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BASELINE STUDY OF PORT NORO, HATHORN SOUND

NEW GEORGIA ISLAND, SOLOMON ISLANDS

Cruise SI-83-1
23 June to 6 July 1983

by

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Prepared for:
COMMITTEE FOR CO-ORDINATION OF
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INTRODUCTION AND BACKGROUND

This cruise was undertaken as a part of the CCOP/SOPAC Work Programme CCSP/SI. 17 (Inshore Studies related to coastal development) in cooperation with the South Pacific Regional Environmental Programme.

Hathorn Sound, a wedge-shaped, 8 km long extension of the Kula Gulf, is located 8 deg 13 min S, 157 deg 12 min E or between Kohinggo and New Georgia Islands, as indicated in Figure 1. It has an approximate area of 13.7 sq km. The north or open end has a depth of about 108 m, and it is approximately 3.5 km wide. The passage at the south end has a depth of approximately 5 m.

The climate is typical of the tropical areas, it has a rather uniform and high temperature and humidity 23-30.9 deg C and 75 to 100%. The rainfall is abundant, 3630 mm annually, usually exceeding 200 mm during all months. Maximum recorded rainfall was 885 mm/month, and lowest recorded rainfall was 31 mm/month. The highest rainfall normally occurs in January. The rainfall tends to be minimum in June. Annual evaporation is reported to be 1916 mm (Buckley, 1980).

The 17 years of records from Munda airport indicate the stronger winds from the west in January and from the east to southeast in July. Wind speeds tend to be less than 20 km/hr. 1% of the time west winds of 41-50 km/hr was recorded in January and 5% SE and S wind of 21-30 km/hr was recorded in July. The forenoon observations show 59-61% calm, and the afternoon observations show 11% calm in both January and July. The prevailing trade winds are east to southeast from May to October or November. The west to northwest winds from January to March are usually lighter and much less persistent. One to two cyclones occur in the Solomon Islands each year.

Taiyo Fishery Co. Ltd. of Japan is planning construction of a Fish Cannery complex at Deep Water Point to replace the Tulagi Cannery. The Noro Plant would be designed to process some 7,000 mt (metric tons) of tuna per year. It would use some 300 tons of fresh water per day during its first stage. The liquid waste would amount to 107 m^3 /day and have a suspended solids concentration of 500 ppm, a BOD of 3,650 ppm, a COD of 1,460 ppm and an oil concentration of 100 ppm (Life Engineering Corp 1982).

A small support village would develop with a projected population of 695 in 1984 which would increase to 1,200 by 1989. Using 50 gpcpd with 75% to sewers plus the cannery effluent, the waste water discharge is expected to be 960 to 1,400 m^3/day by 1989 (Cameron McNamara 1981).

The initial plans were to discharge the above treated liquid wastes to Hathorn Sound through two marine outfalls. The planned discharge sites were near stations 14 and 15 shown in Figure 1 (Life Engineering Corp 1982 and Cameron McNamara 1981).

CRUISE OBJECTIVE

The present survey was conducted to develop baseline data on Hathorn Sound, Solomon Islands. Priority was given to those parameters that would aid in the development of a port and harbour facility to accommodate industries and resulting population to be located on the central east sides of Hathorn Sound.

The Western Province has the responsibility for environmental control of the waters of Hathorn Sound. It is their stated objectives that the fishery resources in the Sound should be protected in its present condition (Baines 1983 and Mayaraarachchi 1983). Hence, special attention was given to the receiving capacity of the waters of Hathorn Sound for the liquid wastes that would be generated by the planned development.

The detailed objectives included current and tide measurements, water profile characteristics, certain biological observations and estimation of the receiving capacity of the water of Hathorn Sound.

PERSONNEL PARTICIPATING

Ralf Carter, Marine Scientist from the UNDP staff in Fiji participated in the survey. He had the support and assistance of the Ministry of Lands, Energy and Natural Resources and financial support from SPREP. Individuals giving direct assistance or participating in the study included:

Mr Stephen Danitofea, Chief Geologist
Mr David Scott, Geologist
Mr Belari, staff
Mr Primu, staff
Mr Patrick, staff
Mr Michael Manelugu, Captain LIGOMO II
CPOSR Peter Walker, Hydro Unit

Others aiding in the study or that were contacted for information include:

Dr Graham Baines, Resources Development Unit, Gizo
Mr J.D. Gwynne, Chief Engineer, Public Utilities
Mr John Lawrence, Consultant, Cameron McNamara
Mr Joseph Hazbun, Ministry of Health
Mr Jim Herd, Planning Department
Mr William Maelangi, Planning Department
Mr Tony Hughes, Solomon Taiyo Ltd.
Mr Jim Cornish, Ministry of Finance
Mr Vincent Lilo, Weather Station Munda

EQUIPMENT, FACILITIES AND METHODS

Two control stations were located in the Kula Gulf just outside Hathorn Sound, Station 11 near the west side and Station 12 near the center line, a km north of the entrance to the Sound. A total of 13 stations were located within Hathorn Sound. Station 1 was located at the entrance to Diamond Narrows and the others were as shown in Figure 1. Current studies were made at Stations 7, 13, 14 and 15, and water profiles were conducted at Stations 1, 2, 3, 4, 5, 7a, 8, 9, 10 and the two control stations.

The water currents, speed, direction and depth were measured using a NBA current meter. A 6 meter vertical spar was employed to study surface currents. Temperature and conductivity were measured by the NBA meter. Transparency was determined using a 23 cm white disk. A 12 cm diam. opening, 80 micron mesh Wisconsin style plankton net was employed in vertical haul to sample plankton, and an eight 25 mm by 75 mm glass microscope slide periphyton sampler was used to measure the five day growth of periphyton in the water.

The tide level was measured using a tide staff surveyed into local datum. The area and bathymetry of Hathorn Sound was determined from the Admiralty Chart No. 1735 and a hydrographic survey made by the Government Marine Division. A line along 8 deg 11.03 min S between Matinasimbuala Is. and Tunguili Pt. was taken to be the northern boundary of Hathorn Sound. The entrance to Diamond Narrows at Bush Island was taken as the southern boundary, 8 deg 15.3 min S. The average tide was assumed to be 0.5 m.

The following equipment was provided by CCOP/SOPAC:

Current meter (NBA DNC-3)
Hand winch
Plankton net
Periphyton growth units
Sextant
Compass
Level and rod
Tools, spare parts and miscellaneous items

The facilities and equipment supplied by the Solomon Island Government included the following:

Equipment storage facilities
Land, sea and air transportation
5 meter boat and motor
LIGOMO II, 63.84 gross ton, 51.45 ft loa Survey Vessel

Crew for LIGOMO II

Various maps, charts etc.

Numerous reports and records

RESULTS

The results of the ocean currents study at Station 15, the site of the proposed Taiyo outfall are given in Table I and the profile characteristics are given in Table II. The density profile during the 24 hour study period at Station 15 is shown in Figure 2. Low slack water occurred at 1500 hrs 27/6/83 and high slack water occurred at 0300 hrs 28/6/83. The predicted and observed tides are shown in Figures 3 and 4 for the 27th and Figures 5 and 6 for the 28th. The ebb currents averaged .07 m/s (.14 K) and the flood current averaged .12 m/s (.23 K) in the surface 5 meters of water. The ebb and flood were .07 m/s, .08 m/s, resulting current vectors were:

Depth (m)	Drift (m)	Ebb Bearing	Drift (m)	Flood Bearing
5	1065	178	1599	63
15	853	196	1003	139
30	1453	30	2910	188

The current observation for Stations 7, 13 and 14 are given in Tables III, IV and V and are summarized in Table VI. The predicted and observed tides are shown in Figures 3 to 13.

The profile characteristics of the general area over the entire Sound are given in Table VII. The plankton concentration is given in Table VIII. The productivity as determined by growth of periphyton at Station 4 was 0.774 gm/m^2 in five days.

The transparency of the water was measured during daylight hours along with the 24 hour current observations at Stations 7, 13, 14 and 15.

The average values were:

Station	Plankton Concentration (ml/m ^{3})	Average Transparency (m)
7	.9	14.6 +/- 3.93
13	-	15
14	3. 4	15.3 +/- 2. 2
15	.23	17
Control	2. 3	21

The wind recorded at the Munda airport during the study period is given in Table IX. The winds observed in Hathorn Sound tended to be somewhat less in speed than that observed at Munda; however the direction appeared to be quite similar at each location. Bathymetric data is given in Figure 14.

DISCUSSION

The following discussion is based upon the data developed during the last week of June 1983.

Tide: The survey was conducted during a spring tide period. The tides of Hathorn Strait are usually diurnal; however, semi-diurnal tides do occur in the Sound. When the tide is semi-diurnal the tidal change may be quite small over several hours as predicted for 15-16 August 1983 when a change of 0.1 m would occur over a 10 hour period. On 1 August 1980 the tide was recorded to remain at 0.6 m over a 13 hour period as shown in Figures 12 and 13. When such tidal conditions occur they persist for two to three days. This condition appears to occur at least 34 times or 10% of the time during 1984 as indicated by the tide prediction (Admiralty Tide Table Vol. 3). These long laps of tidal currents would result in the concentration of discharged effluent in the surface receiving waters and suggest that a high initial dilution or pretreatment would be required to avoid pollution problems from effluent discharged to Hathorn Sound.

Residence Period: The estimation of residence period of Hathorn Sound was made using two separate approaches. One was to assume that the entire basin is well mixed with respect to the residence period and the addition and removal of water from the basin is due to tidal exchange, surge and density currents. The tidal prism was estimated from the measured average tide of 0.5 m and the estimated surface area of the basin. The surge exchange probably due to the semi-diurnal tidal component at depth which resulted in a discharge from Diamond Narrows over a three hour period during flood tide. Assuming that this type of surface flow occurred at either end of the Sound and that it includes the current due to density differences then the total extra amount of flow would amount to around (0.52 x 8,400,000 m^3 = 4,370,000 m^3/day), the tidal prism is 8,400,000 m^3. Hence the total exchange would be 12,770,000 m^3/day and the total exchange to tidal prism ratio or Hydraulic Exchange Factor, F would be 1.52.

Using the above data the retention period required to reduce the residual water to 1% of its original water would require 271 days.

This calculation was made using the following data:

Basin Volume, V	729,000,000 m^3 (see Fig. 13)
Tidal Exchange, Q	8,400,000 m^3
Hydraulic Exchange Factor	1.52
Tidal Day	24 hr 50 min

$$n = V/QF \times \ln (Co/C)$$

This relationship assumes that the basin is well mixed during the residual period, n. This assumption would appear to be reasonable from the density data given in Figure 2.

A water lense of lower salinity water was observed in the central part of Hathorn Sound, and it was determined to have a salinity of 33.86 ppt as compared with the ocean water outside the Sound which had a surface water salinity of 35.78 ppt. The width of the lense was estimated to be on the order of 750 m, its depth at the center was estimated to be 5 m and its volume was estimated to be 5,500,000 m^3. The volume of fresh water required to produce this change in salinity would be approximately 300,000 m^3.

The second method for estimation of the residence period was to assume the time required to attain equilibrium in the lense of lower salinity in the central part of Hathorn Sound, and then calculate the amount of fresh water necessary to produce the lense. This value is then compared with the same value estimated from the observed salinities. The calculation was made by summation of the water that would remain from each days addition of fresh water for the assumed number of days. The above hydraulic exchange factor, F = 1.52 was assumed to apply and the average diurnal tide was taken as 0.5 m. The volume of fresh water that entered the lense from the land surrounding Hathorn Sound was estimated to be 6,200 m^3 from data given by Cameron McNamara, 1982. Using the relationship:

$$R = \sum_{i=1}^{n} (e-1QF/V + e-2QF/V + \ldots .e-nQF/Va) \times So$$

where R is the required volume of fresh water, n is number of days to attain equilibrium, So is the volume of fresh water added daily, V is the volume of the basin, Q is the daily tidal exchange, F is the hydraulic exchange ration. Using values given above a volume of 350,000 m^3 was calculated. This value compares well with the 300,000 m^3 estimated from salinity and volume considerations. Hence, a retention period on the order of nine months appears reasonable for Hathorn Sound.

Currents: As shown by the current pattern at the observation stations, the top flood tide sets northward and the bottom flood tide sets southward. In general the top twenty meters of water set to the south during ebb and to the north during flood. The deeper water sets in or south during flood and out or north during ebb. The water tends to enter Hathorn Sound at the lower depths and to exit the Sound near the surface during flood tides. This results in some upwelling in the southern end of the Sound during flood tide. This current pattern reversed direction during ebb tide.

The direction of flow reversed itself in Diamond Narrows during the flood tide. The flow was to the north for 3 hrs then changed to the south for 3 hrs. There was a 7 minute and a 36.7 minute harbour surge in the top

6 meters depth at Station 14 during the current measurements at that station. A 0.5 m/s (1 knot) current surge set to the north during current measurements at Station 15. The current occurred at 1427 hrs on the 27 June at low slack water and it lasted approximately 12 minutes. The fundamental period for an open end basin having a length of 7,700 m, a width of 1750 m and an average depth of 53 m is 22.5 minutes. The first harmonic would be 7.5 minutes and the second harmonic would be 4.5 minutes. Apparently the first harmonic was observed during the survey.

Some harbour resonance appeared to be present most of the time during the current study. In general the currents were weak, on the order of 0.07 m/s to 0.12 m/s (0.14K to 0.23K) at Station 15. Currents were even weaker elsewhere in the Sound. A large eddy current appeared to develop in the lea of the Deep Water Point and this gyre includes Stations 5 and 14. Discharge of a waste water into this gyre would reduce the amount of new water available for dilution. The proposed discharge located at Station 5 would be a poor choice.

Density Structure: The 24 hours of water density profile data at Station 15 shown in Figure 2 indicate the continued presence of internal waves within Hathorn Sound. Internal wave amplitude on the order of 15 m appears to occur within the Sound. A meandering surface current was present during the flood tide. The data suggest that the top 30 m of water are probably well mixed during the 9 months of retention period. At times the density gradient in the top 30 m of water are only 0.3 sigma-t units and such a small density gradient is insufficient to maintain a submerged discharge plume.

Proposed Discharge: The proposed volume of liquid waste for discharge are small. The domestic waste produced by a population of 1200 individuals if discharged at 30 m depth through a 50 mm (2" diam) port would be expected to be diluted about 900:1 by the time it surfaced in 2.6 minutes. However, it would tend to pond during times of minimum tidal currents. Floatables could become a nuisance.

The proposed liquid effluent, 107 m^3 /day from the cannery if discharged at 50 m depth through a 50 mm (2" diam) port would be diluted

457:1 for a surfacing BOD concentration of 8 ppm. This concentration when ponded could also be a nuisance.

The salt water used for cooling and for operation of a jet ejector could amount to 537 to 1045 ton per day. Minimum cooling water discharge could be as low as 132 ton per day and the maximum cooling water could be 640 ton per day. The jet ejector was estimated to require 405 ton per day. These large differences in discharge could result in periods of inefficient operation of the outfall diffuser unless an equalizing storage was designed in series with the outfall.

Assume an average combined daily discharge of 898 m^3 having a specific gravity of 1.0189 and an average BOD concentration of 435 ppm (107 m^3 having 3650 ppm BOD diluted with salt water to combined volume of 898 m^3. Assume the average specific gravity of the receiving water to be 1.022 then the resulting maximum BOD concentration at the surfacing plume would be 0.4 ppm from the effluent when three 3-inch diameter horizontal diffuser ports spaced on 18 ft centers were located at a depth of 64 m (210 ft). It would require approximately 11.4 minutes for the combined effluent to reach the surface of Hathorn Sound.

While the above system when operating at design conditions could meet the BOD requirements for dilution of the waste water, during times of minimum tidal exchange the floatables and oils would concentrate in the ponding zone at the surface and surface pollution would result. The long detention period of approximately 270 days estimated for the waters of Hathorn Sound would result in a significant increase in plankton concentration within the receiving water and a corresponding reduction in the transparency of the water would occur.

There would always be the possibility of damage to the outfall pipe due to its exposure on the outside of the vertical reef face, and where a break occurred near the surface the initial dilution would be reduced significantly.

Furthermore the present small fish processing plant results in extensive surface slicks in the Sound, and it appears to have caused a measurable change in the transparency of the waters of the Sound. The change in transparency at the time of the survey was observed to the south of the disposal area in the vicinity of Station 14. An increase in plankton concentration in the water closer to the surface was noted. A plankton increase was noted at the Control Station 12; however, this plankton was at considerable depth and limited the transparency to 21 m. The maximum concentration of plankton was found at Station 14 and as it occurred at less depth it limited the transparency to an average of 15.5 m. The average transparence of the water at Station 15 was 17 m. The minimum transparency, 7.5 m occurred at Station 7 where the average transparency was 14.4 m. It requires a period of time, 3 to 5 days for the plankton to grow so the greater reduction in transparency occurs some distance from the source of nutrient addition.

The general circulation within Hathorn Sound suggests that this increase in plankton and reduction in transparency was due to the disposal of wastes associated with the small fish processing activity. It should be noted that transparencies of 21 m were observed at Station 2, 3 and 4 all south of Station 14 inside of Hathorn Sound, and the maximum transparency 28 m was observed just west of Station 15. Hence, the normal transparency of Hathorn Sound during June could be assumed to be on the order of 20 m to 25 m and the value of 15 m would be assumed to be the result of the present disposal of waste materials. This change in transparency appears to be on the order of a 25% reduction. As the reduction in transparency is an exponential function of the concentration of nutrients, a modest increase in the discharge of nutrients could result in a significant reduction in the transparency of the water inside of Hathorn Sound.

As recommended during the post study meeting held in Honiara last July, the disposal system would be more conservative in design if the waste effluent were to be treated in an oxidation pond system and discharged to ground water. The discharge point could be selected so as to cause the effluent to leach out through the mangrove to the east of the plant.

When construction costs for a safe outfall over the near vertical reef down to the 64 m depth and diffuser system are compared with the cost for land disposal alternative and low cost of operation of the oxidation treatment system, the land disposal alternative will be attractive.

The cooling water if unpolluted except for heat could be discharged to the marine environment. Other waste ocean water used by the cannery should be kept separate from the waste fresh water as it should not be discharged to the ground water. It should be treated and discharged to the mangrove.

Receiving Capacity: In general the amount of nutrient material and BOD that would be discharged to Hathorn Sound would not by itself saturate the receiving capacity of the 729,000,000 m^3 of water within the Sound. However, due to the long time periods of 12 hours or so when the tide level is almost constant, about 10% of the time, the fact that the top 30 meters of water would receive most of the discharged material initially, and the slow surface currents, it is unlikely that the total receiving capacity of the Sound could be used.

Furthermore, it appears that the water below 30 m or so may have sufficient nutrients to support a significant concentration of plankton. It is only the surface water that is low in nutrients and has the high transparency. If the deeper water is caused to mix with surface water, as would occur with a rising waste water discharge plume, then both the waste water and deeper, higher nutrient water would cause an increase in surface plankton concentration. The present disposal of fish bones and associated nutrients into the Sound would not cause a mixing of the deeper water with the surface water. Only the soluble nutrients would be retained by the surface water.

The receiving capacity of Hathorn Sound analysis was based upon the assumption that a 50% reduction in the transparency of the water would be acceptable and that the present level of pollution has produced a 25% decrease in transparency. It is further assumed that the cannery would attract other activities to the area and the amount of surface pollution to reach the Sound would likely equal that from the domestic sewage prior to treatment. At present the fish processing operation at Deep Water Point may contribute 5 m^3 of fish waste per day, most of which is fish bones, to the Sound and this level of activity along with some rejected fish disposed of from the ships associated with the operation have resulted in the increase in productivity of the water. The increase in productivity appears to be on the order of 50% above that found at the unpolluted control station.

Assume approximately 500 kg of waste, mostly fish bone is disposed of to the Sound each working day by the present operation. This amount would be similar to that disposed by the proposed discharge, 390 kg; however, the cannery waste would be higher in nutrients by an estimated factor of two. The proposed waste would have the following composition:

Volume	107 m^3/day
SS	500 ppm
COD	1,460 ppm
BOD	3,650 ppm
n-H	100 ppm

Based on experience elsewhere (Carter, 1983) the combined discharge described above which includes 390 kg from the cannery, 33 kg from treated domestic sewage 330 kg from surface drainage, a total of approximately 753 kg per day or about 2 to 3 times the present discharge rate. This would be expected to reduce the transparency of the water proportional to the increase in plankton concentration or approximately to one-third its present value of 25 m or so. An average transparency on the order of 8 m could result in a relatively short time. During times of minimum tidal change and light wind conditions the reduction in transparency would be much greater. It is the opinion of the author that this amount of reduction in the transparency would not be acceptable.

The present concentration of phosphate was estimated from the observed plankton concentration of 3 ml/m^3. Assuming a density of one, 15% solids, 13% nitrogen and a 7:1 weight ratio of nitrogen to phosphate, then some 2.93 metric tons of phosphate as P would be present in the form of plankton in the top 25 m of the Sound. A phosphate concentration of 0.009 ppm as P could result in a plankton bloom in Hathorn Sound. This would be about 3.15 metric tons, or an 8% increase in phosphate could bring the nutrient level to a critical point in Hathorn Sound. The retention period for the top 25 m of water is on the order of 131 days; hence, the addition of 6.9 kg P/day, the amount required to raise the phosphate level to 0.009 ppm, could exceed the receiving capacity of the Sound. The combined effect of the first stage cannery, domestic waste and surface drainage was estimated to produce 753 kg of organic waste per day, and this amount could supply the 6.89 kg of P.

The receiving capacity of the upper 25 m layer of the Sound is estimated to be less than .05 ppm N and .009 ppm available P. Less than these amounts of nutrients would not result in significant plankton blooms. At present it appears that the concentration of nutrients in the surface waters of Hathorn Sound, top 25 m, are just less than this amount. While the Sound might receive the first stage of the cannery waste part of the time, it is unlikely that it can safely receive additional waste from either the cannery or other sources or even the first stage of the time. The more conservative and likely the more economic plan would be land disposal.

RECOMMENDED WATER STANDARDS

The following receiving water criteria are suggested as water quality standards for Hathorn Sound. The concentrations given are for the surfacing discharge plume prior to horizontal dispersion by the surface water currents in the Sound.

a)
1) BOD (five day) not to exceed 5 ppm
2) COD not to exceed 2 ppm
3) Suspended solids not to exceed 20 ppm or be larger than 1 mm in size
4) Coliform bacteria not to exceed MPN of
   1000/100 ml 50% of time
   3000/100 ml 10% of time
5) Settleable volative solids (measured in effluent prior to discharge) not to exceed 25 ppm
6) pH not to depart ambient more than 0.2 pH units
7) No more than traces of petroleum oil should occur

b) Downstream 1,000 to 4,000 m the transparency of the water should not be reduced by more than 50% of that found in a nearby unpolluted control area. The monomolecular film forming material should not cover more than 30% of the area of the Sound when wind speeds of 2-4 knots are present. Exceeding these limits will require additional treatment or reduction in operations until they are met.

RECOMMENDED ONE YEAR MONITORING PROGRAMME

With the onset of development about Hathorn Sound it is desirable to document the present water quality for use in the interpretation of future quality changes that may occur and for the enforcement of future water quality standards. High transparency of the waters in the Sound would be the more sensitive parameter to respond to pollution. This measurement would involve the minimum of equipment or cost for documentation. Transparency would decrease with increased bacterial concentration, phytoplankton growth, colloidal suspensions and emulsions. Except for the chemical reduction of oxygen concentration, excess thermal discharge, radio isotopes, pathogenic bacteria, or toxic materials, almost all types of pollution result in an increase turbidity in the water; hence, transparency would in this instance be an excellent parameter of water quality in Hathorn Sound. Another visible parameter of pollution is the development of excessive surface slicks on the ocean water. An estimate of the extent of surface coverage by film material would also be a useful parameter. Natural conditions in nearshore areas can be expected to have on the order of 10% slick area under 2-5 knots of wind. A good quality water usually has less than 30% coverage.

Other parameters that require a modest amount of equipment to evaluate include the electrical conductivity and the water temperature. Such parameters as BOD, DO, phytoplankton, zooplankton, benthic organisms, bio-indices, nitrogen and phosphate, productivity etc., all require special techniques and equipment. Heavy metals, toxicity, TLM's, growth factor, algal growth potential, carbon-14 productivity, ATP, Chlorophyll A all require additional equipment.

It is recommended that four parameters be monitored during the coming year. They include:

1) Transparency, (all white 30 cm secchi disc)
2) Surface film, (aerial photographs)
3) Temperature profiles, (surface, 5, 15, 30 m)
4) Conductivity, (surface, 5, 15, 30 m depths)

The observations should be made from Stations 1, 4, 6, 7, 8, 9, 12 and 13 shown on Figure 1. As daylight hours are necessary for making the transparency observation it is recommended that one set of observations be made near the end of ebb tide and during the following period a second set of observations be made when the end of flood tide occurred during daylight hours. However, at least one set of observations should be made each month.

SPECIAL STUDIES

The following studies are recommended for baseline data collection with or without marine discharge. The information developed to be used in the interpretation of future water quality changes that may occur in Hathorn Sound.

Local or Water Front Population Census: An estimate of the present human population living near the shoreline should be made. Groups should be characterized with respect to location and probable nutrient contribution to the waters of the Sound.

This survey would include villagers, schools, day-time workers, shipboard crews etc. The survey should include the entire shoreline of the Sound and the area at Noro Passage.

Fish Processing and/or Other Inputs: An estimate of the organic material added to the Sound at Deep Water Point and the number and type of ships using that facility should be made. The traffic to Cutter Point and pollution input from that area should also be included in the study. The logging activity at Moro Passage should also be evaluated.

PREDISCHARGE SURVEY AT DEEP WATER POINT

The following studies should be conducted at the selected site for an outfall disposal facility if the outfall disposal alternative is selected. This data would be used in post discharge monitoring should a pollution problem develop. It is assumed that the required dilution of the waste will be known from the outfall designer along with the discharge characteristics and cycles (g/port, port size and orientation, depth, temperature and salinity of the effluent). A discharge permit should be required and the submission of this survey data would be a part of the requirement for getting the permit. The survey for the pipe alignment, protection in the breaker zone, method of anchoring, diffuser alignment, anchoring, cover etc., will be conducted by the firm designing and building the facility. The following studies are for future evaluation of the outfall performance.

Current Study: The general current pattern in the vicinity of the discharge should be established for surface (0 to 2 m) currents. Both drift cards and 2 m long spars can be employed for the study. A recording current meter should be located at the discharge site to record currents from three depths; surface, 15 m and 30 m. The period of observation should include both an ebb and flood cycle during a near tide period. The drift cards should be collected from the shore (reef) over a 48 hours period and their time and point of recovery noted. The study should be made during a minimum wind period. The wind and swell should be noted during the study. Temperature and salinity observation from the surface, 5, 10, 15, 30 and 60 m should be made at 1 hour intervals during the study. If the current meter is suspended from a boat the craft should be anchored fore and aft to prevent yaw. One study should be done during the minimum current period and a second repeated during maximum current conditions (spring tide).

Monitoring Study: A five station minitoring pattern should be established for the selected disposal site. One station at the site, three at right angles 500 m from the site and one control station outside the discharge area. Observations and samples to be collected are:

Water

Suspended solids (fixed and volatile)
Transparency
Temperature, profile
Salinity, profile

DO, BOD	TMB*
Total Nitrogen	TMB
Available Phosphate	TMB
Turbidity	TMB
Phytoplankton	TMB
Zooplankton, 30 m vertical net haul, (80 micron mesh)	
MPN	TMB

Record the time, tide, wind, sea and swell, recent rains etc.

Benthos

Two grab sample of two kg/grab from each station

Note: odour, appearance, texture, depth to anaerobic zone, colour and general appearance.

Determine: Bio-mass, Kjeldahl Nitrogen, major species

* Top, 1 m, Mid-depth, 25 m, Bottom 50 m.

Reef Organisms: Collect three species of marine organism/station used locally for food, (giant clam etc.) from near the three shore most stations and the specimen tissue is to be assayed for heavy metals (Pb, Cd, Zn, and Cu), PCB and chlorinated hydrocarbons.

One monitoring survey should be conducted during the monsoonal winds period and one during the trade winds period. Aerial photo of the water surface showing the extent of slicks should be taken at these times. United States Public Health Service Standard Methods or equivalent will be employed in these analysis.

WATER QUALITY CONTROL

Legal and technical machinery necessary for co-ordinating development, definition of beneficial resource use, pollution control, receiving capacity determination, and water resource requirements in the Solomon Islands is now needed. This is evident as undeveloped coastal areas are now under pressure to develop and developed areas are experiencing the pollution impact of industrial and urban growth. In a relatively short period of time abuse of a water resource will result in a general decline in the quality of the resource. Problems will develop and correction of such problems are generally at greater expense than their prevention.

Water quality impacts the entire community, and there are several sectors of the community in competition for use of water resources. Ultimately water quality decisions are made at the political level, generally aided by some technical guidance, but more frequently inspired from economic pressures. Hence, constructive action toward maintenance of water quality requires that all significant sectors of the community be involved in the decision making process. The cooperation and support of the water quality programme by each group is necessary for its success, as it is easy to circumvent the controls and negate any benefits that might have resulted. Pollution control in a technical sense is difficult at best where efficient use of resources is required.

A five member board representing the appropriate sectors of the community can meet four times a year or so to act on important water quality issues. Generally such meetings are open to the public much like a court. The board formulate policy, pass on water quality standards, approve or reject discharge permits, establish beneficial uses of specific water bodies, instigate legal action against pollution violators and formulate long range water quality plans. Such a board will require a technical staff of one or more full-time individuals who are available to the public for access to the board. They coordinate surveillance activities, compile monitoring records, administer water quality research, prepare background material for permit application, develop proof of violation, collect discharge levies and fees, coordinate planning activities and provide information and guidance to both the general public and the board. Much of their work can be contracted out to other existing agencies and in some cases to consultants. In general a small technical staff is desirable. Funding for the staff should be supported in part from discharge permit levies and fees. The cost for water monitoring should also be paid from the same source. A portion of the cost should be from the general funds as all benefit from water quality control.

CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations of this report are based upon the above study and experience elsewhere with similar conditions.

1. The water level within Hathorn Sound can remain almost constant up to periods of 13 hours or longer. Such events tend to occur over several days consecutively and appear to occur for about 10% of the tides.

2. The hydraulic residence period of the Sound was estimated to be nine months. Winds stronger than those observed during the study period could shorten this residence period.

3. The volume of the Sound was estimated to be 729,000,000 m^3 and the daily hydraulic exchange was calculated to be 12,786,000 m^3.

4. A lense of water having a lower salinity than that of the remainder of the sound was found near the central surface area of the Sound. It had a volume estimated to be 5,500,000 m^3. Approximately 300,000 m^3 of fresh water would be required to produce the lense.

5. Some 6200 m^3 of fresh water per day would be required to maintain the above lense of water.

6. The tidal currents within Hathorn Sound averaged around 0.07 m/s to 0.12 m/s or less.

7. Harbour resonance having periods of 7 minutes and 36.7 minutes were observed. The calculated first harmonic was 7.5 minutes.

8. A large gyre was observed in the lea of Deep Water Point in the vicinity of Stations 5 and 14.

9. Internal waves having amplitudes of 15 m were observed in the Sound. The density stratification was positive with depth; however, as little as .01 sigma-t unit per meter was observed.

10. The proposed discharge could be expected to surface.

11. The ocean water used for cooling should be kept separate from the treated fresh waste water if land disposal is used for the treated waste water

12. Land disposal following treatment by oxidation ponds is recommended for both the sanitary waste and fresh water cannery waste. Final disposal should be to the mangrove to the east of the proposed cannery site.

13. The recommended receiving water standards should be adopted for Hathorn Sound.

14. A one year monitoring programme should be implemented in Hathorn Sound.

15. The present human population tributary to the waters of Hathorn Sound should be counted.

16. The BOD, available phosphate, and total nitrogen content and their mass emission rate from the present fish processing facility at Deep Water Point should be determined.

17. If an ocean outfall is employed at Deep Water Point the recommended pre-discharge study should be made.

18. The outlined Water Quality Control Programme should be developed for the Solomon Islands. Each division should have its own board.

19. The receiving capacity of central Hathorn Sound for all sources of organic material that is high in available nutrients appears to be on the order of 700 kg per day.

20. The transparency of the waters of Hathorn Sound have been reduced by 25% or so as a result of the current pollution.

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TABLE I

PORT NORO HARBOR CURRENTS

STATION NO. 15 , 27/6/83

	TOP		MIDDLE		BOTTOM	
HRS	SPEED	BEARING	SPEED	BEARING	SPEED	BEARING
1100	0	320	.2	230	.03	35
1200	.05	210	.03	160	.11	15
1300	.05	175	0	290	.01	30
1400	.02	190	.01	60	.1	20
1500	.06	30	.11	40	.06	32
1600	.18	170	.21	180	.03	220
1700	.09	170	.06	165	.08	200
1800	.03	175	.04	180	.18	190
1900	.11	20	.03	30	.01	175
2000	.01	320	0	210	.04	180
2100	.18	25	.07	15	0	180
2200	.36	40	.12	45	0	72
2300	.2	200	.14	185	.25	180
2400	.05	195	.1	195	.1	210
100	.21	30	.18	30	0	100
200	.01	260	0	280	.04	195
300	.01	310	0	345	.1	170
400	.06	30	.05	40	0	120
500	.15	200	.08	220	.1	175
600	.21	190	.2	190	.12	190
700	.06	180	0	175	0	30
800	.06	170	.08	180	.03	30
900	0	120	0	290	.05	20
1000	.14	22	.15	20	.15	20
1100	.05	360	0	125	.07	10

END LINE 25

TABLE II

PAGE NO. 00001
01/04/84

PROFILE DATA FOR STATION 15 PORT NORO 27-28 JUNE 1983

HRS	M	Deg-C	S-ppt	Sig-t	M	Deg-C	S-ppt	Sig-t	M	Deg-C	S-ppt	Sig-t
1100	5	29.00	34.81	21.95	15	29.10	34.81	21.95	30	29.01	34.87	22.09
1200	5	29.48	34.47	21.52	15	29.18	34.75	21.88	30	29.02	34.86	22.08
1300	5	29.46	34.55	21.60	15	29.30	34.67	21.78	30	29.30	34.87	21.84
1400	5	29.74	34.28	21.30	15	29.33	34.64	21.75	30	29.35	34.63	21.79
1500	5	29.22	34.65	21.75	15	29.05	34.55	21.77	30	28.80	35.03	22.28
1600	5	29.50	34.60	21.62	15	29.00	34.73	21.93	30	28.70	35.10	22.37
1700	5	29.38	34.89	21.84	15	29.10	35.11	22.18	30	29.01	35.24	22.37
1800	5	29.66	34.63	21.59	15	29.25	35.07	22.10	30	29.15	34.99	22.14
1900	5	29.53	34.87	21.81	15	29.30	34.89	21.94	30	29.10	35.10	22.24
2000	5	29.53	34.65	21.65	15	29.15	35.07	22.13	30	28.90	35.25	22.41
2100	5	29.50	34.82	21.78	15	29.20	34.96	22.03	30	28.50	35.62	22.83
2200	5	29.19	34.90	21.95	15	29.30	35.18	22.17	30	28.50	35.55	22.77
2300	5	29.27	34.69	21.76	15	29.15	34.92	22.02	30	28.95	35.07	22.26
2400	5	29.46	34.70	21.71	15	29.22	35.24	22.24	30	29.05	35.14	22.28
0100	5	29.40	34.89	21.87	15	29.20	35.11	22.14	30	29.10	35.03	22.18
0200	5	29.30	34.82	21.85	15	29.20	35.11	22.14	30	29.12	35.01	22.16
0300	5	29.42	34.58	21.63	15	29.10	34.96	22.06	30	29.10	34.96	22.12
0400	5	29.60	34.60	21.59	15	29.30	34.89	21.94	30	28.55	35.51	22.73
0500	5	29.55	34.78	21.74	15	29.34	34.93	21.96	30	28.70	35.40	22.59
0600	5	29.46	34.70	21.71	15	29.23	35.01	22.06	30	28.95	35.21	22.37
0700	5	29.35	34.71	21.75	15	29.16	34.92	22.01	30	29.00	34.88	22.10
0800	5	29.38	34.68	21.72	15	29.40	35.11	22.08	30	29.10	34.96	22.12
0900	5	29.48	34.76	21.75	15	29.18	34.90	21.99	30	29.05	34.99	22.17
1000	5	29.42	34.58	21.63	15	29.22	34.87	21.96	30	28.95	35.07	22.26
1100	5	29.60	34.60	21.59	15	29.28	34.75	21.85	30	28.50	35.47	22.71

TABLE III

PORT NORO HARBOR CURRENTS

STATION NO. 7 , 28/6/83

	TOP		MIDDLE		BOTTOM	
HRS	SPEED	BEARING	SPEED	BEARING	SPEED	BEARING
1300	.08	140	.06	120	.05	175
1400	.05	50	.09	60	.03	350
1500	.06	75	.1	145	.12	130
1600	.18	220	.03	170	0	35
1700	.09	360	.12	330	.25	160
1800	.14	340	0	340	.14	160
1900	.13	160	.13	155	0	280
2000	.25	170	.22	160	.06	10
2100	.04	160	.13	170	0	180
2200	0	170	.07	170	0	170
2300	0	225	.02	170	0	260
2400	0	40	0	130	0	180
100	0	175	0	150	.05	150
200	0	110	0	170	.09	130
300	0	80	.05	120	0	130
400	.07	70	0	130	0	130
500	.05	155	0	340	.09	80
600	.09	155	0	10	0	45
700	.06	170	0	250	.15	160
800	.08	160	.01	165	.01	190
900	.05	165	.01	145	.03	110
1000	.01	150	.02	10	.01	130
1100	.07	300	.09	80	0	160
1200	.08	90	0	30	.08	205
1300	0	110	.02	180	.01	350

END LINE 75

TABLE IV

PORT NORO HARBOR CURRENTS

STATION NO. 13 , 30/6/83

	TOP		MIDDLE		BOTTOM	
HRS	SPEED	BEARING	SPEED	BEARING	SPEED	BEARING
1800	.06	350	.01	70	.02	160
1900	.08	350	.01	330	.02	145
2000	.05	10	.01	60	.07	140
2100	.01	130	.01	200	.09	160
2200	.1	120	.05	130	.1	150
2300	.01	130	.01	220	.01	60

END LINE 81

TABLE V

PORT NORO HARBOR CURRENTS

STATION NO. 14 , 29/6/83

HRS	TOP		MIDDLE		BOTTOM	
	SPEED	BEARING	SPEED	BEARING	SPEED	BEARING
1500	.12	10	.01	270	.01	20
1600	.01	360	.04	320	.05	170
1700	.01	70	.05	290	.05	335
1800	.06	350	.01	320	.01	40
1900	0	160	.01	220	.01	270
2000	.01	45	.01	130	0	215
2100	.01	120	.07	135	0	240
2200	.01	340	.02	360	.06	30
2300	.07	350	0	180	.06	30
2400	.03	130	.06	160	0	180
100	.06	345	.07	150	.07	170
200	.05	280	.02	165	0	335
300	0	60	0	270	0	120
400	.01	290	0	300	0	145
500	0	310	0	50	0	310
600	.01	315	0	20	.05	155
700	0	345	.01	30	0	155
800	0	95	0	140	0	160
900	.04	5	0	130	.03	130
1000	.08	315	0	10	0	110
1100	.02	10	.01	32	0	160
1200	.07	10	.01	225	.07	10
1300	0	120	.02	10	.06	200
1400	0	90	.02	170	0	70
1500	0	190	0	140	0	30

END LINE 50

TABLE VI

NET CURRENT DRIFT

STATION NO. 15 , 27/6/83

OBSERVATION PERIOD FROM HRS	TO HRS	INTERVAL (MIN)	DEPTH (M)	DRIFT (M)	BEARING (MAG)
1100	1100	60	5	1496	103
1100	1100	60	15	1628	165
1100	1100	60	30	1644	170

STATION NO. 7 , 28.6/83

OBSERVATION PERIOD FROM HRS	TO HRS	INTERVAL (MIN)	DEPTH (M)	DRIFT (M)	BEARING (MAG)
1300	1300	60	2.5	2376	154
1300	1300	60	15	2578	142
1300	1300	60	30	3092	147

STATION NO. 14 , 29/6/83

OBSERVATION PERIOD FROM HRS	TO HRS	INTERVAL (MIN)	DEPTH (M)	DRIFT (M)	BEARING (MAG)
1500	1500	60	5	1870	352
1500	1500	60	15	428	164
1500	1500	60	30	343	92

STATION NO. 13 , 30/6/83

OBSERVATION PERIOD FROM HRS	TO HRS	INTERVAL (MIN)	DEPTH (M)	DRIFT (M)	BEARING (MAG)
1800	2300	60	2.5	545	35
1800	2300	60	15	189	128
1800	2300	60	30	1070	149

Table VII

HATHORN SOUND PROFILE DATA

Depth (M)	Stations 1	2	3	4	7a
Temp	28.0	28.0	28.5	28.0	28.5
Salinity	35.175	35.555	35.106	35.479	35.106
Sigma-t	22.529	22.815	22.312	22.757	22.312
0	52.2	52.7	52.6	52.6	52.6
1	52.5	52.5	52.6	52.6	52.7
5	52.7	52.5	52.7	52.8	52.8
10	52.7	52.5	52.7	52.7	52.7
15	52.8	52.5	52.6	52.5	52.7
20	-	52.5	52.5	52.5	52.6
25	-	52.3	52.5	52.5	52.5
30	-	52.2	52.5	52.5	52.5
Secchi	18	20	21	20	20
Tide	mid-ebb	mid-ebb	mid-ebb	mid-ebb	mid-ebb
Date	1/7/83	1/7/83	1/7/83	1/7/83	1/7/83
start	1012	1035	1048	1101	0953
end	1030	1040	1051	1104	0958

(Cont'd)

Table VII

HATHORN SOUND PROFILE DATA

Depth (M)	Stations 8	9	10	11	12
Temp	29.5	30.5	31.5	28	28
Salinity	34.305	33.244	32.786	35.784	35.784
Sigma-t	21.377	20.242	19.553	22.986	22.986
0	52.5	52.0	52.3	53.0	53.0
1	52.5	52.1	52.7	53.0	53.0
5	52.5	52.5	52.7	53.0	53.0
10	52.8	52.8	52.7	53.1	53.1
15	52.7	52.8	52.7	53.0	53.1
20	52.7	52.7	52.7	53.0	53.0
25	52.7	52.7	52.7	52.8	52.9
30	52.5	52.7	52.7	52.6	52.9
35	–	–	–	52.7	–
40	–	–	–	52.8	–
45	–	–	–	52.6	–
50	–	–	–	51.1	–
Secchi	20	28	25	16	21
Tide	mid-ebb	mid-ebb	mid-ebb	low slack	st-flood
Date	1/7/83	1/7/83	1/7/83	30/6/83	30/6/83
start	0928	0906	0847	1611	1650
end	0935	0921	0901	1622	1710

Table VIII

PLANKTON CONCENTRATION IN HATHORN SOUND
June 1983

Station	Secchi (M)	Tide	Concentration (ml/CM)
7a	20	ebb	1.36
7	17.5	flood	0.91
8	20	ebb	3.40
9	29	ebb	3.18
10	25	ebb	1.36
11	16	low slack	1.82
12	21	flood	2.27
14	19.5	ebb	3.40
15	17	ebb	0.23

Table IX

WIND CONDITIONS AT MUNDA AIRPORT
DURING THE HATHORN SOULD STUDY

					Time, (hrs)	
Dates	0500	0800	1100	1400	1700	2300
26/6/83						
Direction	calm	calm	070	090	070	calm
Speed, k	00	00	05	06	06	00
27/6/83						
Direction	calm	calm	090	090	070	090
Speed, k	00	00	03	05	04	06
28/6/83						
Direction	090	140	160	090	140	calm
Speed, k	06	08	08	07	07	00
29/6/83						
Direction	calm	090	090	110	110	090
Speed, k	00	06	07	09	09	06
1/7/83						
Direction	090	045	135	090	045	calm
Speed, k	06	02	06	10	02	00
Temp	26.9	26.5	28.9	27.4	25.9	26.1

Rain 4.4 (mm/24 hrs)
Evaporation 3.2 (mm/24 hrs)

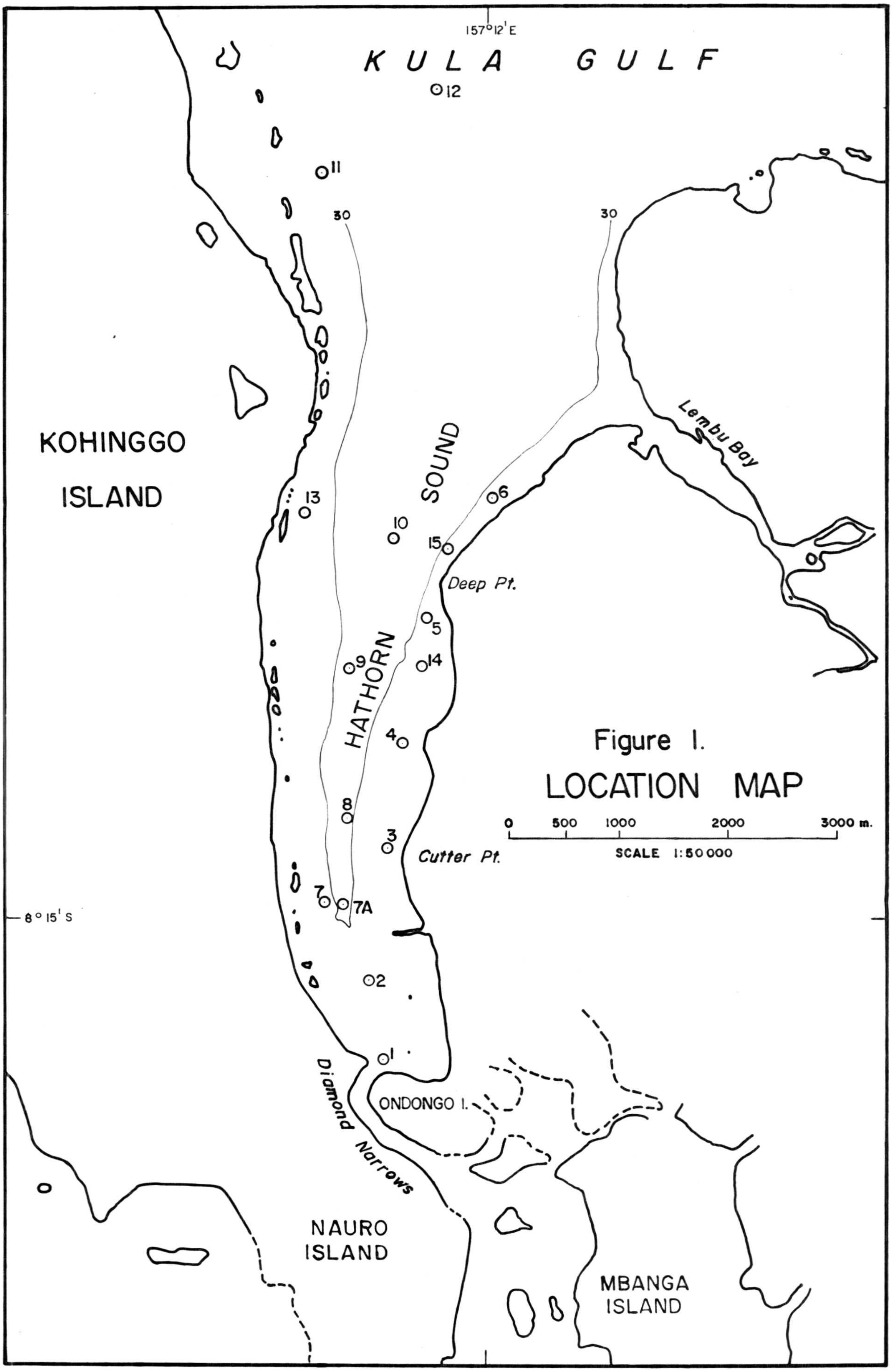


Figure 1.
LOCATION MAP

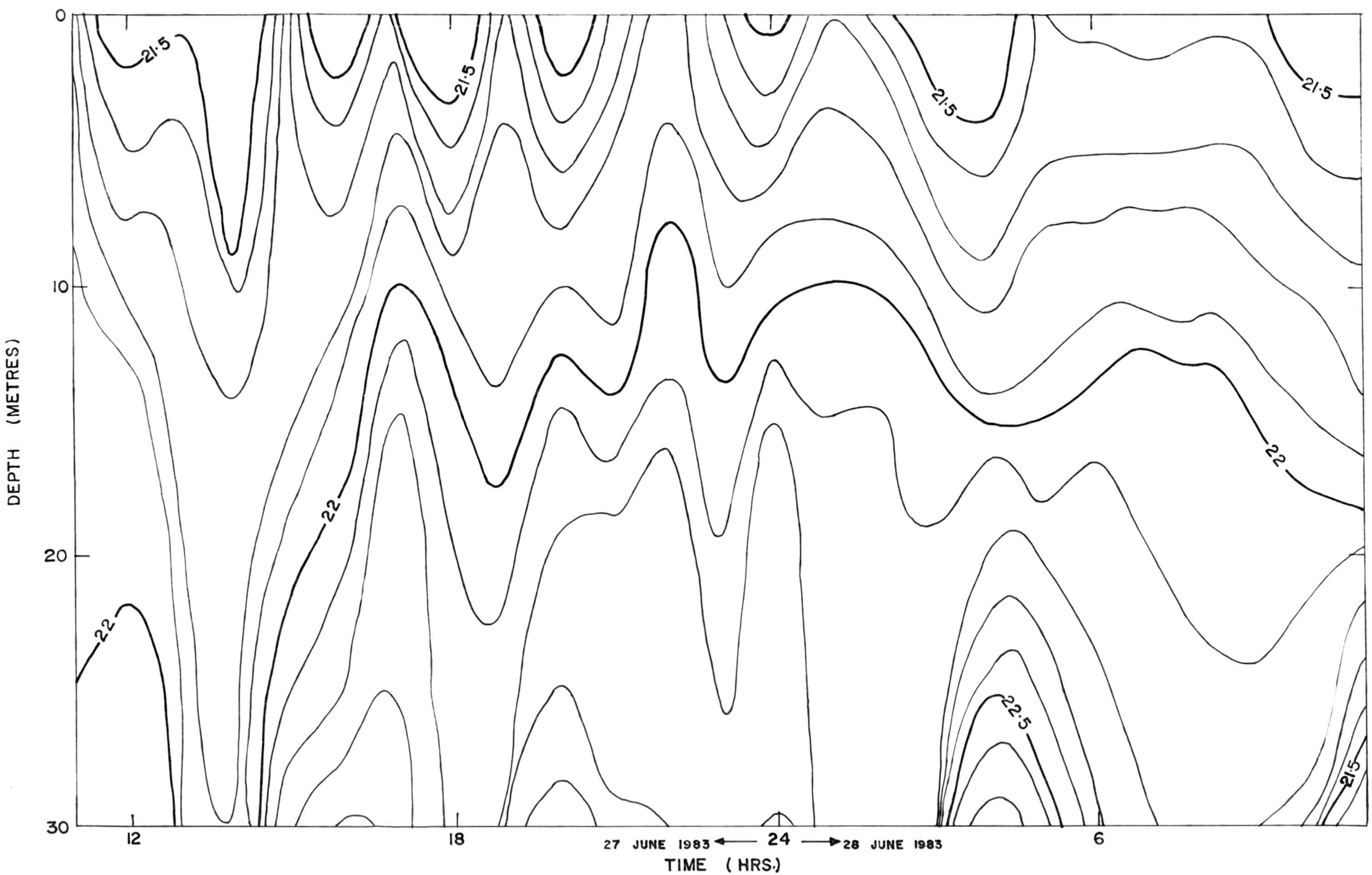
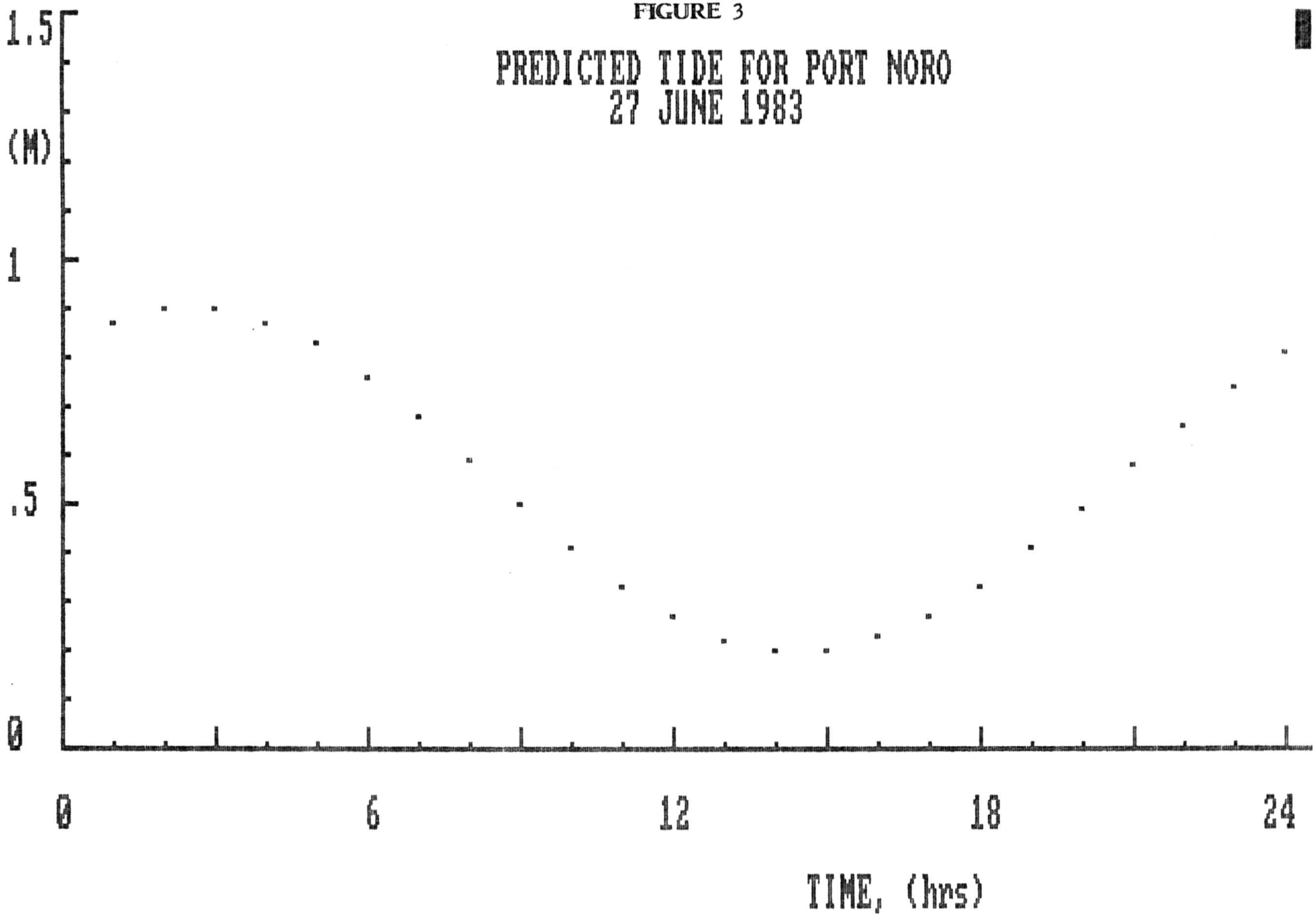


Figure 2 SIGMA-t PROFILE AT STATION 15 HATHORN SOUND

FIGURE 3



PREDICTED TIDE FOR PORT NORO
27 JUNE 1983
1.5
(M)
1
.5
0
0
6
12
18
24
TIME, (hrs)

FIGURE 4

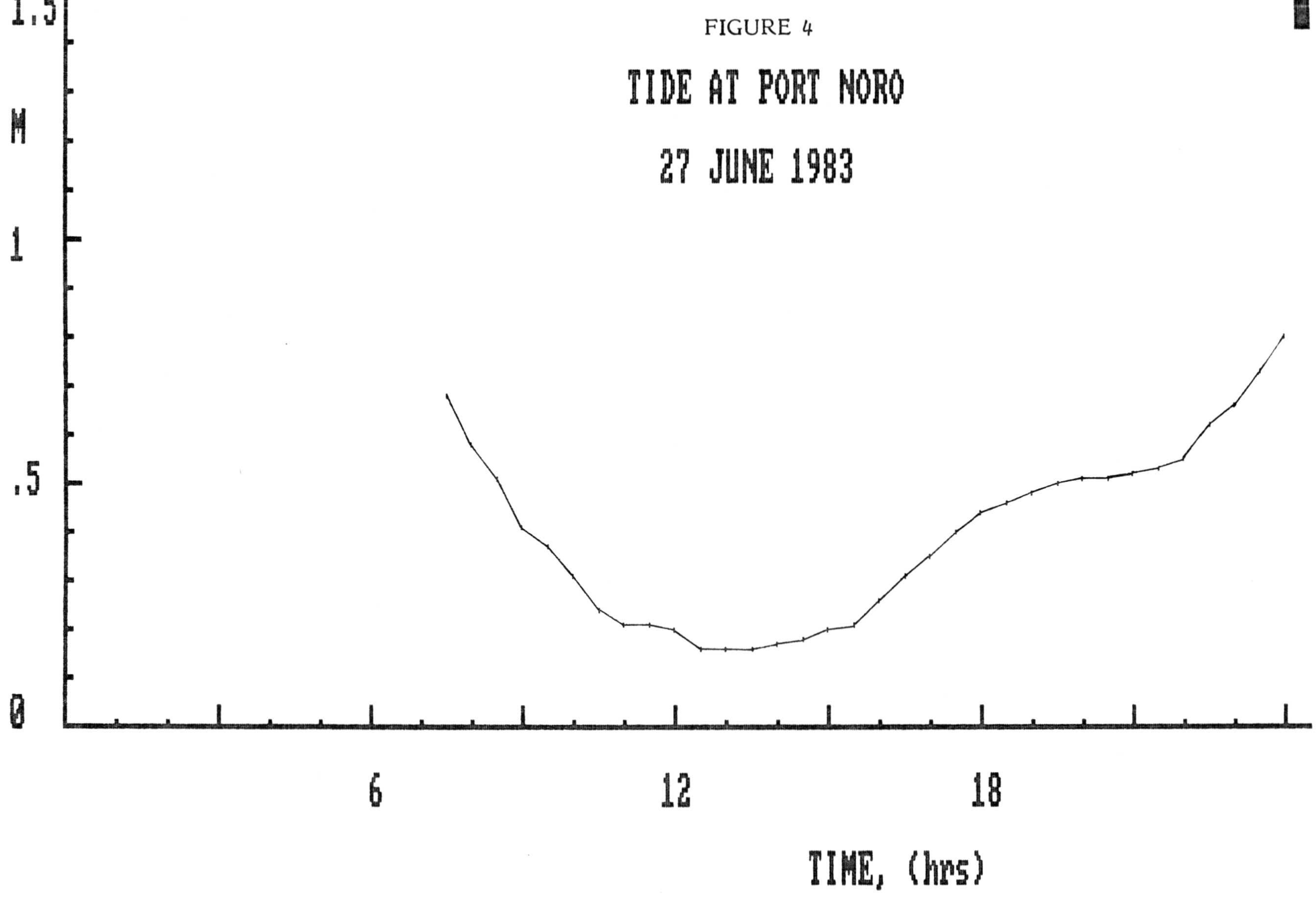


FIGURE 5.

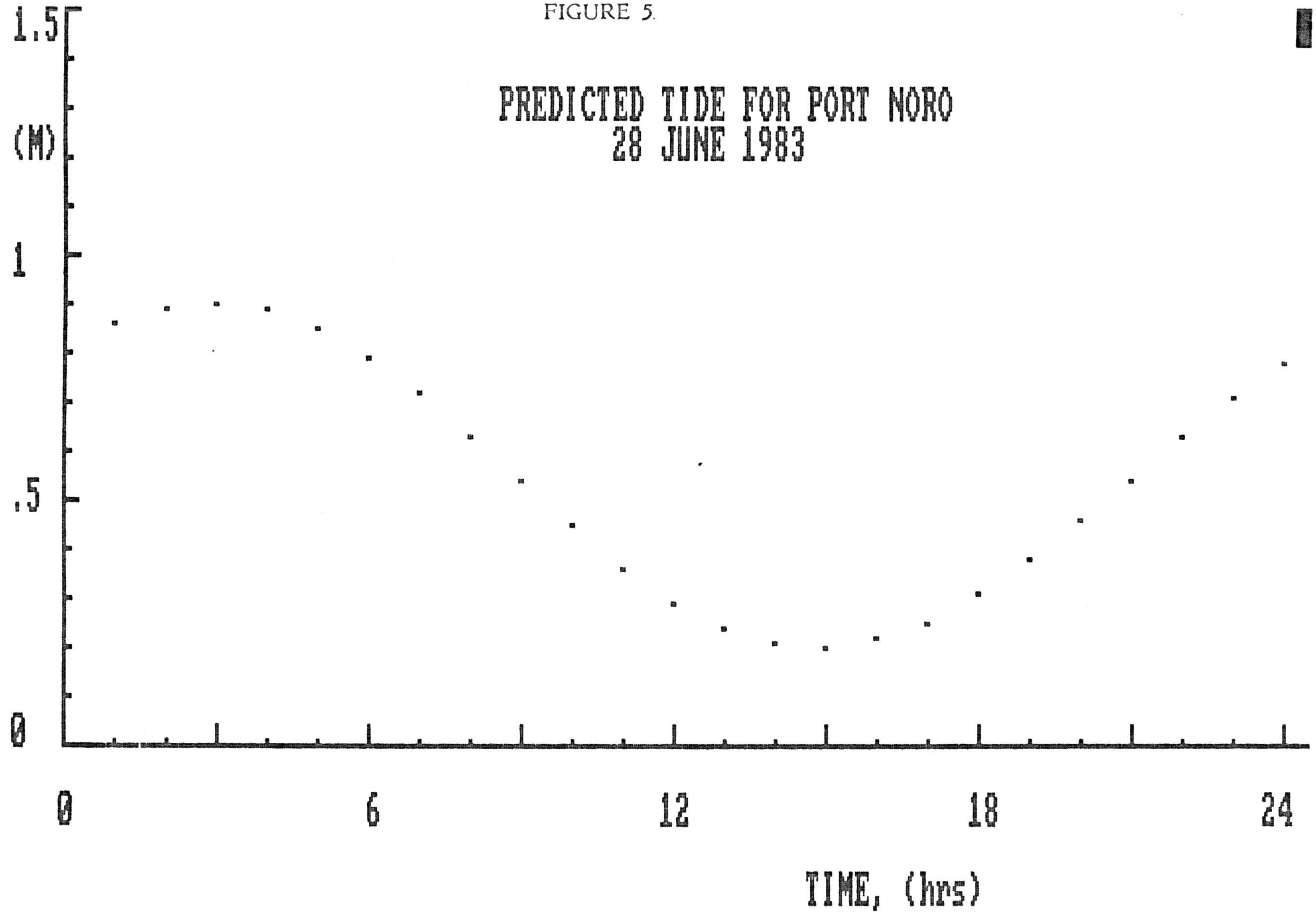

PREDICTED TIDE FOR PORT NORO
28 JUNE 1983
1.5
(M)
1
.5
0
0
6
12
18
24
TIME, (hrs)

FIGURE 6

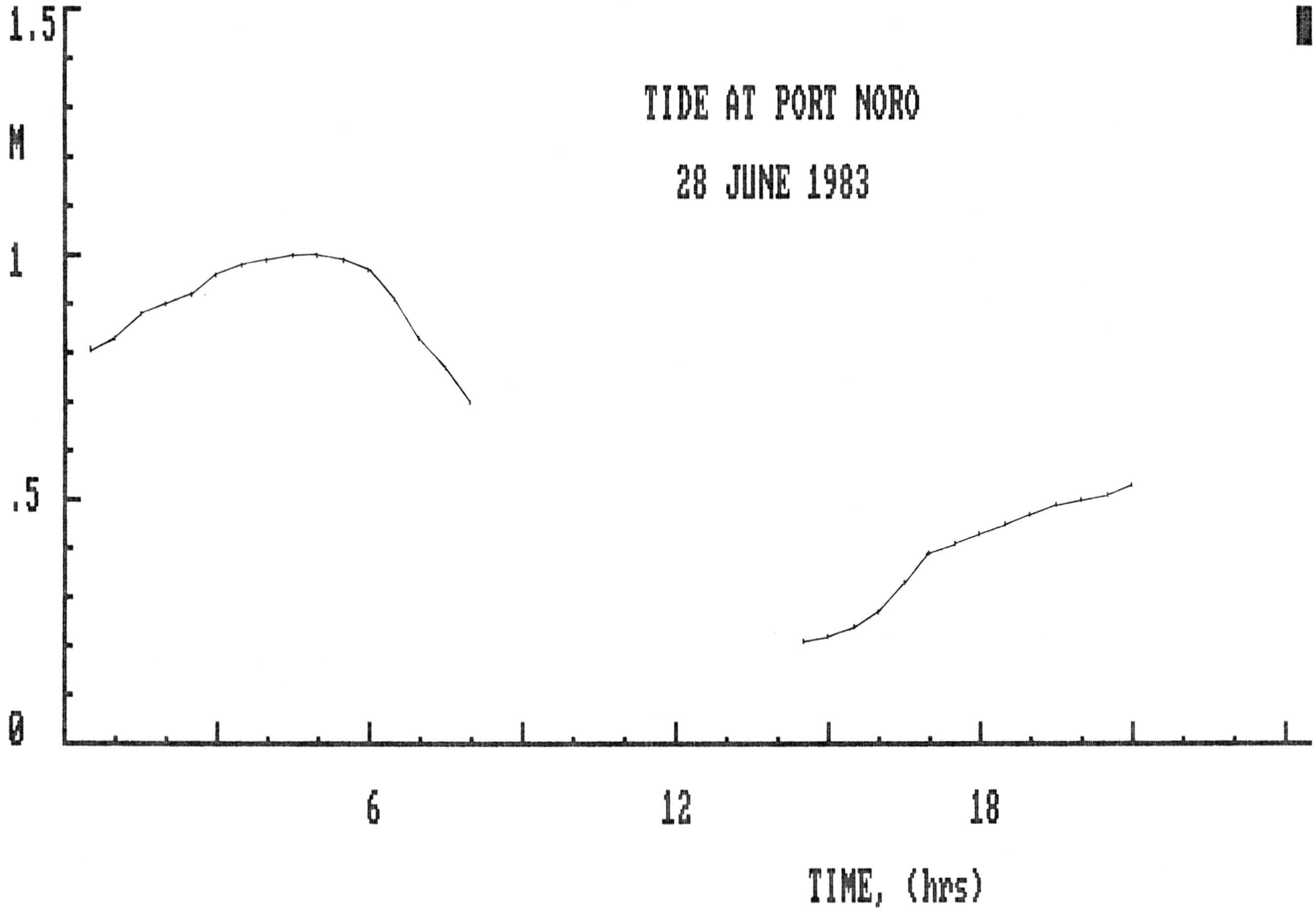


FIGURE 7

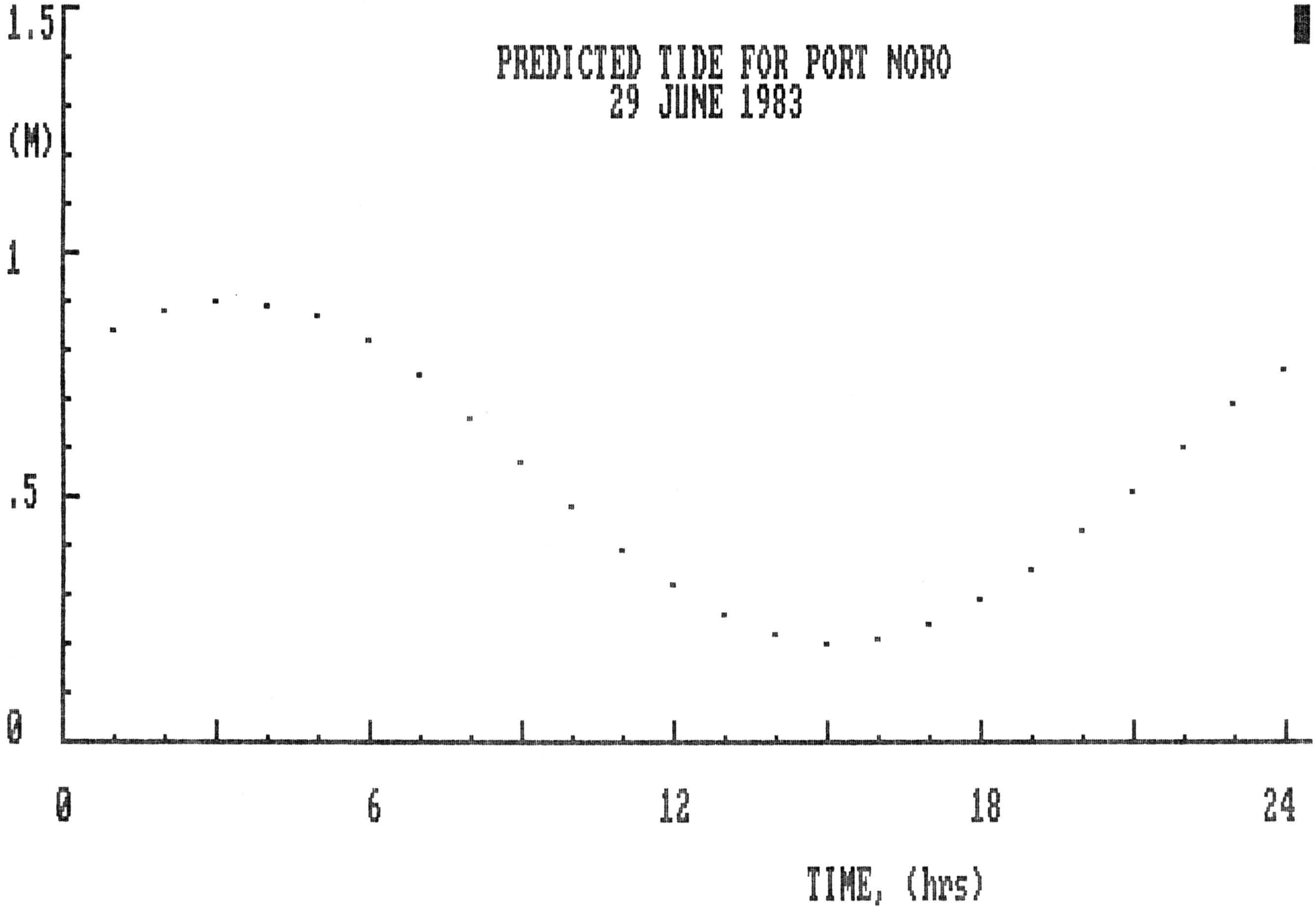

PREDICTED TIDE FOR PORT NORO
29 JUNE 1983
1.5
(M)
1
.5
0
0
6
12
18
24
TIME, (hrs)

FIGURE 8

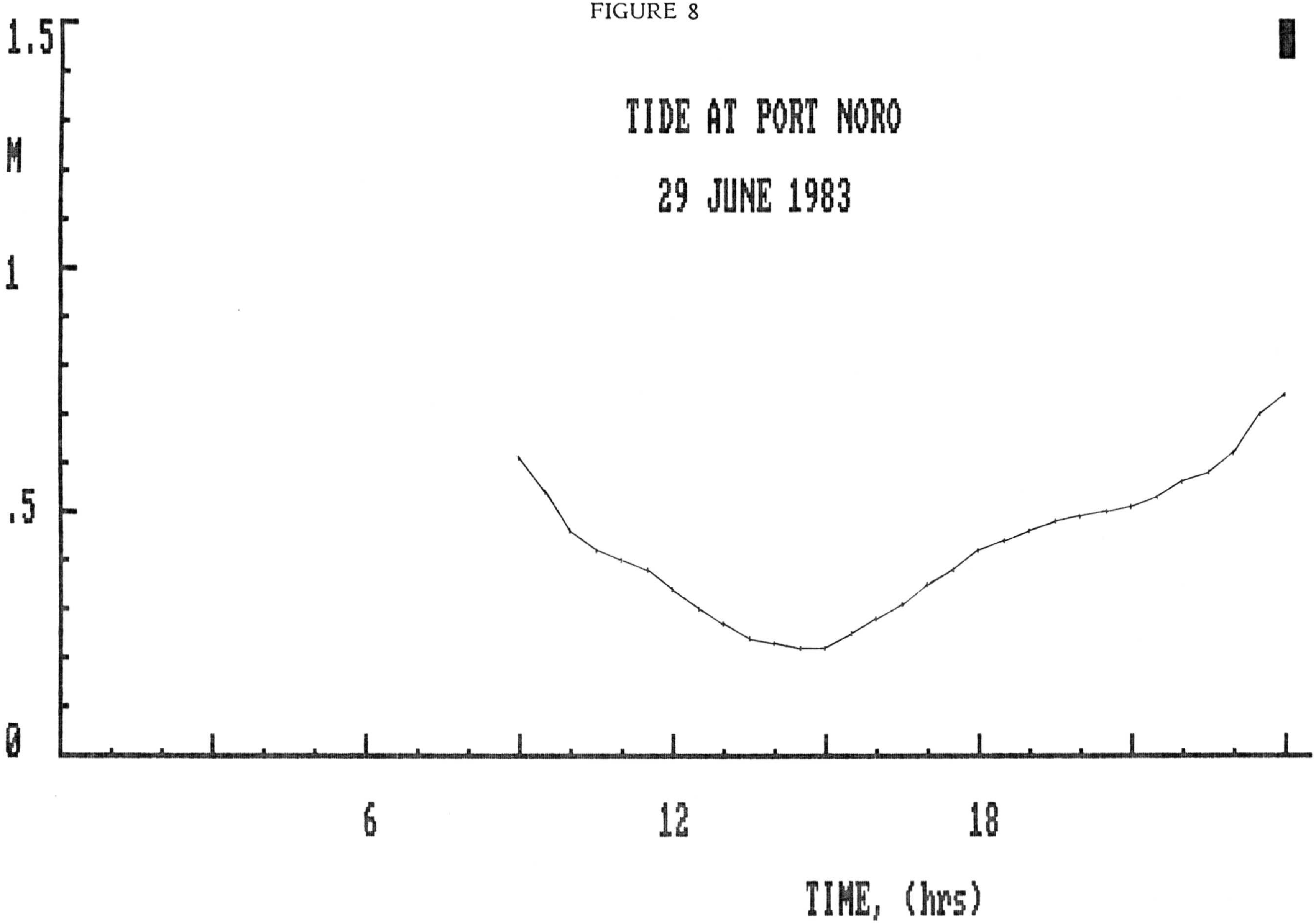


FIGURE 9

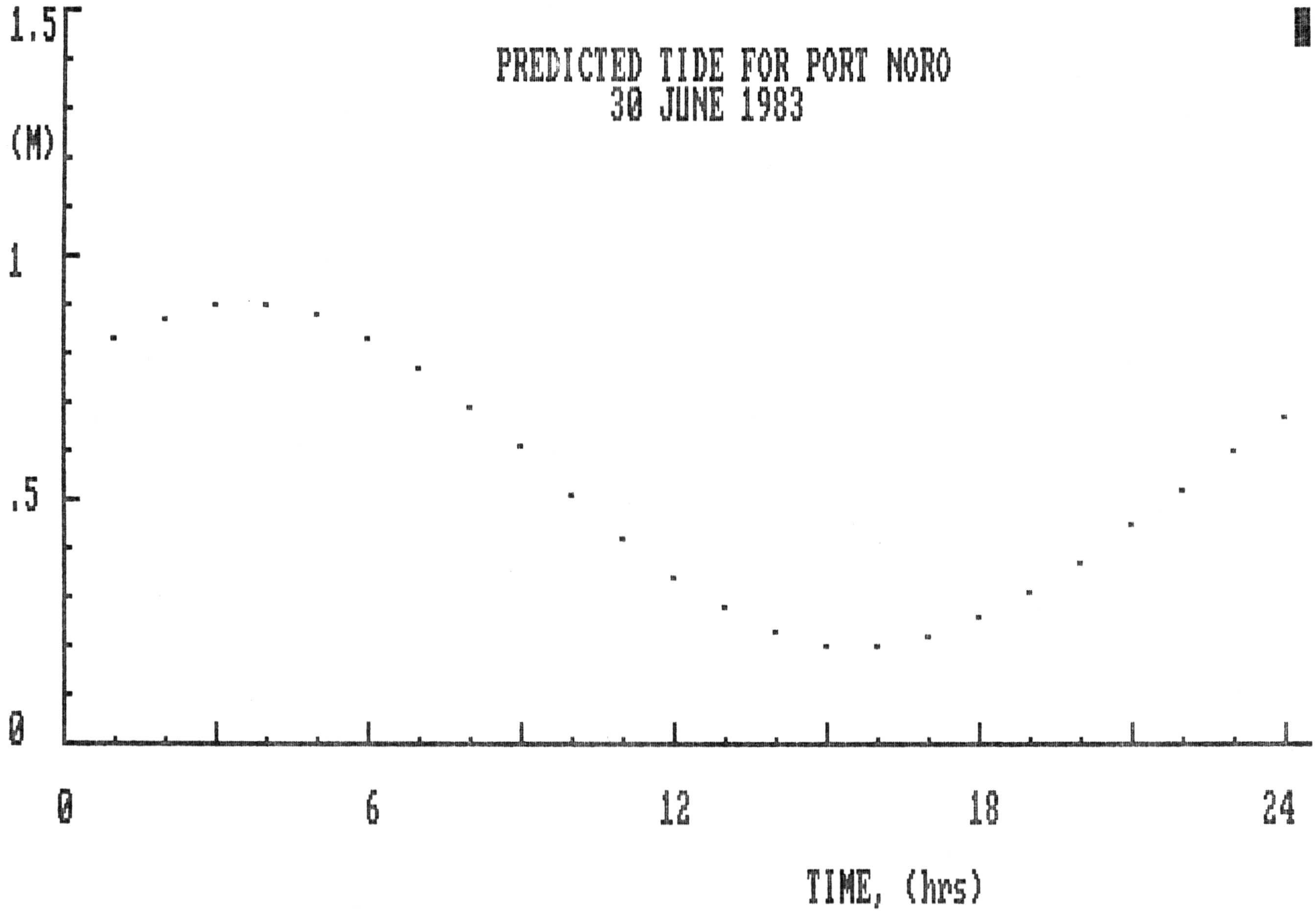

PREDICTED TIDE FOR PORT NORO
30 JUNE 1983
1.5
(M)
1
.5
0
0
6
12
18
24
TIME, (hrs)

FIGURE 10

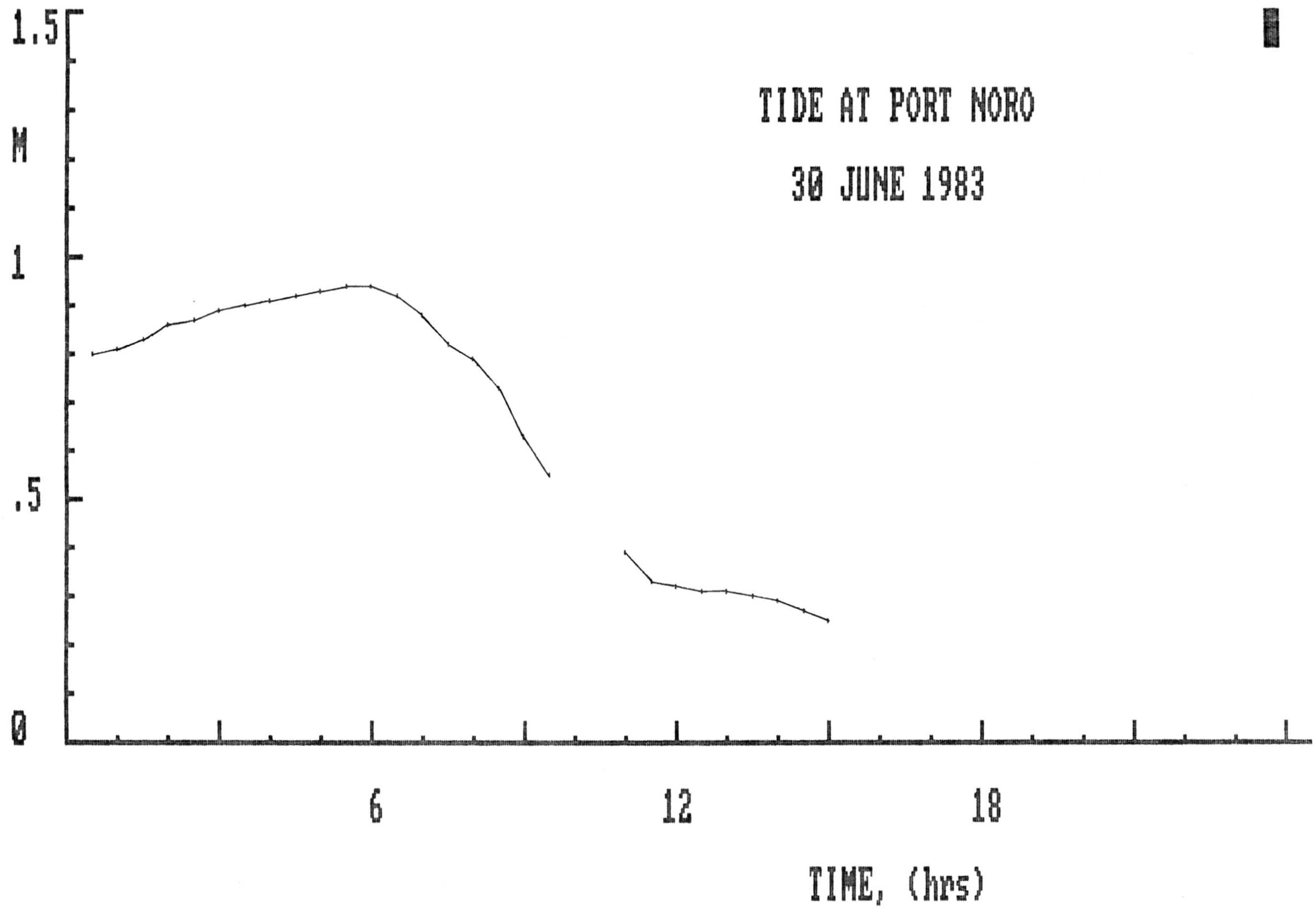


FIGURE 11

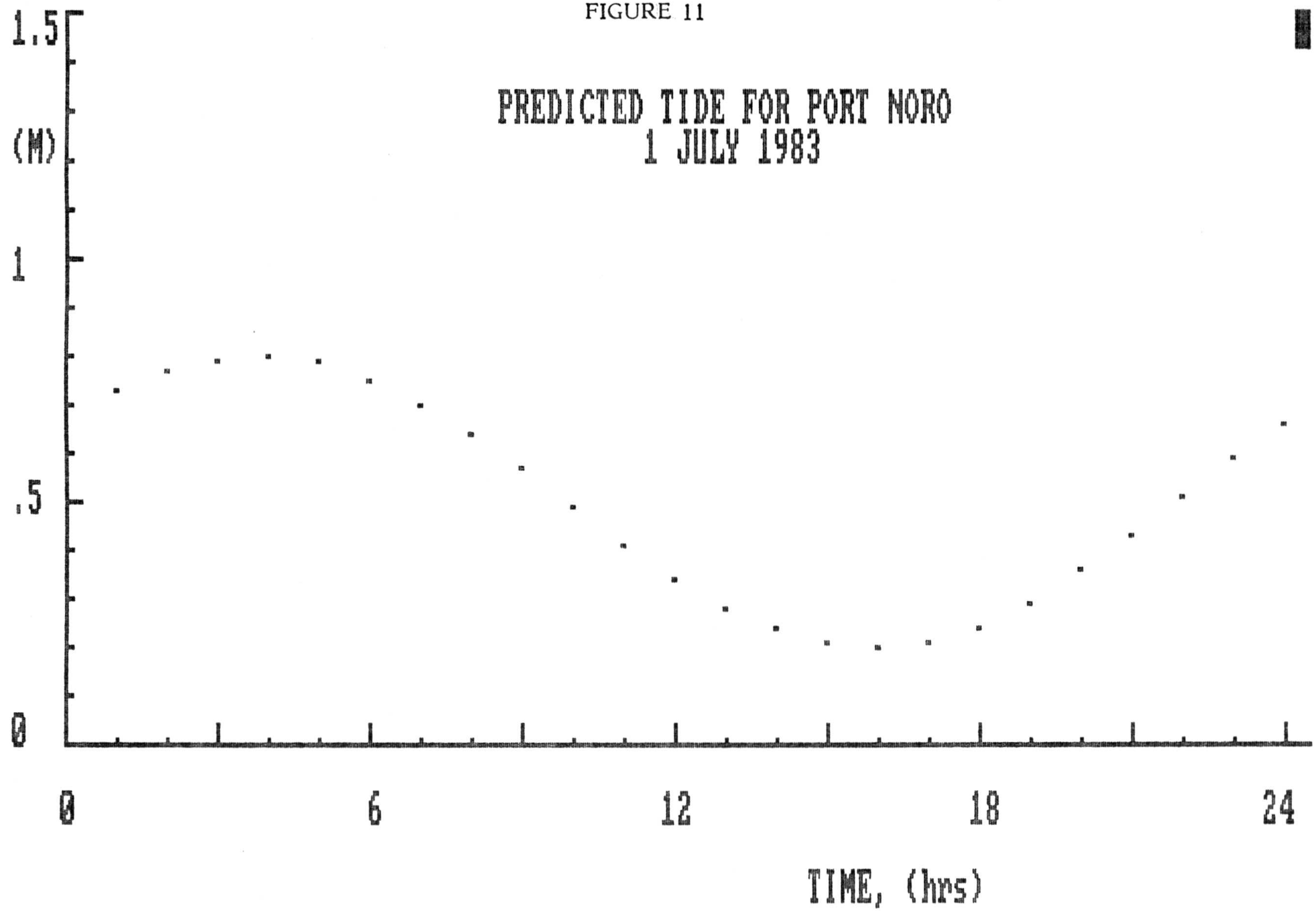

PREDICTED TIDE FOR PORT NORO
1 JULY 1983
1.5
(M)
1
.5
0
0
6
12
18
24
TIME, (hrs)

FIGURE 12

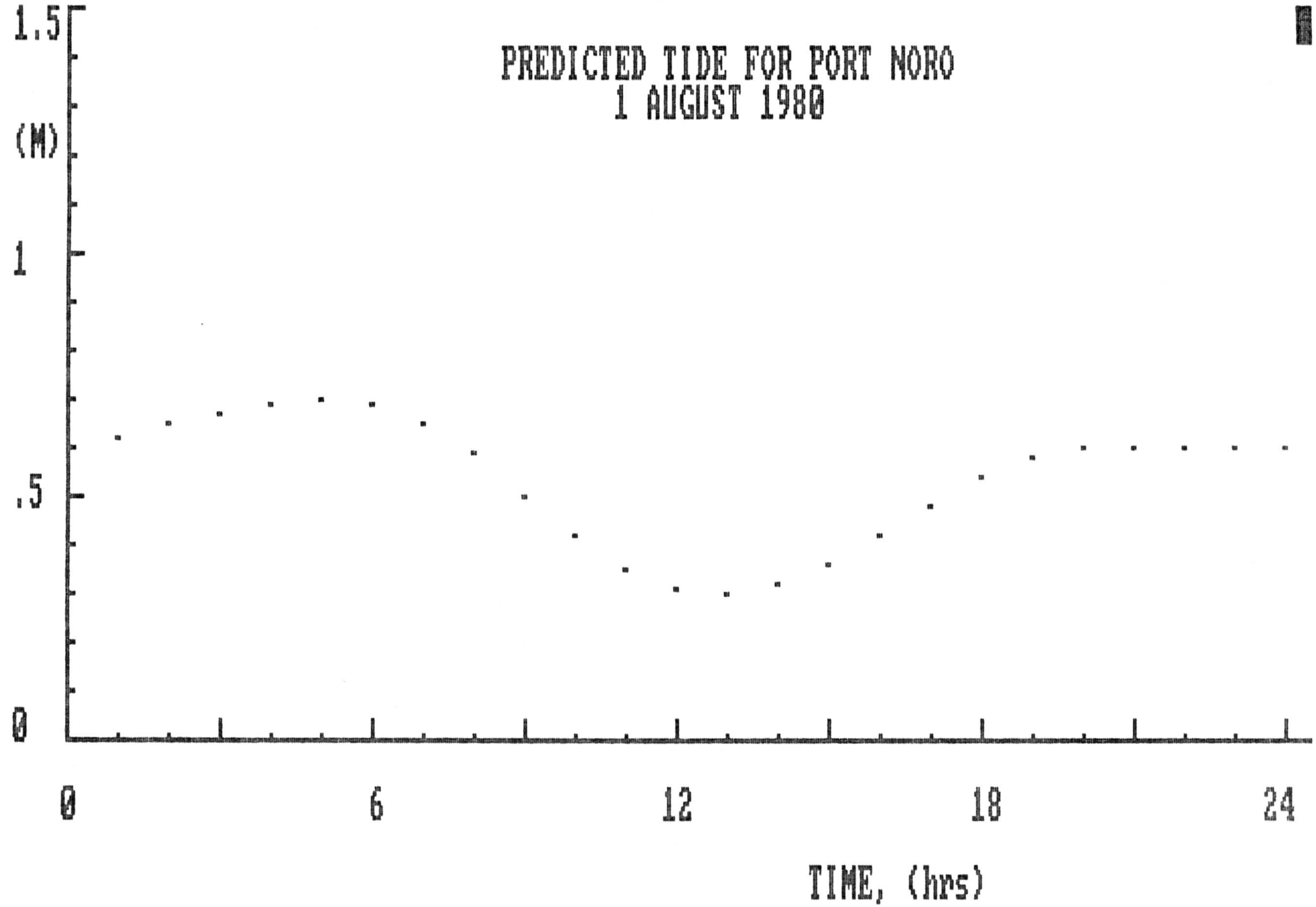

PREDICTED TIDE FOR PORT NORO
1 AUGUST 1980
1.5
(M)
1
.5
0
0
6
12
18
24
TIME, (hrs)

FIGURE 13

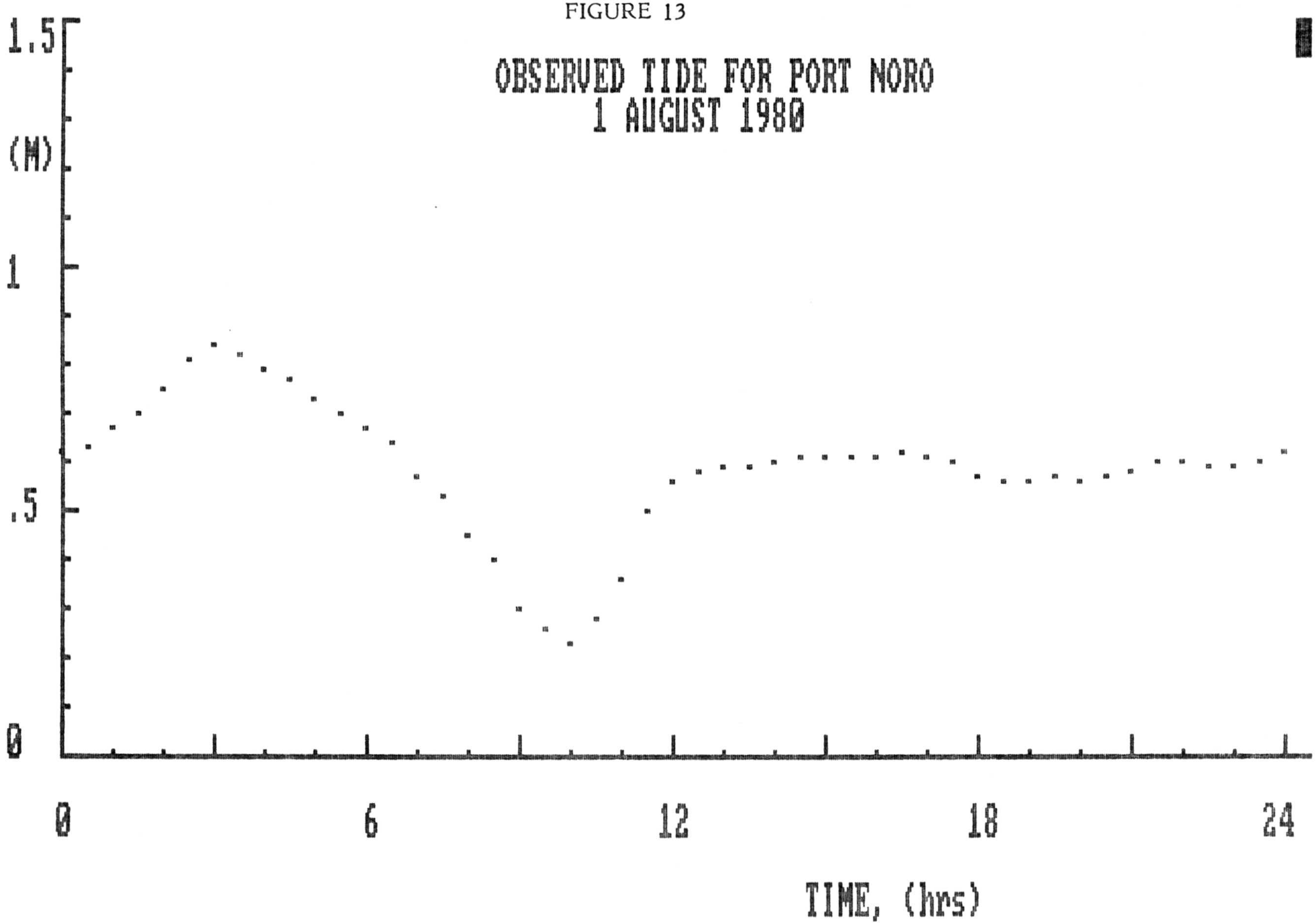
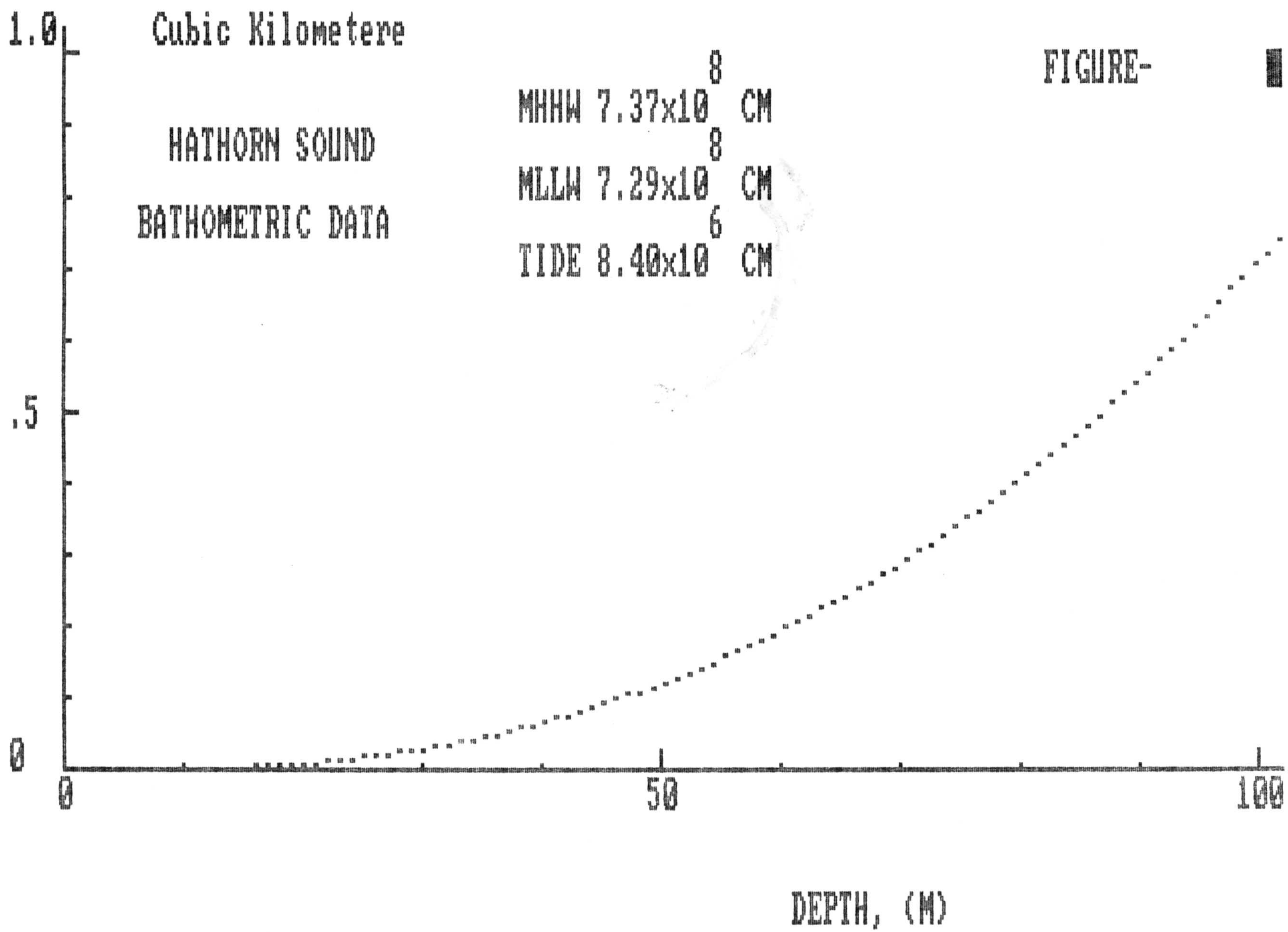

OBSERVED TIDE FOR PORT NORO
1 AUGUST 1980
1.5
(M)
1
.5
0
0
6
12
18
24
TIME, (hrs)

FIGURE 14



1.0
Cubic Kilometere
HATHORN SOUND
BATHOMETRIC DATA
MHHW 7.37x10 8 CM
MLLW 7.29x10 8 CM
TIDE 8.40x10 6 CM
FIGURE-
.5
0
0
50
100
DEPTH, (M)