Description of seakeeping trial carried out on CCGA Roberts Sisters II: November 2004

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https://doi.org/10.4224/8895573

Technical Report (National Research Council of Canada. Institute for Ocean Technology); no. TR-2005-09, 2005

DOCUMENTATION PAGE

REPORT NUMBER	NRC REPORT NUMBER	DATE
TR-2005-09		July 2005
REPORT SECURITY CLASSIFICATION		**DISTRIBUTION**
Unclassified		Unlimited

TITLE

DESCRIPTION OF SEAKEEPING TRIAL CARRIED OUT ON CCGA ROBERTS SISTERS II – NOVEMBER 2004

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PUBLICATION

N/A

SPONSORING AGENCY(S)

Institute for Ocean Technology (IOT), Memorial University of Newfoundland (MUN), Oceanic Consulting Corp. (OCC), Canadian Coast Guard (CCG), the Offshore Safety and Survival Centre (OSSC), Marine Institute, SafetyNet, Search & Rescue (SAR), New Initiatives Fund (NIF) and the Canadian Institutes of Health and Research (CIHR)

IOT PROJECT NUMBER	NRC FILE NUMBER		
42_2017_26			
KEY WORDS	**PAGES**	**FIGS.**	**TABLES**
Seakeeping, Motion Induced Interrupts, Fishing Vessel	vii, 23 App. A-J	25	4

SUMMARY

This report describes seakeeping experiments carried out on the 65 ft. (19.81 m) long fishing vessel CCGA Roberts Sisters II off St. John's, NL November 15, 2004 as part of the Fishing Vessel Safety Project (Proj. 2017). The objective of the project is to acquire quality full-scale motions data on fishing vessels to validate physical model methodology as well as numerical simulation models under development. Eventually, tools will be developed and validated to evaluate the number of Motion Induced Interrupts (MIIs), induced by sudden ship motions, and their impact on crew accidents to develop criteria to reduce MIIs.

Collaborators involved in the fishing vessel sea trials include the Institute for Ocean Technology (IOT), Memorial University of Newfoundland (MUN), Oceanic Consulting Corp. (OCC), Canadian Coast Guard (CCG), the Offshore Safety and Survival Centre (OSSC) of the Marine Institute and SafetyNet – a Community Research Alliance on Health and Safety in Marine and Coastal Work. Primary financial support for the project is provided from federal funding sources including the Search & Rescue (SAR), New Initiatives Fund (NIF) and the Canadian Institutes of Health and Research (CIHR) in addition to significant in-kind contributions from the many participants.

This document describes the CCGA Roberts Sisters II, the trials instrumentation package, data acquisition system, test program, data analysis procedure and presents the results.

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TABLE OF CONTENTS

LIST OF TABLES

TABLE

LIST OF FIGURES

FIGURE

LIST OF ABBREVIATIONS

Accel.	Acceleration
ART	Anti-Roll Tank
AP	aft perpendicular
BOK	bottom of keel
^{o}C	degrees Centigrade
CAD	Computer Aided Design
CCG	Canadian Coast Guard
CCGA	Canadian Coast Guard Auxiliary
CCGS	Canadian Coast Guard Ship
CG	Centre of Gravity
CIHR	Canadian Institutes of Health and Research
cm	centimetre(s)
COG	Course Over Ground
DAS	Data Acquisition System
DC	Direct Current
deg.	degree(s)
DGPS	Differential Global Positioning System
DOT	Department of Transport
EPIRB	Emergency Position Indicating Radiobeacon
FFT	Fast Fourier Transform
FP	forward perpendicular
ft	foot, feet
Fwd.	forward
F/V	frequency/voltage
g	acceleration due to gravity
gal.	gallon(s)
GEDAP	General Data Analysis Program
GM_T	Transverse Metacentric Height

LIST OF ABBREVIATIONS (CONT'D)

GPS	Global Positioning System
H_S, $H_{1/3}$,H_{m0}	Significant Wave Height
HF	High Frequency
h, hr	hour(s)
Hz	Hertz
in	inch(es)
IOT	Institute for Ocean Technology
kg	kilogram(s)
kHz	kiloHertz
km	kilometre(s)
KM_T	transverse metacentric height above keel
KM_L	longitudinal metacentric height above datum
kt(s)	knot(s)
kW	kiloWatt(s)
l	litre(s)
lb(s)	pound(s)
LCG	Longitudinal Centre of Gravity
LT, L. ton(s)	long ton(s)
m	metre(s)
mag.	magnetic
MHz	megaHertz
MII(s)	Motion Induced Interrupt(s)
MUN	Memorial University of Newfoundland
MV	Motor Vessel
mW	milliWatt(s)
NIF	New Initiatives Fund
nm	nautical mile(s)
NMEA	National Marine Electronics Association
NRC	National Research Council

LIST OF ABBREVIATIONS (CONT'D)

NSERC	Natural Sciences and Engineering Research Council of Canada
OCC	Oceanic Consulting Corporation
OEB	Offshore Engineering Basin
OSSC	Offshore Safety and Survival Centre
PPT	Parts Per Thousand
RF	Radio Frequency
RPM	Revolutions Per Minute
s, sec.	second(s)
SAR	Search And Rescue
SNAME	Society of Naval Architects and Marine Engineers
SOG	Speed Over Ground
Stbd.	starboard
St. Dev.	standard deviation
SWH	significant wave height
t	tonne(s)
T_{av}, T_{avg}	average period
T_{max}	maximum period
T_Z	zero crossing period
UHF	Ultra High Frequency
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPS	Uninterruptible Power Supply
V, VAC	volt(s)
VCG	Vertical Centre of Gravity
VHF	very high frequency

DESCRIPTION OF SEAKEEPING TRIAL CARRIED OUT ON CCGA ROBERTS SISTERS II – NOVEMBER 2004

1.0 INTRODUCTION

This report describes seakeeping experiments carried out on the 65 ft. (19.81 m) long fishing vessel CCGA Roberts Sisters II off St. John's, NL November 15, 2004 as part of the Fishing Vessel Safety Project (Proj. 2017). The objective of the project is to acquire quality full-scale motions data on fishing vessels to validate physical model methodology as well as numerical simulation models under development. Eventually, tools will be developed and validated to evaluate the number of Motion Induced Interrupts (MIIs), induced by sudden ship motions, and their impact on crew accidents to develop criteria to reduce MIIs. Although the priority was to collect seakeeping data, a manoeuvring test program was also available in the event that calm seas prevailed.

Collaborators involved in the fishing vessel sea trials include the Institute for Ocean Technology (IOT), Memorial University of Newfoundland (MUN), Oceanic Consulting Corp. (OCC), Canadian Coast Guard (CCG), the Offshore Safety and Survival Centre (OSSC) of the Marine Institute and SafetyNet – a Community Research Alliance on Health and Safety in Marine and Coastal Work. Primary financial support for the project is provided from federal funding sources including the Search & Rescue (SAR), New Initiatives Fund (NIF) and the Canadian Institutes of Health and Research (CIHR) in addition to significant in-kind contributions from the many participants.

This document describes the CCGA Roberts Sisters II, the trials instrumentation package, data acquisition system, test program, data analysis procedure and presents the results. Other Fishing Vessel Research Project related seakeeping trials carried out are described in References 1 to 4.

2.0 BACKGROUND

The Fishing Vessel Safety Project is just a small component of the overall SafetyNet initiative to understand and mitigate the health and safety risks associated with employment in a marine environment. SafetyNet is the first federally funded research program investigating occupational health and safety in historically high risk Atlantic Canada marine, coastal and offshore industries. The Fishing Vessel Safety Project is conducting research on the occupational health and safety of seafood harvesters. Fishing is the most dangerous occupation in Newfoundland and Labrador and is increasingly so: over the past ten years, the rates of reported injuries and fatalities nearly doubled. These trends have the effect of reducing the sustainability of the fishery, increasing health care and compensation costs, and straining the available SAR resources. The development of effective solutions, to prevent or mitigate injury, fatality or

SAR events, has been seriously hindered by the scarcity of the research needed to understand the factors that influence seafood harvester occupational health and safety.

The Fishing Vessel Safety Project is a multi-disciplinary, inter-departmental and inter-sectorial research project. The broad-based and multi-factorial approach in investigating the inter-related factors that influence fishing safety including: fishery policy and vessel regulations, vessel safety design and modeling, human relationships on vessels and health and safety program development, implementation and evaluation. The Fishing Vessel Safety project is composed of six integrated components:

1) Longitudinal Analysis: A statistical analysis of all fishing injuries, fatalities and SAR incidents from 1989 to 2000 to determine trends and influencing factors of seafood harvester occupational health and safety;
2) Perceptions of Risk: An interview-based study, conducted with seafood harvesters, on the perceptions of causes of accidents and near-misses - and the effectiveness of existing accident prevention programs;
3) Motion Induced Interruptions: Sea trials, physical and numerical modeling of the effects of MIIs, sudden vessel motions induced by wave action, on crew accidents and development of criteria to reduce MIIs;
4) Delayed Return to Work: an interview-based study on the psychological and social factors that delay previously injured seafood harvesters from returning to work;
5) Education Program: The development of an interactive, community-based occupational safety education program for seafood harvesters; and
6) Comparative Analysis: A comparative analysis of accident and fatality rates, and regulatory regimes for fisheries management and fishing vessel safety in Canada, the United States, Iceland, Norway, Denmark, France and Australia.

Several of the project components will yield results that can be directly used by stakeholder organizations for designing and implementing injury and fatality prevention programs. The applied nature of the overall project will be represented by a series of recommendations that will provide accessible and applicable information needed to make informed decisions. Additional information on SafetyNet may be found by visiting their web site (Reference 5).

The effort described in this report is part of Component #3 of the overall Fishing Vessel Research Project. The plan involved carrying out seakeeping trials on a total of five Newfoundland based fishing vessels ranging in lengths from 35 ft. to 75 ft. (10.67 m to 22.86 m) over two years. Data was acquired on some of the vessels with and without roll damping devices deployed. Standard seakeeping parameters such as ship motions, speed and heading angle was recorded along with data on the ambient environmental conditions (wave height/direction, wind speed/direction). Physical models of three of the vessels (tentatively the 35, and

the two 65 ft. vessels) suitable for free-running operation in the IOT Offshore Engineering Basin (OEB) will be fabricated and tested by IOT over three years in environmental conditions emulating the full scale conditions. Project participants at the MUN Faculty of Engineering will derive numerical models of all five hull forms and run simulations using their non-linear time domain ship motion prediction codes. Validated simulation tools will then be used to predict the expected level of MIIs for different fishing vessel designs.

Additional information on human factors in ship design is provided in References 6 to 9.

3.0 DESCRIPTION OF THE CCGA ROBERTS SISTERS II

The CCGA Roberts Sisters II (Figure 1) is a typical 65' fibreglass fishing vessel and the hull was built by Universal Marine Ltd. of La Scie, NL in 2001 to a design furnished by C.E.C Marine Consultants of St. John's, NL. The vessel owner completed much of the internal finishing. The vessel primarily participates in the inshore snow crab fishery, but has the ability to harvest other species using a trawl, such as shrimp and ground fish, when the stocks are available. The vessel is usually based in St. John's.

Nominal Principal Particulars:

Length Overall:	64' 11" (19.79 m)
Beam:	23' (7.01 m)
Draft:	12' 6" (3.81 m)
Installed Power:	624 HP (354.2 kW)
Displacement:	224 L. Tons (227,594 kg)
Fuel Capacity:	4500 gal. (20457.4 l)
Fresh Water Capacity:	1300 gal. (5909.9 l)
Fish Hold Volume:	3828 ft^3 (108.4 m^3)
Accommodations:	11 berths

One of the goals of this experiment is to measure the motions of the vessel while it is harvesting its catch, therefore a "half loaded" displacement condition was simulated by adding approximately 47,186 kg. of sea water to two wing tanks normally used for live crab stowage. Once the vessel was ballasted and most of the outfit items installed, an inclining experiment was performed on November 10th by Marine Services International to identify key hydrostatic properties for the trials condition.

The inclining experiment was carried out using standard procedures whereby two pendulums (aft pendulum was 2.781 m long in the fish hold, forward pendulum was 2.54 m long in the forward accommodations) suspended with the weights in a water bath were deployed to measure roll angle. Static roll angles were induced by the shifting of two 55 gal. plastic drums filled with fresh water,

weighing a total of 1050 lbs. (476.3 kg), laterally to various locations on the main deck. The following is a summary of results:

Draft:	13.625 ft @ AP (4.153 m Aft)
	9.25 ft @ FP (2.819 m Fwd.)
Displacement:	221.85 Long Tons (225,410 kg)
Longitudinal Centre of Gravity (LCG):	0.01 feet (0.003 m) Fwd of amidships
Vertical Centre of Gravity (VCG):	11.50 feet (3.505 m) above base plane
Transverse Metacentric Height (GM_T):	3.11 feet (0.947 m)
Transverse Metacentric Height (KM_T):	14.61 feet (4.453 m) above base plane

The inclining report delivered by the contractor is included in Appendix A. Note the vessel was inclined with the anti-roll tank empty. The computation for the approximate shift in the center of gravity due to the addition of the trials working level of sea water has been added by IOT to Appendix A.

The 'Roberts Sisters II' is a round bilge, single screw (fixed pitch propeller in a fixed nozzle), single flat plate rudder vessel with a very large centreline skeg and a passive anti-roll tank fitted just aft of the Bridge. A photograph of the propeller, nozzle and rudder arrangement is provided in Figure 2. The vessel has a normal suite of navigation/ communications electronics including radar, GPS, VHF radio, depth sounder and electronic chart information as well as a ComNav 2001 autopilot. The vessel is fitted with two 12 person inflatable rafts however the lifesaving equipment was augmented with floater suits on loan from the CCG for the trials period. Further information in the vessel particulars, list of outfit items and sketches of the general arrangement can be found in Appendix B.

4.0 DESCRIPTION OF INSTRUMENTATION

IOT was tasked to provide the trials technical support, to install and maintain primary on-board instrumentation, and a data acquisition system with limited online data analysis capability for all the trials. The instrumentation plan is provided in Appendix C while the analog channel calibration information is provided in Appendix D. Note that all analog channel calibrations were verified after completion of the trial. The instrumentation, signal cabling, and data acquisition system used along with the calibration method employed for each parameter is described in this section. The standard IOT sign convention is provided in Reference 10.

4.1 Data Acquisition System (DAS)

The Data Acquisition System (DAS) used for the 'Roberts Sisters II' trial was mounted on the galley table of the vessel (see Figure 3). The data acquisition and analysis software package designed for these trials (described in detail in Reference 11) were run on two ruggedized Panasonic notebook computers, which had the following software attributes:

Off-the-shelf Software:

- Windows 2000 – operating system
- WinZip 8.0 – data compression software
- Excel 2000 – spreadsheet software
- Daqview 2000 – for viewing the data graphically

Hardware:

- Daqboard 2000

Additional Devices:

- CompassPoint 2200 GPS – provides position along with heading, rate of turn, etc.
- IOTech Daqbook 2000 – provides analog-to-digital conversion for analog signals including rudder angle, MotionPak, accelerometers and inclinometers.
- Signal Conditioning and interfacing hardware for analog channels.
- Uninterruptible Power Supply (UPS)

Custom Software:

- FishingVesselLogger – the primary program used to acquire the analog data (data rate was generally 50 Hz for each of 16 analog channels).
- CompassPointGPS – a slave process to the FishingVesselLogger program. It receives data from the DGPS unit and also logs all the GPS data.
- FishingVesselCal – used to post-calibrate the acquired data.
- CompassPointNMEA Parser – used to post-parse the NMEA data stream from the CompassPoint 2200 GPS unit and save the resulting parsed data to ASCII.

4.2 Rudder Angle Measurement

The rudder angle was measured by winding the cable, with wax string extension, from a 10 inch yo-yo type potentiometer linear displacement transducer around a groove cut in a circular ½ inch (1.27 cm) thick Plexiglas plate. The plate was machined with a steel clamp at its centre so that it could be adjusted to any size rudderpost (Figure 4). The transducer was clamped to a convenient vertical frame in the steering gear compartment.

Rudder angle was calibrated with respect to a protractor, drawn using CAD software, fixed to the top of the circular plate with zero degrees from the rudder indicator on the Bridge.

4.3 Ship's Motion Instrumentation

For the seakeeping trials carried out on November 15th, a MotionPak I was used to measure ship motions with six degrees of freedom. The MotionPak was

mounted on a purpose built aluminium bracket fixed to the deckhead in the vessel's fish hold (Figure 5) and outputs the following motion channels:

Roll Rate	Surge Acceleration
Pitch Rate	Sway Acceleration
Yaw Rate	Heave Acceleration

From these six signals, dedicated MotionPak software was available to derive the following 18 channels in either an earth or body co-ordinate system, and move the motions to any point on the rigid platform:

Roll Angle/Rate/Acceleration	Surge Displacement/Velocity/Acceleration
Pitch Angle/Rate/Acceleration	Sway Displacement/Velocity/Acceleration
Yaw Angle/Rate/Acceleration	Heave Displacement/Velocity/Acceleration

The MotionPak angular rate channels were calibrated using manufacturer's specifications while the acceleration channels were physically calibrated by placing the sensors on a set of precision wedges and computing the acceleration. The accelerometers output zero m/s^2 when placed on a horizontal plane and $-9.808\ m/s^2$ (- 1 g) when oriented with the measuring axis vertical. The intermediate accelerations are computed as follows:

Acceleration = $-9.808\ m/s^2$ * sin (angle of inclination)

In addition, orthogonal linear accelerations (sway, surge and heave, Figure 6) were measured on the Bridge, in the main console and physically calibrated using the same procedure as was used for the MotionPak accelerometers. These instruments were used primarily to validate data collected by the MotionPak. From the inclining report presented in Appendix A, the position of the centre of gravity for the sea trial condition is:

LCG = 0.003 m forward of amidships
KG_T(fluid) = 3.505 m

One of the complications faced by IOT was the lack of detailed general arrangement drawings of the 'Roberts Sisters II' – probably due to the fact that most of the internal finishing was carried out by the ship's owner. The only information available to IOT regarding the internal layout of the ship is provided in sketches included in Appendix A and B. A sketch of the location of the motion sensors measured relative to adjacent ship's structure is provided in Appendix C. From this information, the nominal location of the

MotionPak relative to CG:
1.955 m aft, 0.04175 m to port and 0.5385 m above
MotionPak relative to Helmsman's position:
6.257 m aft, 2.62 m to port, 3.475 m below

MotionPak to Bridge accelerometers:
6.257 m aft, 0.2187 m to port, 2.56 m below

Note that the sketches for vessel do not include the arrangement of the Bridge so the distance from the MotionPak to the helmsman's position and Bridge accelerometers are very rough estimates.

Two inclinometers used in the measurement of the pitch and roll angle were also mounted near the DAS and physically calibrated using the series of precision wedges. It should be noted that the inclinometers have a relatively low response rate and were fitted primarily to measure angular motion in the event that manoeuvring trials in calm water were carried out.

4.4 Differential Global Positioning System Data

The Global Positioning System (GPS) is a satellite based navigation system operated and maintained by the US Department of Defence. GPS consists of a constellation of 24 satellites providing world-wide, 24 hour, three-dimensional position coverage. Although originally conceived to satisfy military requirements, GPS now has a broad array of civilian applications including becoming the standard tool for marine navigation.

GPS is currently the most accurate navigation technology available to the public. The GPS receiver computes the distance to a minimum of three GPS satellites orbiting the earth to accurately derive the ship's position. GPS receivers also output precise time, speed of the ship over the ground (SOG) as well as course over ground (COG) measurements. Additional general information on the operation of a GPS system is provided in Reference 12.

Differential GPS (DGPS) provides greater positioning accuracy than standard GPS since error corrections can be included using a GPS signal transmitted via HF from a receiver established at a known location on land. To acquire a DGPS correction, IOT installed a CompassPoint 2200 GPS (a rectangular antenna with dimensions 60 cm x 16 cm x 18 cm) with a fixed based mounting, which was clamped to the top of the aft end deckhouse (Figure 7). Once the antenna was visually aligned parallel to the ship's longitudinal centreline, the system software was initiated by having the vessel perform multiple 360 degree rotations in the harbour prior to the trial.

The DGPS correction signal was acquired from a CCG broadcast at a frequency of 315 kHz from Cape Race, NL. Using DGPS, absolute position accuracies between 3 and 10 m can be achieved along with velocity accuracies within 0.1 knots.

The following digital data channels were acquired using the DGPS receiver in standard National Marine Electronics Association (NMEA) format:

Course Over Ground (COG) – degrees TRUE
Speed Over Ground (SOG) – km/hr
Latitude/Longitude - degrees/minutes/seconds

4.5 Directional Wave Buoy/Mooring Arrangement

Two directional wave buoys were used during the trials:

Neptune Sciences Sentry Wave Buoy
A small (0.75 m diameter, 15.7 kg) discus shaped directional wave buoy manufactured by Neptune Sciences, Inc. of Slidell, Louisiana and procured by MUN for previous sea trials using NSERC funding was used to acquire information on the wave conditions during the seakeeping trials (Figure 8). The buoy was moored in approximately 165 metres of water at 47° 33" 42' N, 52° 26" 11' W. On the day of the trial, the buoy was manually deployed by lifting it over the side of the Roberts Sisters II. Retrieval was accomplished at the end of the trial using the vessel's crab pot hauler. Unfortunately the upper section of the mooring could not be retrieved using the pot hauler, so this section was brought in by hand which was made more difficult due to a strong surface current.

The wave buoy was configured to acquire data for 17.07 minutes (1024 s) every half hour, process and store the data in an ASCII format file on an internal non-volatile flash disk. A radio modem was used to communicate between a base station on the 'Roberts Sisters II' and the buoy over line of sight range using a spread spectrum device operating in the UHF 902-928 MHz frequency band. The buoy assembly is composed of the following components:

- Instrument Housing: composed of a sealed aluminium cylinder with connections for the antenna and on/off plug on top. The housing contains the instrumentation package, onboard computer and onboard radio modem. All components of motion required to transform the buoy-fixed accelerations into an earth-fixed co-ordinate system (vertical, east-west and north-south) are measured using sensors mounted in the instrument package. Earth-fixed accelerations enable determination of non-directional wave information (wave heights, periods, and non-directional spectra) as well as directional wave information (wave directions and directional spectra) with all required computations executed within the onboard computer.

- Battery Housing: comprises a smaller sealed aluminium cylinder fitted below the instrument housing and contains the battery pack composed of 27 disposable D-cell alkaline batteries providing a 1 to 2 week lifetime with the buoy configured for data collection every ½ hour.

- Floatation Assembly: a rugged urethane foam and aluminium cage designed to provide the appropriate buoyancy for the instrument and battery housing.

The floatation assembly was designed such that the instrument and battery housing combination can be removed and replaced without disturbing the mooring or recovering the entire system.

- Ship Based Modem: An RF modem with dedicated power supply and antenna is used to communicate from a ship based laptop computer to the wave buoy. A dedicated, windows based, user friendly software package is supplied by the buoy manufacturer to facilitate the communication between the ship board computer and the wave buoy. The data can also be retrieved using an umbilical connection to the buoy after the buoy has been recovered.

- Mooring Assembly: a mooring system for the wave buoy was designed for a 165 m depth of water by personnel from the MUN Physical Oceanography Group after discussions with the buoy manufacturer. The mooring is described as follows:

    - Neptune Wave Buoy with floating tether
    - 4 meter half inch nylon cord in parallel with 3 meter shock cord
    - ½" (1.27 cm) stainless steel shackle and swivel
    - 55 meters of ¼" (0.635 cm) jacketed wire rope and shackles
    - 183 meters 9/16" (1.4287 cm) polypropylene rope
    - 10' (3.5 m) ½" (1.27 cm) galvanized chain
    - 40 lb. (18.14 kg) Danforth® anchor

Additional information on the Neptune directional wave buoy is provided in Reference 13 while further information and a typical output file is provided in Appendix E.

Datawell Waverider Mark II Wave Buoy

In previous trials the Neptune buoy proved to be unreliable. To ensure acquisition of the required directional wave data, a 0.9 m diameter Datawell Waverider Mark II wave buoy manufactured by Datawell b.v. of the Netherlands was leased from Oceans Ltd. of St. John's, NL. Oceans Ltd. was responsible for providing the buoy and mooring, supervising its launch/recovery from MV Louis M. Lauzier, as well as acquiring the data during the trial and generating a final data product.

The buoy was deployed in 165 m of water in position 47 34.126 N, 52 26.154 W – about 10 nm east of St. John's. Directional wave data was computed hourly and transmitted to the base station at a frequency of 29.760 MHz with an output power of 150 – 200 mW. The high visibility yellow (Figure 9) buoy includes a flashing light that flashes 5 times every 20 seconds. The single point mooring provided by Oceans Ltd. was designed to ensure sufficient symmetrical horizontal buoy response with low stiffness permitting the buoy to follow waves up to a wave height of 40 m with a resolution of 1 cm, and wave periods between 1.6 and 30 s. The wave direction resolution was 1.5º while the wave frequency resolution was 0.005 Hz for frequencies less than 0.1 Hz and 0.01 Hz otherwise.

The 212 kg buoy was anchored using two railway train wheels (Figure 9) weighing a total of 1400 lbs. (635 kg). The buoy was moored for the duration of the trials period (approximately 2 months).

The following sensors/equipment was included in the wave buoy:

- Hippy-40 pitch angle/roll angle/heave displacement
- Three axis flux gate compass
- Two fixed X and Y linear accelerometers
- Sea temperature sensor
- Micro-processor

The receiving system was installed ashore at the Oceans office in St. John's and consisted of a passive 3 m long (Kathrein) whip antenna with base. A dedicated laptop computer interfaced to the wave direction receiver for storing and displaying the acquired wave data. The receiver was set up to receive at 38.760 MHz (a higher frequency than being transmitted by the buoy). The base station was only monitored on the days when sea trials occurred. The specifications for the buoy, the mooring description and a typical output data file are provided in Appendix F. Additional information on the buoy can be obtained from the Datawell b.v. web site (Reference 14) and user's manual that includes a description of the data file format provided by Oceans Ltd. (Reference 15).

4.6 Propeller Shaft Speed

Propeller shaft speed was measured using an optical sensor acting on a piece of reflective tape on the shaft in the engine room. The pulse train from the optical pickup was fed to an IOT designed and built frequency-to-voltage (F/V) circuit that converts the digital pulse train to a linear DC voltage proportional to shaft RPM (Figure 10). This instrumentation was calibrated using a laser tachometer that acted on the reflective target, which was then verified using the vessel's RPM gauge.

4.7 Directional Anemometer

A MUN "Weather Wizard III", manufactured by Davis Instruments, provides monitoring and logging of essential weather conditions such as temperature, wind direction, wind speed and wind chill (Figure 11). This instrument was fixed to an aluminium mast furnished by IOT, which was in turn attached to a guard rail aft port side of the deck house. At dockside the directional indicator was aligned with magnetic north. Wind speed and direction were logged by hand.

4.8 Sea Water Temperature/Density Measurement

To determine whether there are any large variations in water density (which would ultimately change the draft of the vessel) between St. John's harbour

where the ship's draft is recorded and the trials area, a YSI model 30 battery powered hand-held salinity, conductivity and temperature meter was used to measure the parameters required to determine ambient water density. The YSI 30 unit, manufactured by YSI of Yellow Springs, Ohio, consists of a hand held display device and a weighted probe with 25 feet (7.62 m) of cable connecting the two (Figure 12). The required information, i.e. temperature and salinity, is collected by the probe and presented on the hand held display with an accuracy of $\pm$ 2% or $\pm$ 0.1 PPT (parts per thousand) for salinity and $\pm$ 0.1°C for the temperature. The instruments range for salinity and temperature is 0 to 80 PPT and -5° to +95°C respectively.

To obtain a mean density of the sea water, the probe tested the water at about half the draft ~ 2 m. The density is then calculated using the Equation of State of Seawater given in Reference 16, which provided density as a function of temperature, salinity, and pressure. Additional information on the YSI instrument is provided in Reference 17. Note that there was never a requirement to correct the ship's displacement for a difference in water density between St. John's and the trials area.

4.9 Electrical Power

Acquiring quality 120 V electrical power was not a problem on the 'Roberts Sisters II'. IOT filtered all power used for IOT equipment through a UPS, however, to ensure that no power glitches or spikes impaired the data.

4.10 Signal Cabling

Belden 8723 two pair individually shielded cable was used to conduct signals from the MotionPak, accelerometers and inclinometers to the DAS. The inclinometers were located within the unit designed to accommodate the DAS therefore the distance for cable connection was short. The cable for the accelerometers extended from the wheelhouse console along the deckhead aft, down the stairway, and along the galley deckhead forward to the DAS. The cable to the MotionPak was fed from the DAS through an aft window in the galley, then down through the open fish hold hatch into the fish hold.

In addition, one cable was installed to accommodate the yo-yo potentiometer used to measure the rudder angle. This cable was run from the tiller flat forward to the fish hold penetrating the aft fish hold transverse bulkhead through a gland in a Plexiglas access hatch fabricated by IOT to replace the existing aluminium access hatch normally in place. This cable was simply secured to the transverse beams strengthening the top of the hold and, bundled together with the cable for the MotionPak, was passed through the open hatch cover and finally through an aft window in the galley where the DAS was located.

The cable for the shaft RPM signal extended from the DAS along the galley deckhead aft and down into the fish hold. This cable was run through fish hold where it dropped down to the location of the shaft RPM instrumentation. A deck plate in the fish hold had been removed to allow access to the shaft tunnel.

The DGPS antenna and the wind anemometer were both located on top of the deckhouse of the vessel. Cabling was simply extended from the DAS aft along the galley deckhead and up the wheelhouse stairs. The cables then passed through an aft window in the wheelhouse and up to the top of the deckhouse.

5.0 TRIALS DESCRIPTION

The test plan for the trial is given in Appendix G. Prior to proceeding to the trials area, a 10 minute zero speed run was carried out in St. John's harbour in an effort to determine the ship motion natural periods. The seakeeping trials were completed on November 15, 2004 approximately 10 nm due east of St. John's. Prior to departure, all instrumentation was inspected to ensure all sensors were functioning properly. The draft of the vessel was then measured at the bow and stern of the vessel, before departing for the wave buoy located at 47 34.126 N, 52 26.154 W.

Upon arrival at the wave buoy location, the sea conditions were found to be favourable for the experiment. The significant wave height was visually estimated at approximately 2.5 m. The log of the trials events can be found in Appendix H.

Typical Procedure for a Set of Forward Speed Seakeeping Runs:

Each run pattern was carried out in the following manner for each nominal forward speed:

- The ship was first positioned in close proximity to the wave buoy and directional wave data acquired to derive the dominant wave direction.
- After reviewing the wave data from the buoy, the dominant head sea direction (degrees magnetic) was corrected using a value of approximately 21 degrees to determine the direction relative to true north.
- The forward speed over the ground for the first run sequence was adjusted to 4 knots. The heading angle was selected such that the vessel was heading directly into the sea (head sea run). The throttles were adjusted to achieve the desired course and speed. Data acquisition was initiated once steady state conditions were achieved. The course during all runs was maintained under autopilot control.
- After 25 minutes had elapsed on a steady course, data acquisition was terminated.
- The vessel then altered course by 180 degrees to complete the "following" sea run where the wave action is essentially pushing the vessel. The

engine speed was adjusted to maintain a constant speed over ground in order to compare results between runs. Data acquisition was terminated after 40 minutes.

- Course adjustment of 135 degrees was selected to correspond with the next section of the run pattern (bow sea run). The engine speed was adjusted as necessary.
- After 25 minutes had elapsed on a steady course data acquisition was terminated.
- Course adjustment of 135 degrees was selected to correspond with the next section of the run pattern (beam sea run). The engine speed was adjusted as necessary.
- After 25 minutes had elapsed on a steady course data acquisition was terminated.
- Course adjustment of 135 degrees was selected to correspond with the next section of the run pattern (quartering sea run). The engine speed was adjusted as necessary.
- After 25 minutes had elapsed on a steady course data acquisition was terminated.
- After the five runs had been completed, the vessel returned to the wave buoy to verify that the dominant wave direction had not changed and confirm that the wave buoy was working correctly. A 25 minute zero speed drift run in nominally beam seas was carried out at this time.

A second set of runs at a forward speed of 8 knots was carried out on November 15th using the same procedure as was used for the 4 knot runs. Three additional runs at 4 knots (beam, bow and quartering seas) were executed with the passive anti-roll tank filled to ~ 14.75 inches (37.465 cm) deployed.

The dedicated trials team included:

- MUN co-op student – data acquisition and verification
- one IOT research staff
- one IOT electronics staff – support in the event of problems with equipment at sea

In addition, there were two MUN School of Human Kinetics and Recreation staff (one researcher and one grad student) carrying out experiments in the accommodations just forward of the mess on the main deck. The nominal location of these research staff relative to the MotionPak was 8.827 m forward, 0.4628 m to port and 1.3815 m above.

6.0 DESCRIPTION OF ONLINE DATA ANALYSIS

The purpose of performing an online analysis during the trials is to ensure that all the instrumentation is working properly to identify potential problems with the various sensors that may lead to invalid results.

A network of two laptop computers was used in the Data Acquisition System. One computer logged the raw data from the data stream and, using the custom software FishingVesselCal, converted the data into a usable format stored with the appropriate physical units. The second computer was used to analyze the data from the previous acquired run to assess its integrity as well as communicate with the wave buoy. This was done to avoid overloading the computer logging the data, which could have led to program failure and potentially resulted in incomplete data files or even lost data.

Columns of acquired data were converted to Microsoft EXCEL[1] format and standard EXCEL plotting utilities were used to view the data in the time domain. An example time series plot of surge acceleration from the MotionPak and x acceleration from the accelerometers is shown in Figure 13. Note the difference in amplitude between the two signals is due to their separation on the ship.

7.0 DESCRIPTION OF OFFLINE DATA ANALYSIS

Once the trial was complete, ASCII data files were compiled for transfer to MUN Kinetics staff. The following additional data analysis was carried out.

7.1 Wave Data Analysis

Wave data was acquired from two sources during the trial. This section describes the data analysis procedure used to generate the Datawell and Neptune wave buoy data products:

7.1.1 Datawell Wave Buoy Data Analysis

Oceans Ltd. carried out the wave analysis using standard software provided by the manufacturer of the buoy. The data was processed on the buoy and both raw and processed data then transmitted to the receiver on shore.

From the accelerations measured in the X and Y directions in the moving buoy reference frame, the accelerations along the fixed north and west axes are calculated. All three accelerations (vertical, north and west) are then digitally integrated to displacements and filtered to a high frequency cut off (0.6 Hz). Finally an FFT is performed on the data.

Raw data are compressed to motion vertical, motion north and motion west. Energy density, main sea direction, directional spreading angle and the normalized second harmonic of the directional distribution for each frequency band are computed on-board the wave buoy in addition to other standard sea state parameters such as significant wave height (SWH), H_{mo} and mean wave period T_Z.

[1] © Microsoft Corp.

Note that within the wave buoy, sea direction is measured using a flux gate compass and thus the data is generated in degrees magnetic. The magnetic deviation for St. John's approaches during the trials period was ~21 degrees West and this correction was applied to derive wave direction in degrees TRUE.

A summary of wave statistics acquired using the Datawell wave buoy is provided in Appendix I. Nondirectional spectrum plots as well as Mean Wave Direction (corrected to degrees TRUE) versus Frequency plots are also provided in Appendix I for each half hour measurement cycle.

7.1.2 Neptune Wave Buoy Data Analysis

Directional wave data is calculated from the motion of the buoy whereby these motions, recorded by onboard sensors for angular and vertical accelerations, accurately mimic the attitude of the ocean due to its discus shaped floatation device. The recordings are then analyzed using spectral analysis to provide directional and nondirectional wave spectra. A directional wave spectrum describes the distribution of wave energy as a function of both frequency and direction, whereas the nondirectional wave spectrum is a function of frequency only.

More precisely, as a definition:

Nondirectional Wave Spectrum (C_{11}): is a one dimensional wave energy density that has its greatest value at the frequency where the nondirectional wave energy density is greatest.

This nondirectional wave spectrum is then used for computing wave energy where:

$$S(f,\alpha) = C_{11}(f) * D(f, \alpha)$$

By which, D is a directional spreading function with a dependency on both frequency f and direction α. S is a two dimensional wave energy density that has its greatest value at the frequency and direction where the directional wave energy is greatest. D(f, α) may be expanded in an infinite Fourier Series as a function of wave direction α. An approximation of the D(f, α) may be provided by computing the first two terms:

$$D(f, \alpha) \approx [1/\pi] * [(1/2) + r_1 * \cos(\alpha - \alpha_1) + r_2 * \cos(2 * (\alpha - \alpha_2))]$$

Where: alpha1 (α_1) – mean wave direction
alpha2 (α_2) – principal wave direction
r_1 , r_2 – frequency dependent parameters that theoretically lie between zero and one.

The following is a list of definitions needed to fully analyze wave data:

Significant Wave Height: Average height from wave crest to trough of the one-third highest waves measured. It is assumed that the nondirectional spectrum is relatively narrow and thus significant wave height is computed as:

> *Significant Wave Height* = $H_{m0} = 4\ m_0^{1/2}$,
> Where, m_0 is the area under the nondirectional wave spectrum C_{11}.

Dominant Wave Period/Frequency (Peak Wave Period/Frequency): is the period/frequency associated with center frequency of the frequency band that has the largest (peak) energy density in the nondirectional spectrum (C_{11}).

Average Wave Period/Frequency: The average wave period is computed from the spectral moments as follows:

> $T_{av} = m_0/m_1$ and $f_{av} = 1/T_{av}$ where:
> "m_1" – the first moment of area under the nondirectional wave spectrum C_{11}.

Dominant Wave Direction: the value of α_1 for the frequency band where the largest value of C_{11} occurs.

Average Wave Direction: is the weighted average over all frequency bands. This wave direction is the energy density weighted vector average of α_1 over all frequency bands and is computed from:

> Average wave direction = $\tan^{-1}(Y, X)$
> Where: $Y = \Sigma\ [C_{11}(f) * \sin(\alpha_1(f))]$
> $X = \Sigma\ [C_{11}(f) * \cos(\alpha_1(f))]$

Note that within the wave buoy, sea direction is measured using a flux gate compass and thus the data is generated in degrees magnetic. The magnetic deviation for St. John's approaches during the trials period was ~21 degrees West and this correction was applied to derive wave direction in degrees TRUE.

A summary of wave statistics acquired using the Neptune wave buoy is also provided in Appendix I. Nondirectional spectrum plots as well as Mean Wave Direction (corrected to degrees TRUE) versus Frequency plots are also provided in Appendix I for each half hour measurement cycle.

7.2 Interpreting the Raw Data

The data received by all the various instruments onboard the vessel was initially recorded as an analog DC voltage. A calibration file was then applied to the raw

data using the custom software program FishingVesselCal. The calibration file included a five point linear regression curve and instrument offsets for each instrument. A summary of the calibration file along with the regression equations is provided in Appendix D. The data was converted to GEDAP format described in Reference 18 and standard IOT software used to analyze the data.

Example time series plots are provided as follows (trawl speed, beam seas):

Figure 14: Surge, Sway and Heave Displacement vs. Time
Figure 15: Surge, Sway and Heave Acceleration vs. Time
Figure 16: Roll, Pitch and Yaw Angle vs. Time
Figure 17: Roll, Pitch and Yaw Rate vs. Time
Figure 18: Shaft Speed and Rudder Angle vs. Time
Figure 19: Speed Over Ground (SOG and Course Over Ground (COG) vs. Time

7.3 Validation of MotionPak Software and Instrumentation

Within the software used to analyze MotionPak data, there is the capability to translate the accelerations recorded to any position onboard the vessel. To verify the ship motions data acquired, the motions were moved from the location of the MotionPak to the accelerometers located in the wheelhouse and then analyzed in the "Body" fixed coordinate system. All acceleration values have been tared.

Table 1 shows the comparison between the data from MotionPak and the linear accelerometers in beam seas – 4 knots with the anti-roll tank empty. From the values of standard deviation computed, it is demonstrated that the accelerations recorded were very similar. Deviations are likely due to the poor quality of the documentation for the ship and resultant difficulty in determining accurately the linear displacements between the location of the MotionPak and the accelerometers.

Instrument	Parameter	Unit	Mean	St. Dev.	Minimum	Maximum
Accelerometer	Surge Accel.	m/s^2	0.0	0.3864	-1.3594	1.2187
MotionPak	Surge Accel.	m/s^2	0.0	0.3807	-1.3835	1.1690
Accelerometer	Sway Accel.	m/s^2	0.0	1.0552	-3.2601	3.2025
MotionPak	Sway Accel.	m/s^2	0.0	1.0527	-3.1838	3.1023
Accelerometer	Heave Accel.	m/s^2	0.0	0.6860	-2.3900	2.2330
MotionPak	Heave Accel.	m/s^2	0.0	0.6531	-2.3727	2.1186

Table 1: MotionPak Validation

Comparative time series plots of surge, sway and heave accelerations are provided in Figures 20 to 22 indicate a close correlation of the signals.

Note that a comparison between the MotionPak angular data and the inclinometer data was not considered valid for data collected in a seaway due to the inherently low response rate of the inclinometers.

7.4 Ship Motion Analysis

As stated above, there is the capability to translate the accelerations recorded to any position onboard the vessel using the MotionPak software. As part of this seakeeping experiment, data from the MotionPak was used to compute the motions at two positions on the vessel: the vessel's centre of gravity, and the helmsman's position.

Tables of detailed basic information and statistics (average, standard deviation, minimum and maximum) for each run for both locations of interest are provided in Appendix J. A summary of the standard deviations of the basic motions are presented for the runs without anti-roll tank deployed in Table 2 and with the anti-roll tank deployed in Table 3.

Speed (knots)	Run Heading	Roll Angle (deg.)	Pitch Angle (deg.)	Yaw Angle (deg.)	Surge Accel. (m/s^2)	Sway Accel. (m/s^2)	Heave Accel. (m/s^2)
0	Drift1	4.895	1.599	11.376	0.175	0.231	0.398
0	Drift2	4.964	1.872	12.266	0.177	0.236	0.443
4	Head	3.922	1.912	2.203	0.193	0.188	0.513
4	Bow	4.039	1.826	2.261	0.208	0.176	0.482
4	Beam	4.696	1.607	2.376	0.156	0.239	0.502
4	Quartering	4.104	1.572	2.397	0.178	0.222	0.419
4	Following	3.565	1.796	2.717	0.199	0.155	0.405
8	Head	2.947	1.753	1.267	0.200	0.197	0.728
8	Bow	3.988	1.639	1.179	0.189	0.210	0.644
8	Beam	4.776	1.468	1.553	0.164	0.244	0.621
8	Quartering	4.114	1.466	2.150	0.180	0.199	0.443
8	Following	4.010	1.609	2.358	0.201	0.158	0.459

Table 2: Standard Deviation of Motions – No Anti-Roll Tank

Speed (knots)	Run Heading	Roll Angle (deg.)	Pitch Angle (deg.)	Yaw Angle (deg.)	Surge Accel. (m/s^2)	Sway Accel. (m/s^2)	Heave Accel. (m/s^2)
4	Bow	2.089	2.329	1.999	0.222	0.195	0.584
4	Beam	3.028	1.781	2.881	0.185	0.263	0.545
4	Quartering	2.747	1.645	2.624	0.185	0.238	0.461

Table 3: Standard Deviation of Motions – With Anti-Roll Tank

A plot of roll angle, pitch angle and heave acceleration standard deviation at the CG vs. heading angle is provided in Figure 23 (4 knots) and Figure 24 (8 knots).

7.5 Roll and Pitch Frequency Analysis

A variance spectral density analysis was carried out on the roll rate and pitch rate data for the zero speed run carried out in St. John's harbour prior to the trial in an effort to determine the roll and pitch period. The following values for the motion period at the spectral peak were output:

Roll Period: 6.3366 s
Pitch Period: 4.0132 s

8.0 DISCUSSION & RECOMMENDATIONS

The following is a series comments on how the trial was executed with recommendations on how to improve the quality of data collected.

Ballasting Effort:

The 'Roberts Sisters II' is fitted with two water tight 'live hold' wing tanks used for live crab storage and transportation. These tanks were filled with approximately 47,186 kg of sea water to simulate a partially loaded condition. The tanks were pressed up to the hatches to reduce free surface affects. This proved to be a much easier ballasting strategy than filling fish holds with ice or water bags as was used for some of the previous seakeeping trials.

Overall Outfit:
Overall the outfit of the 'Roberts Sisters II' went well with few complications. Not having to install a portable generator to power IOT electronics certainty reduces the complexity of the outfit and operational risks. Since the vessel was less than 3 years old, it afforded a clean, attractive work environment. The existing aluminium Lazarette access hatch in the aft fish hold bulkhead was temporarily replaced with an IOT fabricated Plexiglas hatch with integral cable gland. Installing a Plexiglas hatch was preferable to fitting a gland in the aluminium hatch to be sealed up after the trial as this would minimize potential damage to the ship.

The initial location chosen for the GPS antenna (on the arch above the wheelhouse) was found to be unsatisfactory during alignment of the GPS magnetic compass. The antenna was moved to a new location with a less obstructed view of the sky, and aligned satisfactorily.

Equipment Security:
A number of dedicated components fabricated specifically for this sea trial were missing and substitutes had to be fabricated at the last minute. Security at IOT was an ongoing concern throughout these trials and it is recommended that trials equipment be stored in a secure facility in future.

Environmental Conditions:
The trial was delayed for several days due to inappropriate wave conditions. The trial was eventually carried out Monday November 15, 2004 in ~ 2.5 m SWH however the surface current was exceptionally strong - estimated at 4 to 5 knots for most of the day. This high current likely had a negative impact on the performance of both wave buoys. This resulted in high speed drift runs, delays in returning to the wave buoy position, and higher than desired forward speeds for the trawl speed runs with the current behind us (2 to 3 knots was desired whereas the vessel was traveling at ~ 4 to 5 knots speed over ground with the engines idling).

Wave Buoys
Because of problems found during trials carried out in 2003, a Work Instruction was written to instruct users of the Neptune directional wave buoy (Reference 19). This was fortunate, as several previously unseen anomalies were discovered. Although the Neptune operation manual (Reference 13) lists a 10 nm range, in practice, unless the buoy was in visual line of sight, there were no radio communications. This may be due to the small vessel size (low elevation of buoy antenna) or the seas being outside of the buoy capabilities. It was discovered during the CCGA Miss Jacqueline IV trial (Reference 3) that the Neptune buoy would lose data if communications were occurring during the time period when the buoy normally performed it's on board data analysis. This lost data file was not recoverable. The Work Instruction was thus amended (V2.0) to address this problem and outline the correct communication time periods.

The Neptune buoy appeared to be submerged early in the morning due to the very strong current. The mooring deployed was not designed for the high current. As with previous trials, there were concerns regarding the integrity of the wave direction data. As well it is assumed that the strong current had a negative impact on the acquired wave height data.

Comparison of Neptune and Datawell Wave Buoy Data:
A comparison of wave data acquired from both wave buoys for the same time period is provided in Table 4 below.

Neptune Directional Wave Buoy Data					Datawell Directional Wave Buoy Data		
Time (NF)	Hs (m)	Tmax (s)	Tavg (s)	DirMax (deg. TRUE)	Hs (m)	Tz (s)	DirMax (deg. TRUE)
06:00	2.58	12.34	8.24	38.90	2.38	7.018	118.3
06:30	2.44	12.34	8.04	54.00	2.24	6.78	114.1
07:00	2.34	10.89	7.76	52.00	2.26	6.667	102.9
07:31	2.63	10.89	8.13	37.20	2.29	6.667	122.5
08:00	2.61	10.89	8.24	20.00	2.4	6.78	116.9
08:30	2.55	12.34	7.82	40.00	2.26	6.78	119.7
09:00	2.82	12.34	8.47	13.80	2.26	6.667	108.5
09:30	2.25	10.89	7.67	223.20	2.21	6.557	100
10:01	2.04	12.34	6.99	43.70	2.48	6.557	125.4
10:30	1.98	9.75	6.81	43.90	2.18	6.349	126.8
					2.28	6.452	126.8
11:30	1.99	10.89	6.84	64.50	2.33	6.667	118.3
12:00	2.08	10.89	7.04	116.20	2.22	6.452	132.4
12:30	2.10	9.75	7.00	49.10	2.28	6.349	108.5
13:00	1.90	9.75	6.63	243.90	2.34	6.557	118.3
					2.33	6.557	121.1
14:00	2.17	10.89	6.99	226.50	2.28	6.452	119.7
14:30	2.25	9.75	6.95	60.10	2.24	6.25	112.7
15:00	2.24	10.89	7.17	349.60	2.17	6.061	121.1
15:30	2.25	10.89	7.09	38.60	2.25	5.97	122.5

Table 4: Neptune/Datawell Directional Wave Data Comparison

The results for both buoys were computed using spectral data. Minor differences can be expected for any two wave buoys moored 0.5 nm apart. The significant wave heights are comparable however the Neptune buoy output a higher wave period probably due to the influence of the high current on the mooring. It is apparent that there is a major discrepancy in the wave direction between the two buoys.

Passive Anti-Roll Tank

The passive anti-roll tank was filled to the normal operating level (37.465 cm) for the last three runs. This is less than the level recommended in the tank operating instructions in the ship's Stability Booklet (recommended level: 48.26 cm). It was difficult to determine the operating level using the sight glass (Figure 25) on the moving ship. The Master also stated that the level is normally adjusted to provide optimum results according to the direction of the vessel with respect to the incident waves. The level was maintained at a constant value for all the trial runs, however.

9.0 ACKNOWLEDGEMENTS

The authors would like to thank Capt. Glen Winslow and the crew of the CCGA Roberts Sisters II for their enthusiastic support during the trial, the CCG for the loan of survival equipment, Jack Foley of MUN Oceanography for assistance designing the wave buoy mooring, and IOT technical staff for their efforts

throughout the planning and execution of the trial. Support from the crew of the MV Louis M. Lauzier to deploy the Datawell wave buoy was much appreciated. Funding support from the Search & Rescue (SAR) New Initiatives Fund (NIF) and the Canadian Institutes of Health and Research (CIHR) is gratefully acknowledged.

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FIGURES

Figure 1: CCGA Roberts Sisters II

Figure 2: CCGA Roberts Sisters II – Propeller, Nozzle & Rudder Arrangement

Figure 3: Data Acquisition System

Figure 4: Rudder Angle Measurement

Figure 5: MotionPak Installation in Fish Hold

Figure 6: Orthogonal Linear Accelerometers in Bridge Console

Figure 7: DGPS Antenna on Bridge Top

Figure 8: Neptune Directional Wave Buoy

Figure 9: Datawell Directional Wave Buoy and Anchor

Figure 10: Shaft RPM Measurement

Figure 11: Directional Anemometer

Figure 12: Hand Held Salinometer

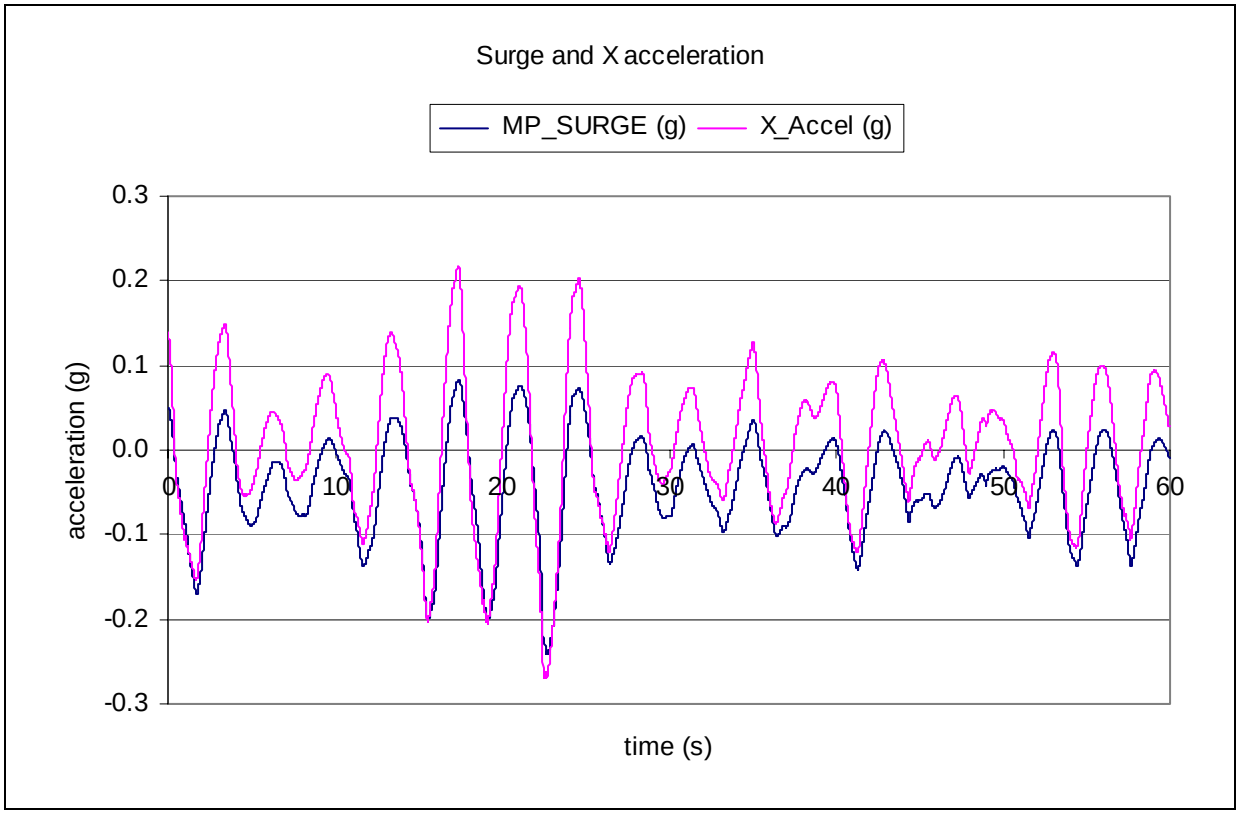


Figure 13: Example Online Data Analysis

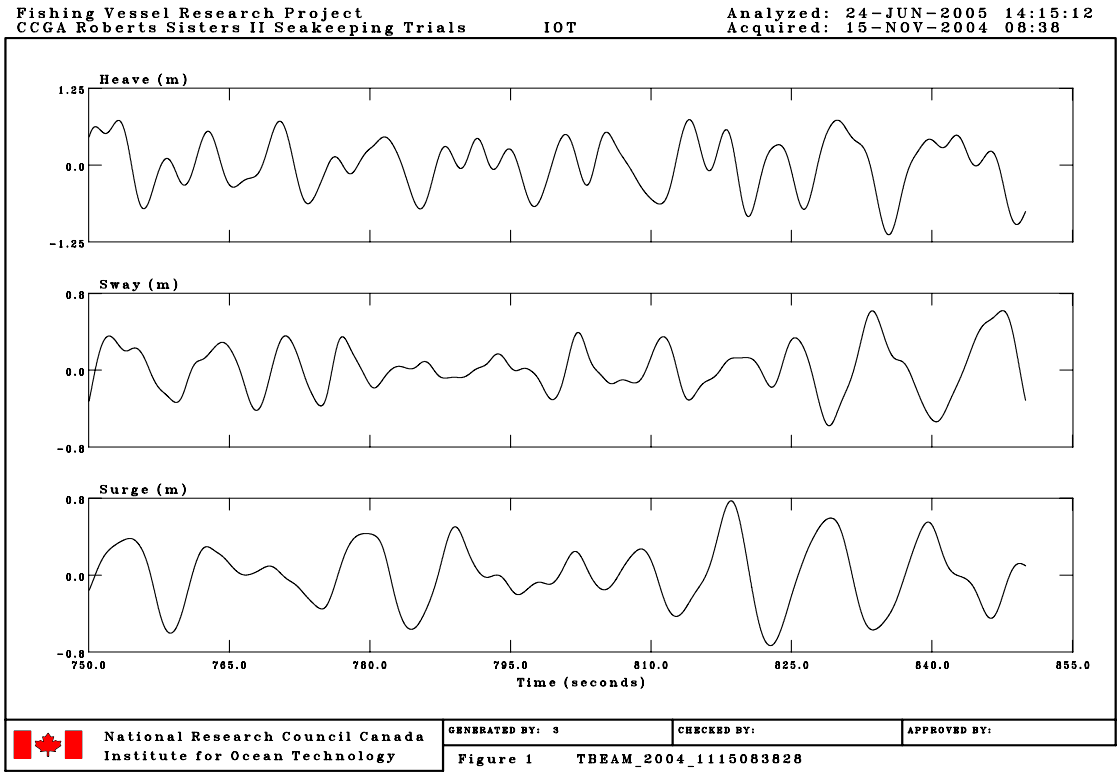


Figure 14: Offline Data Analysis – Surge, Sway and Heave Displacement

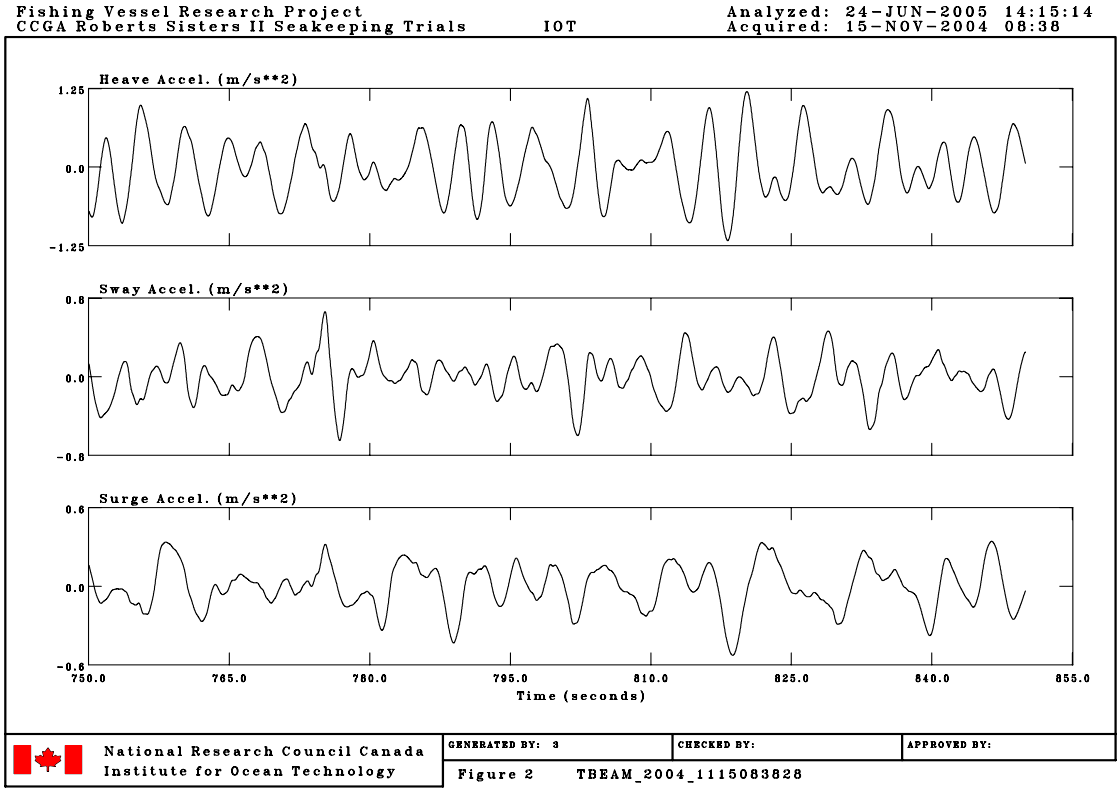


Figure 15: Offline Data Analysis – Surge, Sway and Heave Acceleration

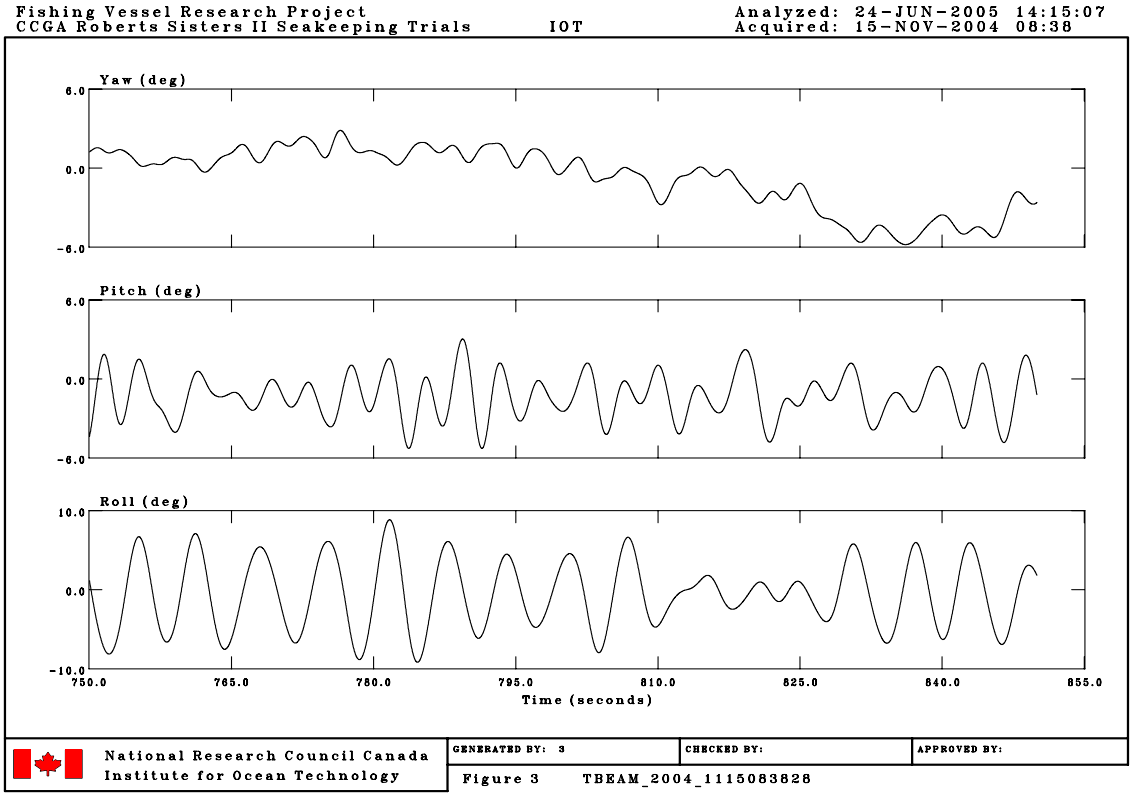


Figure 16: Offline Data Analysis – Roll, Pitch and Yaw Angle

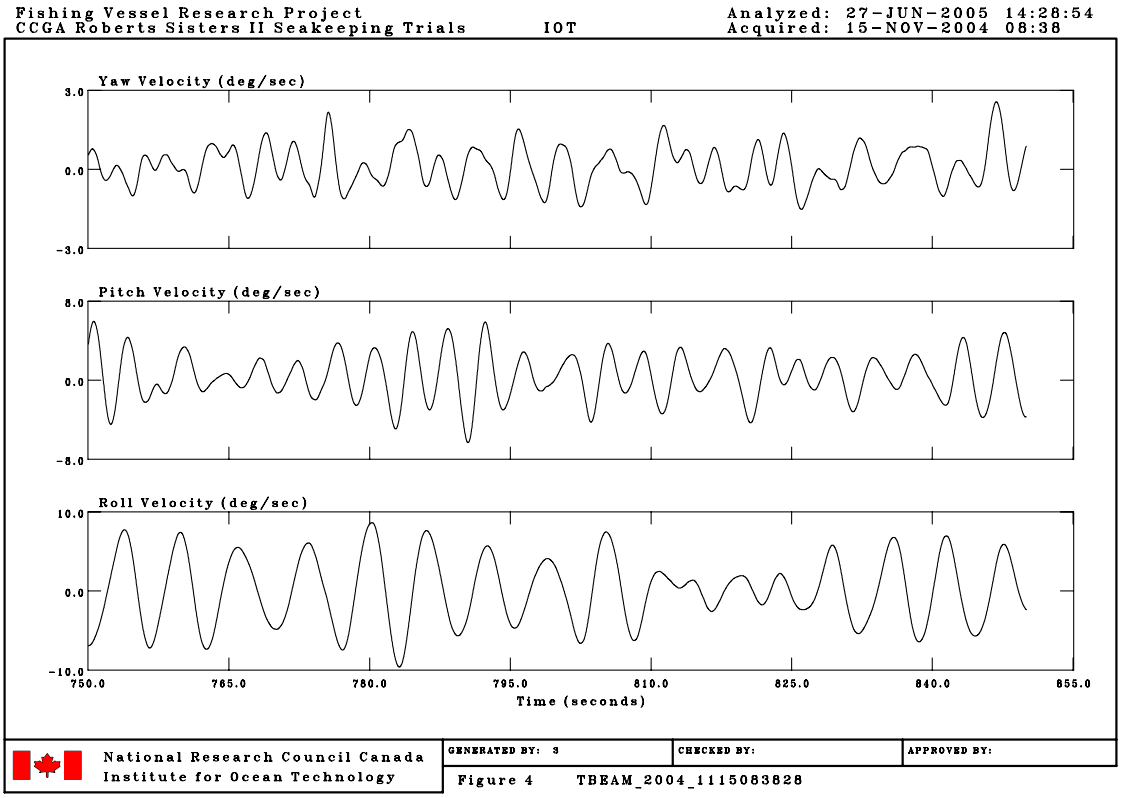


Figure 17: Offline Data Analysis – Roll, Pitch and Yaw Rates

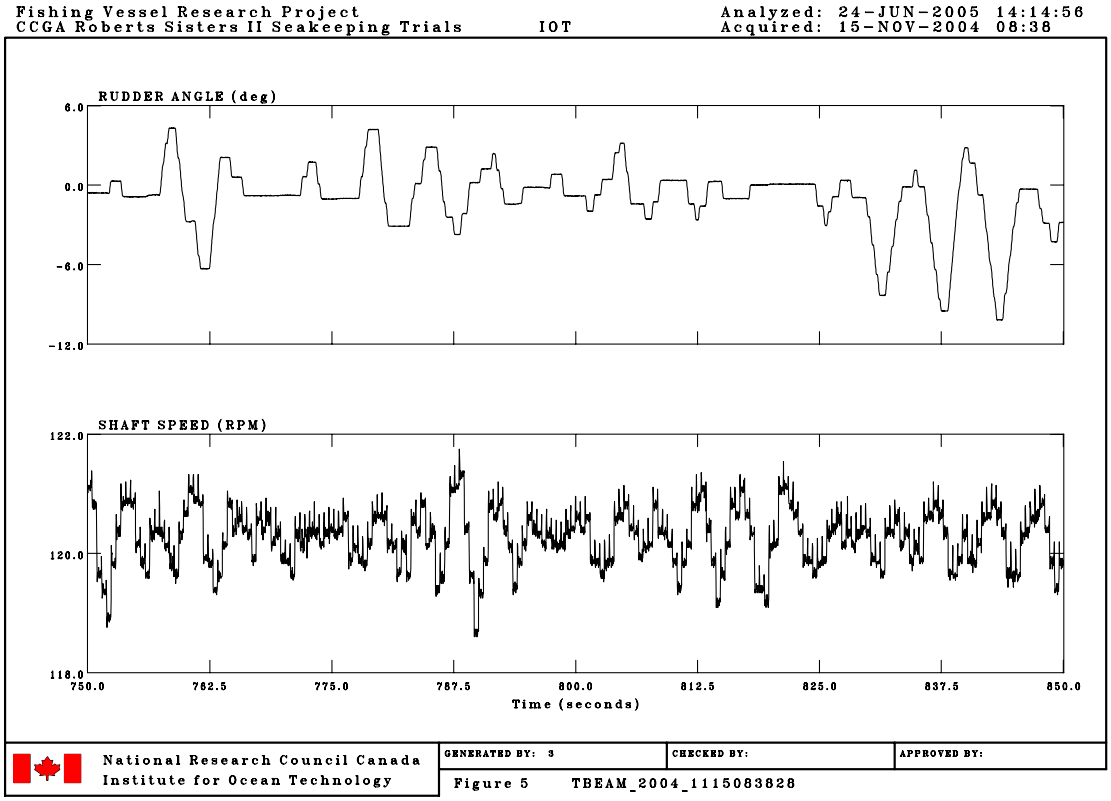


Figure 18: Offline Data Analysis – Shaft Speed and Rudder Angle

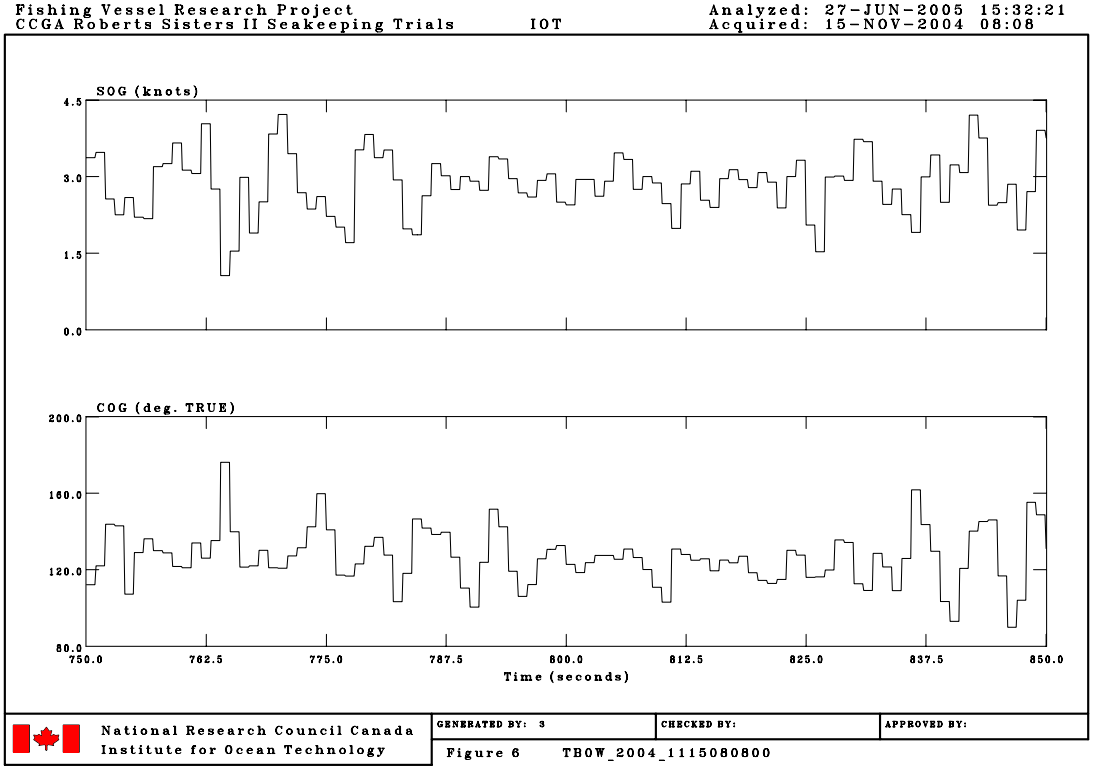


Figure 19: Offline Data Analysis – Speed Over Ground (SOG) and Course Over Ground (COG)

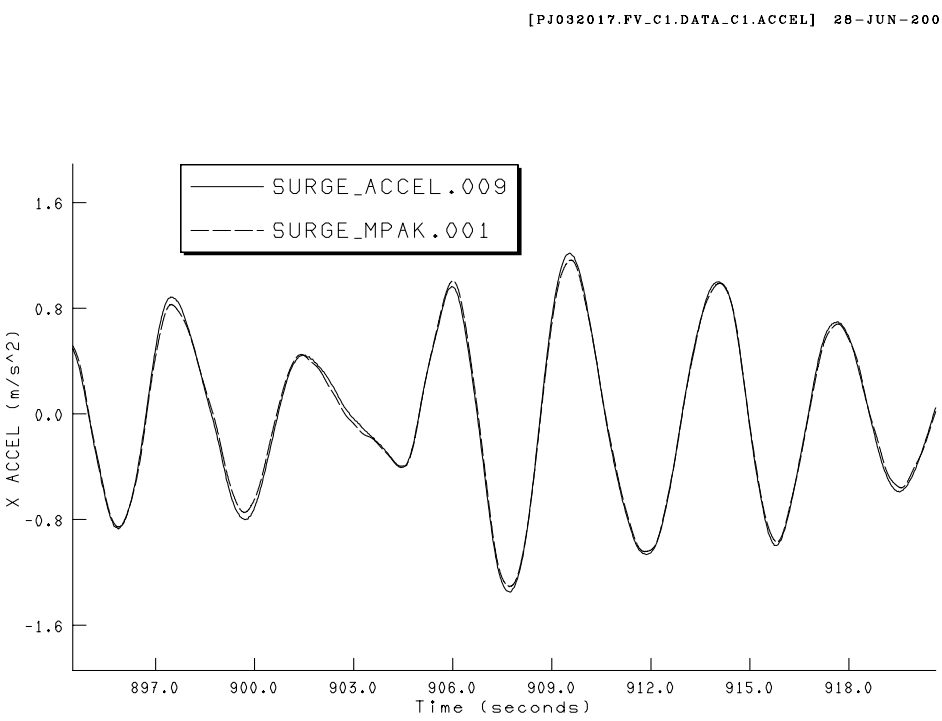


Figure 20: Comparison of MotionPak Surge Acceleration @ CG & Accelerometer Surge Acceleration on Bridge

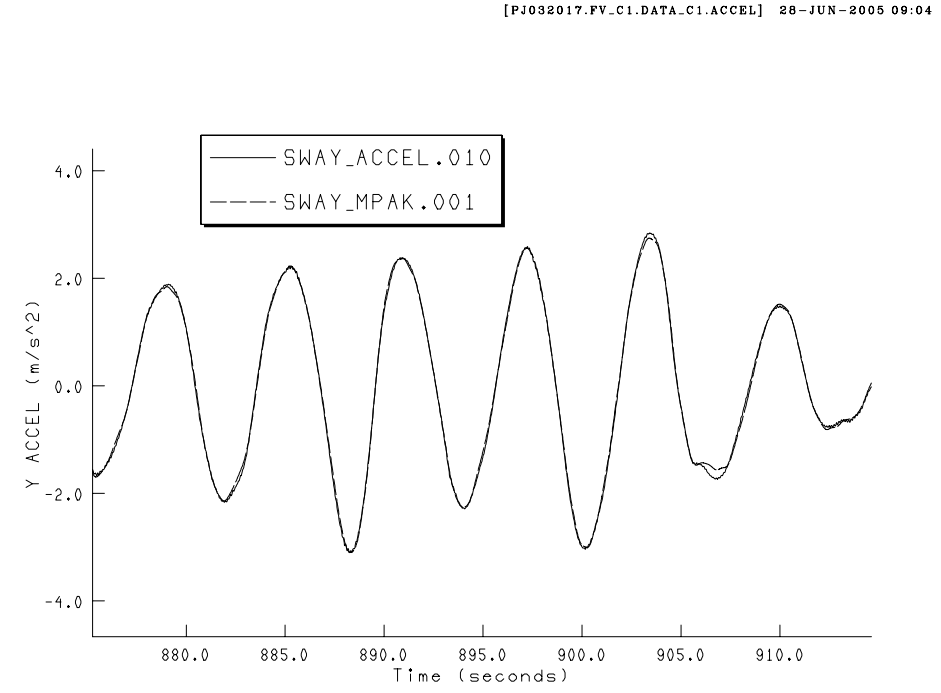


Figure 21: Comparison of MotionPak Sway Acceleration @ CG & Accelerometer Sway Acceleration on Bridge

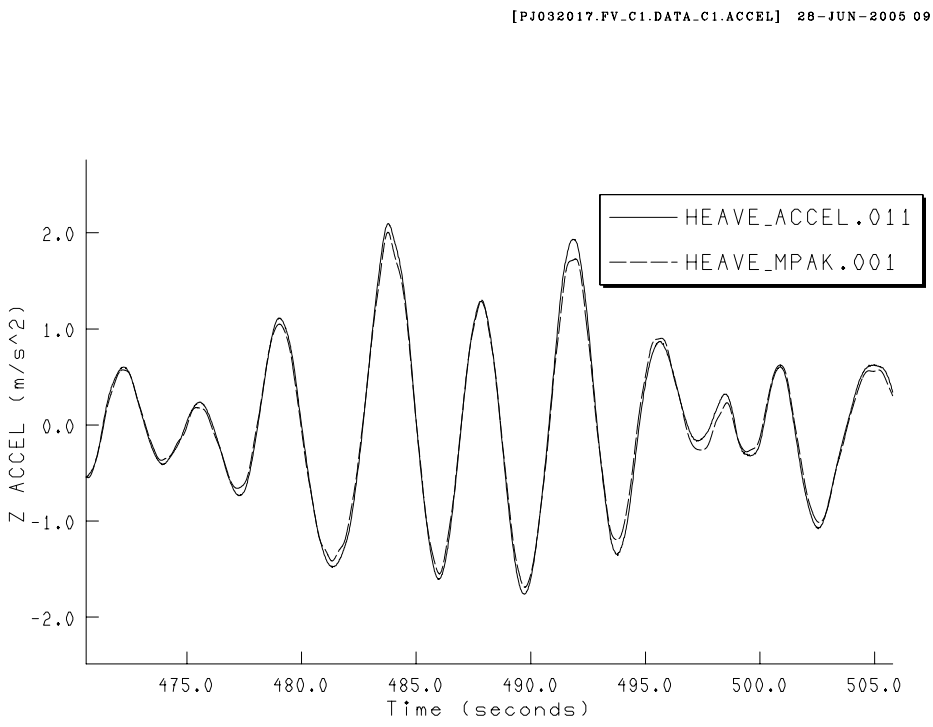


Figure 22: Comparison of MotionPak Heave Acceleration @ CG & Accelerometer Heave Acceleration on Bridge

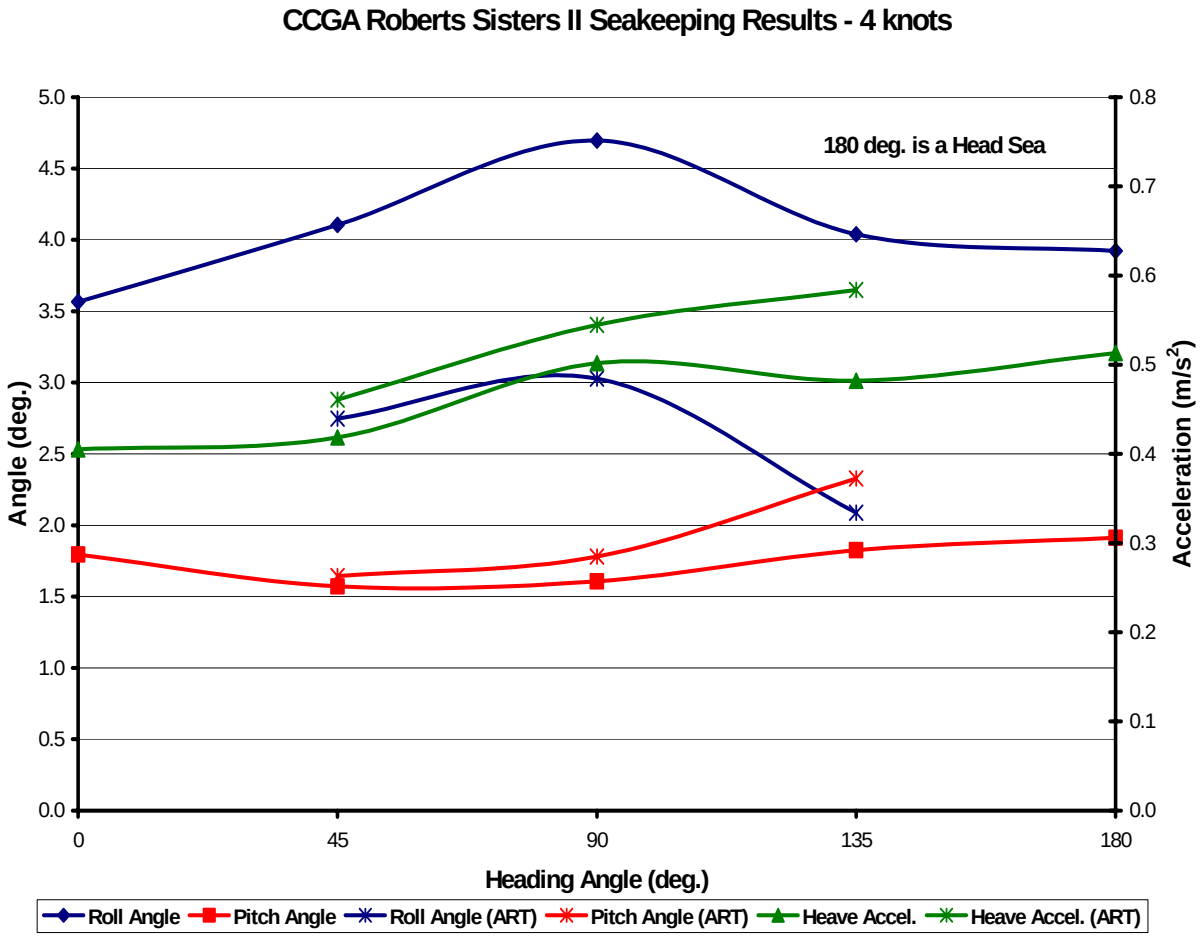


Figure 23: Seakeeping Results @ CG (Standard Deviations) – 4 knots

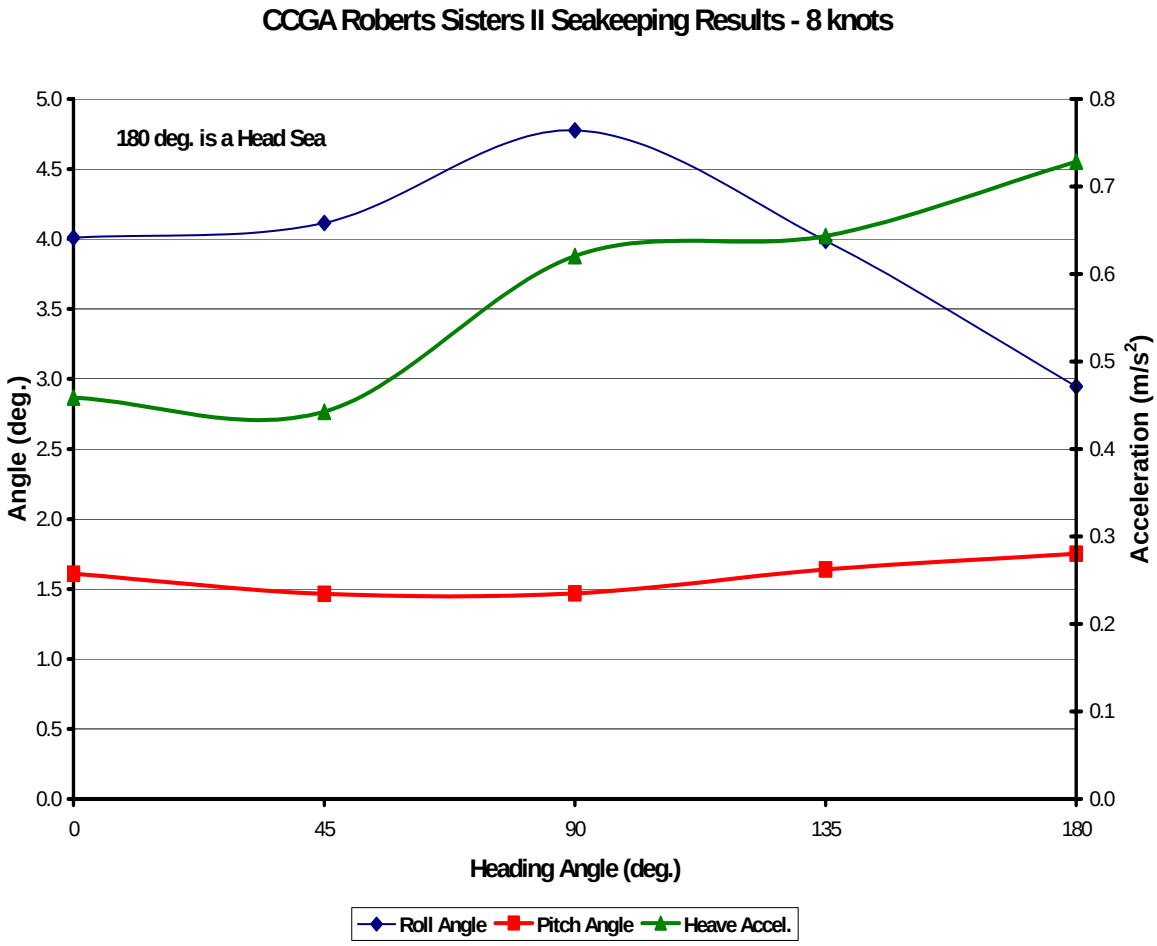


Figure 24: Seakeeping Results @ CG (Standard Deviations) – 8 knots

Figure 25: Anti-Roll Tank Level Indicator

Appendix A
Inclining Experiment Report

Marine Services International

Roberts Sisters II

Incling Experiment Report

Date:	10-Nov-04
Vessel:	Roberts Sisters II
Location:	St. John's Harbour, Fort Amherst Small Boat Basin

Conditions:

Weather:	Overcast
Wind:	Slight on the starboard bow
Sea:	calm
Specific gravity of water:	1.021
Vessel free to incline:	yes

Vessel Condition: Vessel in Sea Trial Condition

FO tks full — Anti Roll Tank empty

FW tks full

RSW tks full

Persons Onboard:

Tim Flemming - NRC

Greg Wiggins - MSI

Two crew members

Incline Weights:

Eight 55 gallon plastic drums were used pressed full of fresh water.

Two barrels were moved for each move for a weight of 1050 lbs.

Weights were moved through a distance of 18 feet 6 inches.

Weights located on the main deck

Penduli:

Forward:	100 inches located in the forward accomodations
Aft:	109.5 inches located in the dish hold

Drafts:

Forward marks on stem:	9'-3"
Aft marks on transom:	13'-7 1/2"

Freeboards:

Fwd at stem:	13'
Aft at transom:	6'-7 1/2"

General Information
Hydrostatic values interpolated from:
Roberts Sisters II Stability Booklet Prepared January 2004
Trim: 2/61.58, No heel, VCG = 0 Hydrostatics, Page 54

Draft Marks
Forward at stem 111 "
Aft at transom 163.5 "

Draft Above BL

Forward at stem	111 "	-34 "	145 "
Aft at transom	163.5 "	34 "	129.5 "

Trim of vessel
15.5 " of trim in length overall 2 % of length

Mean Draft = 11.44 ft

From Hydrostatics:
@ draft of 11.44 ft in salt water.

Displacement = 224.95 L.Tons

At time of inclining ship was in water of 1.021 specific garavity

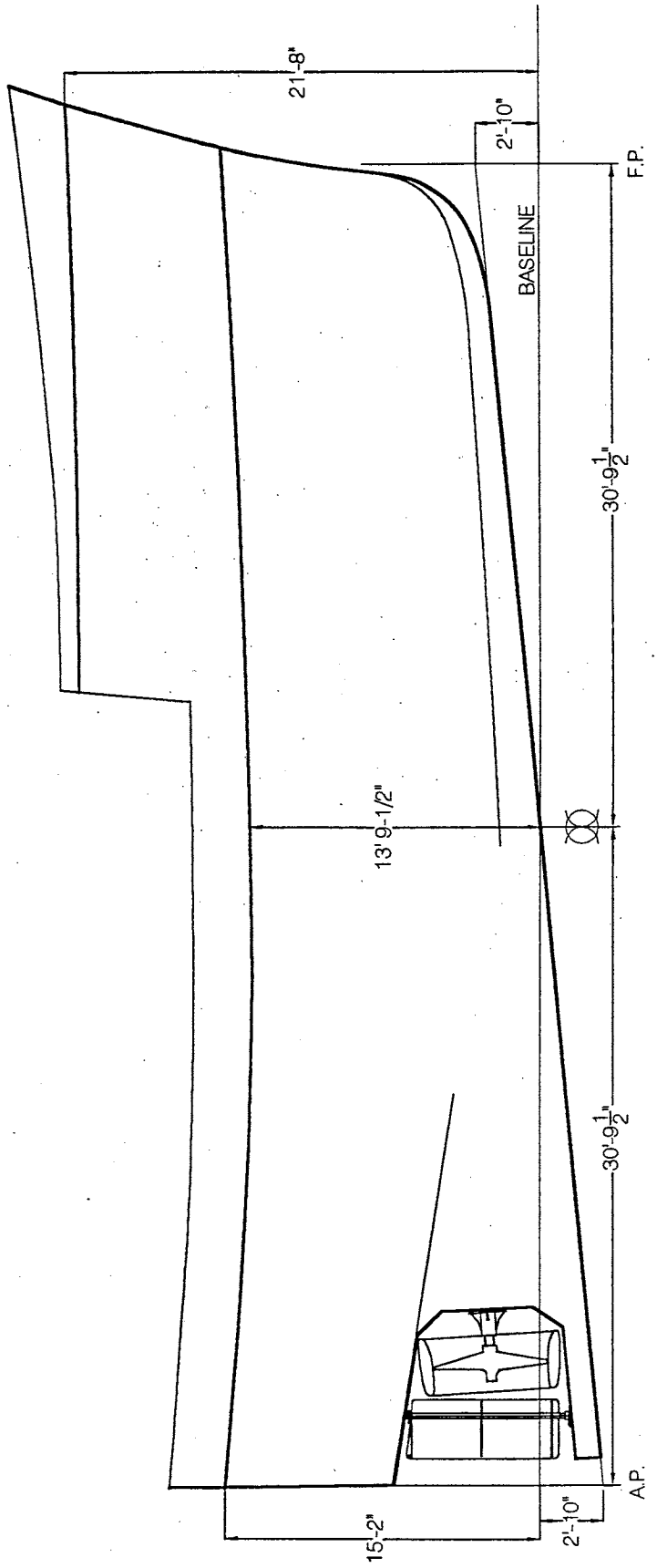
True displacement is: $\frac{1.021}{1.025} \times \Delta =$ 224.07 L.Tons

KM_T = 14.65 ft KM_L= 56.26 ft

Inclining Data
length pendulums: Forward : 100 ins.
Aft 109.5 ins.

Move	Direction of each move	Distance each weight is moved	weight of each move	Applied moment	Deflection as recorded for forward and aft pendulums.		Change in deflection per unit change of moment	Change in deflectionp er unit change of moment
		(ft)	(lbs)		FWD (ins)	AFT (ins)	(ins)	(ins)
1	P-S	18.5	1050	1	1.250	1.292	1.25	1.29
2	P-S	18.5	1050	1	1.250	1.560	1.25	1.56
3	S-P	18.5	2100	-2	-2.500	-2.875	1.25	1.44
4	S-P	18.5	1050	-1	-1.000	-1.167	1.00	1.17
5	S-P	18.5	1050	-1	-1.375	-1.580	1.38	1.58
6	S-P	18.5	2100	2	2.250	2.750	1.13	1.38
						sum	7.25	8.41
						average	1.21	1.40

DRAFT AND BASELINE PARTICULARS



CCGA Roberts Sisters II

Shift in Center of Gravity due to adding an estimated mass of 14.75 inches (37.465 cm) of sea water to the anti-roll tank. Estimated location of center of gravity of tank:

Displacement of Ship (no sea water) from Inclining Experiment: 225.4 t
Longitudinal Position of Center of Gravity from Inclining Experiment: ~ 0 m
Vertical Position of the Center of Gravity from Inclining Experiment: 3.505 m above keel

Estimated Mass of Sea Water in Anti-Roll Tank – from Stability Booklet: 3.39 t
Longitudinal Position of Center of Gravity of Anti-Roll Tank (assuming no trim angle): 0.67 m aft of amidships.
Vertical Position of Center of Gravity of Anti-Roll Tank: 6.91 m above keel
Transverse Position of Center of Gravity of Anti-Roll Tank (assuming no heel angle): 0.0 m

---

Shift of Longitudinal Center of Gravity – taking moments about amidships:

New LCG = (0.67 m *3.39 t)/(225.4 t + 3.39 t) = 0.01 m aft of amidships

Shift of Vertical Center of Gravity – taking moments about keel:

New VCG = (225.4 t * 3.505 m + 3.39 t * 6.91 m)/(225.4 t + 3.39 t)
= 3.555 m

VCG shift = 3.505 m – 3.555 m = -0.0505 m up

Appendix B
Principle Particulars, List of Outfit Items & General Arrangement Sketches

CCGA Roberts Sisters II

Principal Particulars:

Length Overall:	64' 11" (19.79 m)
Beam:	23' (7.01 m)
Draft:	12' 6" (3.81 m)
Depth (BOK):	13' 6" (4.11 m)
Installed Power:	624 HP (354.2 kW)
Displacement:	224 L. Tons (227,594 kg)
Fuel Capacity:	4500 gal. (20457.4 l)
Fresh Water Capacity:	1300 gal. (5909.9 l)
Fish Hold Volume:	3828 ft^3 (108.4 m^3)
Accommodations:	11 berths
Permanent Ballast:	11.0 m^3 of cement on fish hold floor & under fwd. accommodation

Built	2001
Builder:	Universal Marine Ltd., La Scie, NL

Machinery Description:

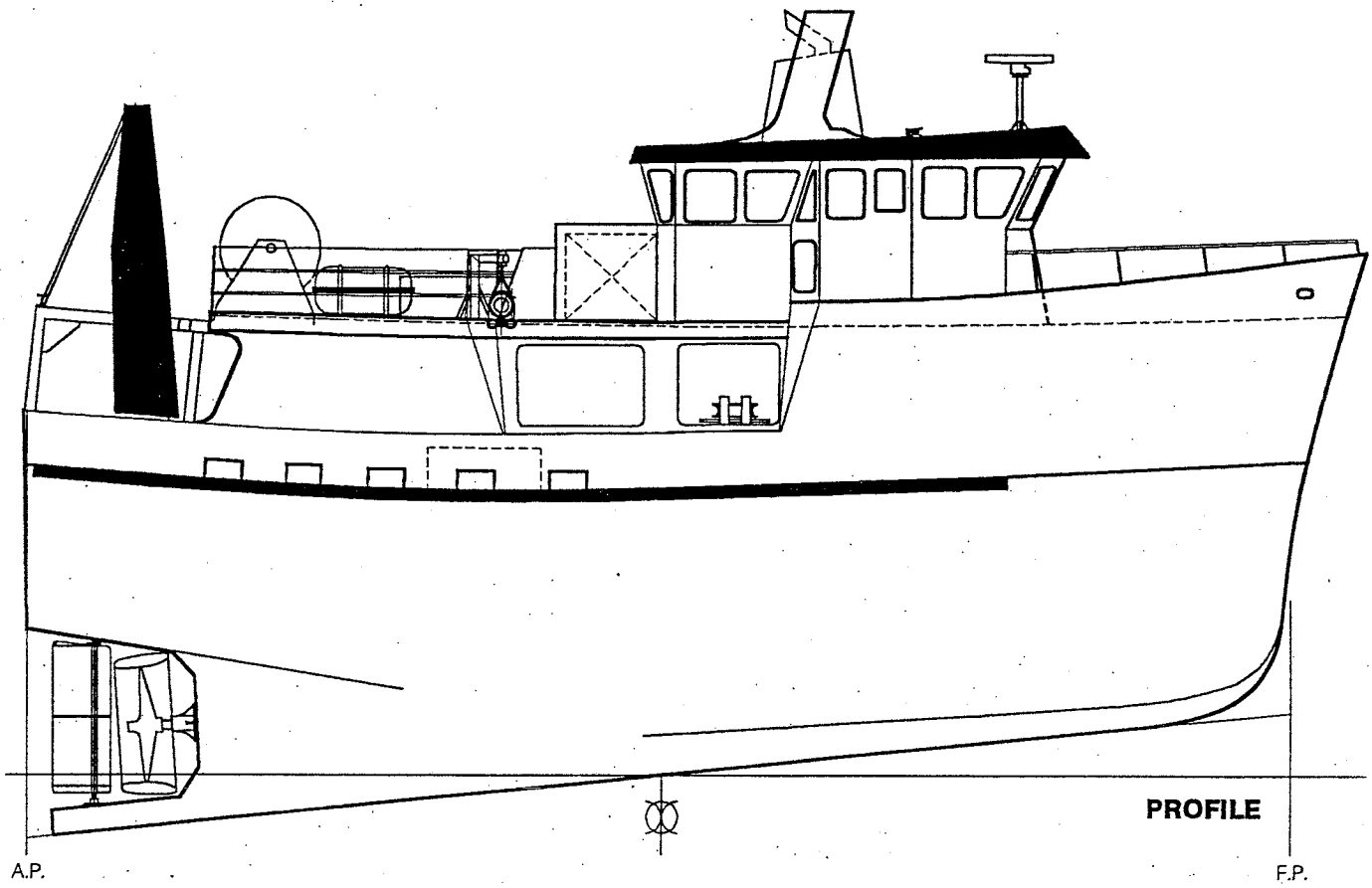
Engine:	Caterpillar
Propulsion Power:	624 HP
Trawl Speed:	2 knots
Cruising Speed:	9 knots
Maximum Rudder Angle:	± 38° (nominal)
Electrical Power:	120 VAC

Life Saving Equipment:

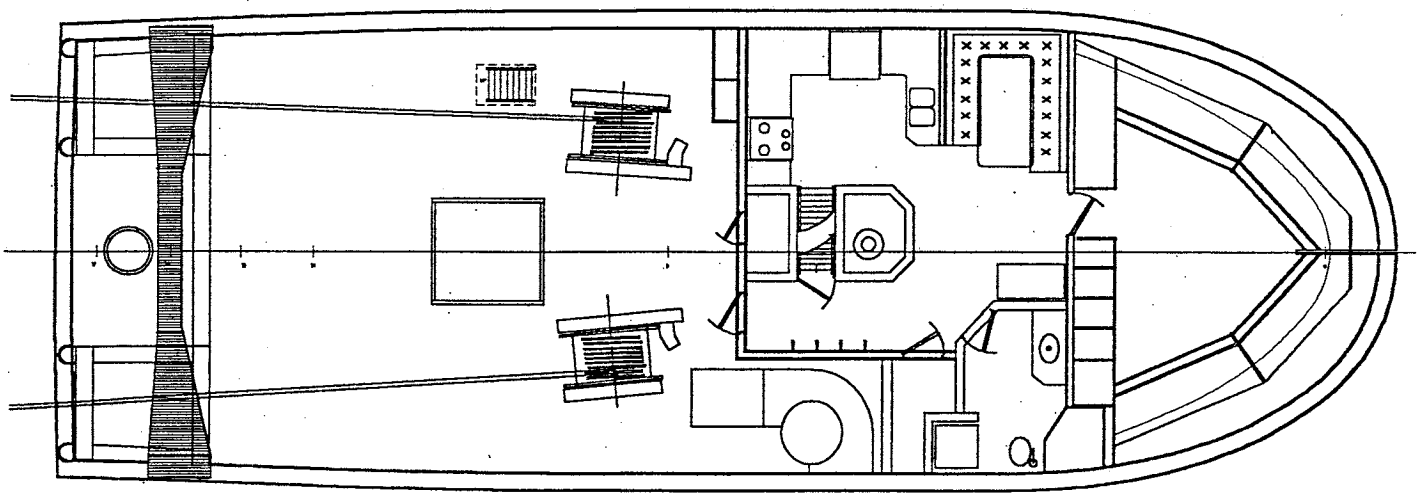
Life raft:	2 X 12 person

Epirb
Full suite DOT approved firefighting and emergency equipment

GENERAL ARRANGEMENT

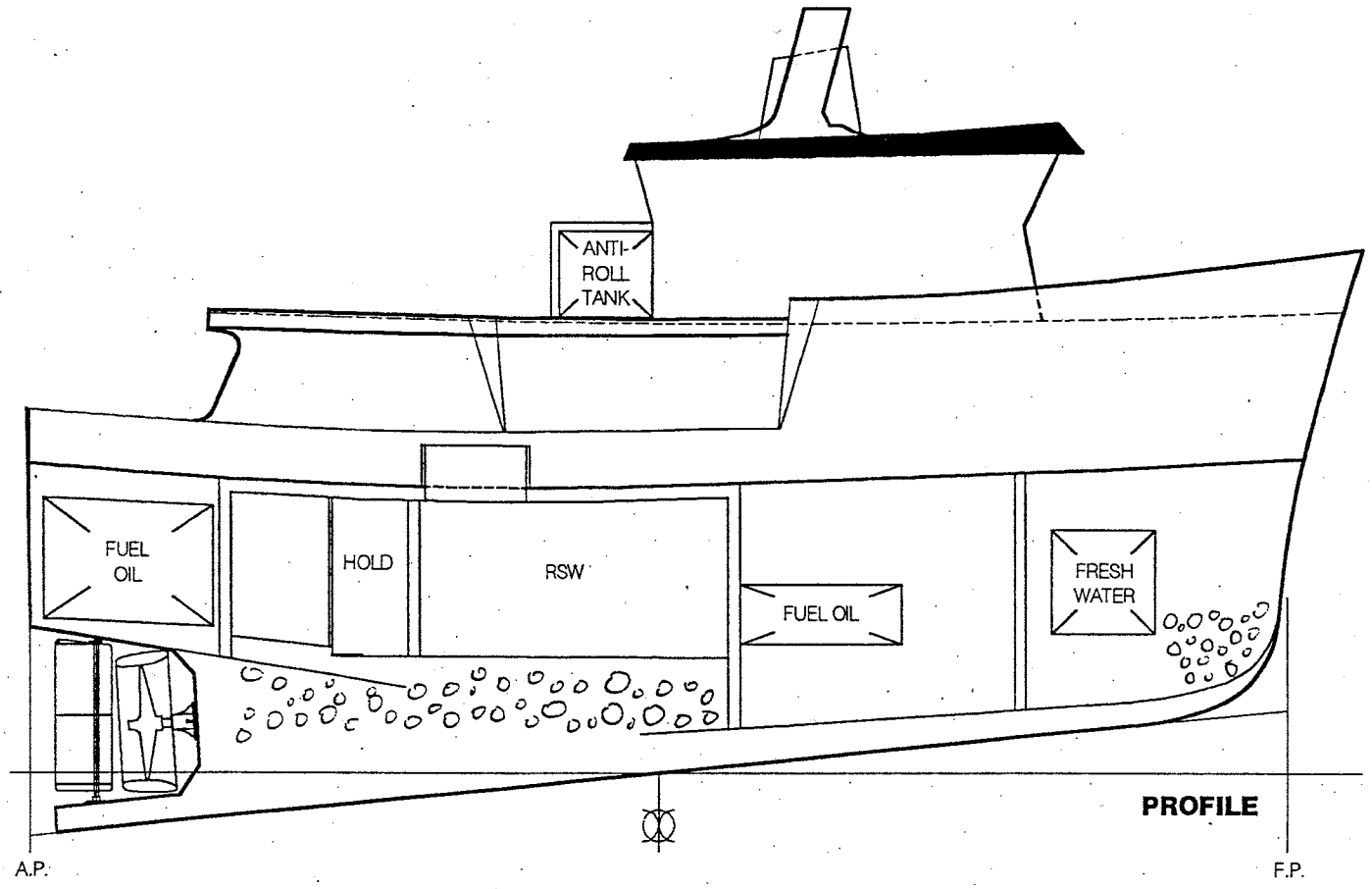


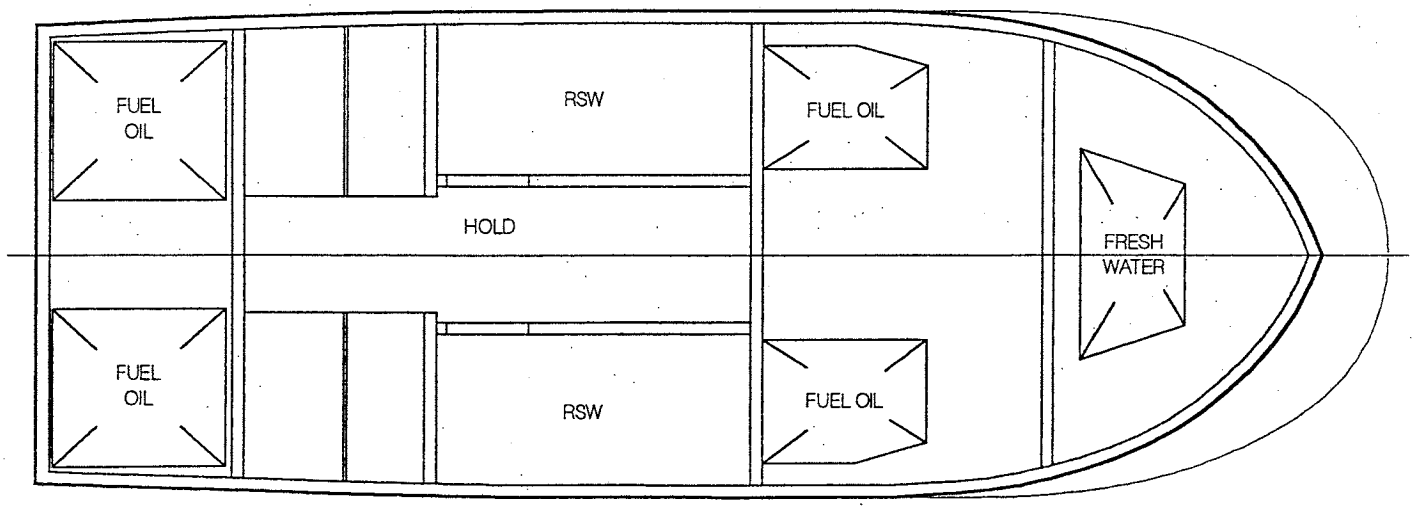
PROFILE



MAIN DECK PLAN

TANK PLAN


ANTI-
ROLL
TANK
FUEL
OIL
HOLD
RSW
FUEL OIL
FRESH
WATER
PROFILE
A.P.
F.P.


FUEL
OIL
RSW
FUEL OIL
HOLD
FRESH
WATER
FUEL
OIL
RSW
FUEL OIL

Appendix C
Instrumentation Plan

Instrumentation Plan for Fishing Vessel Trials

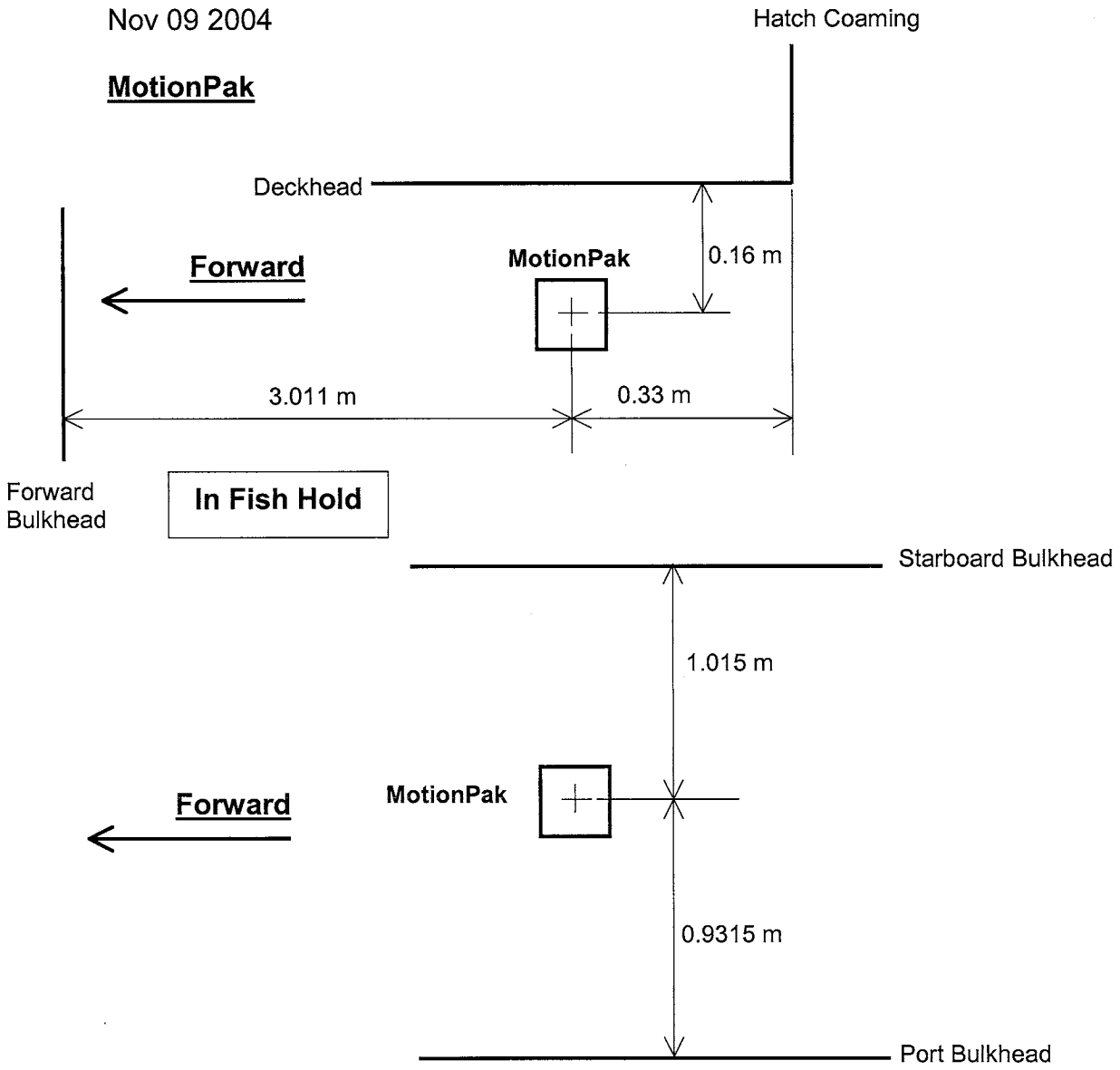
See Proj PIP for additional info on instrumentation requirements incl. critical levels.

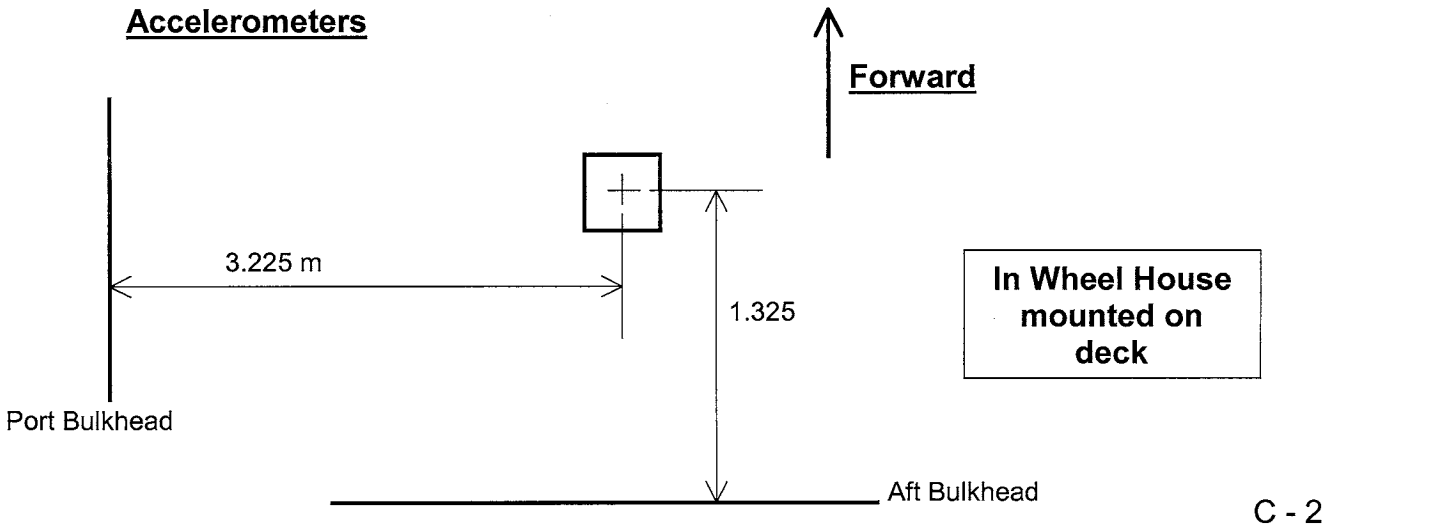
Proj. 2017 **Nov. 15, 2004** **V2.0**

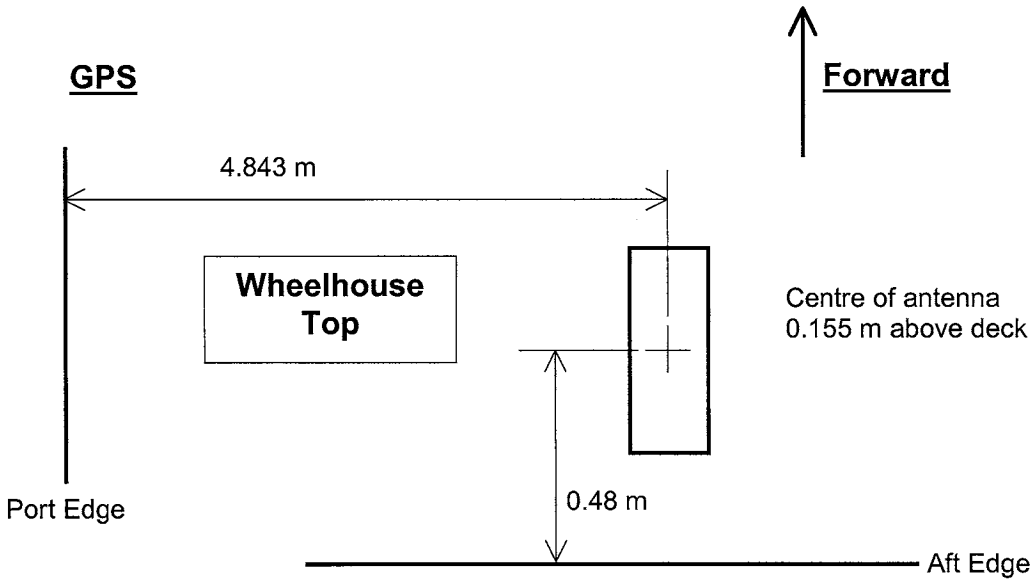
Signal	Device	Calibrated Range	Units	Comments
Vertical Acceleration	MotionPak	+/- 20	m/s^2	
Lateral Acceleration	MotionPak	+/- 20	m/s^2	
Longitudinal Acceleration	MotionPak	+/- 20	m/s^2	
Yaw Rate	MotionPak	+/- 50	deg./s	
Roll Rate	MotionPak	+/- 50	deg./s	
Pitch Rate	MotionPak	+/- 50	deg./s	
Vertical Acceleration	Linear accelerometer	+/- 20	m/s^2	
Lateral Acceleration	Linear accelerometer	+/- 20	m/s^2	
Longitudinal Acceleration	Linear accelerometer	+/- 20	m/s^2	
Roll Angle	Inclinometer	+/- 30	deg.	only required in manoeuvring trials are to be carried out
Pitch Angle	Inclinometer	+/- 20	deg.	low critical parameter
Forward Speed	DGPS	0-20	knots	
Heading Angle	DGPS	0-360	deg. TRUE	
Planar Position	DGPS	-	m	
Rudder Angle	yo-yo potentiometer	+/- 45	deg.	required if manoeuvring trials to be carried out, otherwise measure if convenient
Shaft RPM	freq./volt. converter	0 - 1000	RPM	low critical parameter
Wind Speed/Direction	Directional anemometer			Signal noted by hand – not acquired

Roberts Sisters II Equipment Positions

Nov 09 2004






GPS
Forward
4.843 m
Wheelhouse Top
Centre of antenna
0.155 m above deck
Port Edge
0.48 m
Aft Edge

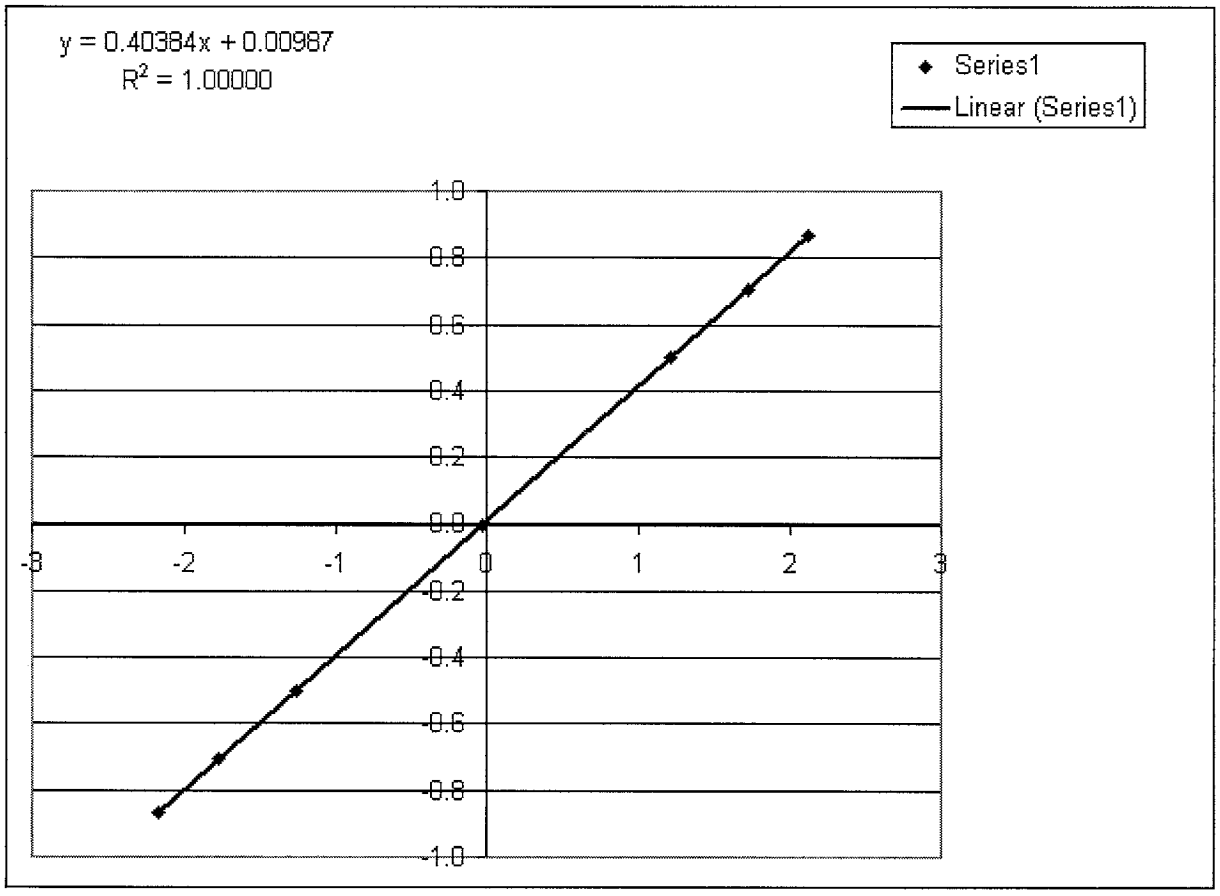
Appendix D
Calibration Information

Ch. 01
Surge Acceleration, MotionPak

S/N 0689

Gravity 1

Angle	Sin(angle)	Acceleration	Voltage	slope	offset
0	0	0.0000	-0.023	0.4038	0.0099
29.994	0.499909307	0.4999	1.213		
45.016	0.707304215	0.7073	1.726		
59.9	0.865151421	0.8652	2.118		
-59.9	-0.865151421	-0.8652	-2.17		
-45.016	-0.707304215	-0.7073	-1.774		
-29.994	-0.499909307	-0.4999	-1.261		



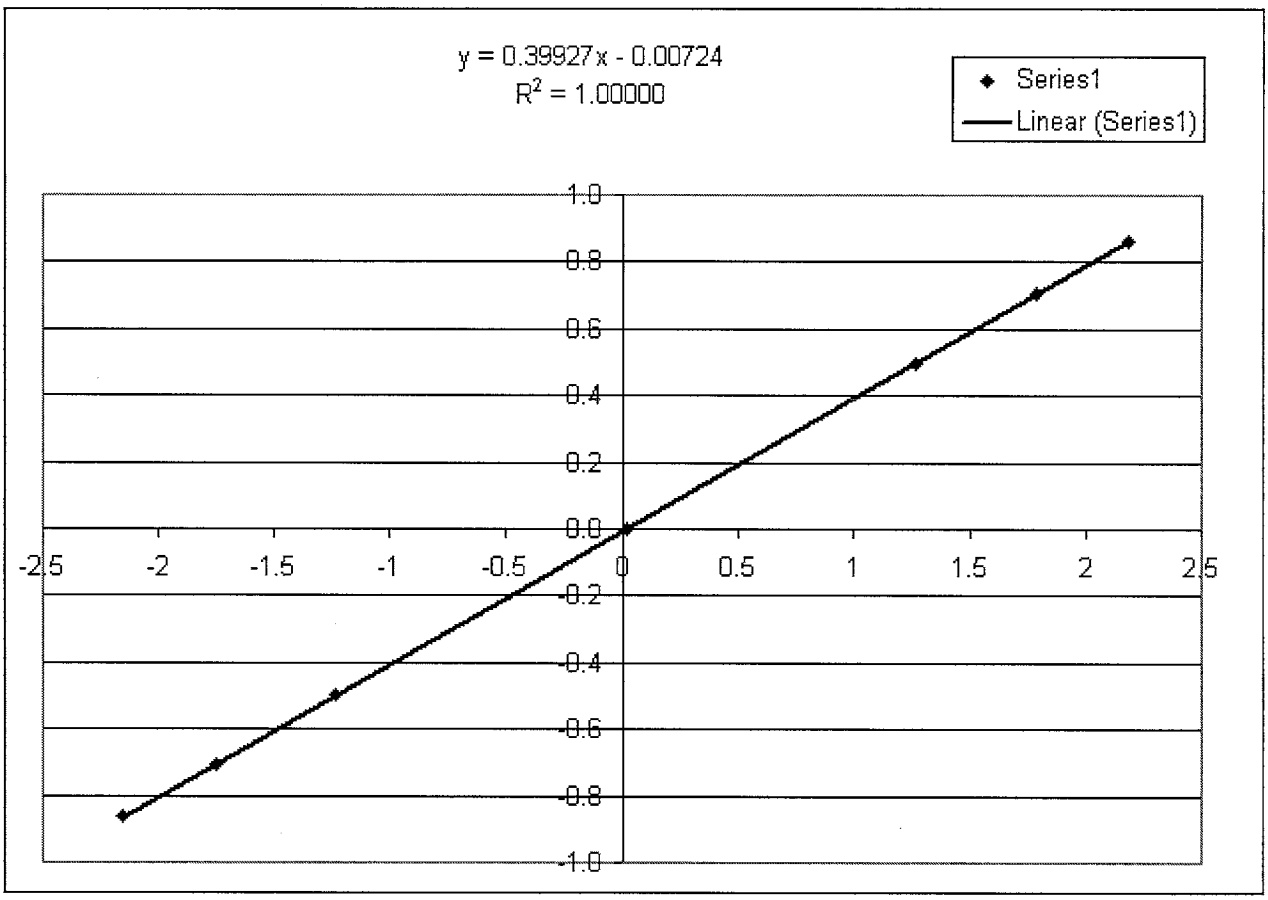
Ch 02
Sway Acceleration, MotionPak

S/N 0689

Gravity 1

Angle	Sin(angle)	Acceleration	Voltage
0	0	0.0000	0.02
29.994	0.499909307	0.4999	1.27
45.016	0.707304215	0.7073	1.788
59.9	0.865151421	0.8652	2.185
-59.9	-0.865151421	-0.8652	-2.152
-45.016	-0.707304215	-0.7073	-1.753
-29.994	-0.499909307	-0.4999	-1.231

slope	offset
0.3993	-0.0072



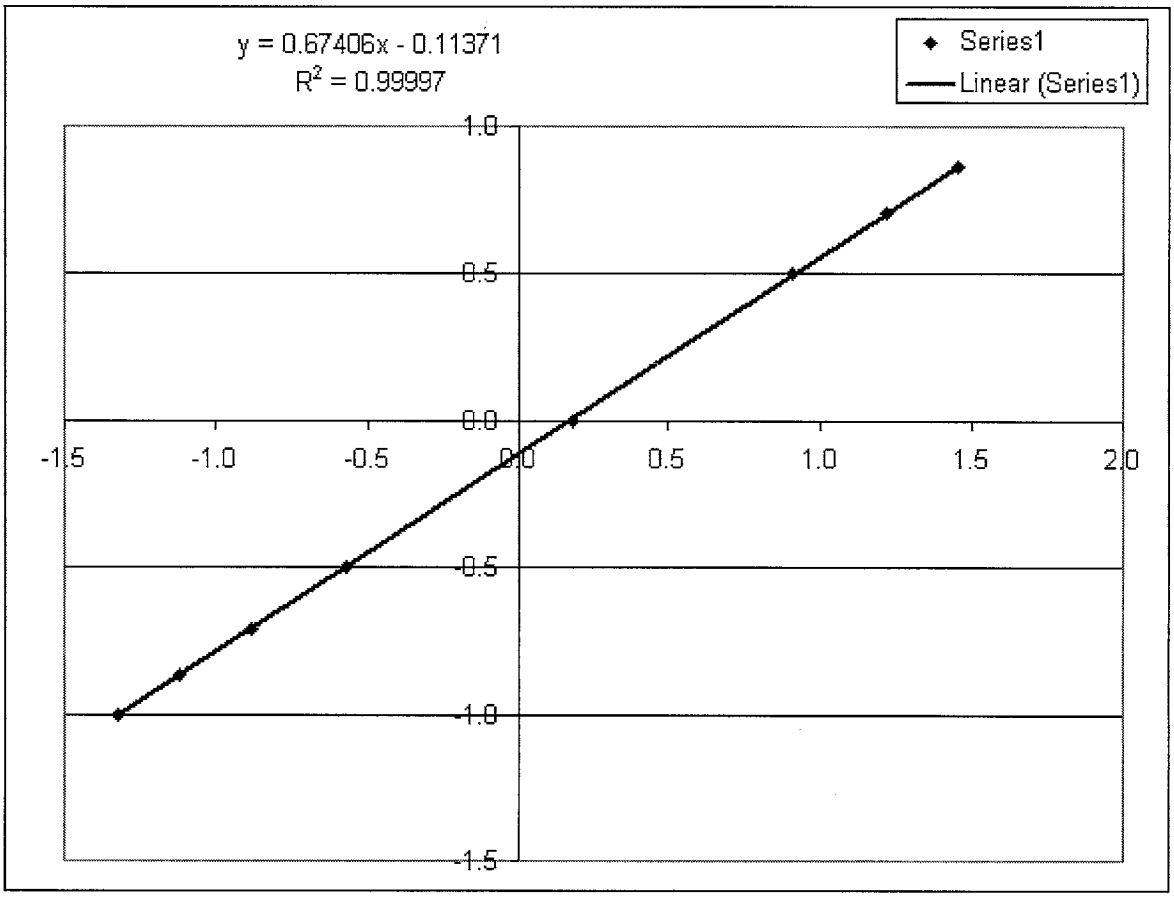
Ch 03
Heave Acceleration, MotionPak

S/N 0689

Gravity 1

wedge	Angle	-Sin(angle)	Acceleration	Voltage
0	90	-1	-1.0000	-1.321
29.994	60.006	-0.866077759	-0.8661	-1.118
45.016	44.984	-0.706909292	-0.7069	-0.879
59.9	30.1	-0.501510737	-0.5015	-0.570
90	0	0	0.0000	0.179
-59.9	-30.1	0.501510737	0.5015	0.905
-45.016	-44.984	0.706909292	0.7069	1.216
-29.994	-60.006	0.866077759	0.8661	1.454

slope	offset
0.6741	-0.1137



Ch. 04
Roll Angular Rate, MotionPak

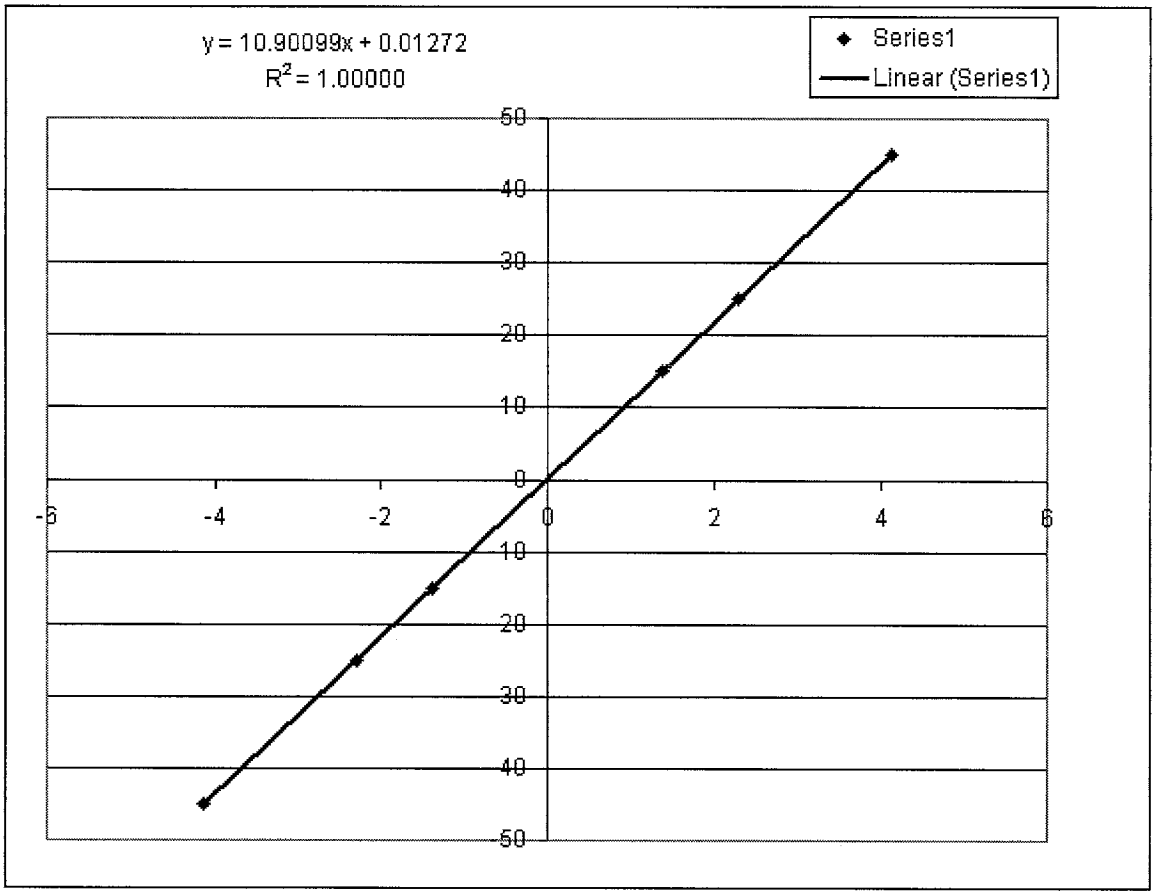
S/N 0689

Scale Factor 24.941mV/deg/s

Universal Source 169644

Deg/second	injected voltage Volts	Output, Volts
45	1.1223	4.127
25	0.6235	2.292
15	0.3741	1.375
-15	-0.3741	-1.377
-25	-0.6235	-2.295
-45	-1.1223	-4.129

slope	offset
10.9010	0.0127



Ch. 05
Pitch Angular Rate, MotionPak

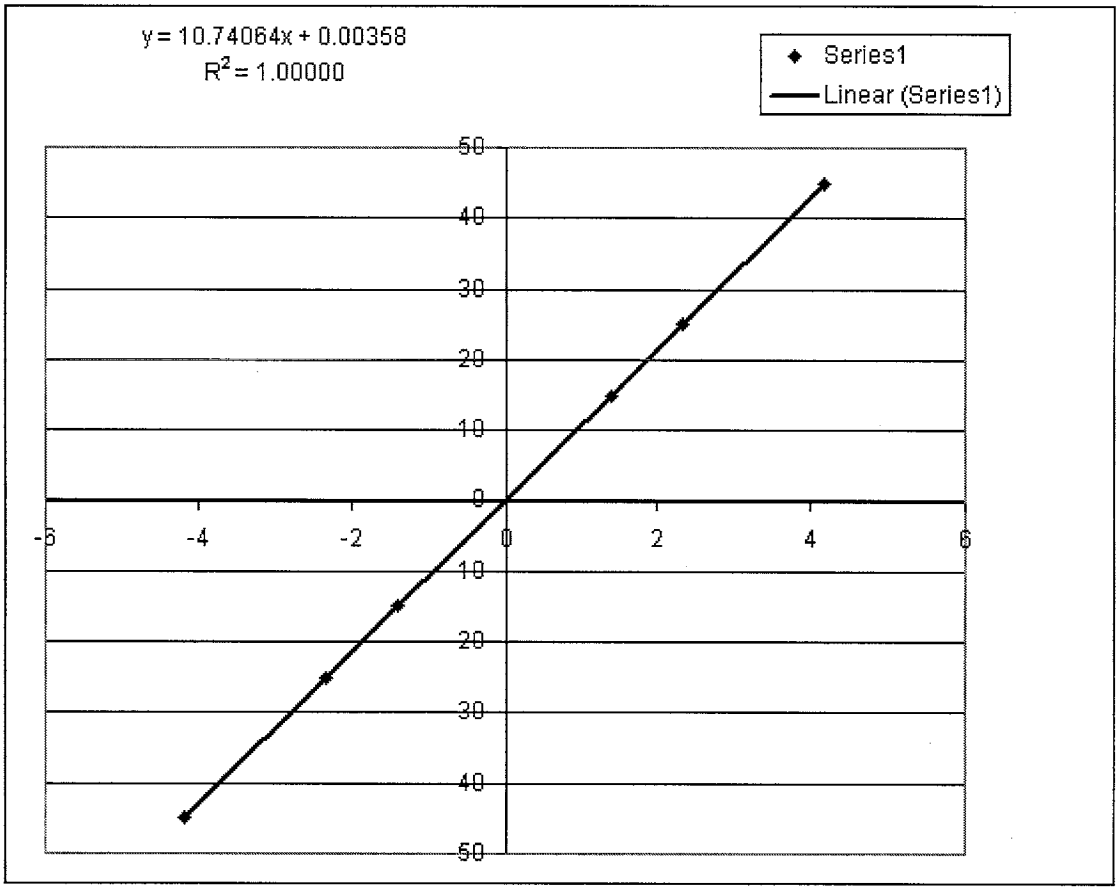
S/N 0689

Scale Factor 25.051 mV/deg/s

Universal Source 169644

Deg/second	injected voltage, V	Output, Volts
45	1.1273	4.189
25	0.6263	2.328
15	0.3758	1.396
-15	-0.3758	-1.397
-25	-0.6263	-2.328
-45	-1.1273	-4.190

slope	offset
10.7406	0.0036



Ch. 06
Yaw Angular Rate, MotionPak

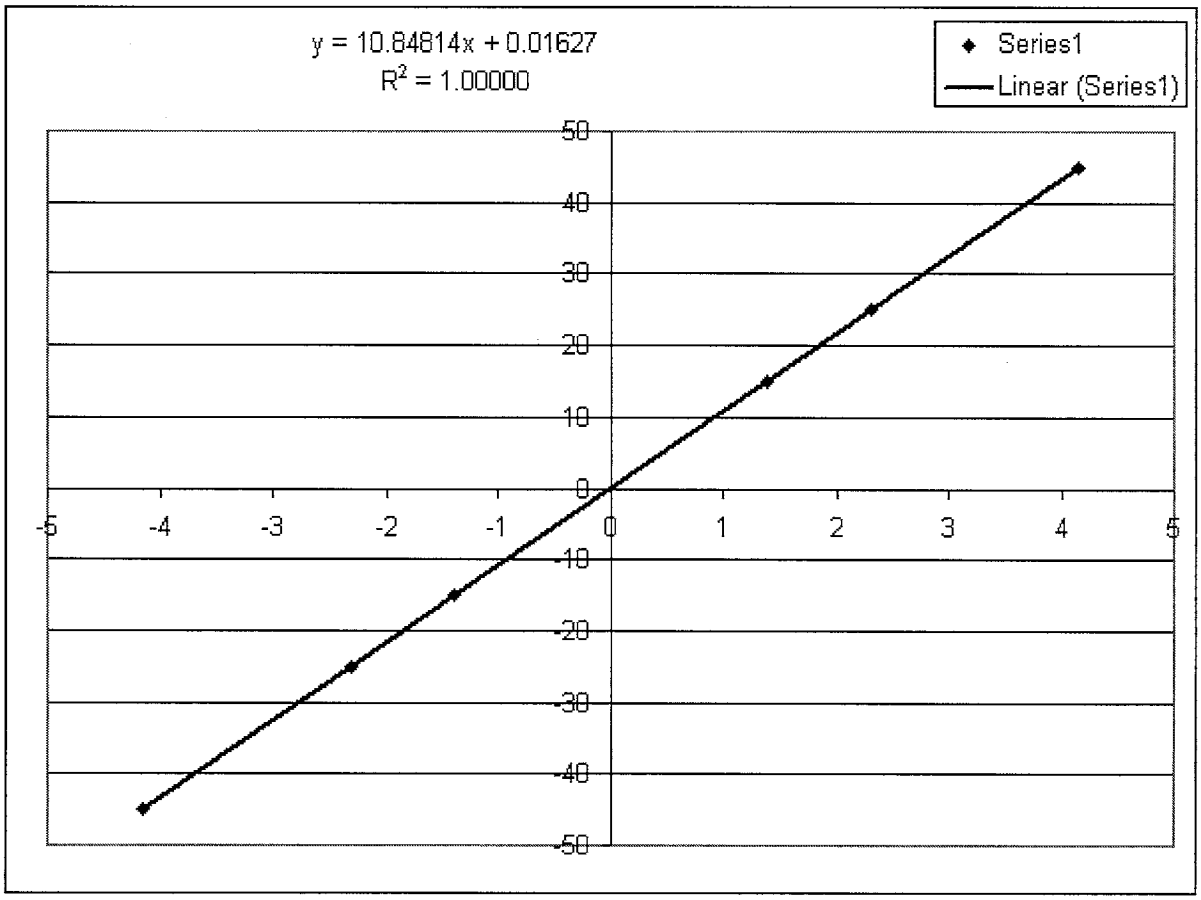
S/N 0689

Scale Factor 24.89mV/deg/s

Universal Source 169644

Deg/second	injected voltage	Output, Volts
45	1.1201	4.146
25	0.6223	2.304
15	0.3734	1.381
-15	-0.3734	-1.384
-25	-0.6223	-2.306
-45	-1.1201	-4.150

slope	offset
10.8481	0.0163



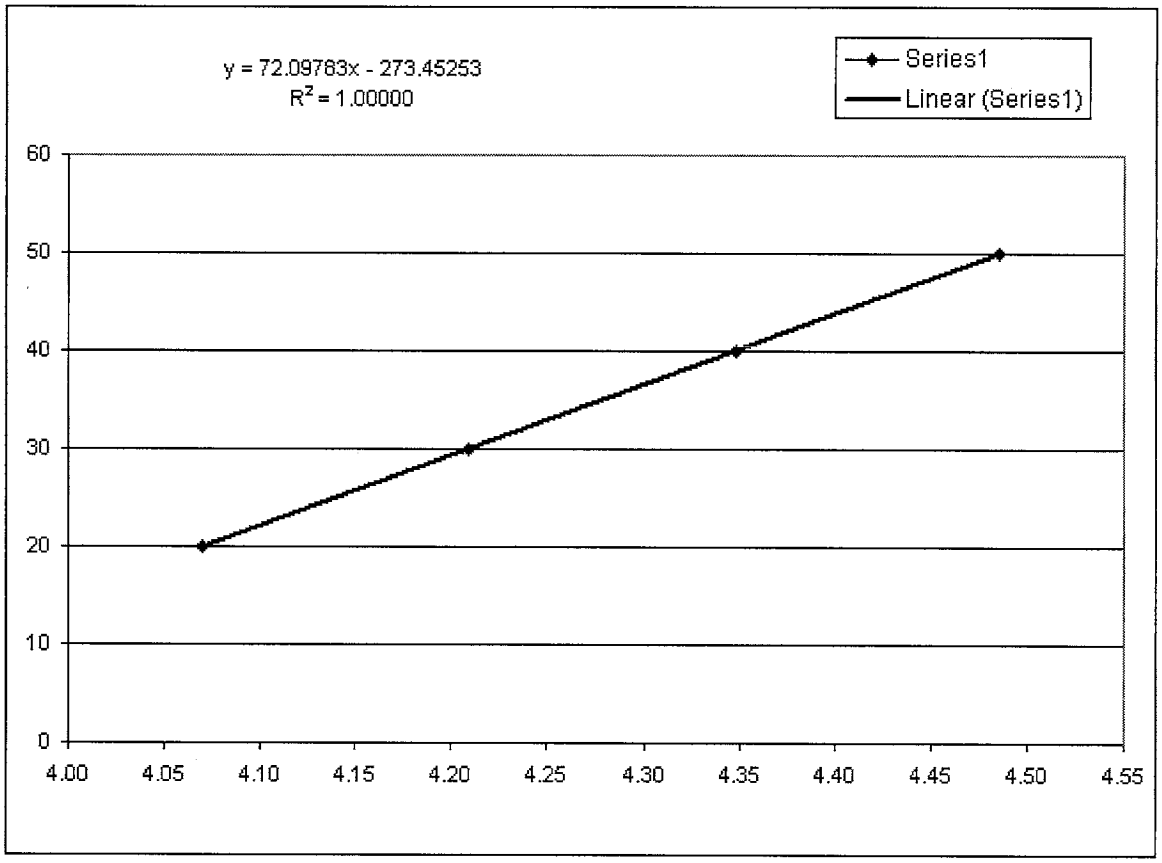
Ch. 07
Internal Temperature, MotionPak

S/N 0326

1.00E-06	A/°K
13.91	Kohms

Temperature	injected voltage	Output, Volts
Celsius	V	Volts
-10	3.660	3.652
0	3.800	3.792
20	4.078	4.070
30	4.217	4.209
40	4.356	4.348
50	4.495	4.486

slope	offset
72.0978	-273.4525



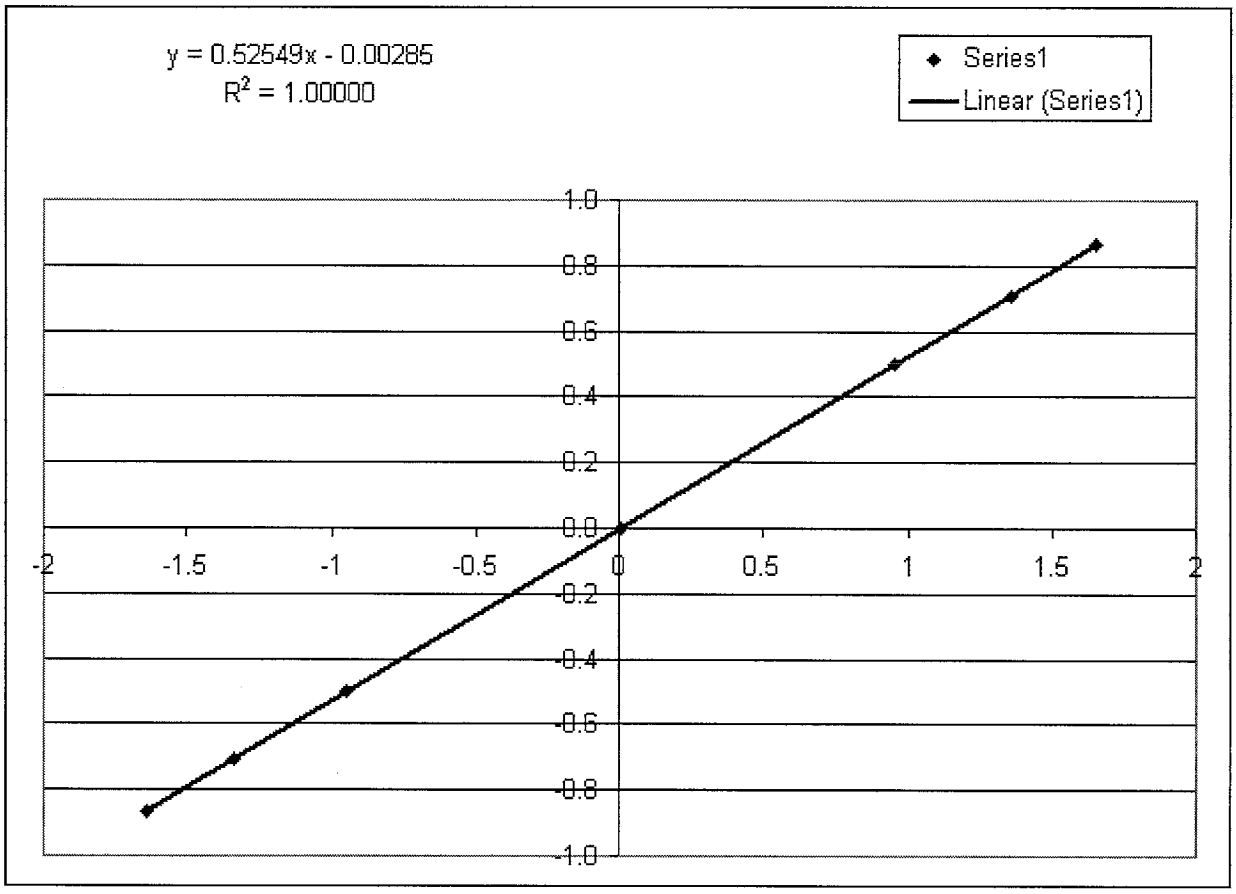
Ch 08
Surge Linear Acceleration

Model **QA1400**
serial # **1102**

Gravity 1

Angle	Sin(angle)	Acceleration	Voltage
0	0	0.0000	0.004
29.994	0.499909307	0.4999	0.954
45.016	0.707304215	0.7073	1.354
59.9	0.865151421	0.8652	1.652
-59.9	-0.865151421	-0.8652	-1.642
-45.016	-0.707304215	-0.7073	-1.339
-29.994	-0.499909307	-0.4999	-0.945

slope	offset
0.5255	-0.0029



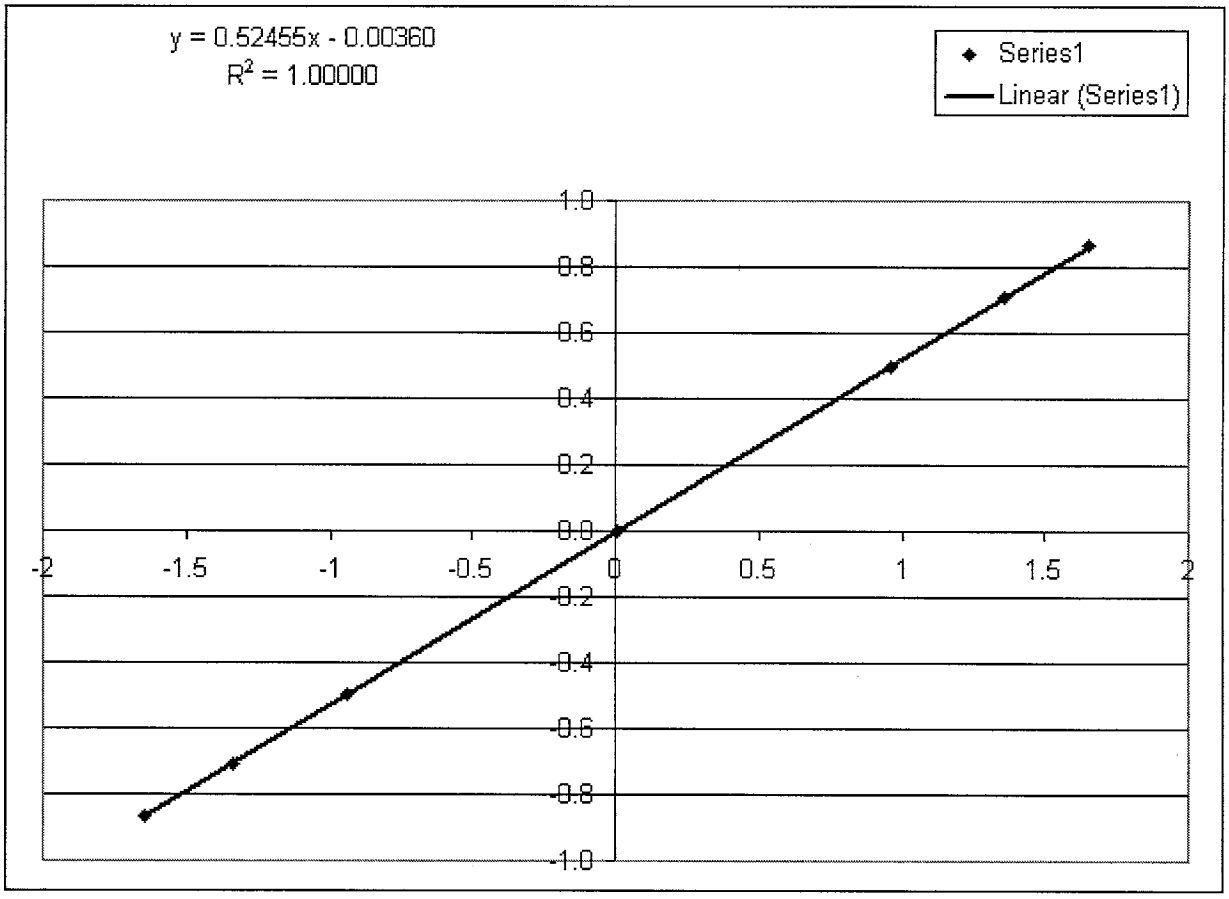
Ch 09
Sway Linear Acceleration

Model **QA1400**
serial # **1101**

Gravity 1

Angle	Sin(angle)	Acceleration	Voltage
0	0	0.0000	0.008
29.994	0.499909307	0.4999	0.959
45.016	0.707304215	0.7073	1.358
59.9	0.865151421	0.8652	1.653
-59.9	-0.865151421	-0.8652	-1.647
-45.016	-0.707304215	-0.7073	-1.34
-29.994	-0.499909307	-0.4999	-0.943

slope	offset
0.5245	-0.0036



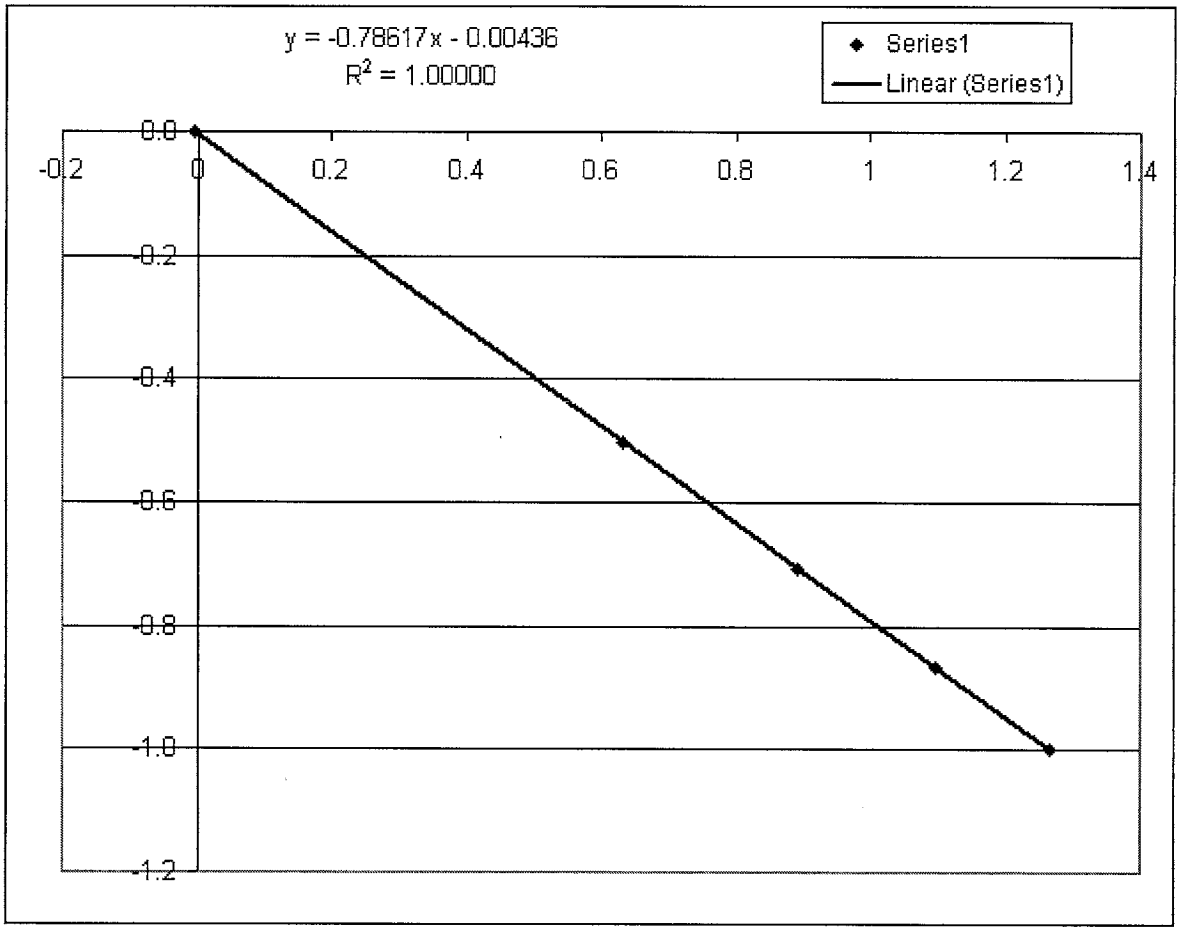
Ch 10
Heave Linear Acceleration

Model **QA1400**
serial # **149**

Gravity 1

wedge	Angle	SIN(angle)	Acceleration	Voltage
0	90	-1	-1.0000	1.267
29.994	60.006	-0.866077759	-0.8661	1.097
45.016	44.984	-0.706909292	-0.7069	0.892
59.9	30.1	-0.501510737	-0.5015	0.632
90	0	0	0.0000	-0.005

slope	offset
-0.7862	-0.0044



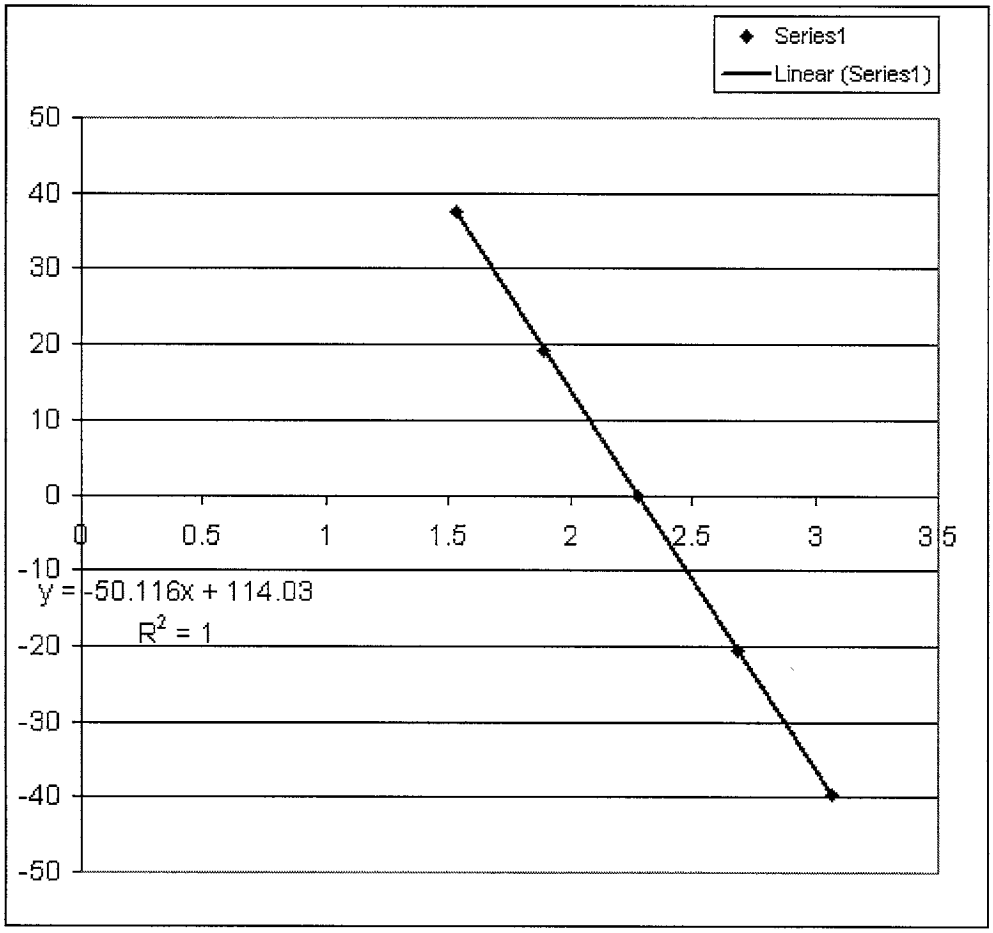
Ch 11
Rudder Angle

Model **PV-25A**
serial # **A1080703-2058206**

Gravity 1

Angle	Voltage
37.5	1.528
19.25	1.887
0	2.281
-20.5	2.683
-39.75	3.068

slope	Intercept
-50.1155	114.0344

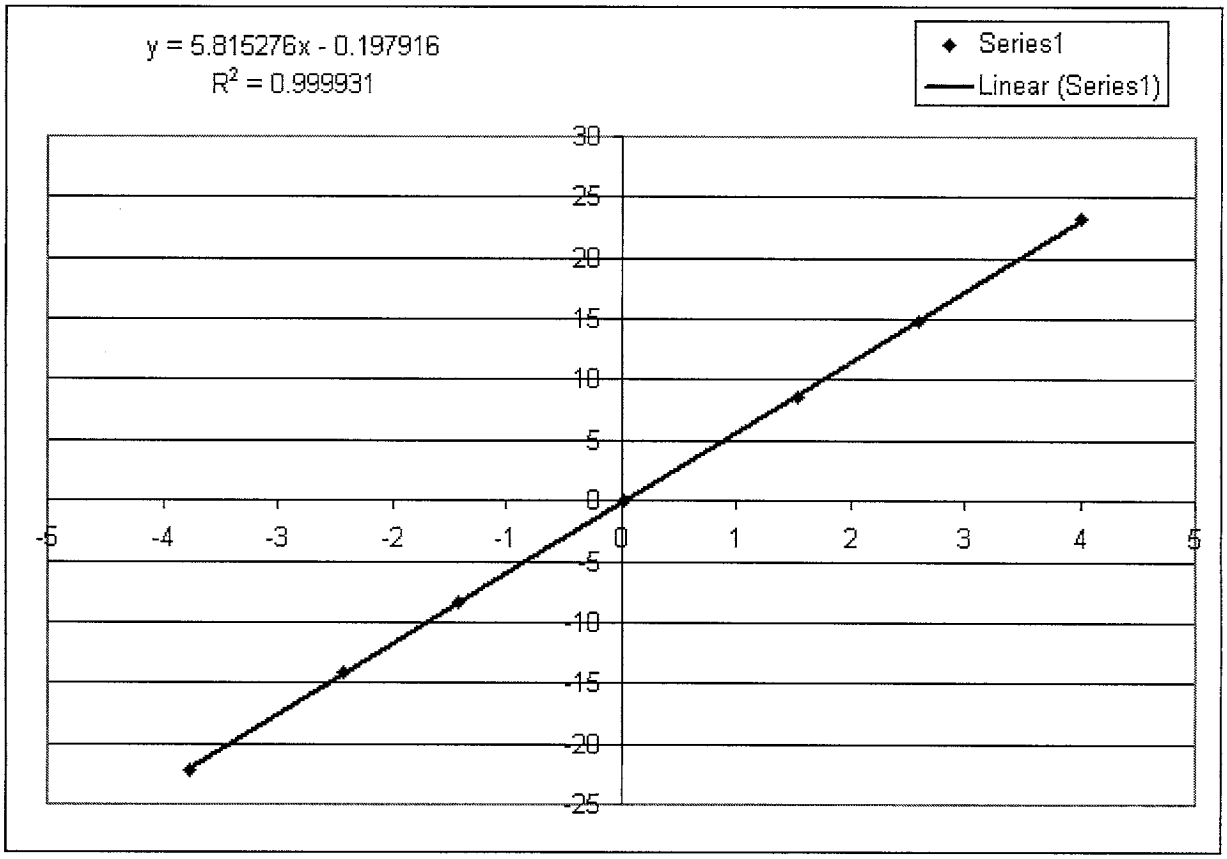


Ch 12
Roll Angle (inclinometer)

Model	**LSOC-30**
serial #	**52732**

Angle	Voltage
23.2	4.003
14.8	2.598
8.62	1.541
-0.01	0.028
-8.34	-1.415
-14.1	-2.421
-22.2	-3.757

slope	offset
5.8153	-0.1979

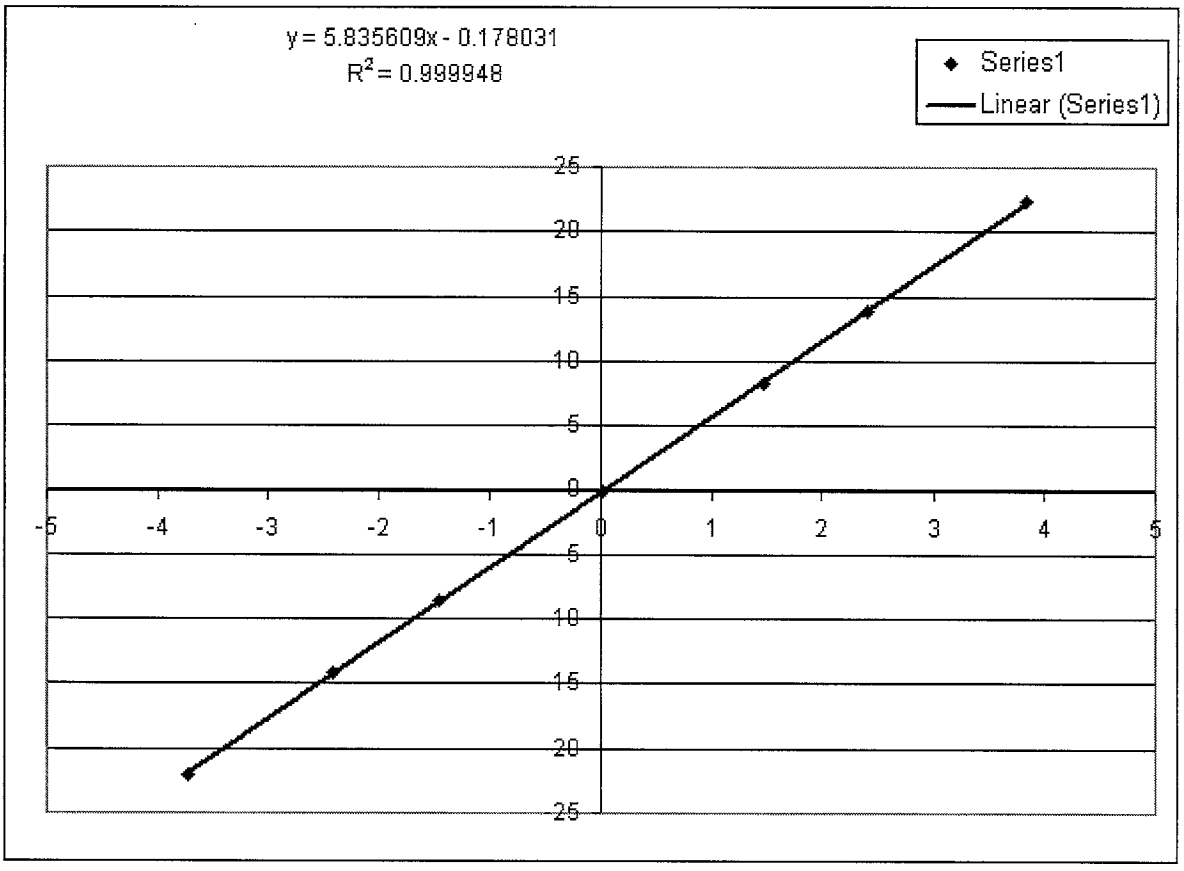


Ch 13
Pitch Angle (inclinometer)

Model	**LSOC-30**
serial #	**52734**
Gravity	1

Angle	Voltage
22.30	3.833
13.80	2.415
8.33	1.476
-0.03	0.024
-8.56	-1.453
-14.10	-2.408
-22.00	-3.718

slope	Offset
5.8356	-0.1780



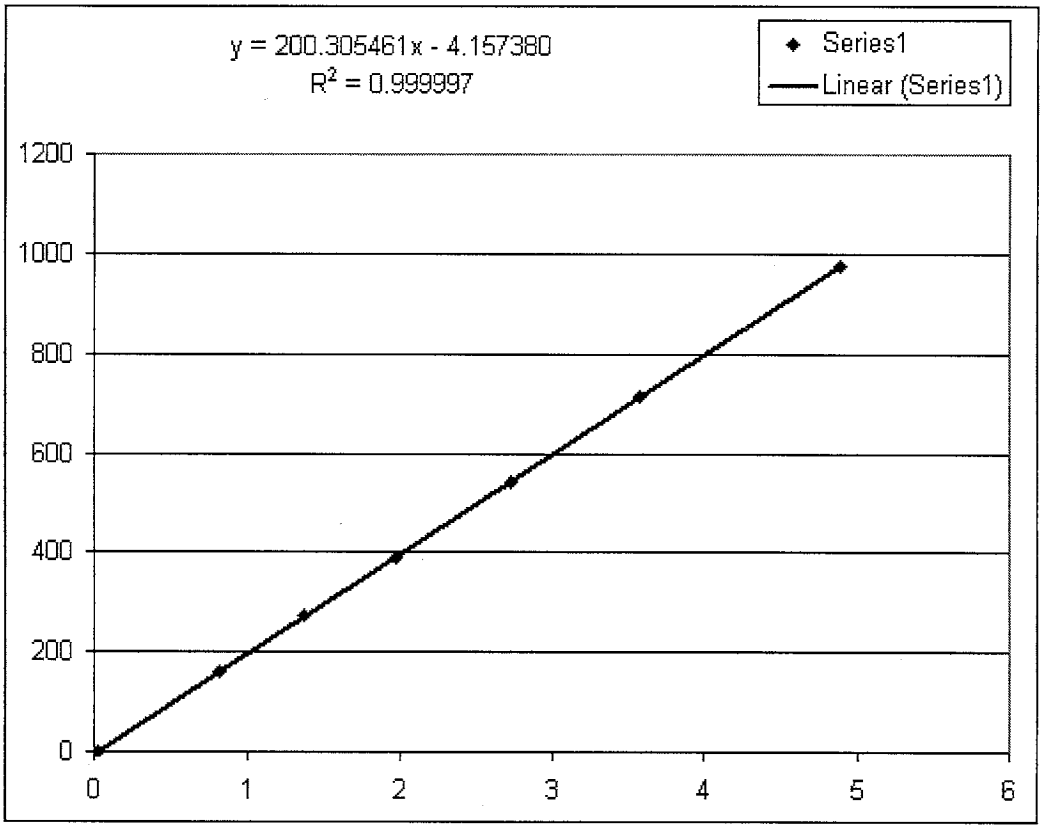
Ch 14
Propeller Shaft RPM
IOT RPM to voltage converter

Model
serial #

rpm	Voltage Out
0	0.025
162	0.827
271	1.37
390	1.97
543	2.73
713	3.58
975	4.89

slope	Offset
200.3055	-4.1574

Note: Model 198 laser tach ser no. 9509281, nrc # 018585 used as a reference



Appendix E
Neptune Wave Buoy Specifications and Typical Output Files

Typical Neptune Wave Buoy Output File:

```
NSI-Neptune Sciences, Inc - Wave Sentry Data Processing Software Version 1.33
Sun Oct 17 11:00:00 2004
VBat = 13.29, Leak = DRY, Temp = 9.1
Significant wave height              =   2.40 m
Dominant and average frequency       =   0.09 Hz    0.12 Hz
Dominant and average period          =  10.89 s     8.04 s

Wave directions are compass headings from which waves approach.
Dominant wave direction =   84.8 deg magnetic
Average wave direction  =   48.8 deg magnetic
--


--
```

bnd	cfrq	c11	r1	r2	0	alpha1	alpha2
1	0.038	0.0000	999.9000	999.9000	0	999.9	999.9
2	0.049	0.0000	999.9000	999.9000	0	999.9	999.9
3	0.060	0.0000	999.9000	999.9000	0	999.9	999.9
4	0.070	4.7444	0.3753	0.2412	0	14.5	91.7
5	0.081	6.0094	0.2542	0.5294	0	92.3	108.6
6	0.092	7.2636	0.3818	0.7142	0	84.8	99.0
7	0.103	5.8444	0.3488	0.5637	0	302.8	278.3
8	0.113	3.0552	0.4300	0.6603	0	77.8	92.4
9	0.124	1.8820	0.3787	0.6811	0	292.8	273.5
10	0.135	0.6413	0.1445	0.2893	0	348.1	292.0
11	0.146	0.5313	0.3082	0.1294	0	116.7	88.4
12	0.156	0.5597	0.5231	0.4023	0	46.4	53.1
13	0.167	0.4211	0.1975	0.3689	0	229.7	269.1
14	0.178	0.3438	0.2008	0.3688	0	301.0	277.8
15	0.188	0.2643	0.4430	0.1492	0	343.2	281.5
16	0.199	0.0693	0.5855	0.2870	0	282.2	274.0
17	0.210	0.1496	0.2919	0.1041	0	335.1	330.1
18	0.221	0.0604	0.1283	0.5735	0	309.0	269.5
19	0.231	0.0652	0.2153	0.3479	0	186.6	171.4
20	0.242	0.0772	0.2703	0.3877	0	227.1	258.7
21	0.253	0.1055	0.4117	0.3117	0	204.8	163.0
22	0.264	0.0760	0.3987	0.0691	0	215.4	146.3
23	0.274	0.1702	0.6832	0.3541	0	193.7	194.6
24	0.285	0.0937	0.7562	0.4358	0	176.4	179.3
25	0.296	0.1658	0.7765	0.5154	0	185.8	181.0
26	0.307	0.1659	0.7884	0.5085	0	177.7	174.3
27	0.317	0.0671	0.5157	0.2361	0	196.9	227.9
28	0.328	0.1472	0.8236	0.6080	0	197.1	194.6
29	0.339	0.0456	0.7009	0.5243	0	189.4	191.6
30	0.350	0.0844	0.7218	0.3789	0	196.3	183.9
31	0.360	0.0555	0.7693	0.5303	0	197.7	198.8
32	0.371	0.0463	0.7093	0.3606	0	156.8	160.2
33	0.382	0.0457	0.7396	0.3248	0	197.2	204.1
34	0.393	0.0245	0.6522	0.6597	0	171.7	165.4
35	0.403	0.0264	0.5883	0.1037	0	180.2	177.8
36	0.414	0.0412	0.8284	0.6495	0	184.6	189.0
37	0.425	0.0363	0.7614	0.5169	0	173.3	168.9
38	0.436	0.0197	0.6973	0.3496	0	172.0	168.2
39	0.446	0.0173	0.7455	0.4232	0	183.7	183.3
40	0.457	0.0217	0.7924	0.5352	0	181.4	179.9
41	0.468	0.0178	0.6057	0.3783	0	168.1	143.9
42	0.479	0.0135	0.5434	0.1797	0	195.6	231.4
43	0.489	0.0151	0.8104	0.4948	0	180.0	183.4
44	0.500	0.0095	0.6900	0.3071	0	182.7	182.2

```
Mean, min, max acc (g)     = -0.01  -0.51   0.35
Mean, min, max pitch (deg) =  -0.0  -12.0    9.9
Mean, min, max roll (deg)  =  -0.0  -12.3   12.8
Maximum tilt (deg)         =  15.0
```

Sentry Wave Buoy Specifications

Physical

- Weight in air with batteries 15.7 kg (42 lb.)
- Mooring varies with location and deployment duration
- Hull size, 0.75 m (2.5 ft.) diameter
- Housing Material, PVC and aluminum
- Discus Hull, Urethane foam collar
- O-ring waterproof seal on battery and instrument housing

Power / Batteries

27 Alkaline D cells provide an approximately 2-3 week lifetime with hourly data collection and processing. When not deployed, the buoy may be powered optionally by an external connector.

Operating Temperature Range

0°C to 60°C (32°F to 140°F)

Sensors

- Accelerations along antenna vertical, bow, starboard axes
- Magnetic field along vertical, bow, starboard axes
- Water Temperature (internal hull-contacting thermistor)
- Leak detector
- Sampling rate, 4.0 Hz.

- Record length, 4096 samples (17.1 min)

Onboard Computer

Embedded 32-bit processor

Radio Frequency

Spread spectrum, 902-928 MHz

Outputs

- Nondirectional wave spectra
- Directional wave spectra
- Wave parameters: Significant wave height, dominant wave period, average wave period, dominant wave direction
- Data Quality Assurance (DQA) parameters: for measured time series, buoy internal temperature, leak detector

Accuracies and Ranges

- Significant Wave Height ±0.03 m, 0-9 m (±0.10 ft., 0-30 ft.)
- Dominant and average wave period: ±0.5 s, 0 - 25 s
- Dominant wave direction: ±2°, 0° - 360°
- Nondirectional and directional spectra are limited by statistical confidence related to record length rather than the instrumentation.

Appendix F
Datawell Wave Buoy Specifications and Typical Output Files

1. General Description of the Datawell Directional Waverider Mark II

The directional waverider buoy is a spherical, 0.9 m diameter buoy which measures wave height and wave direction. The buoy is manufactured by Datawell bv of the Netherlands. The buoy used in the NRC trials transmitted on 29.760 Mhz. Output power is 150-200 mW. The buoy is powered by 85 Leclanche zinc-carbon batteries, 80 Wh per cell. The buoy contains a flashing light that flashes 5 times every 20 seconds.

The direction measurement is based on the translational principle which means that horizontal motions instead of wave slopes are measured. As a consequence the measurement is independent of buoy roll motions and therefore a relative small buoy can be used.

A single point vertical mooring ensures sufficient symmetrical horizontal buoy response also for small motions at low frequencies.

The buoy comes standard with sea surface temperature measurement.

Installed Sensors

The buoy contains:
- heave-pitch-roll sensor Hippy-40
- three axis fluxgate compass
- two fixed "x" and "y" accelerometers
- temperature sensor
- micro-processor

Directional Measurement

From the accelerations measured in the x and y directions of the moving "buoy reference frame" the accelerations along the fixed, horizontal, north and west axis are calculated. All three accelerations (vertical, north and west) are digitally integrated to get filtered displacements with a high frequency cut-off at 0.6 Hz.

Finally, every half hour, FFT transforms of 8 series of 256 data points (200 sec) are summed to give 16 degrees of freedom on 1600 seconds of data.

Data Compression

To save transmitting power the real time data are compressed to motion vertical, motion north and motion west.

Data Reduction

Onboard data reduction computes energy density, main direction, directional spread and the normalized second harmonic of the directional distribution.

Frequency resolution:
0.005 Hz from 0.025 to 0.1 Hz and
0.01 Hz from 0.1 to 0.59 Hz.

Standard Transmission

The Directional Waverider transmits HF in the 27-40 Mhz band continuously. The Directional Waverider transmits:

- Real time data:
  - motion vertical
  - motion north
  - motion west
- Quasi static data:
  - computed spectral density
  - directional parameters
  - Hmo (significant wave height)
  - Tz (mean zero crossing period)
  - Monitoring data such as sea temperature, battery voltage, system status, GPS position (optional) and parity bits for error checking purposes.

Mooring

The Directional Waverider is fitted with a 5 kg chain ballast attached to the mooring eye. This provides stability when only a small vertical mooring force is present (free floating or shallow water).

A single point vertical mooring with 30 m rubbercord ensures sufficient symmetrical horizontal buoy response also for small motions at low frequencies.

The low stiffness of the 30 m rubbercord allows the Directional Waverider to follow waves up to 40 m.

Current velocities of up to 3 m/sec (6 knots) can be accommodated. The static buoyancy of the buoy is 1630 N.

The mooring design used for the NRC trials is shown in Figure 1 at the end of this document.

2. Directional Waverider Mark II Specifications

Hull diameter	0.9 m
Buoy weight	212 kg
Static buoyancy	1630 N
Maximum current speed	3 m/sec
Sampling frequency	3.84 Hz

Heave:

Range	-20 to +20 m
Resolution	1 cm
Scale of accuracy	3 % of measured value
Zero offset	< 0.1 m
Period time	1.6 sec – 30 sec
Cross sensitivity	< 3 %

Direction:

Range	0 – 360 degrees
Resolution	1.5 degrees
Buoy heading error	typical .5 degrees
Period time in free floating condition	1.6 sec – 30 sec
Period time in moored condition	1.6 sec – 20 sec

3. General Description of the Directional Waverider Receiver System

The receiving system installed on the roof of OCEANS Ltd. offices at 85 LeMarchant Rd. St. John's consisted of an omnidirectional antenna (a 3 metre Kathrein radiator whip antenna and 3 radial antennae) and antenna mount connected via a coax cable (RG 213 U) routed from the antenna mount to the wave direction receiver installed in an office below. A laptop interfaced to the wave direction receiver for storing and displaying wave data. The receiver was receiving on 38.760 Mhz. Standard 120 volt AC was used to power the wave direction receiver.

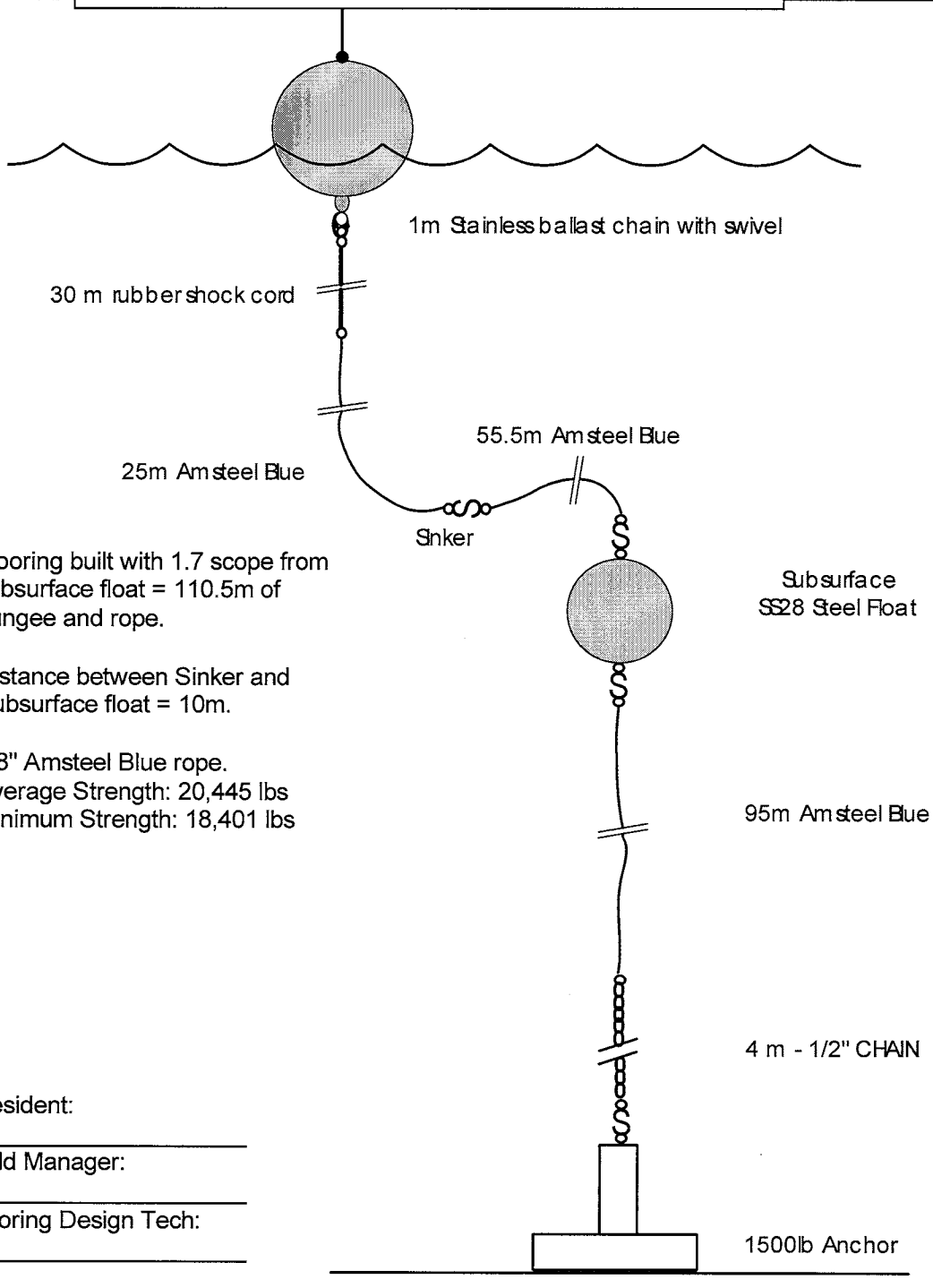
During the trials data was recorded every half hour. The recorded data included spectral, raw and statistics data. These data were passed to NRC within 48 hours after the end of a sea trial. In addition to other wave parameters the following basic wave parameters were included in the wave data provided to NRC:

start time of the data collection in UTC time
significant wave height in centimetres
mean zero crossing period in seconds
direction of the spectral peak in degrees magnetic
directional spread of the spectral peak in degrees

The directional waverider buoy was deployed October 8, 2004 at 17:00 UTC time by the 40 m long Marine Institute training vessel M/V Louis M. Lauzier in position 47 34.126 N 52 26.154 W in a water depth of 163 metres.

NRC September 2004 - Directional Waverider Mooring
Water Depth - 165 Metres

Position 47 34.126 N 52 26.154



Mooring built with 1.7 scope from subsurface float = 110.5m of bungee and rope.

Distance between Sinker and Subsurface float = 10m.

3/8" Amsteel Blue rope.
Average Strength: 20,445 lbs
Minimum Strength: 18,401 lbs

President: _____

Field Manager: _____

Mooring Design Tech: _____

* Diagram Not Drawn to Scale

Typical Raw Datawell Wave Buoy Output Files:

10171100.dat

```
10-17-2004 1100 to 1120 ,100% , 442 ,10.0 , 340 ,11.1 , 272 ,11.1 , 169 , 8.8 ,0.82
  86 , +155 , -173 ,10.91
 126 , +147 , -202 ,11.86
  45 , +105 , -101 ,15.56
  85 ,  +97 , -146 ,14.55
   1 , +128 , -120 ,13.83
   0 , +181 , -141 ,11.92
 118 ,  +27 ,   -5 , 2.30
   5 ,  +71 ,  -61 , 9.96
  44 ,  +62 ,  -90 , 6.57
  87 , +111 ,  -81 ,11.44
 124 ,  +52 ,   -6 , 7.21
 130 ,   +6 ,  -38 , 4.31
 119 ,  +19 ,  -75 , 5.46
  82 ,  +82 , -116 ,13.05
  46 ,  +68 ,  -64 ,15.58
  79 , +110 ,  -39 , 8.55
  29 ,  +66 ,  -74 , 8.07
  90 ,  +38 ,   +0 , 1.08
 131 ,  +77 , -113 ,10.59
  81 ,  +77 ,  -48 , 8.10
  30 ,  +45 ,  -47 , 7.01
  76 ,  +17 ,  -64 , 6.06
  33 ,  +93 , -122 ,10.20
 127 ,  +44 ,   -5 , 1.86
 125 ,  +79 ,  -12 , 7.19
   4 ,  +25 ,  -78 , 5.73
  66 ,  +56 ,  -14 , 4.63
  28 ,  +22 ,  -56 , 5.03
   3 , +100 , -147 ,10.42
 122 , +144 , -131 ,13.73
  89 , +123 , -141 ,11.58
  94 ,  +66 ,   -7 , 6.64
 107 ,  +57 ,  -81 , 7.76
 134 , +148 , -110 , 8.34
  84 , +115 ,  -82 , 8.84
 129 ,  +65 ,  -39 , 6.76
  77 ,   +1 ,  -32 , 3.26
  80 ,  +55 ,  -34 , 2.43
  83 ,  +71 ,  -32 , 7.32
  65 ,  +19 ,  -32 , 2.36
  22 ,  +35 ,  -39 , 3.82
  75 ,  +58 ,  -52 ,10.33
   2 ,   +1 ,  -36 , 2.66
  62 ,  +67 , -138 ,11.01
  43 , +137 , -182 ,11.82
 116 , +184 , -204 ,11.34
 108 , +190 ,  -93 ,10.61
  13 ,  +84 ,  -61 , 9.87
  34 ,  +82 ,  -62 ,10.04
  78 ,  +22 ,  -36 , 3.00
 128 ,  +84 ,  -66 ,10.40
   9 ,  +23 ,  -17 , 1.17
  18 ,  +10 ,  -17 , 3.28
 117 ,  +61 ,  -90 , 9.50
 123 ,  +69 ,  -81 ,12.25
  67 ,  +81 ,  -74 ,10.20
  61 ,  +34 ,   -8 , 3.19
  70 ,  +39 ,  -80 , 7.45
  74 ,  +46 ,  -49 , 5.95
 121 ,  +73 ,  -92 , 8.90
 109 ,  +53 ,  -31 , 9.55
  69 ,  +64 , -114 , 6.83
  59 ,  +90 , -116 ,11.23
  88 ,  +81 ,  -27 , 7.90
 102 ,  +42 ,  -99 , 6.87
  92 , +127 ,  -92 ,11.02
```

```
104 , +123 , -125 ,10.30
132 ,  +89 ,  -93 ,11.25
 55 ,  +78 ,  -61 ,10.59
115 ,  +69 ,  -98 ,11.45
  8 ,  +95 ,  -80 , 9.08
 53 ,  +24 ,  -29 , 2.83
 50 ,  +32 ,  -34 , 8.37
 54 ,  +76 ,  -73 , 9.41
 95 ,  +76 ,  -95 ,10.05
 15 ,  +76 , -133 ,10.56
 73 , +138 , -124 ,11.54
 47 , +119 , -102 , 8.12
105 ,  +99 ,  -96 ,11.21
120 , +117 , -165 ,11.72
133 , +118 , -102 , 9.90
 48 , +139 , -130 , 9.95
 64 , +155 , -132 ,12.15
 16 , +116 , -104 ,13.92
 68 ,  +97 , -129 ,13.99
 32 , +206 , -182 ,10.51
101 , +213 , -229 ,10.01
  7 , +205 , -108 ,12.39
 14 , +112 ,  -53 , 7.45
100 , +100 , -139 , 8.73
 19 , +158 , -115 ,10.75
 57 ,  +38 ,  -13 , 2.34
 93 ,  +60 , -102 ,13.11
 97 ,  +56 ,  -63 ,10.70
 41 ,  +93 , -136 , 9.43
 63 ,  +89 ,  -61 ,14.51
 35 ,  +59 ,   -2 , 6.03
 25 ,  +28 ,  -83 , 6.34
 38 ,  +40 ,   +0 , 2.77
 58 ,  +42 ,   -1 , 2.34
114 ,  +56 ,  -70 , 8.42
 12 ,  +59 ,  -75 , 9.03
 20 ,  +86 ,  -77 , 6.75
 24 ,  +34 ,  -48 , 6.38
 37 ,  +48 , -113 , 8.98
 60 ,  +92 ,  -53 ,10.06
103 ,  +20 ,  -27 , 4.70
 21 ,  +98 , -130 , 9.50
 27 ,  +90 , -109 ,11.89
110 ,  +89 ,  -81 ,11.98
 40 ,  +65 ,  -10 , 6.49
 31 ,  +26 ,  -22 , 2.26
 26 ,  +20 ,  -45 , 3.19
 72 ,  +10 ,   -4 , 2.14
112 ,  +40 ,  -55 , 5.43
 96 ,  +74 ,  -81 ,10.31
 10 ,  +92 , -113 , 9.77
 49 ,  +96 ,  -92 ,13.06
 71 , +165 , -162 ,10.78
 39 , +151 , -146 ,10.39
 91 ,  +68 ,  -77 , 9.01
 23 ,  +90 ,  -81 ,12.30
111 , +137 , -106 ,10.08
106 ,  +82 , -102 ,15.85
 11 , +131 , -171 ,11.27
 99 ,  +84 , -169 ,14.63
 56 , +214 , -203 ,10.18
 51 , +148 , -107 , 9.95
 98 ,  +89 , -106 , 9.03
 17 , +100 , -122 , 7.90
 42 , +146 , -156 , 9.72
 36 , +163 , -107 ,11.22
  6 ,  +97 ,  -64 ,12.78
 52 ,  +63 ,  -82 ,10.88
113 , +122 , -106 , 9.23
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10171026.SPT

```
8
296
8.695652
14.18512
24.95
10.15
7.125
.6275
-.48
-.125
184.2188
68.29102
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.035,3.89752E-04,23.90625,70.94825,2.05442,2.156776
.04,9.303034E-04,53.4375,64.01009,.926271,2.028795
.045,2.357862E-03,61.875,73.29827,.7066005,1.523845
.05,6.158021E-03,115.3125,63.22675,-1.289652,2.09674
.055,1.083472E-02,64.6875,52.93142,1.613002,3.09405
.06,2.351775E-02,63.28125,47.55994,-1.045397,4.093884
.065,.2334004,42.1875,37.93605,-3.554573E-02,6.11615
.07,.6570469,46.40625,28.08834,-1.370019,7.987051
.075,.6376281,33.75,42.85991,-1.64351,3.156254
.08,1,47.8125,26.29785,-1.146525,9.833539
.085,.7710516,47.8125,32.67648,-.9353378,5.688601
.09,.9003245,50.625,35.69794,-.8472674,4.886494
.095,.5627049,45,45.99326,.9481481,4.090817
.1,.4231621,46.40625,50.24568,2.46527,3.431181
.11,.4448581,77.34375,56.4005,.6603481,1.852344
.12,.2187119,78.75,59.64577,.7208301,1.731958
.13,.1119168,46.40625,64.79343,1.906213,2.208256
.14,6.653681E-02,53.4375,70.38872,1.307765,1.756863
.15,6.203851E-02,39.375,71.9554,1.225077,1.881334
.16,3.111703E-02,7.03125,69.71729,-2.330161,2.281087
.17,3.337327E-02,77.34375,74.41733,.7921488,1.550305
.18,1.707739E-02,25.3125,65.46487,.2496473,1.982169
.19,1.221611E-02,2.8125,71.39587,-.718248,1.834045
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.21,5.628007E-03,12.65625,73.8578,.4527259,1.736633
.22,8.270999E-03,247.5,72.51493,.215327,1.842533
.23,7.335719E-03,246.0938,70.38872,.2682666,1.743144
.24,5.247519E-03,286.875,70.16491,.8956103,2.022876
.25,3.829581E-03,302.3438,71.17206,.3562781,1.827769
.26,4.190229E-03,272.8125,69.15775,-.1747531,1.876894
.27,3.810481E-03,257.3438,60.3172,-2.553057E-02,2.130399
.28,3.64281E-03,237.6563,62.3315,4.145059E-02,1.767856
.29,4.361236E-03,230.625,57.07193,-.3189018,2.210175
.3,6.771722E-03,199.6875,48.11947,1.657703,3.700258
.31,6.06634E-03,180,40.06226,2.13799,5.305311
.32,7.867618E-03,188.4375,37.71224,.2346808,4.903982
.33,4.748152E-03,185.625,51.36474,.5334446,2.431004
.34,3.465148E-03,175.7813,46.44089,1.898311,3.445816
.35,3.96599E-03,171.5625,50.91712,.9248894,2.929232
.36,4.471641E-03,167.3438,47.00042,.7582065,3.485711
.37,2.865536E-03,165.9375,48.90281,.7232853,2.914603
.38,3.312673E-03,180,45.54564,-.3845249,2.984397
.39,2.794786E-03,185.625,44.87421,.6010292,3.61412
.4,3.848777E-03,171.5625,37.82415,.6746418,4.777031
.41,2.405494E-03,160.3125,36.03365,-.248804,4.819575
.42,2.46639E-03,158.9063,38.04795,.4527808,4.410443
.43,1.979324E-03,174.375,44.65039,8.639818E-02,2.561805
.44,1.57264E-03,164.5313,39.50273,2.950445E-02,3.81636
.45,2.265409E-03,149.0625,33.34792,1.103734,6.667895
.46,1.064766E-03,163.125,46.6647,.2619462,2.985128
.47,1.294022E-03,164.5313,41.40513,-.8572904,3.305247
.48,1.012837E-03,156.0938,47.11232,-7.029918E-02,2.190486
.49,1.549226E-03,167.3438,35.1384,-.3052134,5.526583
.5,1.353583E-03,153.2813,38.15986,1.603512,5.503655
.51,9.210467E-04,147.6563,44.42658,-.1148203,2.816776
.52,1.124969E-03,154.6875,36.48128,.193304,3.25938
```

Appendix G
Seakeeping Trials Test Plan

Test Program for Seakeeping Trials on 65 ft. long Fishing Vessel Roberts Sisters II - Vessel C1 (fitted with anti-roll tank)

Proj. 2017 Sept. 28, 2004 V2.0

Assumptions:

1) Vessel is docked in St. John's during trials preparation period & will sail from St. John's during trial.
2) Vessel will carry 3 crew members and a maximum of 8 trials personnel.
3) Vessel operator will be responsible for fuelling vessel & acquiring required supplies to operate vessel.
4) Assume vessel has sufficient quality AC power to operate trials instrumentation & DAS and thus no propane generator is to be fitted by IOT. Still require UPS to be fitted however.

Preliminary Preparations:

1) Fit out vessel with instrumentation as per instrumentation plan.
2) Set displacement condition roughly half load condition - this will require loading ballast - either ice or water ballast. Press up water & fuel tanks to minimize free surface.
3) Borrow sufficient lifesaving equipment from CCG for all trials personnel.
4) Select location for trials. Permission from St. John's Traffic Control may be required. Design/compile mooring for wave buoy & sentry buoy once water depth is known (J. Foley/MUN Oceanography).
5) Decision/arrangements required with respect deploying wave buoy & sentry buoy prior to trial
6) Issue Notice to Mariners regarding deployment location (Lat., Long) of wave buoy & buoy identification info (color, dimensions, radar beacon, flashing light etc.)
7) Borrow a cell phone from D&F for trials preparation period & sea trial.(687-3541)
8) Determine/record location (X, Y, Z co-ordinates) of GPS antenna relative to some known ship location
9) Determine/record location (X, Y, Z co-ordinates) of MotionPak & any accelerometers relative to some known ship location.
10) Take digital photos of instrumentation/equipment set up.
11) A more complex process will be required for GPS antenna alignment & set up with new GPS system than previously experienced.
12) Ballast Boat with water
13) Carry out inclining experiment with all instrumentation, consumables & ballast in place.

Prior to departing port on day of trial:

1) Check all instrumentation and data acquisition system.
2) Note draft bow & stern as well as any static list.
3) Record harbour water temperature & salinity at dock.
4) Ensure all freeing ports are open and unobstructed. Ensure all hatches are closed so any water on deck can not accumulate.
5) Inform CCG traffic control that vessel is going to be on trials, name of vessel, location etc. so that vessels in vicinity can be warned.
6) Ensure anti-roll tank is empty.

7) 10 minute collection of data with mooring lines slack, engine off (perform on same day as ballasting)

At Trials Location - whenever vessel is stopped adjacent to wave buoy (ie: before each forward speed set):

1) Verify Communications with wave buoy & transfer any data files. Use initial wave buoy data to determine Average Wave Direction.
If there is a significant difference between dominant & average wave direction from the buoy, there are probably 2 major sea directions.
Some judgment including visual observation will be required to determine the actual sea direction.
Note the wave buoy outputs sea direction information in deg. Magnetic - roughly -21 deg. (exact number to be determined) deviation from deg. True North
2) Record sea temperature and salinity information adjacent to wave buoy.
3) Record wind speed and absolute direction.
4) Record estimated sea conditions from visual observation - sea state, direction.
5) Record general weather conditions, - fog, visibility, precipitation.

Execute Runs as per ITTC Recommended Pattern:

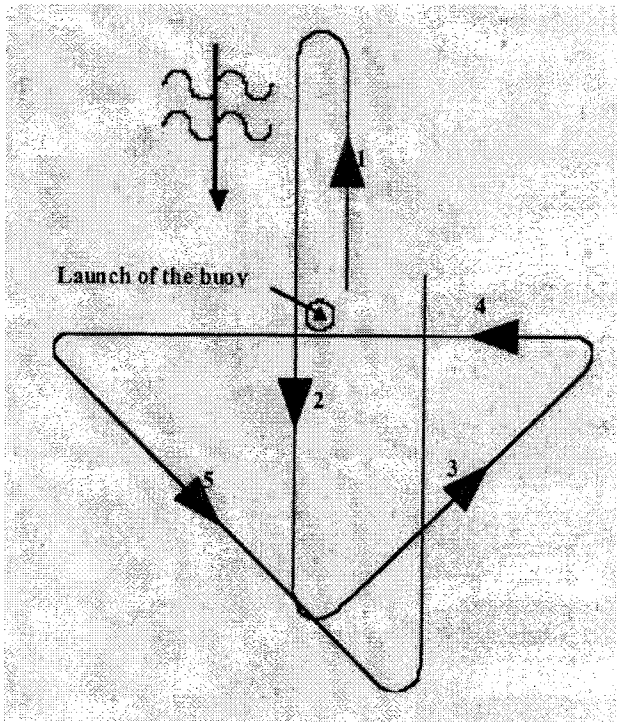
For each run, manually record the following information after vessel attained steady state speed/direction:
wind speed/relative direction
engine speed/ shaft speed from any onboard instrumentation
general motion behavior of vessel (heavy roll, pitch etc.)
incidents of slamming, water on deck, spray - is water accumulating on deck?
difficulty for personnel to maintain balance, seasickness
take digital photos during trial of deployed wave buoy, taking salinity readings etc.

Run 1: 0 speed drift run, initial heading - beam seas

Run 2: trawl speed 4 knots, head seas, 25 minutes
Run 3: trawl speed 4 knots, following seas, 40 minutes
Run 4: trawl speed 4 knots, bow sea, 25 minutes
Run 5: trawl speed 4 knots, beam sea, 25 minutes
Run 6: trawl speed 4 knots, quartering sea, 25 minutes

Return to wave buoy location.

Run 7: full speed 8 knots, head seas, 25 minutes
Run 8: full speed 8 knots, following seas, 40 minutes
Run 9: full speed 8 knots, bow sea, 25 minutes
Run 10: full speed 8 knots, beam sea, 25 minutes.
Run 11: full speed 8 knots, quartering sea, 25 minutes



ITTC Recommended Run Pattern
ITTC Procedures Book, 22nd ITTC, Sept. 1999
Run 1: Head Sea
Run 2: Following Sea
Run 3: Bow Sea
Run 4: Beam Sea
Run 5: Quartering Sea

Return to wave buoy location.

Run 12: 0 knots, beam seas, 25 minutes

Return to wave buoy location - download wave data.
Add ~ 14 " (0.3556 m) salt water to anti-roll tank. Record level of tank when filling complete. **Do NOT vary tank level.**

Run 13: 0 knots, beam seas, 25 minutes
Run 14: trawl speed 4 knots, bow sea, 25 minutes
Run 15: trawl speed 4 knots, beam sea, 25 minutes
Run 16: trawl speed 4 knots, quartering sea, 25 minutes

Return to wave buoy location - download wave data - recover wave buoy & sentry float.

<u>After vessel has returned to dock upon completion of trial:</u>

1) Note draft bow & stern as well as any static list.
2) Record harbour water temperature & salinity at dock.
3) Record fuel, water tank levels. Verify level of fluid in anti-roll tank.
4) Remove all instrumentation, ballast from vessel.
5) Return all borrowed lifesaving equipment, cell phone.

NOTE: 180 deg. is defined as a head sea.
The 65 ft vessel likely has an autopilot & thus all data will be collected with the vessel on autopilot control (other than zero speed drift runs). Trawl speed is actually 2 kts. however the autopilot linked to the magnetic compass would not be able to provide good heading angle control at this low forward speed without dragging trawl so will do 3-4 kts.
May be more convenient to add water to anti-roll tank in port and carry out Runs 13-16 first.

Appendix H
Seakeeping Trials Run Log

Run Log for Seakeeping Trial on CCGA Roberts Sisters II - Vessel 'C1'

Fishing Vessel Research Project (Proj. 2017) Date: Nov. 15 2004

Nov 9, 04: 10 minute drift run in Harbour 10MIN_DRIFT_20041109151656.CSV
Wind 5 knots, 350 degrees magnetic
Salinity 24.0 ppt, sea water temp 6.3 C
Drafts: aft 13' 7" (4.140 m), fwd. 9' 2" (2.794 m)

Nov. 15 Drafts: fwd. 9'2" (2.794 m), aft 13' 7" (4.140 m) Salinity 20.1 ppt, sea water temp 5.9 C Density 1015.8 kg/m^3
04:15 Departed St. John's
05:50 Launch wave Neptune buoy 47 33 42 N, 52 26 11 W, 165 m depth ,1.9 to 2 knot drift
06:30 Visibility excellent, overcast, apparent wave direction 75 degrees true, sea state 2
06:40 At buoy, salinity 31.1 ppt, sea water temp 5.7 C Density 1024.5 kg/m^3
07:00 Low frequency waves not being recorded by Neptune buoy
07:20 Waves appear to be dropping
08:50 No water on deck, or bow spray noted
09:30 Approximately 3 miles from buoy at end of test pattern due to tidal drift
14:00 Filled ART to working level 14.75" (37.465 cm measured at wharf (tank sight glass) at end of trial)
16:20 Recover wave buoy. Significant tension on entire mooring due to tidal current. Steel cable section could not be retrieved with pot hauler and was recovered by hand (very difficult).
16:30 At buoy, salinity 23.7 ppt, sea water temp 6.0 C Density 1018.6 kg/m^3
18:00 At dock salinity 20.8 ppt, sea water temp 6.0 C Density 1016.4 kg/m^3

Run #	File Name	Start / Finish Time	Course Relative to Incident Waves	Location Start/Finish Latitude deg N	Location Start/Finish Long. deg W	Nominal SWH (m)	Nominal Period (s)	SOG (kts.)	COG (Deg. TRUE)	Wind Speed (kts.)	Wind Direction (Deg. Mag.)	Eng. RPM	Shaft RPM	Comments:
1	0DRIFT_2004_1115055619.csv	05:56 06:21	beam drift	47.5544 47.5466	52.4375 52.4496	2.58	12.34	1.8	N/A	12	240	N/A	0	Drift 1.8 knots to SW
2	THEAD_2004_1115064947	06:49 07:14	Head	47.5553 47.5591	52.4332 52.4075	2.44	12.34	2.6	073	20	340	836	141	very strong current, buoy submerging at wave peaks

Run #	File Name	Start / Finish Time	Course Relative to Incident Waves	Location Start/Finish Latitude deg N	Location Start/Finish Long. deg W	Nominal SWH (m)	Nominal Period (s)	SOG (kts.)	COG (Deg. TRUE)	Wind Speed (kts.)	Wind Direction (Deg. Mag.)	Eng. RPM	Shaft RPM	Comments:
3	TFOL_2004_1115072149.csv	07:21 08:01	following	47.555 47.5412	52.417 52.4898	2.63	10.89	4.8	253	7	110	761	128.6	Engine at idle due to current
4	TBOW_2004_1115080800.csv	08:08 08:33	bow	47.5391 47.5279	52.488 52.4648	2.61	10.89	3.0	120	19	290	760	128.4	Engine at idle
5	TBEAM_2004_1115083828.csv	08:38 09:03	beam	47.529 47.545	52.464 52.471	2.55	12.34	2.6	344	17	020	720	121.8	Engine at idle
6	TQUART_2004_1115090757.csv	09:07 09:32	quartering	47.542 47.5156	52.472 52.4949	2.82	12.34	4.8	210	13	200	720	121.8	Engine at idle
7	0DRIFT_2004_1115101000.csv	10:10 10:35	beam drift	47.555 47.5482	52.439 52.4511	2.04	12.34	1.4	N/A	17	050	N/A	0	Drift rate 1.4 knots
8	CHEAD_2004_1115104952	10:49 11:14	head	47.5556 47.5552	52.423 52.3491	1.98	9.75	7.2	092	12	310	1640	274.3	Wind freshening
9	CFOL_2004_1115111949.csv	11:19 12:01	following	47.553 47.555	52.359 52.4769	1.99	10.89	7.1	270	5	080	1320	221.3	Apparent quartering sea, winds shifting
10	CBOW_2004_1115120544.csv	12:05 12:30	bow	47.555 47.5149	52.571 52.421	2.08	10.89	7.0	135	21	280	1420	237.9	waves 25 degrees off of the bow
11	CBEAM_2004_1115123606.csv	12:36 13:01	beam	47.518 47.5678	52.419 52.4144	2.1	9.75	7.0	000	16	010	1660	277.7	

CCGA Roberts Sisters II Seakeeping Trial

Run #	File Name	Start / Finish Time	Course Relative to Incident Waves	Location Start/Finish Latitude deg N	Location Start/Finish Long. deg W	Nominal SWH (m)	Nominal Period (s)	SOG (kts.)	COG (Deg. TRUE)	Wind Speed (kts.)	Wind Direction (Deg. Mag.)	Eng. RPM	Shaft RPM	Comments:
12	CQUART_2004_1115130535.csv	13:05 13:30	quartering	47.5622 47.5273	52.4191 52.4706	1.9	9.75	7.0	225	9	180	1200	201.4	
	ART filled to working level	14:00												
13	ART_TBEAM_2004_1115141318.csv	14:13 14:39	beam	47.553 47.5752	52.445 52.4578	2.25	9.75	3.2	340	20	030	840	141.7	beam sea determined visually
14	ART_TQUART_2004_1115144226.csv	14:42 15:07	quartering	47.572 47.5441	52.4596 52.4819	2.24	10.89	4.7	206	16	210	740	125.1	
15	ART_TBOW_2004_11151923.csv	15:19 15:44	bow	47.539 47.5305	52.482 52.4587	2.25	10.89	2.0	115	19	290	750	126.8	visibility reduced to 1 mile wind increasing

- Wind speed is provided relative in knots, wind direction is magnetic deg.
- SOG - Speed Over Ground COG - Course Over Ground SWH - Significant Wave Height N/A - not applicable
- ART - Anti-Roll Tank T - Trawl Speed C - Cruise Speed
- Exceptionally strong current flowing from the north - enough to partially submerge Neptune wave buoy - current slacked off somewhat as the day progressed and the tide changed.
- Trawl speed is 2 - 3 knots although the following & quartering sea runs were up to 4-5 knots due to the influence of the current even though the engines were on idle.
- Cruise speed was set at 7 knots.
- Trial carried out around moored Neptune directional wave buoy nominally 10 nm east of St. John's, NL in 165 m of water approx. @ 47 33 42 N, 52 26 11 W
- Nominal Draft Aft: 3.249 m Nominal Draft Fwd.: 2.059 m Drafts measured relative to bottom of keel (light ship condition 1 in stability book).
- CCGA Roberts Sisters II used a flat plate rudder and a single, 4 bladed propellor enclosed in a fixed nozzle. Vessel has passive anti roll tank (filled to ~14.75 inches @ 14:00)
- The difference between deg. magnetic and deg. TRUE was approximately 20.94 deg.thus True Direction = Magnetic - 21 deg.
- Weather overcast, air temp. 5 deg. C, good visibility - reduced to 1 mile in mid-afternoon.
- All fuel tanks and fresh water tanks pressed up. As ballast, two refrigerated sea water tanks pressed up with sea water.
- All runs carried out on autopilot. Autopilot is controlled by internal magnetic compass.

- Trials DGPS offset 6 degrees (included in calibrated data)
- OCEANS Ltd. Datawell wave buoy moored at position: 47 34.126 N 52 26.154 W, in 165 metres of water
- CCGA Roberts Sisters II moored Fort Amherst small boat basin

Appendix I
Wave Statistics, Nondimensional Spectrum Plots, and Mean Wave Direction vs. Frequency Plots

NEPTUNE DIRECTIONAL WAVE BUOY DATA: I-1 to I-20

DATAWELL DIRECTIONAL WAVE BUOY DATA: I-21 to I-44

Summary of Wave Statistics Collected Using Neptune Directional Wave Buoy

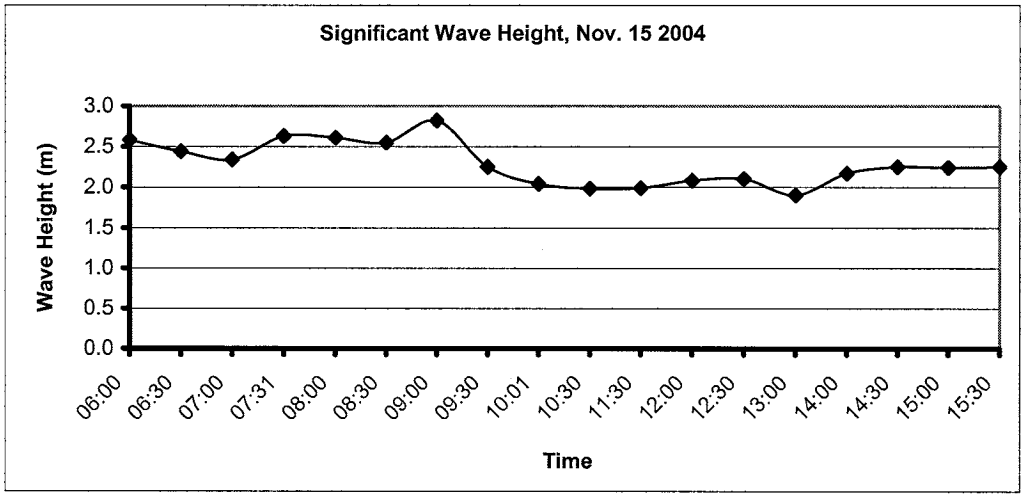
CCGA Roberts Sisters II
November 15, 2004

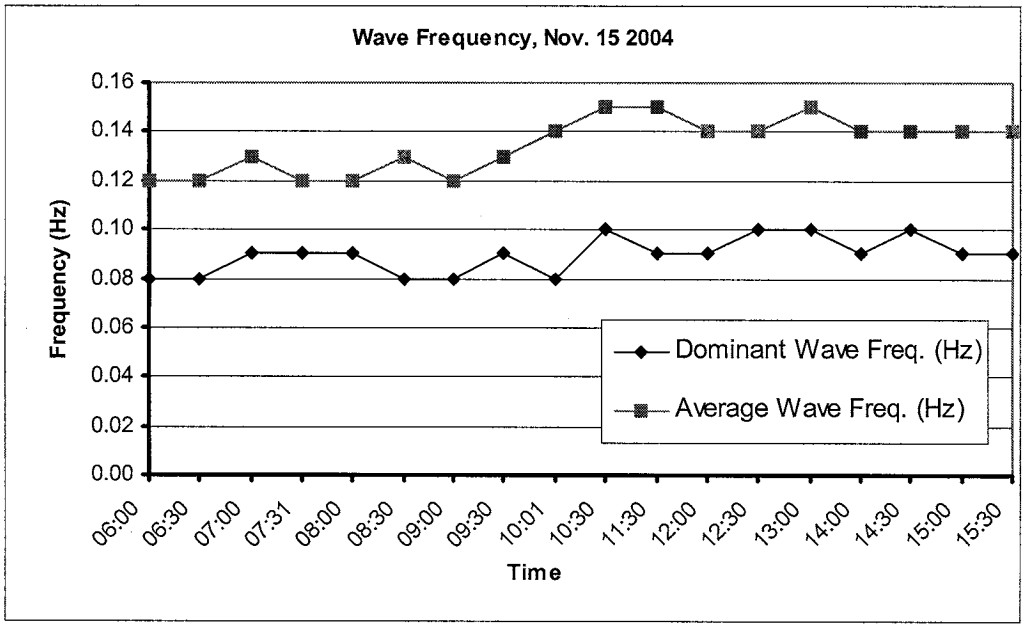
Fishing Vessel Research Proj. 2017

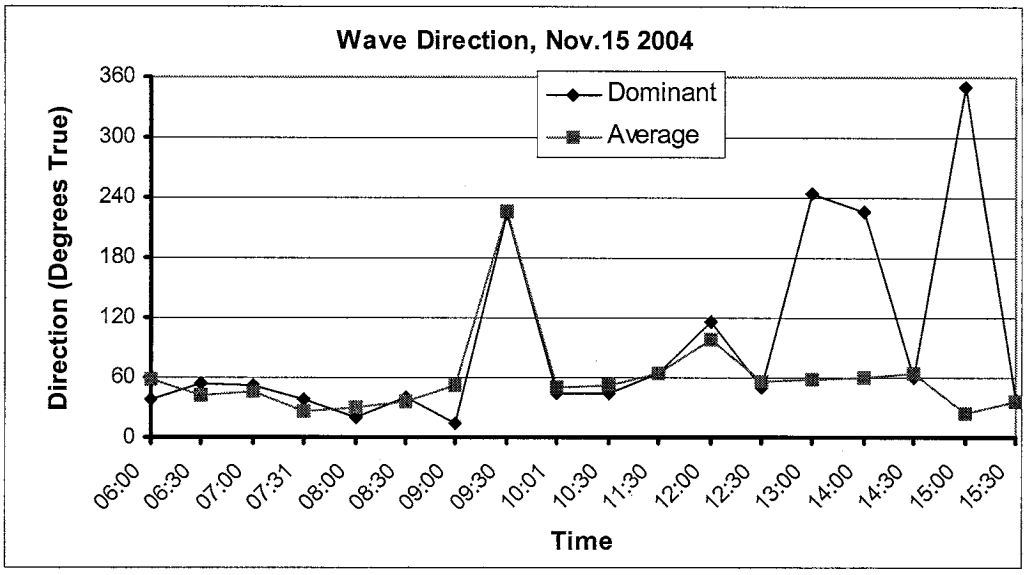
NF Time	Sig. Wave Height (m)	Dominant Wave Freq. (Hz)	Average Wave Freq. (Hz)	Dominant Wave Period (s)	Average Wave Period (s)	Dominant Wave Dir. (deg. mag.)	Average Wave Dir. (deg. mag.)	Dominant Wave Dir. (deg. TRUE)	Average Wave Dir. (deg. TRUE)
06:00	2.58	0.08	0.12	12.34	8.24	59.90	79.50	38.90	58.50
06:30	2.44	0.08	0.12	12.34	8.04	75.00	63.70	54.00	42.70
07:00	2.34	0.09	0.13	10.89	7.76	73.00	67.00	52.00	46.00
07:31	2.63	0.09	0.12	10.89	8.13	58.20	46.90	37.20	25.90
08:00	2.61	0.09	0.12	10.89	8.24	41.00	50.70	20.00	29.70
08:30	2.55	0.08	0.13	12.34	7.82	61.00	57.60	40.00	36.60
09:00	2.82	0.08	0.12	12.34	8.47	34.80	73.70	13.80	52.70
09:30	2.25	0.09	0.13	10.89	7.67	244.20	-112.30	223.20	-133.30
10:01	2.04	0.08	0.14	12.34	6.99	64.70	71.30	43.70	50.30
10:30	1.98	0.10	0.15	9.75	6.81	64.90	72.20	43.90	51.20
11:30	1.99	0.09	0.15	10.89	6.84	85.50	86.00	64.50	65.00
12:00	2.08	0.09	0.14	10.89	7.04	137.20	118.10	116.20	97.10
12:30	2.10	0.10	0.14	9.75	7.00	70.10	76.30	49.10	55.30
13:00	1.90	0.10	0.15	9.75	6.63	264.90	78.80	243.90	57.80
14:00	2.17	0.09	0.14	10.89	6.99	247.50	80.80	226.50	59.80
14:30	2.25	0.10	0.14	9.75	6.95	81.10	84.20	60.10	63.20
15:00	2.24	0.09	0.14	10.89	7.17	10.60	45.10	-10.40	24.10
15:30	2.25	0.09	0.14	10.89	7.09	59.60	56.10	38.60	35.10

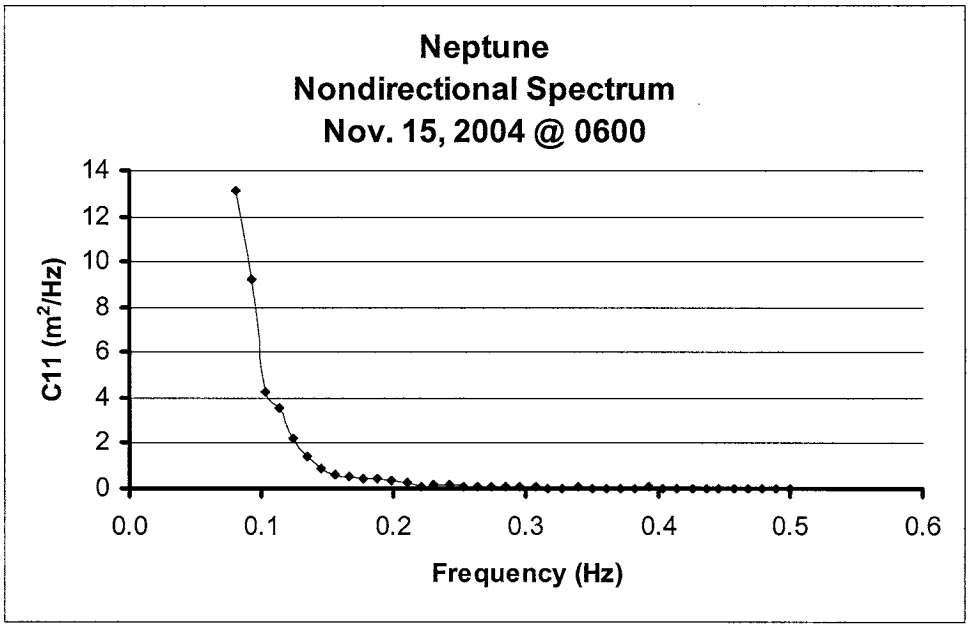
NOTE: Correction used to convert deg. magnetic to deg. TRUE during trial was -21 deg.
Wave buoy moored ~ 10 nm east of St. John's, NL

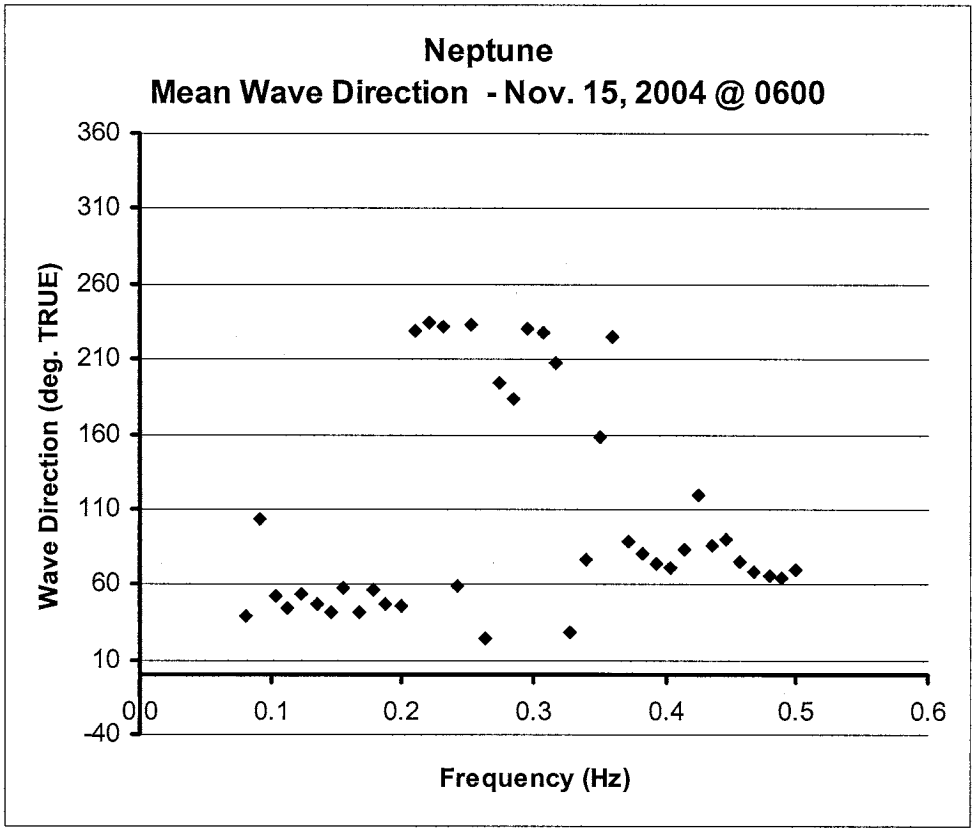
NOTE: File for 0731 has a file name time stamp of 0731, but a internal data time stamp of 0730
File for 1001 has a file name time stamp of 1001, but a internal data time stamp of 1000
File for 1030 has a file name time stamp of 1030, but a internal data time stamp of 1100
File for 1300 has a file name time stamp of 1300, but a internal data time stamp of 1330

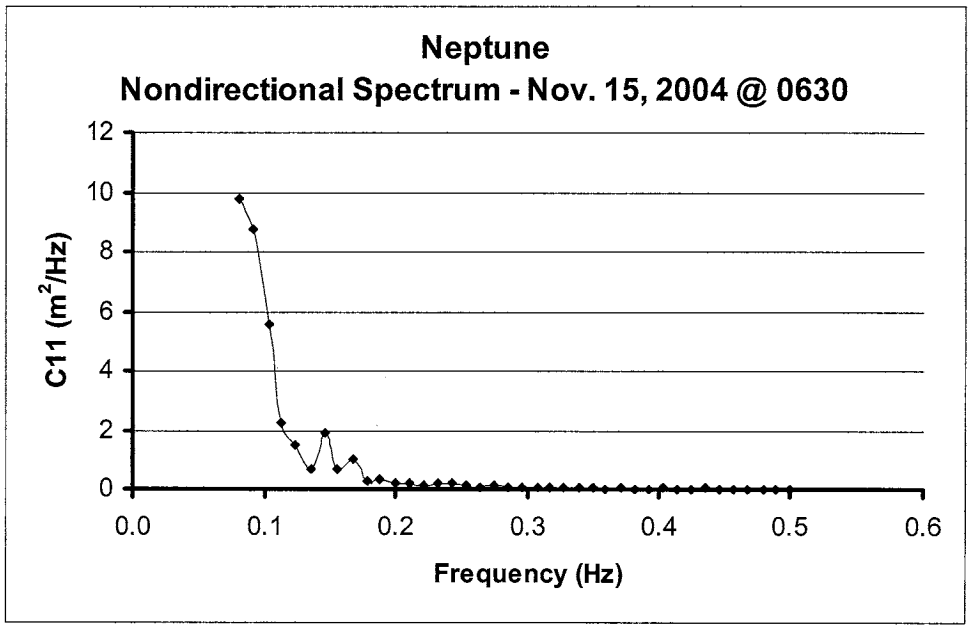

Significant Wave Height, Nov. 15 2004
Wave Height (m)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
06:00
06:30
07:00
07:31
08:00
08:30
09:00
09:30
10:01
10:30
11:30
12:00
12:30
13:00
14:00
14:30
15:00
15:30
Time

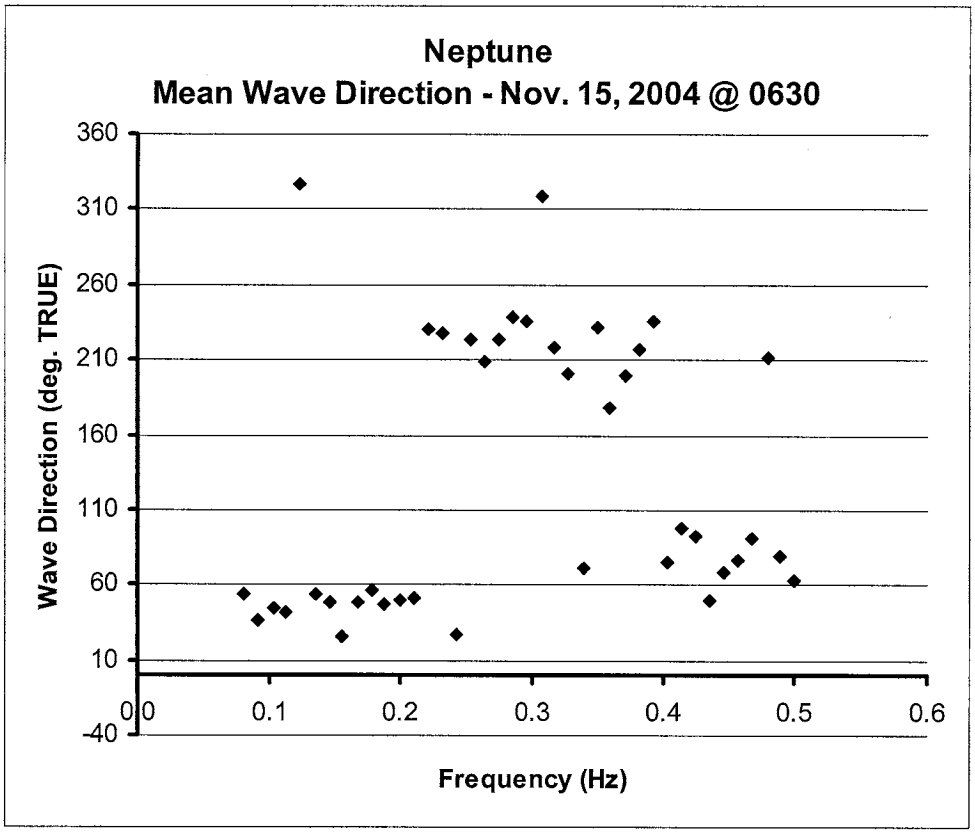

Wave Frequency, Nov. 15 2004
Frequency (Hz)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Dominant Wave Freq. (Hz)
Average Wave Freq. (Hz)
06:00
06:30
07:00
07:31
08:00
08:30
09:00
09:30
10:01
10:30
11:30
12:00
12:30
13:00
14:00
14:30
15:00
15:30
Time

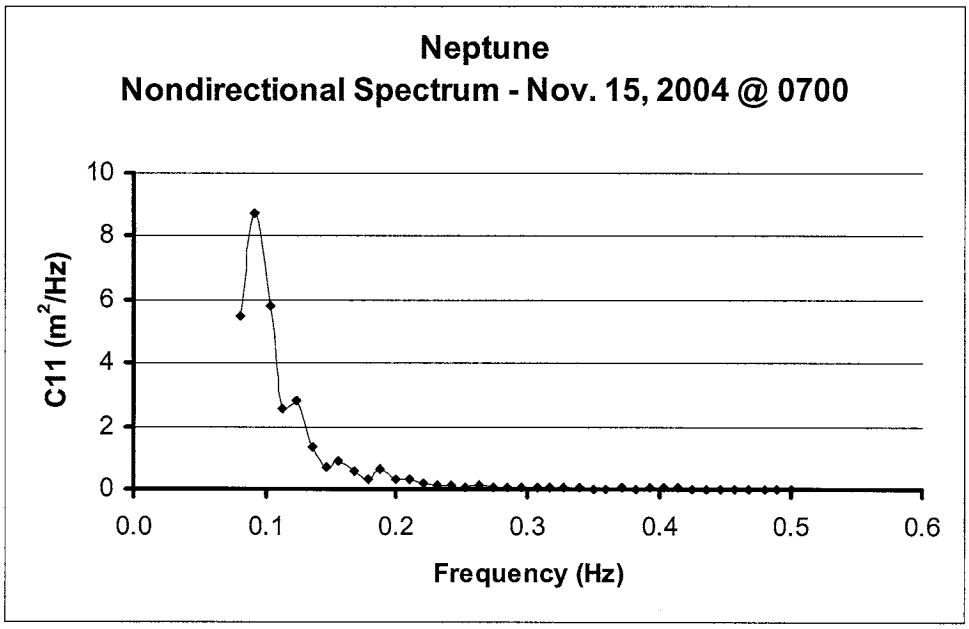

Wave Direction, Nov.15 2004
Direction (Degrees True)
360
300
240
180
120
60
0
Dominant
Average
06:00
06:30
07:00
07:31
08:00
08:30
09:00
09:30
10:01
10:30
11:30
12:00
12:30
13:00
14:00
14:30
15:00
15:30
Time

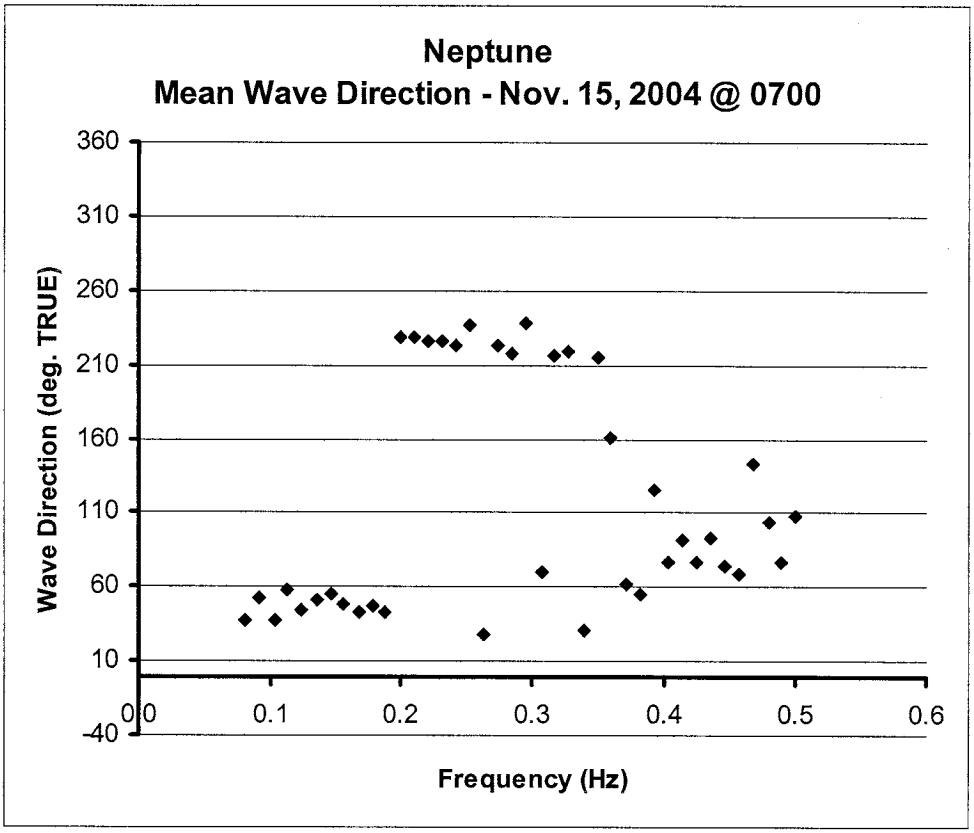

Neptune
Nondirectional Spectrum
Nov. 15, 2004 @ 0600
C11 (m²/Hz)
14
12
10
8
6
4
2
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

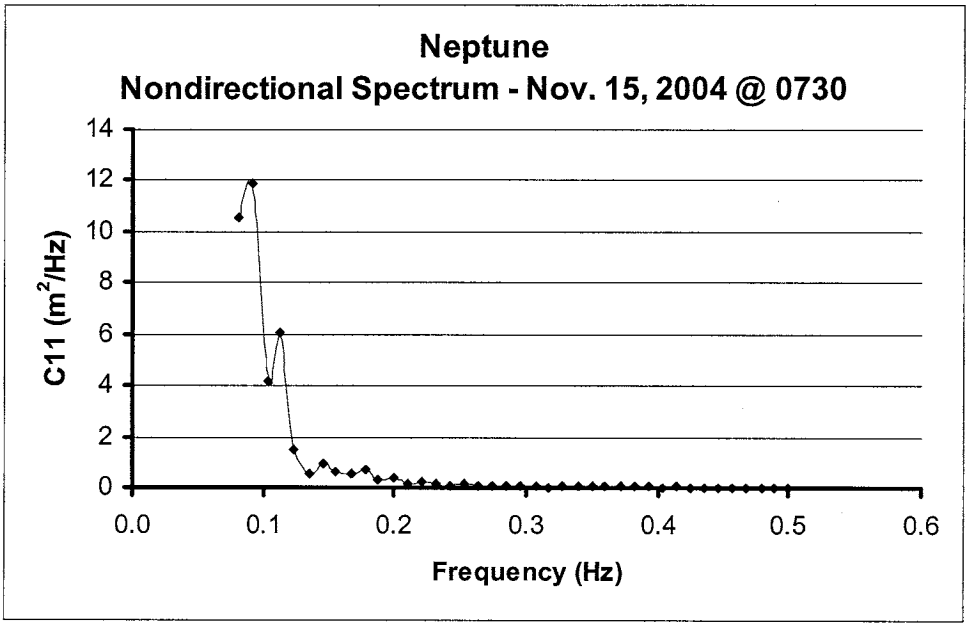

Neptune
Mean Wave Direction - Nov. 15, 2004 @ 0600
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

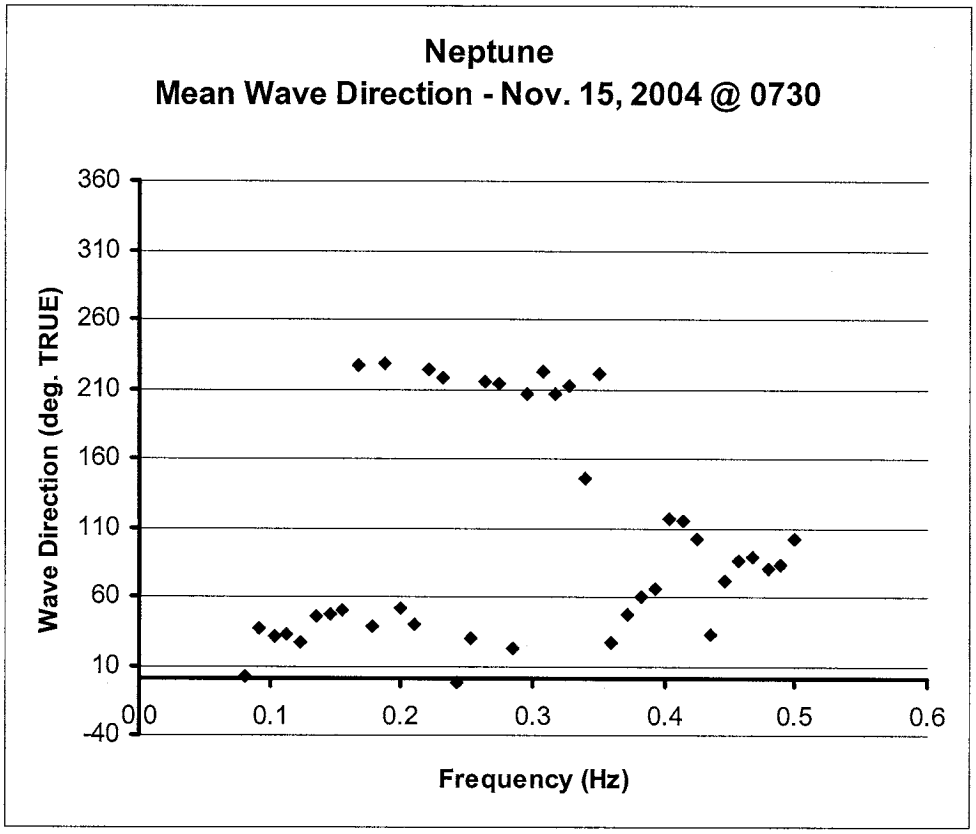

Neptune
Nondirectional Spectrum - Nov. 15, 2004 @ 0630
C11 (m²/Hz)
12
10
8
6
4
2
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

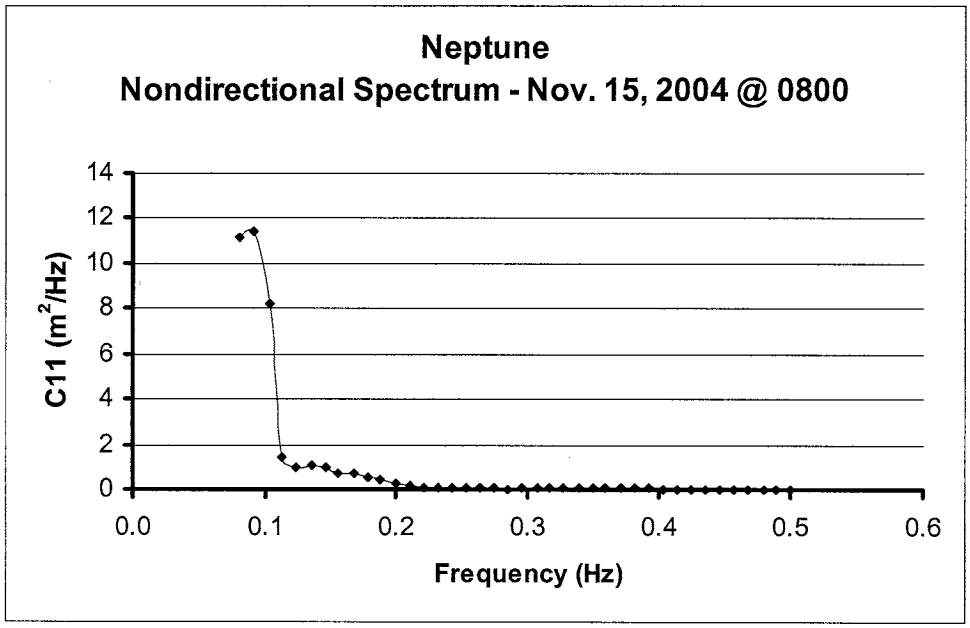

Neptune
Mean Wave Direction - Nov. 15, 2004 @ 0630
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

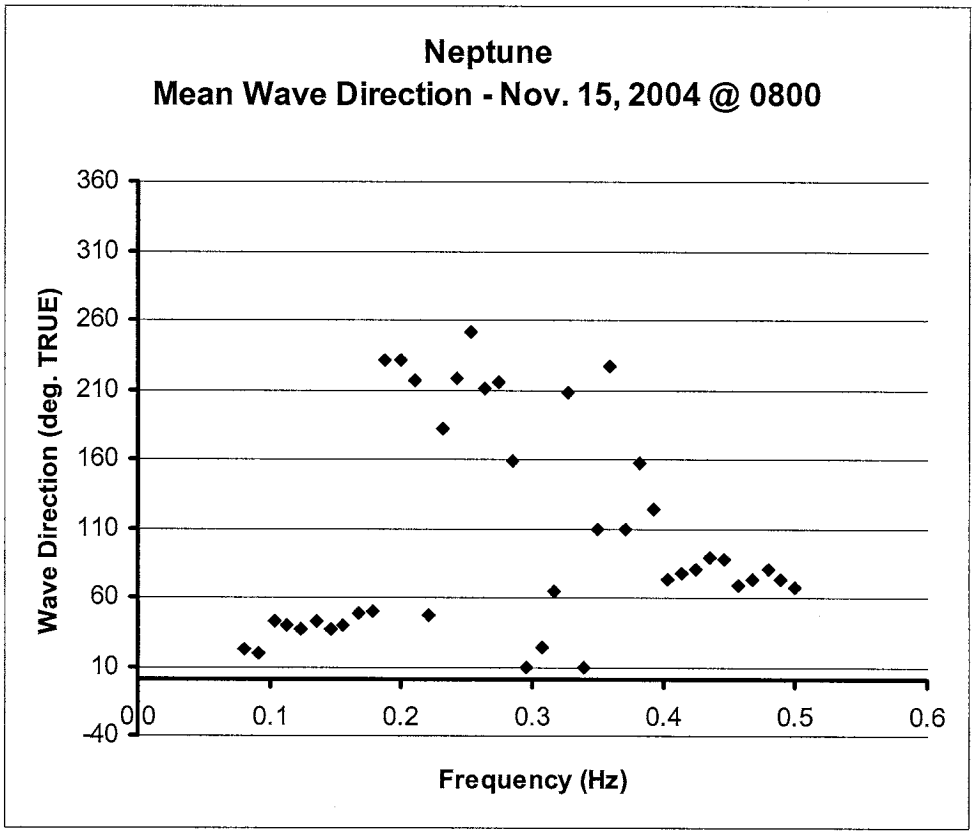

Neptune
Nondirectional Spectrum - Nov. 15, 2004 @ 0700
C11 (m²/Hz)
10
8
6
4
2
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

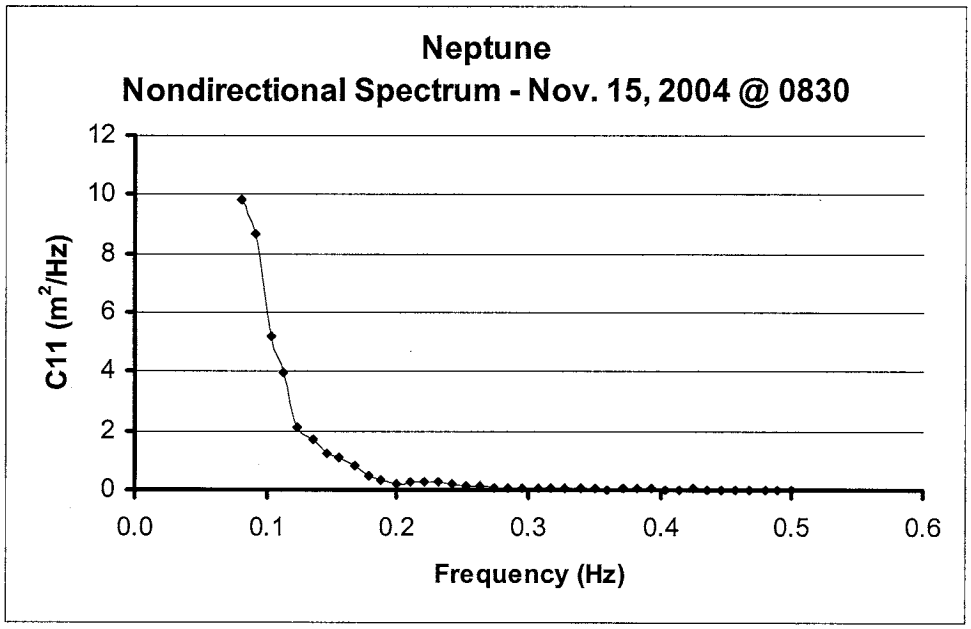

Neptune
Mean Wave Direction - Nov. 15, 2004 @ 0700
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

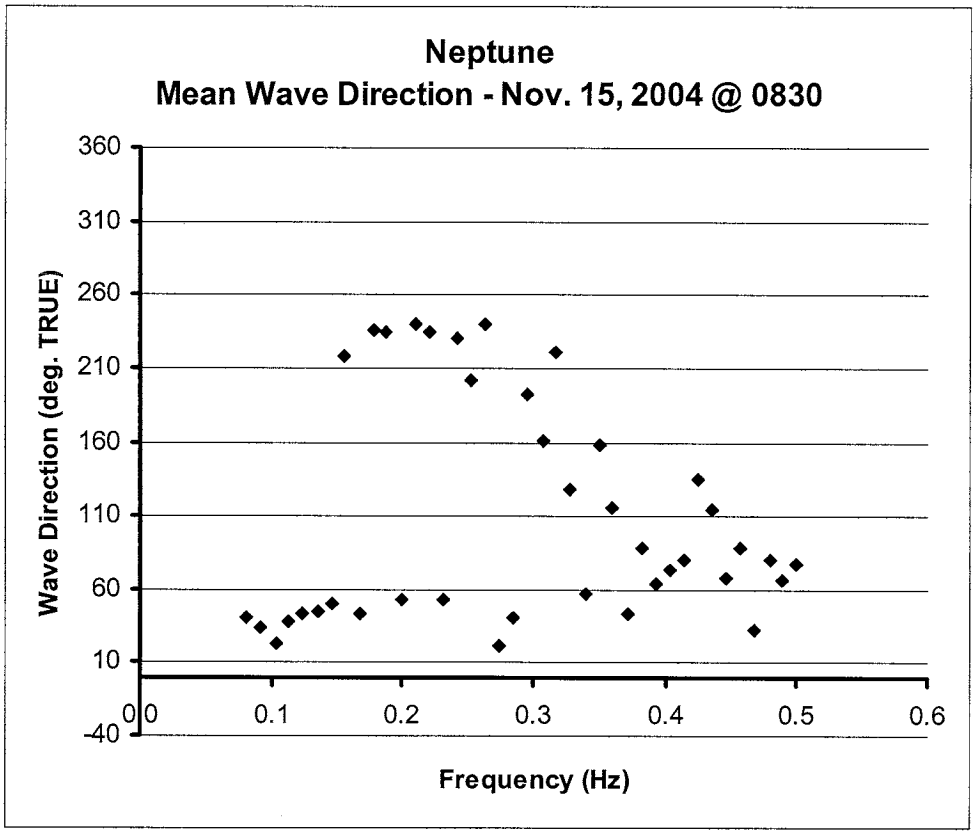

Neptune
Nondirectional Spectrum - Nov. 15, 2004 @ 0730
C11 (m²/Hz)
14
12
10
8
6
4
2
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

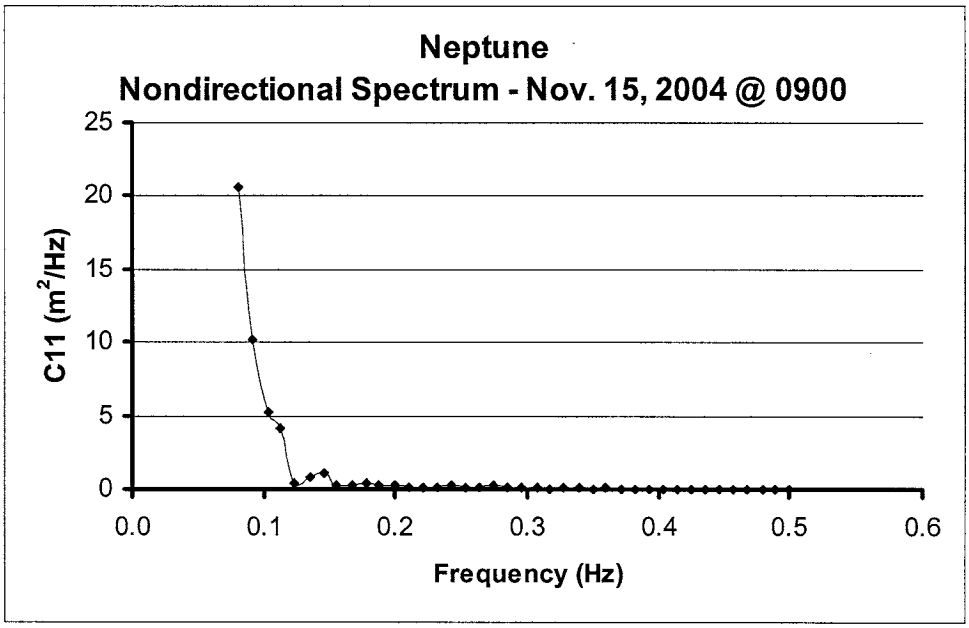

Neptune
Mean Wave Direction - Nov. 15, 2004 @ 0730
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

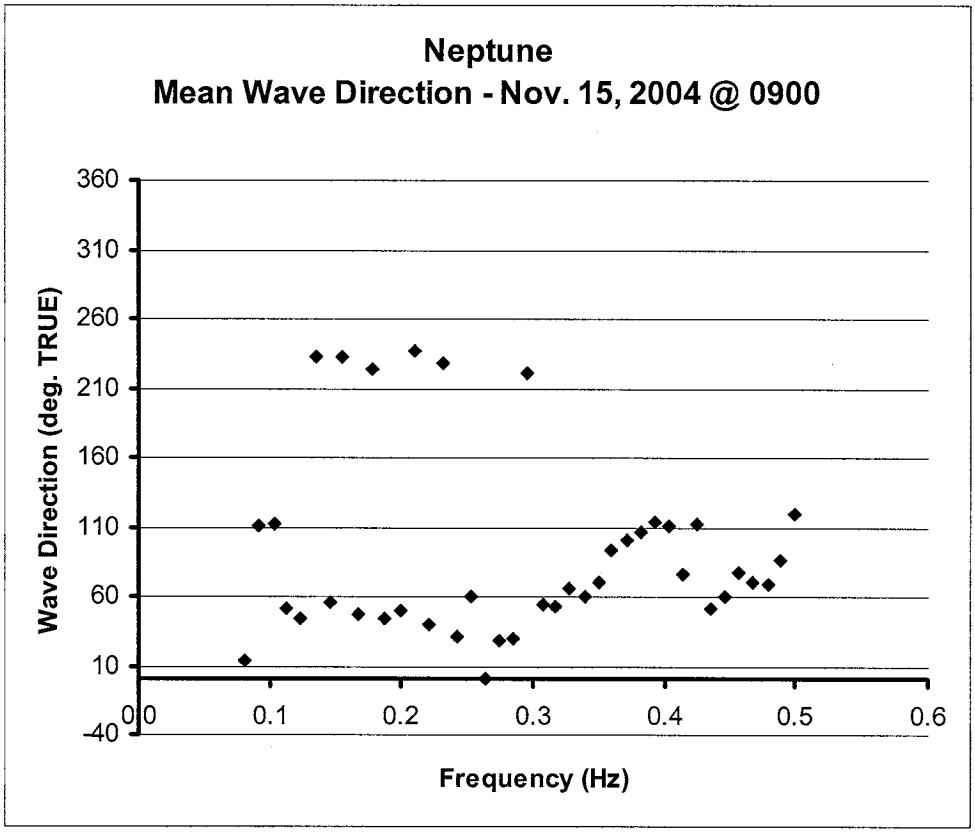

Neptune
Nondirectional Spectrum - Nov. 15, 2004 @ 0800
C11 (m²/Hz)
14
12
10
8
6
4
2
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

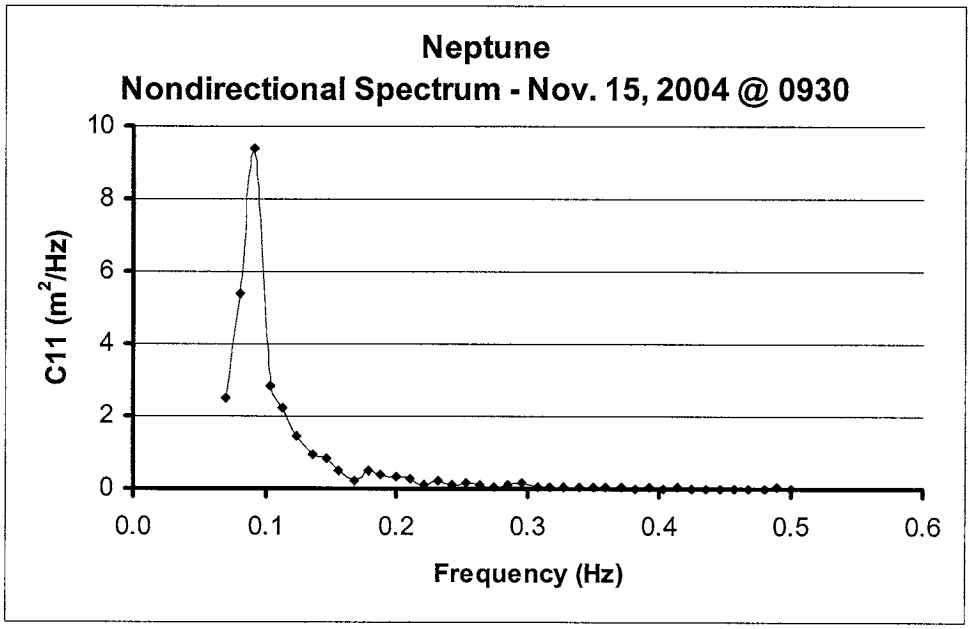

Neptune
Mean Wave Direction - Nov. 15, 2004 @ 0800
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

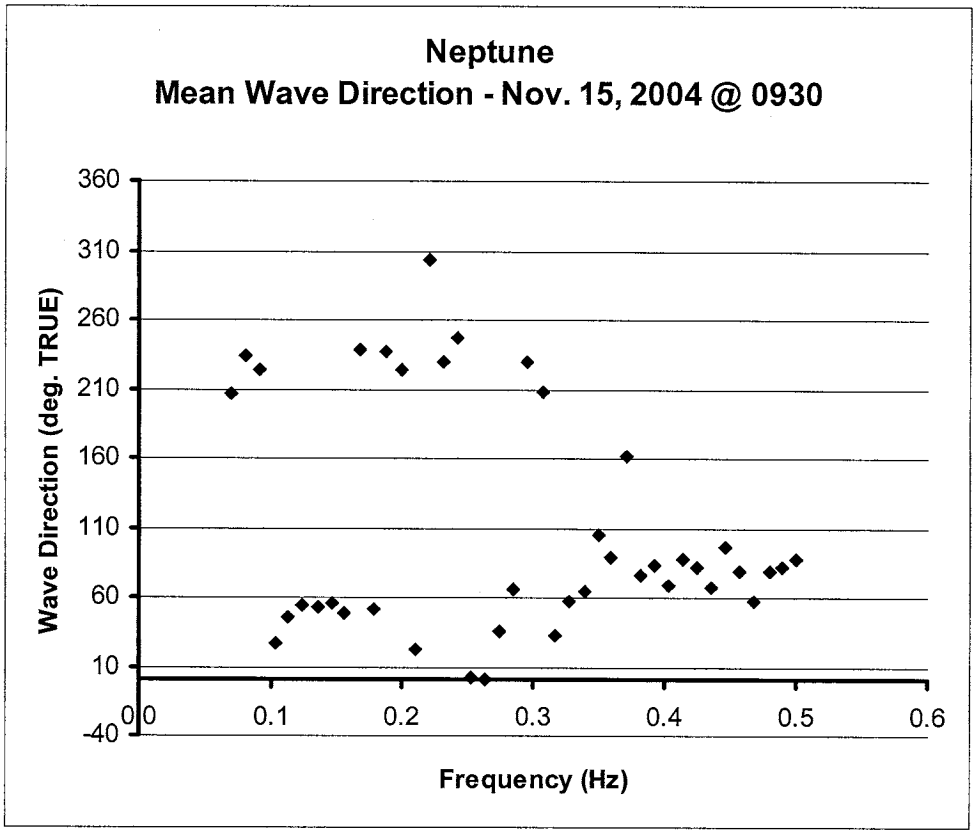

Neptune
Nondirectional Spectrum - Nov. 15, 2004 @ 0830
C11 (m²/Hz)
12
10
8
6
4
2
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

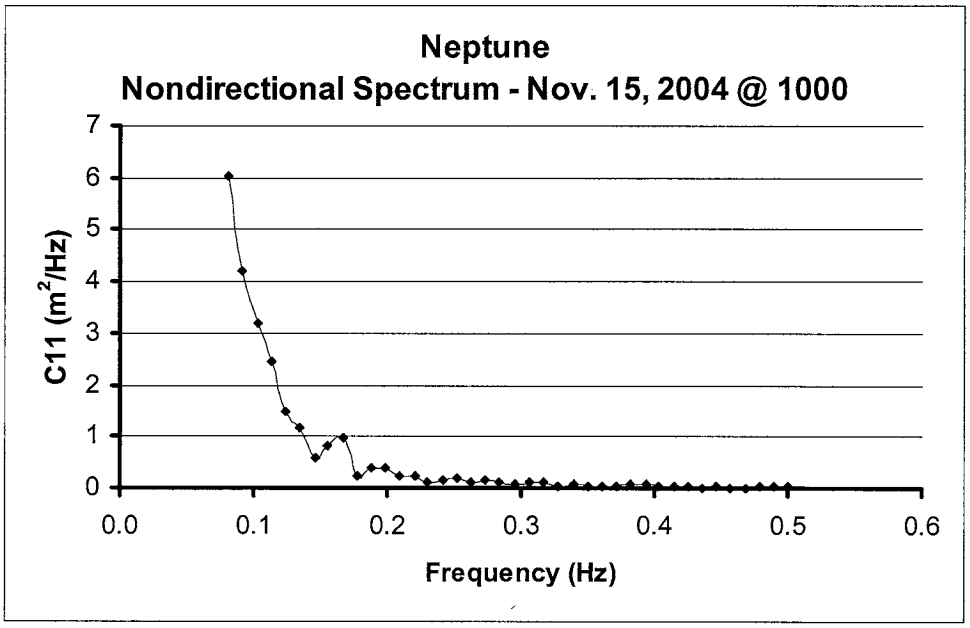

Neptune
Mean Wave Direction - Nov. 15, 2004 @ 0830
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

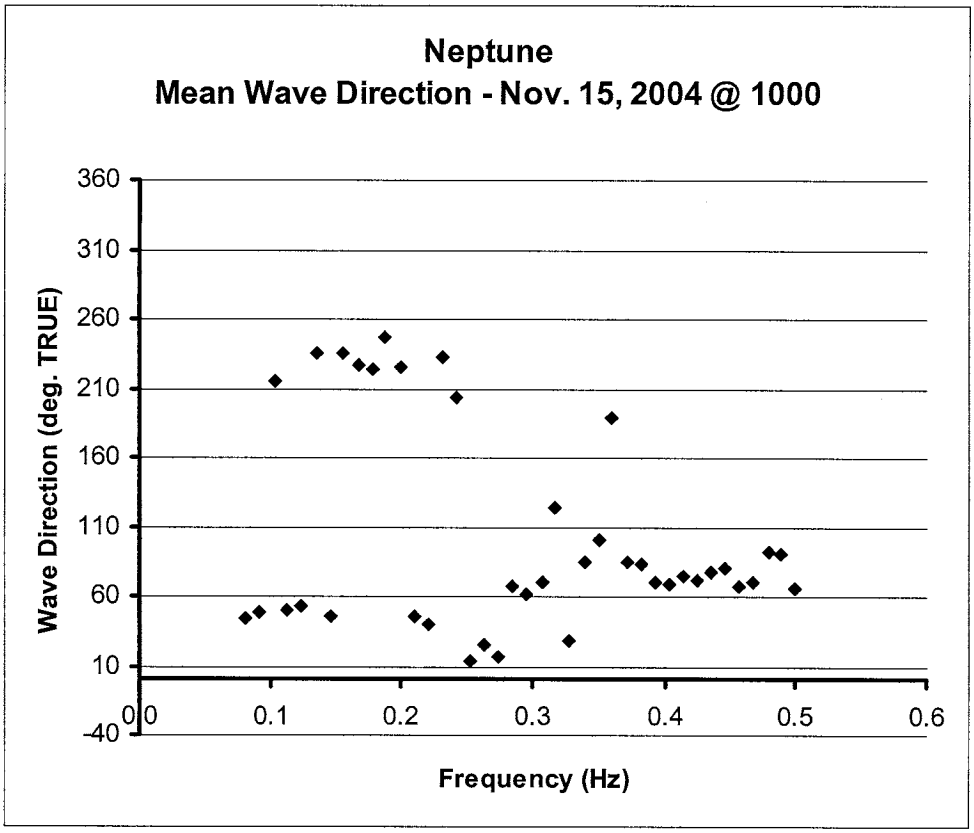

Neptune
Nondirectional Spectrum - Nov. 15, 2004 @ 0900
C11 (m²/Hz)
25
20
15
10
5
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

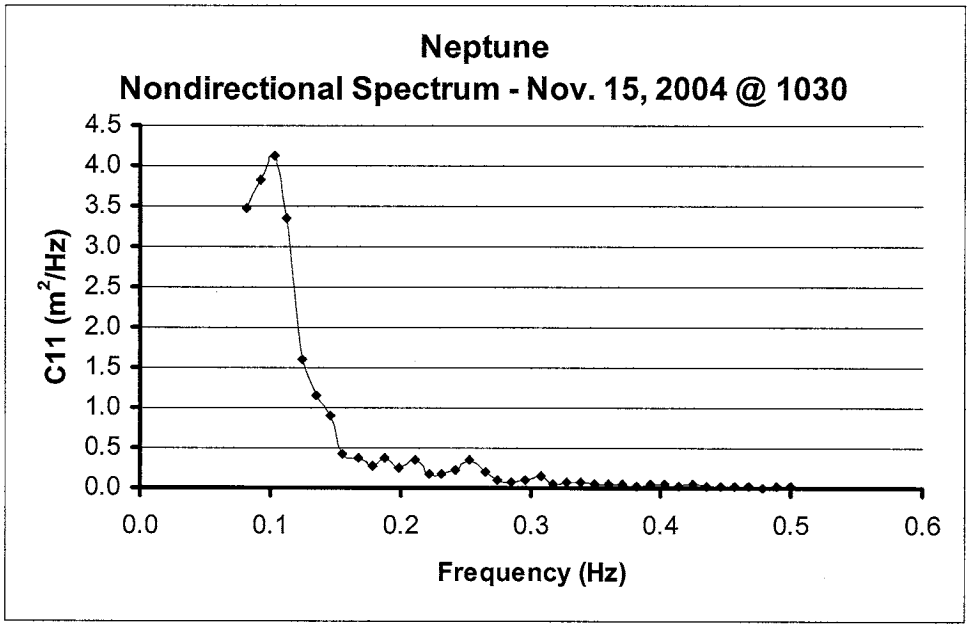

Neptune
Mean Wave Direction - Nov. 15, 2004 @ 0900
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

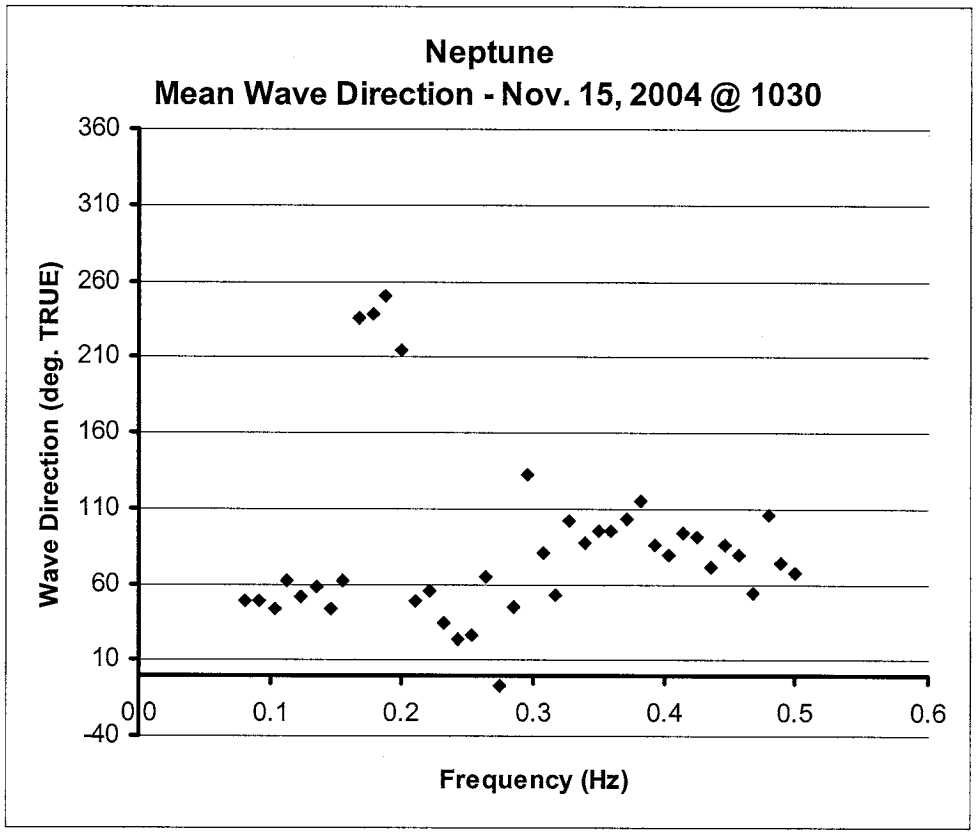

Neptune
Nondirectional Spectrum - Nov. 15, 2004 @ 0930
C11 (m²/Hz)
10
8
6
4
2
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

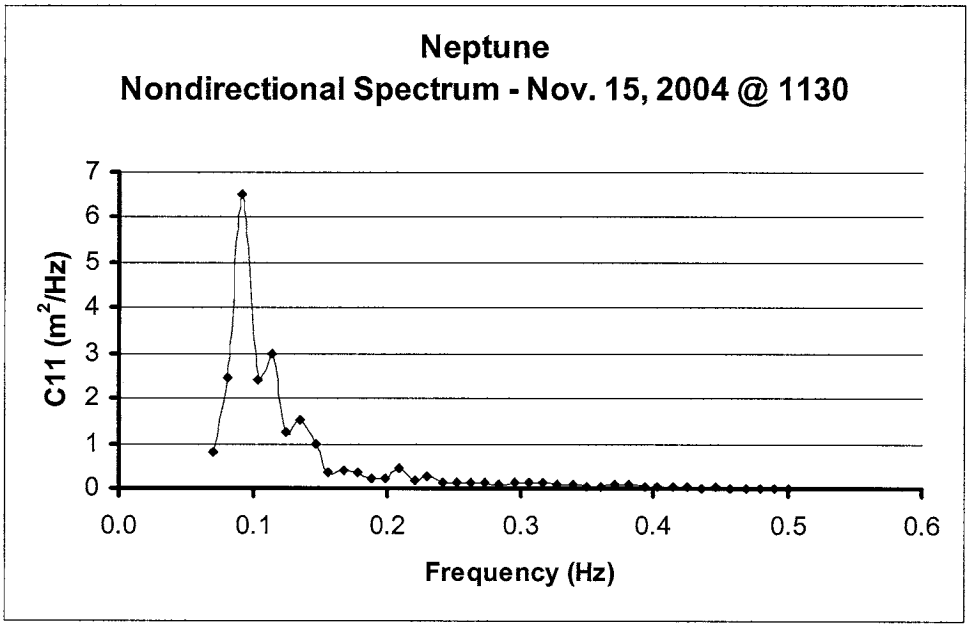

Neptune
Mean Wave Direction - Nov. 15, 2004 @ 0930
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

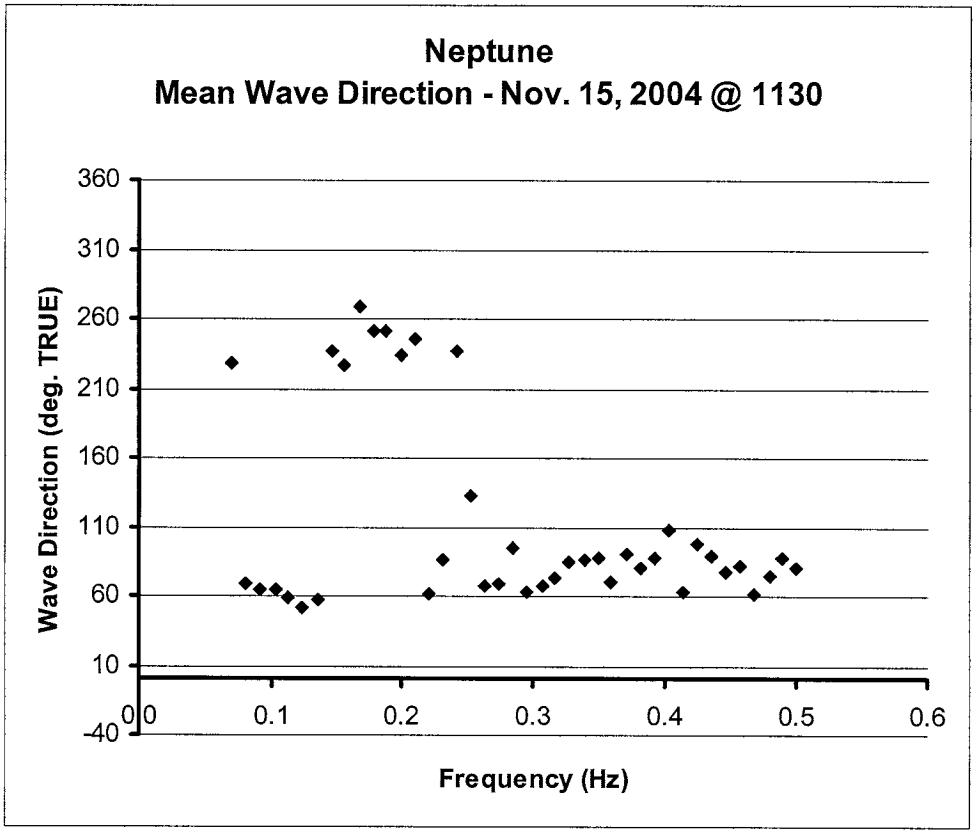

Neptune
Nondirectional Spectrum - Nov. 15, 2004 @ 1000
C11 (m²/Hz)
7
6
5
4
3
2
1
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

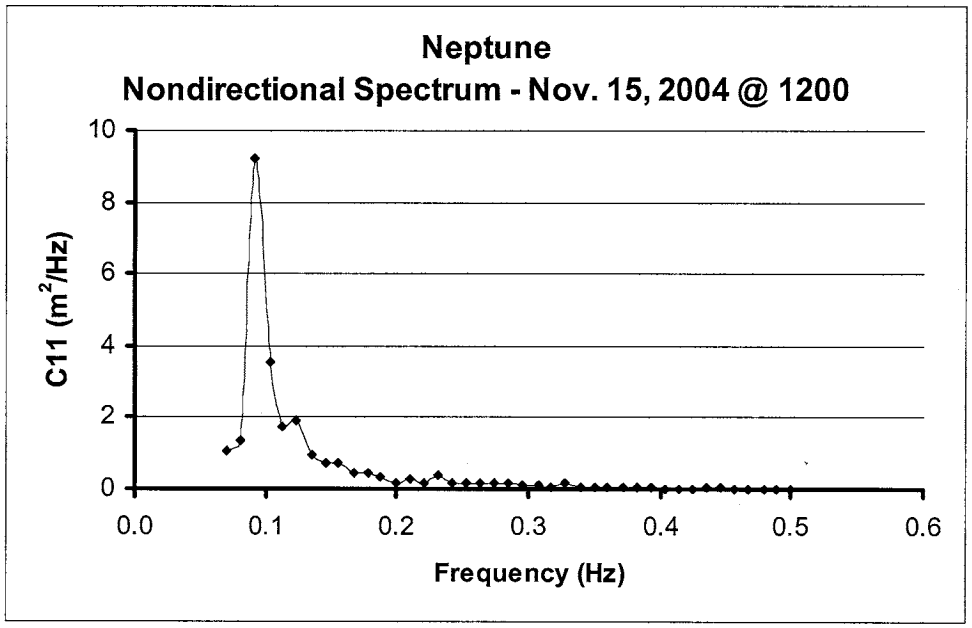

Neptune
Mean Wave Direction - Nov. 15, 2004 @ 1000
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

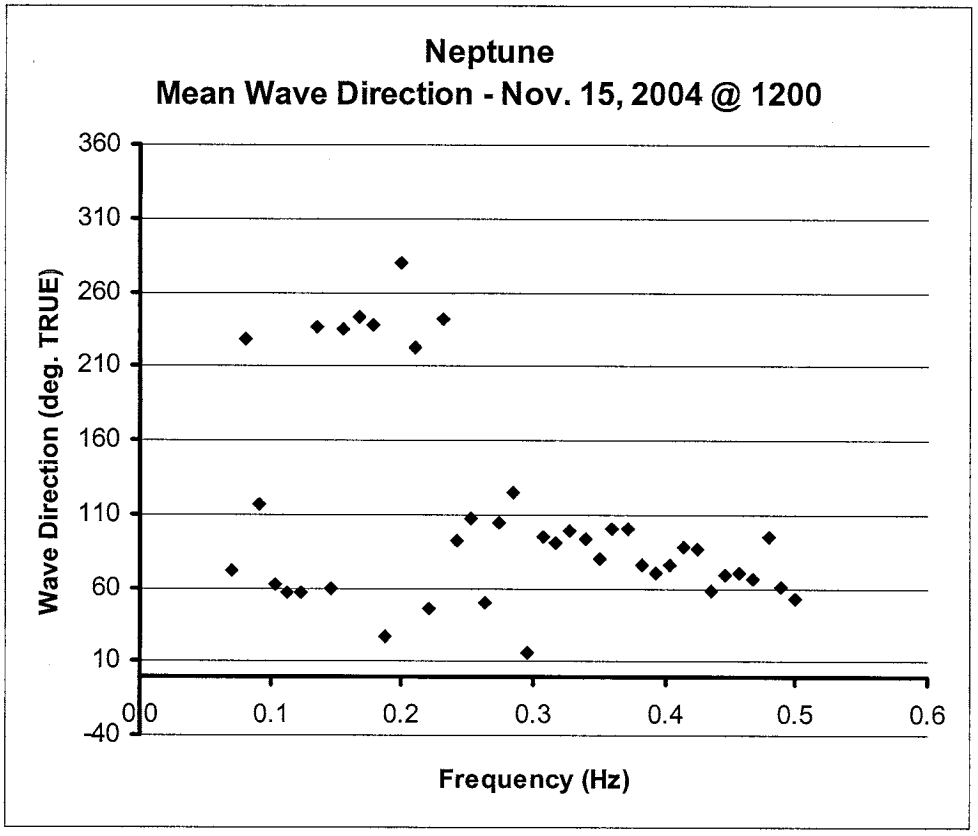

Neptune
Nondirectional Spectrum - Nov. 15, 2004 @ 1030
C11 (m²/Hz)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

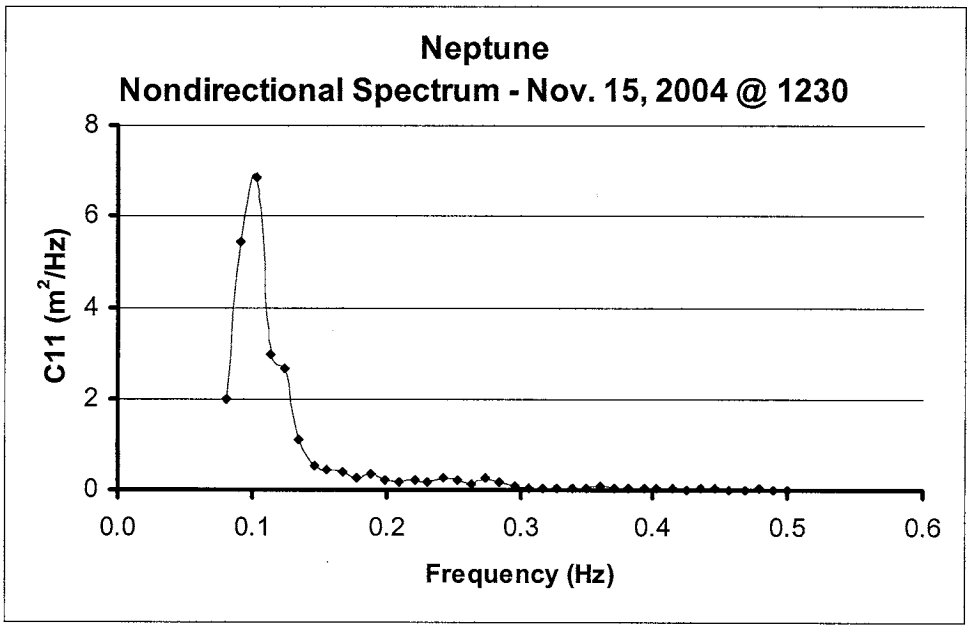

Neptune
Mean Wave Direction - Nov. 15, 2004 @ 1030
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

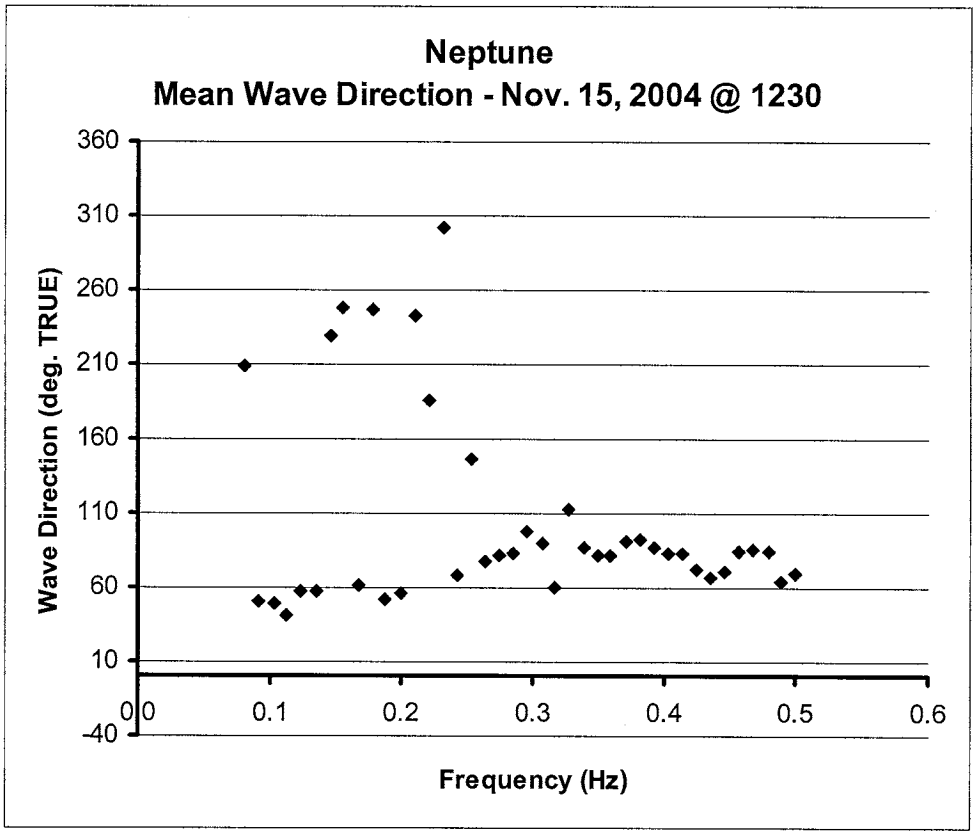

Neptune
Nondirectional Spectrum - Nov. 15, 2004 @ 1130
C11 (m²/Hz)
7
6
5
4
3
2
1
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

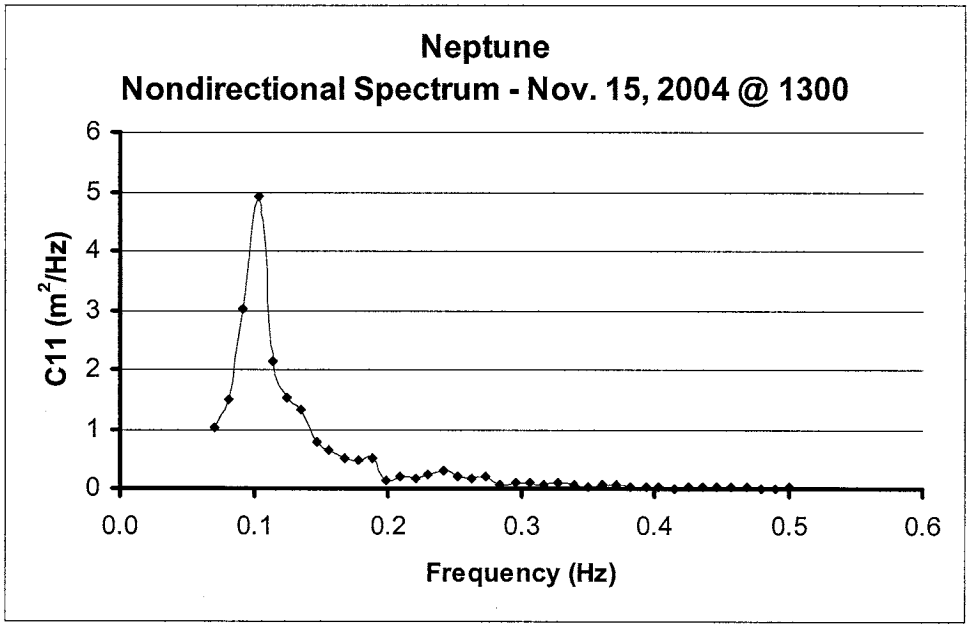

Neptune
Mean Wave Direction - Nov. 15, 2004 @ 1130
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

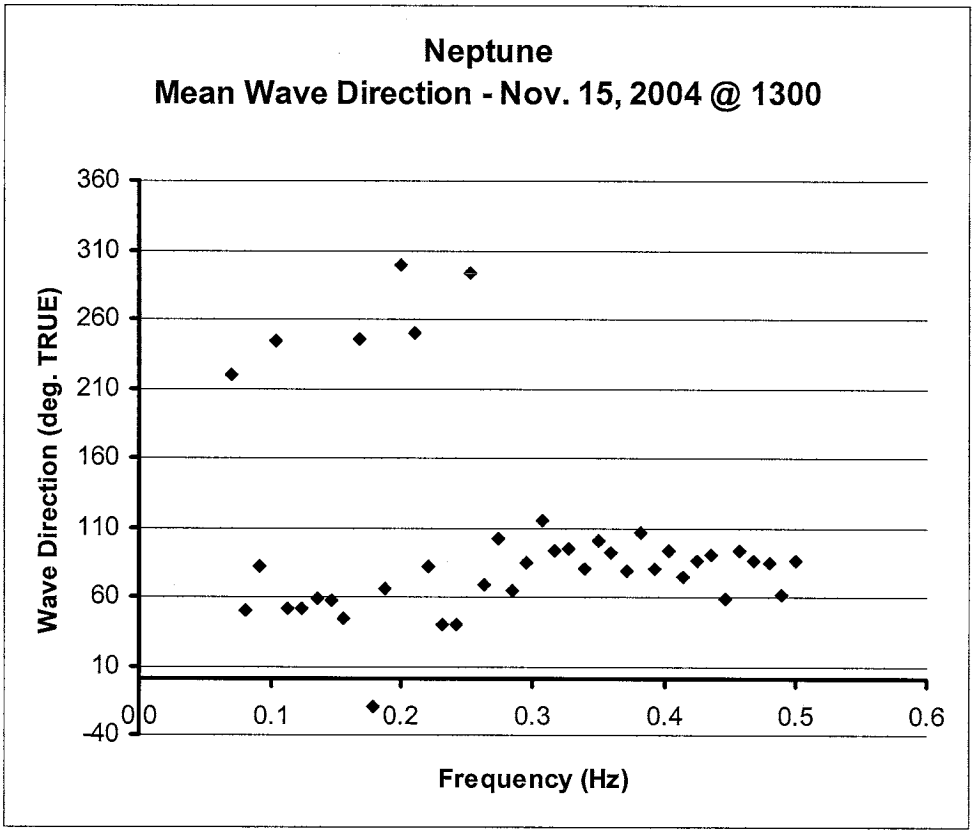

Neptune
Nondirectional Spectrum - Nov. 15, 2004 @ 1200
C11 (m²/Hz)
10
8
6
4
2
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

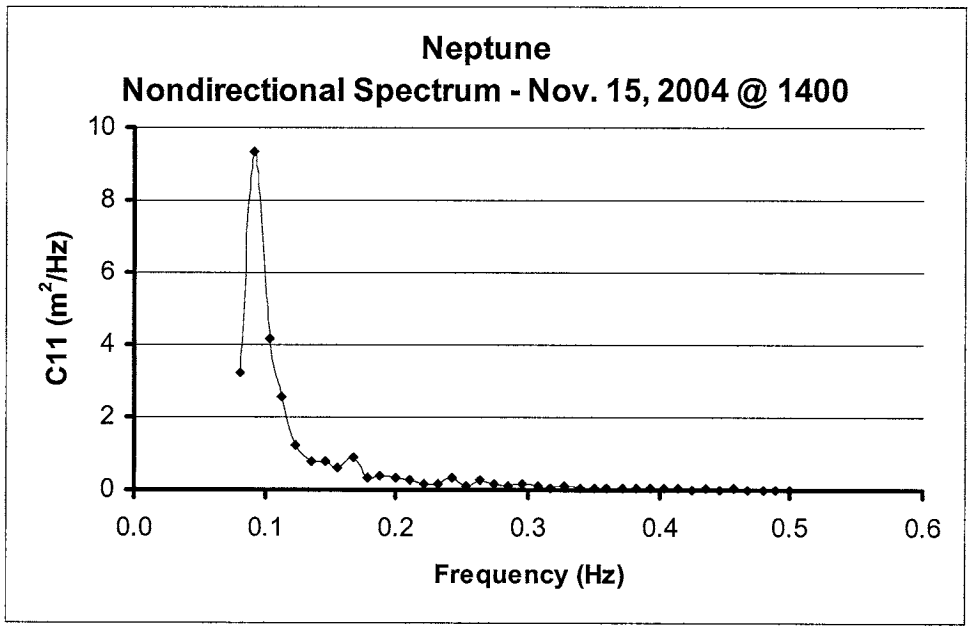

Neptune
Mean Wave Direction - Nov. 15, 2004 @ 1200
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

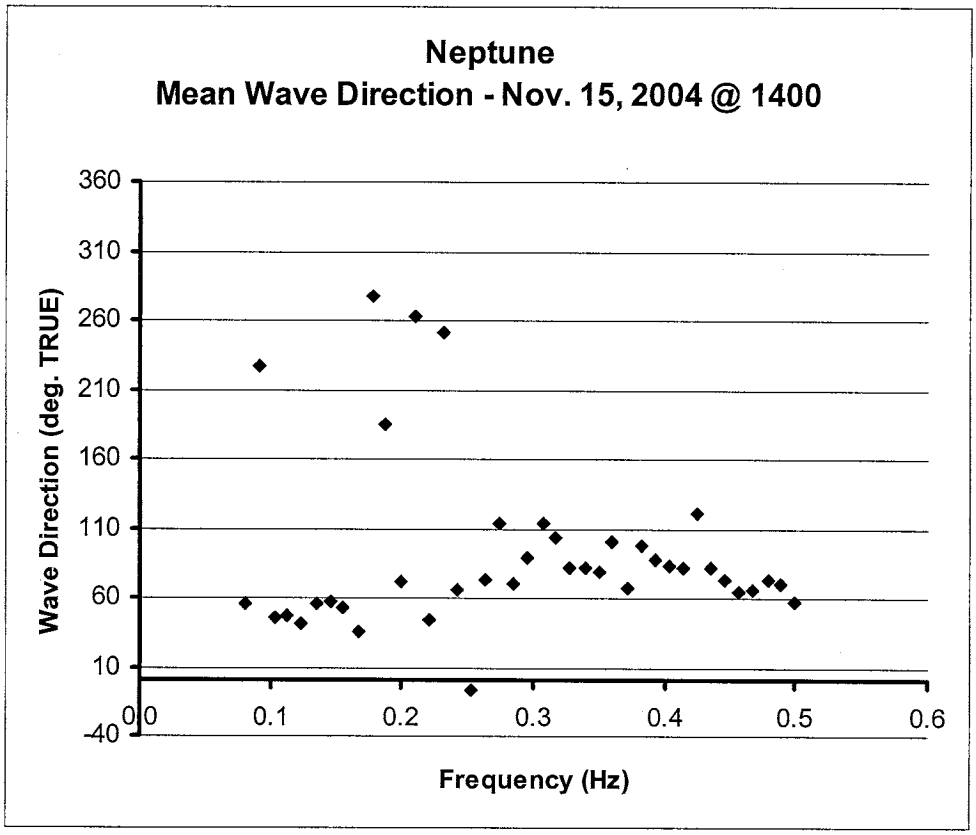

Neptune
Nondirectional Spectrum - Nov. 15, 2004 @ 1230
C11 (m²/Hz)
8
6
4
2
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

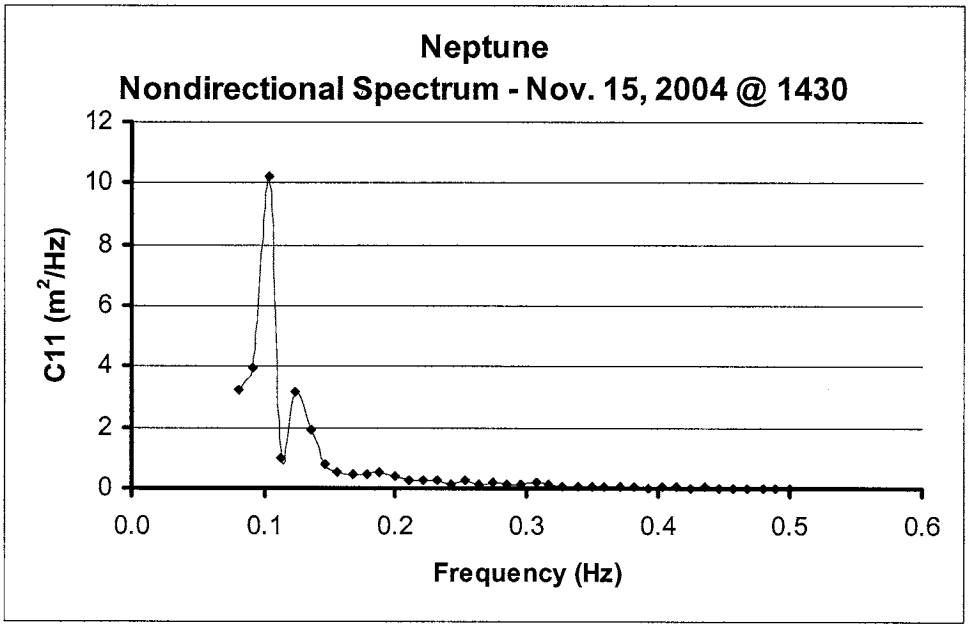

Neptune
Mean Wave Direction - Nov. 15, 2004 @ 1230
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

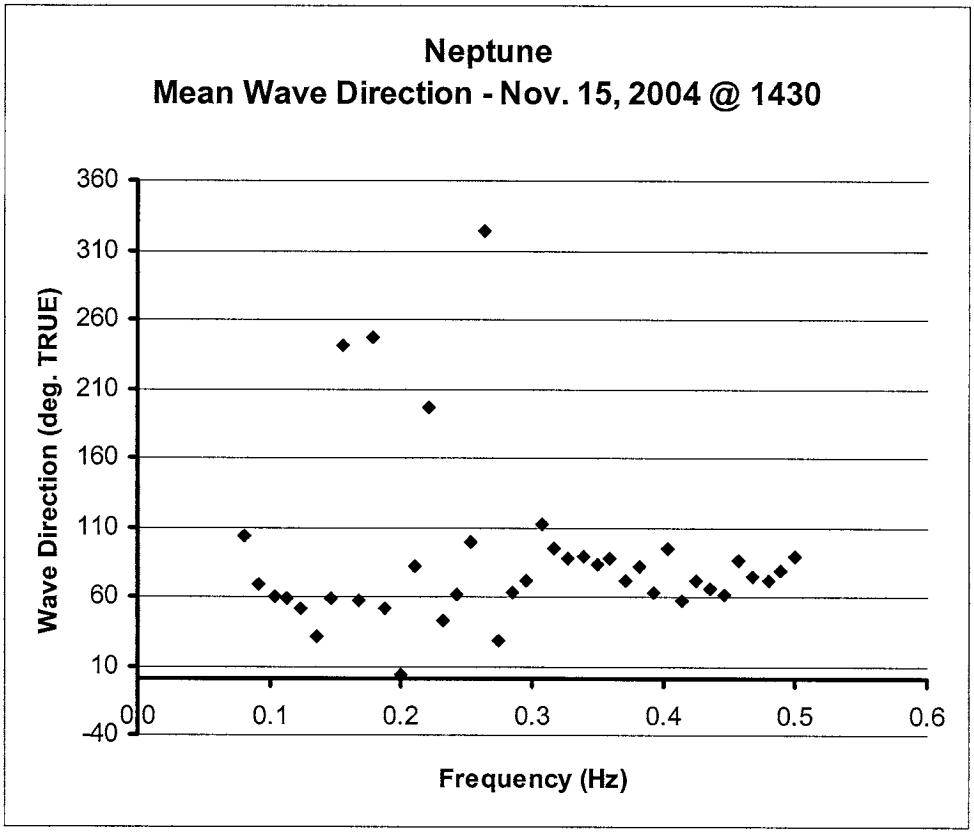

Neptune
Nondirectional Spectrum - Nov. 15, 2004 @ 1300
C11 (m²/Hz)
6
5
4
3
2
1
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

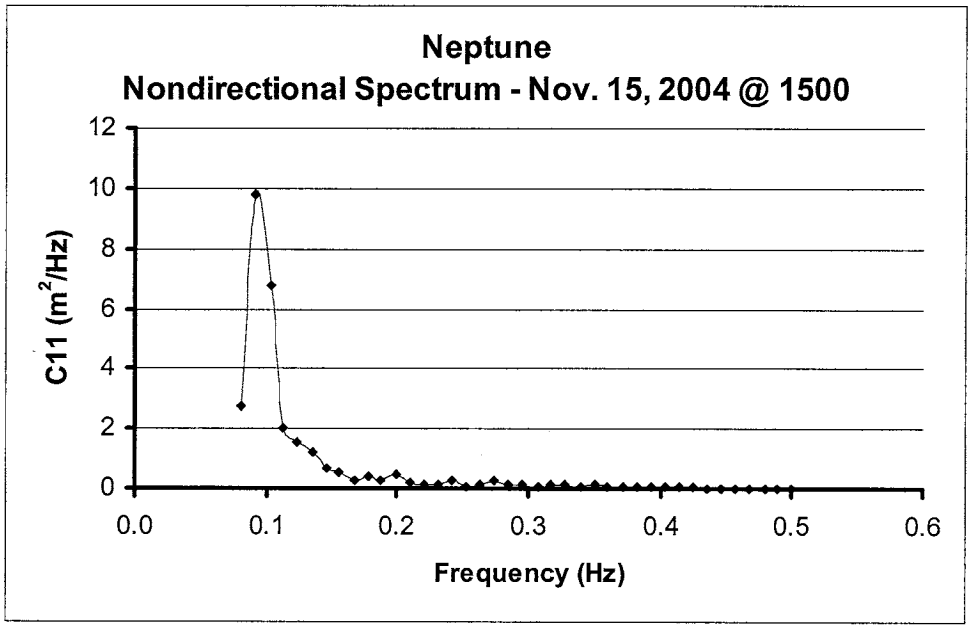

Neptune
Mean Wave Direction - Nov. 15, 2004 @ 1300
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

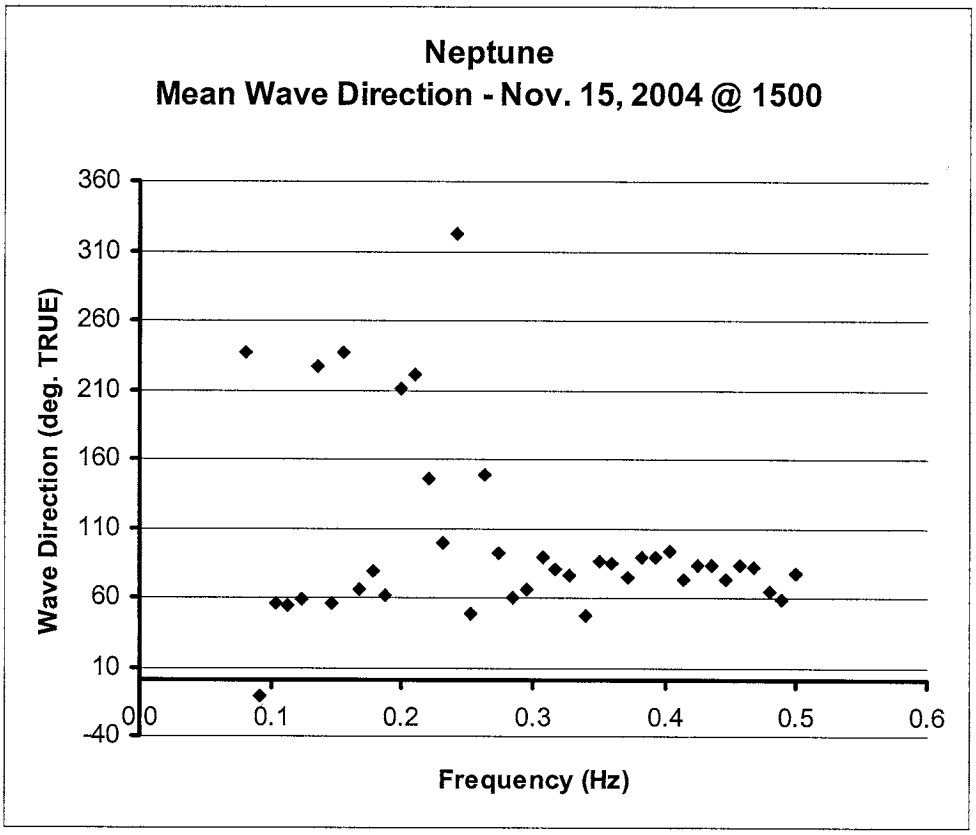

Neptune
Nondirectional Spectrum - Nov. 15, 2004 @ 1400
C11 (m²/Hz)
10
8
6
4
2
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

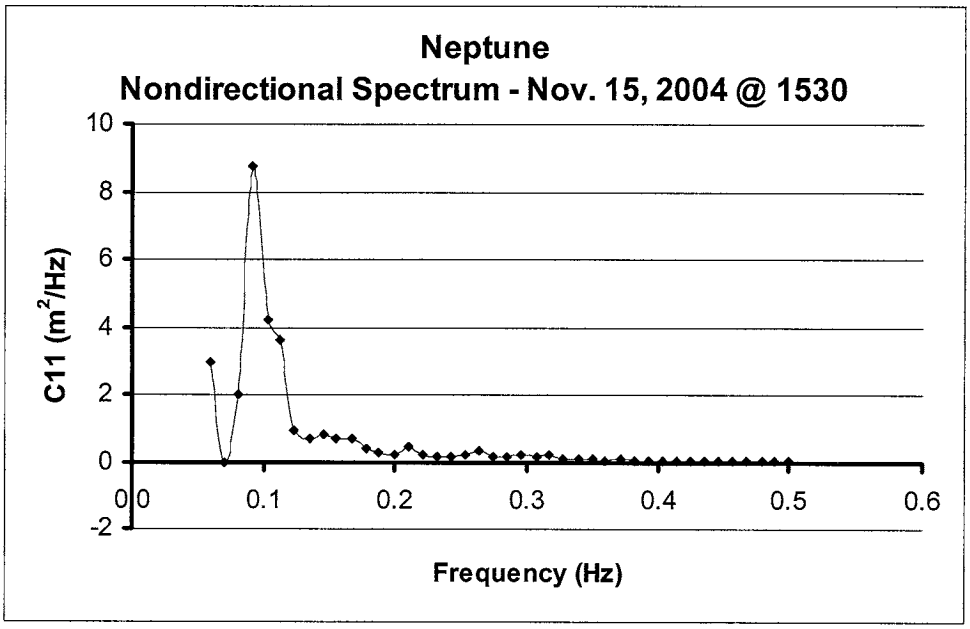

Neptune
Mean Wave Direction - Nov. 15, 2004 @ 1400
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

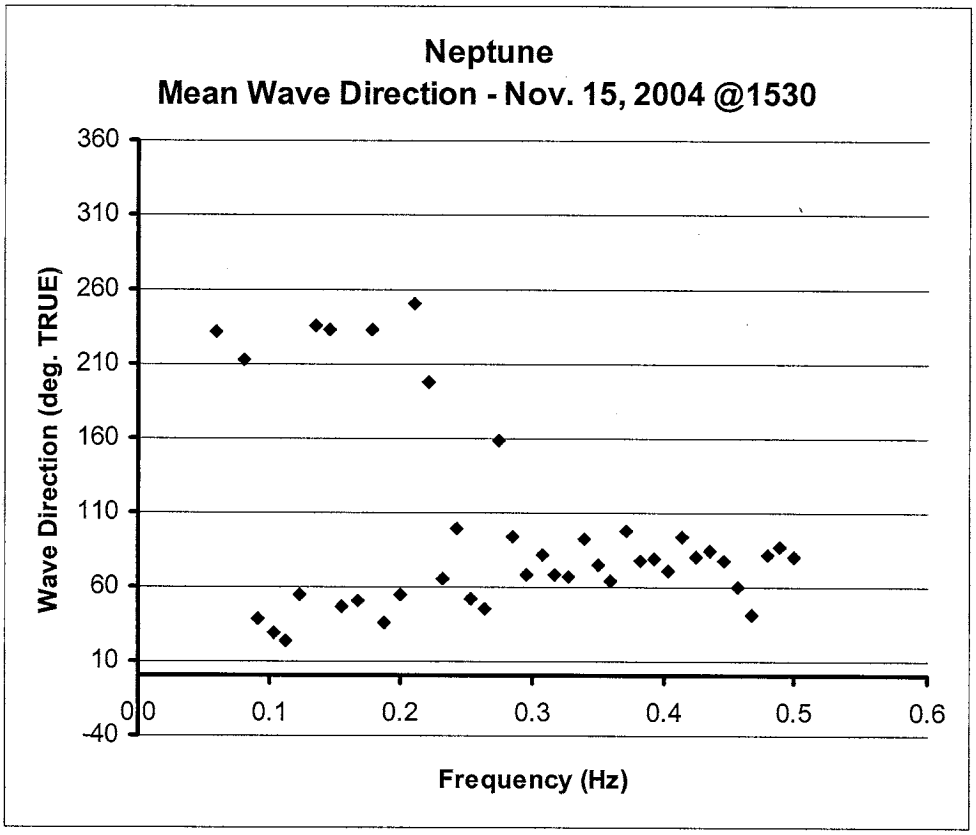

Neptune
Nondirectional Spectrum - Nov. 15, 2004 @ 1430
C11 (m²/Hz)
12
10
8
6
4
2
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)


Neptune
Mean Wave Direction - Nov. 15, 2004 @ 1430
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)


Neptune
Nondirectional Spectrum - Nov. 15, 2004 @ 1500
C11 (m²/Hz)
12
10
8
6
4
2
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)


Neptune
Mean Wave Direction - Nov. 15, 2004 @ 1500
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

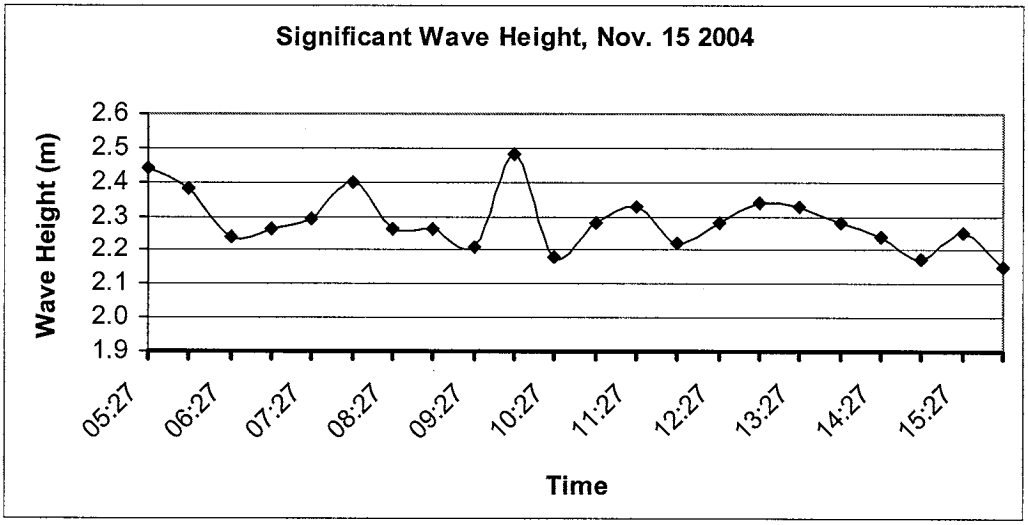

Neptune
Nondirectional Spectrum - Nov. 15, 2004 @ 1530
C11 (m²/Hz)
10
8
6
4
2
0
-2
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

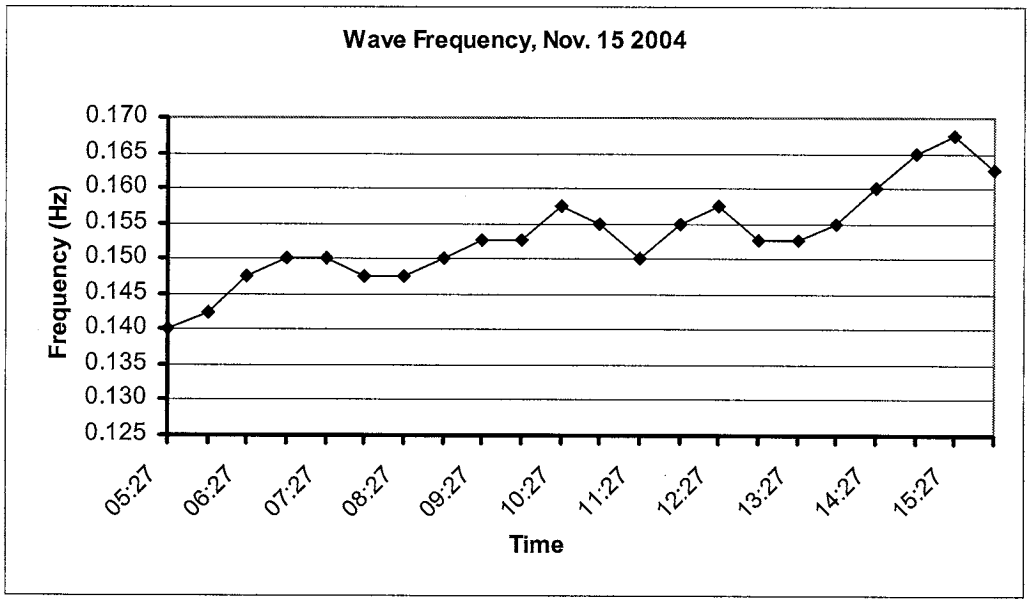

Neptune
Mean Wave Direction - Nov. 15, 2004 @1530
Wave Direction (deg. TRUE)
360
310
260
210
160
110
60
10
-40
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

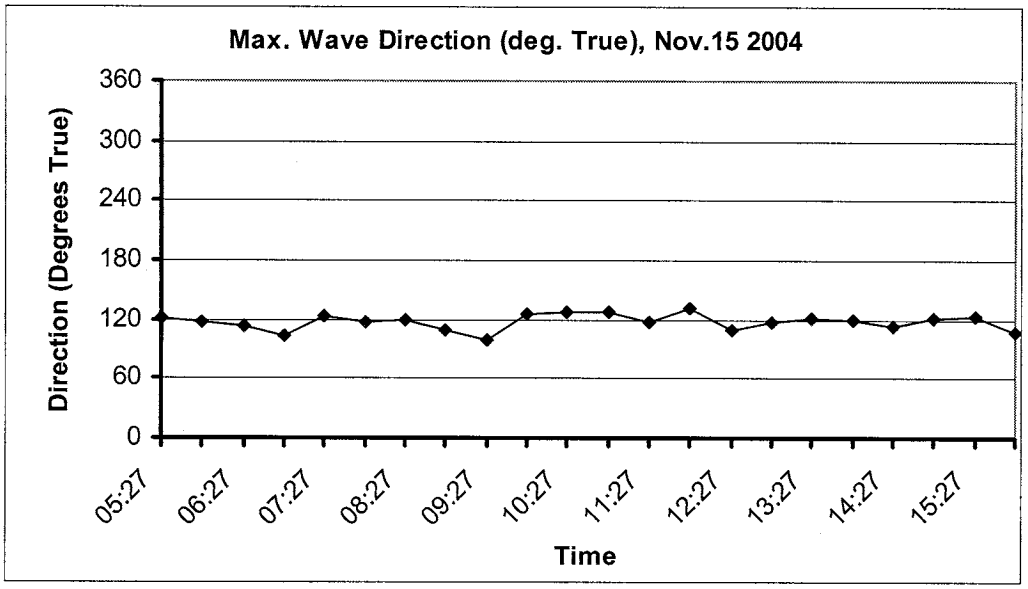
Summary of Wave Statistics Collected Using Datawell Directional Wave Buoy

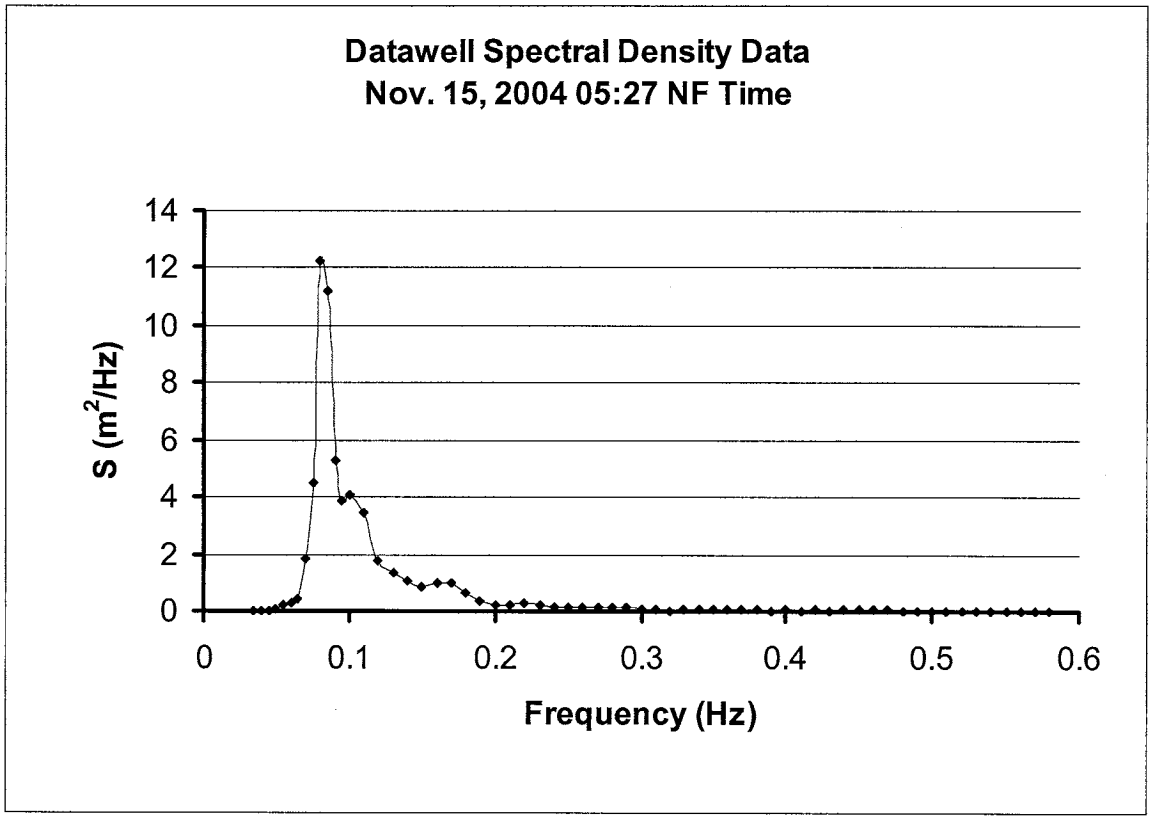
CCGA Roberts Sisters II **Fishing Vessel Research Proj. 2017**
November 15, 2004

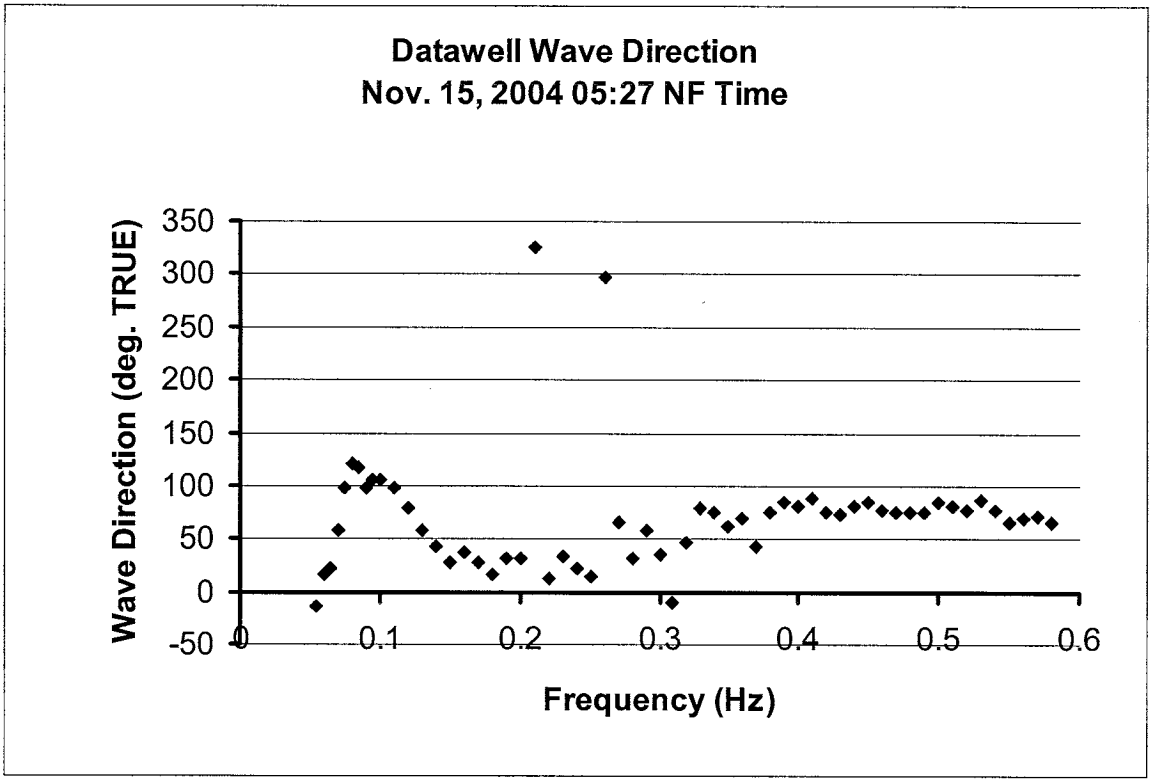
NF Time	Sig. Wave Height (m)	Mean Wave Period (s)	Mean Wave Frequency (Hz)	Maximum Spectral Density (m^2/Hz)	Maximum Wave Direction (deg. TRUE)
05:27	2.44	7.14	0.1400	12.27	121.03
05:57	2.38	7.02	0.1425	9.80	118.22
06:27	2.24	6.78	0.1475	10.40	114.00
06:57	2.26	6.67	0.1500	7.63	102.75
07:27	2.29	6.67	0.1500	9.60	122.44
07:57	2.40	6.78	0.1475	9.85	116.81
08:27	2.26	6.78	0.1475	11.21	119.63
08:57	2.26	6.67	0.1500	7.01	108.38
09:27	2.21	6.56	0.1525	6.37	99.94
09:57	2.48	6.56	0.1525	9.56	125.25
10:27	2.18	6.35	0.1575	8.39	126.66
10:57	2.28	6.45	0.1550	8.31	126.66
11:27	2.33	6.67	0.1500	12.15	118.22
11:57	2.22	6.45	0.1550	8.78	132.28
12:27	2.28	6.35	0.1575	7.30	108.38
12:57	2.34	6.56	0.1525	9.00	118.22
13:27	2.33	6.56	0.1525	12.52	121.03
13:57	2.28	6.45	0.1550	8.14	119.63
14:27	2.24	6.25	0.1600	8.39	112.59
14:57	2.17	6.06	0.1650	6.34	121.03
15:27	2.25	5.97	0.1675	8.69	122.44
15:57	2.15	6.15	0.1625	6.97	106.97

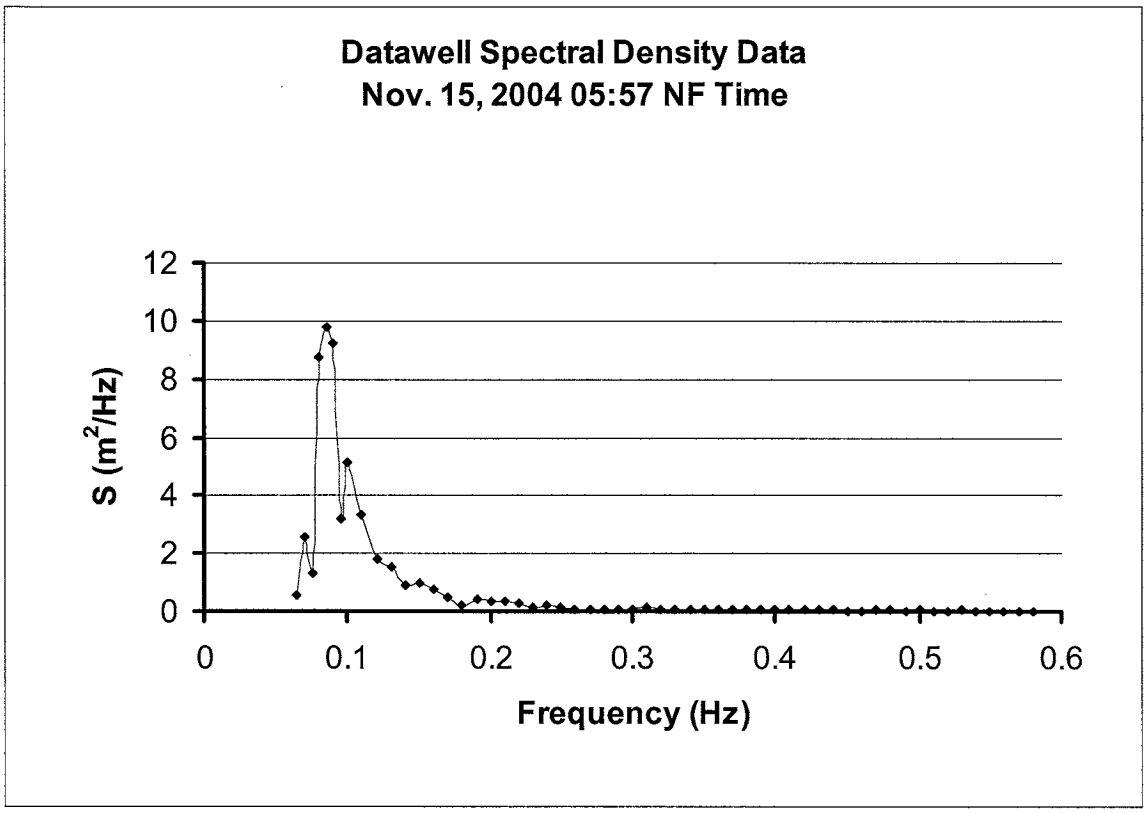

Significant Wave Height, Nov. 15 2004
Wave Height (m)
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
05:27
06:27
07:27
08:27
09:27
10:27
11:27
12:27
13:27
14:27
15:27
Time

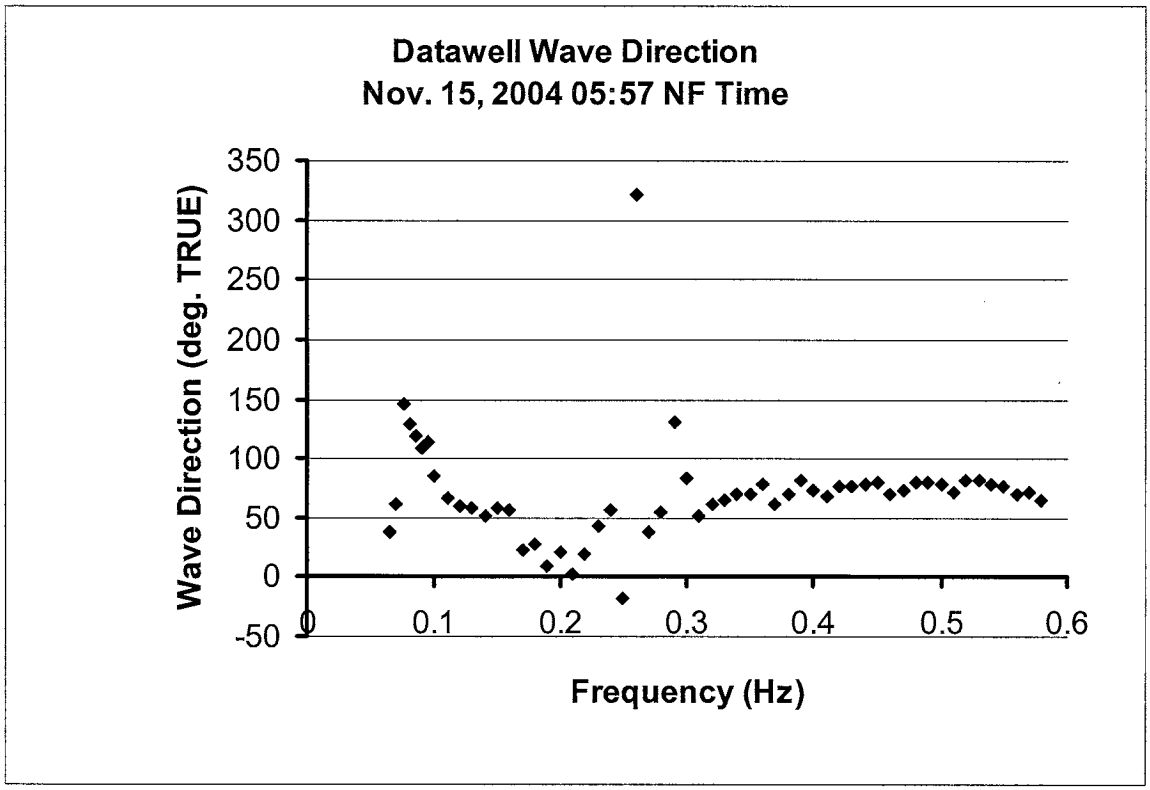

Wave Frequency, Nov. 15 2004
Frequency (Hz)
0.170
0.165
0.160
0.155
0.150
0.145
0.140
0.135
0.130
0.125
05:27
06:27
07:27
08:27
09:27
10:27
11:27
12:27
13:27
14:27
15:27
Time

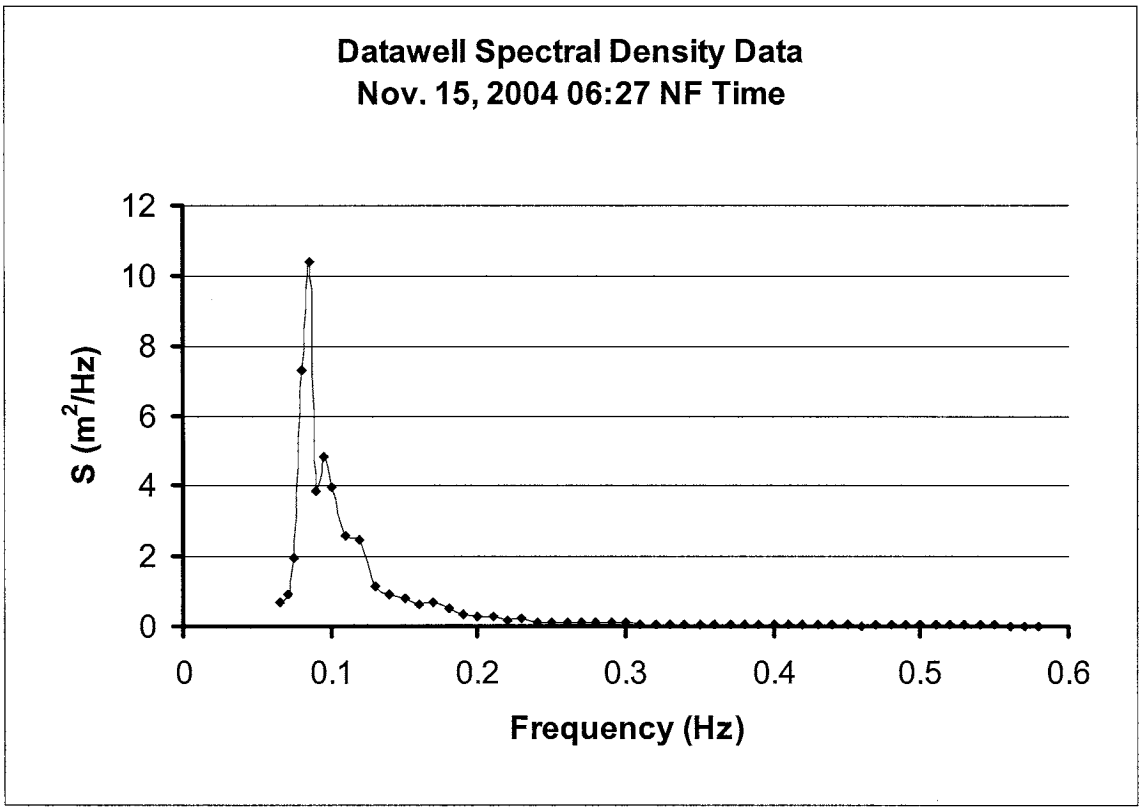

Max. Wave Direction (deg. True), Nov.15 2004
Direction (Degrees True)
360
300
240
180
120
60
0
05:27
06:27
07:27
08:27
09:27
10:27
11:27
12:27
13:27
14:27
15:27
Time

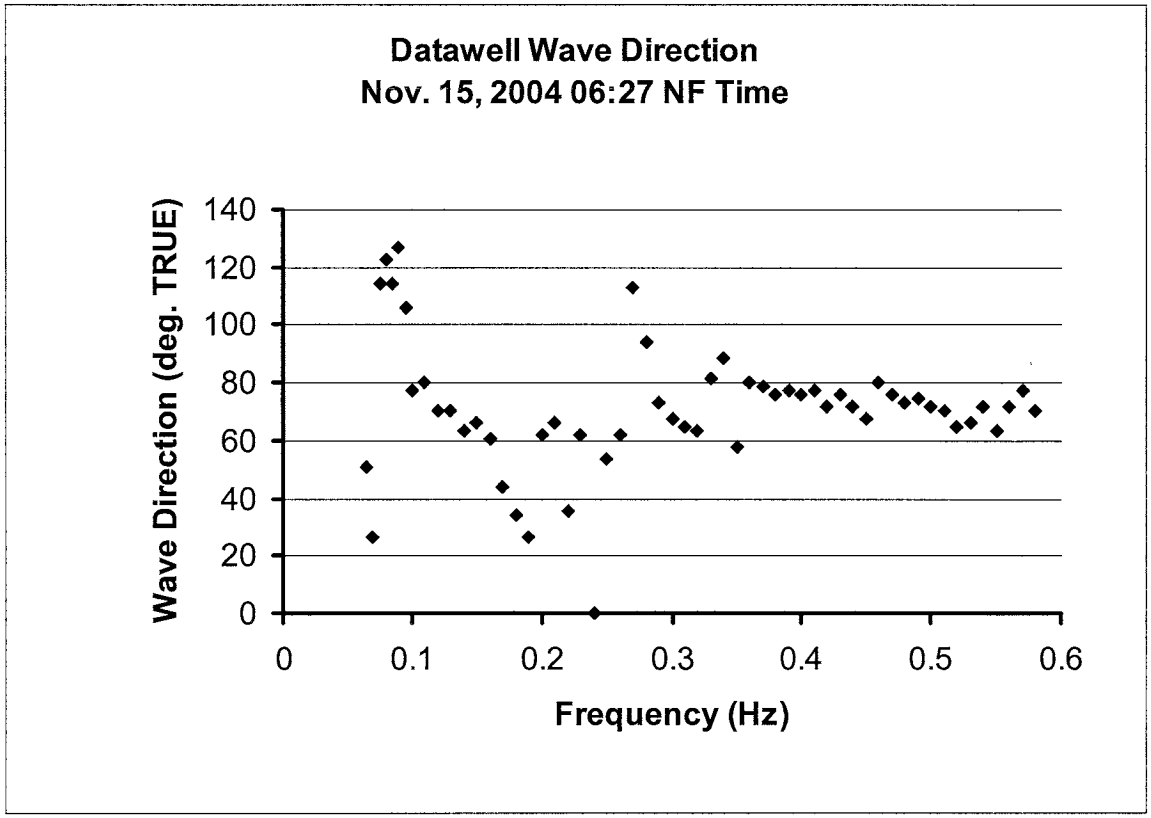

Datawell Spectral Density Data
Nov. 15, 2004 05:27 NF Time
S (m²/Hz)
14
12
10
8
6
4
2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

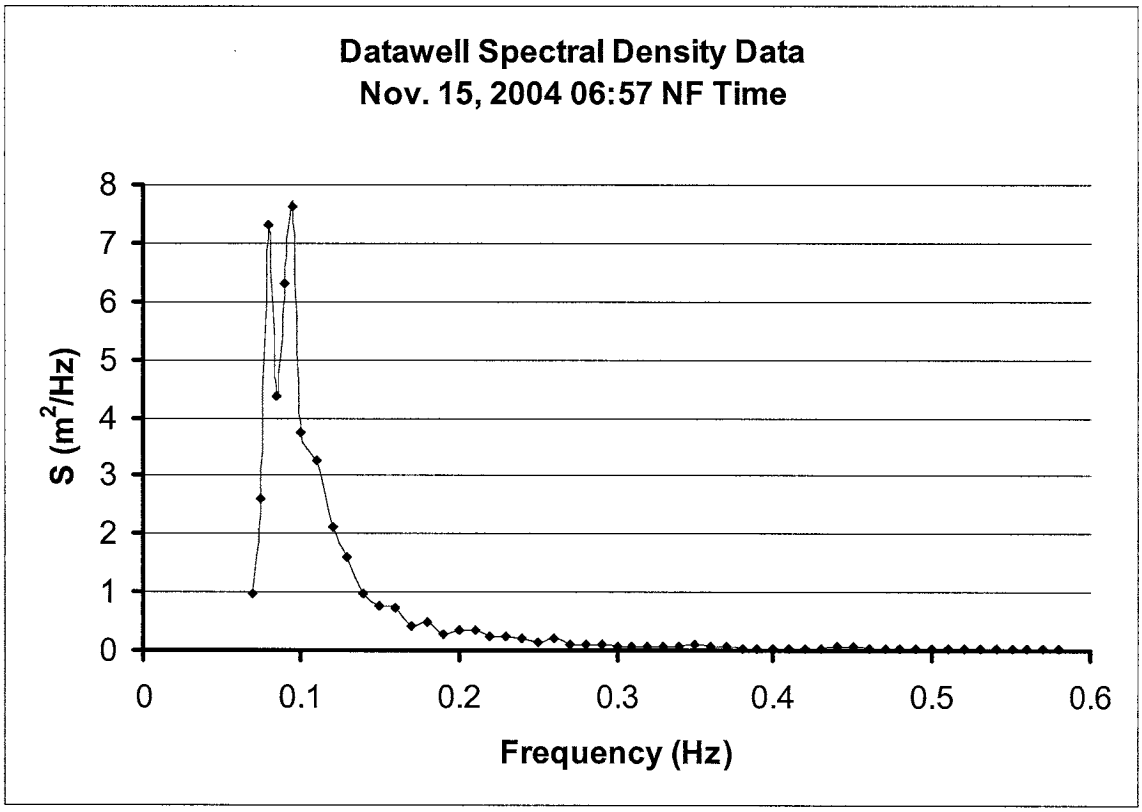

Datawell Wave Direction
Nov. 15, 2004 05:27 NF Time
Wave Direction (deg. TRUE)
350
300
250
200
150
100
50
0
-50
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

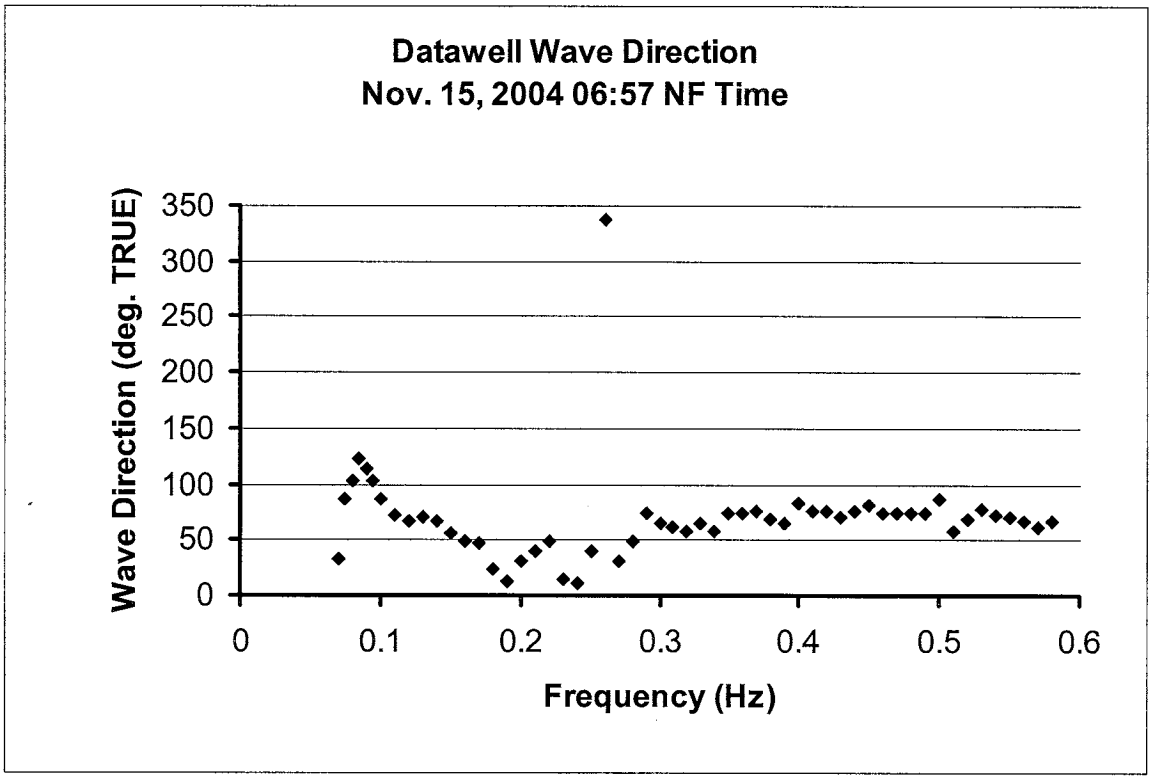

Datawell Spectral Density Data
Nov. 15, 2004 05:57 NF Time
S (m²/Hz)
12
10
8
6
4
2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

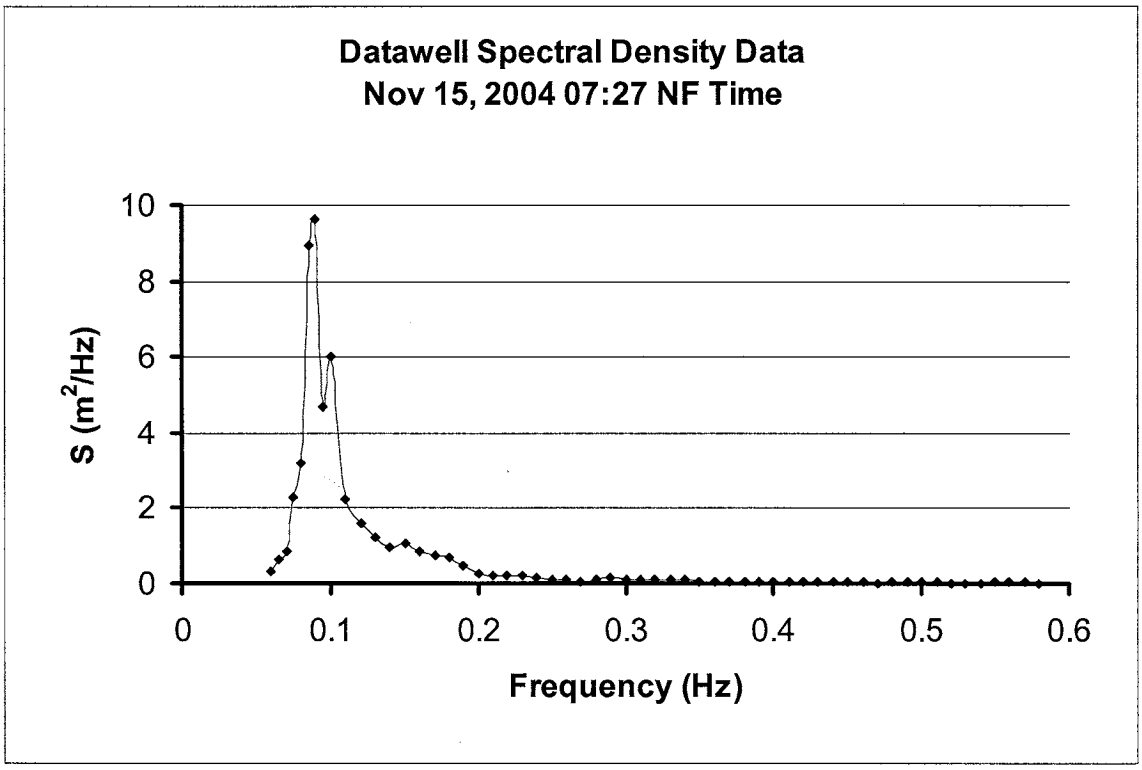

Datawell Wave Direction
Nov. 15, 2004 05:57 NF Time
Wave Direction (deg. TRUE)
350
300
250
200
150
100
50
0
-50
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

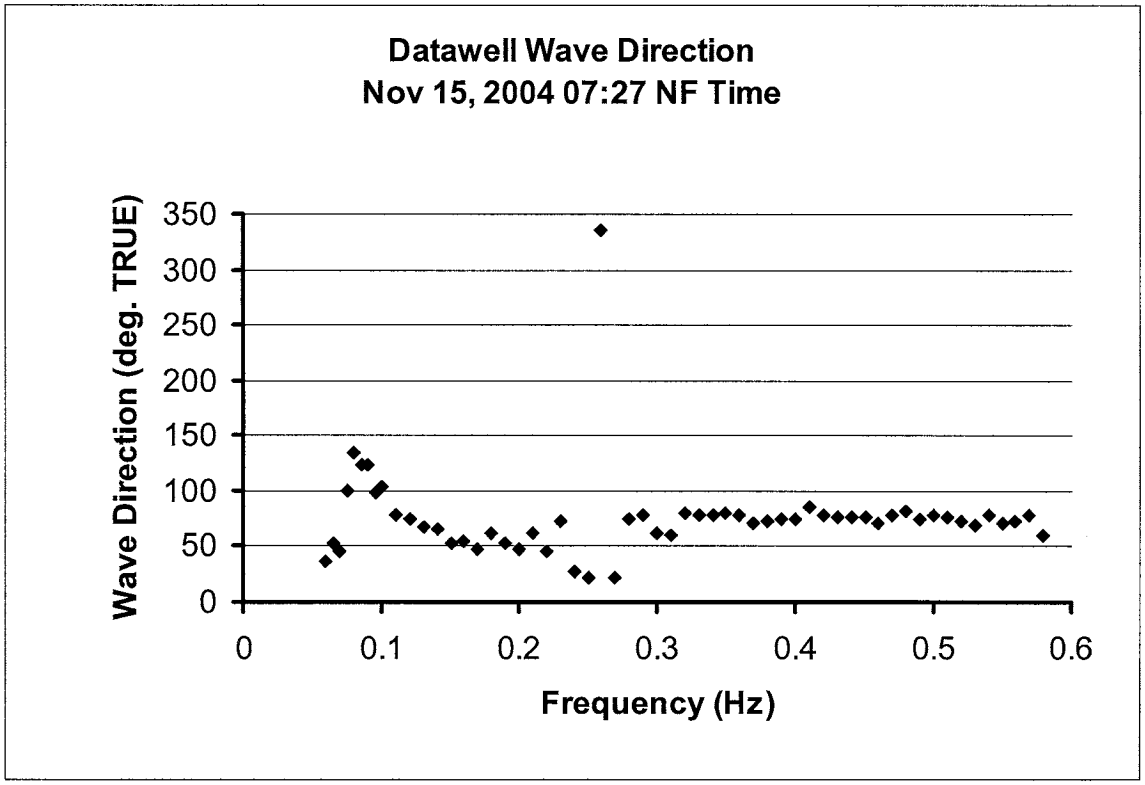

Datawell Spectral Density Data
Nov. 15, 2004 06:27 NF Time
S (m²/Hz)
12
10
8
6
4
2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

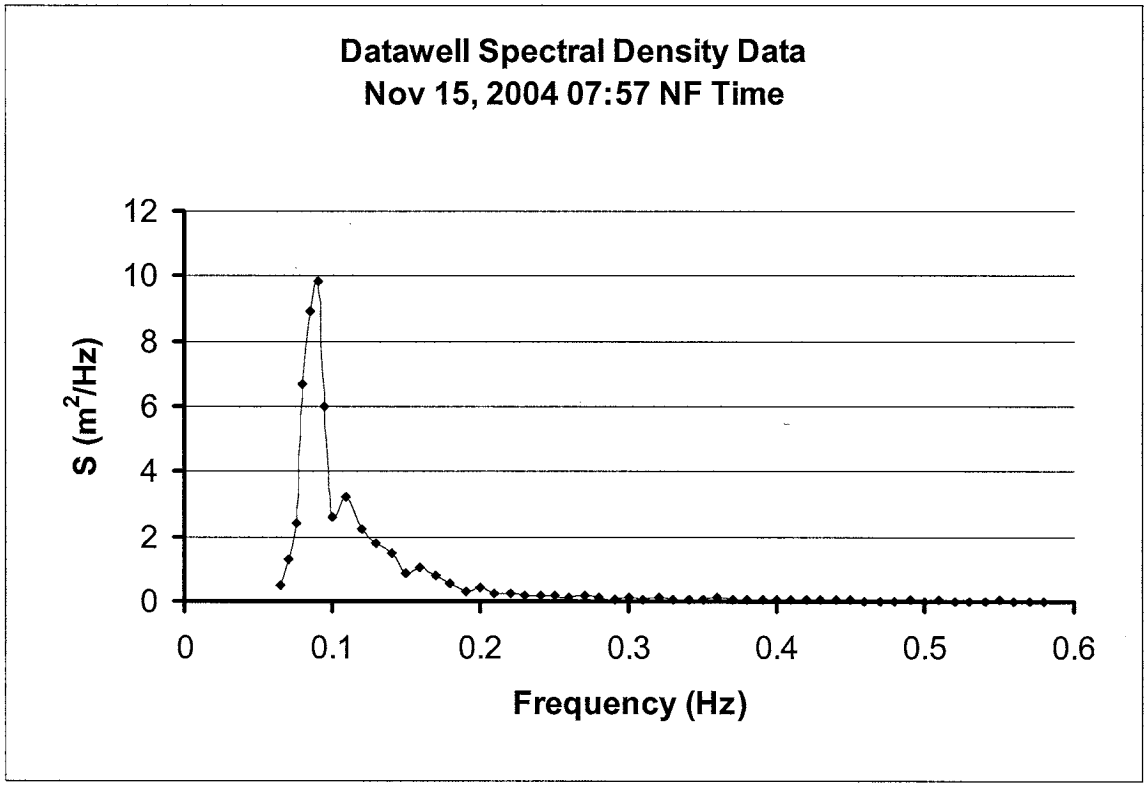

Datawell Wave Direction
Nov. 15, 2004 06:27 NF Time
Wave Direction (deg. TRUE)
140
120
100
80
60
40
20
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

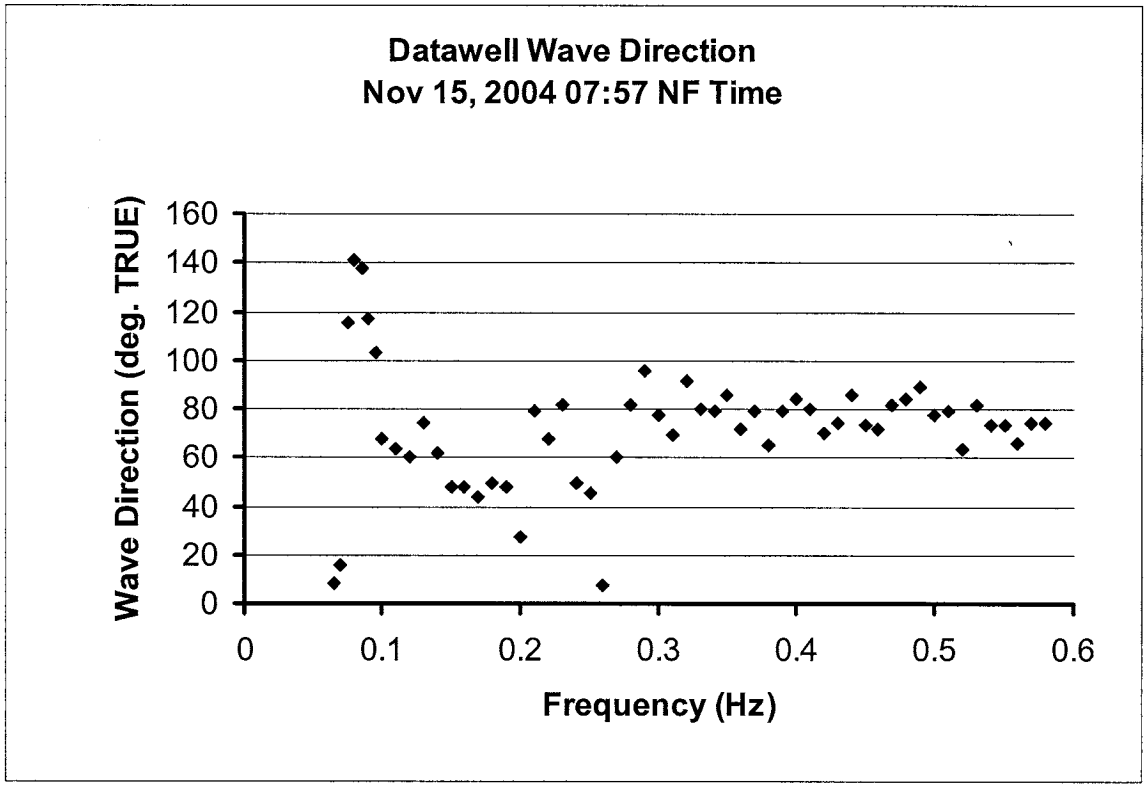

Datawell Spectral Density Data
Nov. 15, 2004 06:57 NF Time
S (m²/Hz)
0
1
2
3
4
5
6
7
8
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

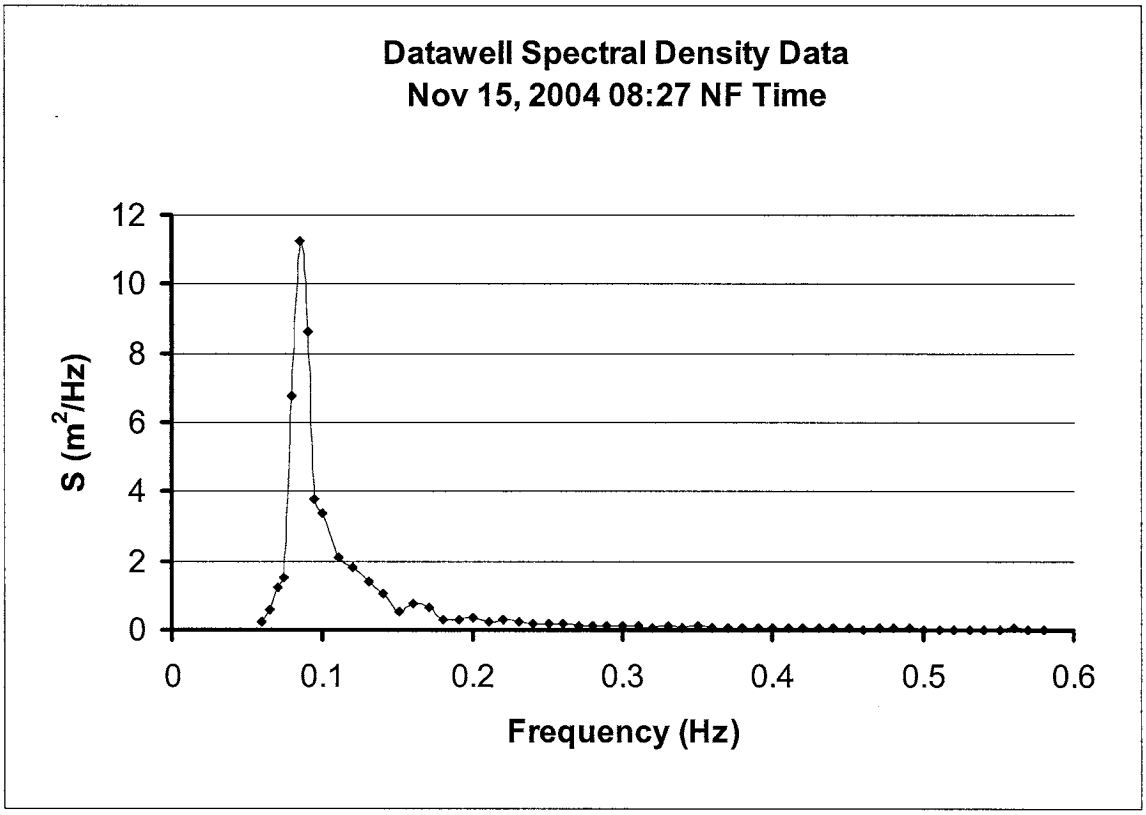

Datawell Wave Direction
Nov. 15, 2004 06:57 NF Time
Wave Direction (deg. TRUE)
0
50
100
150
200
250
300
350
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

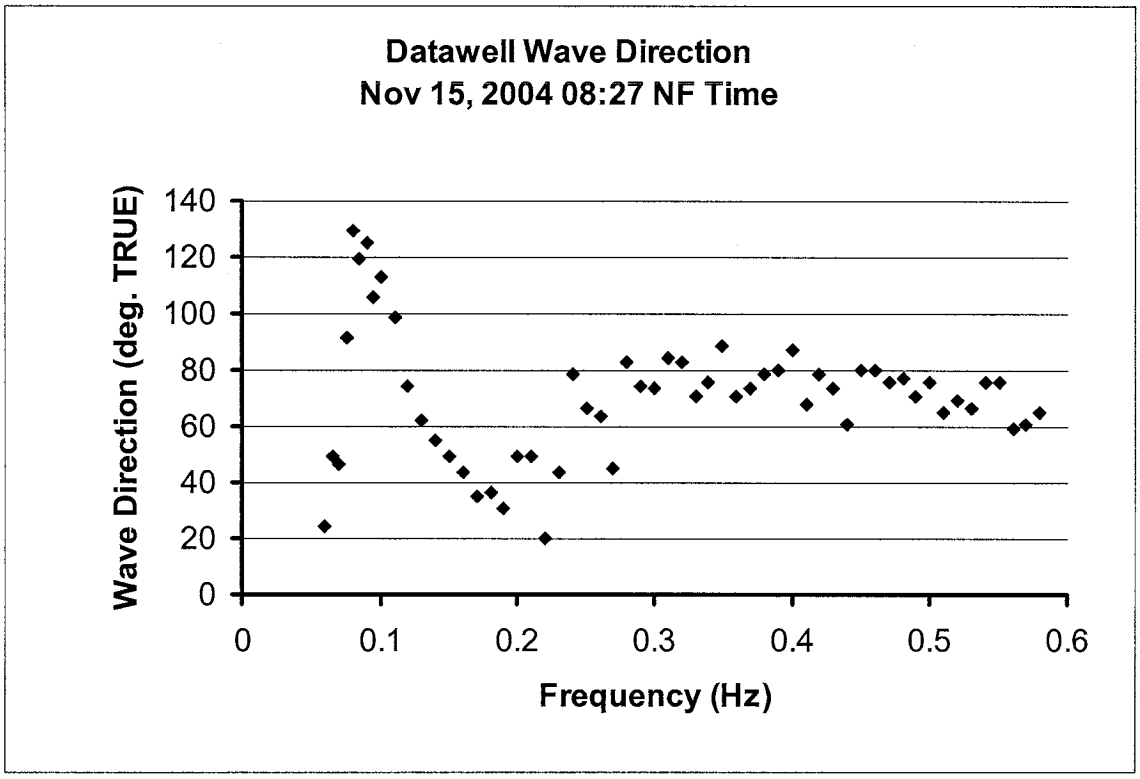

Datawell Spectral Density Data
Nov 15, 2004 07:27 NF Time
S (m²/Hz)
10
8
6
4
2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

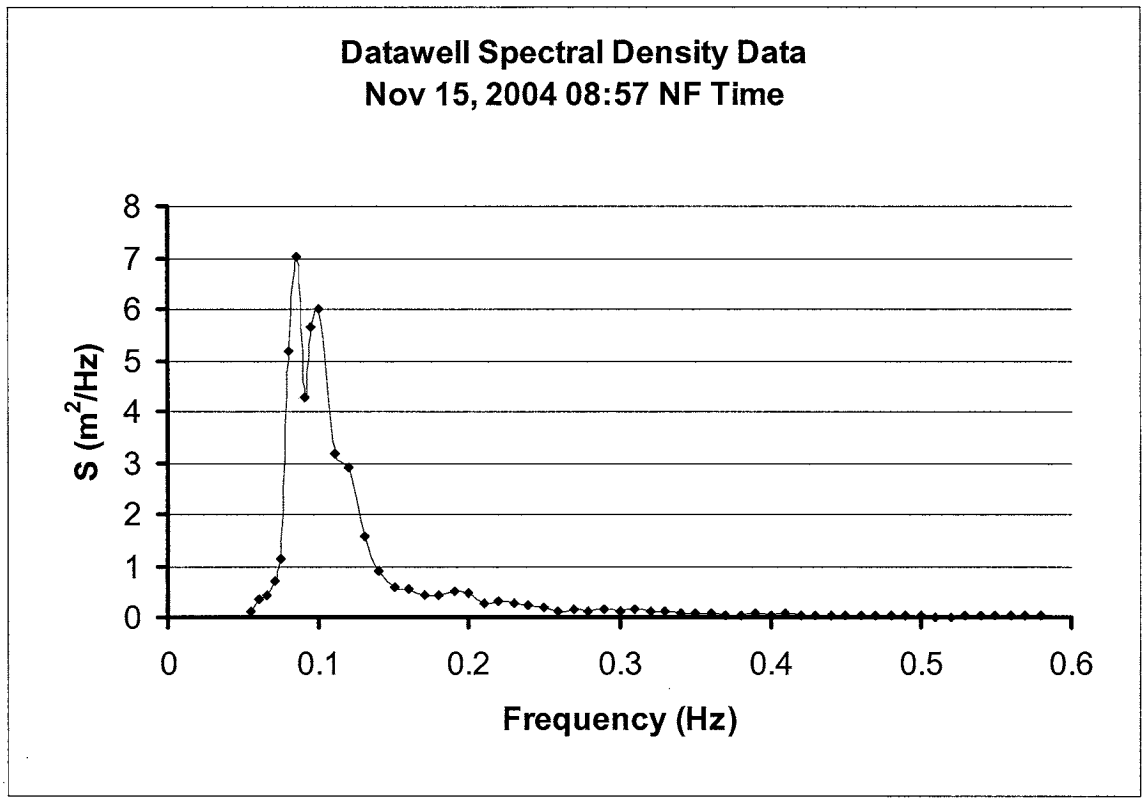

Datawell Wave Direction
Nov 15, 2004 07:27 NF Time
Wave Direction (deg. TRUE)
350
300
250
200
150
100
50
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

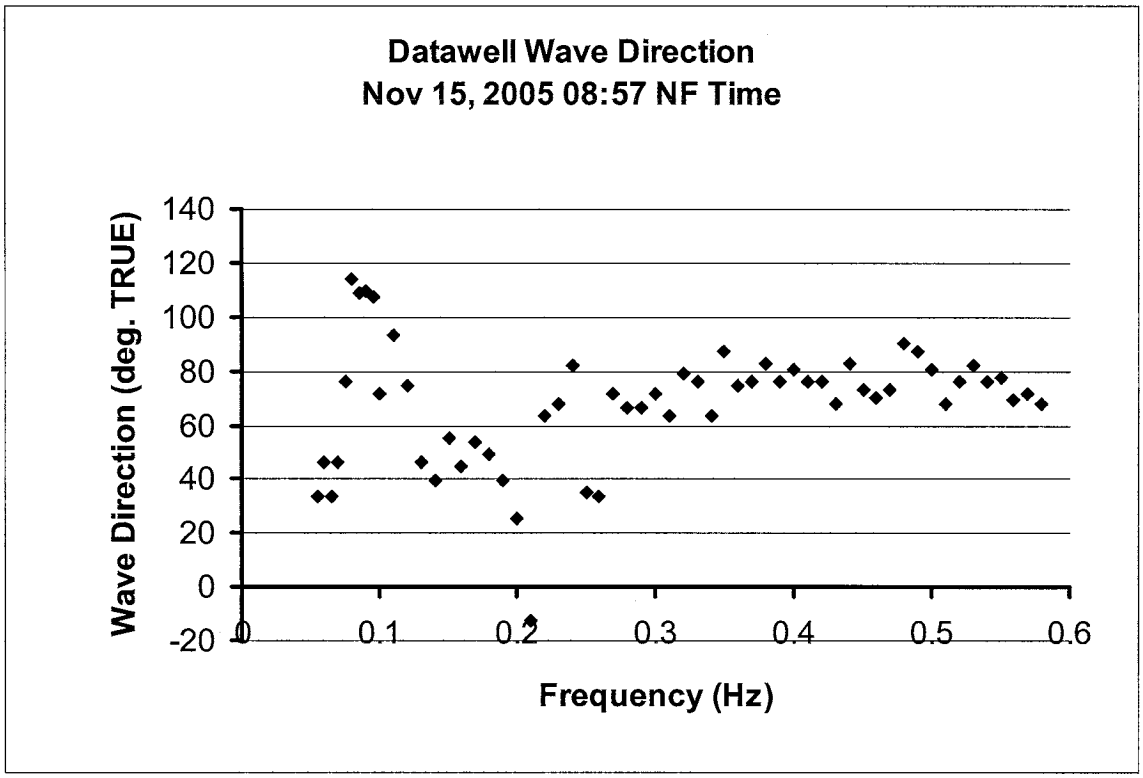

Datawell Spectral Density Data
Nov 15, 2004 07:57 NF Time
S (m²/Hz)
12
10
8
6
4
2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

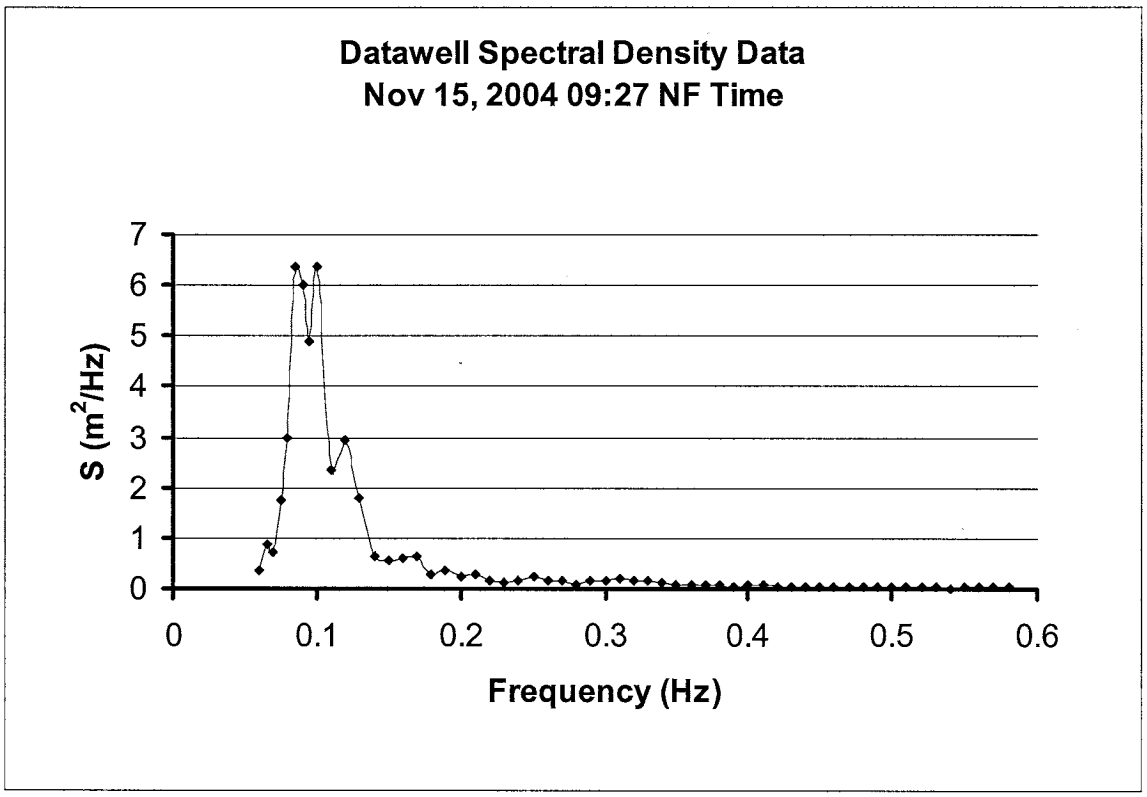

Datawell Wave Direction
Nov 15, 2004 07:57 NF Time
Wave Direction (deg. TRUE)
160
140
120
100
80
60
40
20
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

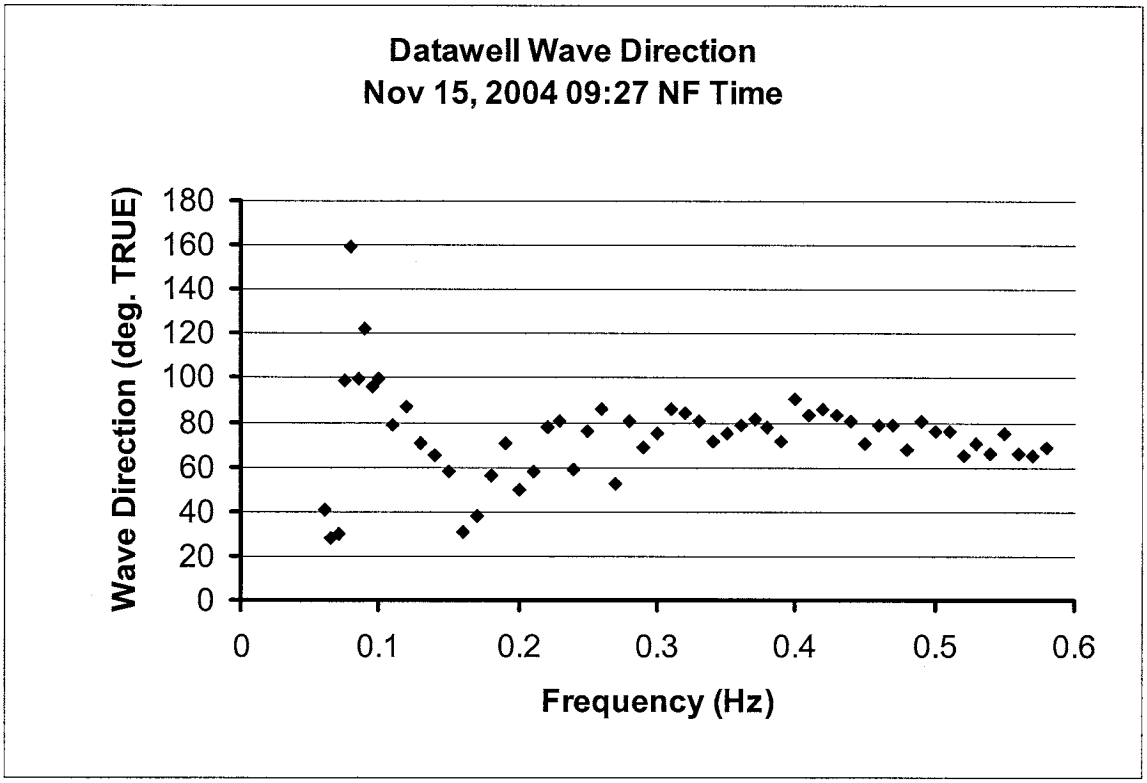

Datawell Spectral Density Data
Nov 15, 2004 08:27 NF Time
S (m²/Hz)
12
10
8
6
4
2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

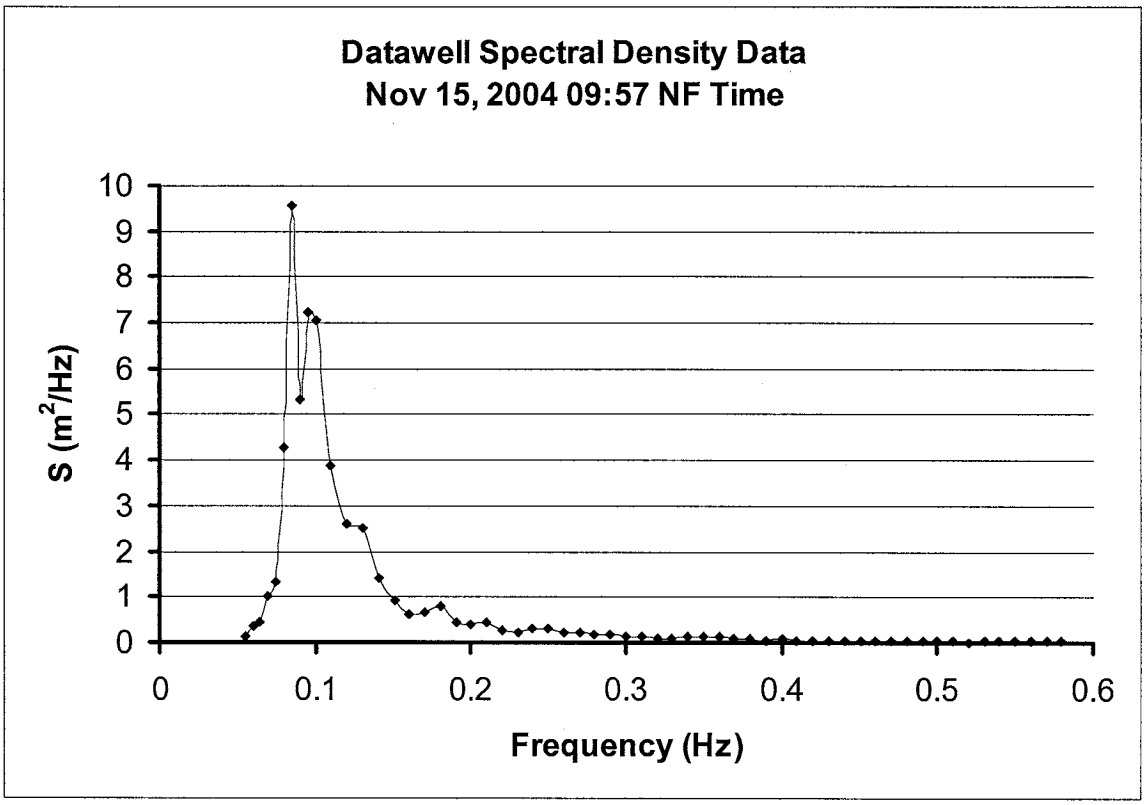

Datawell Wave Direction
Nov 15, 2004 08:27 NF Time
Wave Direction (deg. TRUE)
140
120
100
80
60
40
20
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

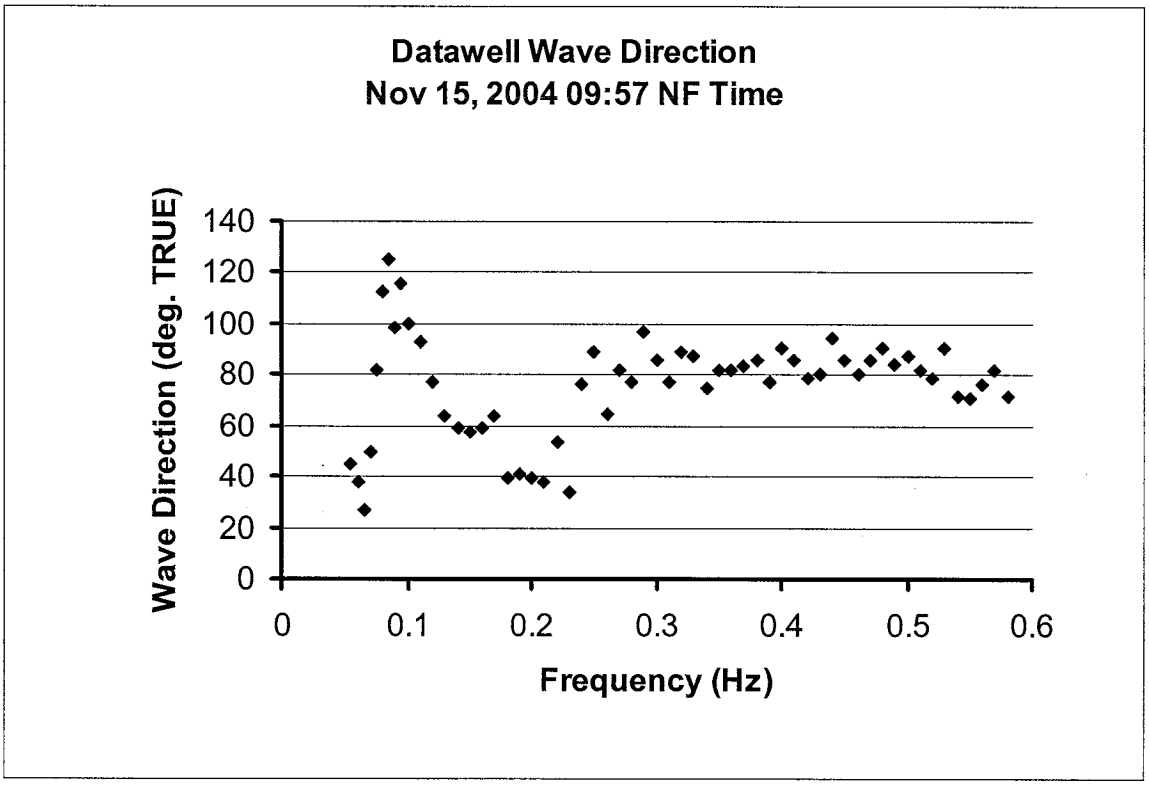

Datawell Spectral Density Data
Nov 15, 2004 08:57 NF Time
S (m²/Hz)
0
1
2
3
4
5
6
7
8
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

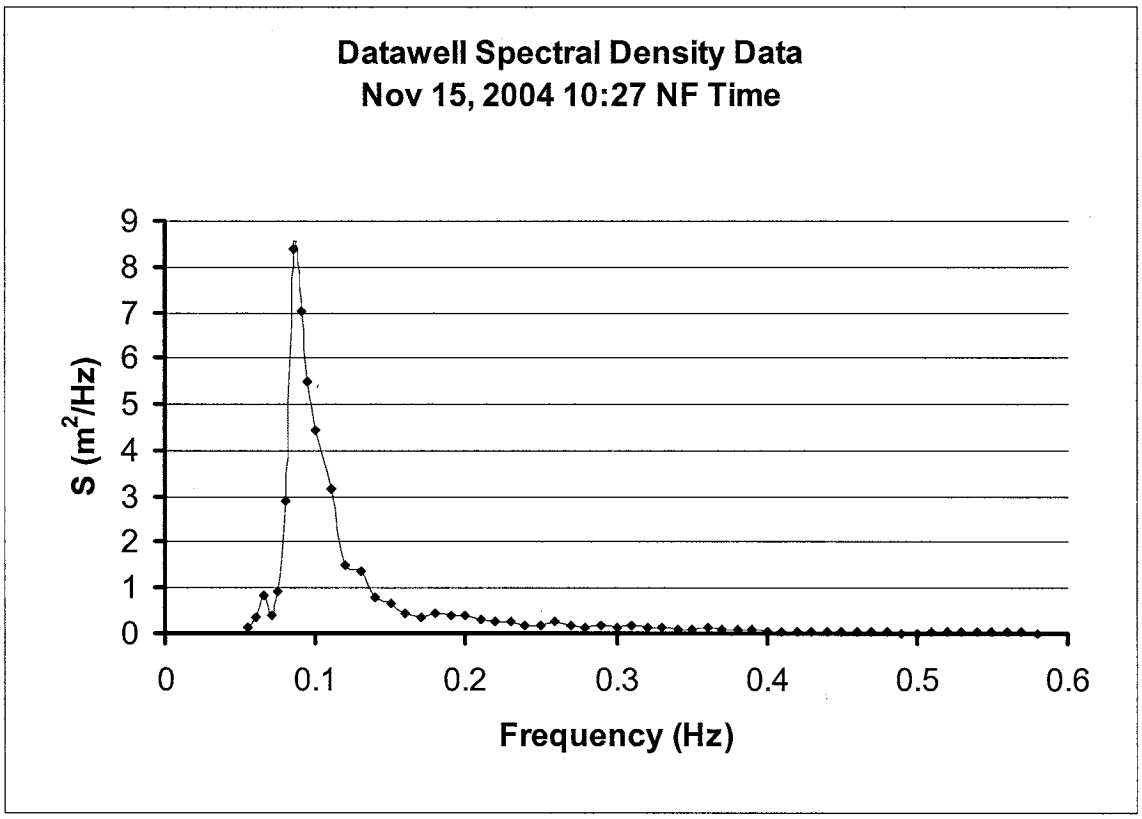

Datawell Wave Direction
Nov 15, 2005 08:57 NF Time
Wave Direction (deg. TRUE)
140
120
100
80
60
40
20
0
-20
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

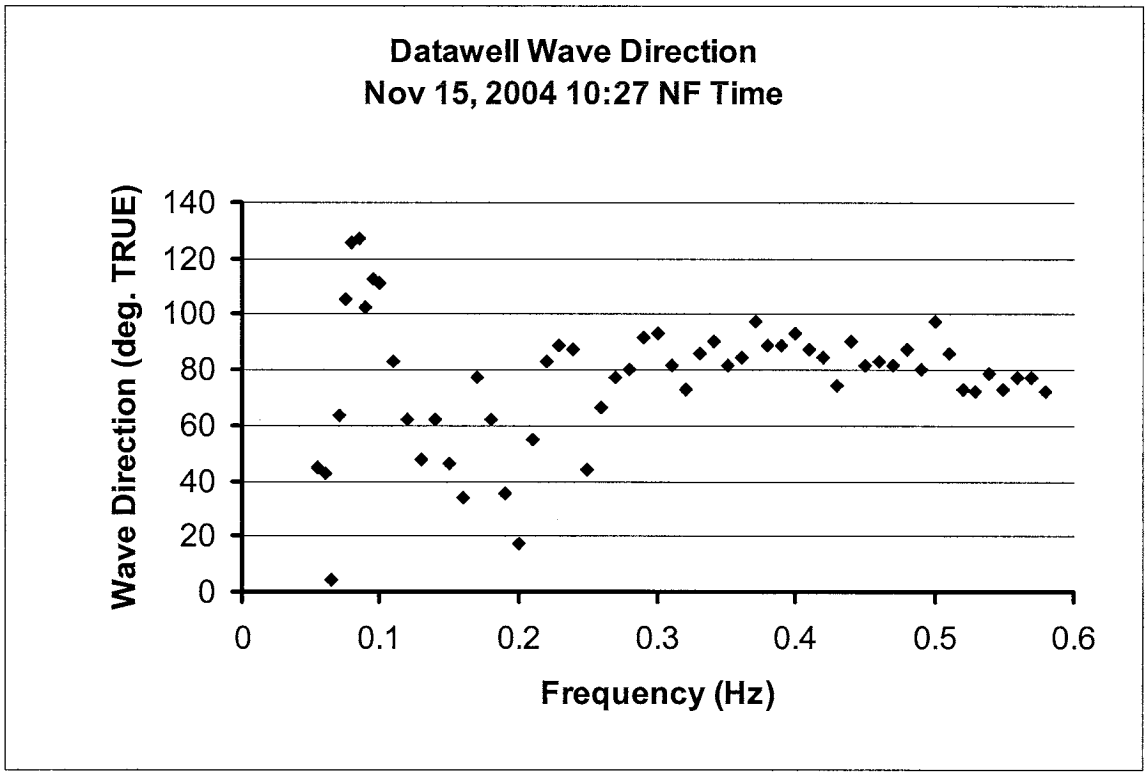

Datawell Spectral Density Data
Nov 15, 2004 09:27 NF Time
S (m²/Hz)
0
1
2
3
4
5
6
7
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

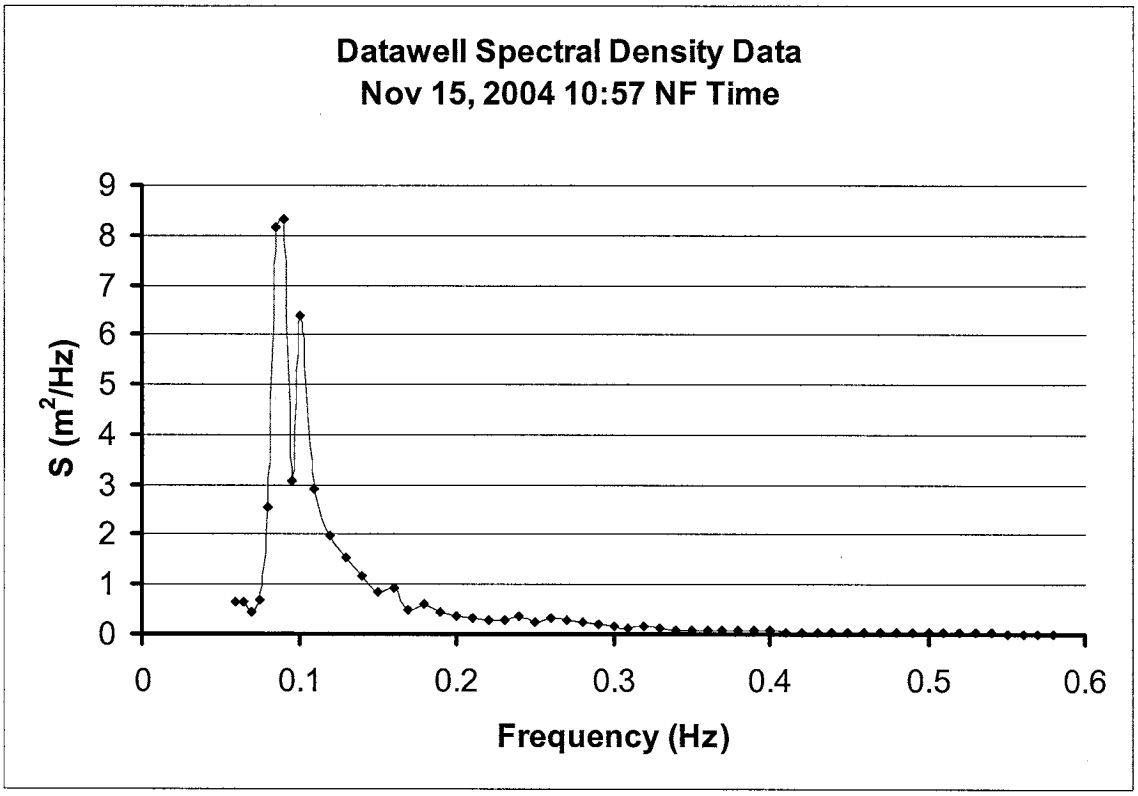

Datawell Wave Direction
Nov 15, 2004 09:27 NF Time
Wave Direction (deg. TRUE)
0
20
40
60
80
100
120
140
160
180
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

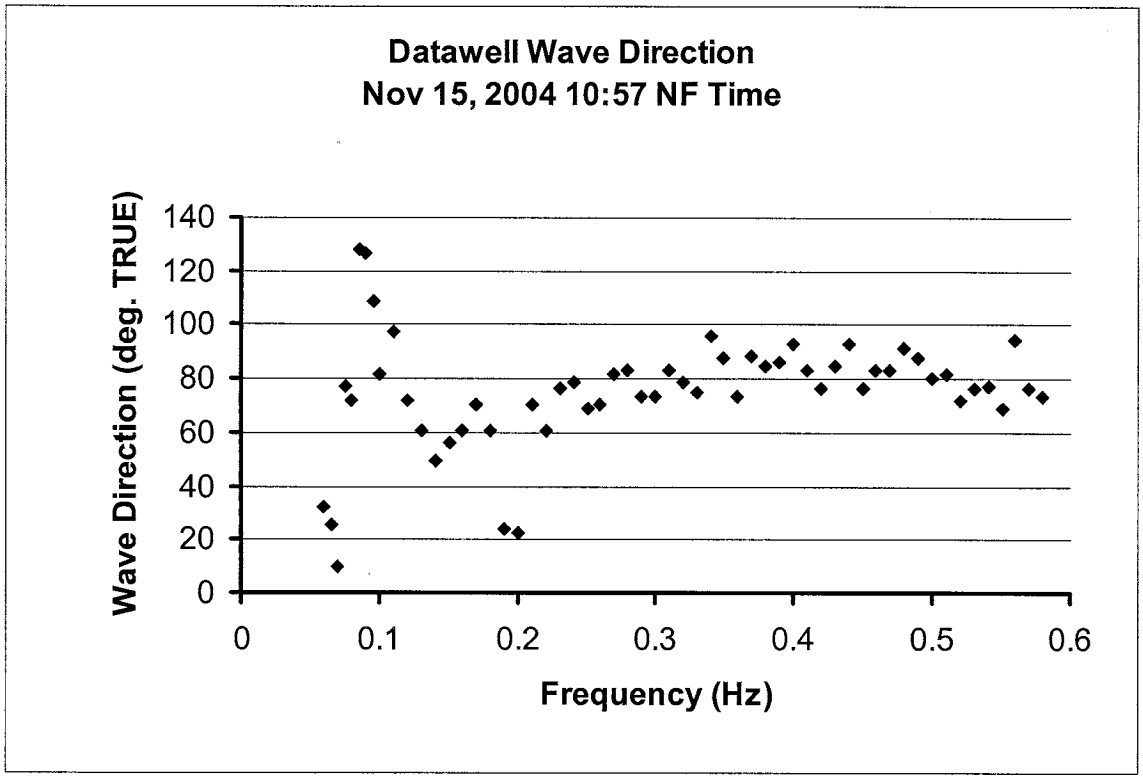

Datawell Spectral Density Data
Nov 15, 2004 09:57 NF Time
S (m²/Hz)
10
9
8
7
6
5
4
3
2
1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

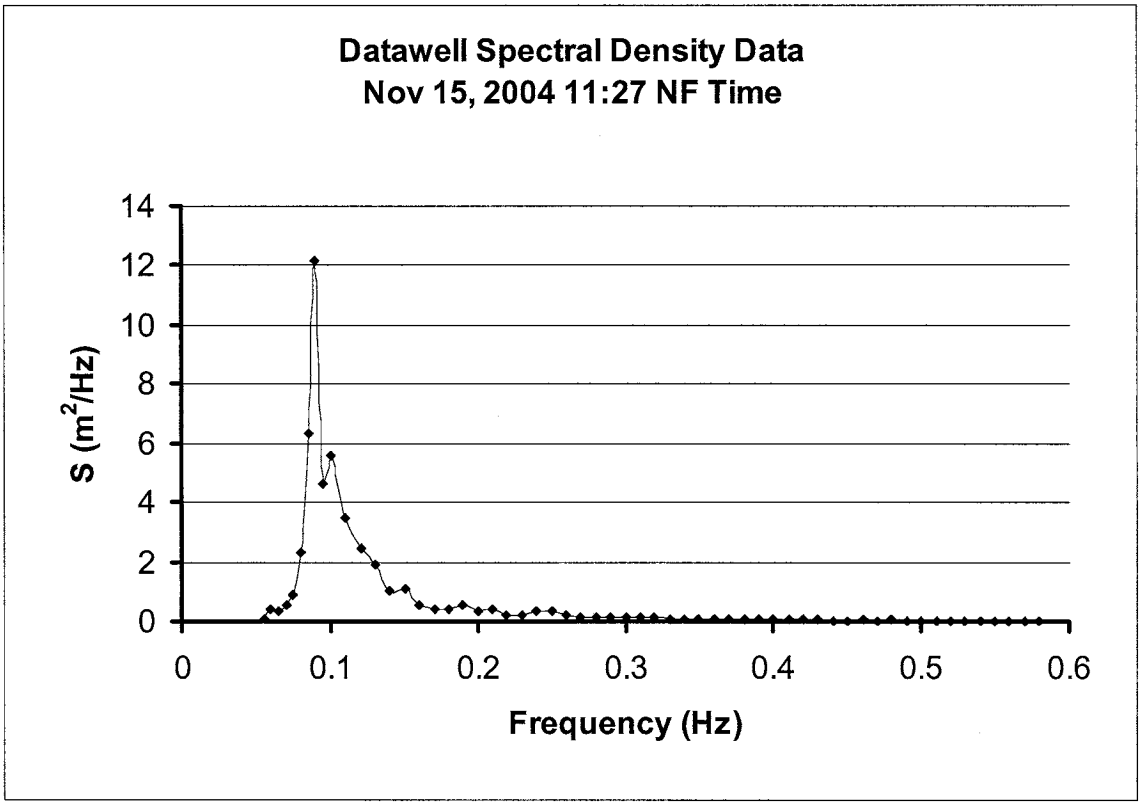

Datawell Wave Direction
Nov 15, 2004 09:57 NF Time
Wave Direction (deg. TRUE)
140
120
100
80
60
40
20
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

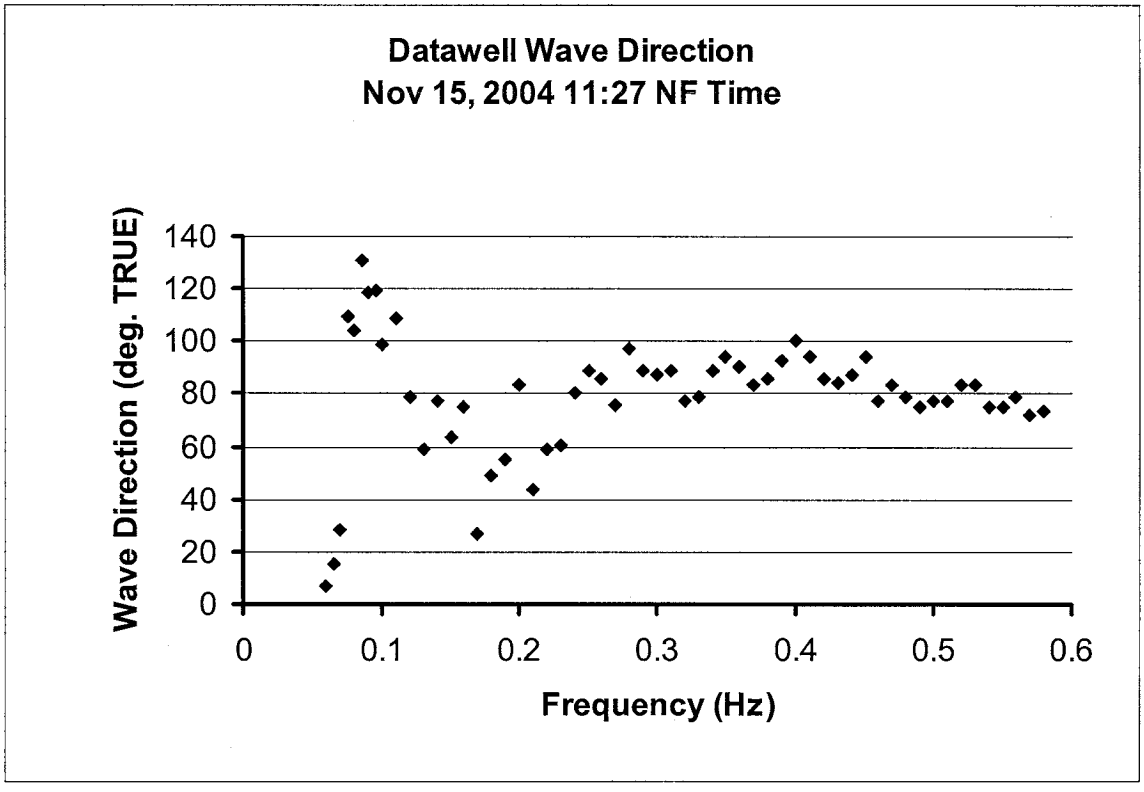

Datawell Spectral Density Data
Nov 15, 2004 10:27 NF Time
S (m²/Hz)
0
1
2
3
4
5
6
7
8
9
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

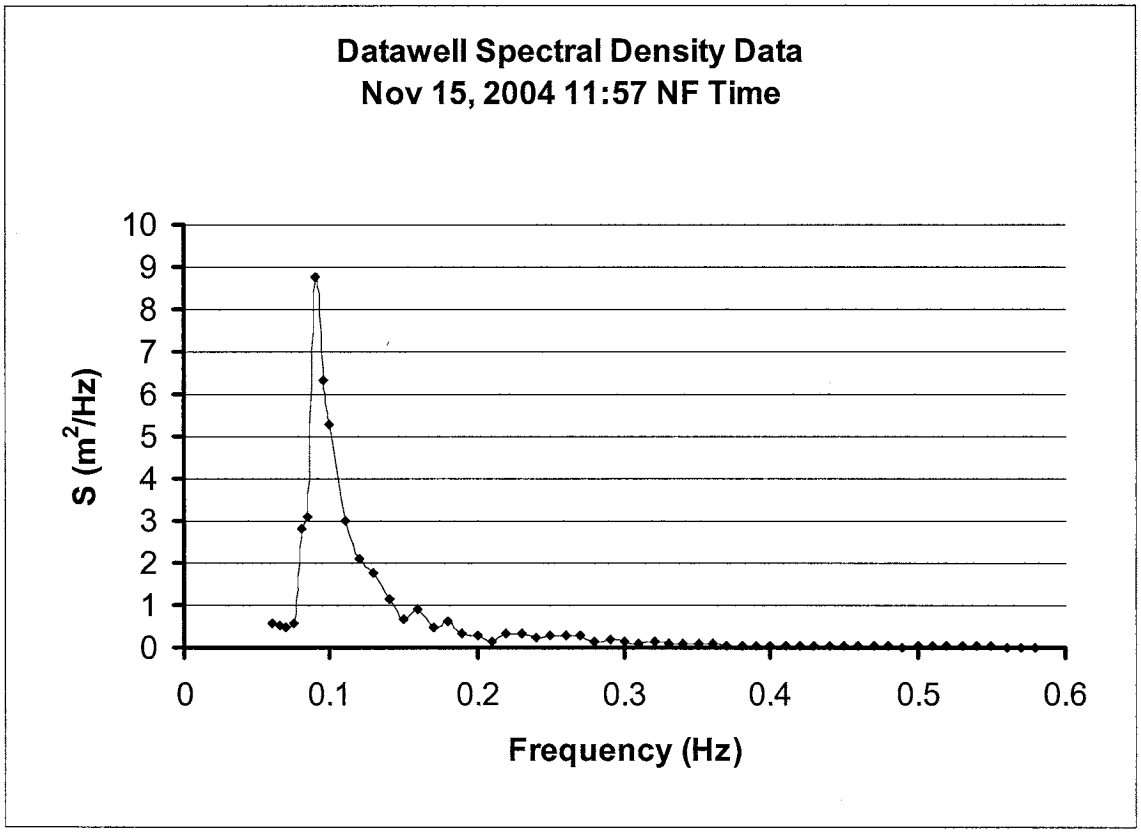

Datawell Wave Direction
Nov 15, 2004 10:27 NF Time
Wave Direction (deg. TRUE)
0
20
40
60
80
100
120
140
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

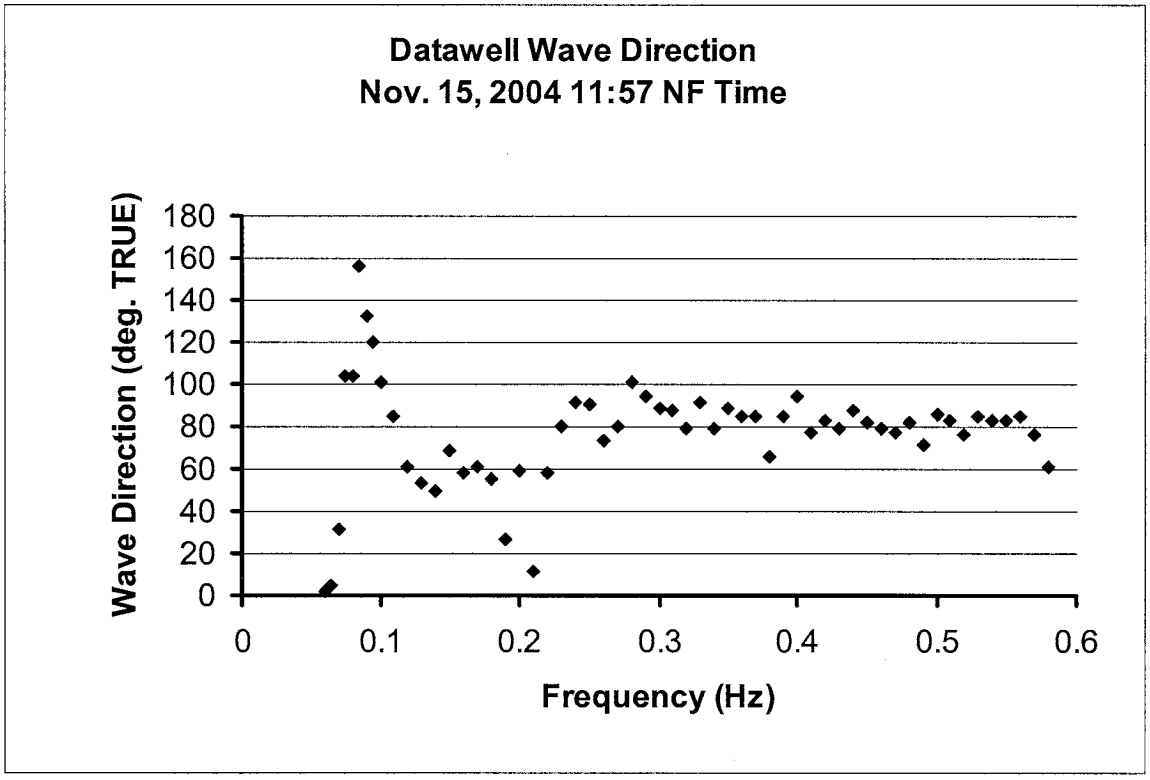

Datawell Spectral Density Data
Nov 15, 2004 10:57 NF Time
S (m²/Hz)
0
1
2
3
4
5
6
7
8
9
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

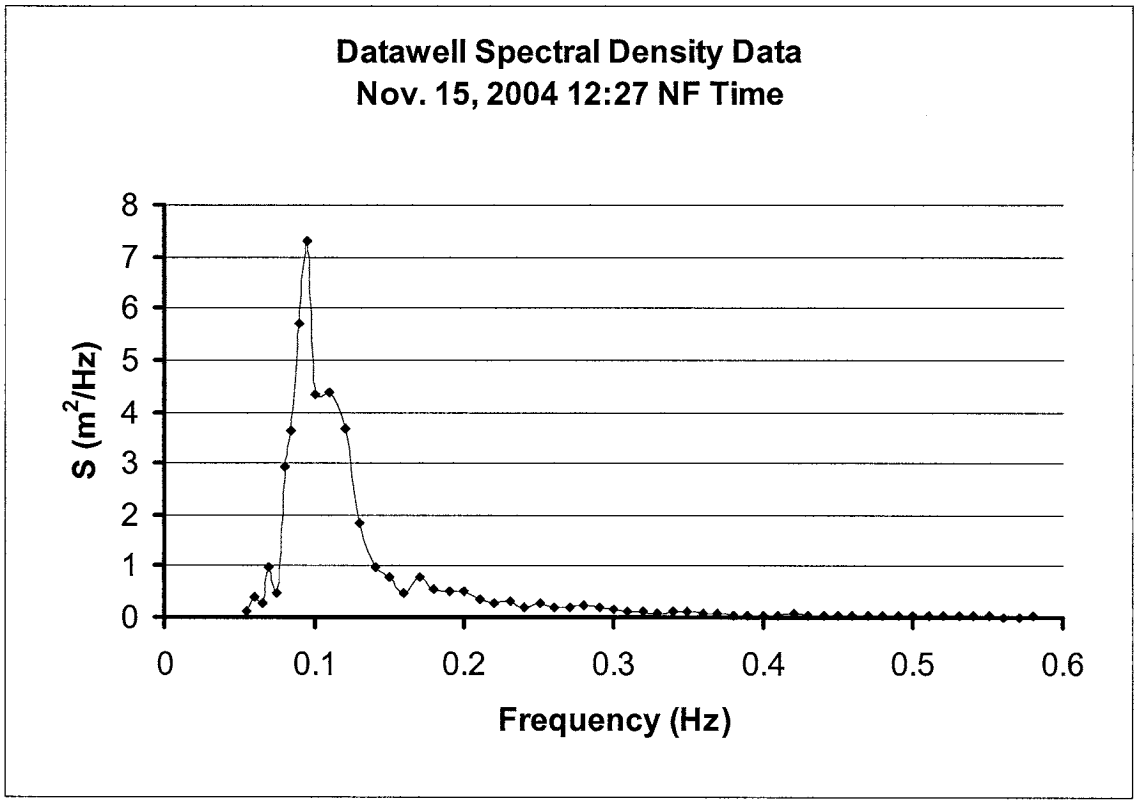

Datawell Wave Direction
Nov 15, 2004 10:57 NF Time
Wave Direction (deg. TRUE)
0
20
40
60
80
100
120
140
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

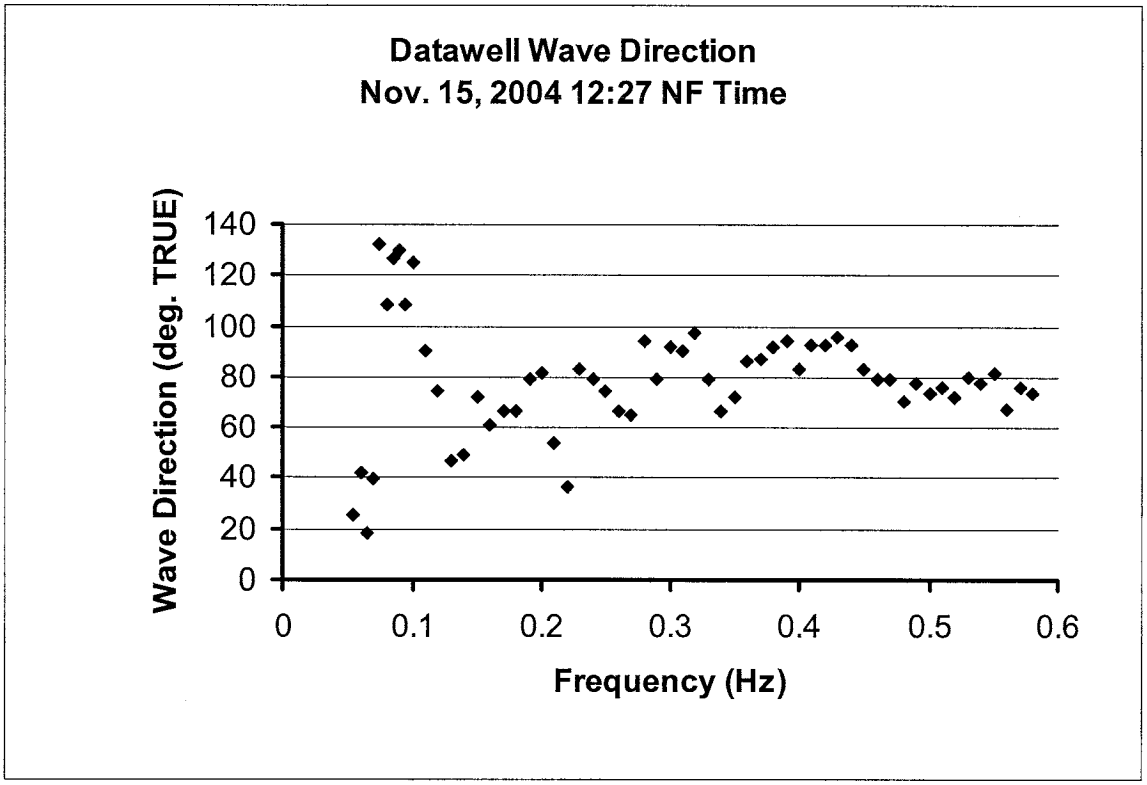

Datawell Spectral Density Data
Nov 15, 2004 11:27 NF Time
S (m²/Hz)
14
12
10
8
6
4
2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

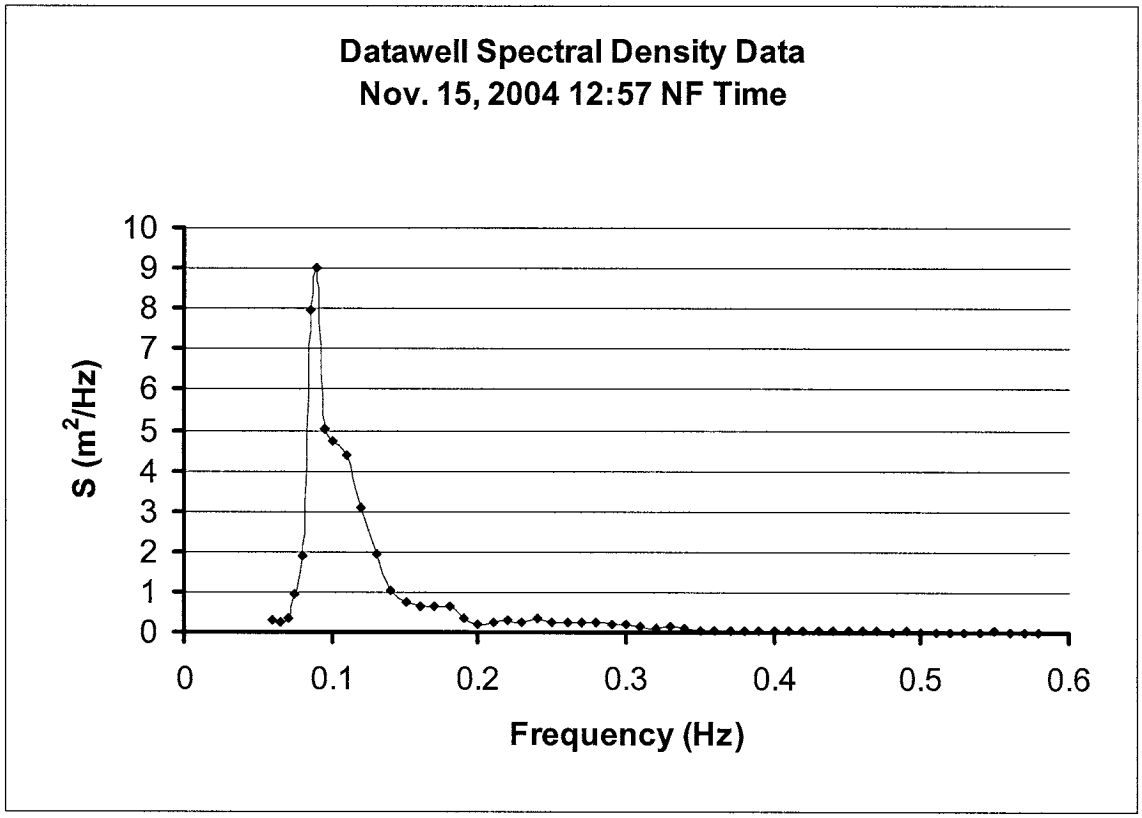

Datawell Wave Direction
Nov 15, 2004 11:27 NF Time
Wave Direction (deg. TRUE)
140
120
100
80
60
40
20
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

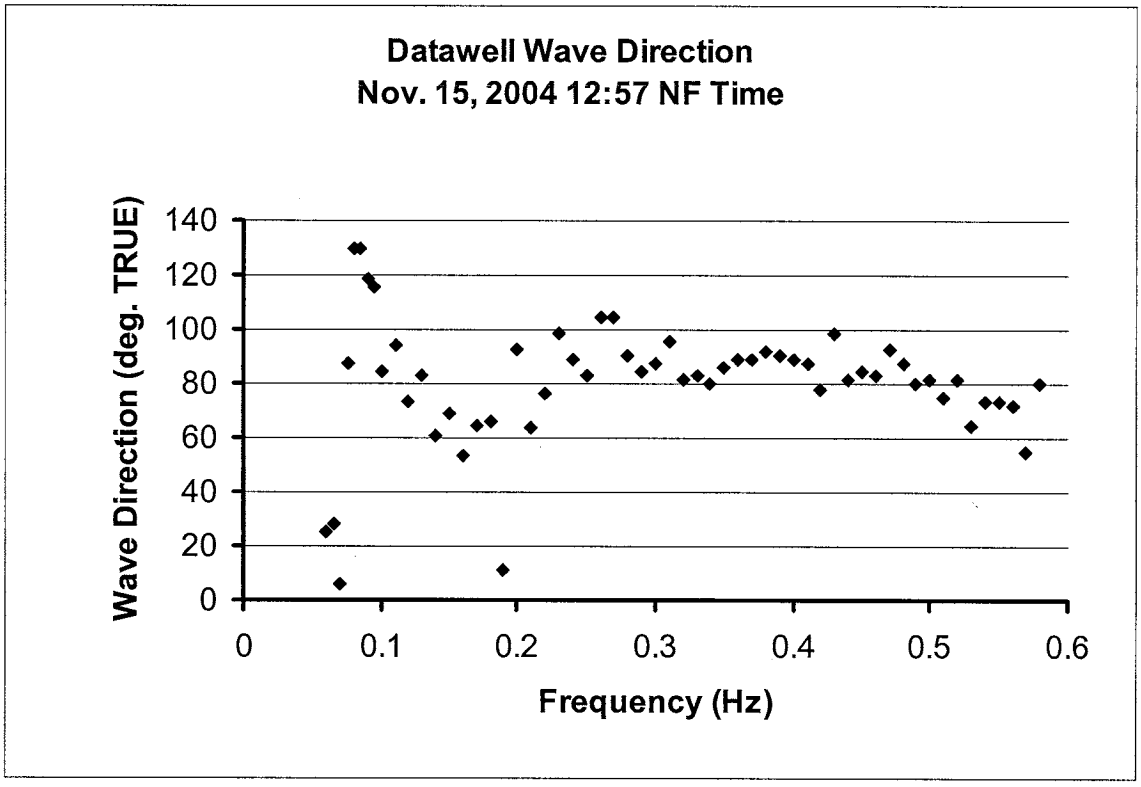

Datawell Spectral Density Data
Nov 15, 2004 11:57 NF Time
S (m²/Hz)
10
9
8
7
6
5
4
3
2
1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

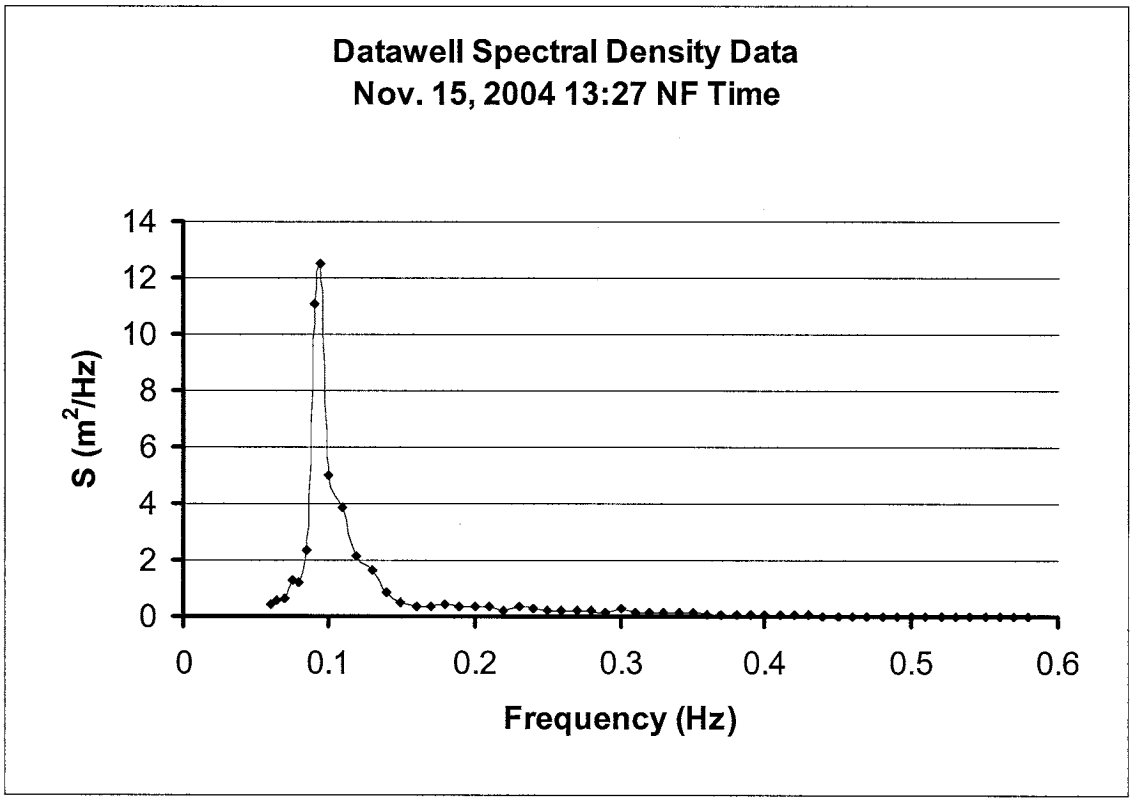

Datawell Wave Direction
Nov. 15, 2004 11:57 NF Time
Wave Direction (deg. TRUE)
180
160
140
120
100
80
60
40
20
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

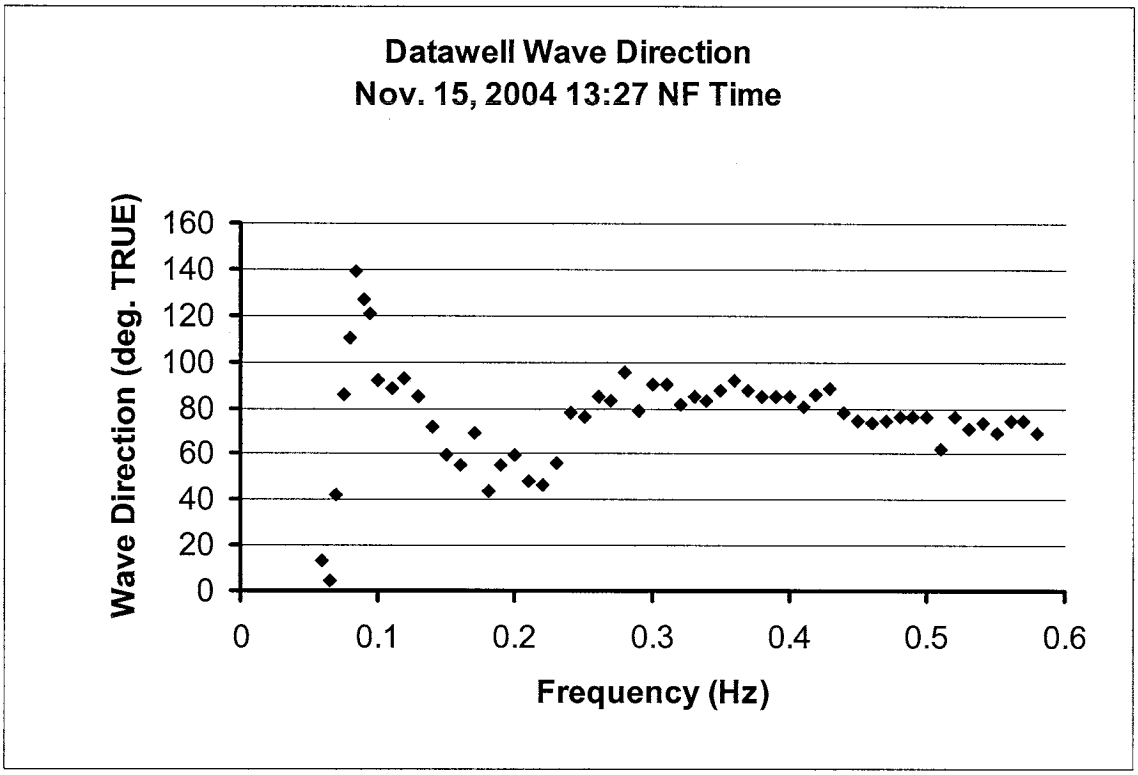

Datawell Spectral Density Data
Nov. 15, 2004 12:27 NF Time
S (m²/Hz)
0
1
2
3
4
5
6
7
8
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

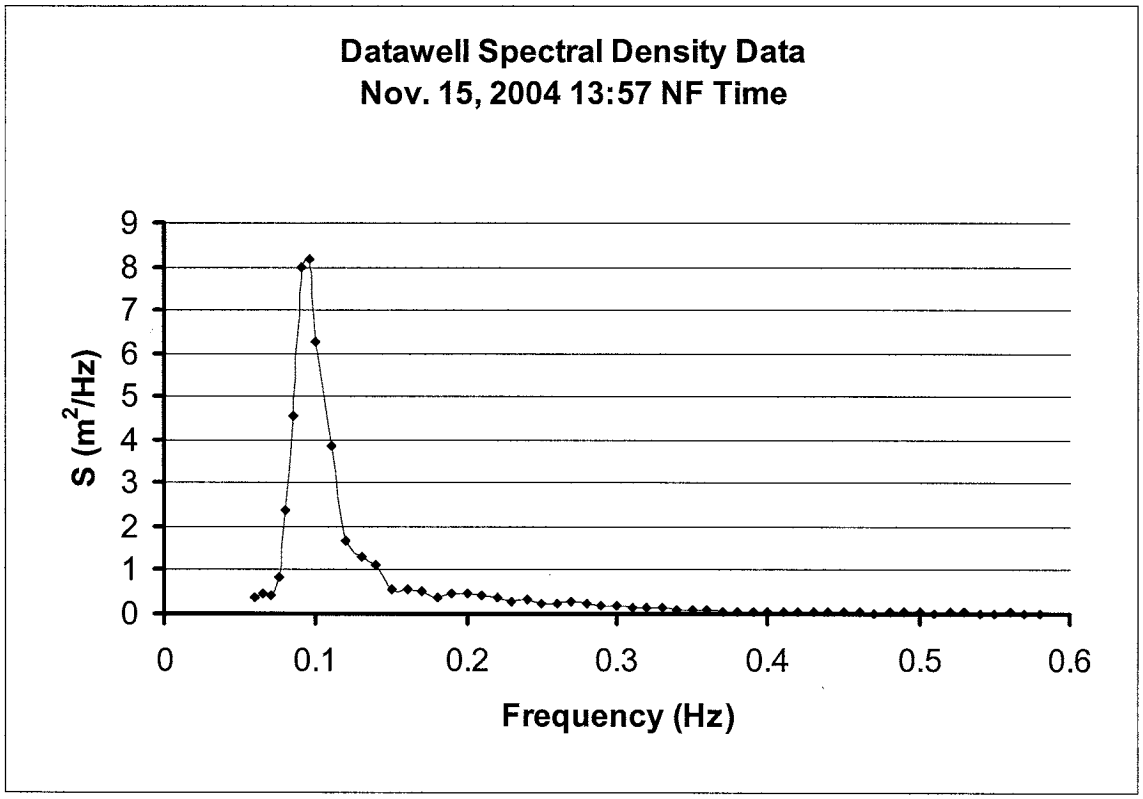

Datawell Wave Direction
Nov. 15, 2004 12:27 NF Time
Wave Direction (deg. TRUE)
0
20
40
60
80
100
120
140
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

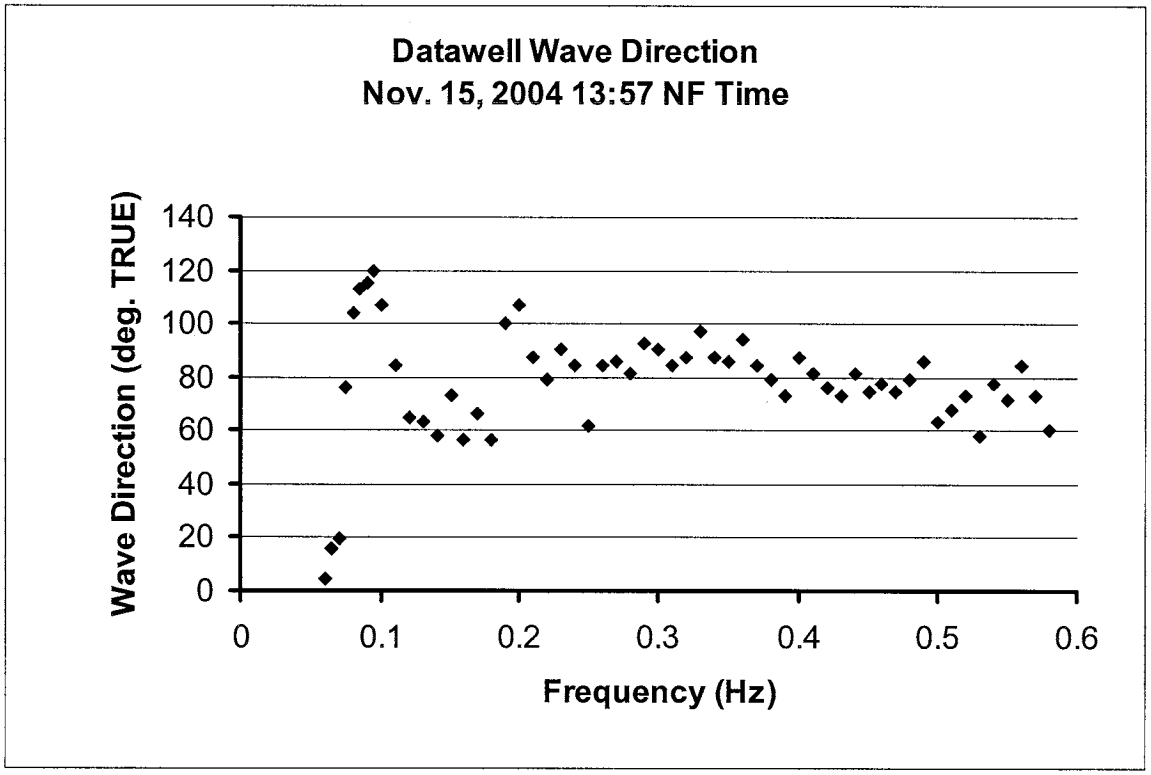

Datawell Spectral Density Data
Nov. 15, 2004 12:57 NF Time
S (m²/Hz)
10
9
8
7
6
5
4
3
2
1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

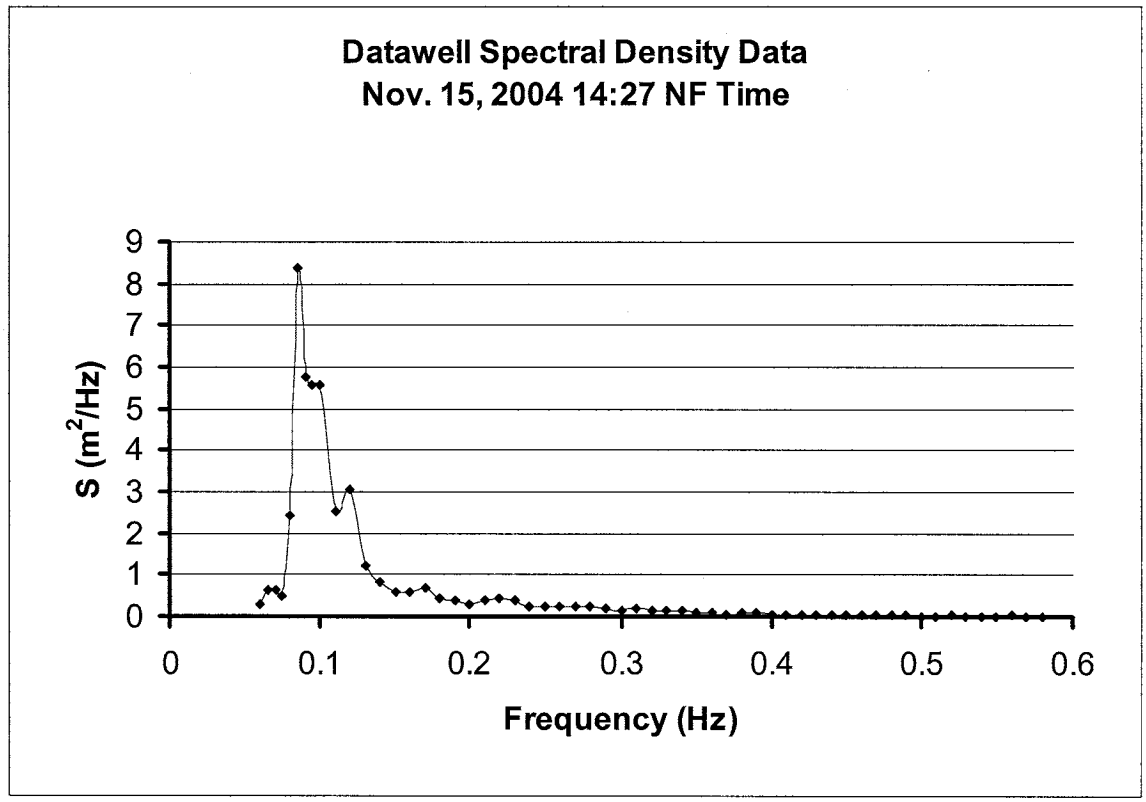

Datawell Wave Direction
Nov. 15, 2004 12:57 NF Time
Wave Direction (deg. TRUE)
140
120
100
80
60
40
20
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

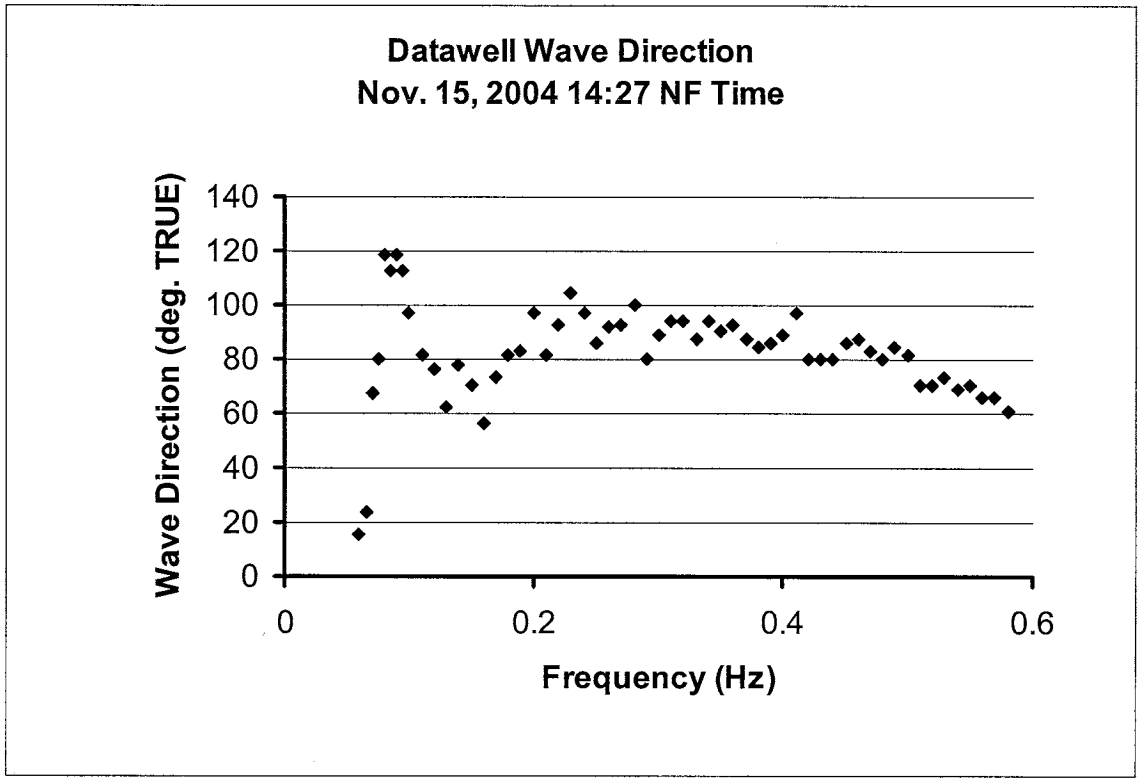

Datawell Spectral Density Data
Nov. 15, 2004 13:27 NF Time
S (m²/Hz)
14
12
10
8
6
4
2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

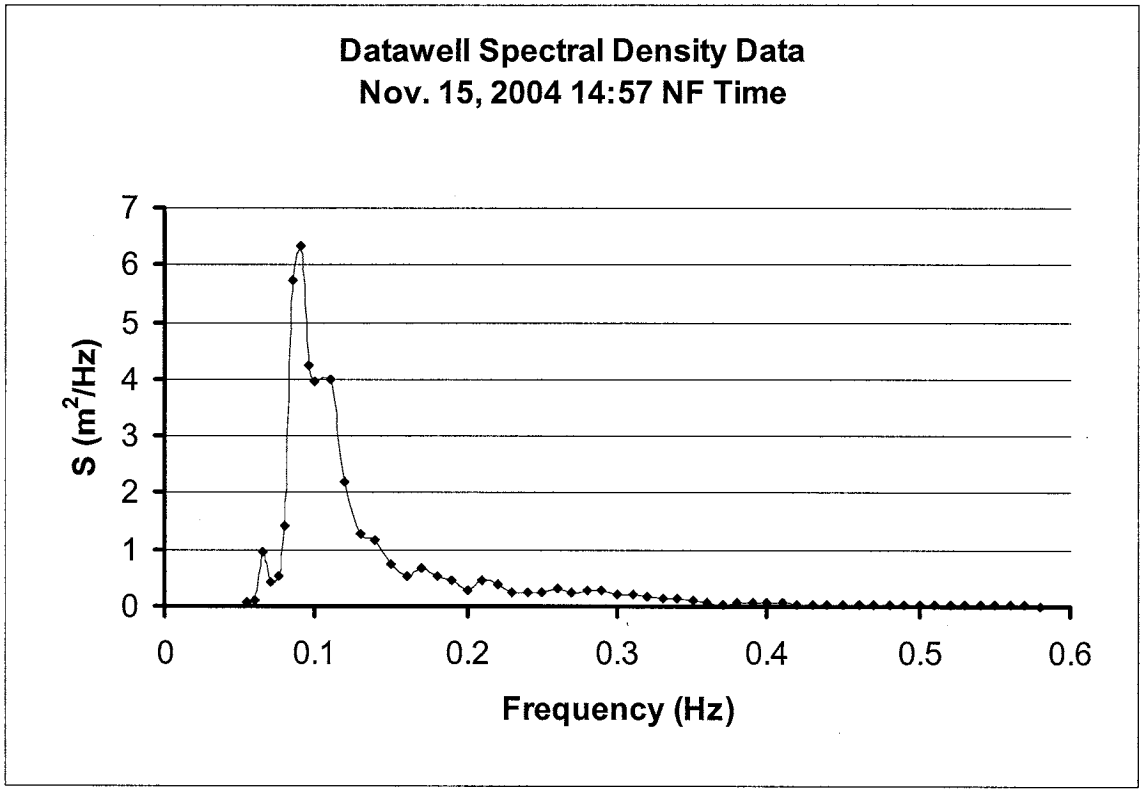

Datawell Wave Direction
Nov. 15, 2004 13:27 NF Time
Wave Direction (deg. TRUE)
160
140
120
100
80
60
40
20
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

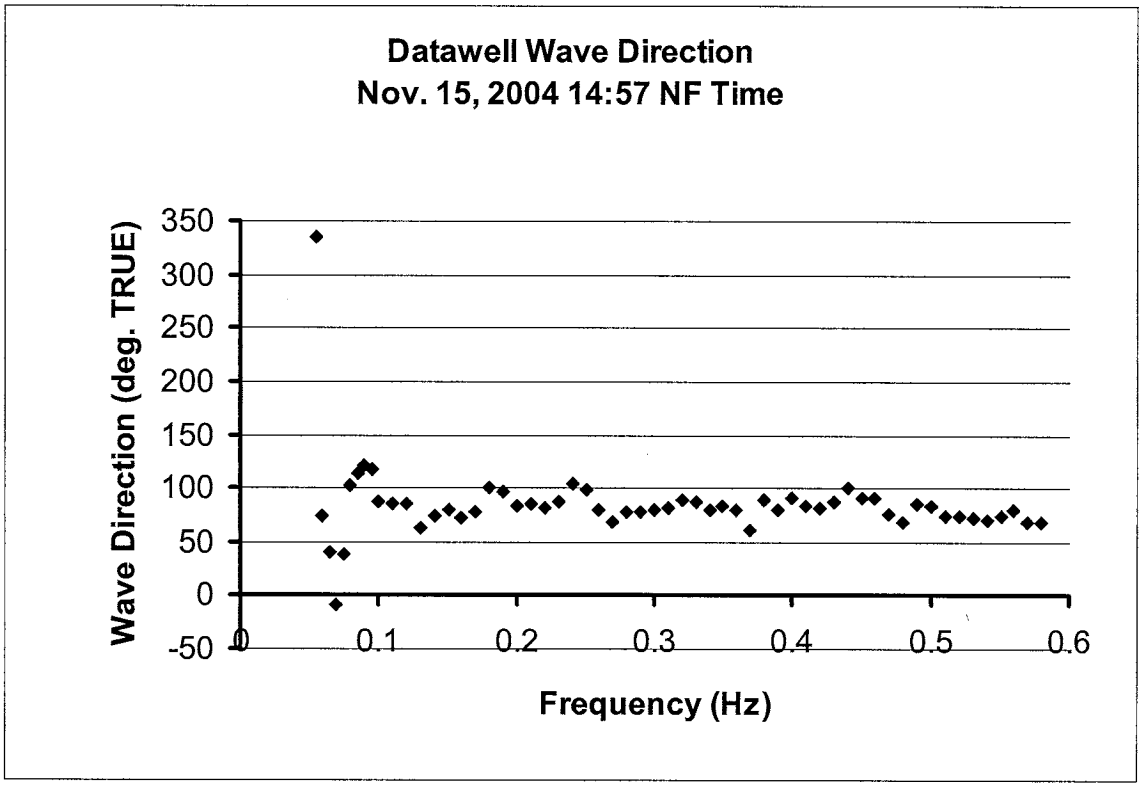

Datawell Spectral Density Data
Nov. 15, 2004 13:57 NF Time
S (m²/Hz)
0
1
2
3
4
5
6
7
8
9
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

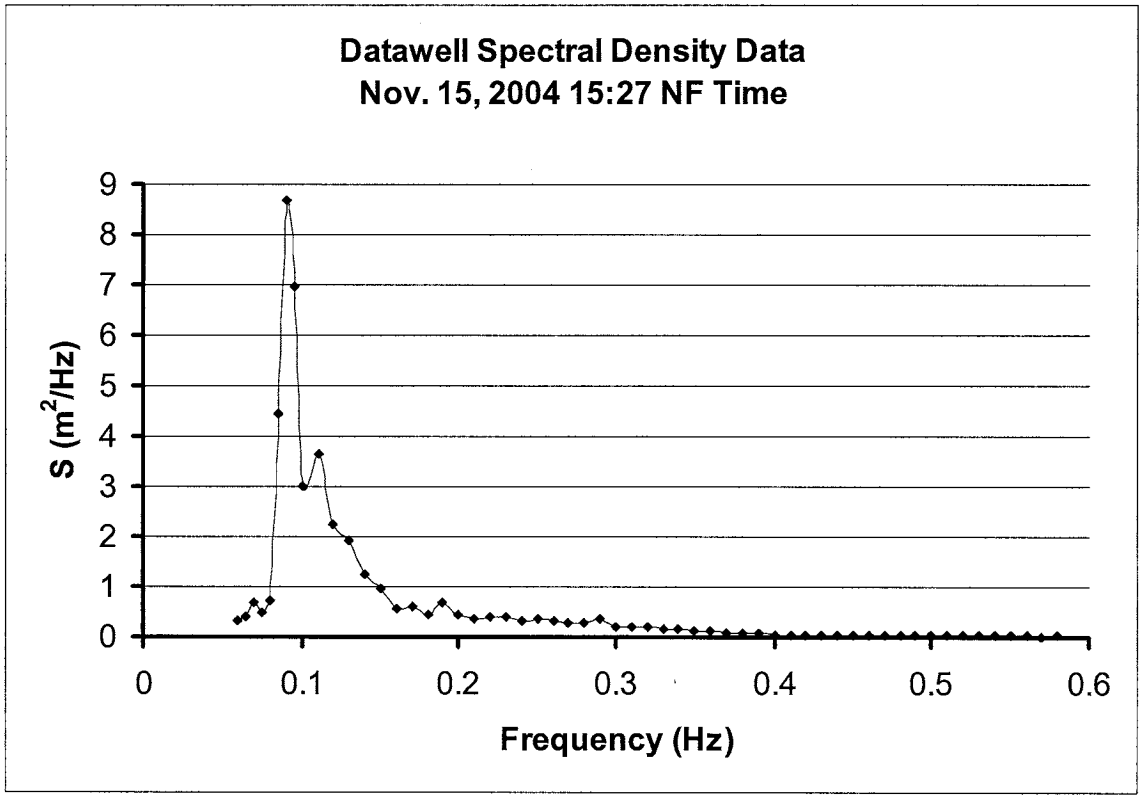

Datawell Wave Direction
Nov. 15, 2004 13:57 NF Time
Wave Direction (deg. TRUE)
0
20
40
60
80
100
120
140
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

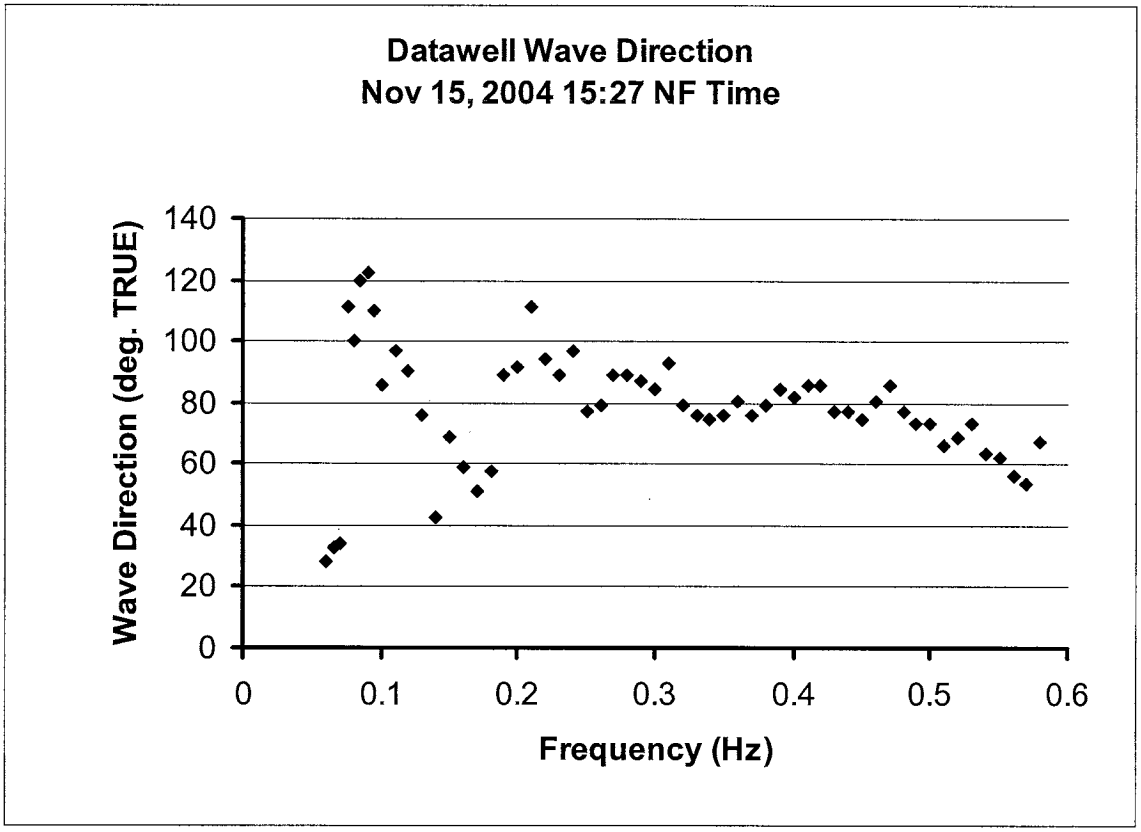

Datawell Spectral Density Data
Nov. 15, 2004 14:27 NF Time
S (m²/Hz)
0
1
2
3
4
5
6
7
8
9
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

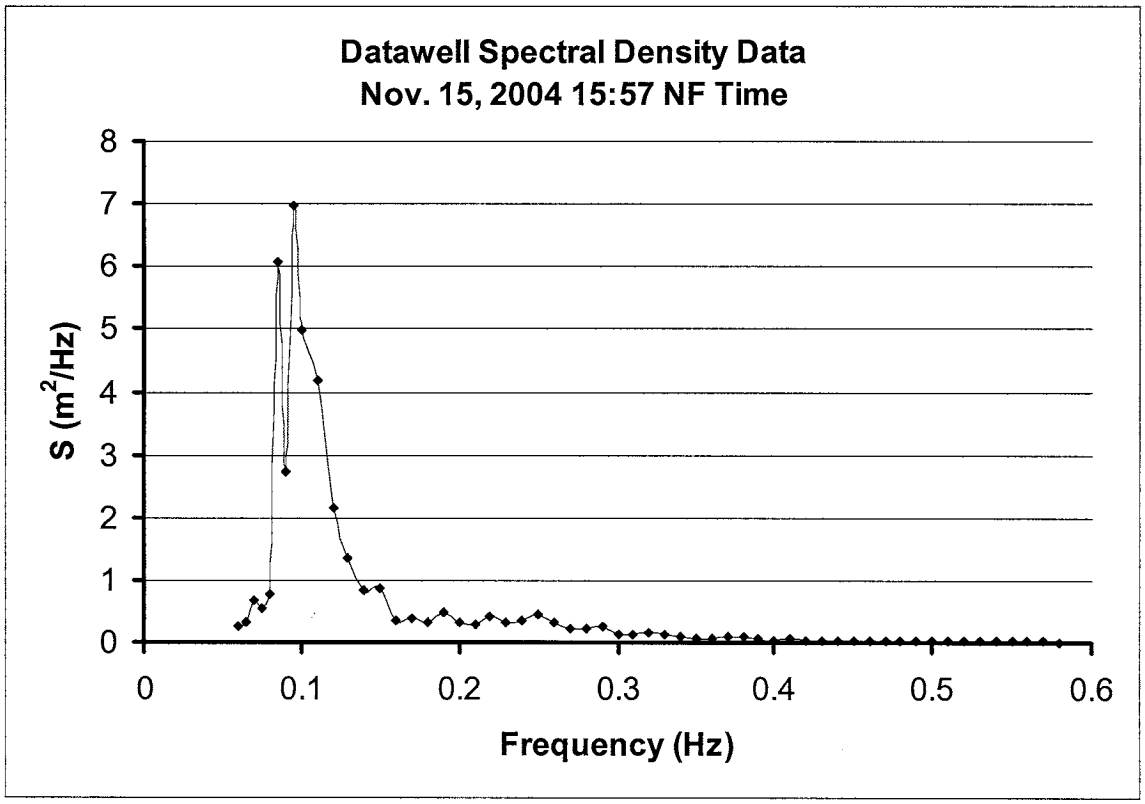

Datawell Wave Direction
Nov. 15, 2004 14:27 NF Time
Wave Direction (deg. TRUE)
0
20
40
60
80
100
120
140
0
0.2
0.4
0.6
Frequency (Hz)

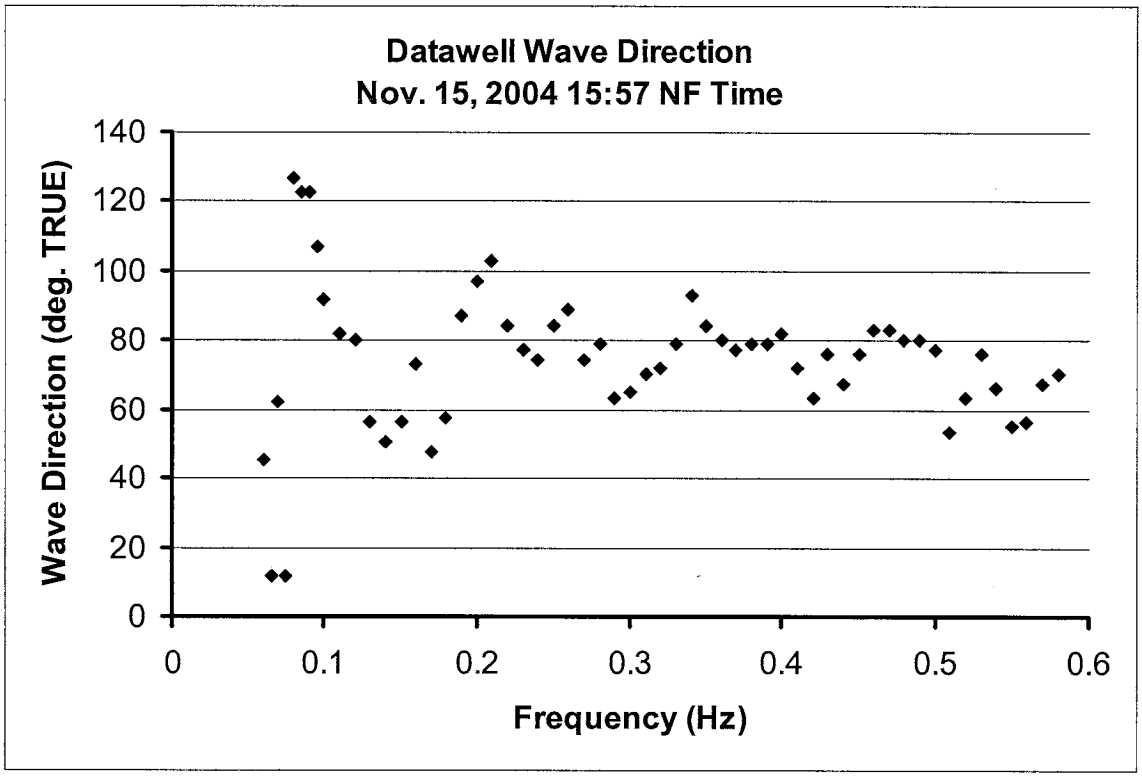

Datawell Spectral Density Data
Nov. 15, 2004 14:57 NF Time
S (m²/Hz)
0
1
2
3
4
5
6
7
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)


Datawell Wave Direction
Nov. 15, 2004 14:57 NF Time
Wave Direction (deg. TRUE)
350
300
250
200
150
100
50
0
-50
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)


Datawell Spectral Density Data
Nov. 15, 2004 15:27 NF Time
S (m²/Hz)
0
1
2
3
4
5
6
7
8
9
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)


Datawell Wave Direction
Nov 15, 2004 15:27 NF Time
Wave Direction (deg. TRUE)
0
20
40
60
80
100
120
140
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)


Datawell Spectral Density Data
Nov. 15, 2004 15:57 NF Time
S (m²/Hz)
0
1
2
3
4
5
6
7
8
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)


Datawell Wave Direction
Nov. 15, 2004 15:57 NF Time
Wave Direction (deg. TRUE)
0
20
40
60
80
100
120
140
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

Appendix J
Tables of Basic Information and Statistics for Each Trial Run

File Name: 0DRIFT_2004_1115055619
Date: November 15 2004 NF Time: 05:56

Dockside
Location: Fort Amherst Small Boat Basin
Nominal Draft AP: 4.140 m Nominal Draft FP: 2.794 m

Water Temperature: 5.9 C Water Density: 1015.8 kg/m^3
Closest Stability Booklet Condition: Condition 4
Static Stability Info: GM_T(Fluid): 0.433 m - from inclining experiment
Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 5.7 C Water Density: 1024.5 kg/m^3
Latitude: 47.5544 North Longitude: 52.4375 West
Duration of Run: Number of Samples:
Nominal Forward Speed Over the Ground: 1.8 knots
Nominal Course Over the Ground: N/A deg. TRUE
Total Distance Traveled During the Run: 0.72 nautical miles
Nominal Relative Wind Speed: 12 knots
Nominal Relative Wind Direction: 240 deg. Mag
Nominal Sea State: 2
Nominal Shaft RPM: 0.0 RPM

Dominant Wave Characteristics:	Datawell	Neptune
Significant Height:	2.38 m	2.58 m
Direction:	118.22 deg. True	38.9 deg. True
Peak Period:	11.765 s	12.34 s

Channel	Minimum	Maximum	Mean	St. Dev.
DGPS Antenna				
COG (deg. TRUE)	12.240	336.650	217.174	30.945
SOG (m/s)	0.061	2.636	0.983	0.397
SOG (knots)	0.119	5.124	1.910	0.771
Rudder Angle (deg.)	-0.615	1.496	0.124	0.553
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	-15.185	15.131	-0.009	4.895
Pitch Angle (deg)	-6.781	3.983	-1.328	1.599
Yaw Angle (deg)	-20.095	27.800	0.645	11.376
Output from Tri-Mounted Accelerometer positioned on Bridge				
Surge Acceleration (m/s^2)	-0.991	1.127	0.016	0.318
Sway Acceleration (m/s^2)	-3.284	3.454	0.273	1.075
Heave Acceleration (m/s^2)	-11.375	-8.001	-9.762	0.513

File Name: 0DRIFT_2004_1115055619
Date: November 15 2004 NF Time: 05:56

Channel	Minimum	Maximum	Mean	St. Dev.
Output from MotionPak positioned at the Center of Gravity				
Surge Acceleration (m/s^2)	-0.606	0.530	0.000	0.175
Sway Acceleration (m/s^2)	-0.853	0.738	0.000	0.231
Heave Acceleration (m/s^2)	-1.301	1.260	-0.024	0.398
Surge Displacement (m)	-0.916	0.930	0.000	0.322
Sway Displacement (m)	-1.284	1.428	0.001	0.431
Heave Displacement (m)	-1.576	1.605	0.000	0.520
Computed for the Master's steering position from MotionPak				
Surge Acceleration (m/s^2)	-0.704	0.659	0.000	0.205
Sway Acceleration (m/s^2)	-1.385	1.497	0.000	0.412
Heave Acceleration (m/s^2)	-2.051	1.822	-0.024	0.551
Surge Displacement (m)	-0.775	0.845	0.000	0.277
Sway Displacement (m)	-1.387	1.796	0.002	0.448
Heave Displacement (m)	-2.081	1.930	0.001	0.573

Notes:
- The draft is referenced to the keel.
- The wave direction sign convention is stated as where the waves are coming from.
- The motions of the vessel were calculated using the earth fixed coordinate system.
- positions below are rough estimates based on information from poor drawings in Stability Booklet.
- The sign convention for Accelerometer is:
  x : '+' forward y : '+' starboard z : '-' downwards
- The sign convention for MotionPak is:
  x : '+' forward y : '+' starboard z : '+' downwards
- The distance to Center of Gravity from MotionPak:
  Δx : 1.955 m Δy : 0.042 m Δz : 0.5385 m
- The distance to the Master's steering position from MotionPak:
  Δx : 6.257 m Δy : 2.620 m Δz : -3.4747 m
- The distance to the triaxial accelerometer position from MotionPak:
  Δx : 6.257 m Δy : 0.219 m Δz : -2.56 m

File Name: THEAD_2004_1115064947
Date: November 15 2004 NF Time: 06:49

Dockside
Location: Fort Amherst Small Boat Basin
Nominal Draft AP: 4.140 m Nominal Draft FP: 2.794 m

Water Temperature: 5.9 C Water Density: 1015.8 kg/m^3
Closest Stability Booklet Condition: Condition 4
Static Stability Info: GM_T(Fluid): 0.433 m - from inclining experiment
Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature; 5.7 C Water Density: 1024.5 kg/m^3
Latitude: 47.5553 North Longitude: 52.4332 West
Duration of Run: Number of Samples:
Nominal Forward Speed Over the Ground: 2.6 knots
Nominal Course Over the Ground: 73 deg. TRUE
Total Distance Traveled During the Run: 1.05 nautical miles
Nominal Relative Wind Speed: 20 knots
Nominal Relative Wind Direction: 240 deg. Mag
Nominal Sea State: 2
Nominal Shaft RPM: 141.0 RPM

Dominant Wave Characteristics:	Datawell	Neptune
Significant Height:	2.26 m	2.34 m
Direction:	102.75 deg. True	52 deg. True
Peak Period:	10.526 s	10.89 s

Channel	Minimum	Maximum	Mean	St. Dev.
DGPS Antenna				
COG (deg. TRUE)	10.820	129.740	76.745	18.290
SOG (m/s)	0.397	2.278	1.355	0.283
SOG (knots)	0.772	4.428	2.635	0.549
Rudder Angle (deg.)	-10.067	7.422	-1.836	1.709
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	-12.182	10.561	-0.537	3.922
Pitch Angle (deg)	-9.735	5.231	-1.368	1.912
Yaw Angle (deg)	-7.693	5.483	-0.003	2.203
Output from Tri-Mounted Accelerometer positioned on Bridge				
Surge Acceleration (m/s^2)	-1.715	1.496	0.003	0.438
Sway Acceleration (m/s^2)	-2.443	3.211	0.369	0.871
Heave Acceleration (m/s^2)	-12.572	-6.873	-9.777	0.736

File Name: THEAD_2004_1115064947
Date: November 15 2004 NF Time: 06:49

Channel	Minimum	Maximum	Mean	St. Dev.
Output from MotionPak positioned at the Center of Gravity				
Surge Acceleration (m/s^2)	-0.726	0.906	0.000	0.193
Sway Acceleration (m/s^2)	-0.617	0.771	0.000	0.188
Heave Acceleration (m/s^2)	-1.959	1.851	-0.026	0.513
Surge Displacement (m)	-1.196	1.050	0.000	0.323
Sway Displacement (m)	-0.994	1.017	0.001	0.313
Heave Displacement (m)	-1.715	1.772	0.000	0.569
Computed for the Master's steering position from MotionPak				
Surge Acceleration (m/s^2)	-0.812	0.901	0.000	0.254
Sway Acceleration (m/s^2)	-1.224	1.247	-0.001	0.349
Heave Acceleration (m/s^2)	-3.151	2.821	-0.026	0.736
Surge Displacement (m)	-0.849	0.939	0.000	0.271
Sway Displacement (m)	-0.955	1.265	0.001	0.348
Heave Displacement (m)	-2.066	2.205	0.000	0.642

Notes:

- The draft is referenced to the keel.
- The wave direction sign convention is stated as where the waves are coming from.
- The motions of the vessel were calculated using the earth fixed coordinate system.
- positions below are rough estimates based on information from poor drawings in Stability Booklet.
- The sign convention for Accelerometer is:
  x : '+' forward y : '+' starboard z : '-' downwards
- The sign convention for MotionPak is:
  x : '+' forward y : '+' starboard z : '+' downwards
- The distance to Center of Gravity from MotionPak:
  Δx : 1.955 m Δy : 0.042 m Δz : 0.5385 m
- The distance to the Master's steering position from MotionPak:
  Δx : 6.257 m Δy : 2.620 m Δz : -3.4747 m
- The distance to the triaxial accelerometer position from MotionPak:
  Δx : 6.257 m Δy : 0.219 m Δz : -2.56 m

File Name: TBOW_2004_1115080800
Date: November 15 2004 NF Time: 08:08

Dockside
Location: Fort Amherst Small Boat Basin
Nominal Draft AP: 4.140 m Nominal Draft FP: 2.794 m

Water Temperature: 5.9 C Water Density: 1015.8 kg/m^3
Closest Stability Booklet Condition: Condition 4
Static Stability Info: GM_T(Fluid): 0.433 m - from inclining experiment

Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 5.7 C Water Density: 1024.5 kg/m^3
Latitude: 47.5391 North Longitude: 52.4880 West
Duration of Run: Number of Samples:
Nominal Forward Speed Over the Ground: 3 knots
Nominal Course Over the Ground: 120 deg. TRUE
Total Distance Traveled During the Run: 1.16 nautical miles
Nominal Relative Wind Speed: 19 knots
Nominal Relative Wind Direction: 290 deg. Mag
Nominal Sea State: 2
Nominal Shaft RPM: 128.0 RPM

Dominant Wave Characteristics:	Datawell	Neptune
Significant Height:	2.40 m	2.61 m
Direction:	116.81 deg. True	20 deg. True
Peak Period:	11.111 s	10.89 s

Channel	Minimum	Maximum	Mean	St. Dev.
DGPS Antenna				
COG (deg. TRUE)	51.310	176.170	124.051	16.801
SOG (m/s)	0.544	2.633	1.480	0.298
SOG (knots)	1.058	5.119	2.878	0.579
Rudder Angle (deg.)	-10.618	7.934	-0.329	2.179
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	-12.225	11.310	-0.037	4.039
Pitch Angle (deg)	-9.737	4.746	-1.331	1.826
Yaw Angle (deg)	-6.250	4.696	-0.139	2.261
Output from Tri-Mounted Accelerometer positioned on Bridge				
Surge Acceleration (m/s^2)	-1.427	1.605	0.010	0.382
Sway Acceleration (m/s^2)	-2.370	3.254	0.289	0.914
Heave Acceleration (m/s^2)	-12.067	-7.106	-9.778	0.662

File Name: TBOW_2004_1115080800
Date: November 15 2004 NF Time: 08:08

Channel	Minimum	Maximum	Mean	St. Dev.
Output from MotionPak positioned at the Center of Gravity				
Surge Acceleration (m/s^2)	-0.624	0.941	0.000	0.208
Sway Acceleration (m/s^2)	-0.667	0.694	0.000	0.176
Heave Acceleration (m/s^2)	-1.462	1.654	-0.022	0.482
Surge Displacement (m)	-1.497	1.148	0.000	0.395
Sway Displacement (m)	-0.812	0.709	-0.001	0.234
Heave Displacement (m)	-2.531	1.898	0.000	0.600
Computed for the Master's steering position from MotionPak				
Surge Acceleration (m/s^2)	-1.015	0.906	0.000	0.256
Sway Acceleration (m/s^2)	-1.155	1.386	0.000	0.360
Heave Acceleration (m/s^2)	-2.365	2.555	-0.022	0.656
Surge Displacement (m)	-0.980	1.036	0.000	0.327
Sway Displacement (m)	-0.968	0.959	0.000	0.322
Heave Displacement (m)	-2.400	1.930	0.000	0.640

Notes:

- The draft is referenced to the keel.
- The wave direction sign convention is stated as where the waves are coming from.
- The motions of the vessel were calculated using the earth fixed coordinate system.
- positions below are rough estimates based on information from poor drawings in Stability Booklet.
- The sign convention for Accelerometer is:
  x : '+' forward y : '+' starboard z : '-' downwards
- The sign convention for MotionPak is:
  x : '+' forward y : '+' starboard z : '+' downwards
- The distance to Center of Gravity from MotionPak:
  Δx : 1.955 m Δy : 0.042 m Δz : 0.5385 m
- The distance to the Master's steering position from MotionPak:
  Δx : 6.257 m Δy : 2.620 m Δz : -3.4747 m
- The distance to the triaxial accelerometer position from MotionPak:
  Δx : 6.257 m Δy : 0.219 m Δz : -2.56 m

File Name: TBEAM_2004_1115083828
Date: November 15 2004 NF Time: 08:38

Dockside
Location: Fort Amherst Small Boat Basin
Nominal Draft AP: 4.140 m Nominal Draft FP: 2.794 m

Water Temperature: 5.9 C Water Density: 1015.8 kg/m^3
Closest Stability Booklet Condition: Condition 4
Static Stability Info: GM_T(Fluid): 0.433 m - from inclining experiment
Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 5.7 C Water Density: 1024.5 kg/m^3
Latitude: 47.5290 North Longitude: 52.4640 West
Duration of Run: Number of Samples:
Nominal Forward Speed Over the Ground: 2.6 knots
Nominal Course Over the Ground: 344 deg. TRUE
Total Distance Traveled During the Run: 0.98 nautical miles
Nominal Relative Wind Speed: 17 knots
Nominal Relative Wind Direction: 20 deg. Mag
Nominal Sea State: 2
Nominal Shaft RPM: 122.0 RPM

Dominant Wave Characteristics:	Datawell	Neptune
Significant Height:	2.26 m	2.55 m
Direction:	119.63 deg. True	40 deg. True
Peak Period:	11.765 s	12.34 s

Channel	Minimum	Maximum	Mean	St. Dev.
DGPS Antenna				
COG (deg. TRUE)	0.020	359.940	348.345	22.104
SOG (m/s)	0.453	2.311	1.308	0.276
SOG (knots)	0.880	4.492	2.542	0.536
Rudder Angle (deg.)	-13.913	12.125	-1.153	2.925
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	-14.538	13.346	-0.485	4.696
Pitch Angle (deg)	-6.692	3.995	-1.333	1.607
Yaw Angle (deg)	-5.815	7.388	0.080	2.376
Output from Tri-Mounted Accelerometer positioned on Bridge				
Surge Acceleration (m/s^2)	-1.348	1.230	0.012	0.386
Sway Acceleration (m/s^2)	-2.905	3.558	0.353	1.055
Heave Acceleration (m/s^2)	-12.151	-7.528	-9.765	0.686

File Name: TBEAM_2004_1115083828
Date: November 15 2004 NF Time: 08:38

Channel	Minimum	Maximum	Mean	St. Dev.
Output from MotionPak positioned at the Center of Gravity				
Surge Acceleration (m/s^2)	-0.527	0.607	0.000	0.156
Sway Acceleration (m/s^2)	-0.963	0.776	-0.001	0.239
Heave Acceleration (m/s^2)	-1.638	1.508	-0.016	0.502
Surge Displacement (m)	-0.733	0.781	0.000	0.250
Sway Displacement (m)	-1.361	1.420	0.000	0.385
Heave Displacement (m)	-1.287	1.754	-0.001	0.495
Computed for the Master's steering position from MotionPak				
Surge Acceleration (m/s^2)	-0.787	0.738	0.000	0.223
Sway Acceleration (m/s^2)	-1.481	1.374	-0.001	0.439
Heave Acceleration (m/s^2)	-2.734	2.226	-0.017	0.704
Surge Displacement (m)	-0.652	0.716	0.000	0.212
Sway Displacement (m)	-1.587	1.503	0.001	0.423
Heave Displacement (m)	-1.734	2.393	-0.001	0.579

Notes:
- The draft is referenced to the keel.
- The wave direction sign convention is stated as where the waves are coming from.
- The motions of the vessel were calculated using the earth fixed coordinate system.
- positions below are rough estimates based on information from poor drawings in Stability Booklet.
- The sign convention for Accelerometer is:
  x : '+' forward y : '+' starboard z : '-' downwards
- The sign convention for MotionPak is:
  x : '+' forward y : '+' starboard z : '+' downwards
- The distance to Center of Gravity from MotionPak:
  Δx : 1.955 m Δy : 0.042 m Δz : 0.5385 m
- The distance to the Master's steering position from MotionPak:
  Δx : 6.257 m Δy : 2.620 m Δz : -3.4747 m
- The distance to the triaxial accelerometer position from MotionPak:
  Δx : 6.257 m Δy : 0.219 m Δz : -2.56 m

File Name: TQUART_2004_1115090757
Date: November 15 2004 NF Time: 09:07

Dockside
Location: Fort Amherst Small Boat Basin
Nominal Draft AP: 4.140 m Nominal Draft FP: 2.794 m

Water Temperature: 5.9 C Water Density: 1015.8 kg/m^3
Closest Stability Booklet Condition: Condition 4
Static Stability Info: GM_T(Fluid): 0.433 m - from inclining experiment

Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 5.7 C Water Density: 1024.5 kg/m^3
Latitude: 47.5420 North Longitude: 52.4720 West
Duration of Run: Number of Samples:
Nominal Forward Speed Over the Ground: 4.8 knots
Nominal Course Over the Ground: 210 deg. TRUE
Total Distance Traveled During the Run: 1.84 nautical miles
Nominal Relative Wind Speed: 13 knots
Nominal Relative Wind Direction: 200 deg. Mag
Nominal Sea State: 2
Nominal Shaft RPM: 122.0 RPM

Dominant Wave Characteristics:	Datawell	Neptune
Significant Height:	2.26 m	2.82 m
Direction:	108.38 deg. True	13.8 deg. True
Peak Period:	11.765 s	12.34 s

Channel	Minimum	Maximum	Mean	St. Dev.
DGPS Antenna				
COG (deg. TRUE)	173.320	246.620	208.891	10.524
SOG (m/s)	1.794	3.650	2.414	0.230
SOG (knots)	3.488	7.095	4.692	0.447
Rudder Angle (deg.)	-12.086	6.657	-2.683	2.012
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	-16.420	17.589	0.569	4.104
Pitch Angle (deg)	-7.162	4.164	-1.362	1.572
Yaw Angle (deg)	-6.372	7.048	0.076	2.397
Output from Tri-Mounted Accelerometer positioned on Bridge				
Surge Acceleration (m/s^2)	-1.243	1.178	0.006	0.324
Sway Acceleration (m/s^2)	-2.987	3.762	0.179	0.982
Heave Acceleration (m/s^2)	-11.879	-7.753	-9.788	0.562

File Name: TQUART_2004_1115090757
Date: November 15 2004 NF Time: 09:07

Channel	Minimum	Maximum	Mean	St. Dev.
Output from MotionPak positioned at the Center of Gravity				
Surge Acceleration (m/s^2)	-0.557	0.727	0.000	0.178
Sway Acceleration (m/s^2)	-0.824	0.670	-0.001	0.222
Heave Acceleration (m/s^2)	-1.492	1.360	-0.016	0.419
Surge Displacement (m)	-1.172	0.984	0.000	0.307
Sway Displacement (m)	-1.246	1.258	-0.001	0.423
Heave Displacement (m)	-1.798	2.015	0.001	0.546
Computed for the Master's steering position from MotionPak				
Surge Acceleration (m/s^2)	-0.680	0.689	0.000	0.209
Sway Acceleration (m/s^2)	-1.169	1.292	-0.001	0.364
Heave Acceleration (m/s^2)	-2.287	2.073	-0.016	0.571
Surge Displacement (m)	-0.948	0.827	0.000	0.254
Sway Displacement (m)	-1.505	1.229	0.000	0.406
Heave Displacement (m)	-1.913	2.219	0.001	0.605

Notes:

- The draft is referenced to the keel.
- The wave direction sign convention is stated as where the waves are coming from.
- The motions of the vessel were calculated using the earth fixed coordinate system.
- positions below are rough estimates based on information from poor drawings in Stability Booklet.
- The sign convention for Accelerometer is:
  x : '+' forward y : '+' starboard z : '-' downwards
- The sign convention for MotionPak is:
  x : '+' forward y : '+' starboard z : '+' downwards
- The distance to Center of Gravity from MotionPak:
  Δx : 1.955 m Δy : 0.042 m Δz : 0.5385 m
- The distance to the Master's steering position from MotionPak:
  Δx : 6.257 m Δy : 2.620 m Δz : -3.4747 m
- The distance to the triaxial accelerometer position from MotionPak:
  Δx : 6.257 m Δy : 0.219 m Δz : -2.56 m

File Name: TFOL_2004_1115072149
Date: November 15 2004 NF Time: 07:21

Dockside
Location: Fort Amherst Small Boat Basin
Nominal Draft AP: 4.140 m Nominal Draft FP: 2.794 m

Water Temperature: 5.9 C Water Density: 1015.8 kg/m^3
Closest Stability Booklet Condition: Condition 4
Static Stability Info: GM_T(Fluid): 0.433 m - from inclining experiment

Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 5.7 C Water Density: 1024.5 kg/m^3
Latitude: 47.5550 North Longitude: 52.4170 West
Duration of Run: Number of Samples:
Nominal Forward Speed Over the Ground: 4.8 knots
Nominal Course Over the Ground: 253 deg. TRUE
Total Distance Traveled During the Run: 3.06 nautical miles
Nominal Relative Wind Speed: 7 knots
Nominal Relative Wind Direction: 110 deg. Mag
Nominal Sea State: 2
Nominal Shaft RPM: 129.0 RPM

Dominant Wave Characteristics:	Datawell	Neptune
Significant Height:	2.29 m	2.63 m
Direction:	122.44 deg. True	37.2 deg. True
Peak Period:	11.111 s	10.89 s

Channel	Minimum	Maximum	Mean	St. Dev.
DGPS Antenna				
COG (deg. TRUE)	220.010	289.090	254.310	9.716
SOG (m/s)	1.508	3.392	2.390	0.275
SOG (knots)	2.932	6.593	4.646	0.535
Rudder Angle (deg.)	-10.174	7.544	-1.201	1.877
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	-13.054	13.487	-0.528	3.565
Pitch Angle (deg)	-8.569	6.369	-1.433	1.796
Yaw Angle (deg)	-9.065	9.628	-0.032	2.717
Output from Tri-Mounted Accelerometer positioned on Bridge				
Surge Acceleration (m/s^2)	-1.534	1.472	-0.004	0.373
Sway Acceleration (m/s^2)	-3.065	3.407	0.365	0.797
Heave Acceleration (m/s^2)	-12.052	-7.214	-9.784	0.607

File Name: TFOL_2004_1115072149
Date: November 15 2004 NF Time: 07:21

Channel	Minimum	Maximum	Mean	St. Dev.
Output from MotionPak positioned at the Center of Gravity				
Surge Acceleration (m/s^2)	-0.712	0.801	0.000	0.199
Sway Acceleration (m/s^2)	-0.642	0.535	0.000	0.155
Heave Acceleration (m/s^2)	-1.444	1.681	-0.026	0.405
Surge Displacement (m)	-1.476	1.608	0.000	0.436
Sway Displacement (m)	-0.877	0.860	0.000	0.273
Heave Displacement (m)	-1.463	1.651	0.001	0.483
Computed for the Master's steering position from MotionPak				
Surge Acceleration (m/s^2)	-0.775	0.805	0.000	0.228
Sway Acceleration (m/s^2)	-1.110	1.309	0.000	0.297
Heave Acceleration (m/s^2)	-2.554	2.534	-0.025	0.610
Surge Displacement (m)	-1.292	1.383	0.000	0.376
Sway Displacement (m)	-1.063	1.230	0.000	0.305
Heave Displacement (m)	-1.678	2.015	0.001	0.554

Notes:

- The draft is referenced to the keel.
- The wave direction sign convention is stated as where the waves are coming from.
- The motions of the vessel were calculated using the earth fixed coordinate system.
- positions below are rough estimates based on information from poor drawings in Stability Booklet.
- The sign convention for Accelerometer is:
  x : '+' forward y : '+' starboard z : '-' downwards
- The sign convention for MotionPak is:
  x : '+' forward y : '+' starboard z : '+' downwards
- The distance to Center of Gravity from MotionPak:
  Δx : 1.955 m Δy : 0.042 m Δz : 0.5385 m
- The distance to the Master's steering position from MotionPak:
  Δx : 6.257 m Δy : 2.620 m Δz : -3.4747 m
- The distance to the triaxial accelerometer position from MotionPak:
  Δx : 6.257 m Δy : 0.219 m Δz : -2.56 m

File Name: 0DRIFT_2004_1115101000
Date: November 15 2004 NF Time: 10:10

Dockside
Location: Fort Amherst Small Boat Basin
Nominal Draft AP: 4.140 m Nominal Draft FP: 2.794 m

Water Temperature: 5.9 C Water Density: 1015.8 kg/m^3
Closest Stability Booklet Condition: Condition 4
Static Stability Info: GM_T(Fluid): 0.433 m - from inclining experiment

Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 5.7 C Water Density: 1024.5 kg/m^3
Latitude: 47.5550 North Longitude: 52.4390 West
Duration of Run: Number of Samples:
Nominal Forward Speed Over the Ground: 1.4 knots
Nominal Course Over the Ground: N/A deg. TRUE
Total Distance Traveled During the Run: 0.63 nautical miles
Nominal Relative Wind Speed: 17 knots
Nominal Relative Wind Direction: 50 deg. Mag
Nominal Sea State: 2
Nominal Shaft RPM: 0.0 RPM

Dominant Wave Characteristics:	Datawell	Neptune
Significant Height:	2.48 m	2.04 m
Direction:	125.25 deg. True	43.7 deg. True
Peak Period:	11.765 s	12.34 s

Channel	Minimum	Maximum	Mean	St. Dev.
DGPS Antenna				
COG (deg. TRUE)	19.130	356.230	220.657	39.310
SOG (m/s)	0.006	4.056	0.882	0.431
SOG (knots)	0.011	7.883	1.715	0.838
Rudder Angle (deg.)	-0.692	0.417	-0.266	0.106
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	-16.281	14.129	-0.363	4.964
Pitch Angle (deg)	-7.881	5.416	-1.284	1.872
Yaw Angle (deg)	-25.471	26.690	0.065	12.266
Output from Tri-Mounted Accelerometer positioned on Bridge				
Surge Acceleration (m/s^2)	-1.272	1.425	0.013	0.392
Sway Acceleration (m/s^2)	-2.654	3.698	0.327	1.120
Heave Acceleration (m/s^2)	-11.908	-7.409	-9.755	0.614

File Name: 0DRIFT_2004_1115101000
Date: November 15 2004 NF Time: 10:10

Channel	Minimum	Maximum	Mean	St. Dev.
Output from MotionPak positioned at the Center of Gravity				
Surge Acceleration (m/s^2)	-0.662	0.627	0.000	0.177
Sway Acceleration (m/s^2)	-0.794	0.831	0.000	0.236
Heave Acceleration (m/s^2)	-1.484	1.559	-0.017	0.443
Surge Displacement (m)	-1.056	1.055	0.000	0.280
Sway Displacement (m)	-1.221	1.330	0.000	0.391
Heave Displacement (m)	-1.942	1.669	-0.001	0.524
Computed for the Master's steering position from MotionPak				
Surge Acceleration (m/s^2)	-0.760	0.865	0.000	0.213
Sway Acceleration (m/s^2)	-1.398	1.441	0.000	0.436
Heave Acceleration (m/s^2)	-2.699	2.363	-0.017	0.649
Surge Displacement (m)	-0.825	1.008	0.000	0.258
Sway Displacement (m)	-1.274	1.529	0.000	0.426
Heave Displacement (m)	-2.090	2.019	-0.001	0.611

Notes:
- The draft is referenced to the keel.
- The wave direction sign convention is stated as where the waves are coming from.
- The motions of the vessel were calculated using the earth fixed coordinate system.
- positions below are rough estimates based on information from poor drawings in Stability Booklet.
- The sign convention for Accelerometer is:
  x : '+' forward y : '+' starboard z : '-' downwards
- The sign convention for MotionPak is:
  x : '+' forward y : '+' starboard z : '+' downwards
- The distance to Center of Gravity from MotionPak:
  Δx : 1.955 m Δy : 0.042 m Δz : 0.5385 m
- The distance to the Master's steering position from MotionPak:
  Δx : 6.257 m Δy : 2.620 m Δz : -3.4747 m
- The distance to the triaxial accelerometer position from MotionPak:
  Δx : 6.257 m Δy : 0.219 m Δz : -2.56 m

File Name: CHEAD_2004_1115104952
Date: November 15 2004 NF Time: 10:49

Dockside
Location: Fort Amherst Small Boat Basin
Nominal Draft AP: 4.140 m Nominal Draft FP: 2.794 m

Water Temperature: 5.9 C Water Density: 1015.8 kg/m^3
Closest Stability Booklet Condition: Condition 4
Static Stability Info: GM_T(Fluid): 0.433 m - from inclining experiment
Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 5.7 C Water Density: 1024.5 kg/m^3
Latitude: 47.5556 North Longitude: 52.4230 West
Duration of Run: Number of Samples:
Nominal Forward Speed Over the Ground: 7.2 knots
Nominal Course Over the Ground: 92 deg. TRUE
Total Distance Traveled During the Run: 2.97 nautical miles
Nominal Relative Wind Speed: 12 knots
Nominal Relative Wind Direction: 310 deg. Mag
Nominal Sea State: 2
Nominal Shaft RPM: 274.3 RPM

Dominant Wave Characteristics:	Datawell	Neptune
Significant Height:	2.28 m	1.98 m
Direction:	126.66 deg. True	43.9 deg. True
Peak Period:	11.111 s	9.75 s

Channel	Minimum	Maximum	Mean	St. Dev.
DGPS Antenna				
COG (deg. TRUE)	75.410	109.270	90.347	5.483
SOG (m/s)	2.417	4.558	3.647	0.307
SOG (knots)	4.698	8.861	7.089	0.597
Rudder Angle (deg.)	-7.880	7.040	-1.635	1.218
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	-10.055	10.144	0.060	2.947
Pitch Angle (deg)	-8.733	4.748	-1.650	1.753
Yaw Angle (deg)	-4.215	4.669	0.055	1.267
Output from Tri-Mounted Accelerometer positioned on Bridge				
Surge Acceleration (m/s^2)	-1.945	1.626	-0.048	0.518
Sway Acceleration (m/s^2)	-2.046	2.640	0.271	0.675
Heave Acceleration (m/s^2)	-13.317	-5.282	-9.801	0.945

File Name: CHEAD_2004_1115104952
Date: November 15 2004 NF Time: 10:49

Channel	Minimum	Maximum	Mean	St. Dev.
Output from MotionPak positioned at the Center of Gravity				
Surge Acceleration (m/s^2)	-0.724	0.683	0.000	0.200
Sway Acceleration (m/s^2)	-0.686	0.739	0.000	0.197
Heave Acceleration (m/s^2)	-2.758	3.589	-0.020	0.728
Surge Displacement (m)	-1.083	1.036	-0.001	0.344
Sway Displacement (m)	-0.895	0.901	0.000	0.235
Heave Displacement (m)	-1.818	1.696	0.001	0.544
Computed for the Master's steering position from MotionPak				
Surge Acceleration (m/s^2)	-1.471	1.429	0.000	0.368
Sway Acceleration (m/s^2)	-1.029	1.198	0.000	0.322
Heave Acceleration (m/s^2)	-3.622	4.291	-0.020	0.937
Surge Displacement (m)	-0.992	0.971	-0.001	0.301
Sway Displacement (m)	-0.799	0.795	0.000	0.251
Heave Displacement (m)	-2.055	2.097	0.001	0.610

Notes:
- The draft is referenced to the keel.
- The wave direction sign convention is stated as where the waves are coming from.
- The motions of the vessel were calculated using the earth fixed coordinate system.
- positions below are rough estimates based on information from poor drawings in Stability Booklet.
- The sign convention for Accelerometer is:
  x : '+' forward y : '+' starboard z : '-' downwards
- The sign convention for MotionPak is:
  x : '+' forward y : '+' starboard z : '+' downwards
- The distance to Center of Gravity from MotionPak:
  Δx : 1.955 m Δy : 0.042 m Δz : 0.5385 m
- The distance to the Master's steering position from MotionPak:
  Δx : 6.257 m Δy : 2.620 m Δz : -3.4747 m
- The distance to the triaxial accelerometer position from MotionPak:
  Δx : 6.257 m Δy : 0.219 m Δz : -2.56 m

File Name: CBOW_2004_1115120544
Date: November 15 2004 NF Time: 12:05

Dockside
Location: Fort Amherst Small Boat Basin
Nominal Draft AP: 4.140 m Nominal Draft FP: 2.794 m

Water Temperature: 5.9 C Water Density: 1015.8 kg/m^3
Closest Stability Booklet Condition: Condition 4
Static Stability Info: GM_T(Fluid): 0.433 m - from inclining experiment
Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 5.7 C Water Density: 1024.5 kg/m^3
Latitude: 47.5550 North Longitude: 52.5710 West
Duration of Run: Number of Samples:
Nominal Forward Speed Over the Ground: 7 knots
Nominal Course Over the Ground: 135 deg. TRUE
Total Distance Traveled During the Run: 2.93 nautical miles
Nominal Relative Wind Speed: 21 knots
Nominal Relative Wind Direction: 280 deg. Mag
Nominal Sea State: 2
Nominal Shaft RPM: 238.0 RPM

Dominant Wave Characteristics:	Datawell	Neptune
Significant Height:	2.22 m	2.08 m
Direction:	132.28 deg. True	116.2 deg. True
Peak Period:	11.111 s	10.89 s

Channel	Minimum	Maximum	Mean	St. Dev.
DGPS Antenna				
COG (deg. TRUE)	112.980	197.780	136.532	7.342
SOG (m/s)	2.400	8.394	3.638	0.312
SOG (knots)	4.665	16.317	7.071	0.606
Rudder Angle (deg.)	-11.206	10.198	-1.216	2.096
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	-11.480	13.881	0.621	3.988
Pitch Angle (deg)	-8.682	4.518	-1.558	1.639
Yaw Angle (deg)	-4.370	4.096	-0.041	1.179
Output from Tri-Mounted Accelerometer positioned on Bridge				
Surge Acceleration (m/s^2)	-1.688	1.647	-0.031	0.452
Sway Acceleration (m/s^2)	-2.928	3.457	0.178	0.936
Heave Acceleration (m/s^2)	-12.401	-6.049	-9.786	0.823

File Name: CBOW_2004_1115120544
Date: November 15 2004 NF Time: 12:05

Channel	Minimum	Maximum	Mean	St. Dev.
Output from MotionPak positioned at the Center of Gravity				
Surge Acceleration (m/s^2)	-0.697	0.585	0.000	0.189
Sway Acceleration (m/s^2)	-0.766	0.750	0.000	0.210
Heave Acceleration (m/s^2)	-2.066	2.584	-0.023	0.644
Surge Displacement (m)	-0.868	0.983	0.000	0.336
Sway Displacement (m)	-0.977	0.844	0.000	0.253
Heave Displacement (m)	-2.021	1.636	0.001	0.537
Computed for the Master's steering position from MotionPak				
Surge Acceleration (m/s^2)	-1.201	1.453	0.000	0.338
Sway Acceleration (m/s^2)	-1.360	1.601	0.000	0.391
Heave Acceleration (m/s^2)	-2.898	3.706	-0.023	0.822
Surge Displacement (m)	-0.874	0.948	0.000	0.289
Sway Displacement (m)	-1.121	1.106	-0.001	0.318
Heave Displacement (m)	-2.446	1.994	0.001	0.577

Notes:
- The draft is referenced to the keel.
- The wave direction sign convention is stated as where the waves are coming from.
- The motions of the vessel were calculated using the earth fixed coordinate system.
- positions below are rough estimates based on information from poor drawings in Stability Booklet.
- The sign convention for Accelerometer is:
  x : '+' forward y : '+' starboard z : '-' downwards
- The sign convention for MotionPak is:
  x : '+' forward y : '+' starboard z : '+' downwards
- The distance to Center of Gravity from MotionPak:
  Δx : 1.955 m Δy : 0.042 m Δz : 0.5385 m
- The distance to the Master's steering position from MotionPak:
  Δx : 6.257 m Δy : 2.620 m Δz : -3.4747 m
- The distance to the triaxial accelerometer position from MotionPak:
  Δx : 6.257 m Δy : 0.219 m Δz : -2.56 m

File Name: CBEAM_2004_1115123606
Date: November 15 2004 NF Time: 12:36

Dockside
Location: Fort Amherst Small Boat Basin
Nominal Draft AP: 4.140 m Nominal Draft FP: 2.794 m

Water Temperature: 5.9 C Water Density: 1015.8 kg/m^3
Closest Stability Booklet Condition: Condition 4
Static Stability Info: GM_T(Fluid): 0.433 m - from inclining experiment
Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 5.7 C Water Density: 1024.5 kg/m^3
Latitude: 47.5180 North Longitude: 52.4190 West
Duration of Run: Number of Samples:
Nominal Forward Speed Over the Ground: 7 knots
Nominal Course Over the Ground: 0 deg. TRUE
Total Distance Traveled During the Run: 2.91 nautical miles
Nominal Relative Wind Speed: 16 knots
Nominal Relative Wind Direction: 10 deg. Mag
Nominal Sea State: 2
Nominal Shaft RPM: 278.0 RPM

Dominant Wave Characteristics:	Datawell	Neptune
Significant Height:	2.28 m	2.10 m
Direction:	108.38 deg. True	49.1 deg. True
Peak Period:	10.526 s	9.75 s

Channel	Minimum	Maximum	Mean	St. Dev.
DGPS Antenna				
COG (deg. TRUE)	0.020	359.990	3.774	8.592
SOG (m/s)	2.667	4.603	3.631	0.254
SOG (knots)	5.184	8.947	7.058	0.494
Rudder Angle (deg.)	-13.883	10.496	-1.673	2.974
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	-16.781	16.506	-0.631	4.776
Pitch Angle (deg)	-6.892	3.516	-1.698	1.468
Yaw Angle (deg)	-5.339	6.049	-0.019	1.553
Output from Tri-Mounted Accelerometer positioned on Bridge				
Surge Acceleration (m/s^2)	-1.809	1.379	-0.047	0.416
Sway Acceleration (m/s^2)	-3.570	4.420	0.380	1.071
Heave Acceleration (m/s^2)	-12.816	-6.632	-9.767	0.809

File Name: CBEAM_2004_1115123606
Date: November 15 2004 NF Time: 12:36

Channel	Minimum	Maximum	Mean	St. Dev.
Output from MotionPak positioned at the Center of Gravity				
Surge Acceleration (m/s^2)	-0.699	0.580	0.000	0.164
Sway Acceleration (m/s^2)	-0.796	0.802	-0.001	0.244
Heave Acceleration (m/s^2)	-2.173	2.268	-0.017	0.621
Surge Displacement (m)	-0.834	0.841	0.000	0.275
Sway Displacement (m)	-1.194	1.307	0.000	0.381
Heave Displacement (m)	-1.827	1.756	-0.001	0.596
Computed for the Master's steering position from MotionPak				
Surge Acceleration (m/s^2)	-0.913	1.088	-0.001	0.269
Sway Acceleration (m/s^2)	-1.351	1.581	-0.001	0.435
Heave Acceleration (m/s^2)	-2.925	2.915	-0.017	0.824
Surge Displacement (m)	-0.795	0.826	0.000	0.233
Sway Displacement (m)	-1.331	1.161	0.000	0.412
Heave Displacement (m)	-2.129	2.307	-0.001	0.688

Notes:
- The draft is referenced to the keel.
- The wave direction sign convention is stated as where the waves are coming from.
- The motions of the vessel were calculated using the earth fixed coordinate system.
- positions below are rough estimates based on information from poor drawings in Stability Booklet.
- The sign convention for Accelerometer is:
  x : '+' forward y : '+' starboard z : '-' downwards
- The sign convention for MotionPak is:
  x : '+' forward y : '+' starboard z : '+' downwards
- The distance to Center of Gravity from MotionPak:
  Δx : 1.955 m Δy : 0.042 m Δz : 0.5385 m
- The distance to the Master's steering position from MotionPak:
  Δx : 6.257 m Δy : 2.620 m Δz : -3.4747 m
- The distance to the triaxial accelerometer position from MotionPak:
  Δx : 6.257 m Δy : 0.219 m Δz : -2.56 m

File Name: CQUART_2004_1115130535
Date: November 15 2004 NF Time: 13:05

Dockside
Location: Fort Amherst Small Boat Basin
Nominal Draft AP: 4.140 m Nominal Draft FP: 2.794 m

Water Temperature: 5.9 C Water Density: 1015.8 kg/m^3
Closest Stability Booklet Condition: Condition 4
Static Stability Info: GM_T(Fluid): 0.433 m - from inclining experiment

Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 5.7 C Water Density: 1024.5 kg/m^3
Latitude: 47.5622 North Longitude: 52.4191 West
Duration of Run: Number of Samples:
Nominal Forward Speed Over the Ground: 7 knots
Nominal Course Over the Ground: 225 deg. TRUE
Total Distance Traveled During the Run: 2.95 nautical miles
Nominal Relative Wind Speed: 9 knots
Nominal Relative Wind Direction: 180 deg. Mag
Nominal Sea State: 2
Nominal Shaft RPM: 201.0 RPM

Dominant Wave Characteristics:	Datawell	Neptune
Significant Height:	2.34 m	1.90 m
Direction:	118.22 deg. True	243.9 deg. True
Peak Period:	11.111 s	9.75 s

Channel	Minimum	Maximum	Mean	St. Dev.
DGPS Antenna				
COG (deg. TRUE)	197.370	251.840	224.917	7.168
SOG (m/s)	2.864	4.494	3.637	0.247
SOG (knots)	5.567	8.737	7.069	0.480
Rudder Angle (deg.)	-9.233	4.608	-1.628	1.483
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	-17.259	18.874	0.242	4.114
Pitch Angle (deg)	-6.321	3.150	-1.541	1.466
Yaw Angle (deg)	-7.686	7.597	0.041	2.150
Output from Tri-Mounted Accelerometer positioned on Bridge				
Surge Acceleration (m/s^2)	-1.209	1.108	-0.021	0.307
Sway Acceleration (m/s^2)	-3.734	4.344	0.240	0.894
Heave Acceleration (m/s^2)	-11.843	-7.671	-9.789	0.563

File Name: CQUART_2004_1115130535
Date: November 15 2004 NF Time: 13:05

Channel	Minimum	Maximum	Mean	St. Dev.
Output from MotionPak positioned at the Center of Gravity				
Surge Acceleration (m/s^2)	-0.668	0.567	0.000	0.180
Sway Acceleration (m/s^2)	-0.702	0.676	0.001	0.199
Heave Acceleration (m/s^2)	-1.658	1.540	-0.018	0.443
Surge Displacement (m)	-1.155	1.211	0.000	0.384
Sway Displacement (m)	-1.225	1.168	0.000	0.373
Heave Displacement (m)	-2.081	1.821	0.000	0.524
Computed for the Master's steering position from MotionPak				
Surge Acceleration (m/s^2)	-0.737	0.757	0.000	0.227
Sway Acceleration (m/s^2)	-1.075	1.413	0.001	0.352
Heave Acceleration (m/s^2)	-1.953	2.089	-0.018	0.569
Surge Displacement (m)	-1.130	1.046	0.000	0.331
Sway Displacement (m)	-1.215	1.244	0.000	0.378
Heave Displacement (m)	-1.842	1.631	0.000	0.566

Notes:

- The draft is referenced to the keel.
- The wave direction sign convention is stated as where the waves are coming from.
- The motions of the vessel were calculated using the earth fixed coordinate system.
- positions below are rough estimates based on information from poor drawings in Stability Booklet.
- The sign convention for Accelerometer is:
  x : '+' forward y : '+' starboard z : '-' downwards
- The sign convention for MotionPak is:
  x : '+' forward y : '+' starboard z : '+' downwards
- The distance to Center of Gravity from MotionPak:
  Δx : 1.955 m Δy : 0.042 m Δz : 0.5385 m
- The distance to the Master's steering position from MotionPak:
  Δx : 6.257 m Δy : 2.620 m Δz : -3.4747 m
- The distance to the triaxial accelerometer position from MotionPak:
  Δx : 6.257 m Δy : 0.219 m Δz : -2.56 m

File Name: CFOL_2004_1115111949
Date: November 15 2004 NF Time: 11:19

Dockside
Location: Fort Amherst Small Boat Basin
Nominal Draft AP: 4.140 m Nominal Draft FP: 2.794 m

Water Temperature: 5.9 C Water Density: 1015.8 kg/m^3
Closest Stability Booklet Condition: Condition 4
Static Stability Info: GM_T(Fluid): 0.433 m - from inclining experiment
Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 5.7 C Water Density: 1024.5 kg/m^3
Latitude: 47.5530 North Longitude: 52.3590 West
Duration of Run: Number of Samples:
Nominal Forward Speed Over the Ground: 7.1 knots
Nominal Course Over the Ground: 270 deg. TRUE
Total Distance Traveled During the Run: 4.74 nautical miles
Nominal Relative Wind Speed: 5 knots
Nominal Relative Wind Direction: 80 deg. Mag
Nominal Sea State: 2
Nominal Shaft RPM: 221.0 RPM

Dominant Wave Characteristics:	Datawell	Neptune
Significant Height:	2.33 m	1.99 m
Direction:	118.22 deg. True	64.5 deg. True
Peak Period:	11.111 s	10.89 s

Channel	Minimum	Maximum	Mean	St. Dev.
DGPS Antenna				
COG (deg. TRUE)	246.740	294.620	270.952	7.273
SOG (m/s)	2.644	4.617	3.545	0.300
SOG (knots)	5.140	8.974	6.891	0.583
Rudder Angle (deg.)	-17.852	8.172	-1.568	2.028
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	-13.559	13.248	-0.080	4.010
Pitch Angle (deg)	-8.514	4.407	-1.560	1.609
Yaw Angle (deg)	-10.406	9.907	0.110	2.358
Output from Tri-Mounted Accelerometer positioned on Bridge				
Surge Acceleration (m/s^2)	-1.351	1.114	-0.025	0.338
Sway Acceleration (m/s^2)	-2.844	3.472	0.289	0.871
Heave Acceleration (m/s^2)	-12.171	-7.271	-9.788	0.621

File Name: CFOL_2004_1115111949
Date: November 15 2004 NF Time: 11:19

Channel	Minimum	Maximum	Mean	St. Dev.
Output from MotionPak positioned at the Center of Gravity				
Surge Acceleration (m/s^2)	-0.698	0.811	0.000	0.201
Sway Acceleration (m/s^2)	-0.550	0.657	0.000	0.158
Heave Acceleration (m/s^2)	-1.616	1.797	-0.019	0.459
Surge Displacement (m)	-1.818	1.745	0.000	0.563
Sway Displacement (m)	-0.909	0.792	0.000	0.244
Heave Displacement (m)	-1.853	1.613	-0.001	0.504
Computed for the Master's steering position from MotionPak				
Surge Acceleration (m/s^2)	-0.953	1.032	0.000	0.248
Sway Acceleration (m/s^2)	-0.997	1.295	0.000	0.317
Heave Acceleration (m/s^2)	-2.559	2.501	-0.019	0.645
Surge Displacement (m)	-1.637	1.637	0.000	0.500
Sway Displacement (m)	-1.118	0.945	0.000	0.303
Heave Displacement (m)	-1.873	1.842	-0.001	0.580

Notes:

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  x : '+' forward y : '+' starboard z : '-' downwards
- The sign convention for MotionPak is:
  x : '+' forward y : '+' starboard z : '+' downwards
- The distance to Center of Gravity from MotionPak:
  Δx : 1.955 m Δy : 0.042 m Δz : 0.5385 m
- The distance to the Master's steering position from MotionPak:
  Δx : 6.257 m Δy : 2.620 m Δz : -3.4747 m
- The distance to the triaxial accelerometer position from MotionPak:
  Δx : 6.257 m Δy : 0.219 m Δz : -2.56 m

File Name: ART_TBOW_2004_11151923
Date: November 15 2004 NF Time: 15:19

Dockside
Location: Fort Amherst Small Boat Basin
Nominal Draft AP: 4.140 m Nominal Draft FP: 2.794 m

Water Temperature: 5.9 C Water Density: 1015.8 kg/m^3
Closest Stability Booklet Condition: Condition 4
Static Stability Info: GM_T(Fluid): 0.433 m - from inclining experiment
Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 5.7 C Water Density: 1024.5 kg/m^3
Latitude: 47.5390 North Longitude: 52.4820 West
Duration of Run: Number of Samples:
Nominal Forward Speed Over the Ground: 2 knots
Nominal Course Over the Ground: 115 deg. TRUE
Total Distance Traveled During the Run: 1.11 nautical miles
Nominal Relative Wind Speed: 19 knots
Nominal Relative Wind Direction: 290 deg. Mag
Nominal Sea State: 2
Nominal Shaft RPM: 126.8 RPM

		Datawell	Neptune
Dominant Wave Characteristics:	Significant Height:	2.25 m	2.25 m
	Direction:	122.44 deg. True	38.6 deg. True
	Peak Period:	11.111 s	10.89 s

Channel	Minimum	Maximum	Mean	St. Dev.
DGPS Antenna				
COG (deg. TRUE)	68.860	183.930	119.892	13.088
SOG (m/s)	0.228	2.561	1.398	0.325
SOG (knots)	0.443	4.978	2.718	0.631
Rudder Angle (deg.)	-8.025	9.594	-0.103	2.051
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	-8.883	9.426	0.500	2.089
Pitch Angle (deg)	-9.640	7.724	-1.285	2.329
Yaw Angle (deg)	-6.598	6.347	-0.031	1.999
Output from Tri-Mounted Accelerometer positioned on Bridge				
Surge Acceleration (m/s^2)	-2.195	2.077	-0.001	0.579
Sway Acceleration (m/s^2)	-1.964	2.751	0.194	0.525
Heave Acceleration (m/s^2)	-12.850	-6.226	-9.804	0.902

File Name: ART_TBOW_2004_11151923
Date: November 15 2004 NF Time: 15:19

Channel	Minimum	Maximum	Mean	St. Dev.
Output from MotionPak positioned at the Center of Gravity				
Surge Acceleration (m/s^2)	-0.786	0.786	0.000	0.222
Sway Acceleration (m/s^2)	-0.734	0.688	0.000	0.195
Heave Acceleration (m/s^2)	-1.886	2.079	-0.019	0.584
Surge Displacement (m)	-1.095	1.152	0.000	0.350
Sway Displacement (m)	-0.914	0.999	0.000	0.240
Heave Displacement (m)	-1.839	1.781	-0.001	0.512
Computed for the Master's steering position from MotionPak				
Surge Acceleration (m/s^2)	-1.226	1.563	0.000	0.361
Sway Acceleration (m/s^2)	-1.263	1.192	0.000	0.304
Heave Acceleration (m/s^2)	-3.189	3.389	-0.018	0.874
Surge Displacement (m)	-0.942	1.012	0.000	0.292
Sway Displacement (m)	-0.832	0.816	0.000	0.240
Heave Displacement (m)	-1.979	2.043	-0.001	0.575

Notes:
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- The sign convention for MotionPak is:
  x : '+' forward y : '+' starboard z : '+' downwards
- The distance to Center of Gravity from MotionPak:
  Δx : 1.955 m Δy : 0.042 m Δz : 0.5385 m
- The distance to the Master's steering position from MotionPak:
  Δx : 6.257 m Δy : 2.620 m Δz : -3.4747 m
- The distance to the triaxial accelerometer position from MotionPak:
  Δx : 6.257 m Δy : 0.219 m Δz : -2.56 m

File Name: ART_TBEAM_2004_1115141318
Date: November 15 2004 NF Time: 14:13

Dockside
Location: Fort Amherst Small Boat Basin
Nominal Draft AP: 4.140 m Nominal Draft FP: 2.794 m

Water Temperature: 5.9 C Water Density: 1015.8 kg/m^3
Closest Stability Booklet Condition: Condition 4
Static Stability Info: GM_T(Fluid): 0.433 m - from inclining experiment
Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 5.7 C Water Density: 1024.5 kg/m^3
Latitude: 47.5530 North Longitude: 52.4450 West
Duration of Run: Number of Samples:
Nominal Forward Speed Over the Ground: 3.2 knots
Nominal Course Over the Ground: 340 deg. TRUE
Total Distance Traveled During the Run: 1.38 nautical miles
Nominal Relative Wind Speed: 20 knots
Nominal Relative Wind Direction: 30 deg. Mag
Nominal Sea State: 2
Nominal Shaft RPM: 141.7 RPM

Dominant Wave Characteristics:	Datawell	Neptune
Significant Height:	2.28 m	2.17 m
Direction:	119.63 deg. True	226.5 deg. True
Peak Period:	10.526 s	10.89 s

Channel	Minimum	Maximum	Mean	St. Dev.
DGPS Antenna				
COG (deg. TRUE)	0.020	359.740	316.439	81.168
SOG (m/s)	0.653	2.817	1.714	0.294
SOG (knots)	1.269	5.475	3.331	0.572
Rudder Angle (deg.)	-12.223	10.825	-1.254	2.612
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	-12.214	10.393	-0.711	3.028
Pitch Angle (deg)	-8.439	4.138	-1.405	1.781
Yaw Angle (deg)	-7.438	6.559	-0.102	2.881
Output from Tri-Mounted Accelerometer positioned on Bridge				
Surge Acceleration (m/s^2)	-1.464	1.197	-0.004	0.408
Sway Acceleration (m/s^2)	-2.637	2.900	0.394	0.711
Heave Acceleration (m/s^2)	-12.381	-7.200	-9.794	0.728

File Name: ART_TBEAM_2004_1115141318
Date: November 15 2004 NF Time: 14:13

Channel	Minimum	Maximum	Mean	St. Dev.
Output from MotionPak positioned at the Center of Gravity				
Surge Acceleration (m/s^2)	-0.623	0.614	0.000	0.185
Sway Acceleration (m/s^2)	-0.872	1.003	-0.001	0.263
Heave Acceleration (m/s^2)	-2.164	2.298	-0.016	0.545
Surge Displacement (m)	-1.020	1.074	0.000	0.336
Sway Displacement (m)	-1.313	1.242	0.000	0.390
Heave Displacement (m)	-1.856	2.112	0.001	0.535
Computed for the Master's steering position from MotionPak				
Surge Acceleration (m/s^2)	-0.817	0.826	0.000	0.229
Sway Acceleration (m/s^2)	-1.365	1.394	-0.001	0.390
Heave Acceleration (m/s^2)	-2.791	2.578	-0.016	0.736
Surge Displacement (m)	-0.939	0.987	0.000	0.283
Sway Displacement (m)	-1.319	1.097	0.000	0.357
Heave Displacement (m)	-2.038	2.555	0.001	0.606

Notes:
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- The sign convention for MotionPak is:
  x : '+' forward y : '+' starboard z : '+' downwards
- The distance to Center of Gravity from MotionPak:
  Δx : 1.955 m Δy : 0.042 m Δz : 0.5385 m
- The distance to the Master's steering position from MotionPak:
  Δx : 6.257 m Δy : 2.620 m Δz : -3.4747 m
- The distance to the triaxial accelerometer position from MotionPak:
  Δx : 6.257 m Δy : 0.219 m Δz : -2.56 m

File Name: ART_TQUART_2004_1115144226
Date: November 15 2004 NF Time: 14:42

Dockside
Location: Fort Amherst Small Boat Basin
Nominal Draft AP: 4.140 m Nominal Draft FP: 2.794 m

Water Temperature: 5.9 C Water Density: 1015.8 kg/m^3
Closest Stability Booklet Condition: Condition 4
Static Stability Info: GM_T(Fluid): 0.433 m - from inclining experiment

Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 5.7 C Water Density: 1024.5 kg/m^3
Latitude: 47.5720 North Longitude: 52.4596 West
Duration of Run: Number of Samples:
Nominal Forward Speed Over the Ground: 4.7 knots
Nominal Course Over the Ground: 206 deg. TRUE
Total Distance Traveled During the Run: 1.89 nautical miles
Nominal Relative Wind Speed: 16 knots
Nominal Relative Wind Direction: 210 deg. Mag
Nominal Sea State: 2
Nominal Shaft RPM: 125.1 RPM

Dominant Wave Characteristics:	Datawell	Neptune
Significant Height:	2.24 m	2.25 m
Direction:	112.59 deg. True	60.1 deg. True
Peak Period:	11.765 s	9.75 s

Channel	Minimum	Maximum	Mean	St. Dev.
DGPS Antenna				
COG (deg. TRUE)	181.340	243.190	208.629	8.822
SOG (m/s)	0.897	3.894	2.362	0.254
SOG (knots)	1.744	7.570	4.592	0.494
Rudder Angle (deg.)	-11.428	6.015	-3.001	1.869
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	-9.393	10.831	0.546	2.747
Pitch Angle (deg)	-7.036	3.671	-1.417	1.645
Yaw Angle (deg)	-5.899	6.450	0.046	2.624
Output from Tri-Mounted Accelerometer positioned on Bridge				
Surge Acceleration (m/s^2)	-1.156	1.101	-0.006	0.344
Sway Acceleration (m/s^2)	-2.333	2.390	0.190	0.629
Heave Acceleration (m/s^2)	-12.145	-6.982	-9.809	0.612

File Name: ART_TQUART_2004_1115144226
Date: November 15 2004 NF Time: 14:42

Channel	Minimum	Maximum	Mean	St. Dev.
Output from MotionPak positioned at the Center of Gravity				
Surge Acceleration (m/s^2)	-0.649	0.624	0.000	0.185
Sway Acceleration (m/s^2)	-1.092	0.804	0.000	0.238
Heave Acceleration (m/s^2)	-2.152	2.280	-0.016	0.461
Surge Displacement (m)	-1.095	0.936	-0.001	0.305
Sway Displacement (m)	-1.599	1.716	0.000	0.402
Heave Displacement (m)	-2.099	2.337	0.001	0.545
Computed for the Master's steering position from MotionPak				
Surge Acceleration (m/s^2)	-0.713	0.743	0.000	0.213
Sway Acceleration (m/s^2)	-1.326	1.138	0.000	0.332
Heave Acceleration (m/s^2)	-2.280	2.832	-0.016	0.567
Surge Displacement (m)	-0.992	0.843	-0.001	0.251
Sway Displacement (m)	-1.193	1.322	0.000	0.341
Heave Displacement (m)	-2.737	2.558	0.001	0.563

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- The distance to the triaxial accelerometer position from MotionPak:
  Δx : 6.257 m Δy : 0.219 m Δz : -2.56 m