Second order wave generation in the OEB-I

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SUMMARY

In order to eliminate the unwillingly generated parasitic waves form the resulted wave profiles, a 2nd order wave generation technique is essential to carry out correct model test in the wave basin. These so-called parasitic waves cause an amplification of long wave phenomena, such as harbour resonance and oscillations of moored ships. These parasitic waves can be eliminated by means of compensating free waves imposed on the system by second-order paddle motion reproducing the natural set-down. The control signal for this motion has to be introduced along with the primary waves. The code SPWNW is utilized to serve the above purposes. In the present experimental work we have employed 2nd order wave generation technique to generate regular wave in the OEB basin. Measured surface elevations at different locations in the wave basin for each case we considered here are compared to check the wave propagation in the basin. Later the relevant surface elevations measured for both the 1st order and 2nd order wave generation technique and those predicted by the SPWNW code are compared and presented in this report.

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SECOND ORDER WAVE GENERATION IN THE OEB - I

TR-2006-13

Hasanat Zaman and Lawrence Mak

May 2006

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Abstract

When the interaction between frequencies is considered then the second order solution of Laplace equation produces two extra components: (i) bounded sub harmonics or bounded low frequency waves and, (ii) bounded super harmonics or bounded high frequency waves and they travel locked with their generating / fundamental wave components. These nonlinear components play a predominant role in the intermediate and shallow water region. So when doing any test it is important to make sure that those nonlinear wave components are properly reproduced in the basin along with the primary components. When first-order natural waves are reproduced in the laboratory using the first order wave generation technique, the primary waves and their locked bounded waves are generated along with some unwanted free waves. Those free waves are evidently generated and propagate towards the test model and reflect from the boundaries. The free parasitic waves, having the same frequency of the bounded wave are reproduced, as the boundary conditions of the wave paddle are not properly satisfied up to second-order. The other two types of free waves are due to the wave paddle displacement and local disturbances. These so-called free waves cause an amplification of long wave phenomena, such as harbour resonance and oscillations of moored ships. These parasitic waves can be eliminated by means of compensating free waves imposed on the system by second-order paddle motion. The control signal for this motion has to be introduced along with the primary waves.

Introduction

Recently, correct generation of second order waves and reproduction of group-induced second order low and high frequency waves have been considered essential for physical model test in the laboratory to understand the effects of the wave-action phenomena on, for instance, offshore structures, mooring system, floating vessels, harbour resonance, etc..

Fig.1 shows a simple example of a situation where two waves of two different frequencies f_1 (=0.833 Hz) and f_2 (=0.926 Hz) form a wave group.

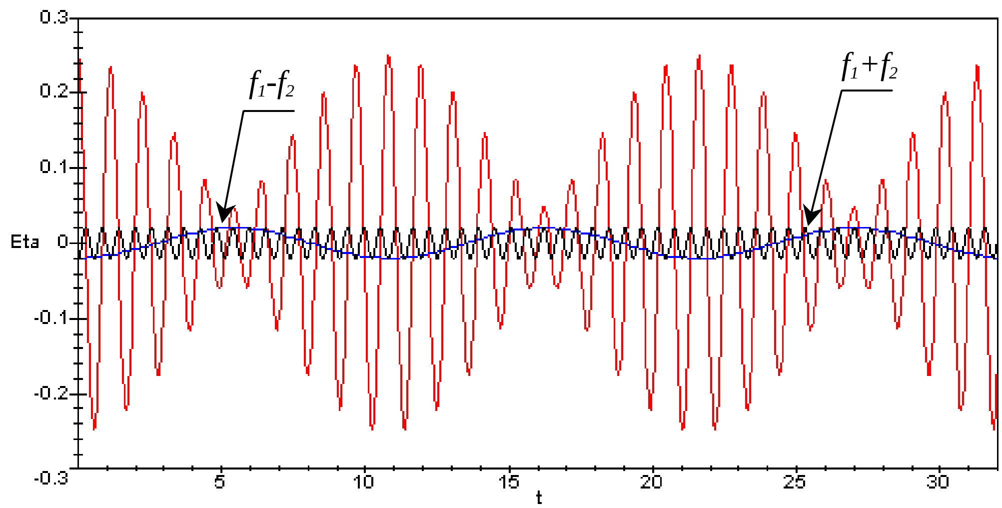


Fig. 1 An example of wave group and generation of high and low frequency waves

A low frequency wave or long wave will be produced due to the difference (f_1 - f_2) of the frequencies and a high frequency or short wave would be generated due to the summation (f_1 + f_2) of the frequencies.

This kind of long wave (f_1 - f_2) is generally termed as set-down/set-up. These set-down and set-up phenomena were first investigated and reported by Longuet-Higgins and Stewart (1960 to 1964) in a series of papers. They introduced the radiation stress concept, which explains that in a wave group individual wave components exert an internal compressive force in the direction of wave propagation. To balance this force the mean water level goes down in the region of larger waves known as set-down and goes up in the region of smaller waves known as set-up. Bowen et al (1968) later explained the set-down and set-up phenomena with experimental data.

Theory

A wave group would be generated with the presence of at least two frequencies. Difference of these two frequencies would generate a long period bound wave with a period equal to the period of the wave group. This long wave is also known as 'set-down'.

A pair of regular waves with frequencies f_n and f_m and, surface elevations $\eta_n(t)$ and $\eta_m(t)$ respectively would constitute a wave group as follows (Sand 1982):

$$\begin{aligned}\eta_{nm}(t) &= \eta_n + \eta_m \\ &= a_n \cos(\sigma_n t - k_1 x_1) + b_n \sin(\sigma_n t - k_1 x_1) + a_m \cos(\sigma_m t - k_1 x_1) + b_m \sin(\sigma_m t - k_1 x_1)\end{aligned}$$

Here, σ is the wave angular frequency, k the wave number, t the time and, a and b are the Fourier coefficients.

The second order long wave $\eta^l_{nm}(t)$ generated by the above wave group would be as follows:

$$\eta^l_{nm}(t) = G_{nm} h^2 \left[\left(\frac{a_n a_m + b_n b_m}{h^2} \right) \cos(\Delta\sigma_{nm} t - \Delta k_{nm} x_1) + \left(\frac{a_m b_n - a_n b_m}{h^2} \right) \sin(\Delta\sigma_{nm} t - \Delta k_{nm} x_1) \right]$$

Here, h is the water depth. $\Delta\sigma_{nm} = \sigma_n - \sigma_m$, $\Delta k_{nm} = k_n - k_m$ and $\Delta f_{nm} = f_n - f_m$. The transfer function G_{nm} can be given as follows:

$$G_{nm} = \frac{1}{h} \left[\frac{4\pi^2 h D_n D_m \Delta k_{nm} \cosh(\Delta k_{nm} h)}{\cosh h(k_n + k_m) - \cosh(\Delta k_{nm} h)} + \frac{\Delta k_{nm} h^2 (D_n - D_m)(k_n D_m + k_m D_n) \coth(\Delta k_{nm} h)}{2 D_n D_m} - 2\pi^2 (D_n - D_m)^2 - \Delta k_{nm} h \right] / \left[4\pi^2 (D_n - D_m)^2 \coth(\Delta k_{nm} h) - \Delta k_{nm} h \right]$$

where, $D_n = (h/g)^{0.5} f_n$ and $D_m = (h/g)^{0.5} f_m$; g is the acceleration due to gravity.

The first order control signal for only one frequency can be derived as follows [see also Barthel et al (1983)]:

$$X_0^1 = \frac{\cosh(k_n h)\sinh(k_n h) + k_n h}{2\sinh^2(k_n h)}(a_n \sin\sigma_n t - b_n \cos\sigma_n t)$$

The second order control signal for the above wave group having only two frequencies is given by the following expression:

$$X_0^2 = \left[(a_n b_m - a_m b_n)(F_{11} + F_{12}) + (a_n a_m - b_n b_m)F_{23}\right]\cos\Delta\sigma_{nm} t + \left[(a_n a_m + b_n b_m)(F_{11} + F_{12}) + (a_m b_n - a_n b_m)F_{23}\right]\sin\Delta\sigma_{nm} t$$

The transfer functions F_{11}, F_{12} and F_{23} are related to the wave generation and propagation phenomena.

The function F_{11} is the contribution to the control signal required for the bounded long wave and used to eliminate the parasitic long waves:

$$F_{11} = \frac{G_{nm} h\Delta k_f h\left[(\Delta k_{nm} h - \Delta k_f h)\sinh(\Delta k_{nm} h + \Delta k_f h) + (\Delta k_{nm} h + \Delta k_f h)\sinh(\Delta k_{nm} h - \Delta k_f h)\right]}{2h(\Delta k_{nm}^2 h^2 - \Delta k_f^2 h^2)\sinh(\Delta k_{nm} h)\sinh(\Delta k_f h)}$$

The function F_{12} is required to eliminate the free long wave generated due to the displacement of the wave peddle from its original position at $x=0$:

$$F_{12} = \frac{1}{h}\frac{f_m \Delta k_f hk_m h(1 + G_n)\left[\delta k_m^- h\sinh(\delta k_m^+ h) + \delta k_m^+ h\sinh(\delta k_m^- h)\right]}{8\Delta f(k_m^2 h^2 - \Delta k_f^2 h^2)\sinh(\Delta k_f h)\sinh(k_m h)\tanh(k_n h)} + \frac{1}{h}\frac{f_n \Delta k_f hk_n h(1 + G_m)\left[\delta k_n^- h\sinh(\delta k_n^+ h) + \delta k_n^+ h\sinh(\delta k_n^- h)\right]}{\Delta f\, 8(k_n^2 h^2 - \Delta k_f^2 h^2)\sinh(\Delta k_f h)\sinh(k_n h)\tanh(k_m h)}$$

The quantities Δk_f and, $\delta k_m^\pm$ and $\delta k_n^\pm$ are obtained, respectively from the following relationships:

$$(\Delta\sigma_{nm})^2 = g\Delta k_f \tanh(\Delta k_f h)$$

$$\delta k_i^\pm = k_i \pm \Delta k_f \quad : \quad i = m \text{ or } n$$

To eliminate the free second order long waves produced from the local disturbances, a third transfer function F_{23} is essential. This function can be described as follows:

$$F_{23} h = F_2 h(F_m - F_n)$$

Here,

$$F_{23} = \frac{\Delta k_f h(1 + G_n)(1 + G_m)}{8h\tanh(k_n h)\tanh(k_m h)}$$

$$G_i = \frac{2k_i h}{\sinh(2k_i h)} \quad : \quad i = m \ \ or \ \ n$$

$$F_i = \frac{f_i}{\Delta f}\sum_{j=1}^{\infty}\frac{2k_j h\sin(k_j h)\left[k_j h\sin(k_j h)\coth(\Delta k_f h)+\Delta k_f h\cos(k_j h)\right]}{(k_j^2 h^2+\Delta k_f^2 h^2)\left[\sin(k_j h)\cos(k_j h)+k_j h\right]} \quad : \quad i = m \ \ or \ \ n$$

The term $k_j h$ in the above equation can be evaluated within the $\left(j-\frac{1}{2}\right)\pi < k_j h < j\pi$ limit from the following equation:

$$4\pi^2 h f_m^2 = -g k_j h \tanh(k_j h)$$

Scope of the present research

In order to achieve correct second order wave generation capability in the OEB at IOT, an internal project named Wave-quality (42_2103_10) commenced in February 2005. We mainly concentrated on the generation of regular wave (*i.e.* $f_n = f_m$). The aim of this project was to investigate the possibility of accurate generation of the second order wave in the OEB. In these experiments our focus would be to understand and use the second order wave generation technique to generate correct primary and bounded waves in the basin.

When a regular wave in the shallow water is generated in the wave basin using the Ist order generation method then parasitic free waves having same frequency as the bounded waves are involuntarily generated. The parasitic free waves, free waves due to displacement of the wave paddles and free waves due to local disturbance have to be eliminated to ensure the correct reproduction of the wave in the basin for model test. The so-called second order wave generation technique was employed for this purpose.

Experimental conditions

Twelve (12) wave probes were employed to record the experimental data in the OEB. Fig. 2 shows the experimental setup and red circles are the locations of the wave probes. The distances of the wave probes from the wave paddle are shown in Table 1.

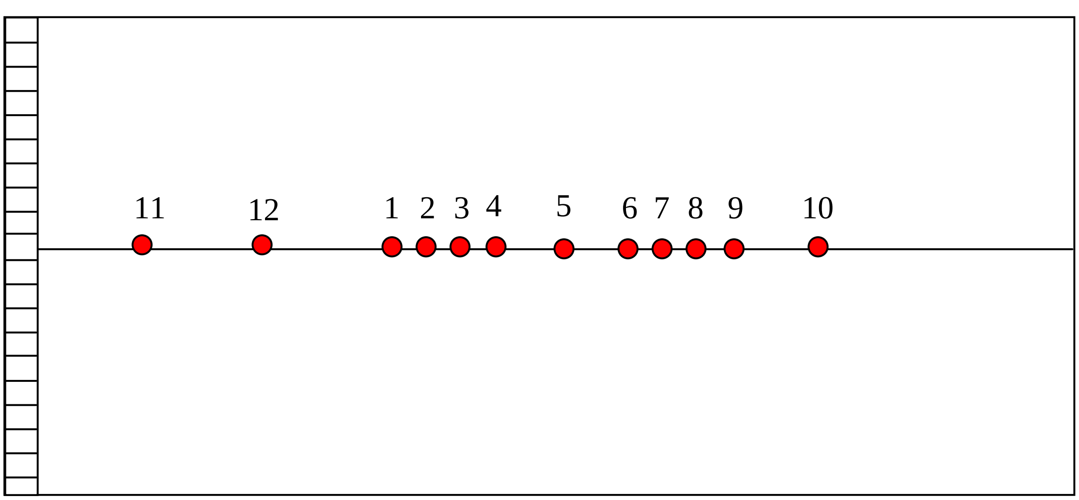


Fig. 2 Top view of the experimental setup in the OEB

Table 1 Location of the wave probes in the OEB

No of the probe	Distance from the paddle (m)	Distance from the south wall (m)
11	8.455	13.5
12	15.71	13.5
1	21.645	13.102
2	22.221	13.102
3	22.925	13.102
4	23.757	13.102
5	25.645	13.102
6	27.601	13.102
7	28.177	13.102
8	28.881	13.102
9	29.713	13.102
10	31.601	13.102

As mentioned above, we designed this experiment for regular waves. In the experiment we have used two sets of regular waves with two different steepness. The water depth in the OEB was 1.9m. The bottom of the basin was flat and the blanking plates were deployed to cover the north beach. The experimental conditions are shown in Table 2.

Table 2 Experimental wave parameters

Depth d(m)	Wave period T(s)	Wave height H(m)	Wave length L(m)	Steepness (H/L)	Relative depth (d/L)
1.9	2.0	0.060139070	6.01390700	0.01	0.315934383
1.9	3.0	0.111148100	11.1148100	0.01	0.170943093
1.9	4.0	0.158875904	15.8875904	0.01	0.119590193
1.9	5.0	0.204819832	20.4819832	0.01	0.092764455
1.9	2.0	0.120278140	6.01390700	0.02	0.315934383
1.9	3.0	0.222296200	11.1148100	0.02	0.170943093
1.9	4.0	0.317751808	15.8875904	0.02	0.119590193
1.9	5.0	0.409639664	20.4819832	0.02	0.092764455

Methodology

The surface elevations from which the required drive signal would be produced is consisted of the following components surface elevations:

PW = Primary wave
BW = Bounded wave
FPW = Free parasitic wave
FPDW = Free wave due to wave paddle displacement
FLDW = Free wave due to local disturbance

CFPW = Correction for FPW
CFPDW = Correction for FPDW
CFLDW = Correction for FLDW

Following the above abbreviations the surface elevation for the correctly generated wave should be:

$$\eta(t) = PW + BW + FPW + FPDW + FLDW - CFPW^{*} - CFPDW^{*} - CFLDW^{*}$$

The quantities with * sign have to be subtracted from the resulted wave profile to eliminate the unwillingly generated free waves components. The numerical code SPWNW implemented the above equation. This code produces the above $\eta(t)$ and the code DWREP2 used this $\eta(t)$ to produce the required drive signal to generate the wave in the basin. Then the deployed wave probes would acquire the wave data in the basin. The acquired data could be split up into its contributing components.

Results

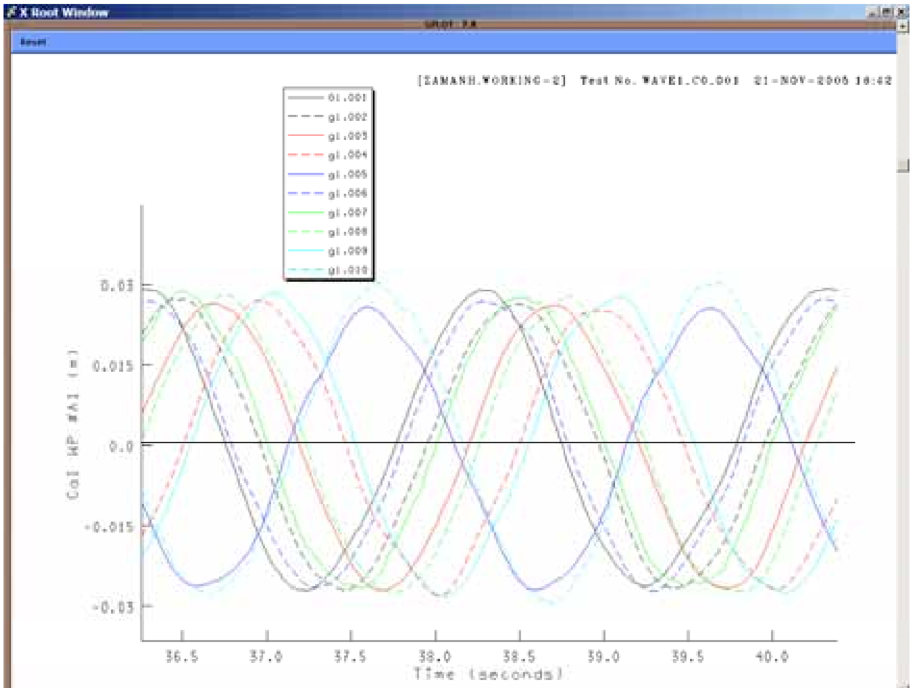
The tests were conducted in between other test projects. Due to time constraints the water depth inherited from the previous experiment was not changed. In such a situation, the use of low frequency waves was the only means to have the shallow water waves in the basin. Since the low frequency waves travel very fast, reflection from the beach could quickly contaminate the wave field. In such condition it is very difficult to make an assessment on the acquired data.

The initial results obtained from the experiments confirmed that waves with lower frequencies are quickly contaminated by the reflections from the beach. To avoid this, the water depth should be made physically shallow for this kind of experiments.

In the following analyses it is observed that when the wave frequency is less than 1/3 Hz then the wave data get contaminated very fast. That is, higher frequency wave takes longer time to build up the reflection. Figs. 3 to 6 show the wave propagations at Probe #1 to Probe #10 for the wave conditions shown in Table 2. It may be observed that the wave profiles are uniform and pretty close to each other in terms of their magnitude at all the wave probes locations except at those probes, which are close to the beach. This is due to the contamination of the reflected wave. As the wave period increases the wavelength and shallowness increases and thus the nonlinear and second order effects in the wave profile increases. In this experiment the acquired waves data with larger wave period got contaminated very fast.

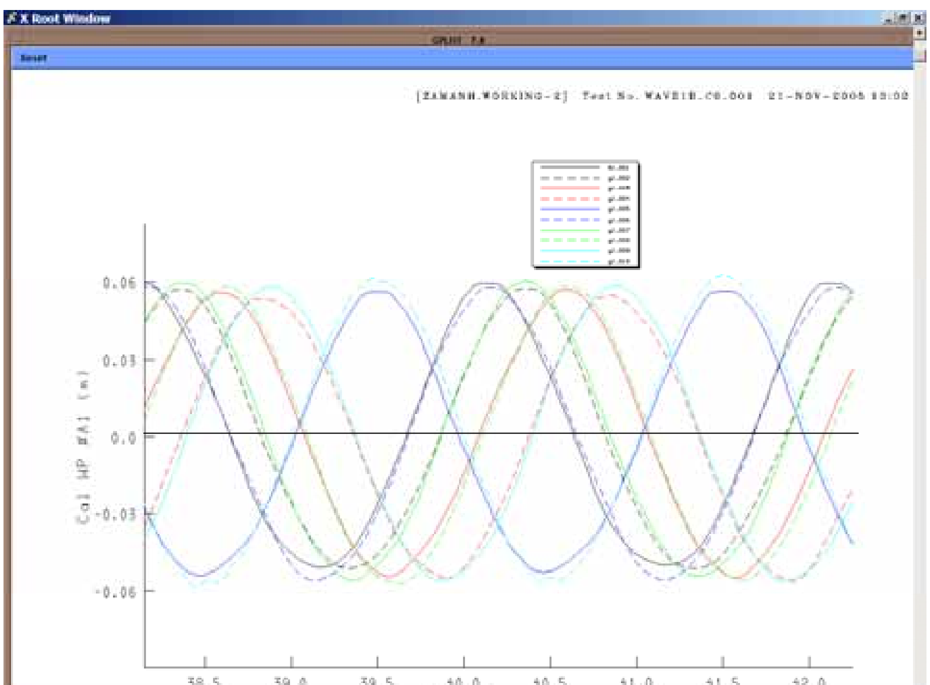
Figs. 7 to 10 show the comparisons of the surface elevations obtained due to the Ist order wave generation technique, second order wave generation technique and those predicted by the code SPWNW.

Figs. 11 to 14 illustrate the energy flux density for the primary and the second order waves for parameters shown in Table 2 due to the second order wave generation technique.



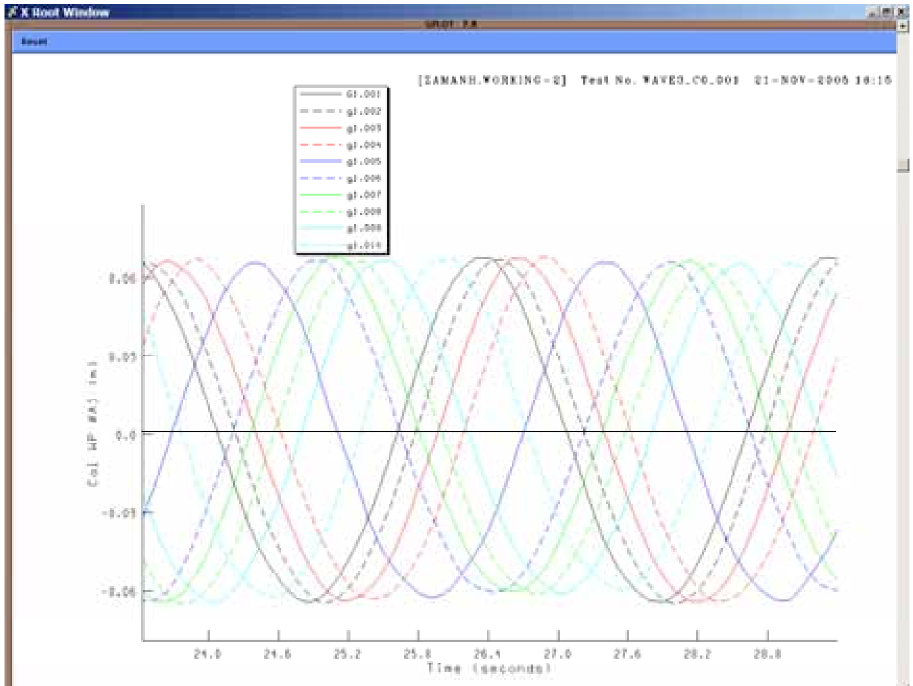
Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	2	0.06013907	6.013907	0.01	0.315934383

Fig. 3a Surface elevation at Probe #1 to Probe #10.



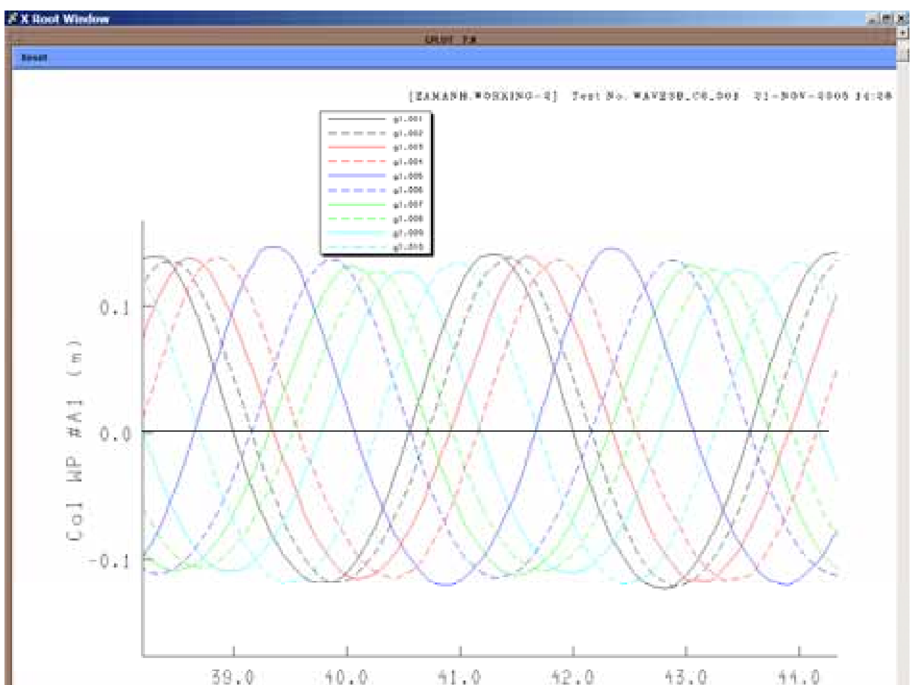
Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	2	0.12027814	6.013907	0.02	0.315934383

Fig. 3b Surface elevation at Probe #1 to Probe #10.



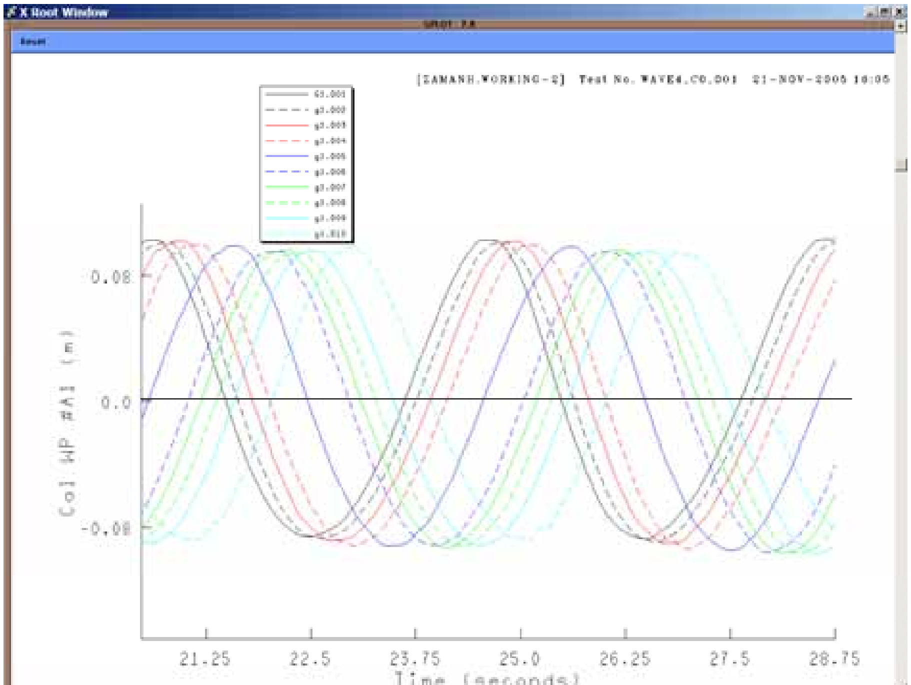
Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	3	0.1111481	11.11481	0.01	0.170943093

Fig. 4a Surface elevation at Probe #1 to Probe #10.



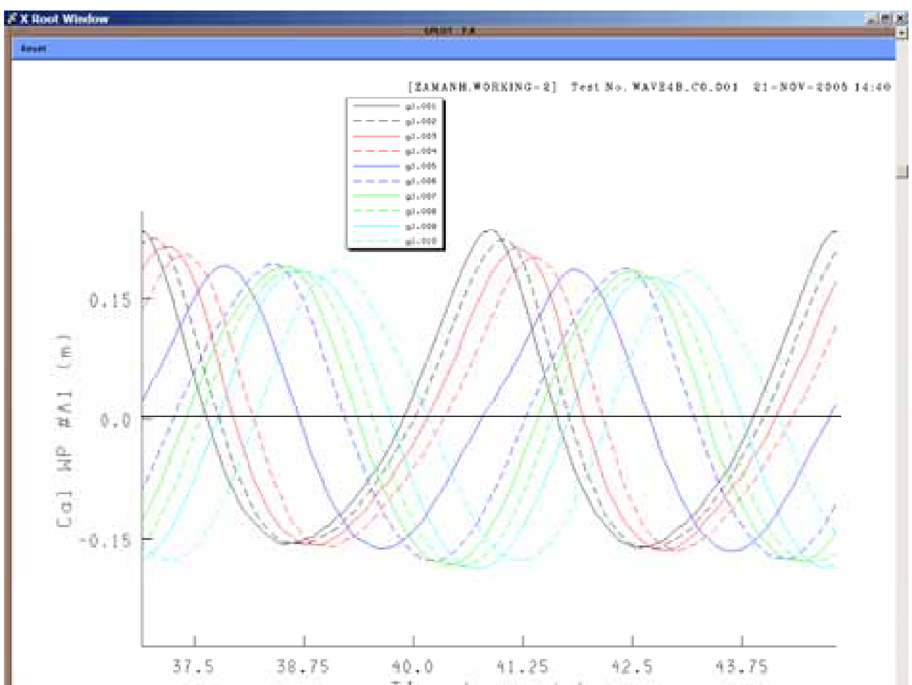
Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	3	0.2222962	11.11481	0.02	0.170943093

Fig. 4b Surface elevation at Probe #1 to Probe #10.



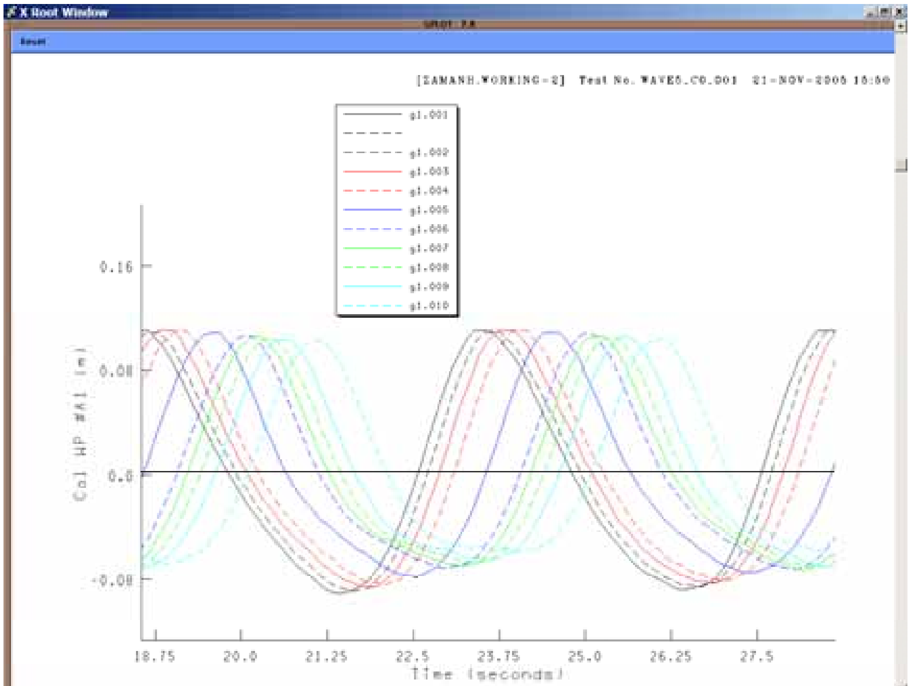
Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	4	0.158875904	15.8875904	0.01	0.119590193

Fig. 5a Surface elevation at Probe #1 to Probe #10



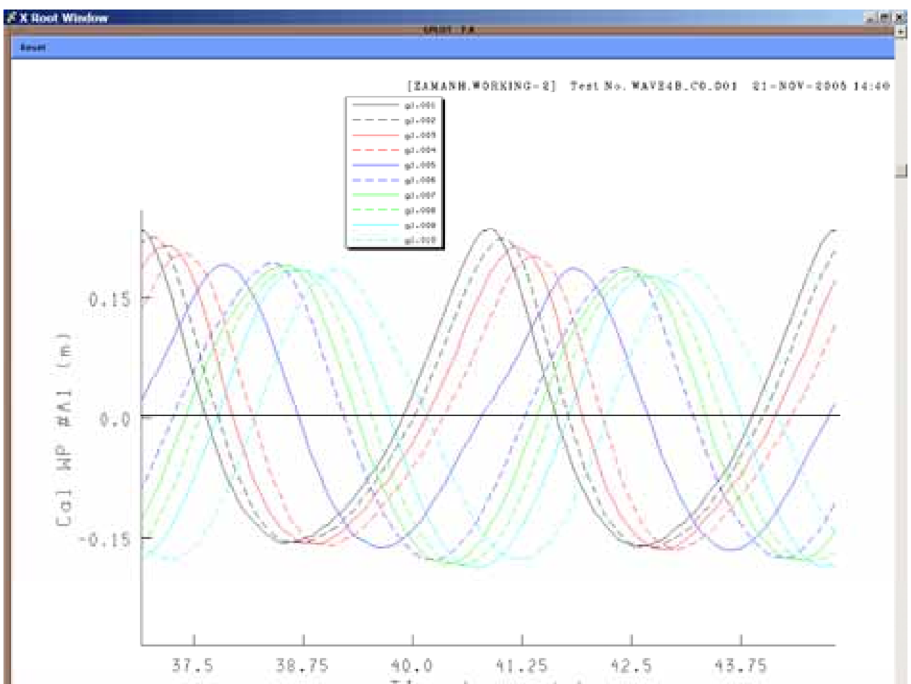
Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	4	0.317751808	15.8875904	0.02	0.119590193

Fig. 5b Surface elevation at Probe #1 to Probe #10



Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	5	0.204819832	20.4819832	0.01	0.092764455

Fig. 6a Surface elevation at Probe #1 to Probe #10



Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	4	0.317751808	15.8875904	0.02	0.119590193

Fig. 6b Surface elevation at Probe #1 to Probe #10

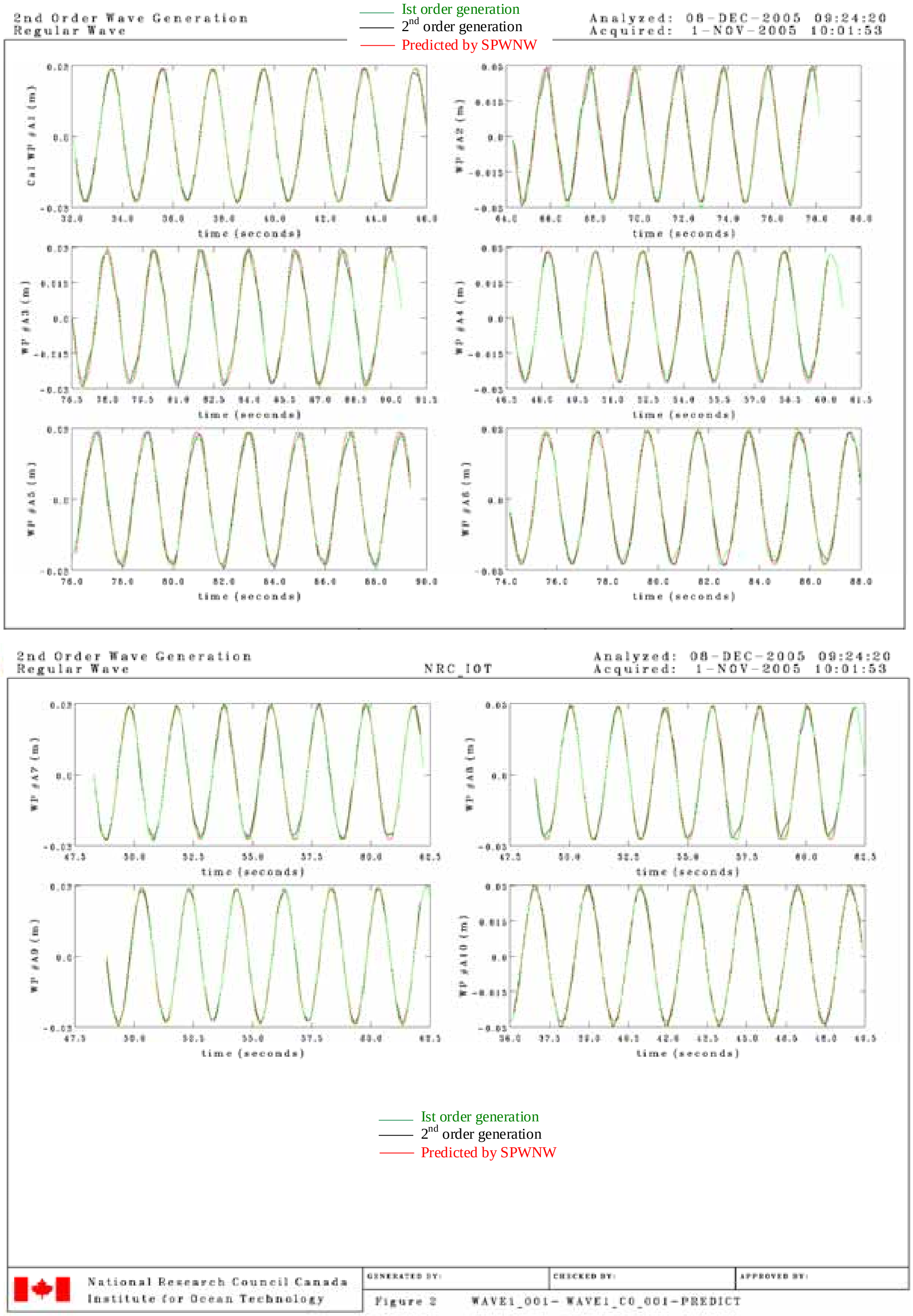
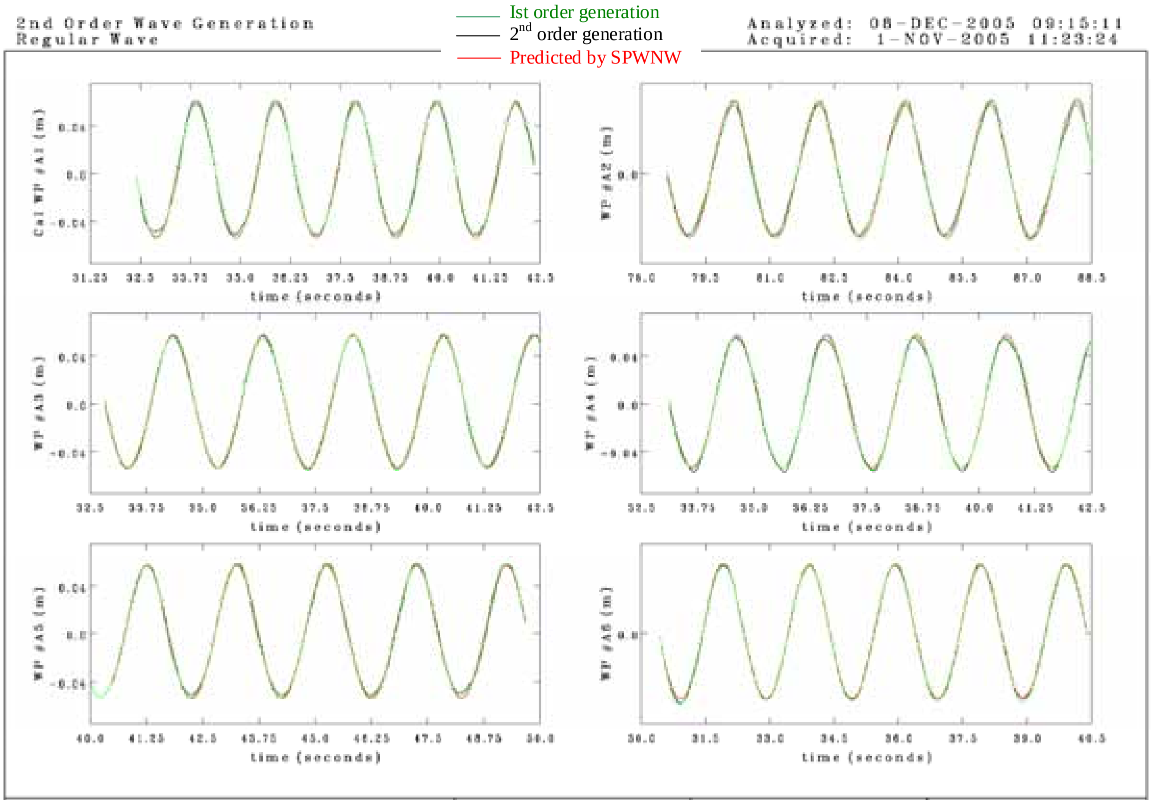


Fig. 7a Comparisons of the surface elevations at Probe #1 to Probe #10

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	2	0.06013907	6.013907	0.01	0.315934383



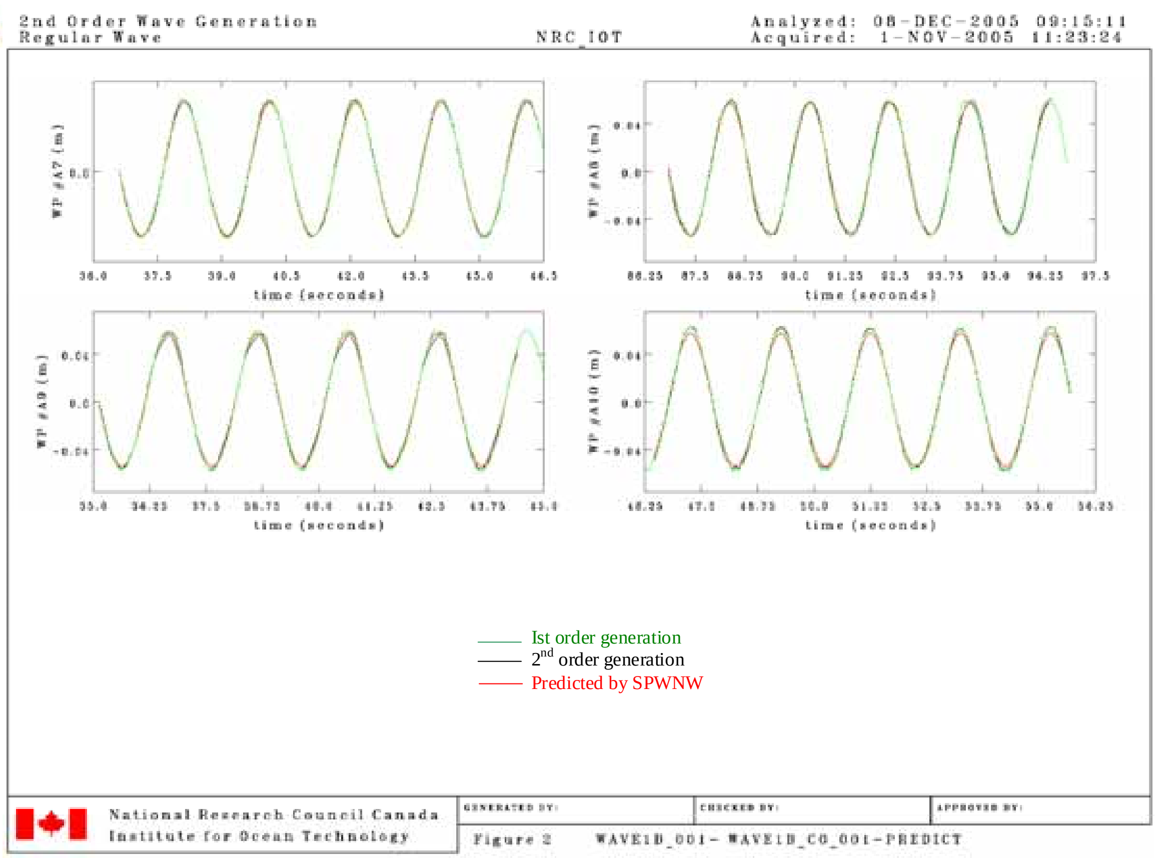


Fig. 7b Comparisons of the surface elevations at Probe #1 to Probe #10

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	2	0.12027814	6.013907	0.02	0.315934383

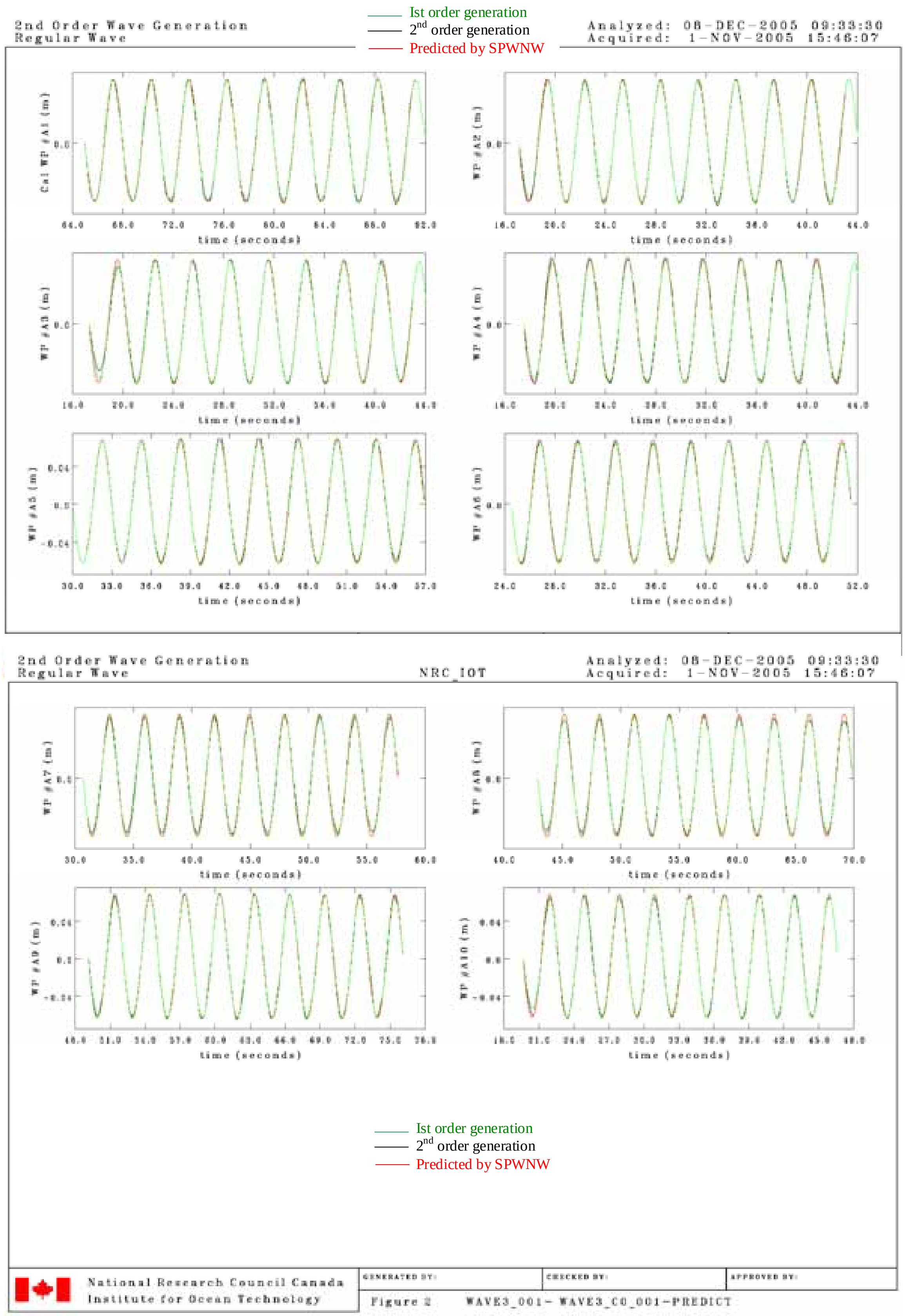


Fig. 8a Comparisons of the surface elevations at Probe #1 to Probe #10

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	3	0.1111481	11.11481	0.01	0.170943093

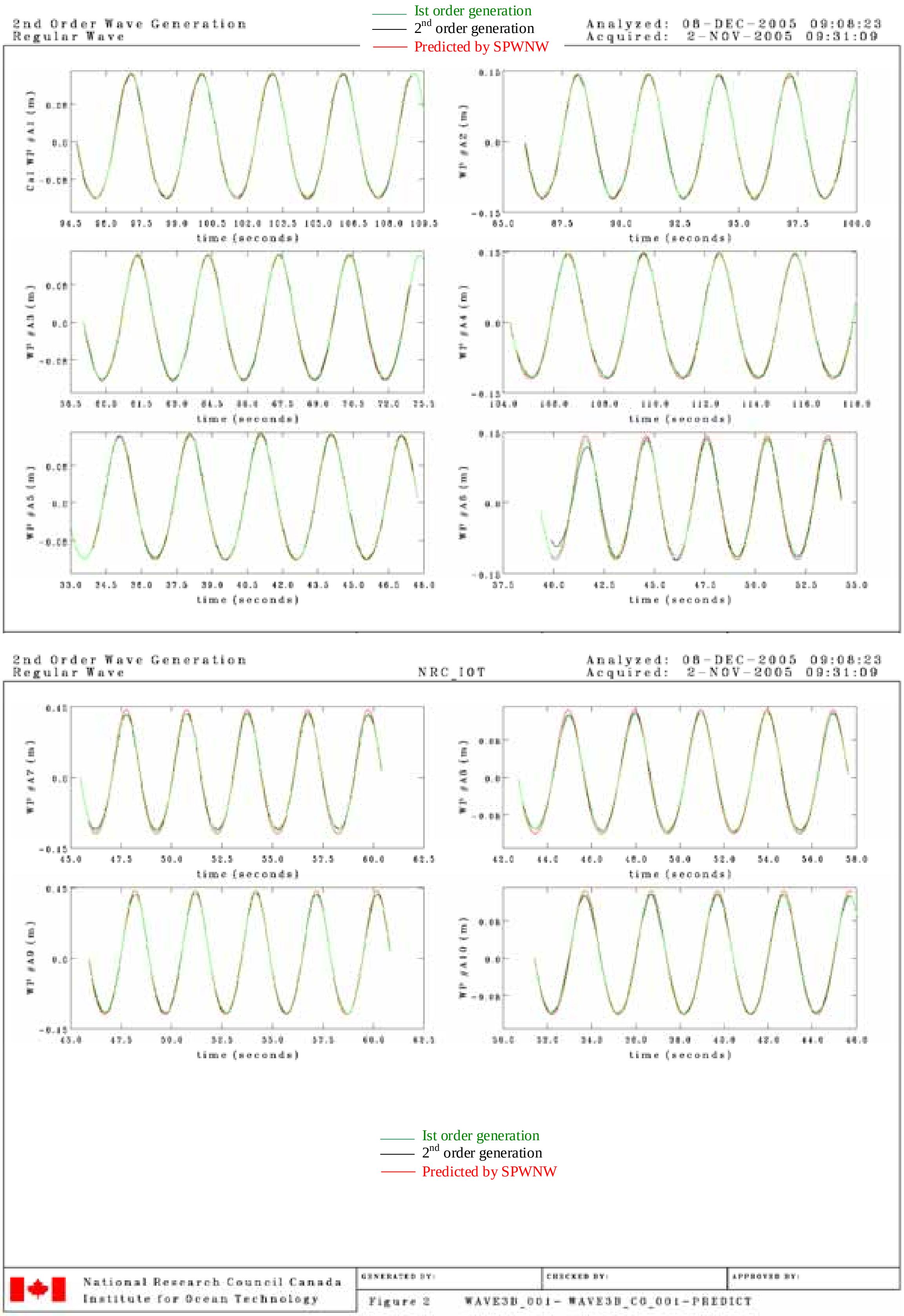


Fig. 8b Comparisons of the surface elevations at Probe #1 to Probe #10

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	3	0.2222962	11.11481	0.02	0.170943093

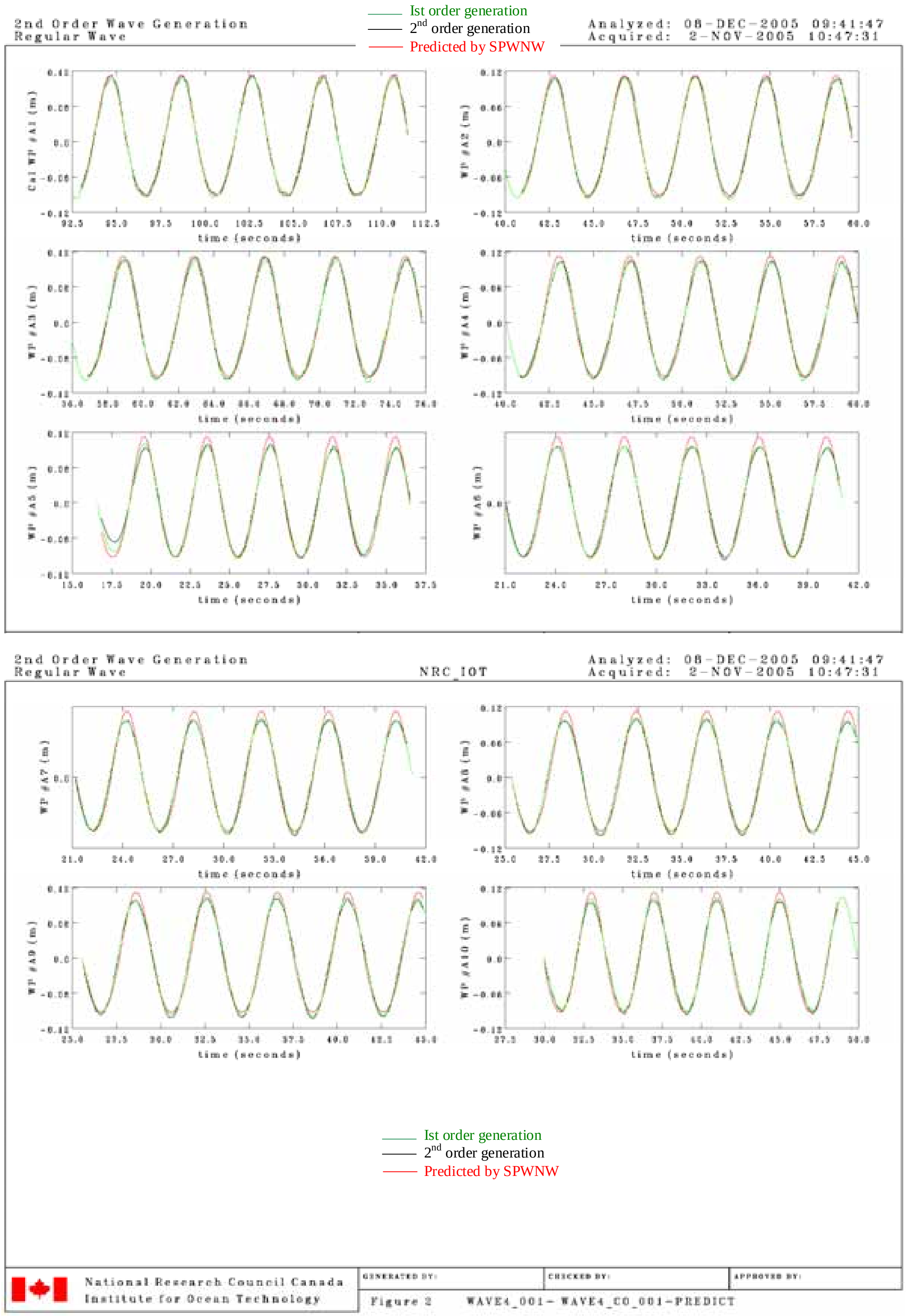


Fig. 9a Comparisons of the surface elevations at Probe #1 to Probe #10

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	4	0.158875904	15.8875904	0.01	0.119590193

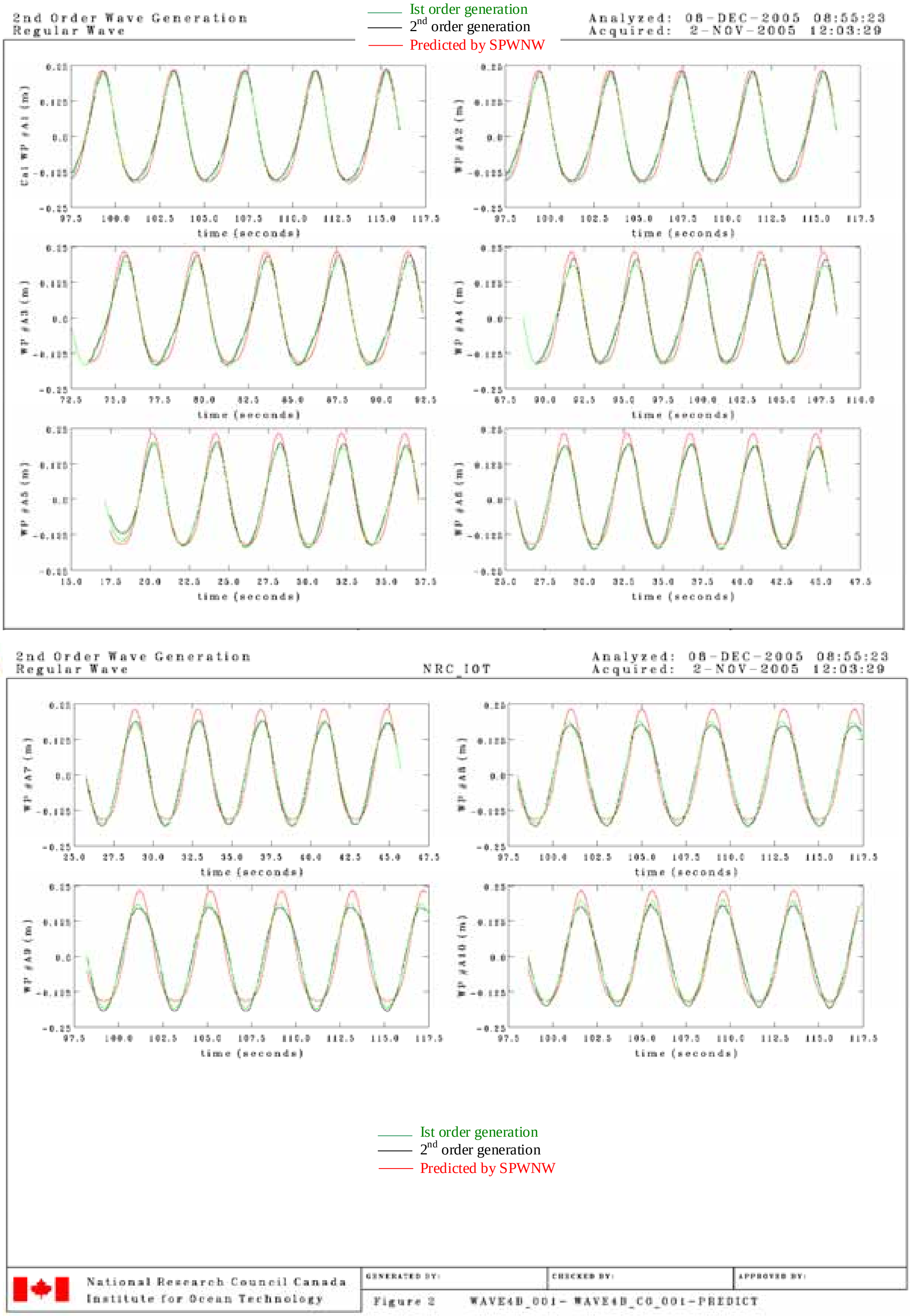


Fig. 9b Comparisons of the surface elevations at Probe #1 to Probe #10

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	4	0.317751808	15.8875904	0.02	0.119590193

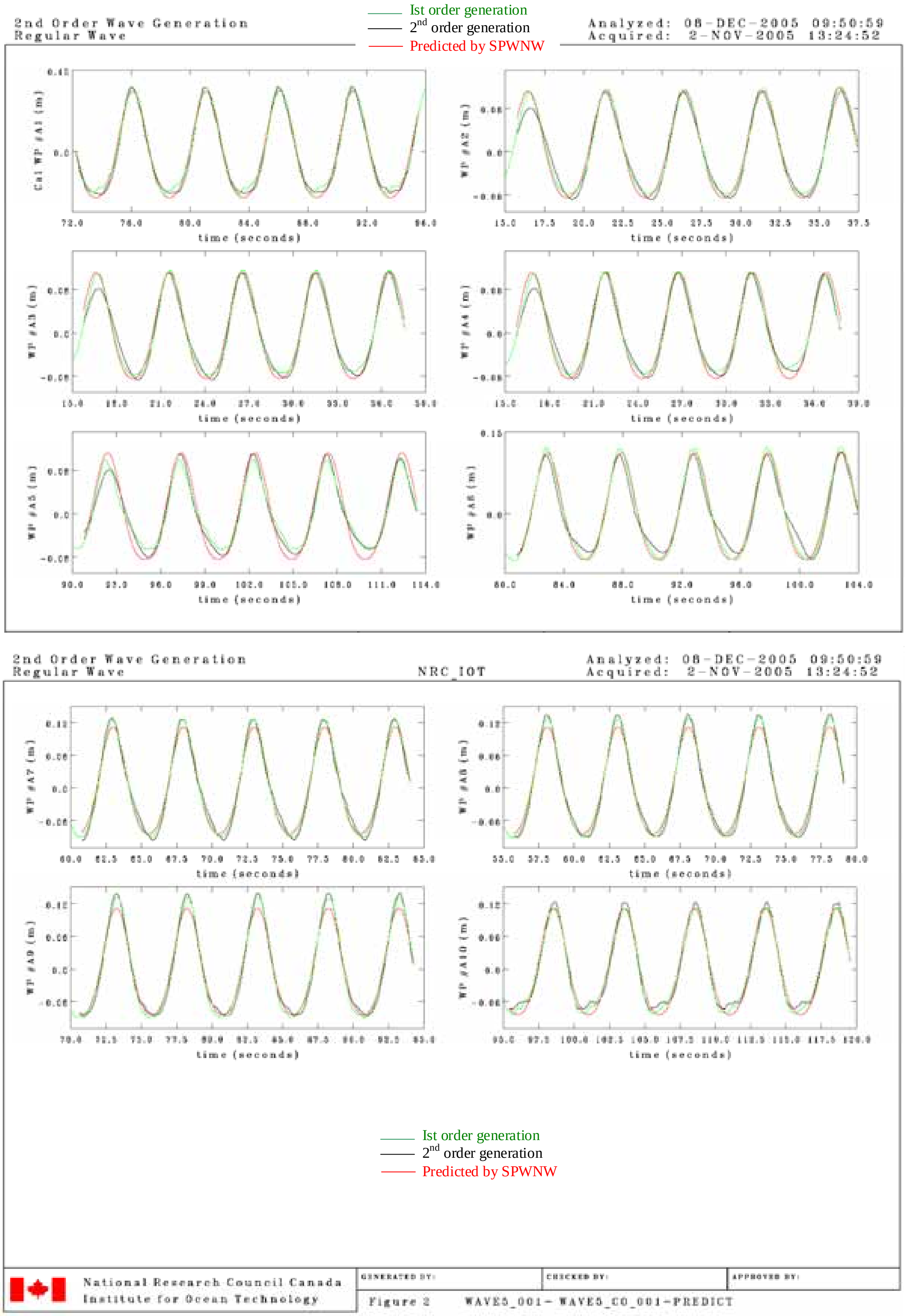
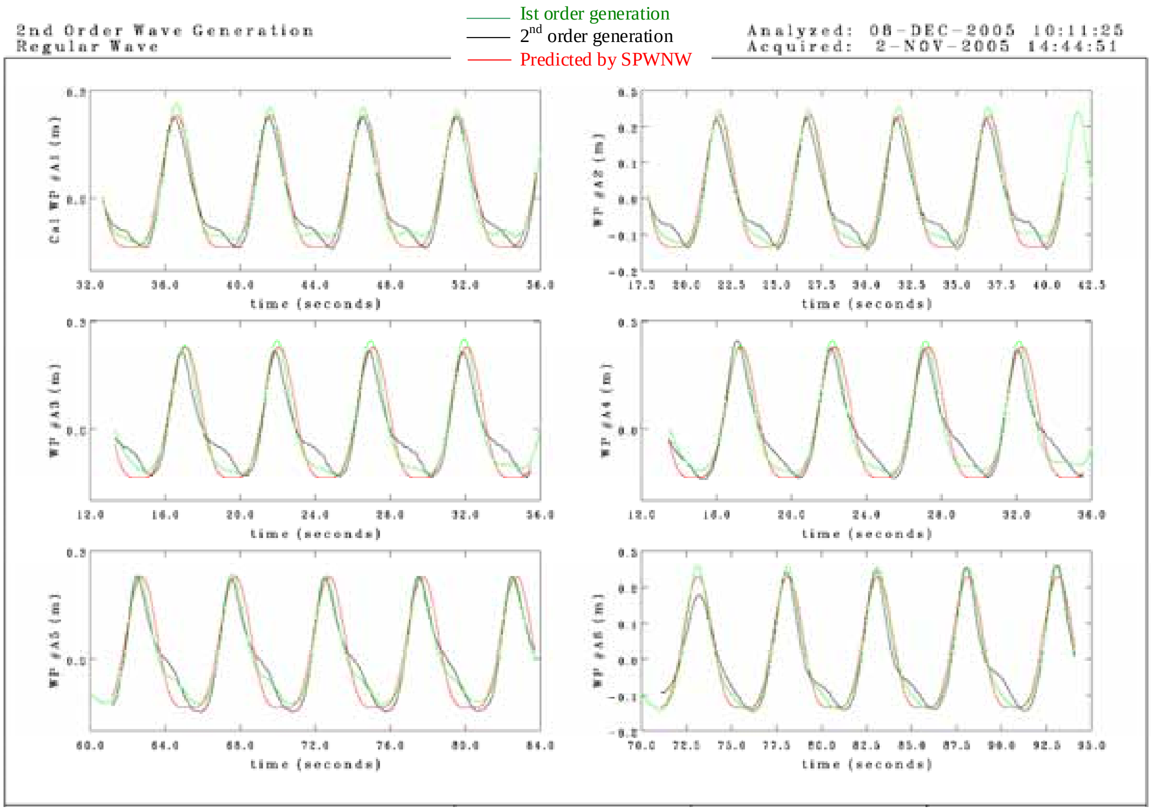


Fig. 10a Comparisons of the surface elevations at Probe #1 to Probe #10

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	5	0.204819832	20.4819832	0.01	0.092764455



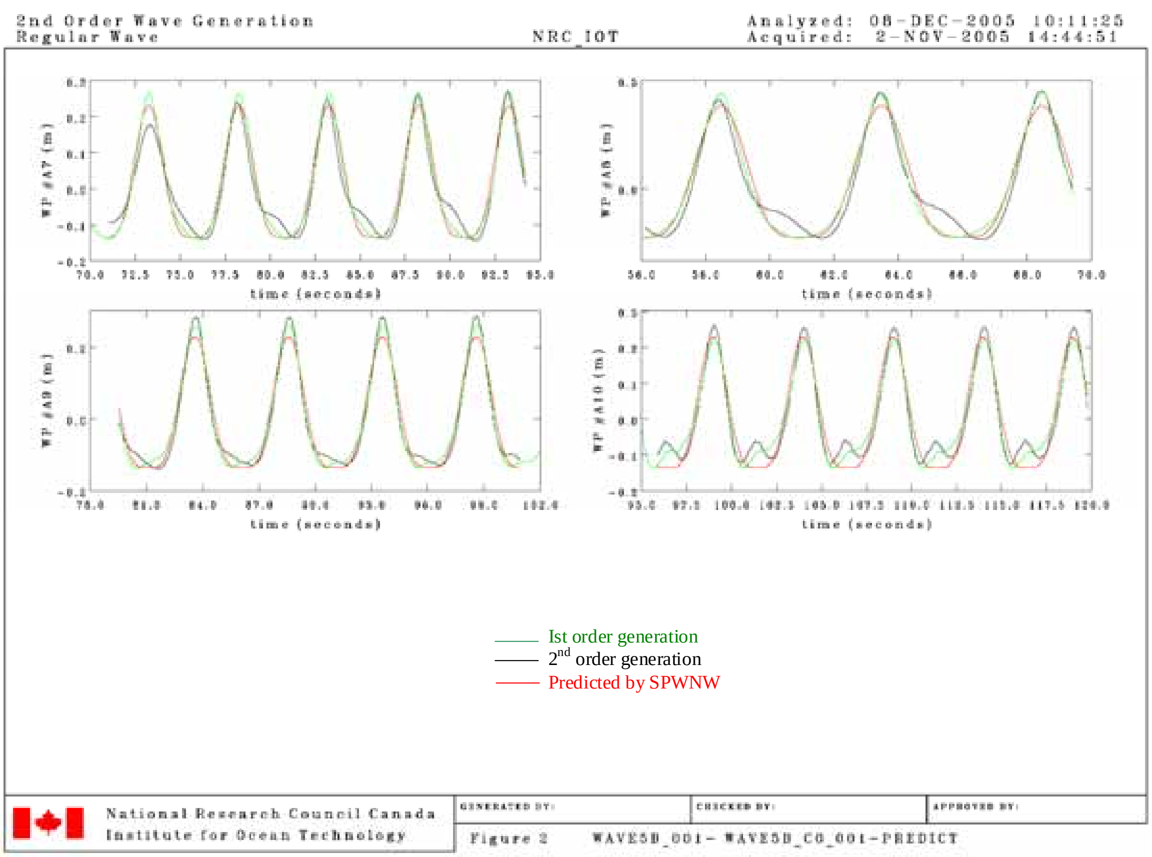


Fig. 10b Comparisons of the surface elevations at Probe #7 to Probe #10

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	5	0.409639664	20.4819832	0.02	0.092764455

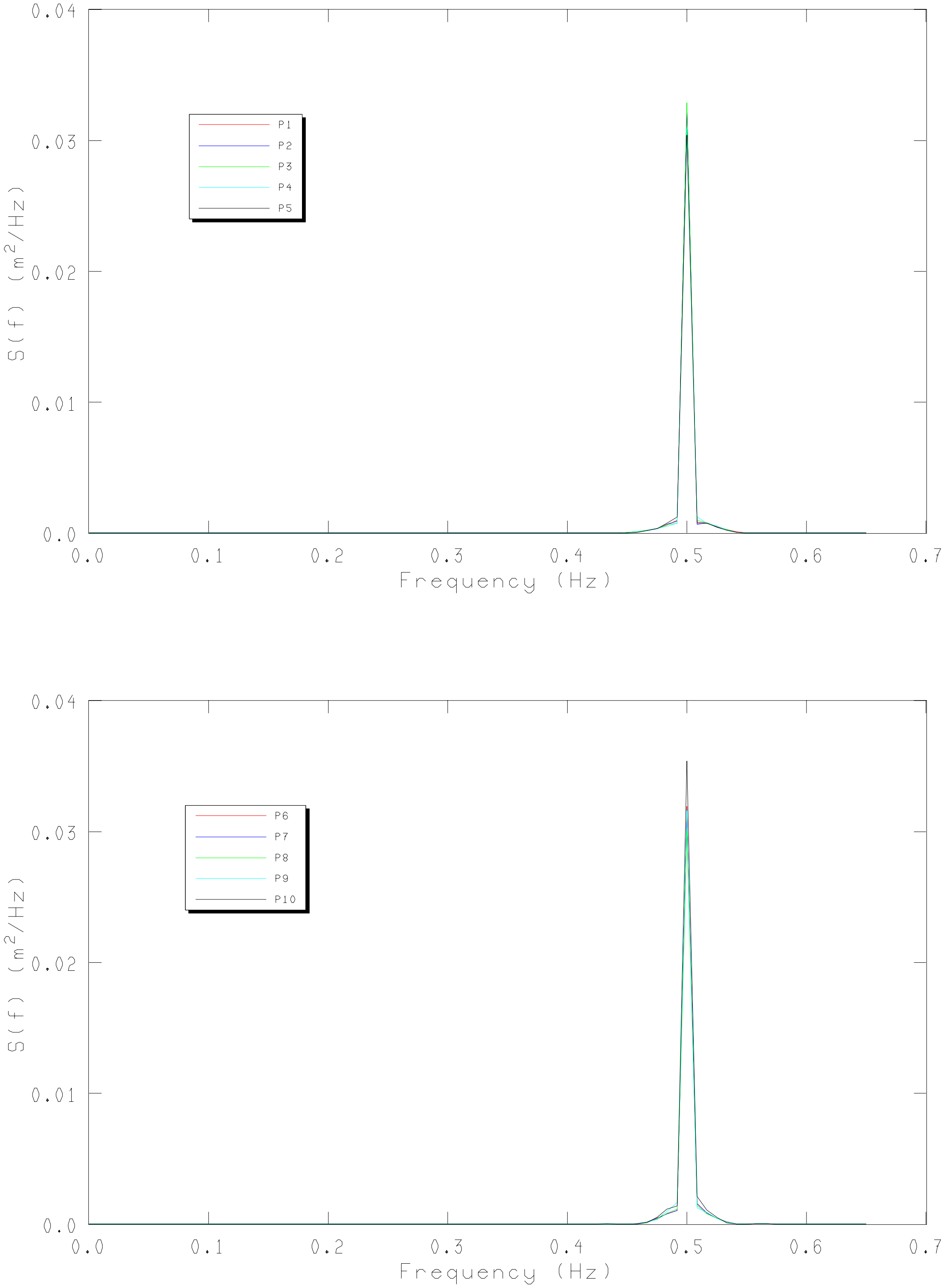
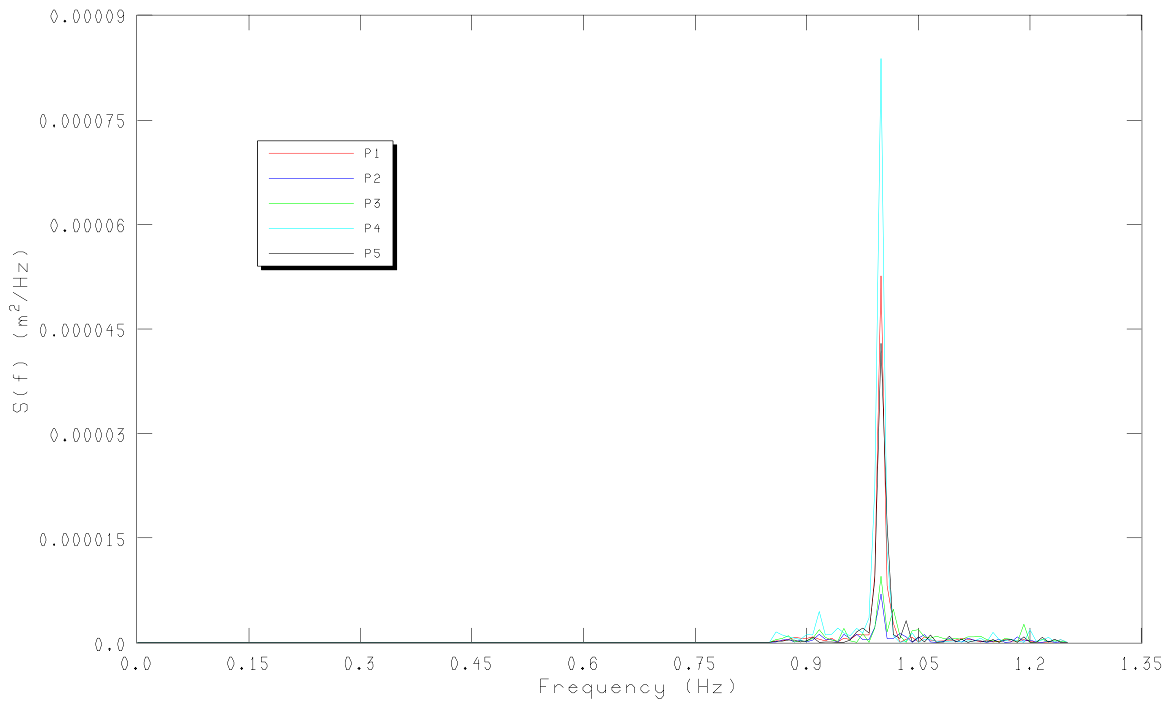


Fig. 11a(P1) Energy density at probes #1 to #10 for primary waves

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	2	0.06013907	6.013907	0.01	0.315934383



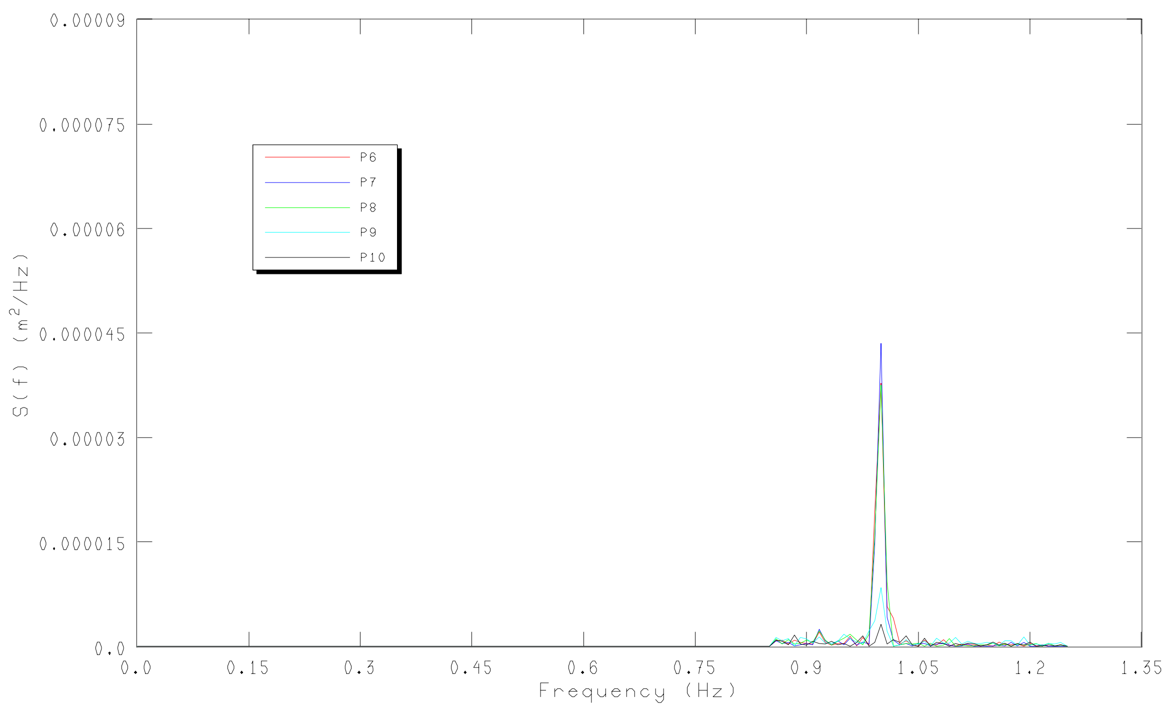
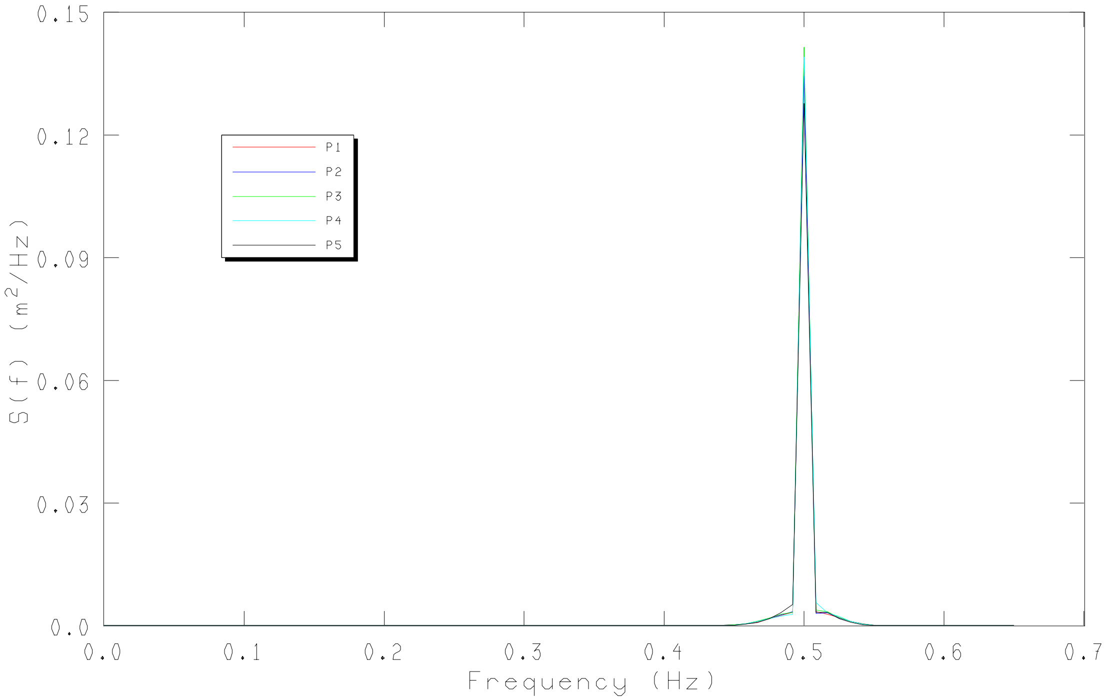


Fig. 11a(P2) Energy density at probes #1 to #10 for second order waves

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	2	0.06013907	6.013907	0.01	0.315934383



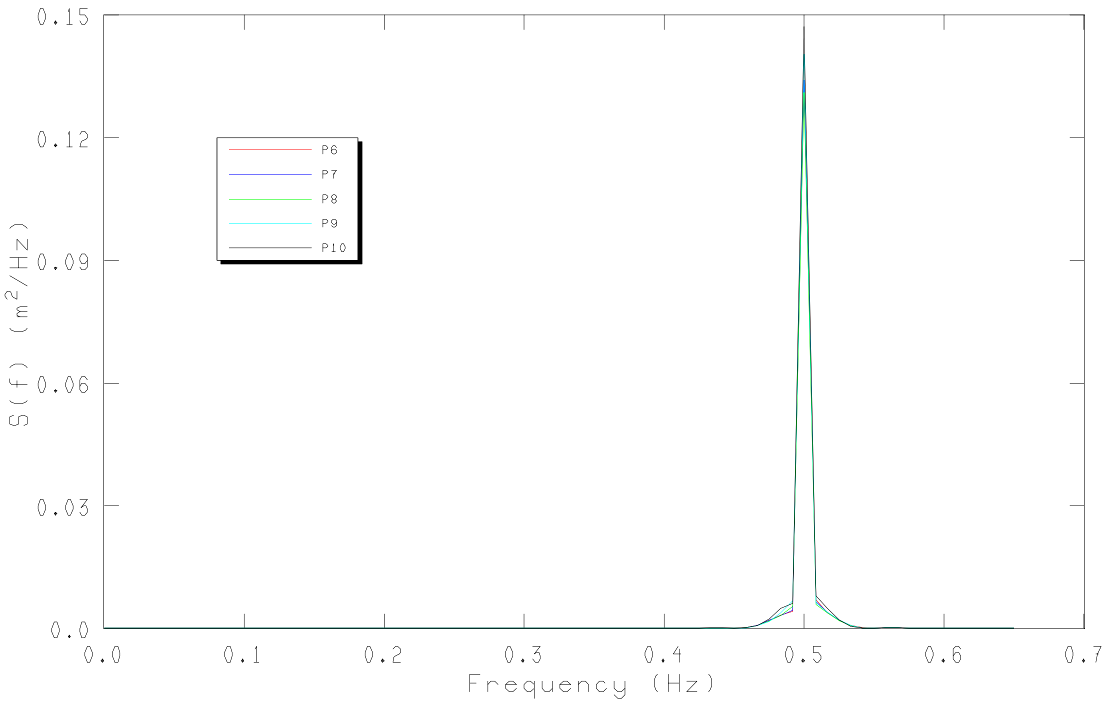
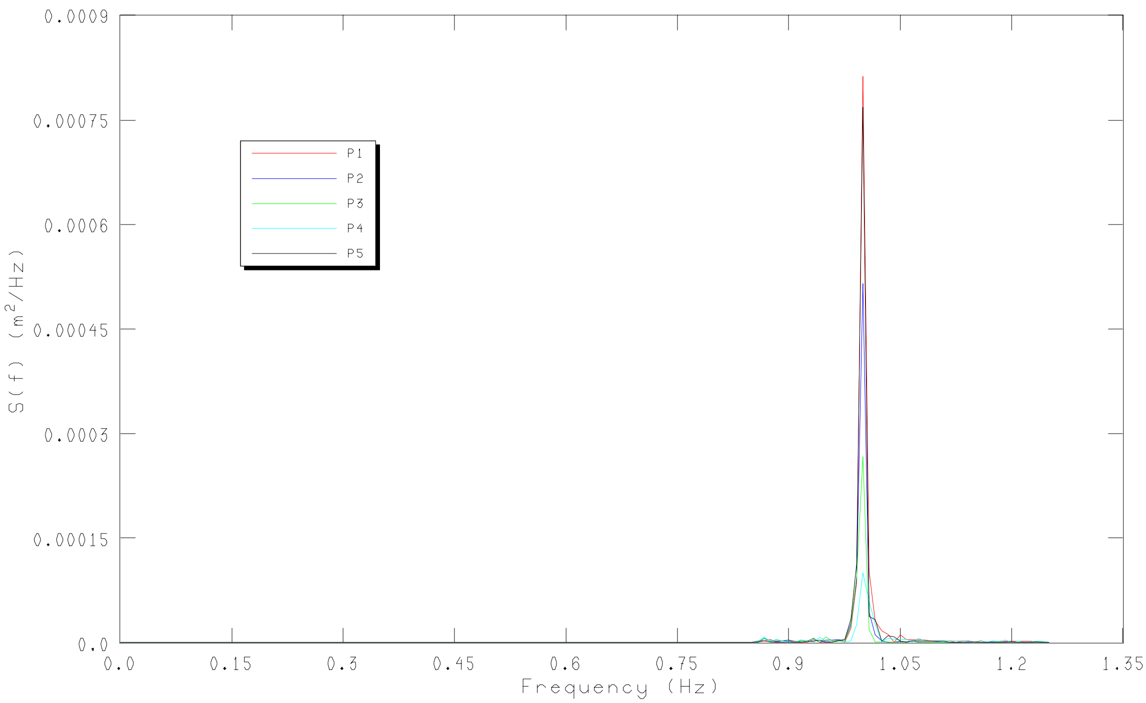


Fig. 11b(P1) Energy density at probes #1 to #10 for primary waves

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	2	0.12027814	6.013907	0.02	0.315934383



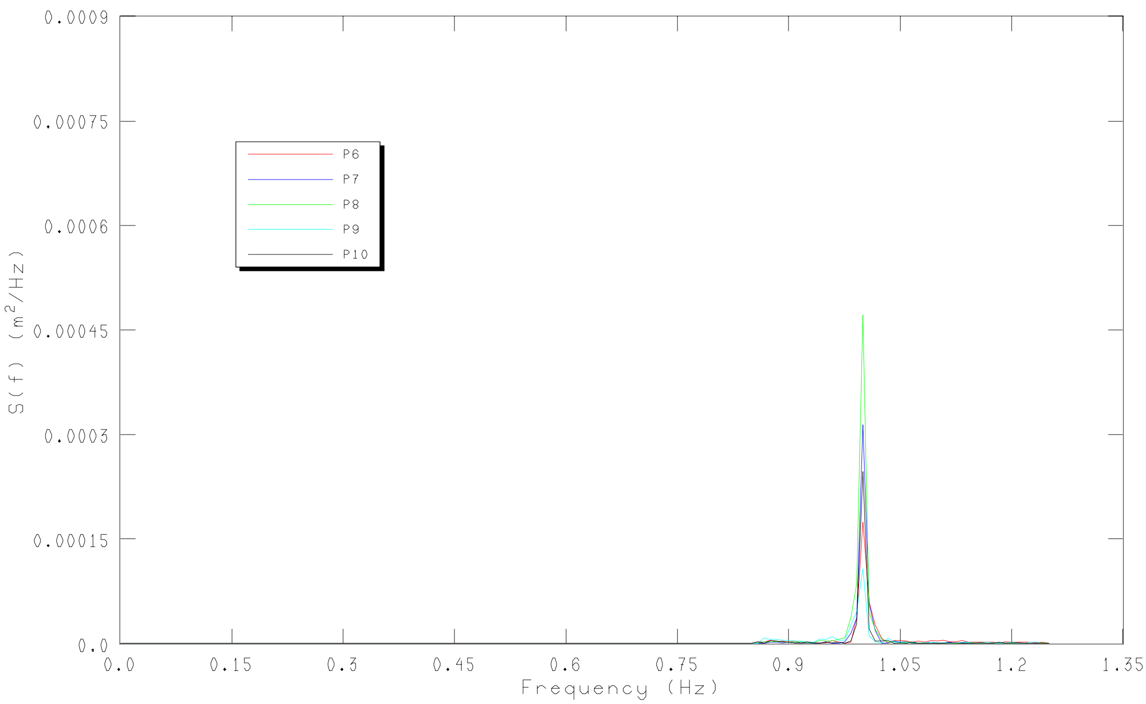
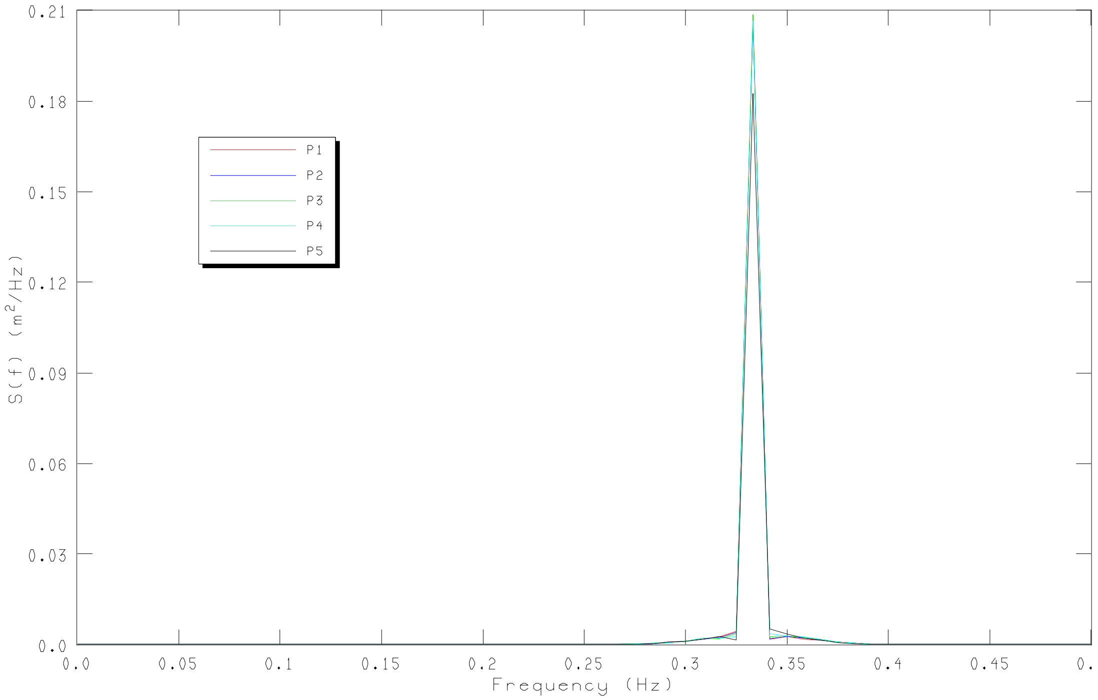


Fig. 11b(P2) Energy density at probes #1 to #10 for second order waves

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	2	0.12027814	6.013907	0.02	0.315934383



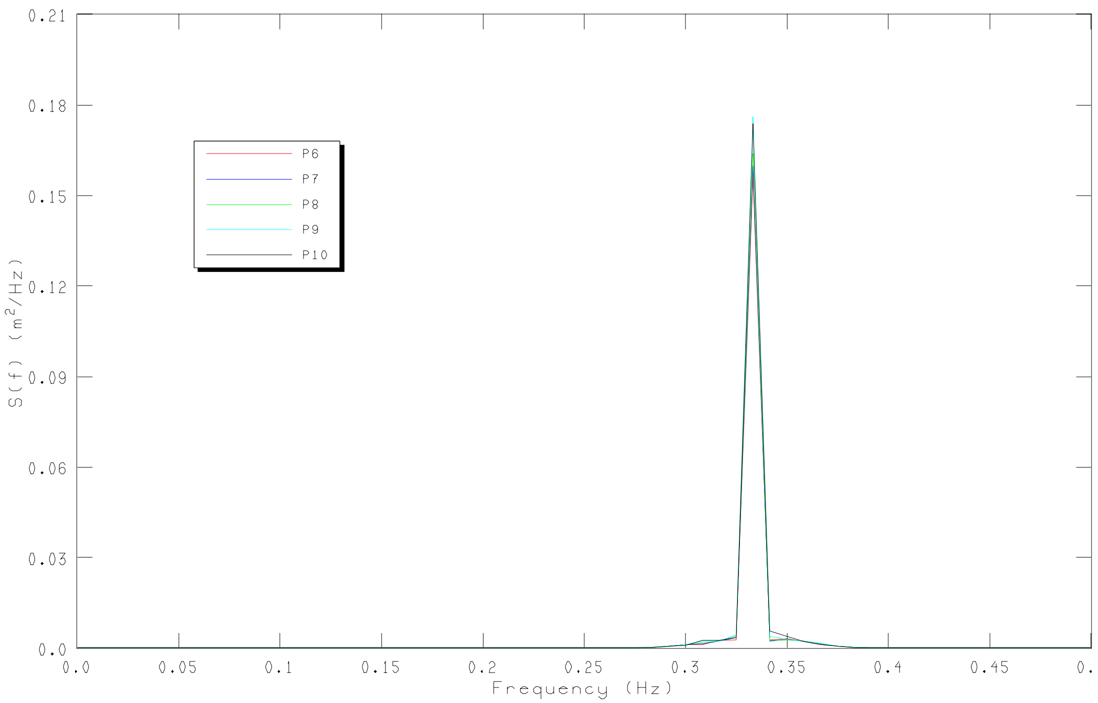
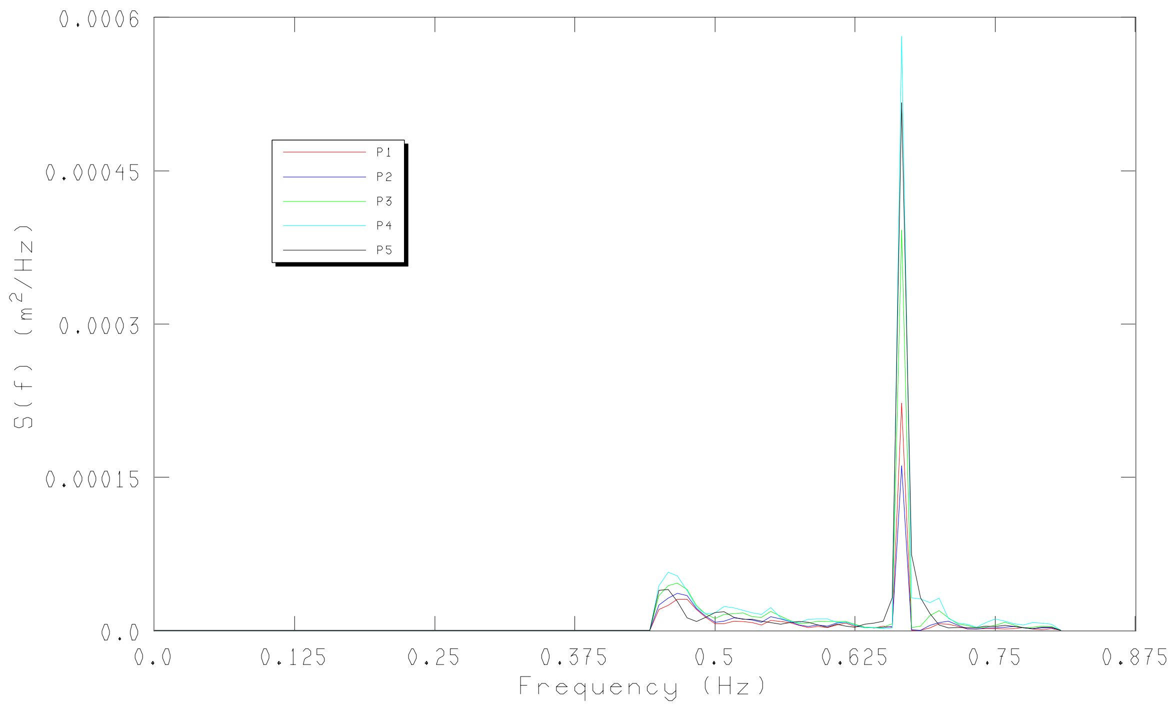


Fig. 12a(P1) Energy density at probes #1 to #10 for primary waves

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	3	0.1111481	11.11481	0.01	0.170943093



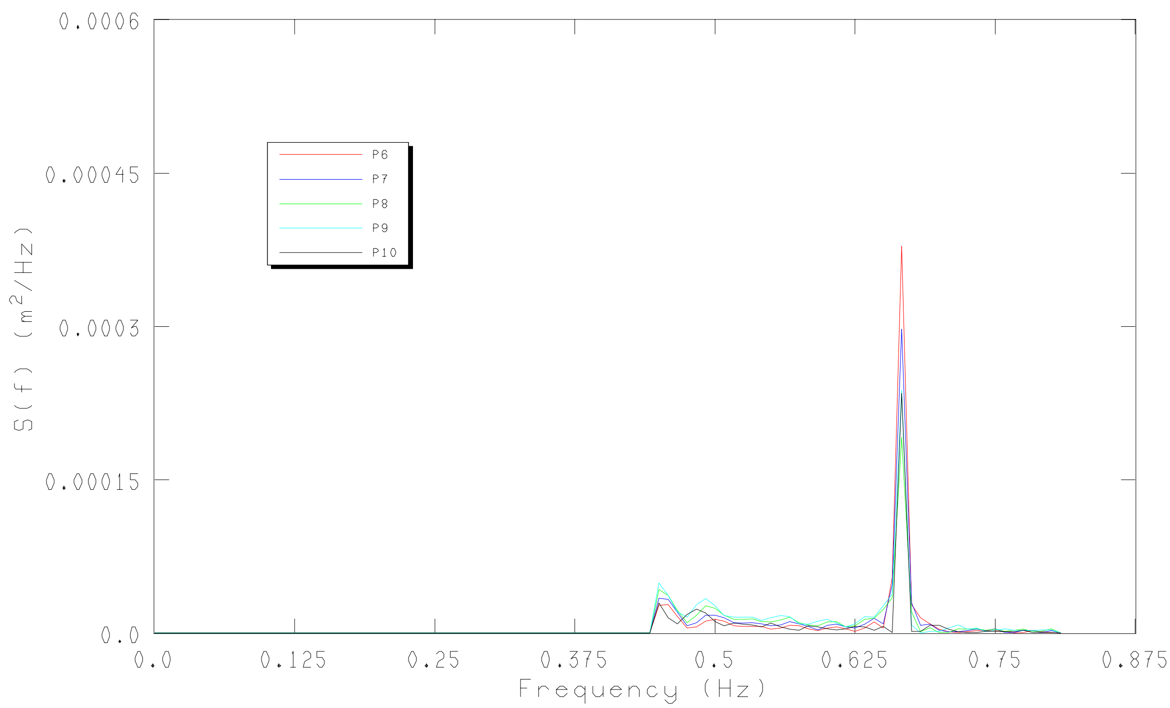
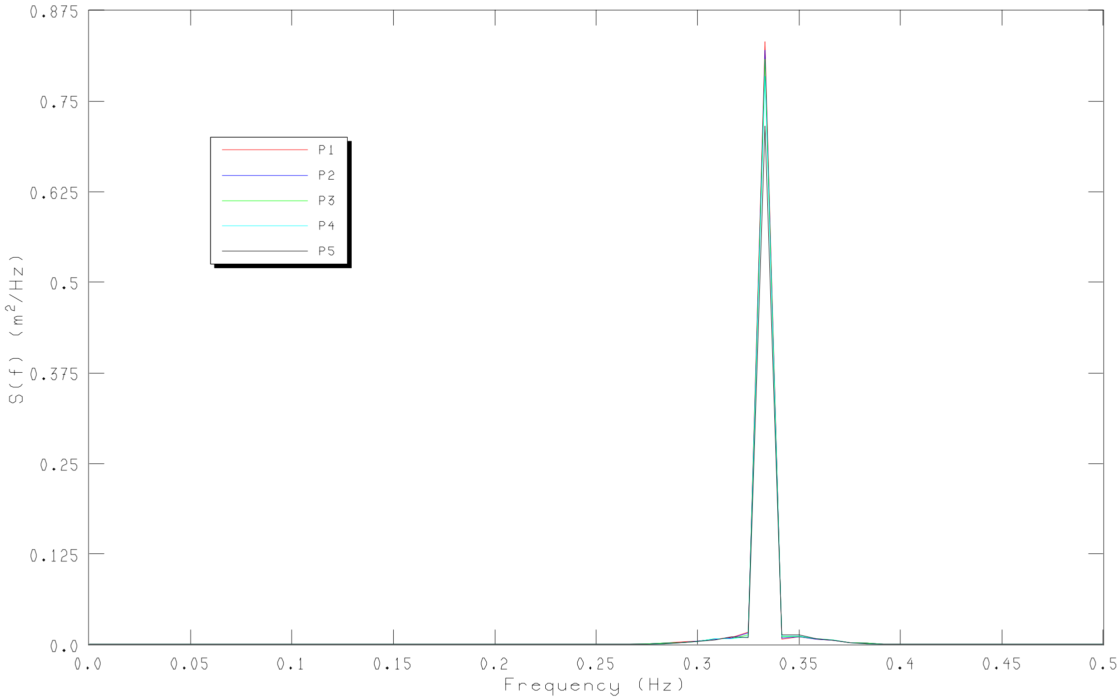


Fig. 12a(P2) Energy density at probes #1 to #10 for second order waves

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	3	0.1111481	11.11481	0.01	0.170943093



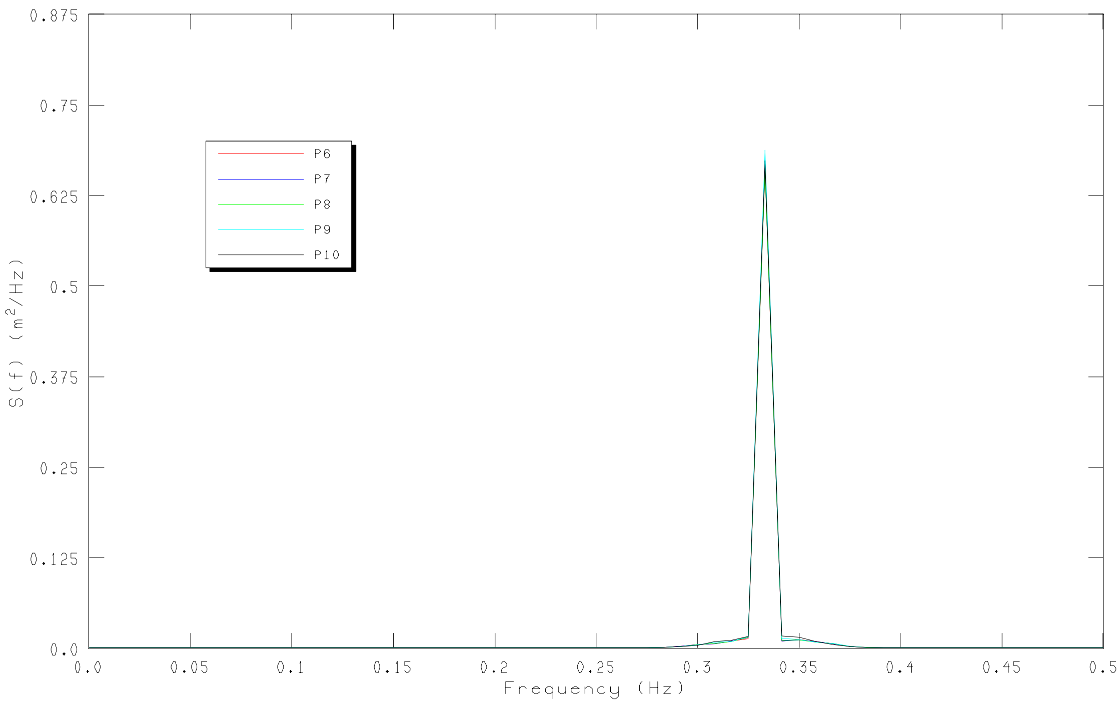
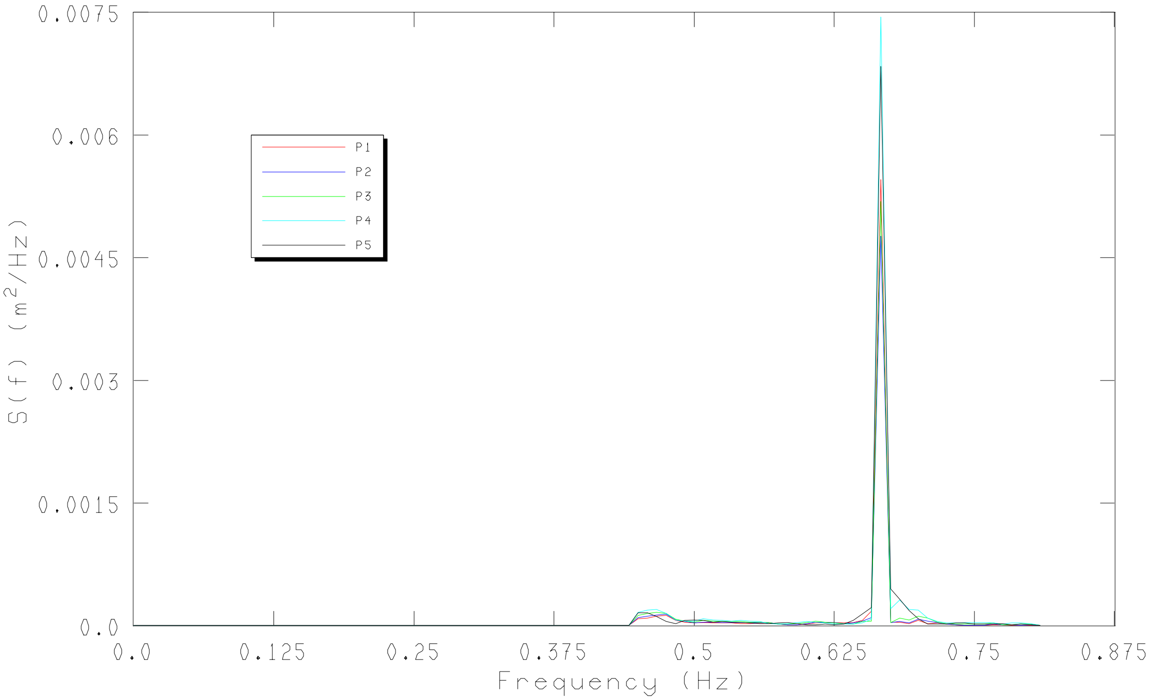


Fig. 12b(P1) Energy density at probes #1 to #10 for primary waves

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	3	0.2222962	11.11481	0.02	0.170943093



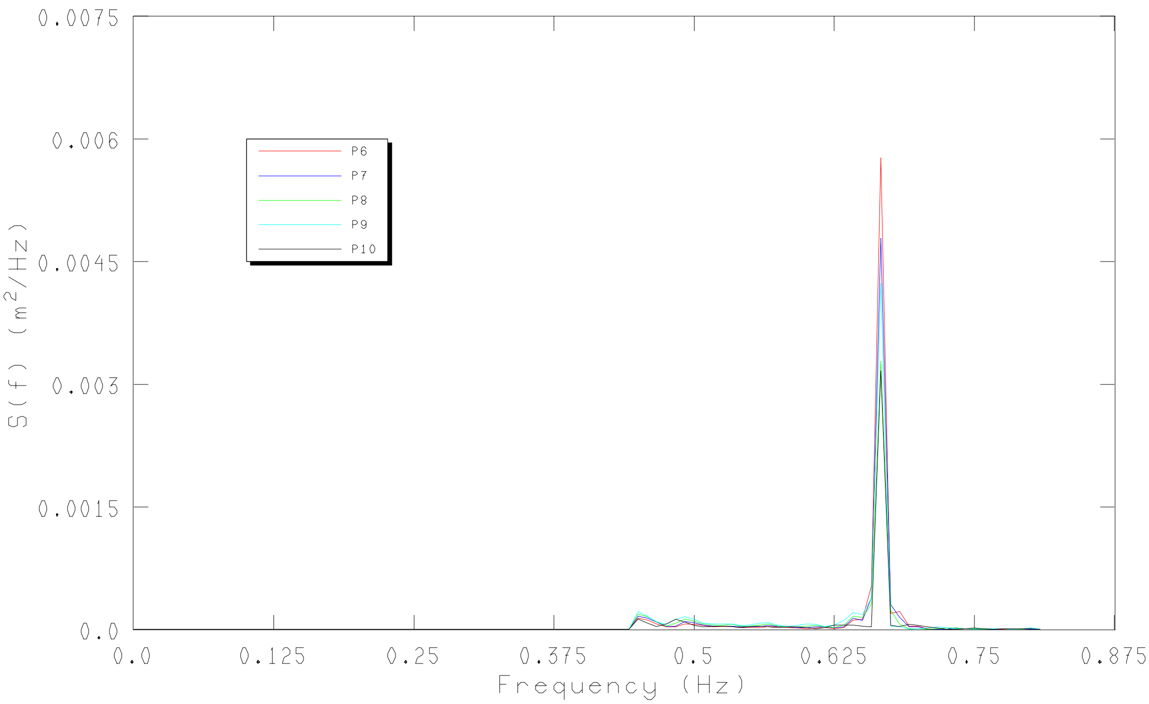
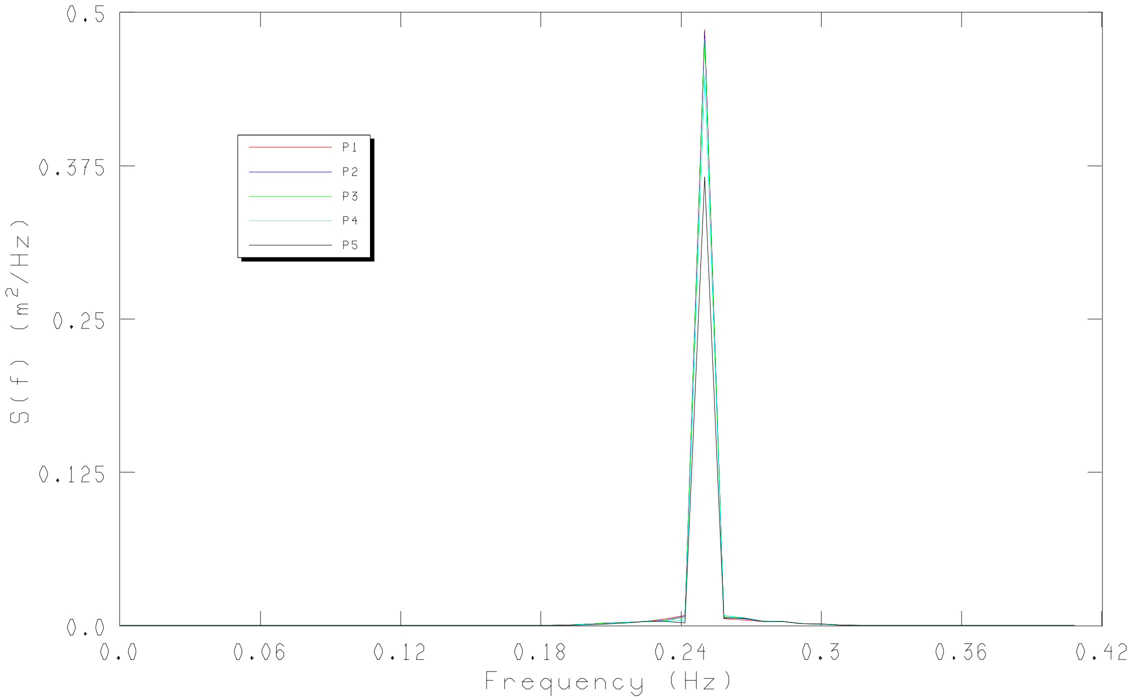


Fig. 12b(P2) Energy density at probes #1 to #10 for second order waves

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	3	0.2222962	11.11481	0.02	0.170943093



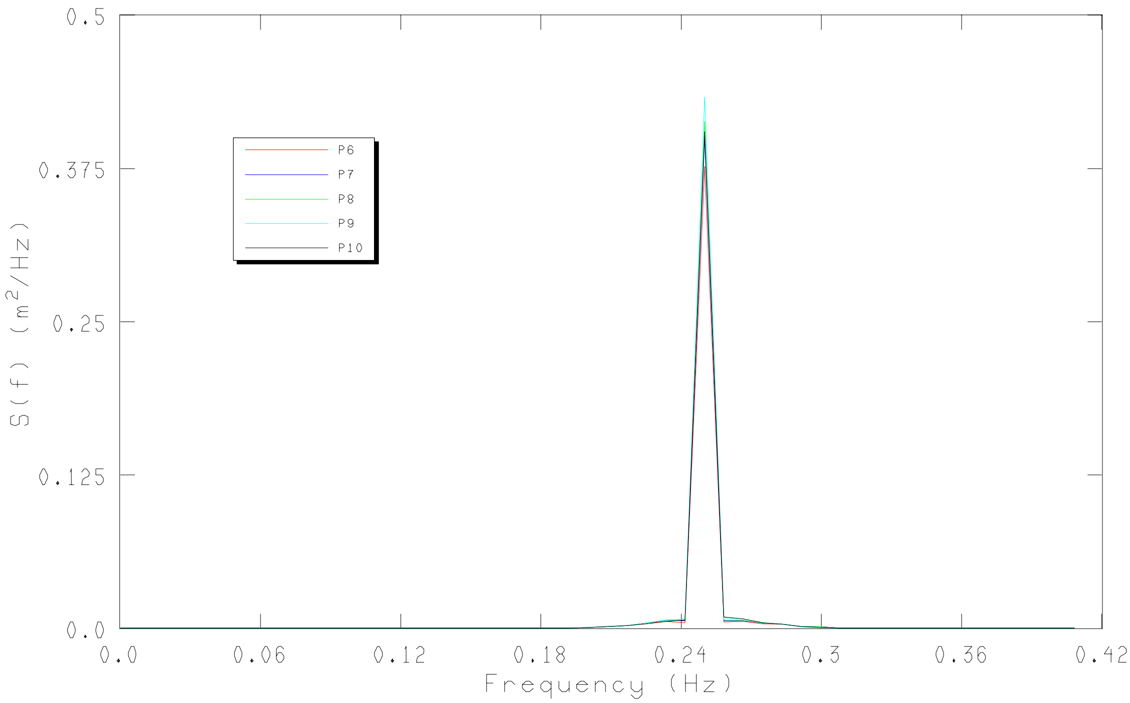
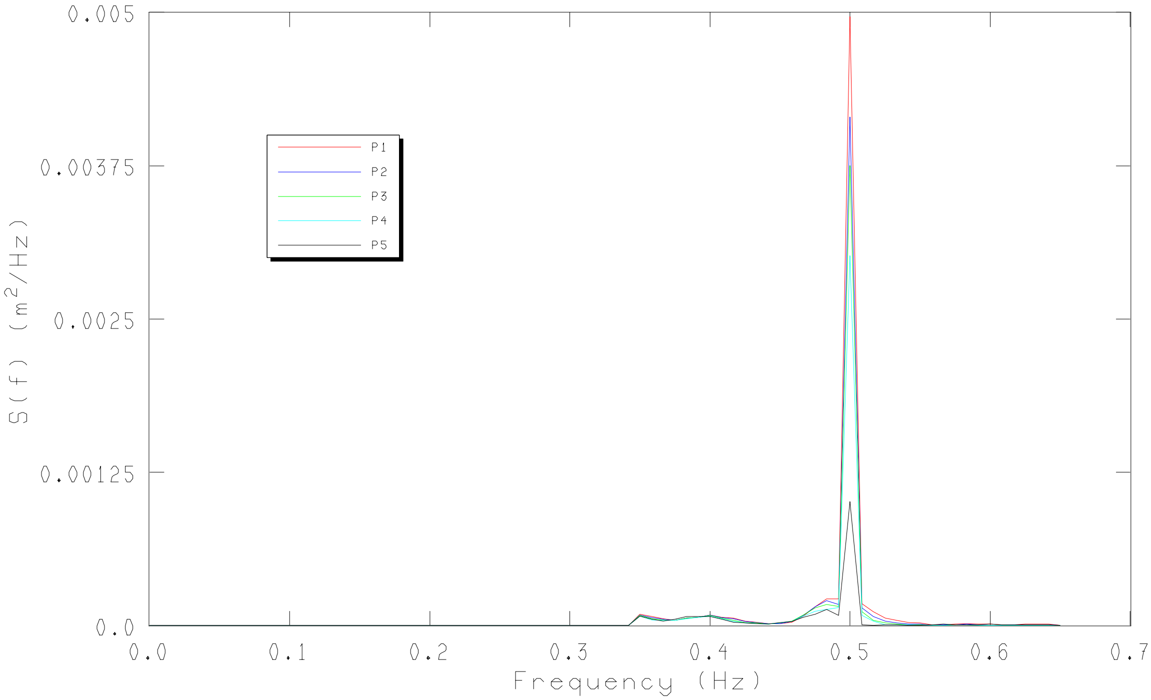


Fig. 13a(P1) Energy density at probes #1 to #10 for primary waves

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	4	0.158875904	15.8875904	0.01	0.119590193



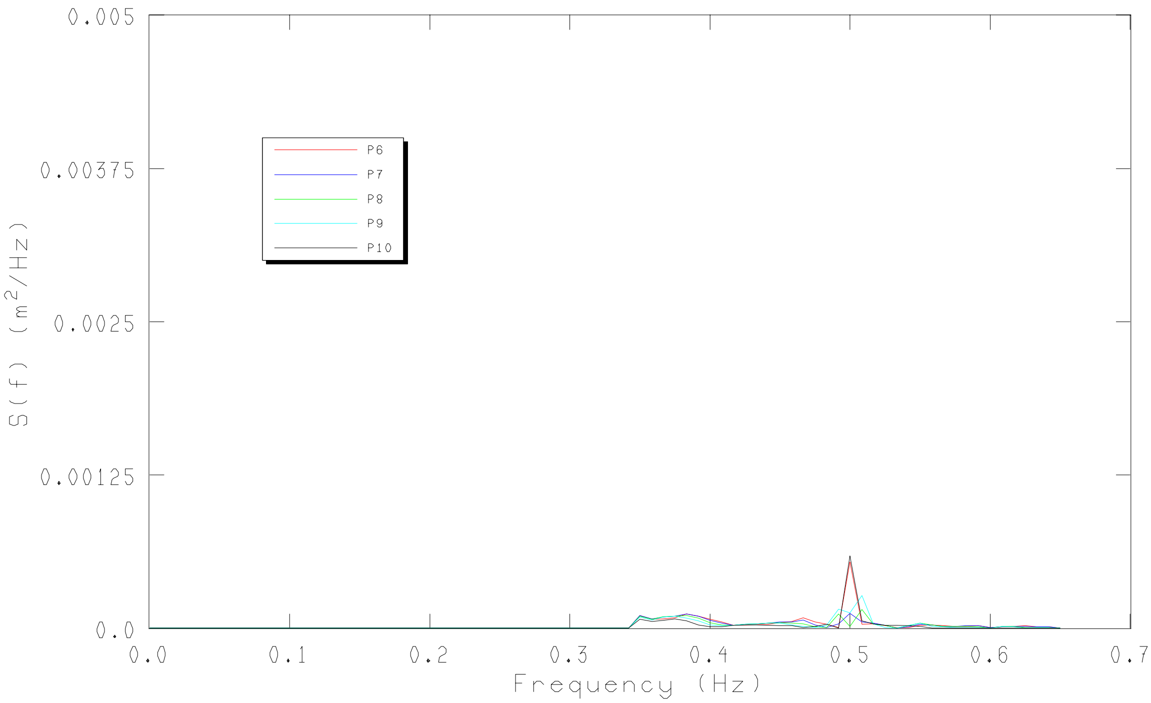
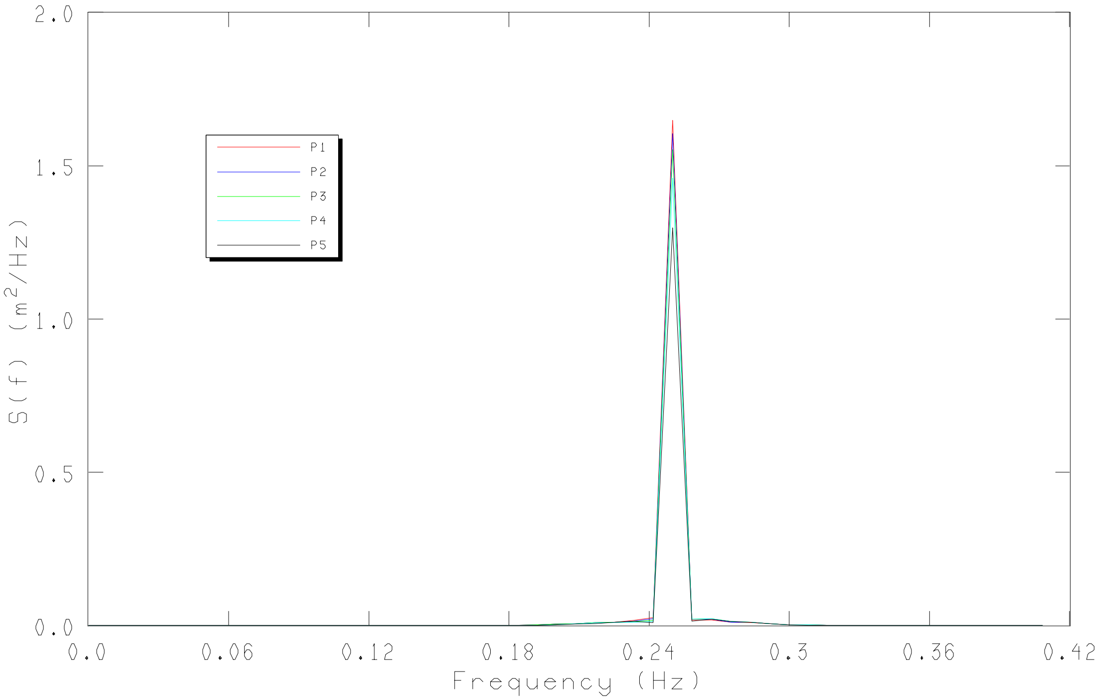


Fig. 13a(P2) Energy density at probes #1 to #10 for second order waves

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	4	0.158875904	15.8875904	0.01	0.119590193



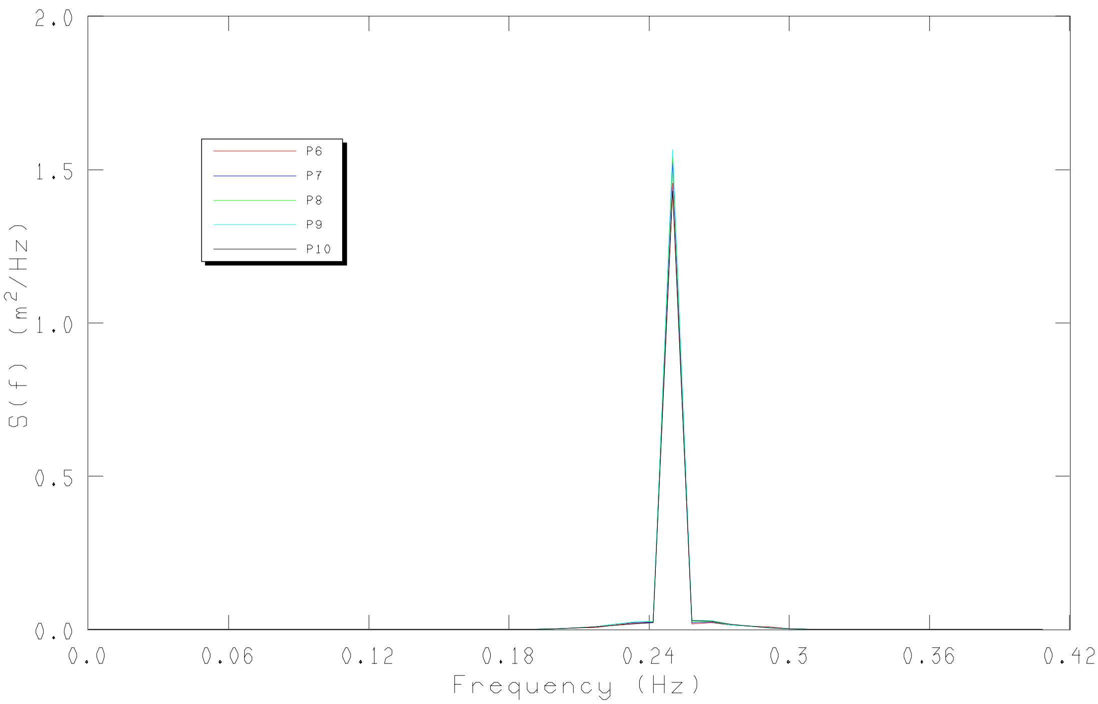
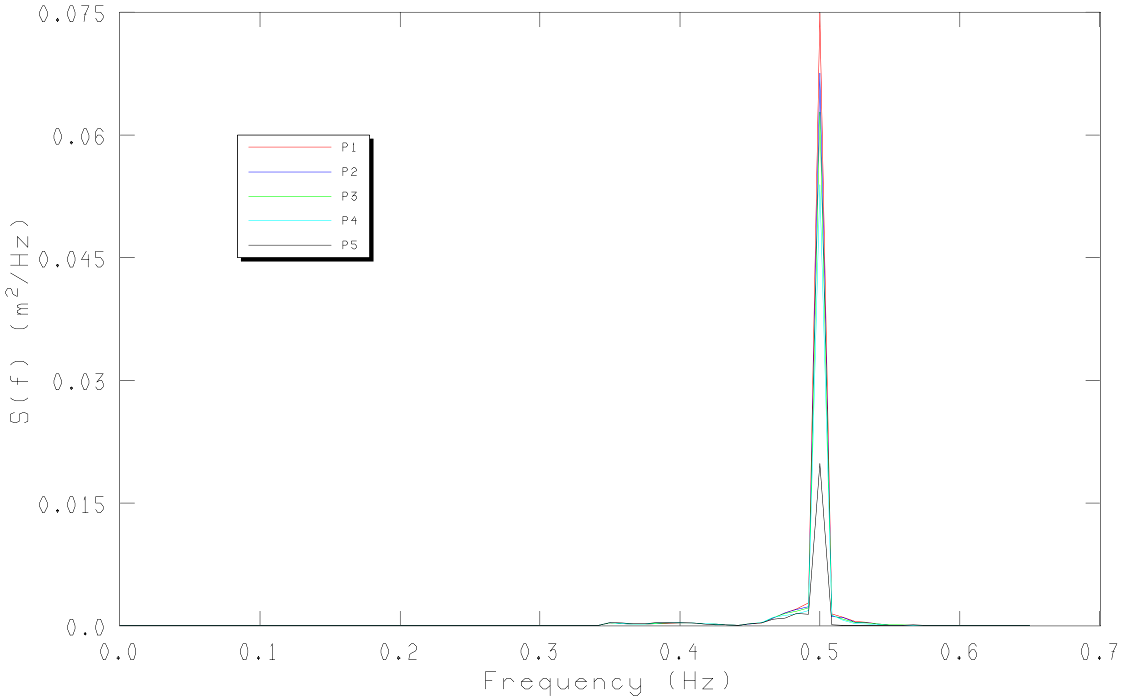


Fig. 13b(P1) Energy density at probes #1 to #10 for primary waves

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	4	0.317751808	15.8875904	0.02	0.119590193



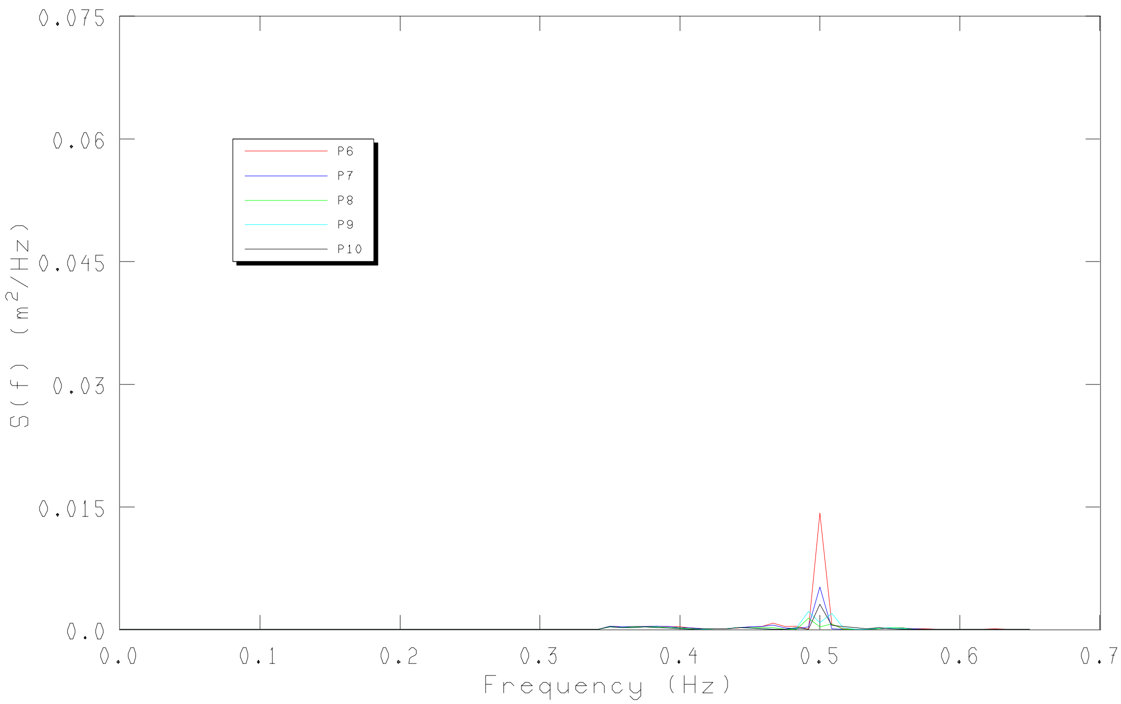
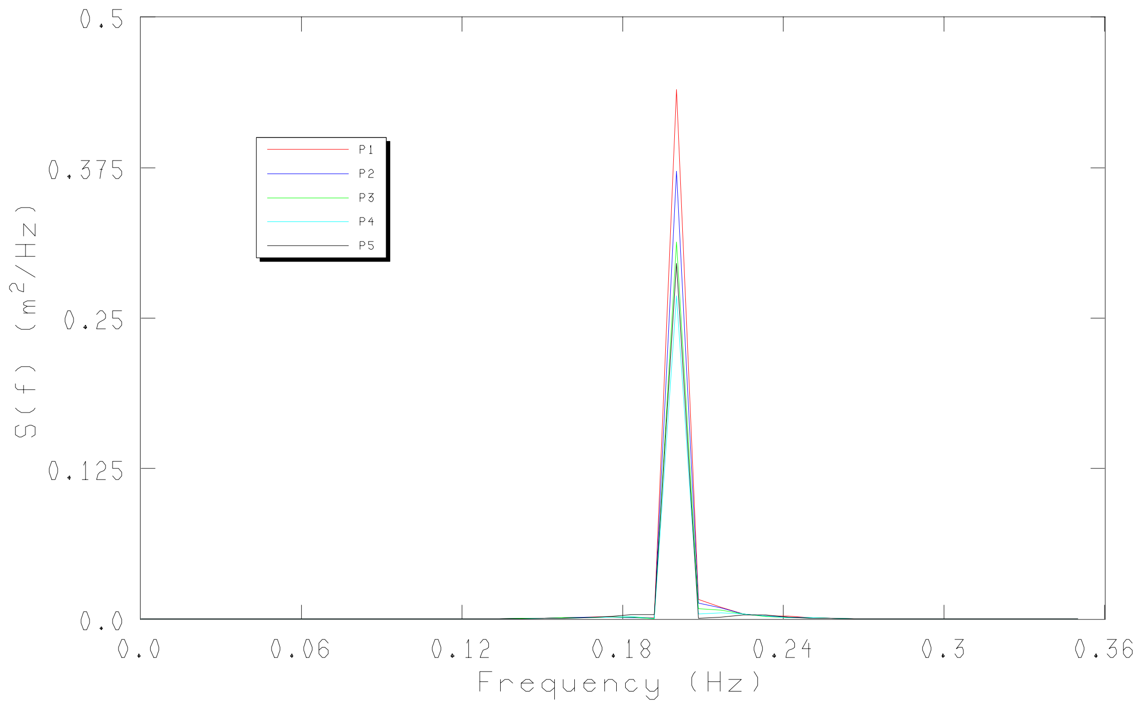


Fig. 13b(P2) Energy density at probes #1 to #10 for second order waves

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	4	0.317751808	15.8875904	0.02	0.119590193



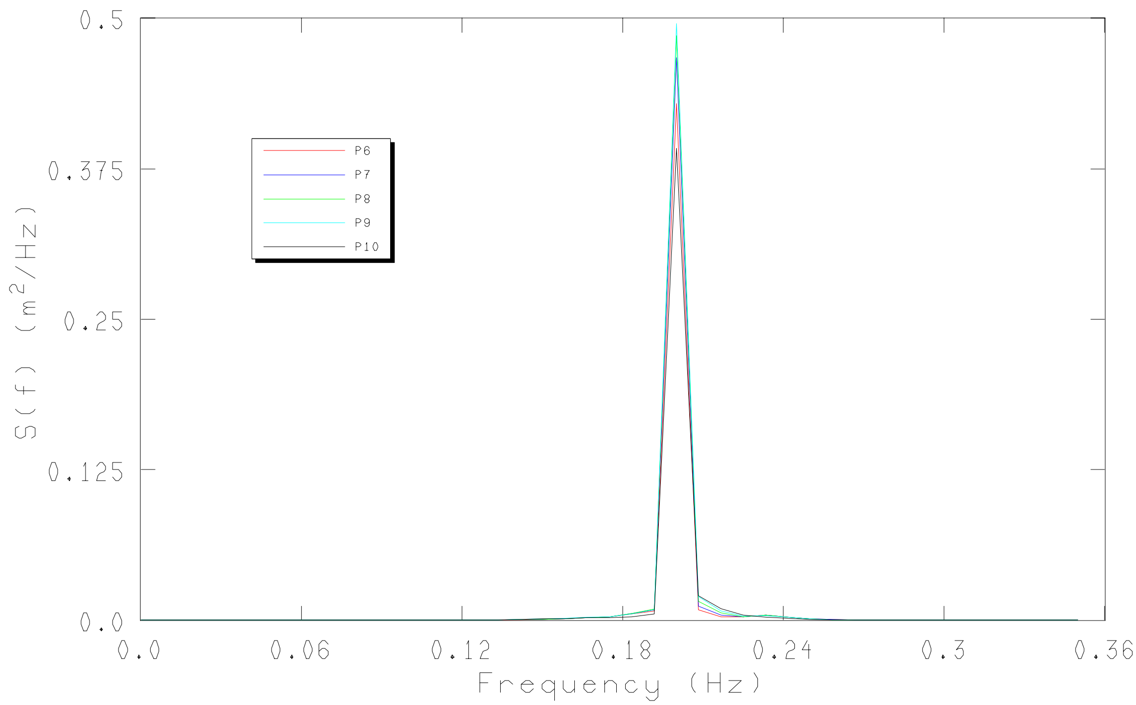
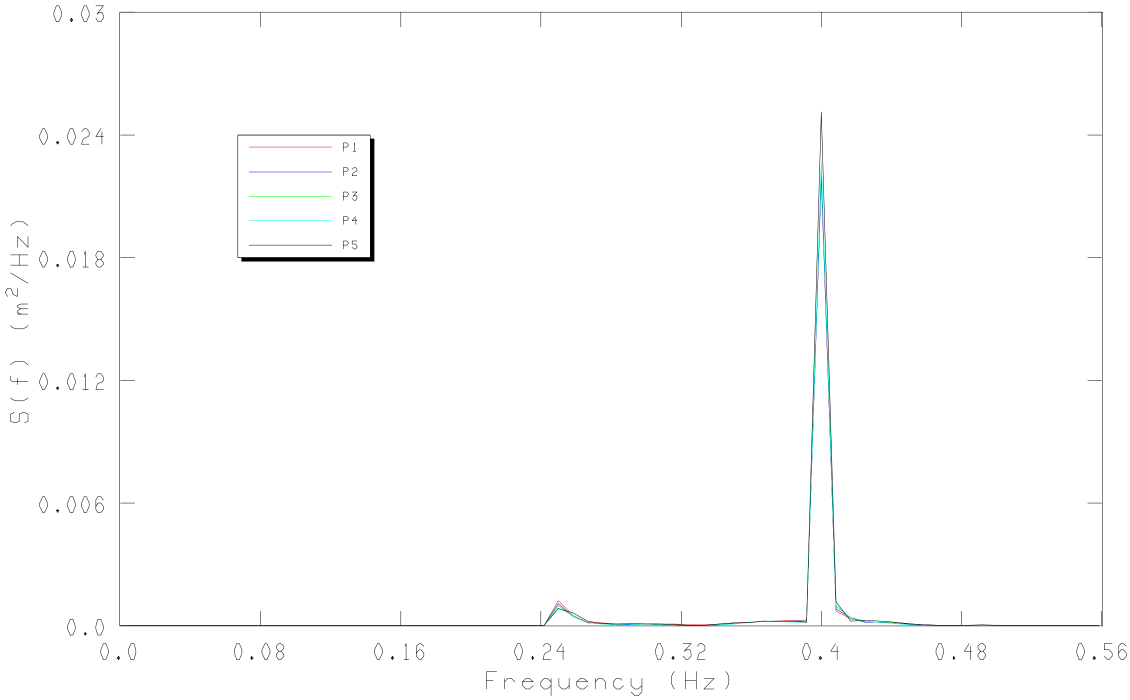


Fig. 14a(P1) Energy density at probes #1 to #10 for primary waves

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	5	0.204819832	20.4819832	0.01	0.092764455



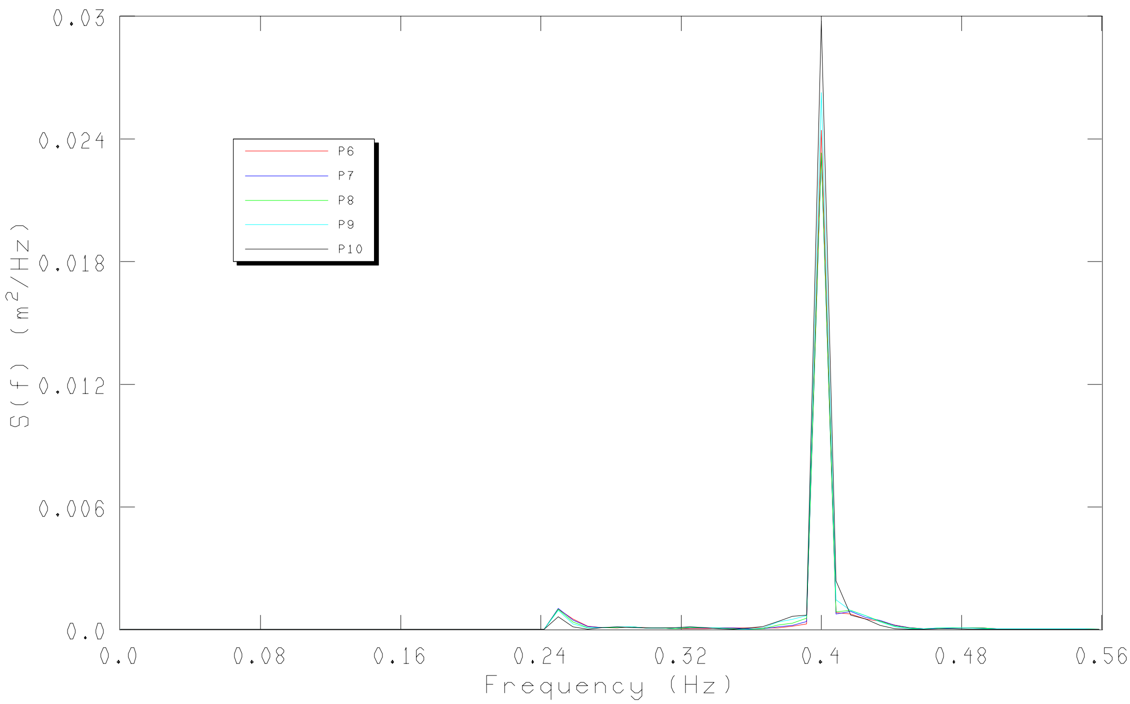
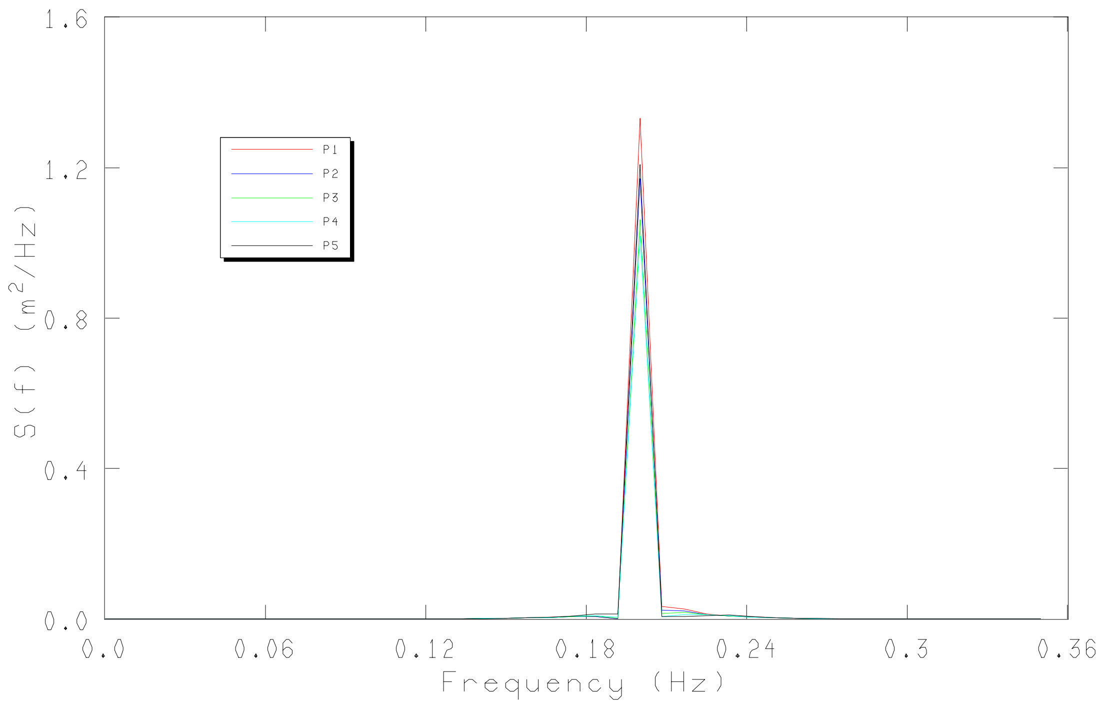


Fig. 14a(P2) Energy density at probes #1 to #10 for second order waves

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	5	0.204819832	20.4819832	0.01	0.092764455



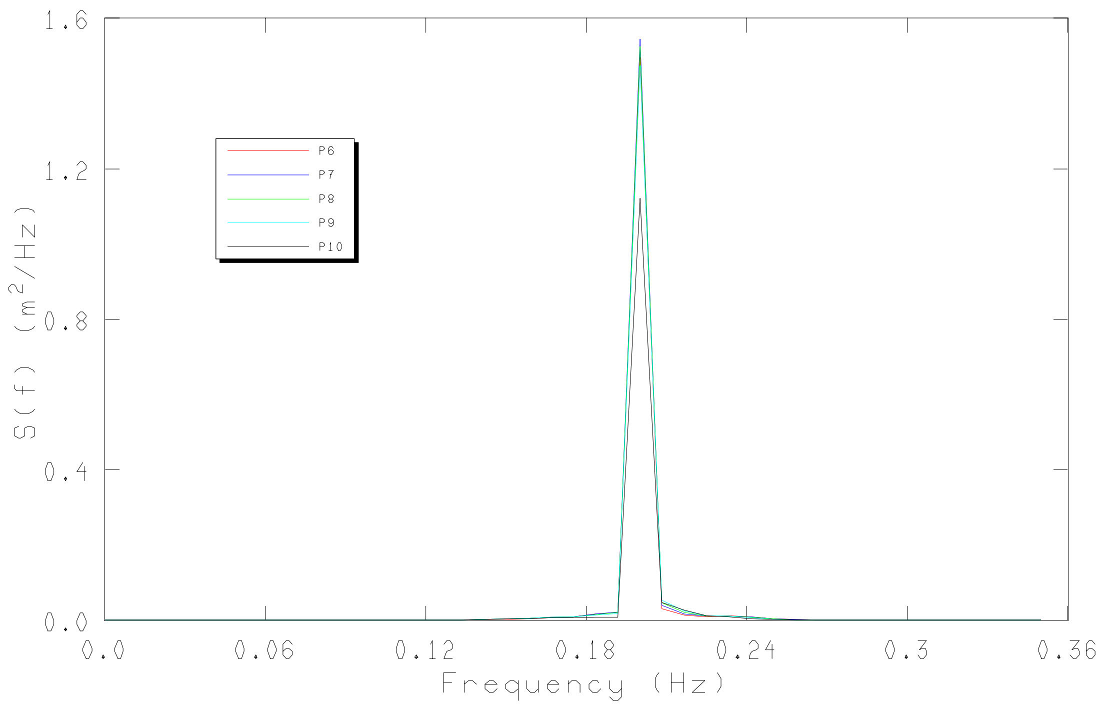
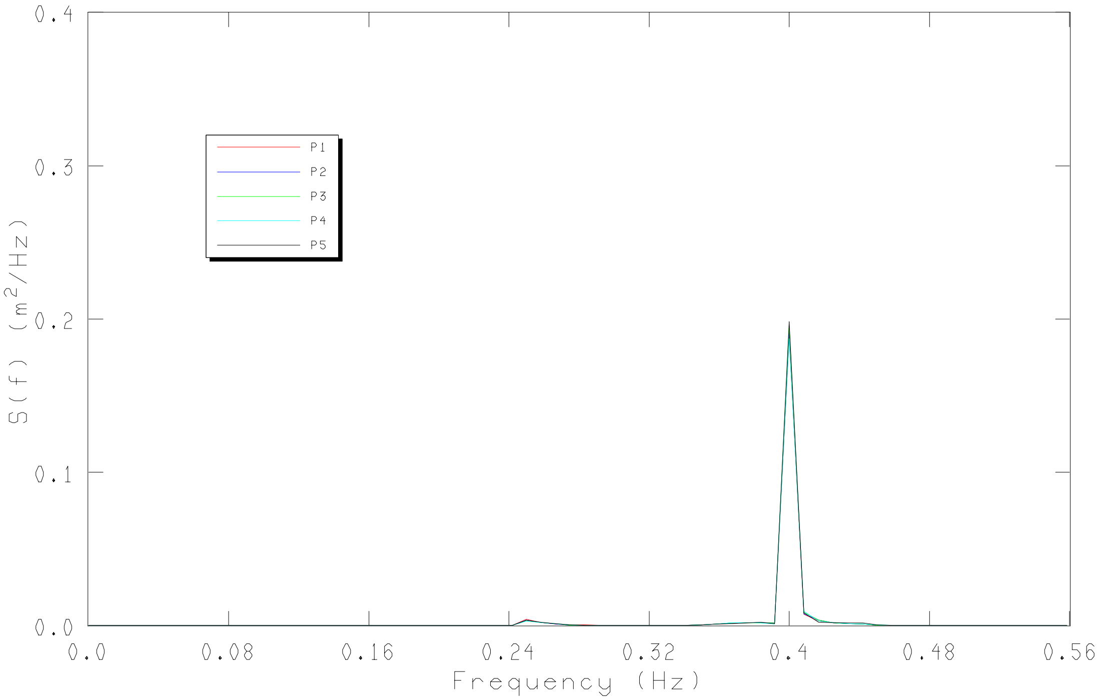


Fig. 14b(P1) Energy density at probes #1 to #10 for primary waves

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	5	0.409639664	20.4819832	0.02	0.092764455



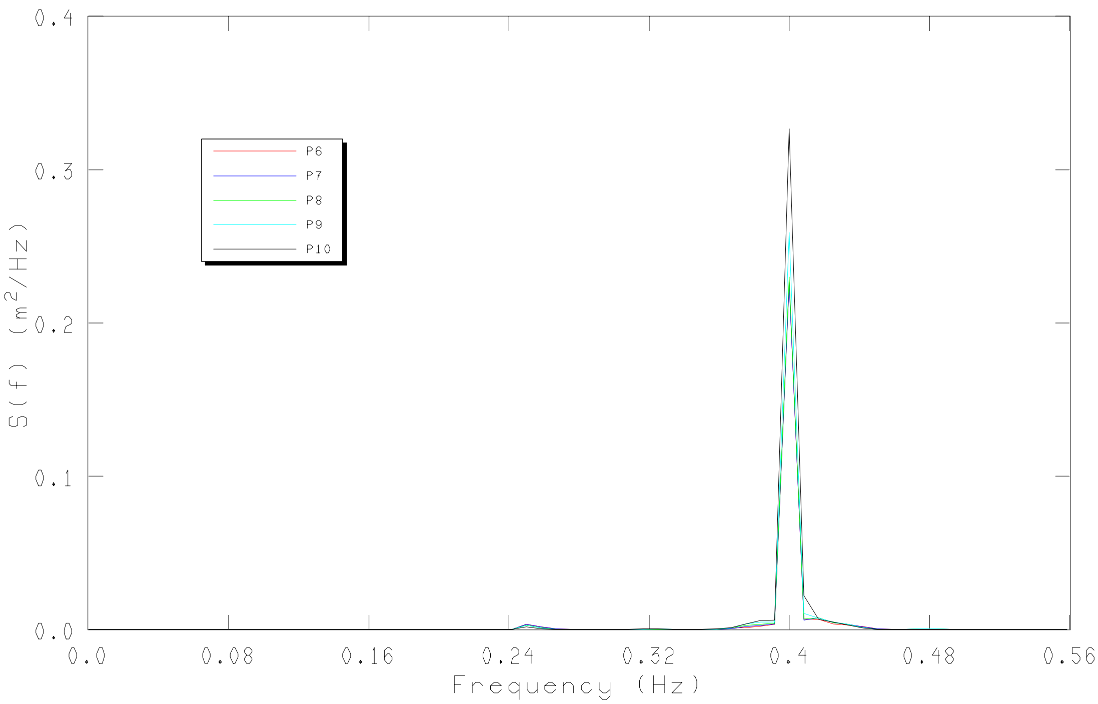


Fig. 14b(P2) Energy density at probes #1 to #10 for second order waves

Water depth d (m)	Wave Period T(s)	Wave height (m)	Wave length (m)	Steepness H/L	Relative depth h/L
1.9	5	0.409639664	20.4819832	0.02	0.092764455

Conclusions

In this experiment the water depth was 1.9m and to generate a shallow water wave we had to choose larger wave period and the acquired data got contaminated due to the faster reflection from the beach.

To avoid this problem we have conducted similar experiments once again with physically shallow water depth (0.6m and 0.8m) and that have allowed us to use smaller wave periods to avoid massive reflection. The analyses of the obtained data are yet to be completed. When the analysis is completed then another report would be produced.

Difficulties

The software used here is designed and coded by CHC. It is important to get this software properly fit with the OEB. This software is very big in size and took pretty long time to develop.

Acknowledgement

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