the river to carry out their daily life activities.

During this study, 90 % of the correspondents claimed that they had seen crocodiles in Sungai Sibu Laut, with 47 % of them had seen crocodiles measuring approximately 5 to 6 m long (Figure 3). All of the correspondents are also aware and knew about the violence behavior of the animals. Eighty-nine percent of them prefer to run away or avoid the crocodile when encountering the animal in the river.

A total of 90 % of the correspondents knew that crocodile is a protected animal by law and cannot be killed without permit from local government agency. Most of them (47 %) obtained this information from programmes such as talks, meetings with local communities and other activities conducted by local agencies including Sarawak Forestry Corporation (SFC). Some of the correspondents also knew about crocodiles as protected animal through mass media such as newspaper, radio or televisions (21 %) and poster/signboard (21 %) as shown in Figure 4. This shows that the most effective ways to disseminate information about crocodiles to communities were through programmes involving talk and meeting face-to-face with the local peoples.

Based on the results of the study, there is no incident of crocodiles attack in the villages along Sungai Sibu Laut. Although the correspondent shad slight concern about the increasing number of crocodiles sighted in the river, none of them had any plan to leave the village because they had already adapt with the situation and co-existed with crocodiles peacefully. A total of 52 % of the correspondents suggest killing the crocodiles in Sungai Sibu Laut as a solution to problems related to human-crocodile conflicts (Figure 5). Other respondents (29 %) prefer to transfer the crocodiles to another place or farm and a small number of them (19 %) proposed monitoring the crocodiles in the river. In conclusion, the local people in Telaga Air are in full support for the effort to downlist this species from CITES Appendix I to Appendix II so that this resource could be used to further improve their livelihood.

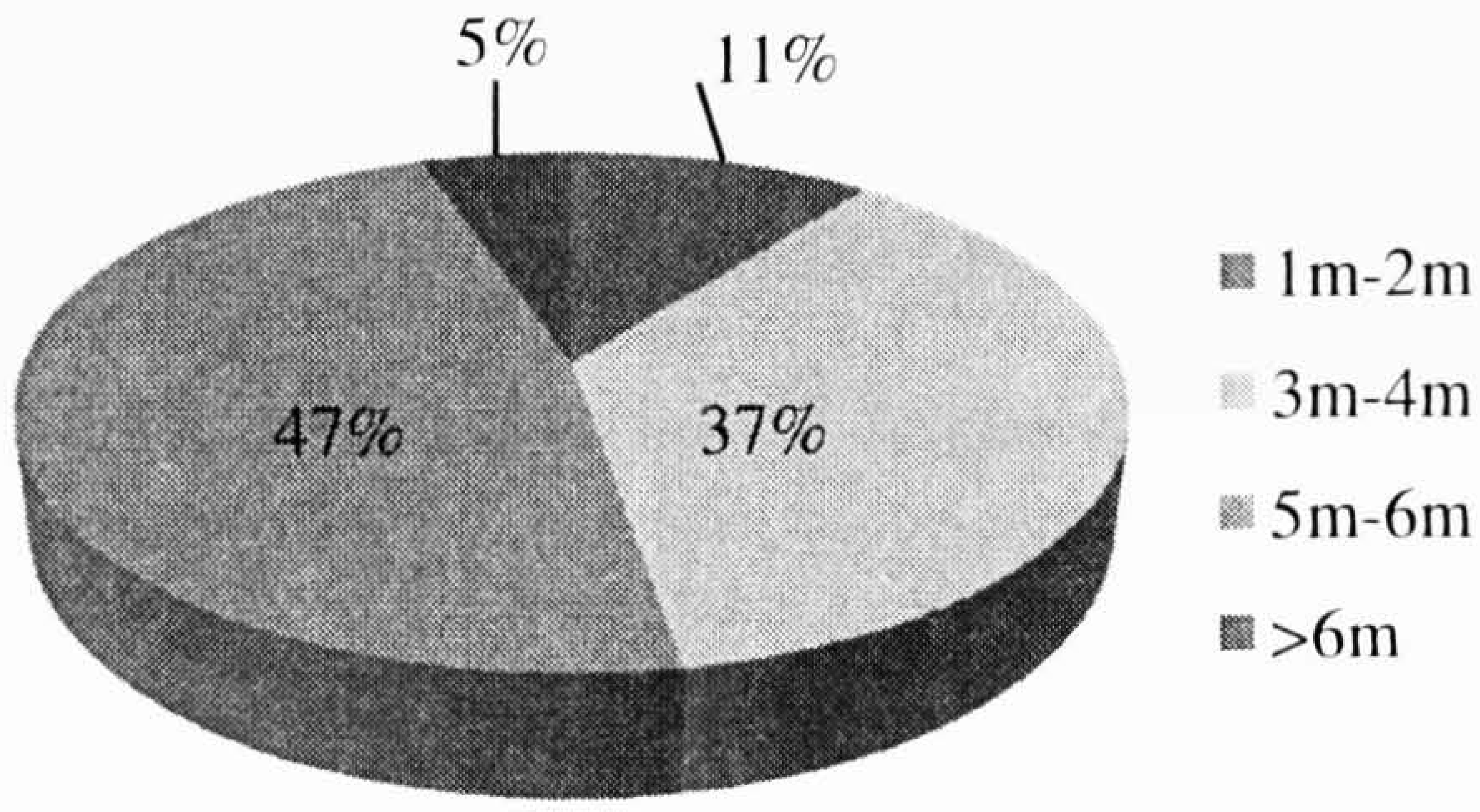

Figure 3: Approximate largest size of crocodiles reported from Sungai Sibu Laut.

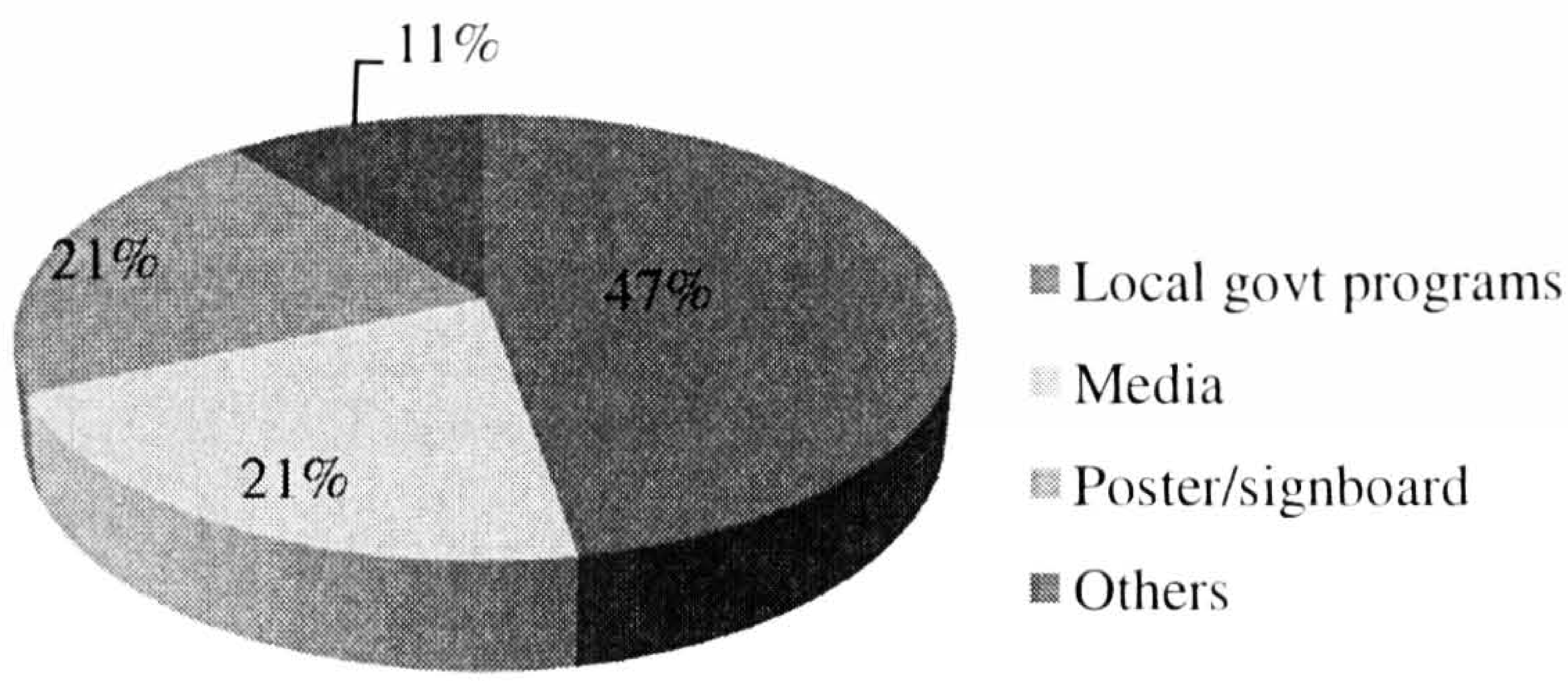

Figure 4: Sources of information about crocodiles as protected animals.

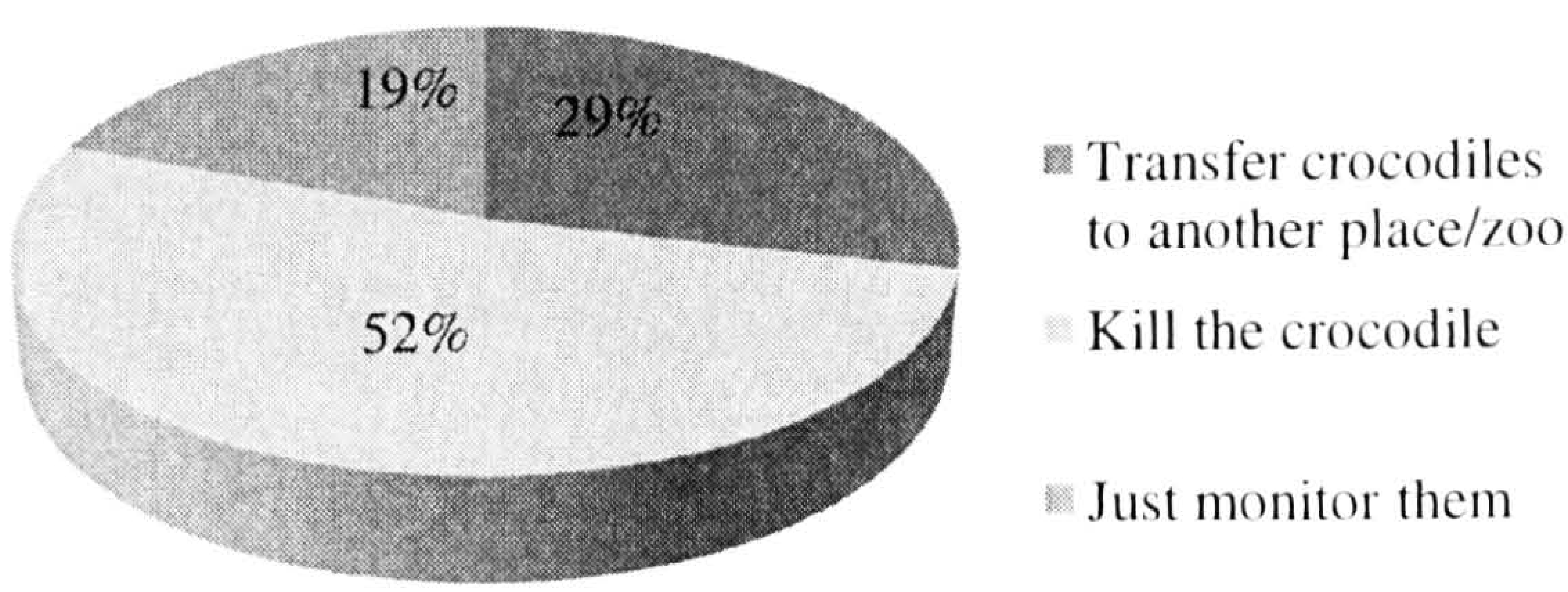

Figure 5: Preferences for solution to human-crocodile conflict.