19.3 Mangrove Aqua Culture

(1) Introduction

Mangroves are trees that have adapted to living in salty water environments in tropical areas of the world. They are an important coastal habitat providing many ecological functions:

- trapping sediments thus protecting soft sediment shorelines;
- recycling of nutrients;
- breeding and nursery grounds for fish and invertebrates ;
- nesting and feeding sites for bird life;
- resources for human use in the form of fuel, building materials and food stuff (mollusca and fish).

Mangrove areas within Oman have high conservational value due to their scarcity (WS Atkins, 1999). Figure 19.3.1 shows the position of the mangrove areas. The mangrove areas in this study are situated either side of the Salalah Hilton. They are protected as Nature Reserve and Scenic Reserves (SR9) by Royal Decree 49/97 and fenced off by their surroundings to protect them.

The mangroves are situated in khawrs, areas of water cut off from the sea by a sand barrier. The sand barrier of both mangroves is relatively low relief and change relief and shape seasonally: relatively low and close to strand line in SW monsoon, the high time of coastal erosion occur toward inland with landward monsoon wind and upwelling that causes sea level higher near shore line.

The fresh seawater charge flashing over the sand barrier to the mangrove areas was observed later on February 15, 2000 morning during high tide along the coast of the Hilton and mangrove areas. In SW monsoon season, this is common to see at both mangrove areas.

There is almost no influence of river since no river but only wadi exist, and also almost no surface water influence charging fresh water to the mangroves except meteorological events such as cyclone hit and/or flash flood that occur only few in decades in the Study Area.

The water in the khawrs is brackish and of stable salinity as groundwater is fed from wadis and seawater infiltrates through or over the sand barrier. The water samples were collected at four points for both mangrove forests on February 6 to monitor the present water quality. These are shown in Table 19.3.1.

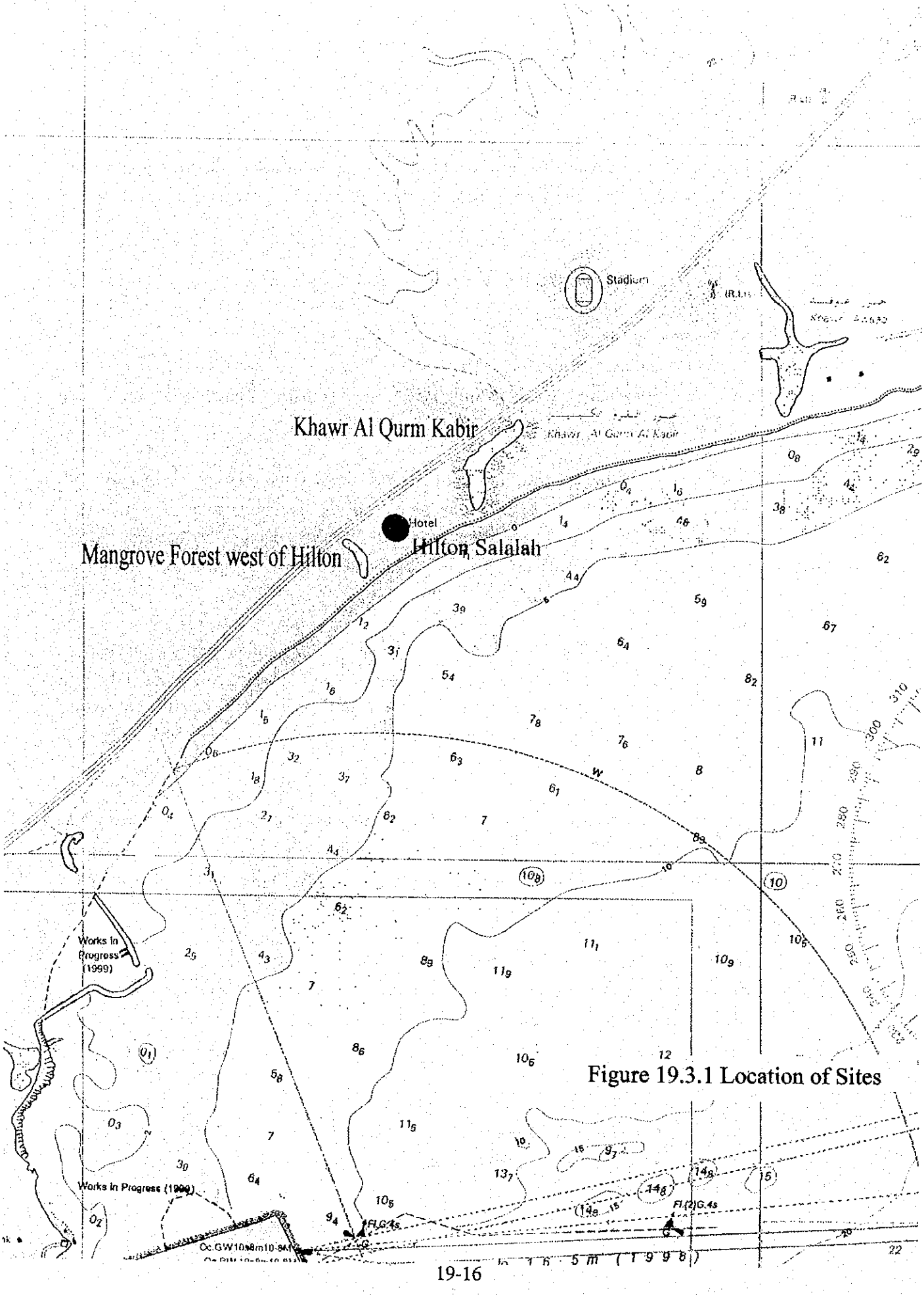


Figure 19.3.1 Location of Sites

Table 19.3.1 WATER QUALITY FOR MANGROVE FORESTS

ITEMS OF OBSERVATIONS				Forest # 1, West Mangrove	Forest # 2, West Mangrove	Forest # 1, East Mangrove	Forest # 2, East Mangrove
ITEMS	Test		METHOD	RESULT		RESULT	
1	Temperature	°C	CTD profiler SBE 19	23	23	23	23
2	Color	Pt Co		4	5	8	5
3	Salinity	‰	CTD profiler SBE 19	34.96	59.63	62.84	71.72
4	pH		CTD profiler SBE 19	-	-	-	-
5	DO	Mg/lt	CTD profiler SBE 19	-	-	-	-
6	Transparency	m	Secchi's disk	1	1	2	2
7	Depth	m	Manual	1	1	2	2

RESULTS OF LABORATORY TEST							
ITEMS	Test		METHOD	RESULT		RESULT	
1	pH		pH meter	7.43	8.03	7.34	7.88
2	Coliform group		AWWA	Positive	Positive	Absent	Absent
3	Fecal coriform group		AWWA	Absent	Absent	Absent	Absent
4	Surface active agent		AWWA	0.09	0.10	0.10	0.12
5	Oil (Hexan Extracts)	mg/L	AWWA 5520 D	10	7	9	6
6	Phenol	mg/L	HACH Calorimeter	0.15	0.18	0.15	0.18
7	Oxygen	mg/L	AWWA 4500 -°C	9.2	9.1	8.9	9.0
8	Oil (Total)	mg/L	2530 C	16	10	12	15
9	Suspended solids	mg/L	HACH	4	3	19	6
10	Copper (Cu)	mg/L	AA	0.055	0.051	0.058	0.073
11	Cadmium (Cd)	mg/L	AA	0.027	0.052	0.051	0.063
12	Lead (Pb)	mg/L	AA	0.25	0.48	0.47	0.61
13	Chromium (Cr)	mg/L	AA	0.016	0.037	0.030	0.040
14	Nickel (Ni)	mg/L	AA	0.232	0.335	0.365	0.351
15	Zinc (Zn)	mg/L	AA	0.050	0.065	0.060	0.047
16	Iron (Fe)	mg/L	AA	0.28	0.32	0.28	0.43
17	Total Mercury	mg/L	AA	0.006	0.014	0.090	0.120
18	Manganese (Mn)	mg/L	AA	0.040	0.060	0.015	0.015
19	Fluoride (F)	mg/L	HACH	1.09	1.26	1.24	1.37

POLLUTION LOAD							
ITEMS OF OBSERVATIONS				Forest # 1, West Mangrove	Forest # 2, West Mangrove	Forest # 1, East Mangrove	Forest # 2, East Mangrove
ITEMS	Test		METHOD	RESULT		RESULT	
1	Temperature (oC)	°C	CTD profiler SBE 19	25.21	25.15	25.36	25.32
2	Color	Pt Co	HACH	4	5	8	5
3	Salinity	‰	CTD profiler SBE 19	32.25	36.45	38.41	39.71
4	pH		CTD profiler SBE 19	7.43	8.03	7.34	7.88
5	Oxygen	Mg/lt	CTD profiler SBE 19	9.2	9.1	8.9	9.0
6	Depth	m	Manual	1	1	2	2
7	COD	mg/L	AWWA 5220 -B	56	52	56	60
8	T-Nitrogen	mg/L	4500 N-B	0.88	0.86	0.66	0.71
9	T-Phosphate	mg/L	4500 P-C	0.11	0.21	0.28	0.31

RESULTS OF LABORATORY TEST							
ITEMS	Test		METHOD	RESULT		RESULT	
1	pH		pH meter	7.43	8.03	7.34	7.88
2	Coliform group		AWWA	Positive	Positive	Absent	Absent
3	Fecal coriform group		AWWA	Absent	Absent	Absent	Absent
4	Oxygen	mg/L	AWWA 4500 -oC	9.2	9.1	8.9	9
5	Suspended solids	mg/L	HACH	4	3	19	6

(2) Survey Method

The survey was conducted at mangrove stands between 26th and 28th January 2000. In order to conduct a comprehensive baseline survey of the areas the following activities were undertaken:

- a walk around each mangrove stand mapping the distribution of mangrove
- taking photographs to illustrate the different features
- observing the bird life using the khawr and mangrove area
- a broad survey was carried out to determine the species of crustacea and other invertebrates living in the mangrove:
  - the number of Fiddler crab (*Uca* sp.) burrows per meter square were counted in the sand to provide an idea of the density of crustacea in the area. *Uca* sp. are known to be a good indicator of stress in a mangrove, i.e. a stressed mangrove has less crabs.
  - a close investigation of the mangrove roots to identify invertebrates living on the roots.
- noting any other wildlife or land use in and around the khawrs

(3) Results

1) Mangrove Community Distribution

(a) Khawr Al Qurm Kabir (Larger Mangrove to the North East of the Hilton)

Figure 19.3.2 and Plate 1 illustrate the distribution of mangrove in this area. This mangrove lay to the North east of the Salalah Hilton. The mangroves in the stand are *Avicennia marina*. The maximum height of the stand is 4-5m.

In general the mangrove fringe around the standing water was one mangrove tree thick and it did not exceed three trees thick (between water and land).

The mangrove trees were limited to the landward half (NW end) of the khawr. Parallel with the road the mangroves trees were most dense (see Plate 2). Trees along NE fringe were very bare except at top of tree (Plate 3). The mangrove trees depleted towards the seaward end, and the South East (nearest the sea) was devoid of mangroves (see Figure 19.3.2 and Plate 4).

The khawr was separated from the sea by a stable sand bar (Plate 4). However, there was evidence that the sea regularly breached the bar as there were cuttlefish bones on khawr side of the sand bar.

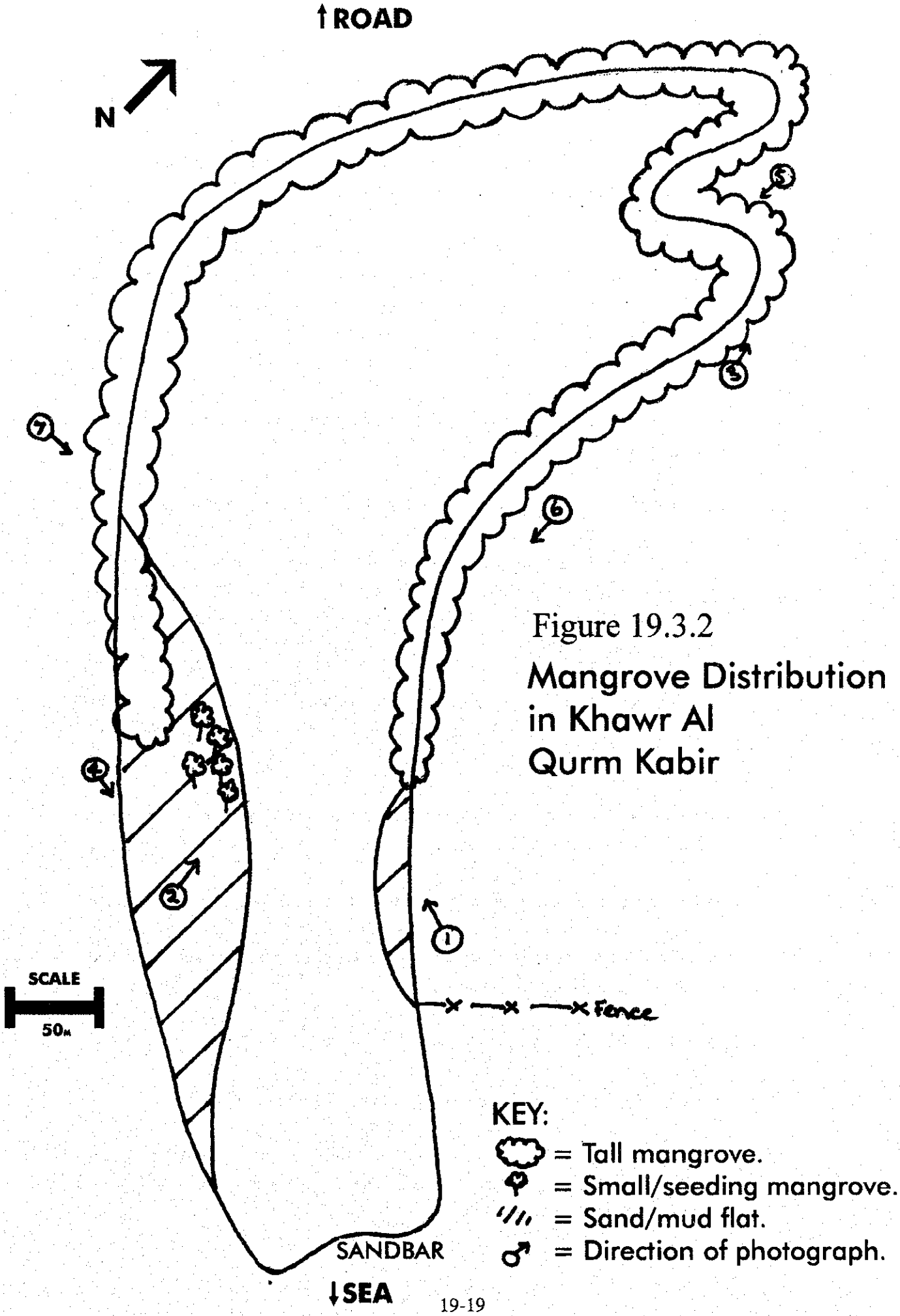


Figure 19.3.2

Mangrove Distribution in Khawr Al Qurm Kabir

During the exceptional meteorological occasion like a flash rains or cyclone hit that was recorded in 1996 as latest one, the mangroves may be subjected to freshwater running down the wadi since its level of flat land near coast. There was clear evidence of high water levels, in excess of 1m above current levels, by the presence of debris tangled in the mangrove branches (Plate 5).

Goats were kept on the NE side of the khawr (Plate 6), and empty feed bags were observed littering the mangrove roots. The feed was kept in cages/sheds, which were covered, in plastic sheeting. Camels wandered freely within the mangrove area, grazing the trees (Plate 7) and low lying vegetation growing on the surrounding land.

(b) Mangrove Forest West of Hilton (Smaller Mangrove area to the South West of the Hilton)

Figure 19.3.3 and Plate 8 show the distribution of mangrove in this area.

The mangrove species present in the Khawr was *Avicennia marina*. The substrate of the khawr was more sandy than the other mangrove area and was firmer underfoot. The mature mangrove trees at the end of the khawr by the road formed a dense stand that averaged 4-5m in height (see Plate 9).

There were a high proportion of seedlings (50-70 cm height) at the edge of the mangrove stand (Plate 10). At the seaward end the banks were devoid of vegetation (see Figure 19.3.3 and Plate 11).

The West shore showed evidence of mans influence where tarmac and rubble had been tipped next to the khawr (Plate 12).

The water in the khawr at road end (away from sea) was stagnant and green algal mats were present. The watercourse at top end was a maximum of 3m wide and was shaded by dense growth of mangrove. The mangrove again is one tree thick along the banks of the khawr.

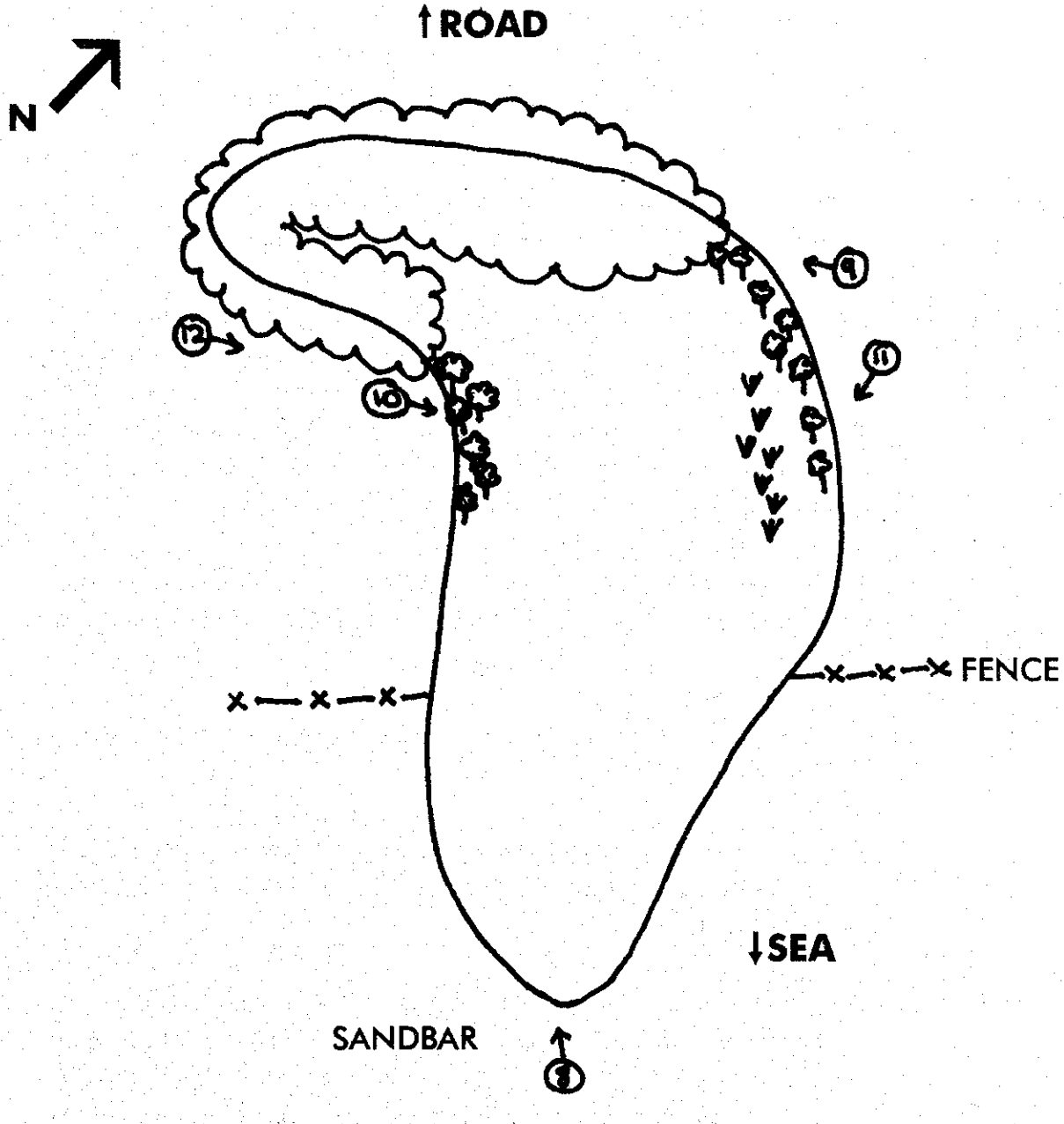
2) Aquatic Organisms and Rare Species in the Community

(a) Khawr Al Qurm Kabir (Larger Mangrove to the North East of the Hilton)

There was an obvious trend as the surveyor walked from the seaward (SE) end to the North West end near the road. Near the sea there were no crustacea burrows evident in the substrate.

Figure 19.3.3

Mangrove Distribution in Mangrove area West of Hilton.



Moving up the khawr, the number of *Uca* burrows in the sand increased. On the sand/mud flats (see Figure 19.2.2) there were 12 holes per meter square. Progressing up towards the mangrove, the no. of burrows increased to an average of 108 per square meter, and approximately 20m from where the mangrove fringe began, 216 per meter square were recorded in the sand/mudflat. Once in the mangrove the number of burrows per meter square reached 344.

The burrows discussed above were predominantly those of Fiddler crabs (*Uca* sp.); however, *Nasima* sp. (was called *Cleistostoma* sp) were also noted which constructed chimney like structures on top of the burrows. At road end there were few burrows in the sand around the mangrove roots (<40 per meter square).

Swimming crabs (family Portunidae) were observed in the margins (5-15cm depth) of the khawr. Many small fish were observed in the khawr.

Bird species observed during the study period included, Marsh Harriers (*Circus aeruginosus*)(Plate 13), Palm Doves (*Streptopeia senegalensis)* and an African Paradise Flycatcher (*Terpsiphone viridis)* in the mangrove trees. Feeding in the khwar were Curlew (*Numenius arquata)* (Plate 14), Little Green Heron (*Butorides striatus),* Grey Heron (*Ardea cinerea)* (Plate 15), Great White Egret (*Egretta alba)* and Plover (*Chradrius* sp.).

The plants growing on the sand areas around the mangrove included *Zygophyllum simplex*, *Suaeda* sp. together with grasses of the Graminaceae family.

(b) Mangrove Forest West of Hilton (Smaller Mangrove area to the South West of the Hilton)

The crustacean burrows were the most conspicuous evidence of fauna within the mangrove.Ghost crab (*Ocypode* sp.) burrows and mounds were present on the sand of the beach.

There were no *Uca* sp. burrows at the seaward end of the khawr. Burrows were present approx 70m from the tip where between 60 and 80 holes per square meter were recorded on the sand flat. A further 10m the occurrence of Uca sp. increased to 280 per square meter. Where the small mangroves were growing there were 100-160 per square meter. There were few burrows at the landward end of the khawr, between 20-40 square meter were recorded

Cerithidae, small (1cm long) spiral shelled gastropods, were found attached to the roots of the mangrove. They feed on micro algae and detritus caught by the mangrove root.

Bird species observed using the mangrove area included Flamingo (*Phoenicopterus ruber),* Grey Heron (*Ardea cinerea),* Cormorant (*Phalacrocorax carbo),* numerous Plover (*Charadnus* sp.), and a pair Marsh Harriers (*Circus aeruginosus*).

A small bed of seagrass (*Halodule uninervis*) was present in the khawr (see Figure 19.3.3). Attached to the seagrass were bunches of mussels (Mytilidae).

The plants growing on the sand areas around the mangrove included *Zygophyllum simplex, Suaeda* sp. together with grasses of the Graminaceae family.

(4) Preliminary suggestions

The survey revealed that the mangroves either side of the Hilton are important wetland areas, in terms of the birdlife, crustacean and molluscan fauna. All species found rely on the mangrove habitat for food and/or shelter.

Loss of the habitat would result in loss of all the flora and fauna observed. This, coupled with the fact that there are few mangrove stands within Oman, makes it important to preserve all mangrove areas wherever possible.

It is recommended that regular monitoring of the mangroves carried out by trained ecologists to assess the general health.

It is important to ensure that the mangrove fauna and flora is protected from the possible deleterious impacts of the port development. It may be advisable to conduct a similar survey of these mangrove areas in the wet season in order to compare results and form a report that will consider seasonal variations.

The current impacts on the mangrove area are relatively insignificant and include grazing from domestic animals, littering, and utilizing as a place for roaring boat.

Possible impacts on the mangroves caused by the construction activities include:

- increased erosion or accretion in the mangrove areas due to changes in current patterns
- increased sedimentation due to sediments from dredging activities being carried into the mangrove
- increased traffic and noise during construction may disturb wildlife

- the new port and associated industries may lead to further development and encroachment of the area, which may in turn threaten the mangrove in the future
- changes in water quality may adversely affect the mangrove in many ways and should be closely monitored

It is advised that the following actions be taken in order to ensure that the mangroves are maintained in their current state throughout development and construction works:

- Employ use of silt curtains at any sites of dredging to avoid increased sediment load in the seawater which may not only affect the mangrove but other marine habitats, tourist hotels and beaches along the coast.
- Limit/control the noise from traffic and construction works. Noise can have a great impact on wildlife that has previously lived in a tranquil area and is suddenly subjected to high noise levels.
- Vibration and dust should be kept to a minimum, and monitored at regular intervals.

(5) Other marine considerations

It is important to consider the marine mammals that use the coastal waters between Raysut and Salalah. Port development works could have a deleterious effect of the local population of Hunmpbacked Dolphin (*Sousa chinensis*).

These dolphin feed in inshore coastal areas, estuaries and mangroves. They are known to have a coastal territory in which they feed, any construction could cause disturbance to these, and other marine mammals.

A short mammal survey may be advisable to establish the species of dolphin in the vicinity of the port in order to advise the developers on best practice to limit the disturbance of these creatures.

PLATE 1

EXTENT OF MANGROVES IN THE KHAWR AL QURM KABRI

PLATE 2

DENSE MANGROVE TREES AT NORTH WEST SIDE OF THE KHAWR

PLATE 3

THE MANGROVES ON THE NORTH EAST SIDE OF THE KHAWR

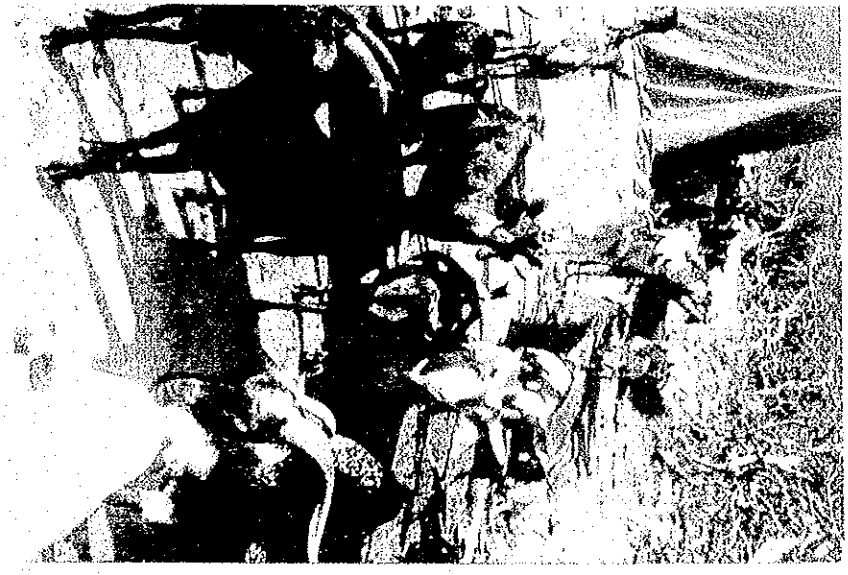
PLATE 4

THE KHAWR WAS SEPARATED FROM THE SEA BY A STABLE SAND BARAND THE SEAWARD END WAS DEVOID OF MANGROVES

PLATE 5

DEBRIS IN THE MANGROVE BRANCHES WAS EVIDENCE OF RECENT FLOODS

PLATE 6



GOATS THAT WERE KEPT ON THE NORTH EAST SHORE OF THE KHAWR

PLATE 7

CAMEL GRAZING ON MANGROVE

PLATE 8

EXTENT OF THE MANGROVE IN THE KHAWR TO THE WEST OF THE HILTON

PLATE 9

DENSE MANGROVE AT THE ROADSIDE

PLATE 10

MANGROVE SEEDLINGS IN WATER EDGE

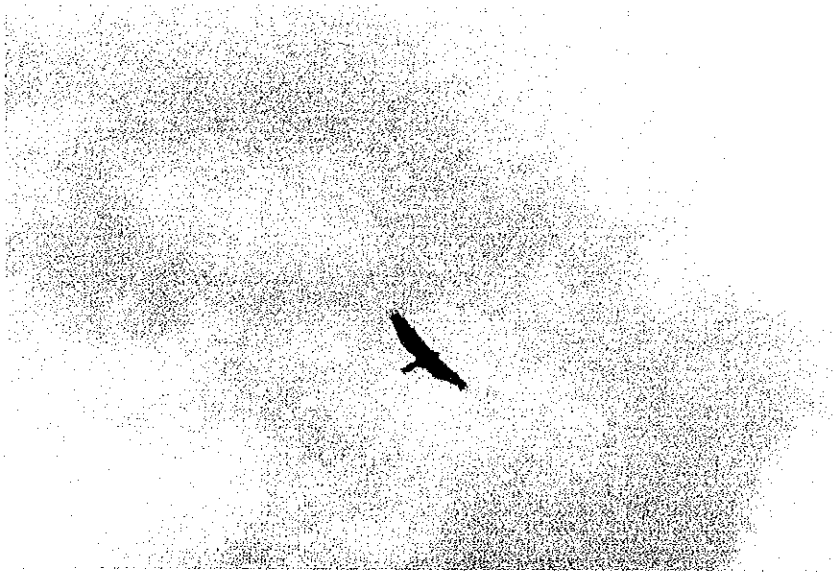
PLATE 11

THE SEAWARD END OF THE KHAWR WAS DEVOID OF MANGROVE

PLATE 12

RUBBLE WAS PRESENT ON THE SHORES OF THE KHAWR

PLATE 13

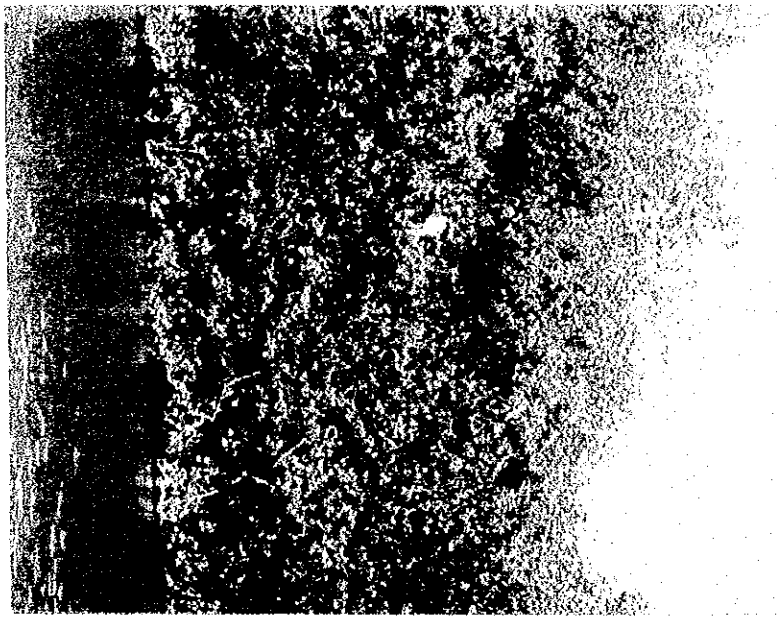


MARSH HARRIER [CIRCUS AERUGINOSUS] SOARING ABOVE MANGROVE STAND

PLATE 14

A PAIR OF CURLEW [NUMENTUS ARQUATA] FEED AT WATERS EDGE

PLATE 15



GREY HERON [ARDEA CINEREA] IN AVICENNIA MARINA

19.4 Air Quality and Car Traffic

(1) Survey Periods

On January 26 and January 28, the air quality and traffic volume were surveyed near the Salalah port area. These surveys were planned to observe the traffic volume and air quality related to the port activities.

1) 1st Session

(a) Date:	Wednesday, January 26, 2000
(b) Duration:	24 hours base in weekdays
(c) Relation to port activities:	Peak of loading/unloading bulk cargo

2) 2nd Session

(a) Date:	Friday, January 28, 2000
(b) Duration:	14 hours base in weekend
(c) Relation to port activities:	Weekend/holiday

(2) Survey Sites

Four (4) survey sites were selected based on the reconnaissance survey that was conducted on January 1, 2000, and these are shown in Figure 19.4.1. In this figure, the points P1, P2, and P4 were located at the intersections that connect the Salalah port and major city and/or facilities. The point P3 was located alongside the road that connects the port and Mughsail. The description of the sites are shown in Figure 19.4.2.

(3) Survey Method

1) Traffic Volume

As shown in Figure 19.4.2, the survey personnel were stationed at each survey site and counted the number of cars coming /passing through in assigned direction. The counted cars were recorded with respect to their types that divided into 5 types of car, 9 types of tracks, pedestrian, bicycle, and motorcycle. One session of counting of the cars was five minutes, and it continued at the end of the survey duration.

2) Air Quality

At each site, the dosi-tube, an air-pollution detecting devices for CO, SO_2, and NO_2 were set and monitored at about 1.5 meters high with temperature and humidity sensors.

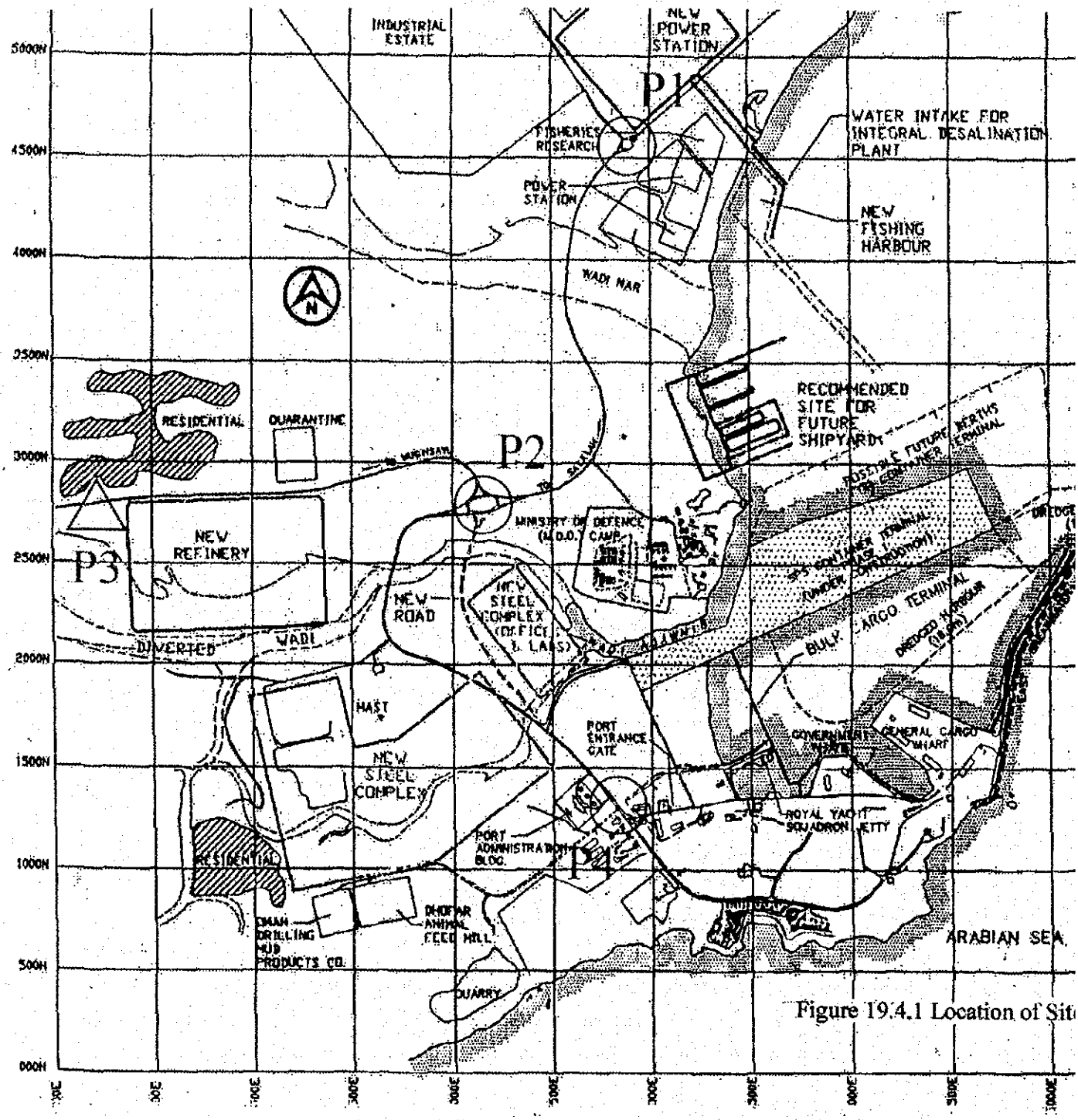


Figure 19.4.1 Location of Sit

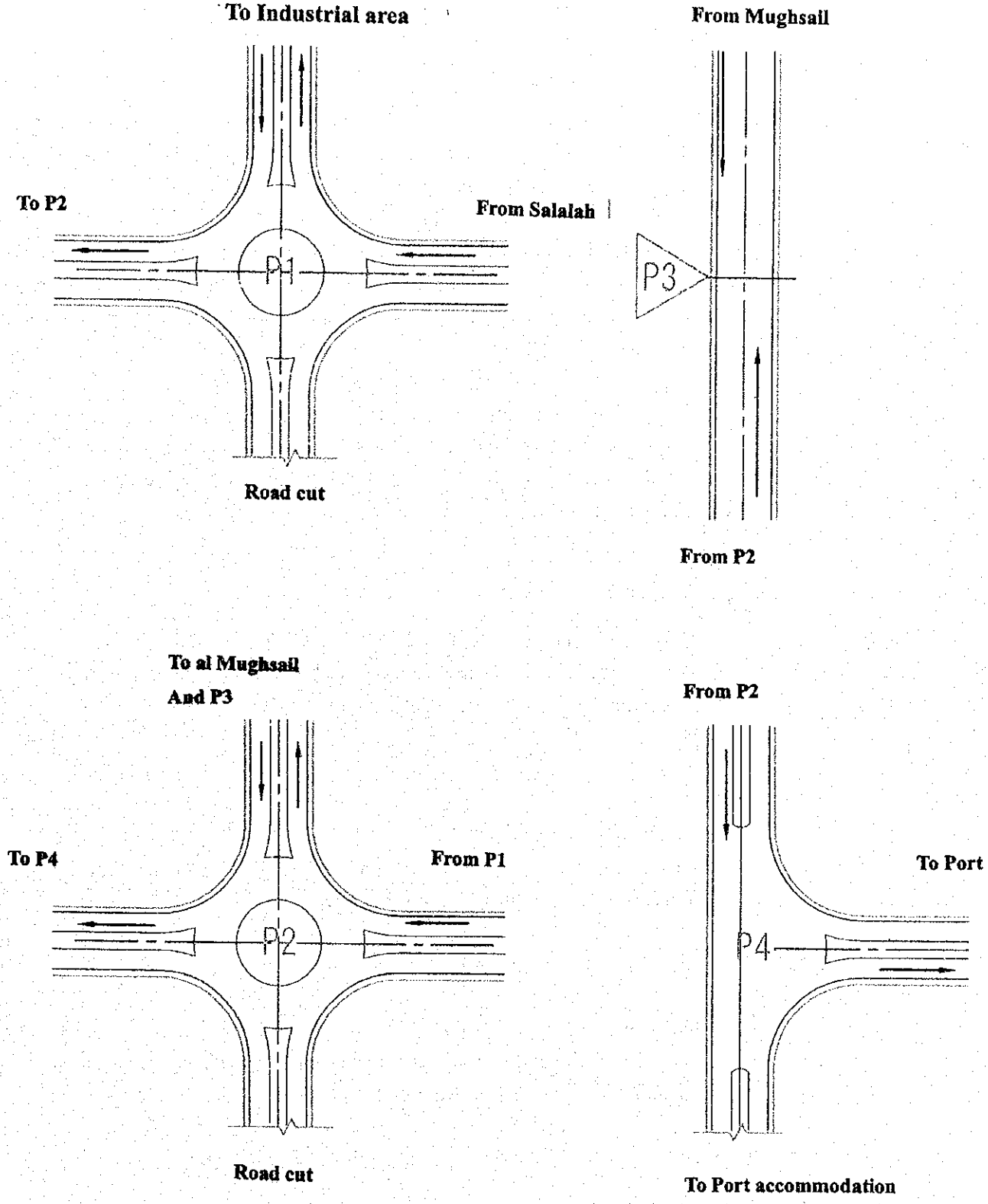


Figure 19.4.2 Site Descriptions

(4) Survey Results

1) Traffic Volume Census

The daily maximum total traffic volume is only 421 cars that was observed during 1st Session (24hours base observation). This was observed at the point of P1 that connects Salalah city, Raysut industrial estate area, and Salalah port.

About half of the total traffic volume was a sedan type cars which commuted between a residential area in Salalah city and either Raysut industrial estate area or Salalah port. There are two peaks of time counting heavy traffic. These are 7 am and 8 am and also 3 pm and 4 pm.

There is no significant traffic volume transporting container and/or bulk cargo between Raysut industrial estate area and Salalah port, roughly less than ten, relating to the port Salalah as transship terminal. A prime component of survey results on each point are as follows.

(a) P1

Dominant in car types:	Sedan
Peak of traffic:	7to 8 a.m. in weekdays / 3 to 4 p.m. in weekend
Direction:	From Salalah city

(b) P2

Dominant in car types:	Sedan
Peak of traffic:	7 to 8 a.m. in weekdays / 3 to 4 p.m. in weekend
Direction:	To port from P1

(c) P3

Dominant in car types:	Sedan
Peak of traffic:	4 to 5 p.m. in weekdays / 5 to7 p.m. in weekends
Direction:	To Mughsail

(d) P4

Dominant in car types:	Sedan
Peak of traffic:	10 to 11 a.m. in weekdays and weekend
Direction:	To Port from P2

Figure 19.4.3 through Figure19.4.12 show the above trend of the results of census.

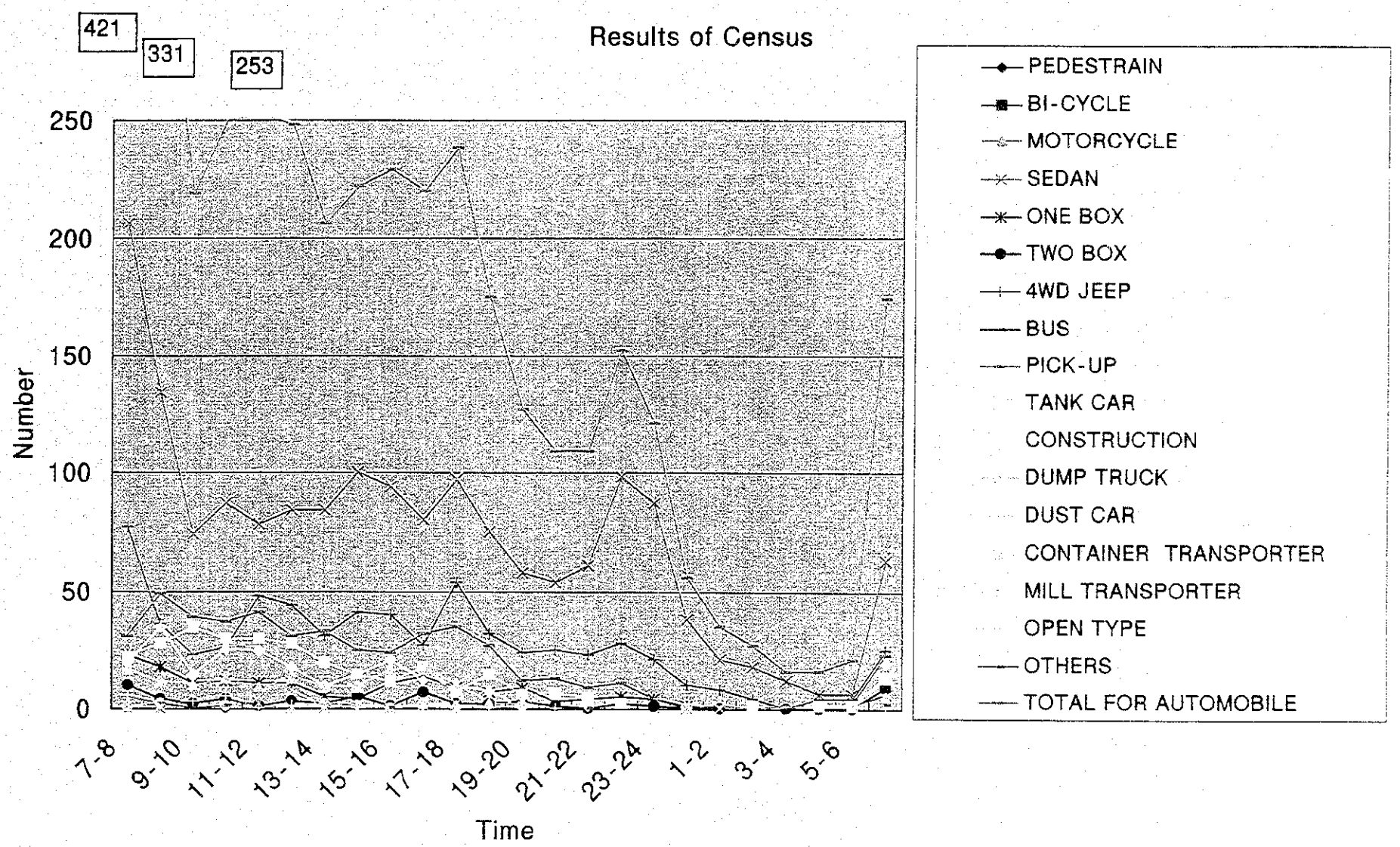


Figure19.4.3P1 24hrs(From Salalah)

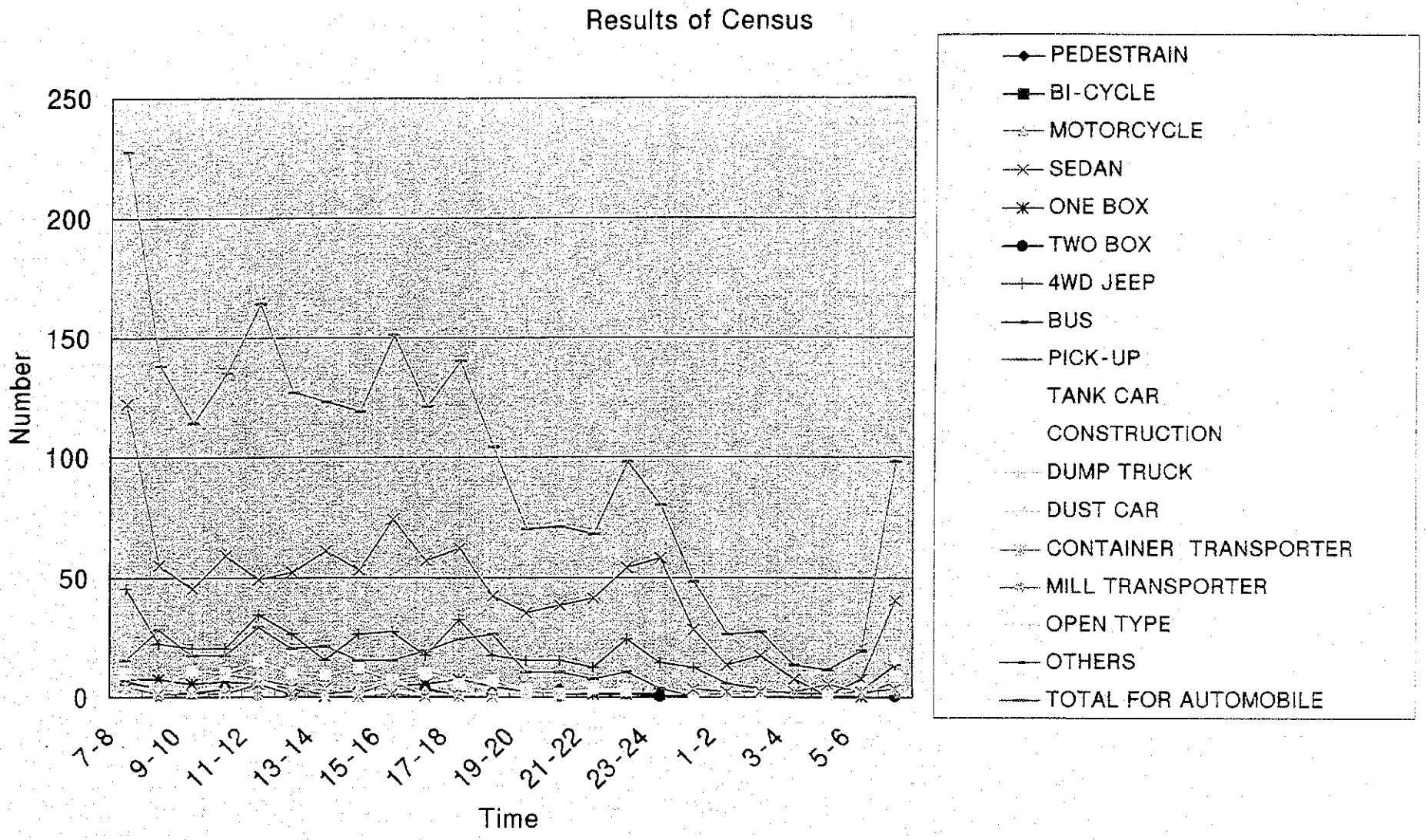
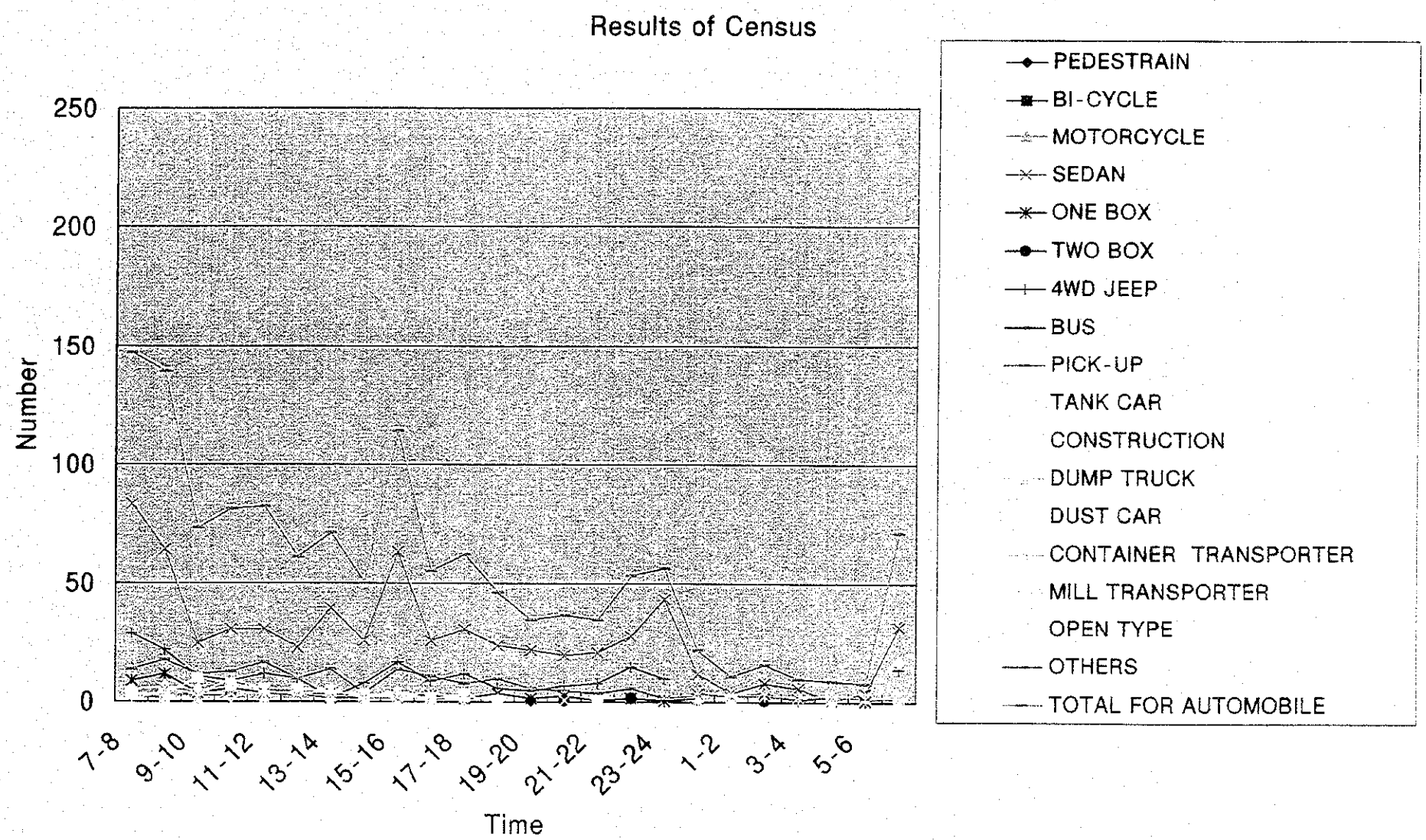


Figure19.4.4P1 24hrs(Industrial Estate/Raysut)



Firure19.4.5P2 24hrs(To Port)

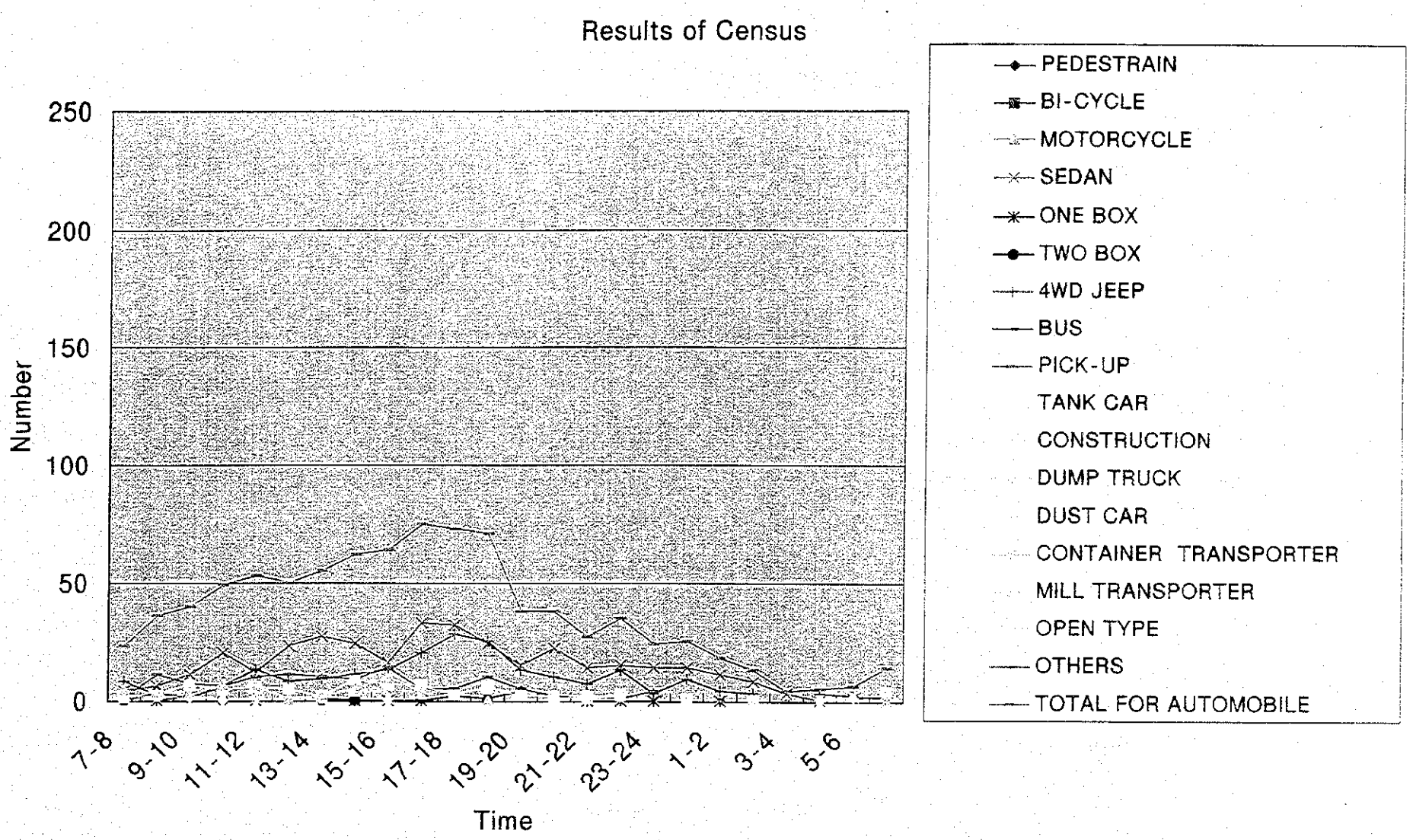


Figure19.4.6P2 24hrs(To Mughsail)

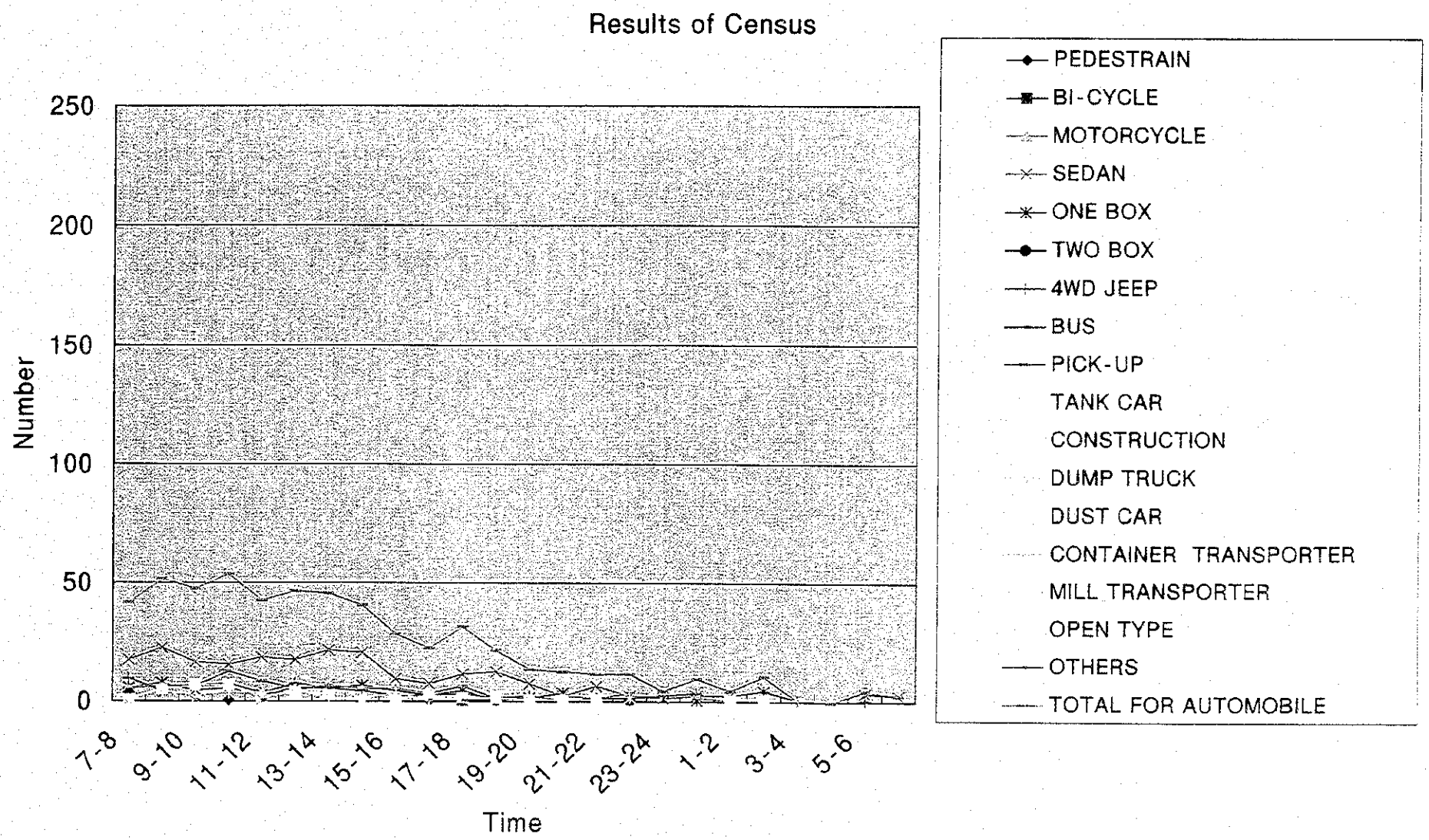


Figure19.4.7P4 24hrs(To Port)

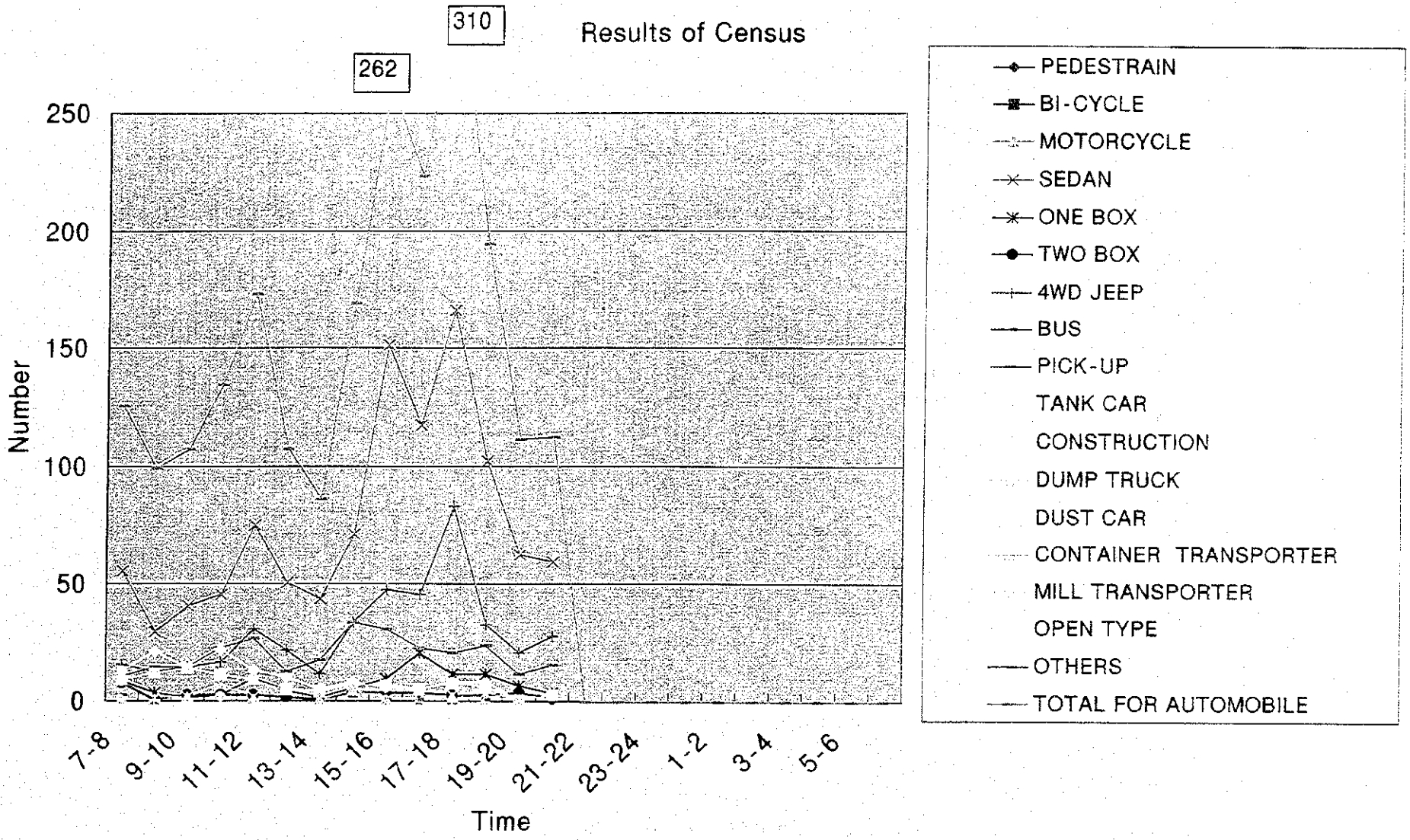


Figure19.4.8P1 14hrs(From Salalah)

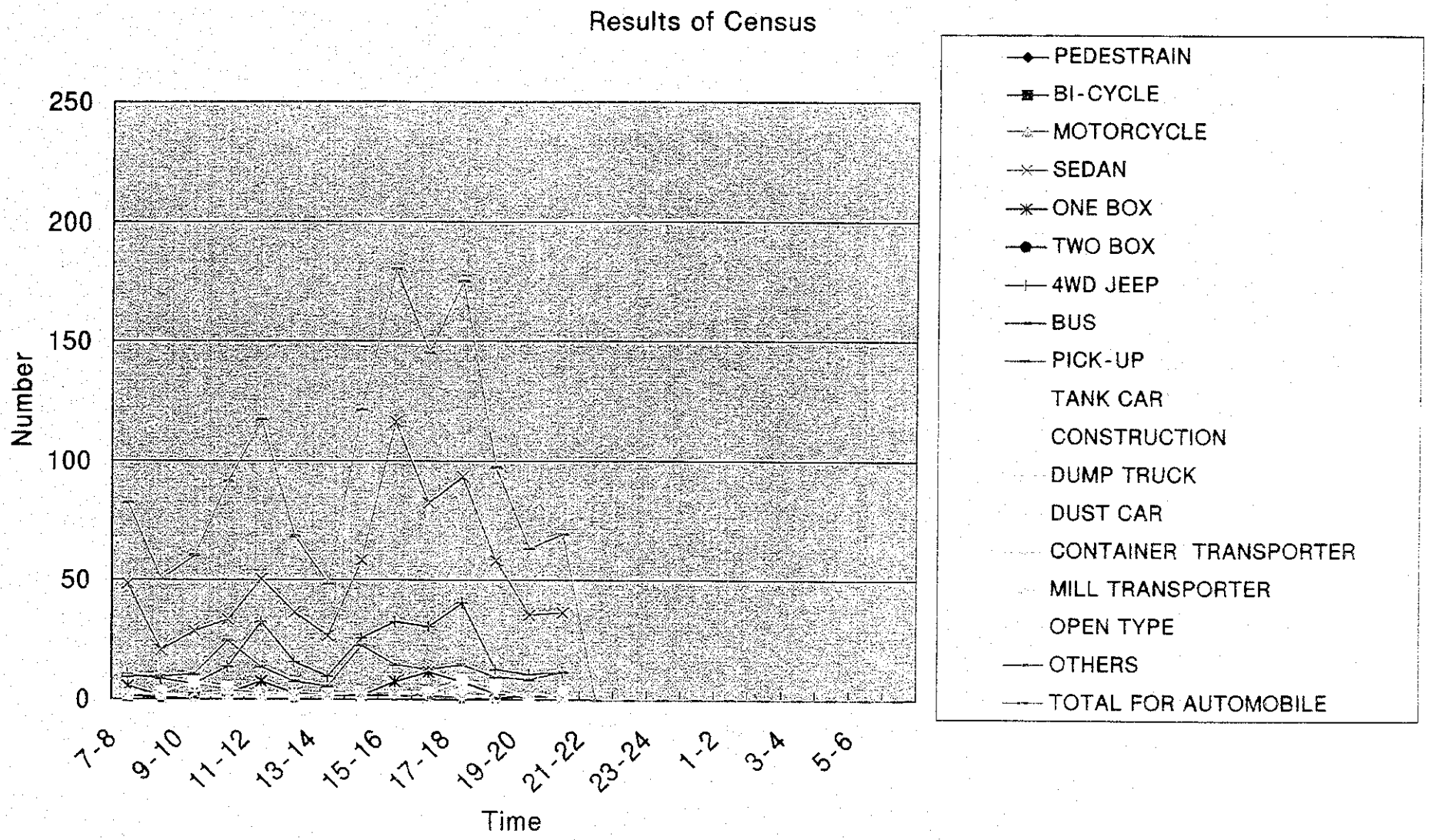


Figure19.4.9P1 14hrs(To Industrial Estate/Raysut)

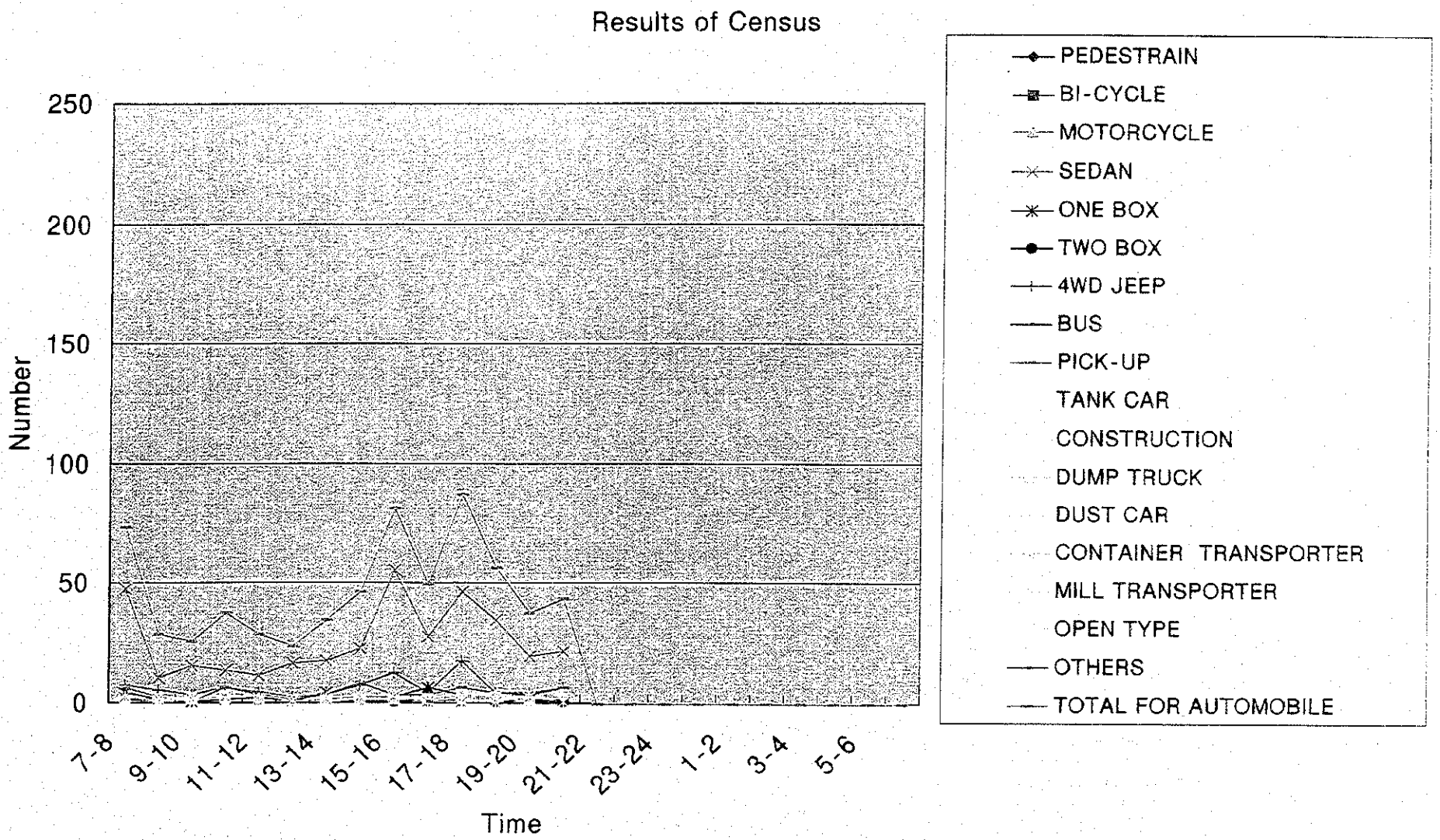


Figure19.4.10P2 14hrs(To Port)

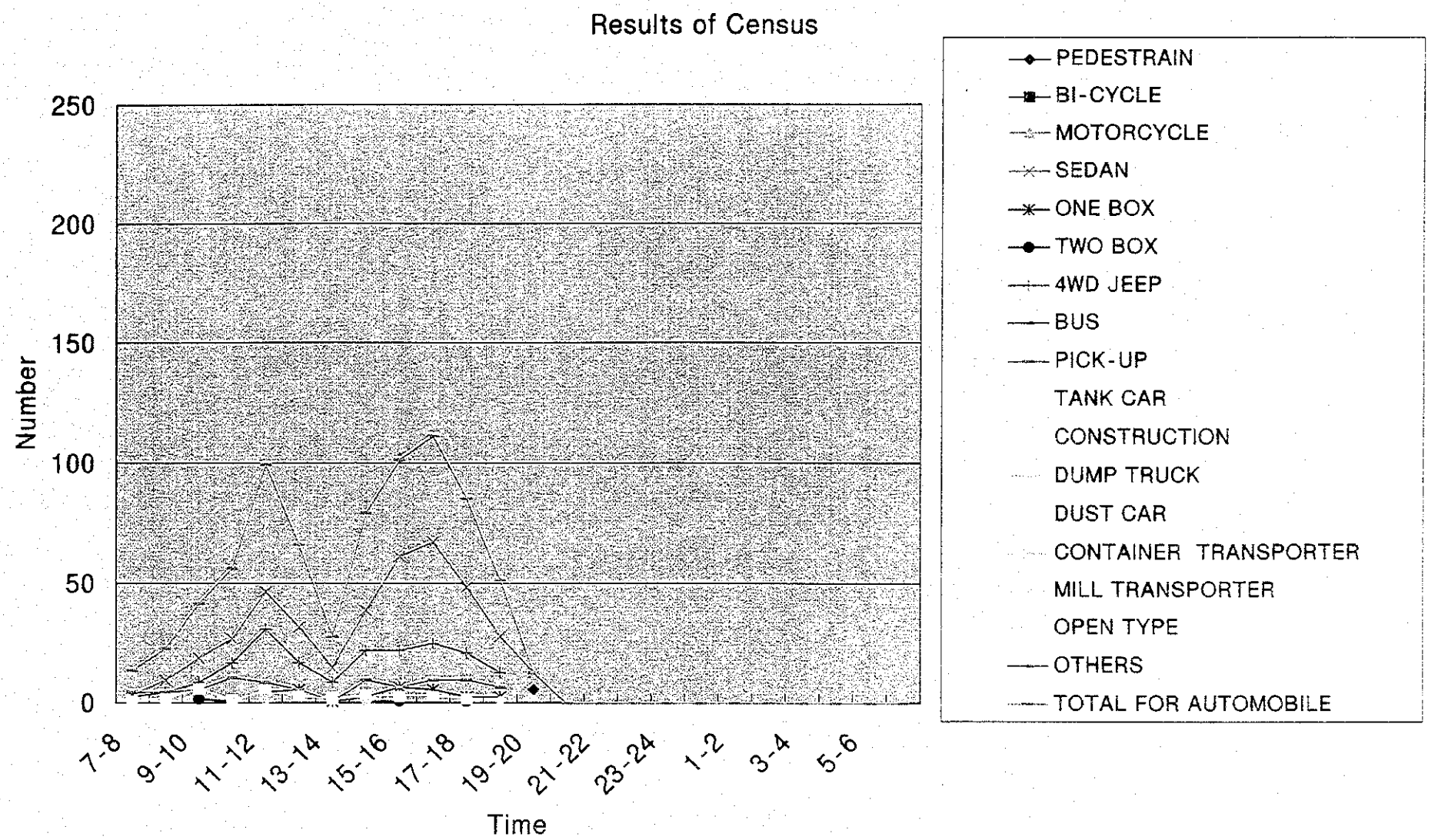


Figure19.4.11P2 14hrs(To Mughsail)

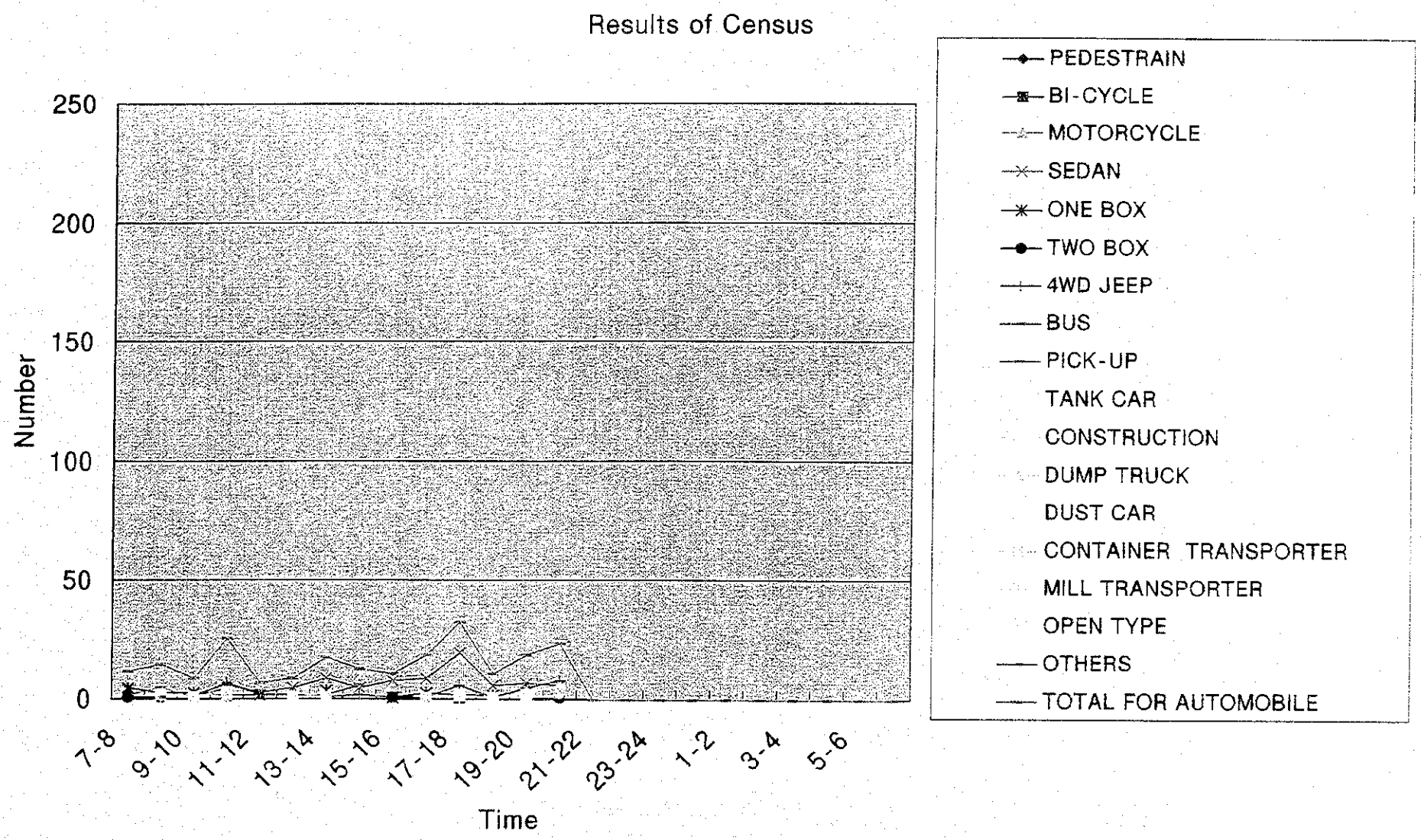


Figure19.4.12P4 14hrs(To Port)

2) Air Pollution

At each monitoring site, air polluted materials were not detected. This is related to,

(a) Less traffic volume
(b) Geographic setting of the site: a relatively vast flat land exposing to wind.