Description of seakeeping trial carried out on CCGS Shamook: December 2003

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SUMMARY

This report describes seakeeping experiments carried out on the 75 ft. (22.86 m) research vessel CCGS Shamook off St. John's, NL December 15, 2003. 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. 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.

This document describes the CCGS Shamook, the trials instrumentation package, data acquisition system, test program, data analysis procedure and presents the results. Future reports will provide the results of correlation of the full scale data with physical model test results, the output from numerical models and the development of criteria to reduce MIIs.

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LIST OF ABBREVIATIONS

AP	Aft Perpendicular
^{o}C	degrees Centigrade
CAD	Computer Aided Design
CCG	Canadian Coast Guard
CCGS	Canadian Coast Guard Ship
CG	Center of Gravity
CIHR	Canadian Institutes of Health and Research
cm	centimeter(s)
COG	Course Over Ground
CP	changing pitch
DAS	Data Acquisition System
DC	Direct Current
deg.	degree(s)
DGPS	Differential Global Positioning System
FFT	Fast Fourier Transform
FP	Forward Perpendicular
ft	foot, feet
Fwd.	Forward
F/V	frequency-to-voltage
g	acceleration due to gravity
GM_T	Transverse Metacentric Height
GPS	Global Positioning System
HF	High Frequency
h, hr	hour(s)
H_{M0}	significant wave height
Hz	Hertz
IC	integrated circuit
in	inches
IOT	Institute for Ocean Technology

LIST OF ABBREVIATIONS
(cont'd)

ITTC	International Towing Tank Conference
kg	kilogram(s)
kHz	kiloHertz
km	kilometre(s)
KM_L	Longitudinal Metacentric Height Above Keel
KM_T	Transverse Metacentric Height Above Keel
kPa	kiloPascal(s)
kt(s)	knot(s)
lb(s)	pound(s)
LCB	Longitudinal Center of Buoyancy
LCF	Longitudinal Center of Flotation
LCG	Longitudinal Center of Gravity
LT	long ton(s)
m	metre(s)
mHz	megaHertz
MII(s)	Motion Induced Interrupt(s)
MUN	Memorial University of Newfoundland
mW	megaWatt(s)
N	Newton(s)
NIF	New Initiatives Fund
nm	nautical mile(s)
NMEA	National Marine Electronics Association
NRC	National Research Council
OCC	Oceanic Consulting Corporation
OEB	Offshore Engineering Basin
OSSC	Offshore Safety and Survival Centre
PPT	Parts Per Thousand
QA	Quality Assurance

LIST OF ABBREVIATIONS
(cont'd)

RF	Radio Frequency
RPM	Revolutions Per Minute
s, sec.	second(s)
SA	Selective Availability
SAR	Search And Rescue
S(m)	maximum spectral density
SNAME	Society of Naval Architects and Marine Engineers
SOG	Speed Over Ground
St. Dev.	standard deviation
SWH	Significant Wave Height
t	tonne(s)
TPI	tons per inch immersion
T_Z	mean wave height
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPS	Uninterruptible Power Supply
V	volt(s)
VCB	Vertical Center of Buoyancy
VCG	Vertical Center of Gravity
VHF	very high frequency

1.0 INTRODUCTION

This report describes seakeeping experiments carried out on the 75 ft. (22.86 m) fisheries research vessel CCGS Shamook off St. John's, NL December 15, 2003. 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. 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. The 'Shamook', although not a fishing vessel, was deemed to be a convenient subject vessel at the upper end of the fishing vessel length range. 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.

This document describes the CCGS Shamook, the trials instrumentation package, data acquisition system, test program, data analysis procedure and presents the results. Future reports will provide the results of correlation of the full scale data with physical model test results, the output from numerical models and the development of criteria to reduce MIIs.

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 1).

The effort described in this report is part of Component #3 of the overall Fishing Vessel Research project. The tentative plan involves 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 will be acquired on some of the vessels with and without roll damping devices deployed. Standard seakeeping parameters such as ship motions, speed and heading angle will be 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, 45 and 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 2 to 5.

3.0 DESCRIPTION OF THE CCGS SHAMOOK

The ‘Shamook’ (see Figure 1) is a 75’ long inshore fisheries research vessel operated by the Canadian Coast Guard (CCG) and based in St. John’s, NL. The vessel was built by Georgetown Shipyard, Georgetown, P.E.I., in 1975 and is generally used by scientists from Memorial University of Newfoundland and/or the federal Department of Fisheries and Oceans to carry out fisheries related research around coastal of Newfoundland.

One of the goals of this experiment is to measure the motions of the vessel while in a normal working load condition. To address this requirement, the equipment used for a science trip carried out immediately prior to the trial was left on board and the fuel and water tanks pressed full. In the week following the trial, an inclining experiment was performed by Poseidon Marine Consultants Ltd. of St. John’s, NL to identify key hydrostatic properties for the trials condition.

The inclining experiment was carried out December 18th using standard procedures whereby a single 65.5 inch (166.37 cm) pendulum was suspended from a transverse beam in the cargo hold with the motion of the weight damped in a fluid bath deployed to measure roll angle. Static roll angles were induced by the shifting of two 500 lb (226.8 kg) static weights supplied by the CCG laterally to various locations on the quarterdeck using the vessel’s deck crane. The inclining experiment had to be deferred for three days after the trial due to high winds in St. John’s, however the crew of the ‘Shamook’ made every effort to retain the trials condition (note the Datawell wave buoy and associated anchor, mooring etc. were removed during the inclining) until the inclining experiment had been completed.

The following is a summary of results:

- Draft Forward: 8.686 ft. (2.6475 m) corrected to FP @ hydrostatic baseline
- Draft Aft: 9.161 ft. (2.7923 m) corrected to AP @ hydrostatic baseline

where hydrostatic baseline is at the moulded baseline.

- Inclined Displacement: 198.621 Long Tons (201,807.2 kg) – with inclining weights deducted
- Longitudinal Center of Buoyancy (LCB): 2.114 feet (0.644 m) aft of midships
- Vertical Center of Buoyancy (VCB): 5.696 feet (1.736 m) above the keel
- Longitudinal Center of Floatation (LCF): 6.101 feet (1.860 m) aft of midships
- Transverse Metacentric Height (GM_T(fluid)): 2.604 feet (0.793 m)

The inclining report delivered by the contractor is provided in Appendix A.

The ‘Shamook’ is a round bilge, steel hulled, single screw (variable pitch, 4 blade propeller), single wing section rudder vessel with a centerline skeg and no dedicated anti-roll device other than a set of 8 inch (20.3 cm) bilge keels extending roughly 30 ft. (9 m) about midships. The ‘Shamook’ has the normal suite of navigation/communications electronics including two X band radars, GPS, VHF radio, depth sounder, directional anemometer and electronic chart as well as a Comnav autopilot. A detailed list of the Shamook’s principle particulars, list of outfit items and a number of drawings can be found in Appendix B.

4.0 DESCRIPTION OF INSTRUMENTATION

IOT was tasked to provide the trials technical support, 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 calibration information for the analog channels is provided in Appendix D. Note that the calibrations were verified after 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 6.

4.1 Data Acquisition System

The Data Acquisition System (DAS) used for the ‘Shamook’ was mounted in the Dry Lab of the vessel (Figure 2). The software package designed for these trials were run on two rugged 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 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 center so that it could be adjusted and secured to the top end of the rudder stock (Figure 3). The transducer was clamped to the door of an adjacent storage cage – the cable aligned with the grove cut in the plate.

Rudder angle was calibrated with respect to the ship's rudder indicator on the Bridge.

4.3 Rudder Azimuth Rate Measurement

The rudder azimuth rate was recorded using the linear velocity output from the same yo-yo potentiometer that was used to measure the rudder angle. The rudder azimuth rate channel was calibrated using manufacturer's specifications. Since the circumference of the adapter was not known during calibration in the lab at IOT, the channel was calibrated as velocity in in/s. Based on the diameter of the circular Plexiglas plate on top of the rudder stock, the output can be converted to deg./s.

4.4 Ship's Motion Instrumentation

A MotionPak I was used to measure ship motions with six degrees of freedom. The MotionPak was mounted on a steel bracket clamped to a rigid hanger just below the deck head in the engine room above the main engine (Figure 4) 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) were measured on the Bridge near the helmsman's position (Figure 5) for all seakeeping trials 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 and adjusting the location of the LCG for the weight of the six person trials team, the vessel CG is:

TCG: 0.0 m
LCG: 2.045 ft. (0.623 m) aft of midships
VCG: 9.022 ft. (2.750 m) above the baseline

The position relative to the center of gravity for each instrument is as follows:

MotionPak: 0.469 m aft, 0.508 m Port, and 0.344 m above the CG.
Accelerometers: 4.217 m fwd, 0.140 m Starboard, and 3.574 m above the CG.

The above values are included (in units of inches) on General Arrangement drawings in Appendix B.

Two inclinometers (Figure 5) used to measure pitch and roll angle were also mounted on the table in the Dry Lab 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.

4.5 Differential Global Positioning System Data

The Global Positioning System (GPS) is a satellite based navigation system operated and maintained by the US Department of Defense. 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 7.

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 secured to an existing ship's davit support bracket situated on top of the deckhouse, port side (Figure 6). Once the antenna was visually aligned parallel to the ship's longitudinal centerline (1.42 m forward, 2.33 m Port, and 4.77 m above the vessel's CG), the system software was initiated by having the vessel perform multiple 360 degree rotations in the harbour.

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

4.6 Directional Wave Buoy/Mooring Arrangement

The MUN Neptune Sciences, Inc. directional wave buoy used for other trials in the Fishing Vessel Research Program was unavailable for the 'Shamook' seakeeping trial in December. To acquire 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 the ’Shamook, 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 47º 34’ 17” N, 52º 26’ 13” W – about 10 nm east of St. John’s. Directional wave data was computed hourly and transmitted to the ship at a frequency of 29.760 MHz with an output power of 150 – 200 mW. The high visibility yellow (Figure 7) 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 7) weighing a total of 1400 lbs. (635 kg).

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 installed on the ‘Shamook’ consisted of a passive 3 m long (Kathrein) whip antenna with base mounted on the port side of the forward railing above the wheelhouse (Figure 6). 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). Power for both the laptop and receiver was furnished through the IOT UPS.

A photograph of the moored wave buoy is given in Figure 8. The specifications for the buoy, the mooring description and a typical output data file are provided in Appendix E. Additional information on the buoy can be obtained from the Datawell b.v. web site (Reference 8).

4.7 Propeller Shaft Speed

Propeller shaft speed was measured using an optical sensor acting on a piece of reflective tape on the shaft just aft of the engine in the engine room (Figure 9). 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. This instrumentation was calibrated using

a laser tachometer that acted on the reflective target, which was then verified using the vessel's RPM gauge.
Since the 'Shamook' has a CP propeller, the recorded shaft RPM values were virtually constant. Note the propeller pitch angle was not measured due to the difficulty in acquiring a quality signal.

4.8 Wind Anemometer

Since the 'Shamook' was fitted with a directional anemometer for monitoring ambient wind speed and direction, it was not necessary for IOT to install the MUN trials anemometer. The 'Shamook' is fitted with a Young Wind Tracker (Figure 10) providing a digital output of relative wind speed (knots) and nominal direction relative to the ship (i.e. 000' wind direction is wind coming from the bow of the ship). Wind speed and direction were logged manually at the beginning of each run during the seakeeping trials.

4.9 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 of cable connecting the two (Figure 11). The required information, i.e. temperature and salinity, is collected by the probe and presented on the hand held display with an accuracy of ± 2% or ± 0.1 PPT (parts per thousand) for salinity and ± 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 (~ 1.5 m) roughly amidships. The density is then calculated using the Equation of State of Seawater given in Reference 9, which provides density as a function of temperature, salinity, and pressure. Note that 1.5 m depth of water is approximately equivalent to 15 kPa of pressure. Additional information on the YSI instrument is provided in Reference 10.

4.10 Electrical Power

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

4.11 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 adjacent to the unit designed to accommodate the DAS in the Dry Lab therefore the distance for cable connection was short. The cable to the tri-mounted accelerometers was fed up the stairway outside the Dry Lab to a shelf supporting the ship's gyrocompass at the top of the stairway just aft of the Bridge – so also not a long cable run. The cable to the MotionPak was fed through an existing opening in the aft bulkhead of the Dry Lab to the Wet Lab, out a second existing opening in the aft bulkhead of the Wet Lab and through an open access hatch down the adjacent stairway into the engine room (the hatch into the engine room was kept open throughout the trial). This cable was then run along the deck head to the desired location above the main engine. The cable for the shaft RPM was run from the DAS to the engine room following the same route as the MotionPak cable – terminating at the propeller shaft aft of the main engine.

In addition, one cable was installed to accommodate the yo-yo potentiometer used to measure the rudder angle and azimuth rate. This cable was run from the DAS to the engine room bundled together with the MotionPak and shaft RPM cable. From the engine room, the cable was fed through an existing gland in the aft bulkhead of the engine room into the store room, and on through an existing gland in the aft bulkhead of the store room into the tiller flat to the rudder stock location.

The DGPS antenna was secured to an existing ship's davit support bracket situated on top of the deckhouse, port side. Cabling to this unit was installed down the external aft bulkhead of the deckhouse and into the Wet Lab - bundled together with IOT cables routed from the engine room.

For the wave buoy, a single coax cable (RG 213 U) was routed from the antenna mounted on the port side of the forward railing above the wheelhouse down the aft external bulkhead of the deckhouse to the wave direction receiver installed on an existing table in the Wet Lab on the port side of the vessel immediately aft of the IOT DAS location in the Dry Lab.

5.0 TRIALS DESCRIPTION

The seakeeping trials were completed on December 15, 2003 in nominally 165 m of water 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. Note that the drafts were measured with the wave buoy and buoy mooring/anchor weight on board so a more accurate trials draft is assumed to have been measured during the inclining experiment carried out by Poseidon

Marine Consultants Ltd. after completion of the trial - after the wave buoy and associated equipment had been removed from the vessel. 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.

Upon arrival at the wave buoy location, the sea conditions were found to be very favorable for the experiment. Staff from Oceans Ltd. supervised the launch of the directional wave buoy at position 47º 34' 17" North and 52º 26' 13" West. The significant wave height was recorded at a nominal two meters throughout the day with winds light at 10 -15 knots from the west. The data obtained from the wave buoy indicated that the dominant wave direction was coming generally from the north.

A total of ten forward speed runs were carried out; five at 4 knots in head, following, bow, beam and quartering seas, and five at 8 knots in similar directions. Data for an additional run at zero forward speed in a beam sea was acquired at the start of the day and between the two sets of forward speed runs. This drift test was carried out to estimate the magnitude and direction of the resultant wind, wave and current vector acting on the ship. Several cm of water were noted sloshing around on the quarterdeck for many of the runs – especially in beam seas runs. A run log is provided in Appendix F.

During the trial, research was being carried out in the ship's Wet Lab by MUN Kinesiology[1] staff. The Kinesiology experiments consisted of measuring various parameters on an instrumented student while the student performed tasks primarily consisting of lifting and moving known weights. The approximate position of the Kinesiology research relative to the CG was as follows: 3.730 m fwd., 1.458 m to port, and 0.969 m above.

<u>Typical Set of Forward Speed Seakeeping Runs:</u>

The test plan for these trials is given in Appendix G. Each set reflected the recommended ITTC run pattern and was observed 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 21.1 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

[1] Dr. Scott MacKinnon, Assistant Professor, MUN Human Kinetics Faculty & student

initiated once steady state conditions were achieved. The course during all runs were 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 propeller pitch 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 propeller pitch 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 propeller pitch 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 propeller pitch 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 using the same procedure as was used for the 4 knot runs.

The dedicated trials team included:

- MUN Project Engineer – data acquisition and verification
- MUN co-op student – data acquisition and verification
- one IOT electronics staff – support in the event of problems with equipment at sea
- one Oceans Ltd. staff member responsible for the operation of the wave buoy
- two MUN Kinesiology researchers

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. Once logged the raw data was calibrated, using the custom software FishingVesselCal, into a usable format with relevant physical units and transferred to the second computer. The second computer was used to analyze the data to assess its integrity. Two identical laptop computers were used to avoid overloading the computer logging the data, which could have led to program failure and therefore undoubtedly resulted in incomplete or even lost data.

Columns of acquired data were converted to MicroSoft EXCEL[2] format and standard EXCEL plotting utilities were used to view the data in the time domain. An example time series plot of heave acceleration along with pitch and roll angle experienced during the 8 knots head seas run is provided in Figure 12.

7.0 DESCRIPTION OF OFFLINE DATA ANALYSIS

Once the trial was complete, it was then necessary to inspect the acquired data more closely. The following example time series plots for all channels from the 4 knots, beam seas run, illustrate the preliminary stages of the offline analysis:

Figure 13: Surge, Sway, and Heave Displacement vs. Time
Figure 14: Surge, Sway, and Heave Velocity vs. Time
Figure 15: Surge, Sway, and Heave Acceleration vs. Time
Figure 16: Pitch, Roll, and Yaw Angle vs. Time
Figure 17: Pitch, Roll, and Yaw Rates vs. Time
Figure 18: Pitch, Roll, and Yaw Acceleration vs. Time
Figure 19: Shaft Speed and Rudder Angle vs. Time
Figure 20: COG, SOG vs. Time

7.1 Wave 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 the ship.

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

[2] © MicroSoft Corp.

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.

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 21.1 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 H. Nondirectional spectrum plots as well as Mean Wave Direction (corrected to degrees TRUE) versus Frequency plots are also provided in Appendix H for each 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 voltage differential. 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 for each instrument generated in the electronics lab at IOT (with the exception of the shaft RPM and rudder angle channels calibrated on the vessel), and instrument offsets were recorded. A summary of the calibration file along with the regression equations is provided in Appendix D.

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 motions data acquired, the motions were moved from the location of the MotionPak to the accelerometers located just aft of the Bridge and then analyzed in the “Body” fixed coordinate system. During this process, it became evident that there was a problem with the acquired motion data. The MotionPak motions computed at the accelerometer position were over predicting the motions that the tri-mounted accelerometers were measuring. Further investigation indicated that there was an intermittent glitch in the MotionPak sway accelerometer data. This anomaly was most prominent in the beam seas, as illustrated in Figure 21. With an unreliable accelerometer signal from the MotionPak, the accelerations measured using the tri-mounted accelerometers, along with the angular rates measured by the MotionPak were used to predict the motions at the center of gravity of the ‘Shamook’. Furthermore, a low pass filter (2.5 Hz) was used on all MotionPak rate channels to smooth out the noise caused by vibrations from the ship’s engine room contaminating the data.

For validation of the MotionPak software, the motions were translated from the accelerometer position to the MotionPak position. The comparison of the accelerations is given in Table 1 for the 8 knots beam seas run. It can be seen from the values of standard deviation that the accelerations recorded were very similar for the surge and heave accelerations. However, due to the glitch in the MotionPak sway accelerometer, there is a large difference for the sway accelerations.

Instrument	Parameter	Unit	Mean	St. Dev.	Min.	Max.
Accelerometer	Surge Accel.	(m/s^2)	0.376	0.116	-0.074	0.835
MotionPak	Surge Accel.	(m/s^2)	0.548	0.116	0.120	0.999
Accelerometer	Sway Accel.	(m/s^2)	0.020	0.695	-3.053	2.390
MotionPak	Sway Accel.	(m/s^2)	0.459	0.997	-3.820	3.626
Accelerometer	Heave Accel.	(m/s^2)	0.010	0.493	-1.549	2.025
MotionPak	Heave Accel.	(m/s^2)	0.046	0.515	-2.043	2.147

Table 1: MotionPak Validation

Note that a comparison between the MotionPak angular data and the inclinometer data was not considered valid 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 experiment, the accelerations from the tri-mounted accelerometers and the rates from the MotionPak were used to compute the motions at two positions on the vessel: the vessel's center of gravity and position of the MotionPak.

The following table is a summary of standard deviations at the ship's CG obtained from the experiment. Note that run Drift A was acquired in the vicinity of the wave buoy prior to the 4 knot run set, while run Drift B was acquired between the 4 knot and 8 knot run sets. Tables of basic information, peak response frequency for roll angle, pitch angle and heave acceleration as well as basic statistics (average, standard deviation, minimum and maximum) for each run are provided in Appendix I.

Speed (kts)	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	Drift A	4.723	1.483	9.285	0.187	0.249	0.426
0	Drift B	4.405	1.519	13.784	0.186	0.226	0.355
4	Head	1.592	2.174	1.509	0.211	0.124	0.595
4	Bow	2.719	1.910	2.191	0.201	0.233	0.617
4	Beam	4.717	0.906	1.899	0.110	0.297	0.438
4	Quartering	4.463	1.264	2.211	0.186	0.211	0.325
4	Following	2.444	1.560	2.269	0.230	0.114	0.233
8	Head	1.295	2.050	0.959	0.190	0.133	0.855
8	Bow	3.226	1.580	1.295	0.168	0.258	0.791
8	Beam	4.084	0.871	1.120	0.112	0.283	0.509
8	Quartering	2.549	1.235	1.439	0.197	0.172	0.306
8	Following	1.475	1.248	1.604	0.191	0.093	0.228

Table 2: Standard Deviation of Motions

A plot of roll angle, pitch angle and heave acceleration standard deviation vs. heading is provided in Figure 22 and Figure 23 for the 4 knot and 8 knot run sets respectively.

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 (run Drift A) in an effort to determine the roll and pitch period. The following values of the spectral peak were output:

Roll Period: 6.0750 s
Pitch Period: 3.9405 s

8.0 DISCUSSION & RECOMMENDATIONS

The seakeeping trial carried out on 'Shamook' was considered a success. The following is a series comments on how the trial was executed with recommendations on how to improve the quality of data collected.

<u>Ballasting Efforts:</u>

Due to the lack of significant available cargo space on the 'Shamook', there was limited flexibility in ballasting the vessel. Retaining the equipment from the previous science trip and topping up fuel and water tanks was assumed to render the vessel in a typical operational loading condition however. Getting an accurate measurement of vessel draft upon departure for the trials area was not feasible due to the fact that the Datawell wave buoy and 1400 lb anchor were on deck. Thus the trials displacement condition derived by Poseidon during the inclining experiment carried out December 18th is deemed to be a more accurate reflection of the trials condition.

Salinity Readings:

Salinity readings were taken ~ mid-draft/midships prior to departure from port, at the wave buoy location as well as after return to port as noted in the Run Log (Appendix F). A maximum difference in water density between St. John's harbour and the trials area in the order of 1 kg/m^3 was noted – not enough to warrant a correction to the measured drafts. Although the water density was not measured during the inclining experiment carried out on December 18th, it is assumed that there was a minimal change from the measurements taken after the trial. It is recommended that in future, however, that if the drafts of record are noted during an inclining experiment after completion of the trial, then the water density should also be determined at this time.

'Shamook' Drawings:

It was noted that on the CAD drawings of the 'Shamook' supplied by the CCG, the reference for the frame spacing was different for different views (decks) of the general arrangement drawings resulting in confusion as well as errors and delays in completing the data analysis. The longitudinal distances on one view were different when determined from a different view. It is recommended that caution be exercised in future when relying on information from external sources.

Wave Buoy Issues:

Although the Datawell buoy performed well during the trial, it was noted that the relatively heavy buoy and anchor were difficult to handle on the moving deck of a small vessel although the 'Shamook' has more than sufficient crane lift capacity. Ocean's staff expressed some concern as to whether the buoy could be launched/recovered safely even though the seas were only ~ 2 m SWH. The wave buoy operators were also concerned about recovering the buoy in darkness. If a Datawell wave buoy is to be considered as a primary or secondary directional wave measurement tool for future trials:

1) There is a possibility that the Oceans Ltd. buoy may not be available in the time frame required and an alternative may have to be used; and
2) It is unlikely that for a future trial on a small fishing vessel, the subject vessel will have the required crane equipment to safely launch/recover the buoy especially in a heavy sea and thus the services of a dedicated buoy tending vessel would have to be retained at considerable additional expense.

An alternative wave measurement strategy worth investigating that may reduce the overall risks associated with acquiring directional wave data during seakeeping experiments on small vessels involves using one of the X-band radar interfaced wave measurement tools recently developed although this would likely be an expensive and technically complex option. Example systems are described in References 11,12.

<u>MotionPak Issues:</u>

The intermittent signal fluctuation on the sway MotionPak channel during the Shamook Sea Trial was traced back to the IOTech DBK45 card used in the data acquisition system. From looking at the data, it appears that this intermittent glitch was taking place in the amplification or filter section of the DBK45 card. Upon reassembly of the DAS system, it was not possible to reproduce this signal fluctuation. The DBK45 card was visually inspected, and the channel in question extensively tested, but seemed to work fine. It may have been a module seating problem, since during the trouble shooting process, filter modules were extracted, inspected for fabrication flaws, and reseated in their on board IC sockets. As a further check, the MotionPak and associated cabling was also reassembled and powered up without problems. This check ruled out any transducer or cabling issues for this channel.

The MotionPak is one of the most important pieces of instrumentation used for a seakeeping trial. Similar to the wave buoy on this trial, without an operational MotionPak, the sea trial would have limited success. That is why performing a high level QA on the device is very important. Performing the necessary equipment checks before, during, and after a set of experiments, however does not always uncover malfunctions in the hardware. Therefore, it is recommended that for future seakeeping trials, a tri-mounted accelerometer unit be installed on the vessel along with the MotionPak for hardware and software validation. After a sea trial and before the gear is to be removed from the vessel, validation of the MotionPak with the stand-alone accelerometers should be performed to ensure a properly working instrument.

If a problem or glitch is noted in the data during or after the trial, the MotionPak should be replaced with either another MotionPak or a combination of rate gyros and accelerometers, and the sea trial should be repeated. If validation cannot be done on site, then two MotionPaks should be installed on the vessel to reduce the risk of faulty equipment.

It is IOT standard practice to fit the MotionPak as closed as possible to the vessel's CG. In some cases, however, this means that the MotionPak will be in close proximity to the vessel's engine(s) or other sources of vibration. If this is the case, high frequency noise may contaminate measured signals and post-filtering may be required. The resonance can easily be handled by passing the data through a low-pass filter before post processing.

<u>Rudder Rate</u>:

Offline analysis of the rudder rate channel uncovered a faulty filter module in which one end of a resistor was not properly welded within the module. This introduced a sinusoidal response to the channel. Although the channel passed all calibration tests before the sea trial, the resistor became unattached sometime before the beginning of the first sea trial run. Since the rudder rate was not an essential channel, it was not monitored with the same scrutiny as other channels. In the future, all channels, essential or non essential, should be monitored with the same amount of importance. Regardless of this, the problem was within the tiny filter module and the problem could not have been identified onboard the ship.

<u>Water on Deck:</u>

There was a significant amount of water accumulating on the quarterdeck throughout the trial – especially in beam seas runs.

Water collected on deck due to the fact that:

- There was no bulwark across the stern of the vessel on the main deck;
- the freeing ports did not appear to operate properly; and
- water came over the side bulwarks especially in beam seas

Water on deck results in a varying change in displacement as well as the static and dynamic stability attributes that are impossible to quantify. The static stability is influenced not only by the weight of water on the deck but also the impact of the free surface. The water on deck will no doubt complicate the effort to correlate the trials data with the output from any numerical model. To mitigate the influence of water on deck during future seakeeping trials, it is recommended that the freeing ports be inspected and repaired if necessary to ensure their effective operation.

9.0 ACKNOWLEDGEMENTS

The authors would like to thank Capt. Bruce Thorne and the crew of the CCGS Shamook for their enthusiastic support during the trial, R. Fitzgerald of Oceans Ltd. for support to acquire directional wave data, and IOT technical staff for their efforts throughout the planning and execution of the trial. Support from Oceanic Consulting Corp. for transport support and the Offshore Safety and Survival Centre (OSSC) for Marine Emergency Duty (MED) survival training for IOT staff 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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12) MIROS A/S web site describing the SM-050 Motion Compensated Directional Wave and Surface Current Radar: www.miros.no January 2004.

Figures

Figure 1: CCGS Shamook

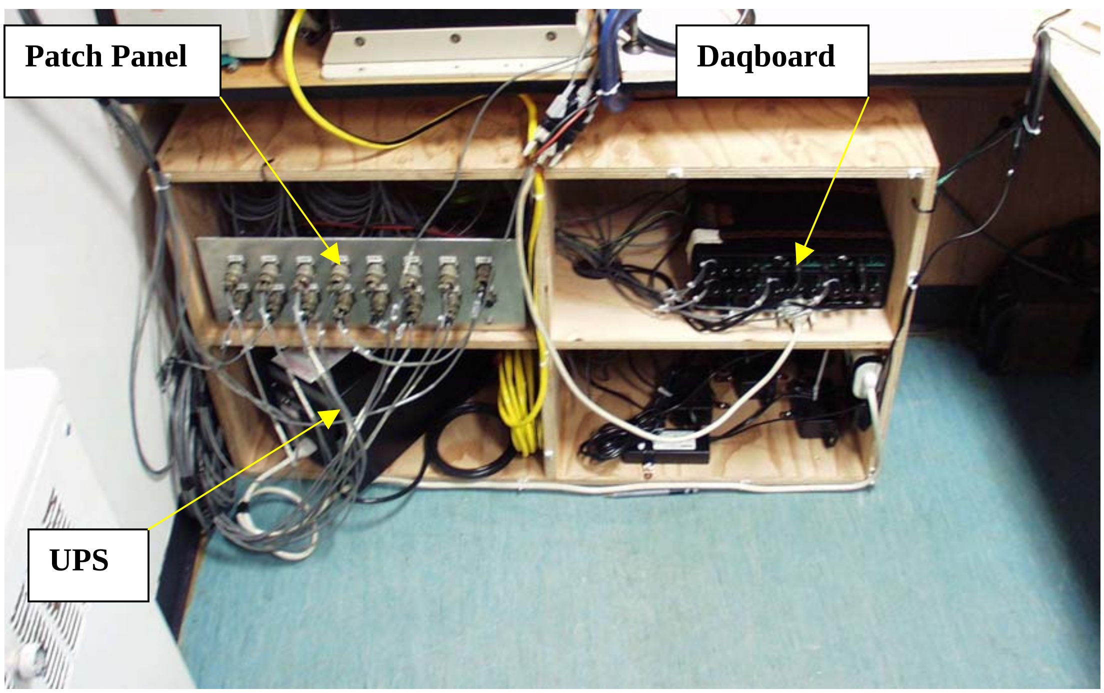


Figure 2: Data Acquisition System Components on Deck against aft bulkhead – Dry Lab
Two DAS Laptops were secured to table – Dry Lab forward.

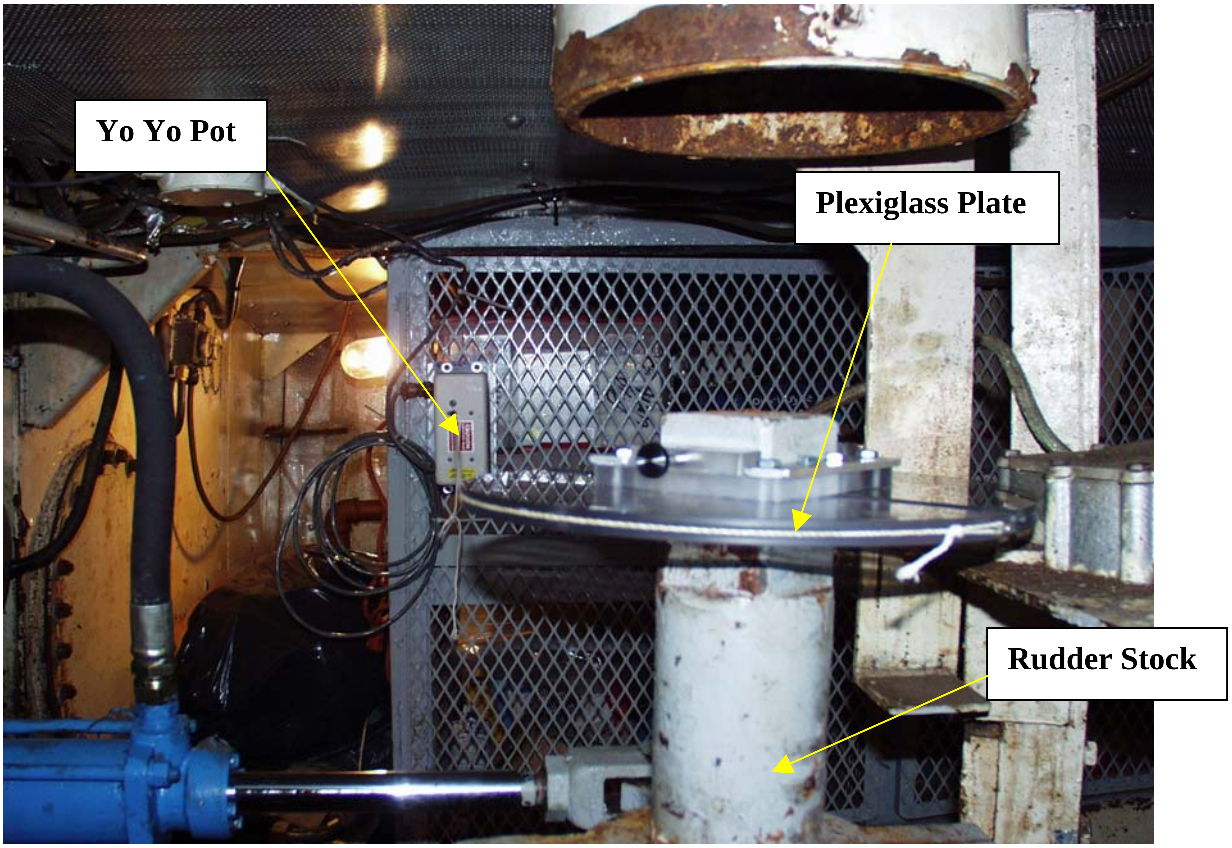


Figure 3: Rudder Angle Measurement

Figure 4: MotionPak I Installation in Engine Room

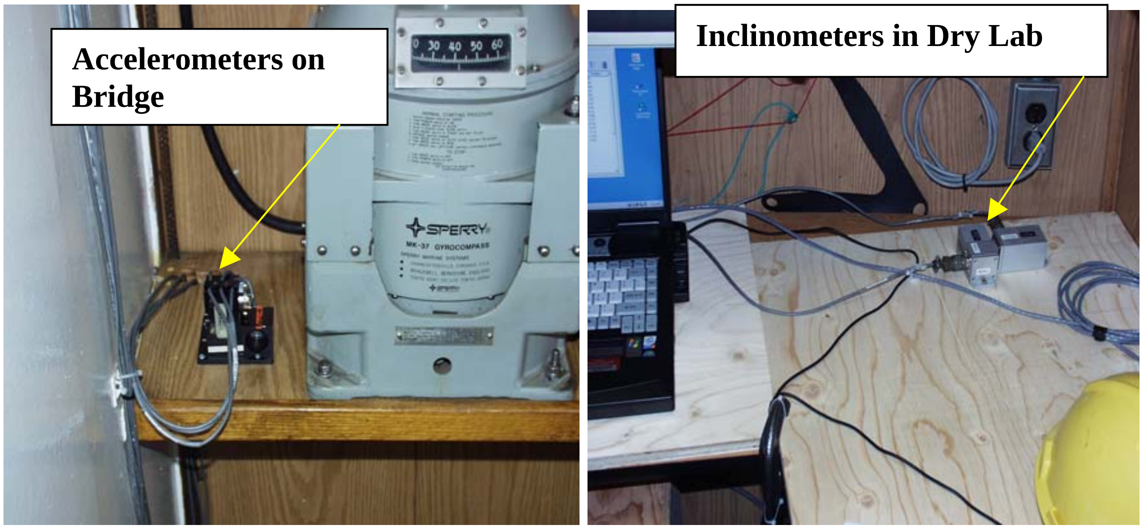


Figure 5: Accelerometers Inclinometers

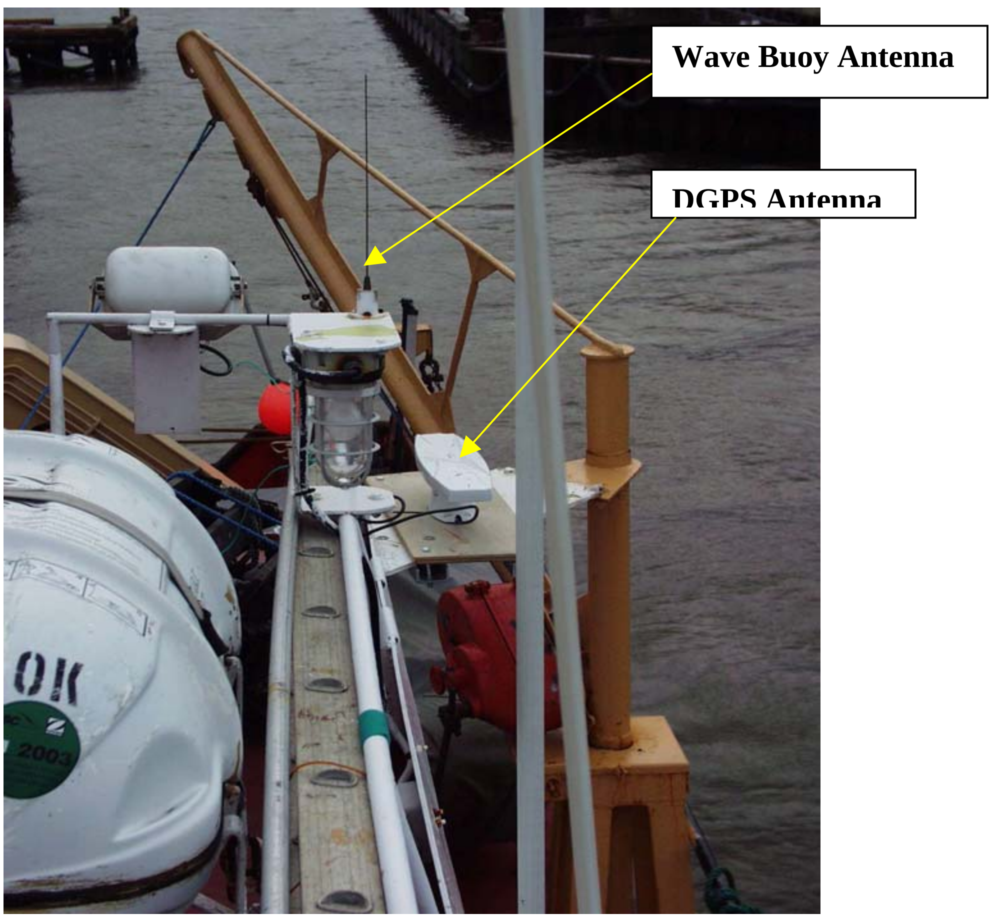


Figure 6: DGPS Antenna Mounting

Figure 7: Datawell Directional Wave Buoy & Anchor

Figure 8: Datawell Wave Buoy Deployed

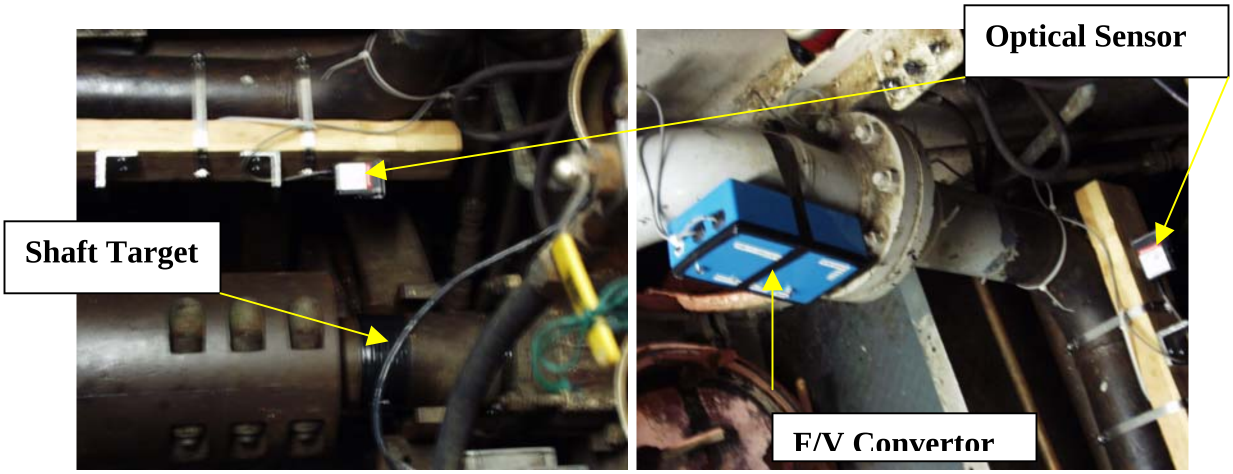


Figure 9: Shaft RPM Instrumentation

Figure 10: Shamook's Directional Anemometer

Figure 11: Water Density Instrumentation

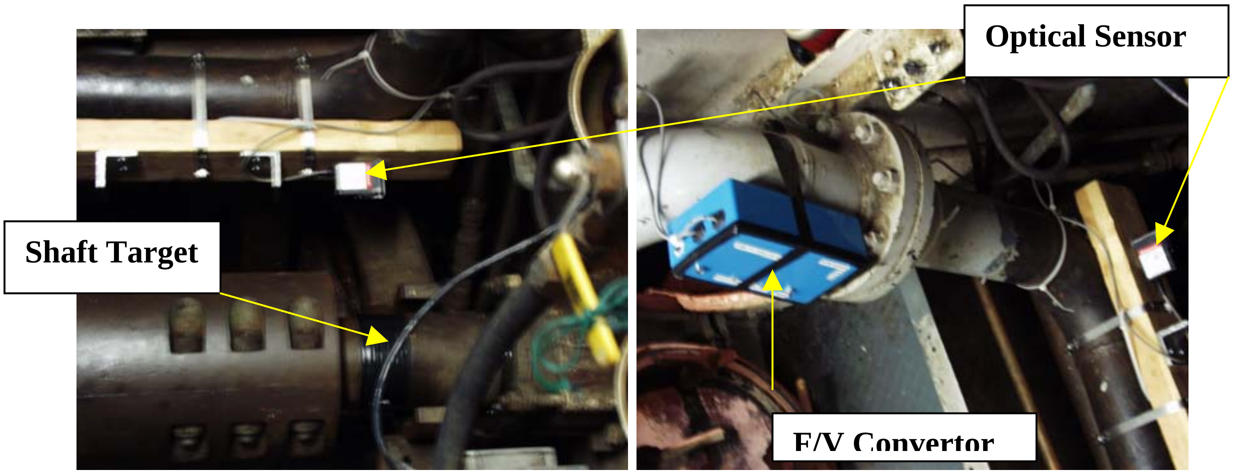


Figure 9: Shaft RPM Instrumentation

Figure 10: Shamook's Directional Anemometer

Figure 11: Water Density Instrumentation

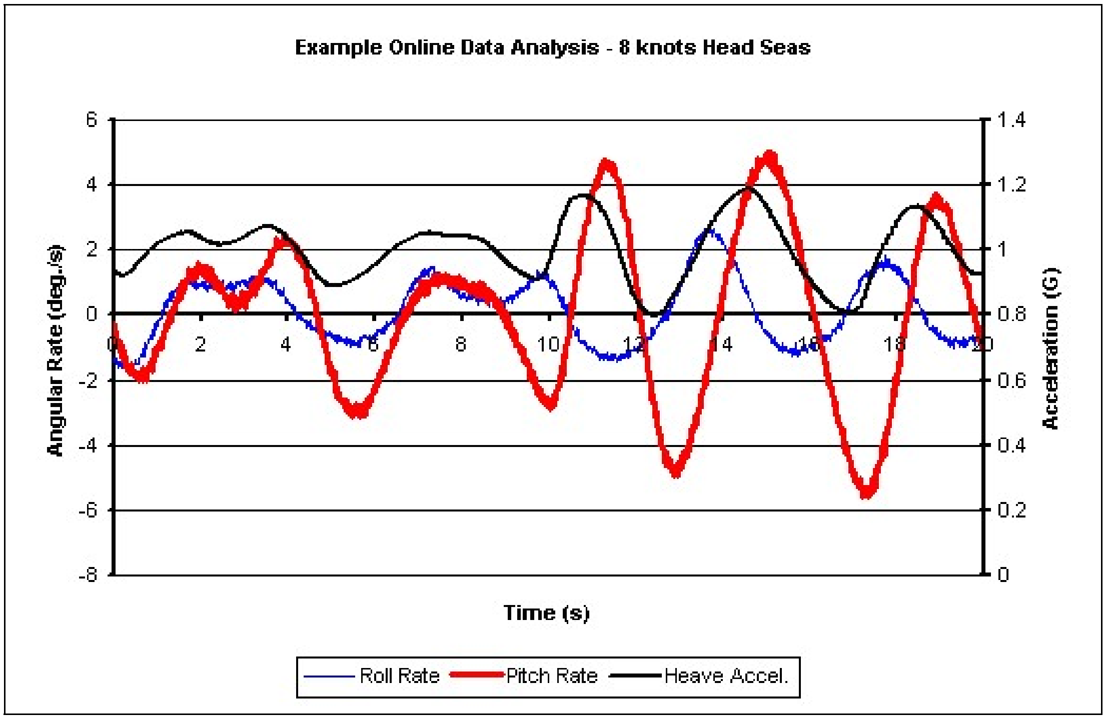


Figure 12: Example Online Data Analysis

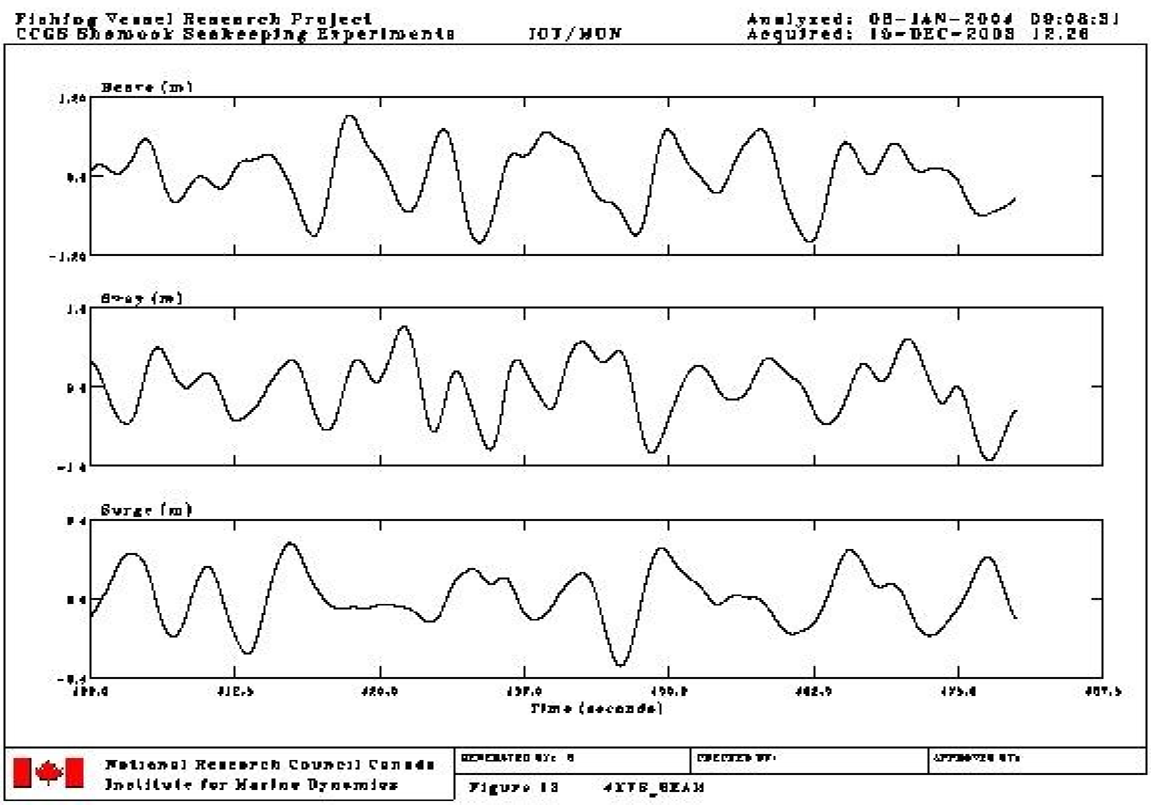


Figure 13: Offline Data Analysis – Surge, Sway and Heave Displacement

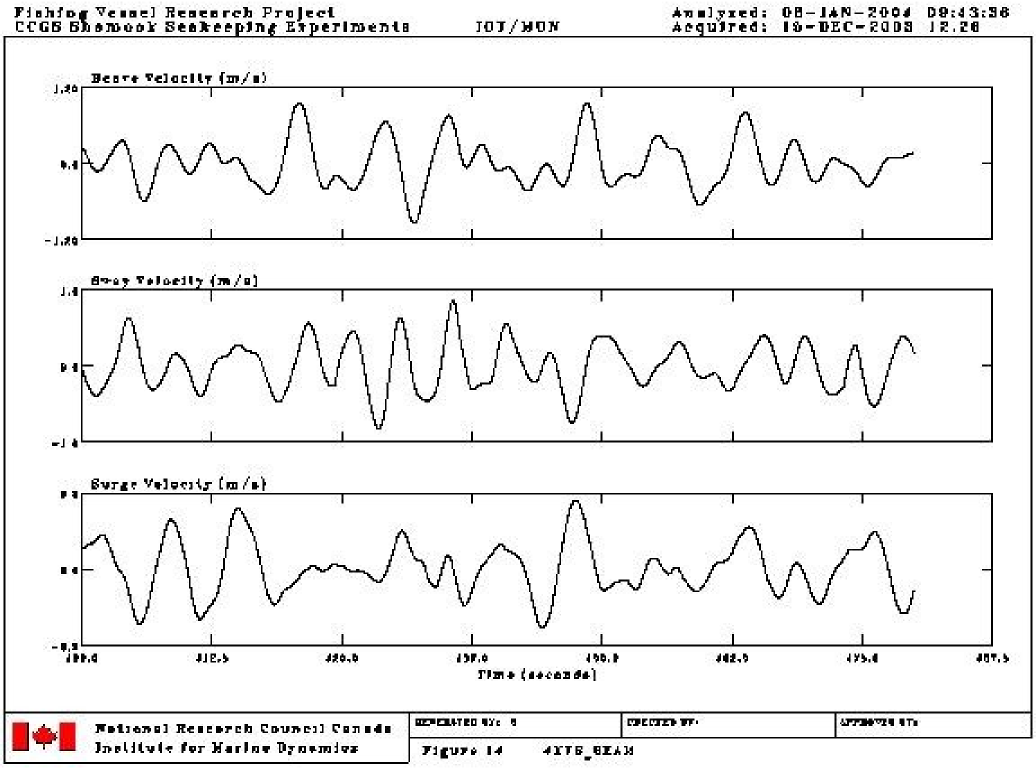


Figure 14: Offline Data Analysis – Surge, Sway and Heave Velocity

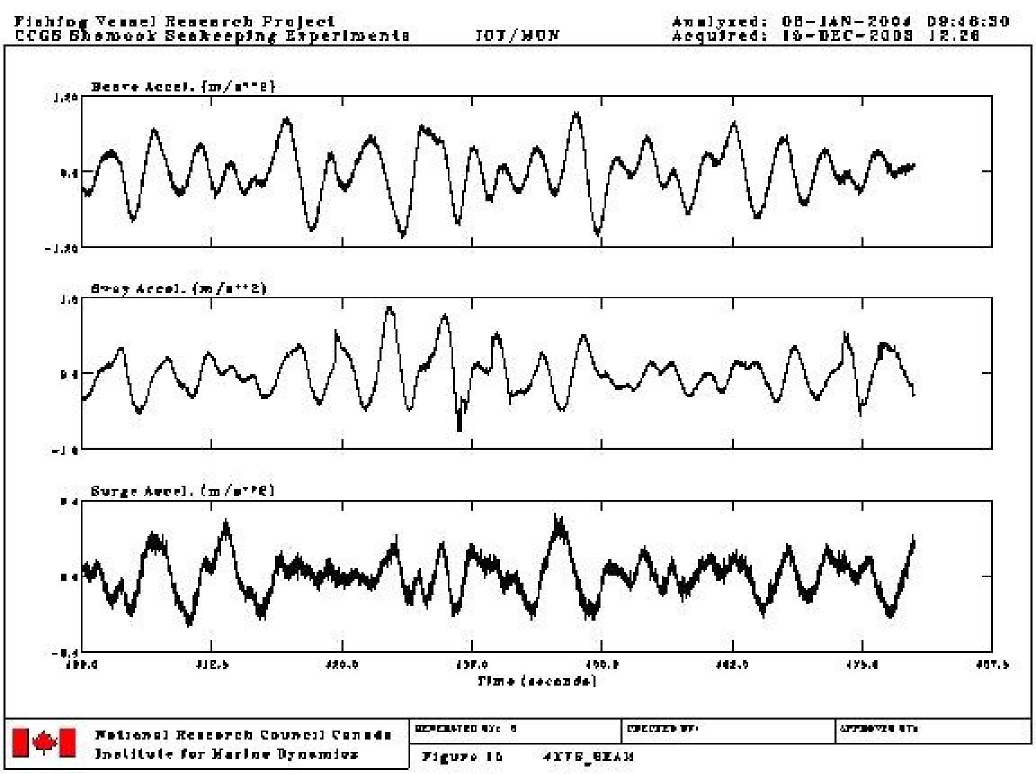


Figure 15: Offline Data Analysis – Surge, Sway and Heave Acceleration

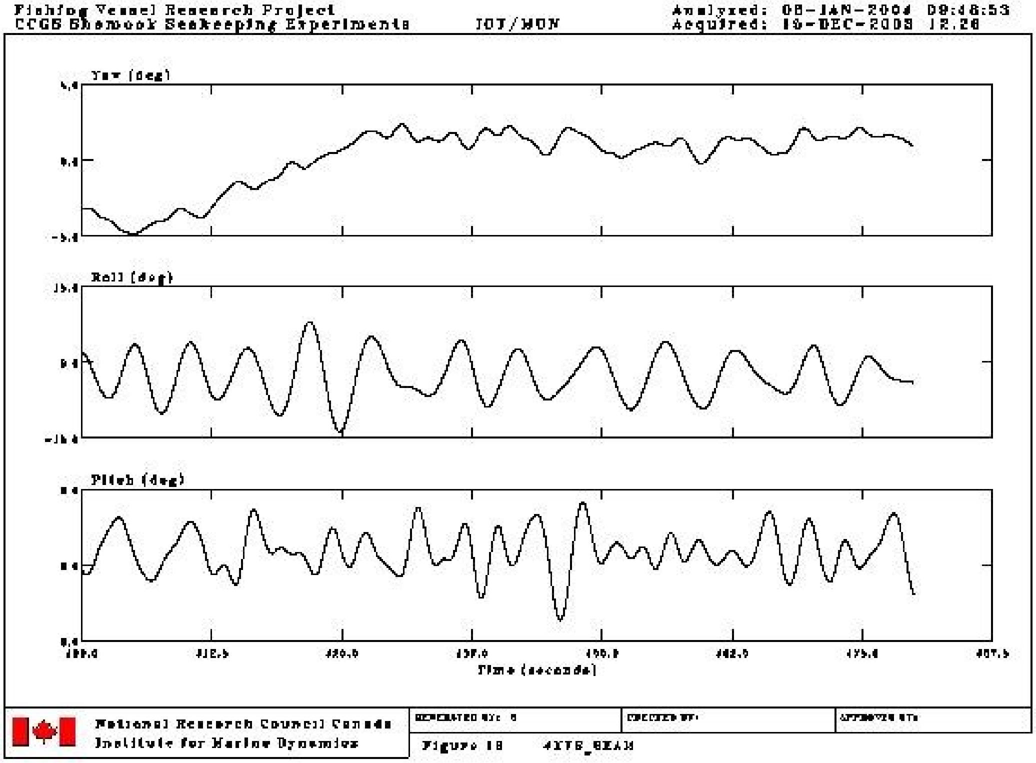


Figure 16: Offline Data Analysis – Pitch, Roll and Yaw Angle

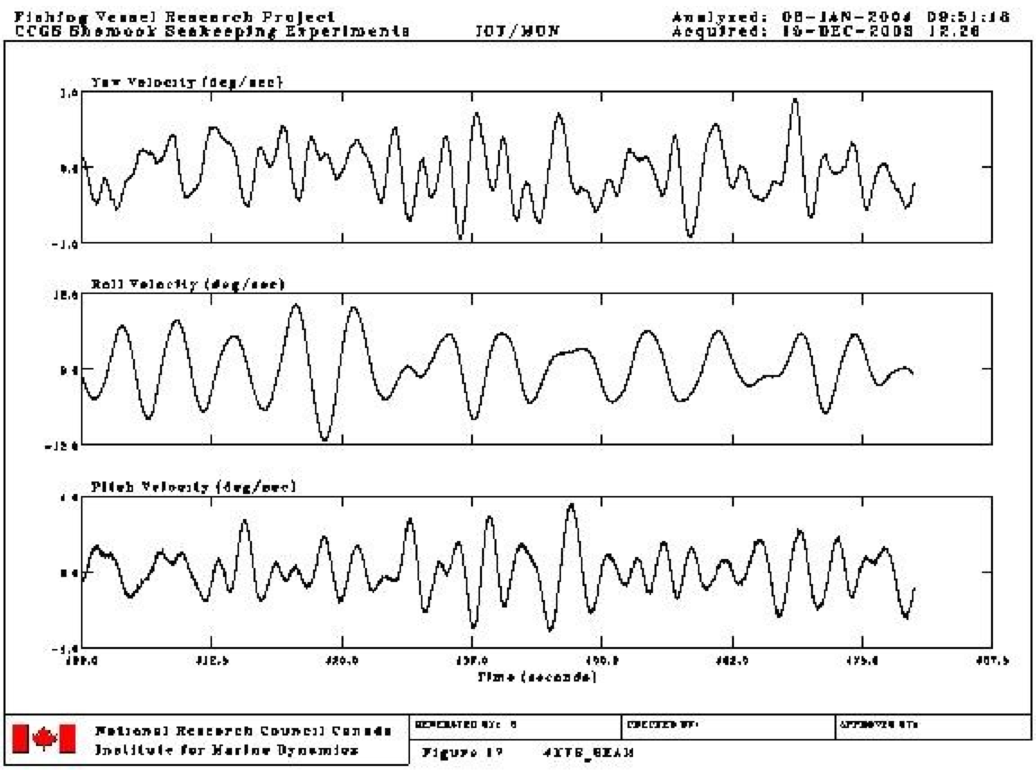


Figure 17: Offline Data Analysis – Pitch, Roll and Yaw Rate

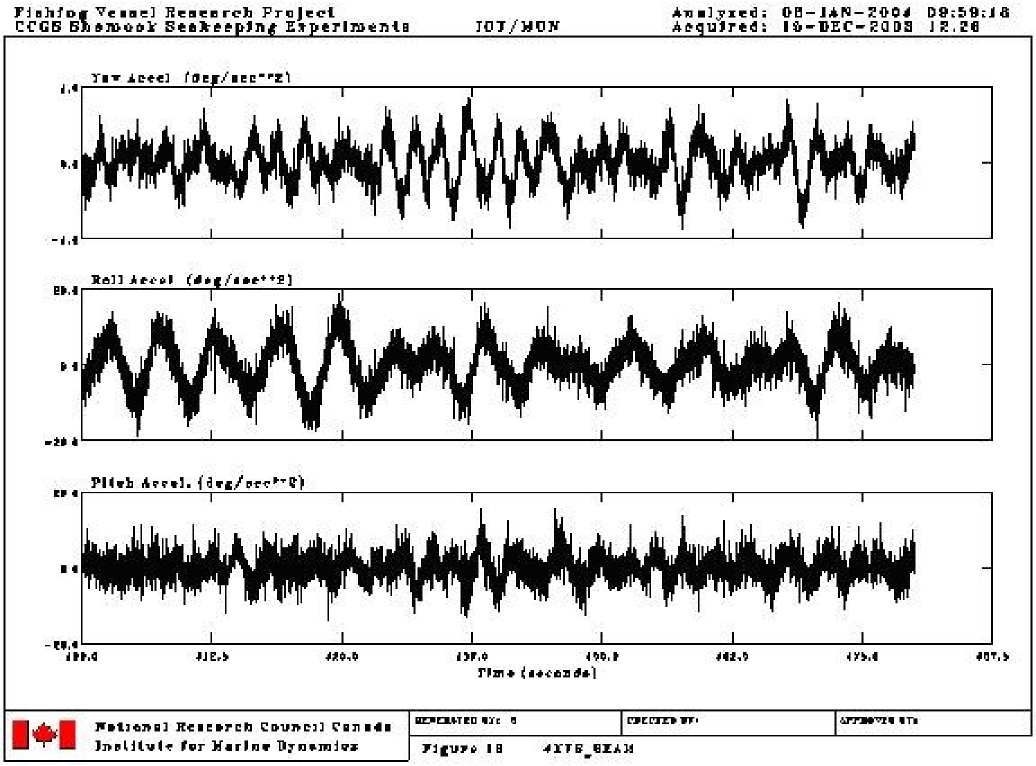


Figure 18: Offline Data Analysis – Pitch, Roll and Yaw Acceleration

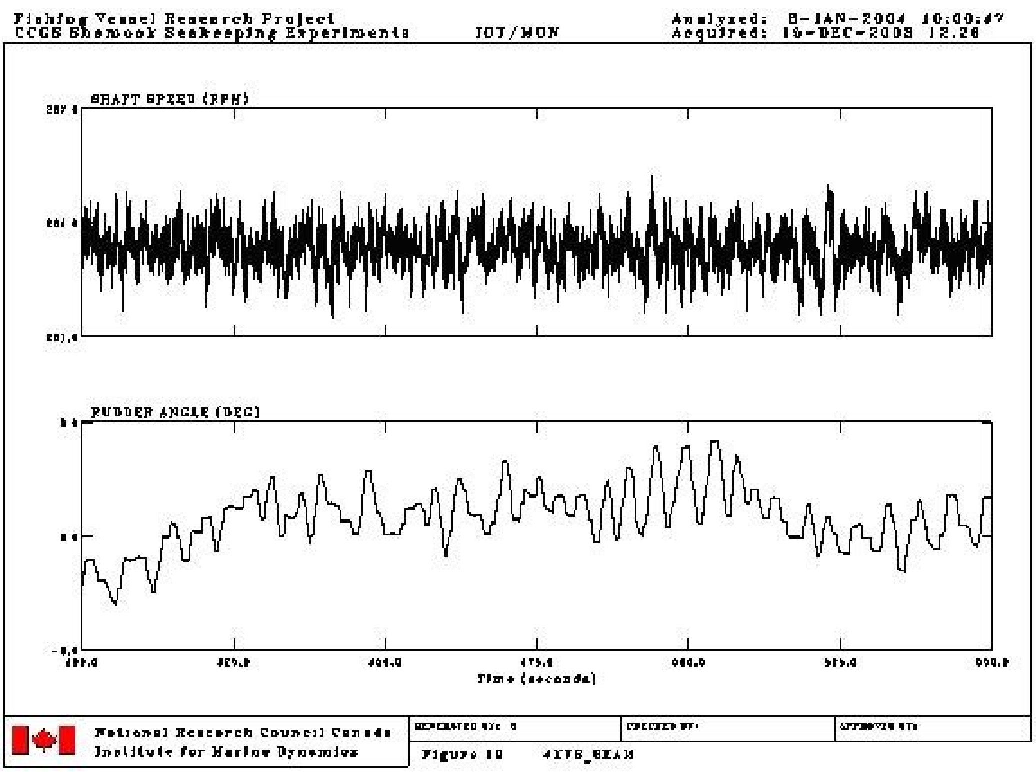


Figure 19: Offline Data Analysis – Shaft Speed and Rudder Angle

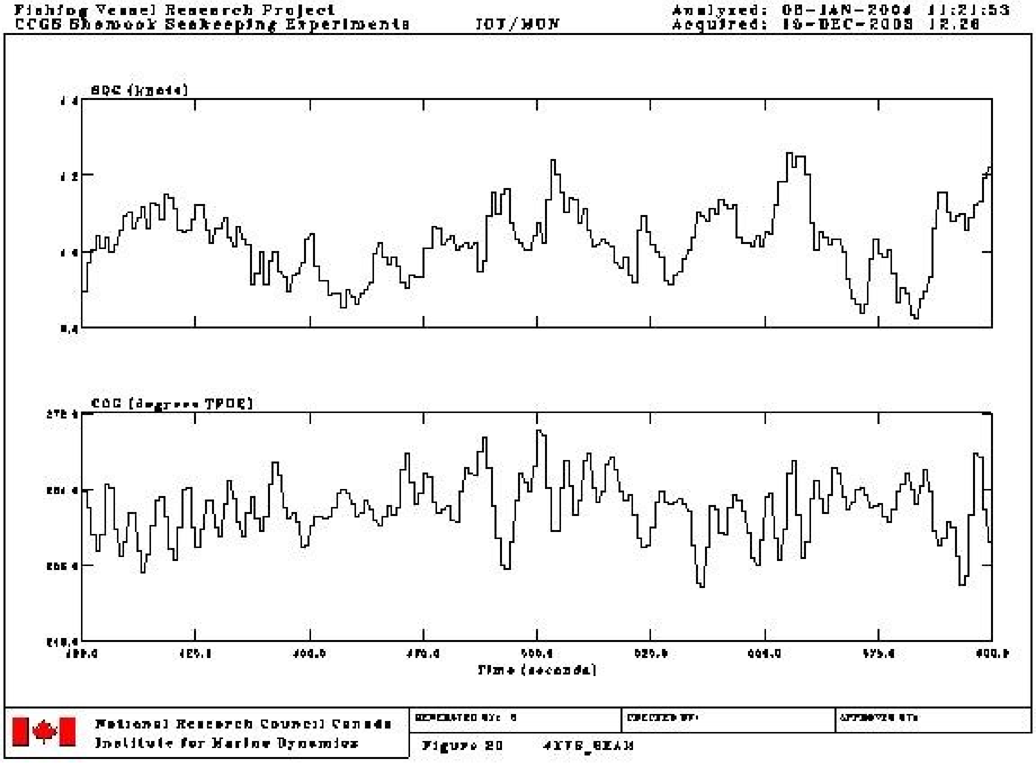


Figure 20: Offline Data Analysis – COG, SOG

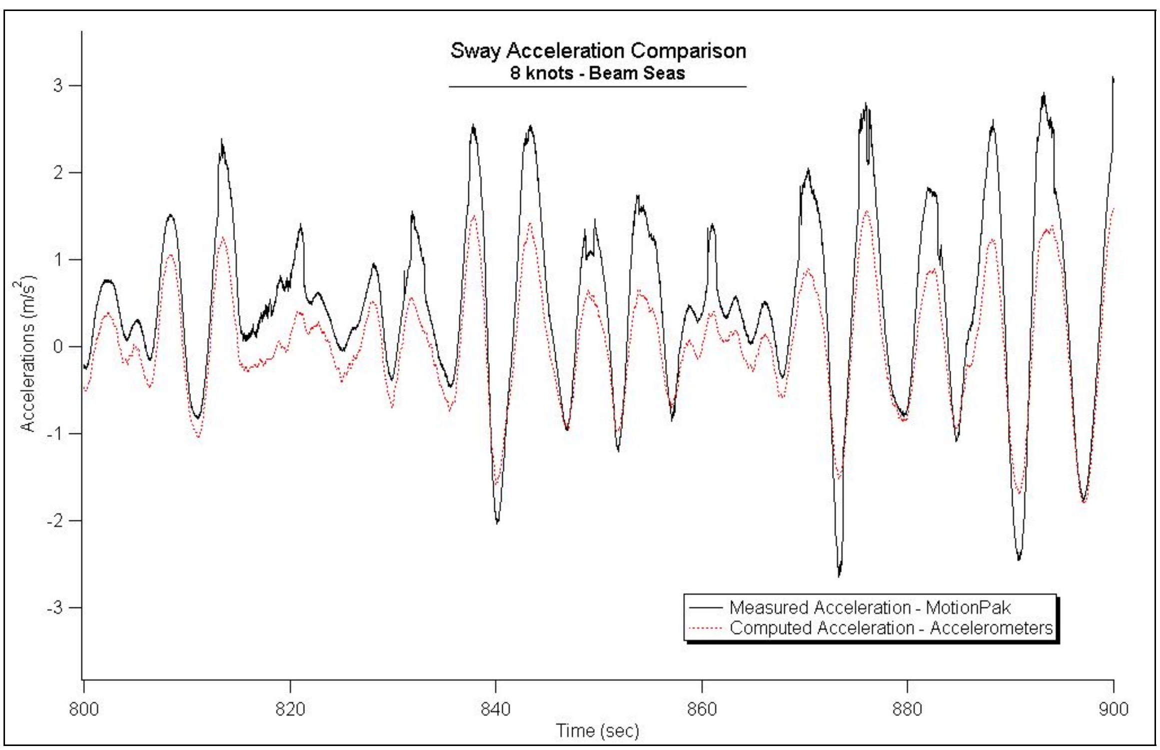


Figure 21: Sway Acceleration Comparison

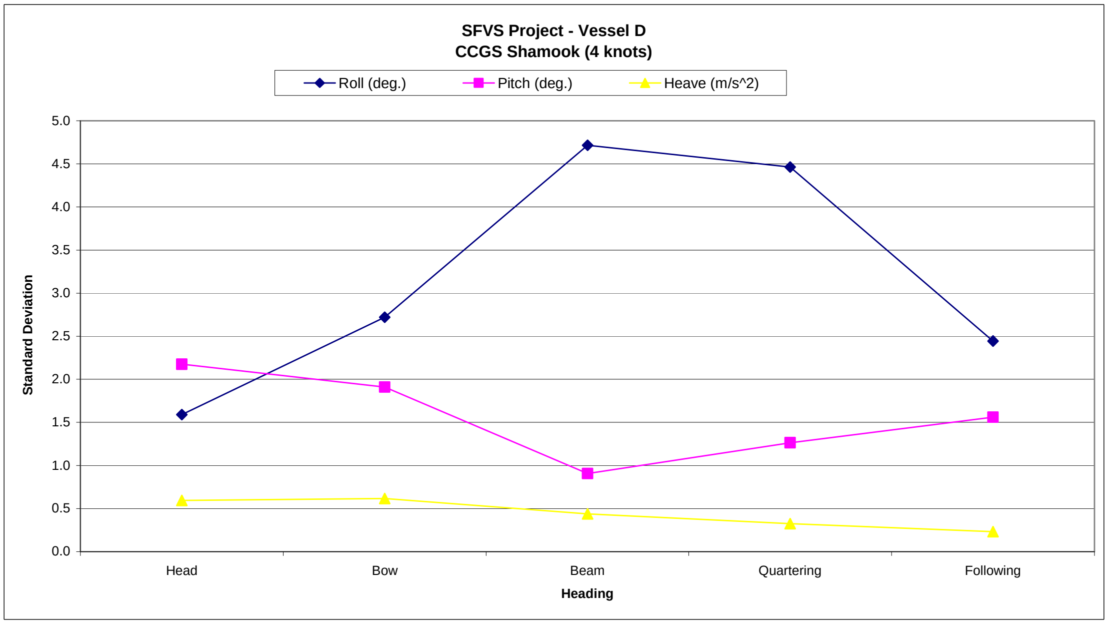


Figure 22: Offline Analysis – Standard Deviation vs. Heading (4 knots)

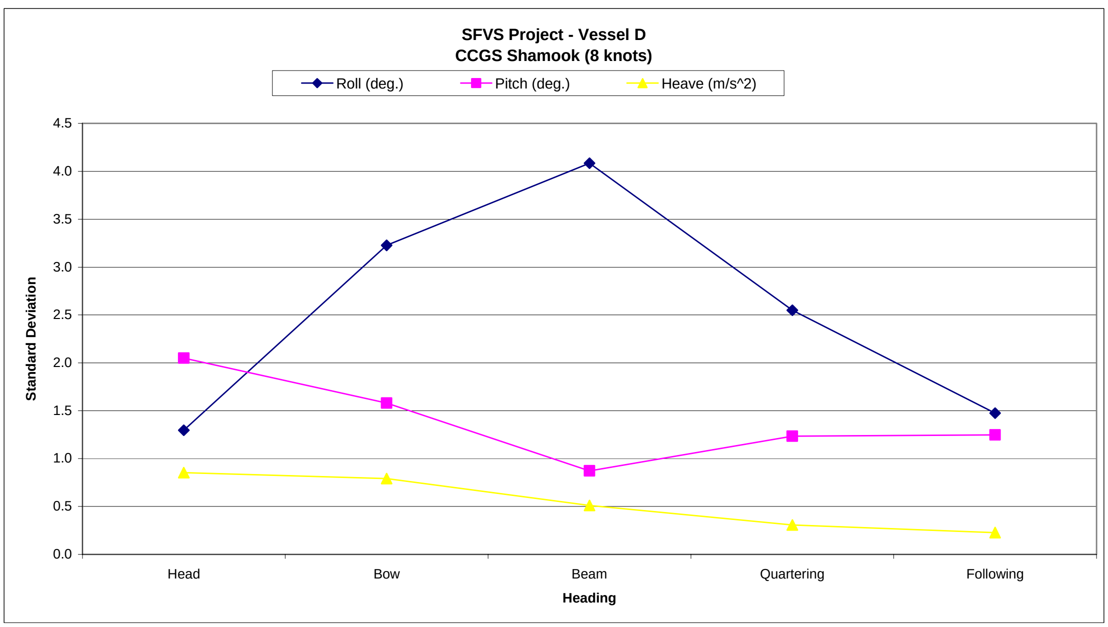


Figure 23: Offline Analysis – Standard Deviation vs. Heading (8 knots)

Appendix A
Inclining Experiment Report

MV SHAMOOK

81'- 8" RESEARCH VESSEL
INCLINING REPORT

PREPARED BY: **POSEIDON MARINE CONSULTANTS LTD.**
391 STAVANGER DRIVE
ST. JOHN'S NL
A1A 5G1
TELEPHONE: (709) 739-4321
TELEFAX: (709) 739-4421

PREPARED FOR: **MR. D. BASS**
MEMORIAL UNIVERSITY OF
NEWFOUNDLAND AND LABRADOR
St. John's Main Campus
St. John's, NL
A1C 5S7
Canada

ISSUED 29th DECEMBER, 2003
Job Number 2003-122

PRINCIPAL PARTICULARS

LENGTH OVERALL	81'-8"
LENGTH BETWEEN PERPENDICULARS	75.0'
LENGTH BETWEEN DRAFT MARKS	59'-5"
DEPTH AMIDSHIPS	10'-6"
BREADTH MOULDED	21'-6"
RAKE OF KEEL (BETWEEN DRAFT MARKS)	2.151'
DEPTH OF KEEL	5-3/4"

THIS IS TO CERTIFY that the undersigned surveyor(s) did at the request and on behalf of Mr. Don Bass attend on board the single screw motor vessel.

MV SHAMOOK

at pier 31, St. John's, Newfoundland for the purpose of conducting an inclining experiment to determine the vessels displacement and centers of gravity at time of incline.

REPRESENTATIVES PRESENT

Mr. V. Gibbons
Poseidon Marine Consultants Limited

Mr. A. Mercer
Poseidon Marine Consultants Limited

LOCATION

Pier 31 St. John's Newfoundland

TIME

Date: Dec. 18, 2003
Commenced: 1000 hours
Completed: 1215 hours

WEATHER CONDITIONS

Winds: Approximately 5 kts. on bow
Skies: Overcast
Temperature: +1^{0}C

VESSEL CONDITION

Vessel was reported to be in the same condition as experiment conducted three days prior to incline. The vessel was upright, mooring lines slack, gangway ashore and vessel free to incline.

WATER SPECIFIC GRAVITY

1.008 t/m^3 as measured

PENDULUMS

Aft: Located in cargo hold suspended from a transverse beam.
Pendulum Length : 65-1/2"

INCLINING WEIGHTS

Two (2) inclining weights located on main deck, one per shift, situated on the outboard sides of the main deck, one port & one starboard. The weight of each weight are as follows:

Weight	Weight (lbs.)	Weight (Lt)
1	500	0.223
2	500	0.223

DRAFTS AS MEASURED

Draft marks from the underside of keel are located at the forward perpendicular and projected to the shell. While the aft draft marks are located at frame 4 located 15'-7" fwd of the aft perpendicular. Draft marks are measured in feet above the underside of keel.

Drafts Observed

Draft Fwd	7'-11" (7.916')
Draft Aft Stbd.	10'-6"
Draft Aft Port	10'-7"
Mean Draft Aft	10'-6-1/2" (10.5416')

Drafts Corrected :

Draft Fwd corrected to FP @ hydrostatic Basline	Fwd Draft +correction 7.916' + depth from baseline to USK @ FP 7.916' + 0.77 8.686 Ft
Draft Aft corrected to AP @ hydrostatic Baseline	Aft Draft - correction 10.5416 - (depth of keel + depth from baseline to USK @ Aft Draft Mark) 10.5416 - (0.479 + 0.901) 9.161 Ft
Mean Draft @ Hydrostatic Baseline	(9.161 + 8.686)/2 = 8.923 Ft.
Trim Between Draft Marks	Draft Aft - Draft Fwd 9.161 - 8.686 0.475 aft

Hydrostatic Baseline is at the Moulded Baseline

PENDULUM DEFLECTIONS

SHIFT	Weight/ Direction	WEIGHT (LT)	SHIFT (feet)	MOMENT (LT-Ft)	AFT Deflection (mm)
1	P-S	0.223	18.166	4.0510	13.0
2	P-S	0.223	18.166	4.0510	13.0
3	P-S	0.223	18.166	4.0510	14.0
4	P-S	0.223	18.166	4.0510	14.0
5	S-P	0.223	18.166	4.0510	12.0
6	S-P	0.223	18.166	4.0510	12.0
TOTALS				24.306	78

$$GMf = \frac{\text{(sum of moments)(25.4)(length of pendulum)}}{\text{(inclined displ.)(sum of deflections)}} \quad \text{(FT)}$$

$$GMf = \frac{24.306 \times 25.4 \times 65.5}{199.094 \times 78} = 2.604 \text{ Ft}$$

FROM HYDROSTATICS AT 0.475 FT TRIM BY THE STERN

MEAN DRAFT = 8.923 ft at amidships
DISPLACEMENT = 199.094 LT
KMT = 11.625 ft above baseline
Gmf as inclined = 2.604 ft
LCB = 2.114 ft aft of amidships
VCG AS INCLINED = KMT - GMT = 11.625 - 2.603 = 9.022 above baseline
LCG AS INCLINED = 2.114 ft aft of amidships

LIGHTSHIP SUMMARY OF WEIGHTS

WEIGHTS TO BE REMOVED	WEIGHT LT	VCG ft	VMMT LT-ft	LCG ft	LMMT LT-ft
INCLINING WEIGHTS	0.446	11.683	5.211	18.229	8.130
INCLINE EQUIPMENT AFT	0.027	4.975	0.134	18.000	0.486
TOTAL	**0.473**	**11.300**	**5.345**	**18.216**	**8.616**

SUMMARY	WEIGHT LT	VCG ft	VMMT LT-ft	LCG ft	LMMT LT-ft
INCLINED VESSEL	199.094	9.022	1796.226	2.114	420.885
WEIGHTS TO BE REMOVED	-0.473	11.300	-5.345	18.216	-8.616
Vessel Only	**198.621**	**9.017**	**1790.881**	**2.076**	**412.269**

VCG ABOVE BASELINE AT MOULDED LINE AMIDSHIPS
LCG ABOUT AMIDSHIPS + AFT - FWD

SUMMARY

Please refer to tables of Weights to be removed.

INCLINED DISPLACEMENT = 198.621 LT
VCG = 9.017 FT above baseline
LCG = 2.076 FT aft of amidships
$GM_{(Fluid)}$ as Inclined = 2.604 Ft

Vincent Gibbons
Naval Architect
Poseidon Marine Consultants

Aaron Mercer
Naval Architect
Poseidon Marine Consultants

Hydrostatic Properties

Draft is from Baseline.
Trim: aft 0.46 deg., No heel, VCG = 0.00

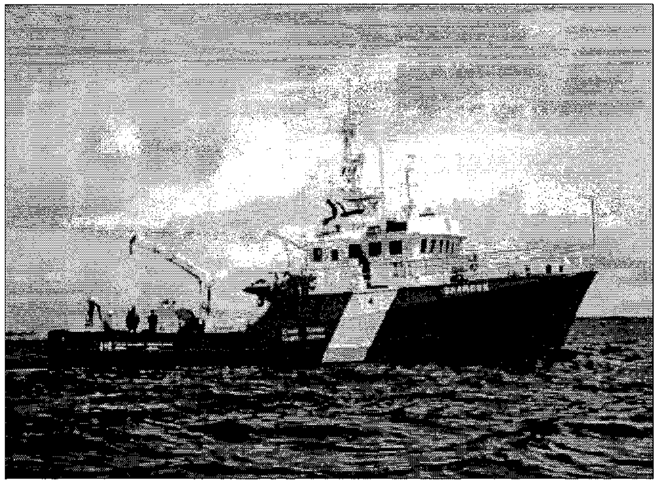
Draft at Origin (ft)	Displ (LT)	LCB (ft)	VCB (ft)	LCF (ft)	TPI (LT/inch)	MTI (LT-ft /deg)	KML (ft)	KMT (ft)
8.923	199.094	2.114a	5.696	6.101a	3.121	256.896	73.920	11.625

Water Specific Gravity = 1.008.

Appendix B
CCGS Shamook Principle Particulars, List of Outfit Items, Drawings

CCGS SHAMOOK

Official Number: 347507 **Call Sign: CG2676**



Vessel Type: Inshore Fisheries Research
Port of Registry: Ottawa
Region: Newfoundland
Home Port: St. John's, Nfld.
Year Built: 1975
Material: Steel
Builder: Georgetown Shipyard, Georgetown, P.E.I.
Modernized:
Complement: **Officers:** 3 **Crew:** 3
Total: 6
Crewing Regime: Lay Day
Avail. Berths: 3

Certificates

Class of Voyage: Home Trade II
Ice Class: N/A
MARPOL: N/A
IMO: 7393573

Holds and Decks

Hold #1	50 **m3**	**Hatch size**	1.5 **m by** 1.5 **m**
Hold #2	None **m3**	**Hatch size**	**m by** **m**
Main Deck Area:	40 **m2**		
Boat Deck Area:	**m2**		
Focsle Deck Area:	**m2**		
After Deck Area:	**m2**		

Scientific Equipment

Laboratory Type:	Wet aft dk	13 **m2**
Laboratory Type:	Dry	10 **m2**
Laboratory Type:	No	**m2**
Laboratory Type:	No	**m2**

Side Scan Sonar: Yes
LAN: No
Winches: sample winch
Sounders: See nav equipment
Power on deck **Hydraulic:** Yes **Electrical:** Yes
Container Capacity: No

Engineering

Propulsion: Geared Diesel
Description: 1 - Caterpillar D3795SCAC 8 cyl
Power: 416 **kw**
Propellers: 1 controlable pitch
Generator No1: 40kw
Generator No2: 15kw
Generator No3: N/A
Emergency Gen.:
Thrusters: **Bow** No **Stern** No
UPS:

Navigation

Gyro: Sperry Mk 37
Radar (1): Decca Racal BM 914 - X Band
Radar (2): Raython R41 - Bande X
Radar (3): No
Elec. Charts: Infonav V 2.1
Auto pilot: Comnav
Speed Log: Sperry SRD-301
GPS: 2-Northstar
LORAN: No
MF DF: No
VHF DF: JMC DF-550
Depth Sounder: 3-Simrad EQ100, 1-Simrad EQ50, 1-Suzuri Sonar

Deck Equipment

Main Hoist:	TICO Crane	**SWL:**	8 **t.**
Other Crane:	Boat Crane		
Other Crane:	No		
Towing Equip:	Nylon Rope	**Bollard Pull:**	**t.**
Workboat 1:	Zodiac inflatable	Boat Crane	
Workboat 2:	No		
Workboat 3:	No		
Workboat 4:	No		

Communications

VHF AM: No
VHF FM: 1-Raython 580, 1-Triton M100
HF: 1-Harris RF-3200
SatComm: M-Sat
Weather Fax: No
DATAHAIL: No

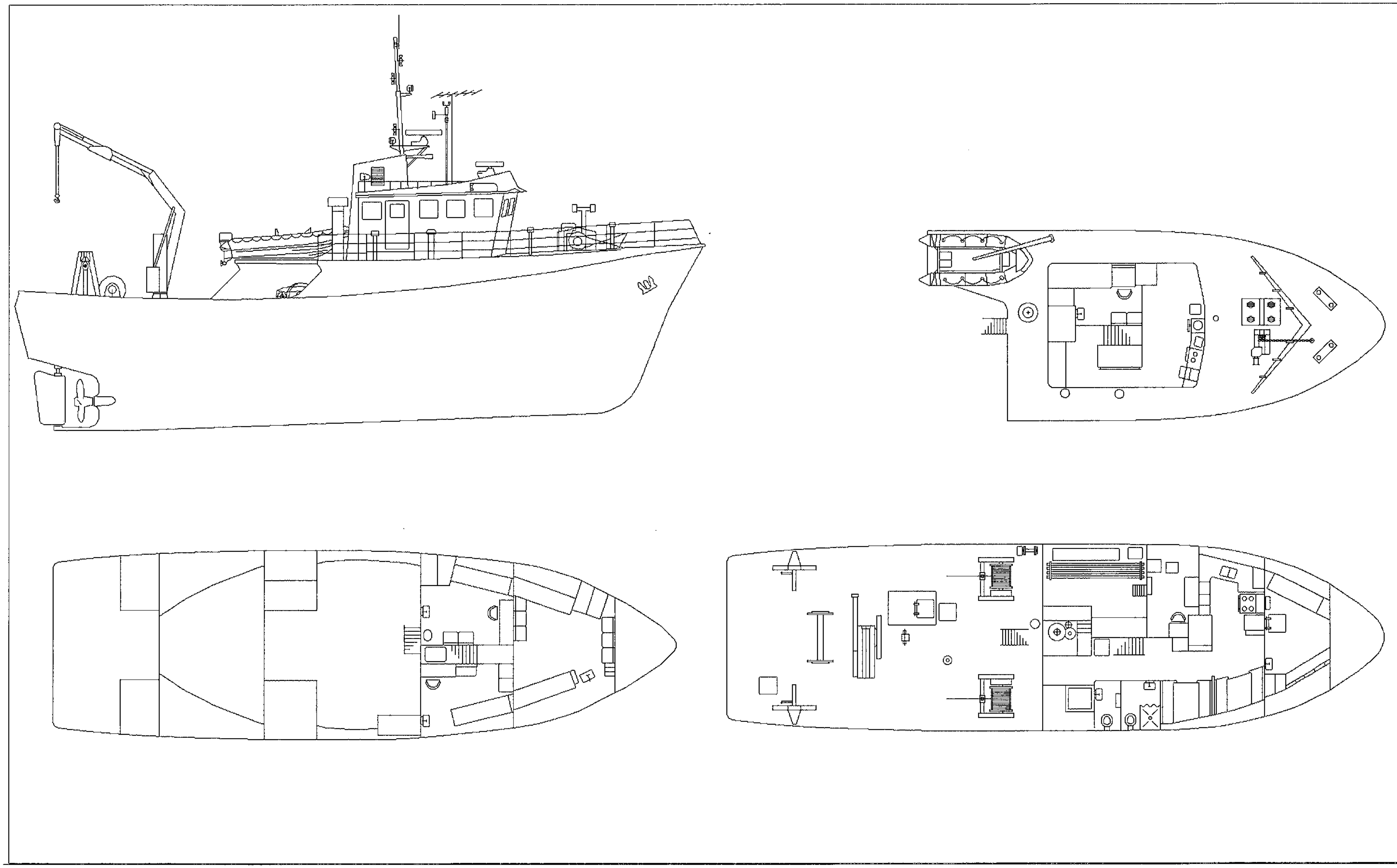
Helicopter

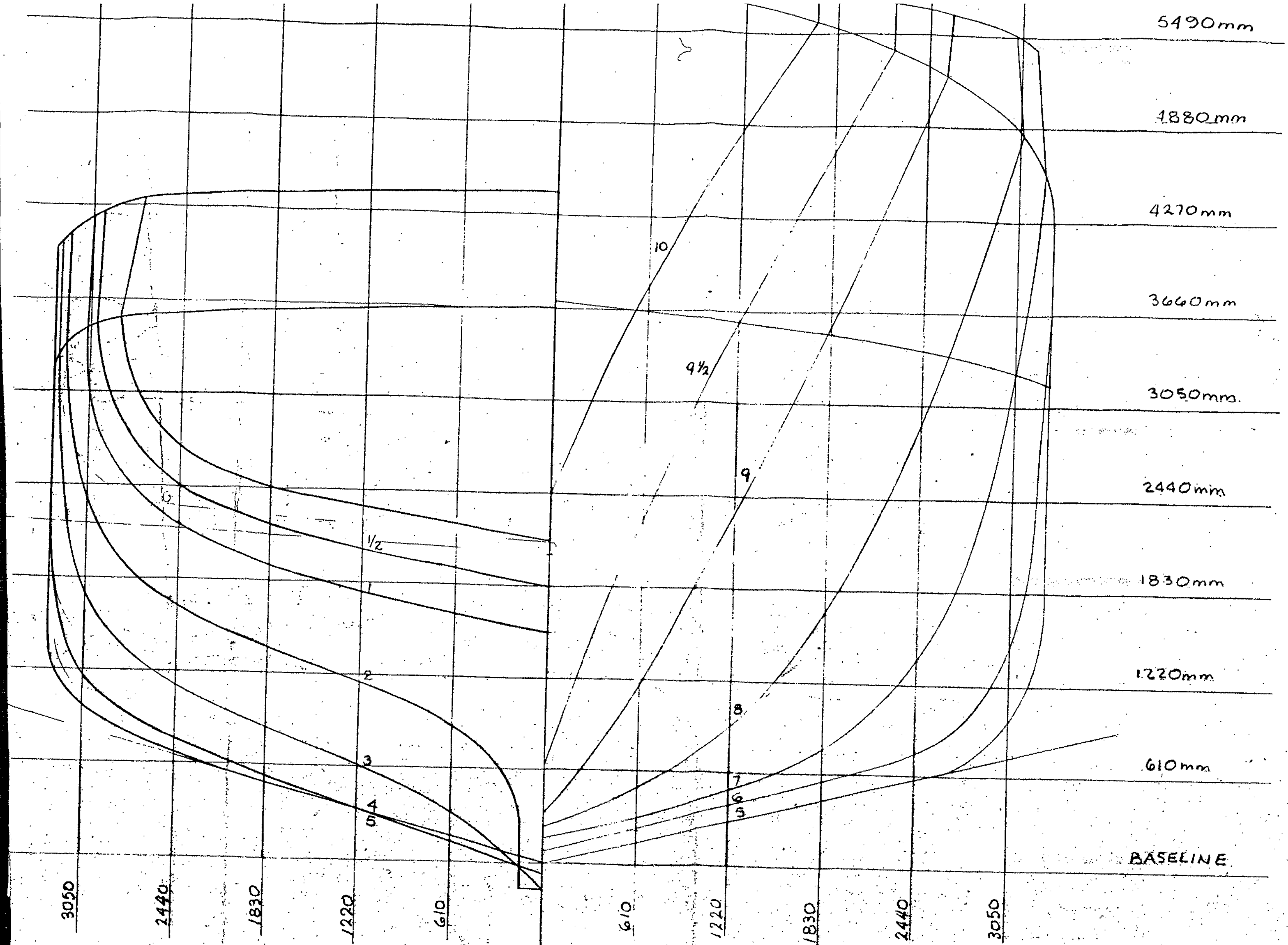
Flight Deck:	No	**Area:**	**m2**
Hangar:	No	**Area:**	**m2**
Storage:	No		
Fuel:	No		

Other info: All Deck Equipment is Hydraulic, most is portable, and is routinely changed to meet program requirements. Vessel has 2 trawl winches aft and 2 Gallows Frames.

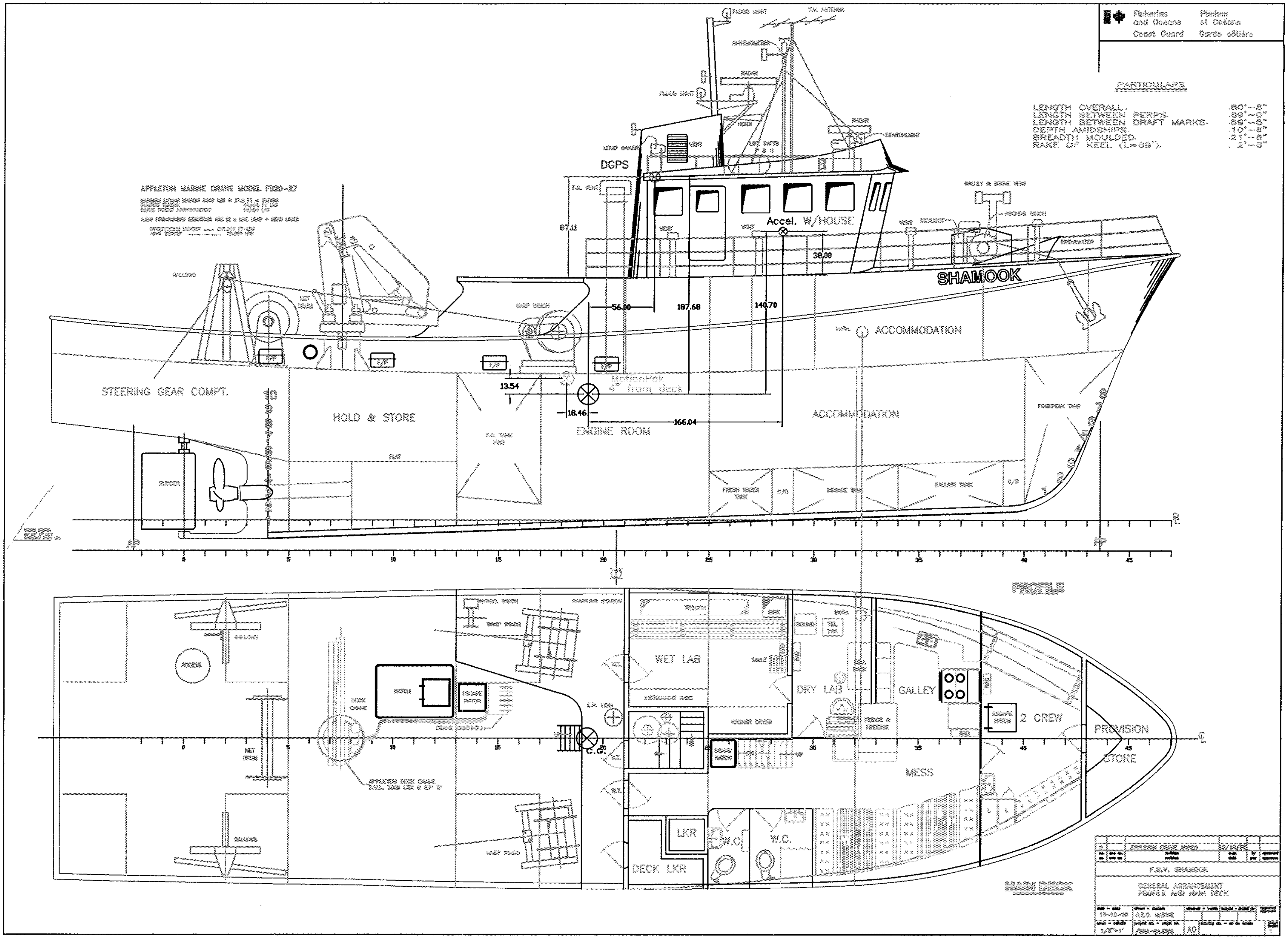
CCGS SHAMOOK

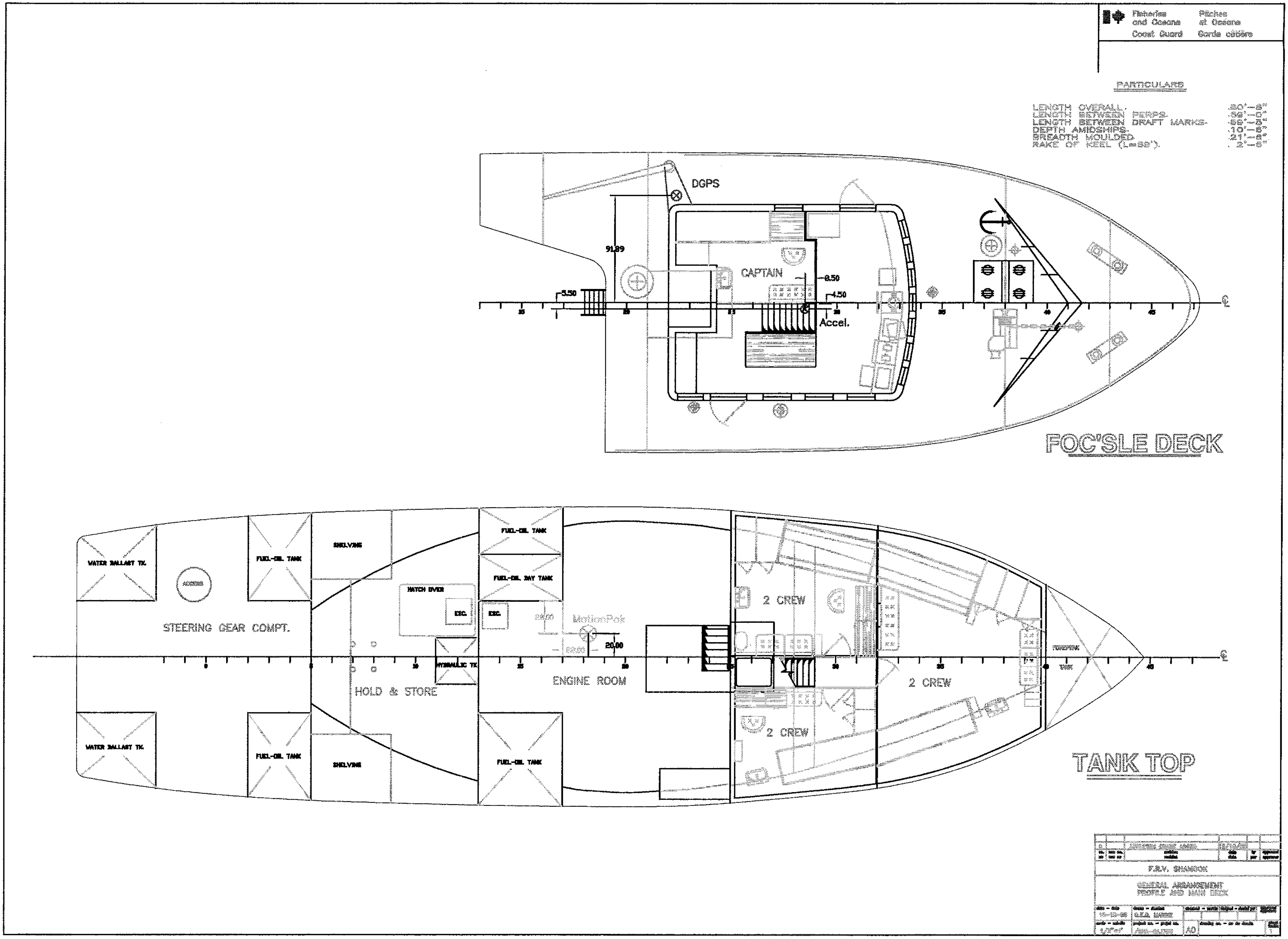
Length:	24.9 m	Gross Tonnage:	117 grt	Cruising Range:	2500 nm	Fresh Water:	2.3 m3
Breadth:	6.7 m	Net Tonnage:	18 nrt	Endurance:	5 days	Fuel Capacity:	23 m3
Draft:	3.5 m	Freeboard:	1 m	Speed Cruising:	8 kts Max: 10 kts	Fuel Consumption:	1.6 m3/day

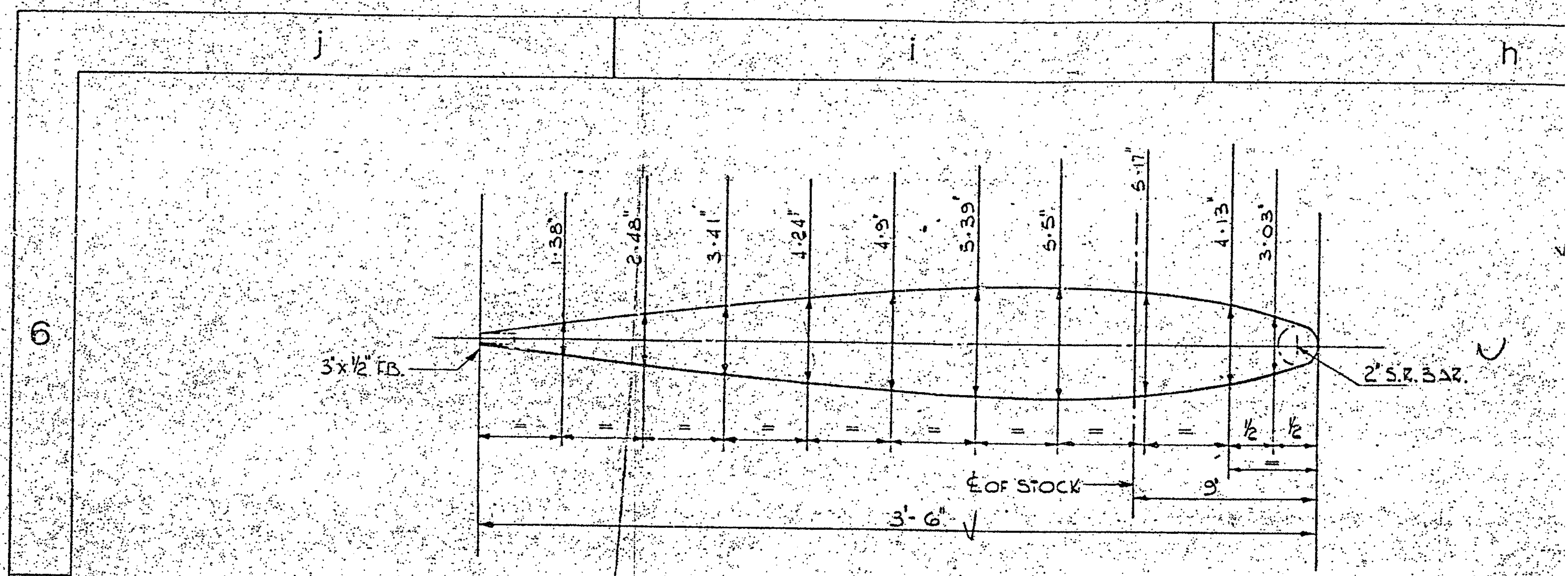




BODY PLAN SCALE 1:25

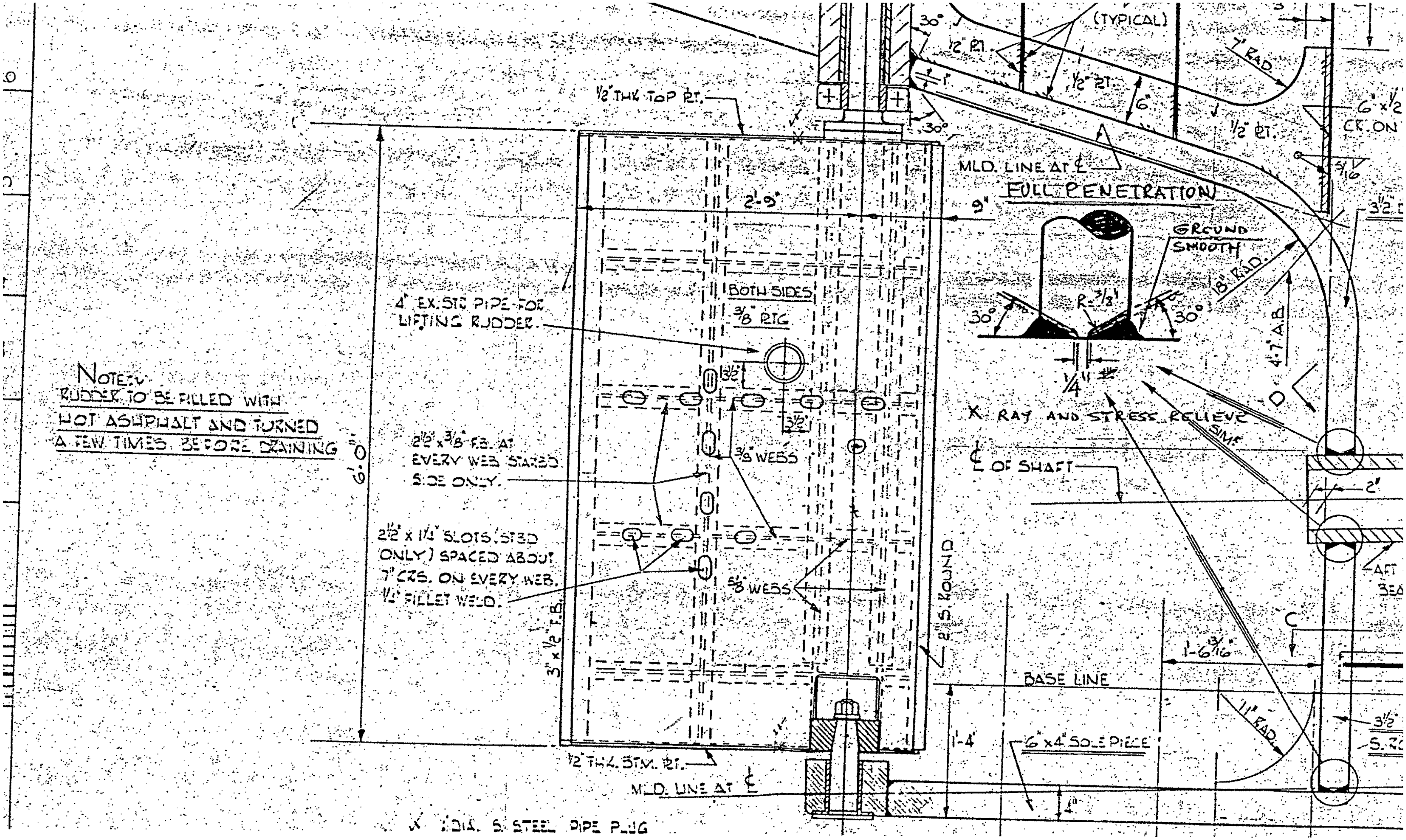

Fisheries and Oceans
Pêches et Océans
Coast Guard
Garde côtière
PARTICULARS
LENGTH OVERALL. 80'-8"
LENGTH BETWEEN PERPS. 69'-0"
LENGTH BETWEEN DRAFT MARKS. 59'-5"
DEPTH AMIDSHIPS. 10'-8"
BREADTH MOULDED. 21'-6"
RAKE OF KEEL (L=69'). 2'-3"
APPLETON MARINE CRANE MODEL F820-27
DGPS
Accel.
W/HOUSE
SHAMOOK
ACCOMMODATION
STEERING GEAR COMPT.
HOLD & STORE
ENGINE ROOM
MotionPak
4" from deck
56.00
187.68
140.70
38.00
67.11
13.54
18.46
166.04
PROFILE
WET LAB
DRY LAB
GALLEY
2 CREW
PROVISION
STORE
MESS
C.G.
LKR
W.C.
DECK LKR
MAIN DECK
F.R.V. SHAMOOK
GENERAL ARRANGEMENT
PROFILE AND MAIN DECK


Fisheries and Oceans
Pêches et Océans
Coast Guard
Garde côtière
PARTICULARS
LENGTH OVERALL
LENGTH BETWEEN PERPS.
LENGTH BETWEEN DRAFT MARKS.
DEPTH AMIDSHIPS.
BREADTH MOULDED.
RAKE OF KEEL
DGPS
91.89
5.50
CAPTAIN
8.50
4.50
Accel.
FOC'SLE DECK
WATER BALLAST TK.
FUEL-OIL TANK
SHELVING
FUEL-OIL DAY TANK
HATCH OVER
STEERING GEAR COMPT.
HOLD & STORE
HYDRAULIC TK
ENGINE ROOM
MotionPak
20.00
2 CREW
2 CREW
2 CREW
TANK TOP
F.R.V. SHAMOOK
GENERAL ARRANGEMENT
PROFILE AND MAIN DECK
A0



RUDDER OFFSETS (TO OUTSIDE OF PLT.)

NOTE:- FOR DETAILS OF RUDDER STOCK


NOTE:
RUDDER TO BE FILLED WITH
HOT ASPHALT AND TURNED
A FEW TIMES BEFORE DRAINING
1/2" THK TOP PL.
4" EX. STD PIPE FOR LIFTING RUDDER.
BOTH SIDES
3/8" PLG
2 1/2" x 3/8" F.B. AT EVERY WEB STARBD SIDE ONLY.
2 1/2" x 1 1/4" SLOTS (STBD ONLY) SPACED ABOUT 7" CRS. ON EVERY WEB. 1/4" FILLET WELD.
3/8" WEBS
5/8" WEBS
3" x 1/2" F.B.
2'-9"
9"
6'-0"
2'-5" ROUND
1/2" THK. BTM. PL.
MLD. LINE AT ℄
X 1" DIA. S. STEEL PIPE PLUG
(TYPICAL)
1/2" PL
7" RAD.
6" x 1/2
CK. ON
MLD. LINE AT ℄
FULL PENETRATION
GROUND SMOOTH
18" RAD.
R-3/8"
30°
1/4"
4'-7" A.B.
X RAY AND STRESS RELIEVE SIM.
℄ OF SHAFT
BASE LINE
1-6 13/16"
11" RAD.
6" x 4" SOLE PIECE
1'-4
AFT
2"

Appendix C
Instrumentation Plan

Instrumentation Plan for Fishing Vessel Trials

See Proj PIP for additional info on instrumentation requirement

Proj. 2017 **Sept. 11, 2003** **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. convertor	0 - 1000	RPM	low critical parameter

NOTES: Sampling rate is 50 Hz (filter 10 Hz) for all analog channels

Forward Speed as measured by the DGPS is Speed Over the Ground (SOG).

Heading Angle measured using DGPS is Course Over Ground (COG).

Heading Angle as measured by DGPS is Heading True.

Antenna alignment and set up for the new GPS unit is going to be more complex than previous experience.

Even though Selective Availability (SA) has been shut down on GPS by the US Government, an HF correction signal is still broadcast via HF radio by the CCG and DGPS correction signal will be accessed for increased accuracy.

UPS will be required for all trials.

An algorithm is available to move acceleration motions to any other point on the rigid body.
Mount MotionPak as close to ship's CG as possible.
Three linear accelerometers will fitted in orthogonal tri-axial mount in wheelhouse.
Instrumentation on ship to be used to manually record wind speed/direction.
Record shaft RPM from ship's instrumentation or with IOT frequency/voltage based inst. if possible.
IOT to bring hand held instrumentation to determine sea water temperature/density. To be measured roughly mid-draft, amidships. Wave height/direction to be measured recorded using MUN directional wave buoy or a leased Datawell buoy from Oceans Ltd.
Note wave direction from buoy is deg. Magnetic.

Offline analysis software is available to derive the following additional motions from the rate/accel. (MotionPak) data assuming the stimulation freq. is high enough:
Roll/Pitch/Yaw Angle
Roll/Pitch/Yaw Angular Accel.
Surge/Sway/Heave Displacement
Surge/Sway/Heave Velocity

Appendix D
Calibration Information

Summary of Analog Channel Calibrations

CCGS Shamook **Dec. 2003**

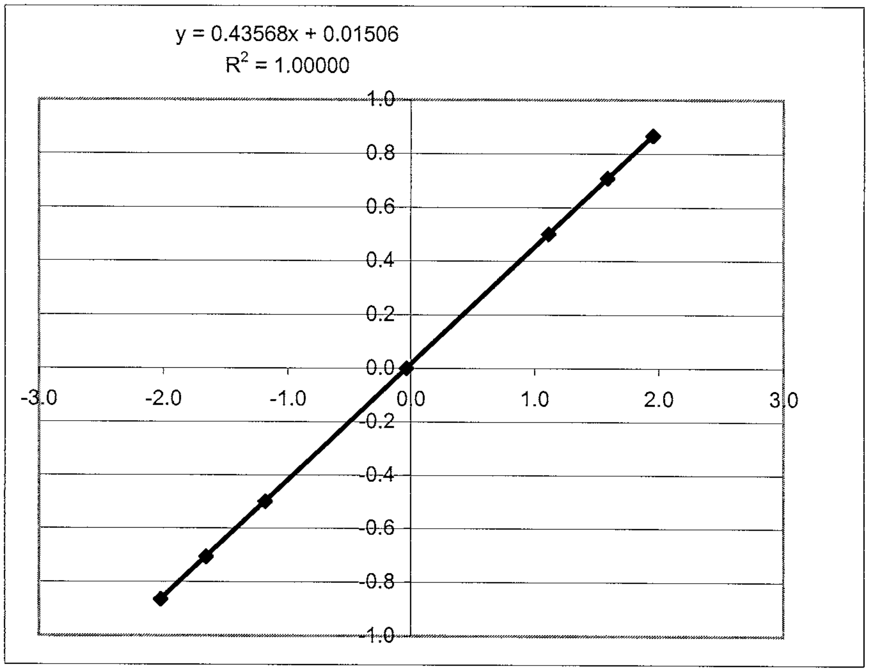
Fishing Vessel Research Project (Proj. 2017)

Channel Number	Channel Description	Units	Slope	Offset
1	MotionPak X-accel, SURGE	g	0.4357	0.0151
2	MotionPak Y-accel, SWAY	g	0.4194	-0.0065
3	MotionPak Z-accel, HEAVE	g	0.6252	-0.0028
4	MotionPak ROLL RATE	deg/s	10.8763	0.0073
5	MotionPak PITCH RATE	deg/s	10.8681	-0.0036
6	MotionPak YAW RATE	deg/s	10.9010	0.0091
7	MotionPak TEMP OUTPUT	deg C	71.9424	-272.8058
8	Linear Accel, X-SURGE	g	0.5260	-0.0009
9	Linear Accel, Y-SWAY	g	0.5249	0.0009
10	Linear Accel, Z-HEAVE	g	0.7890	-0.0002
11	Rudder Angle, Yo-yo Pot	deg	-57.0622	103.2826
12	Roll Angel, Jewell Inclinometer	deg	5.8151	0.1080
13	Pitch Angle, Jewell Inclinometer	deg	5.8202	-0.0422
14	Shaft RPM	rpm	401.0364	-8.1781
15	Rudder Slew Rate	in/s	5.9605	0.0094

Ch. 01
X Accel, Motion Pak
S/N 0326

Gravity 1

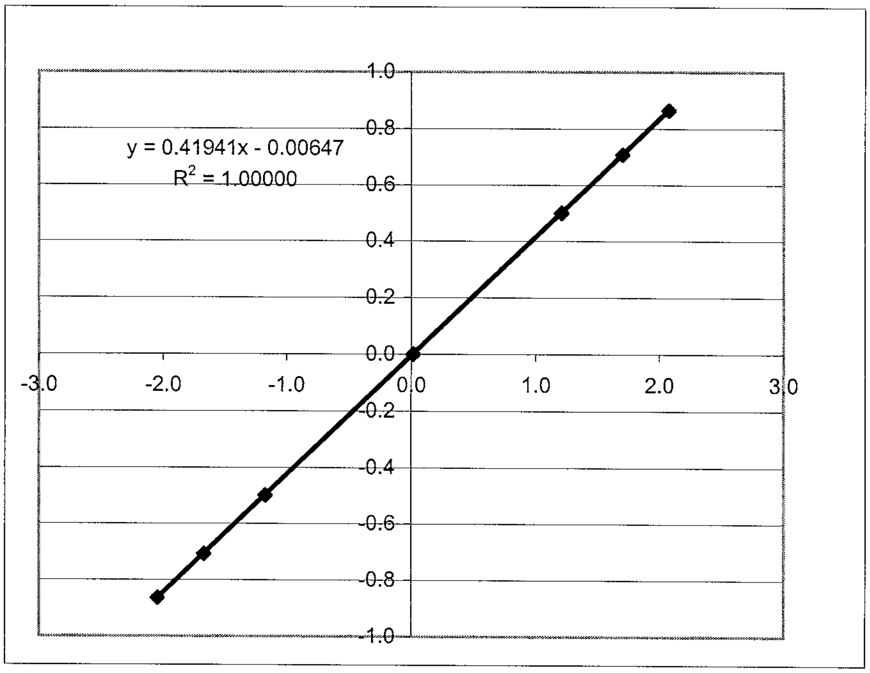
Angle	Sin(angle)	Acceleration	Voltage
0	0	0.0000	-0.036
29.994	0.499909307	0.4999	1.112
45.016	0.707304215	0.7073	1.588
59.9	0.865151421	0.8652	1.953
-59.9	-0.865151421	-0.8652	-2.022
-45.016	-0.707304215	-0.7073	-1.656
-29.994	-0.499909307	-0.4999	-1.181



slope	offset
0.4357	0.0151

Ch 02
Y Accel, Motion Pak
S/N 0326

Gravity	1		
Angle	Sin(angle)	Acceleration	Voltage
0	0	0.0000	0.016
29.994	0.499909307	0.4999	1.206
45.016	0.707304215	0.7073	1.701
59.9	0.865151421	0.8652	2.079
-59.9	-0.865151421	-0.8652	-2.05
-45.016	-0.707304215	-0.7073	-1.671
-29.994	-0.499909307	-0.4999	-1.173

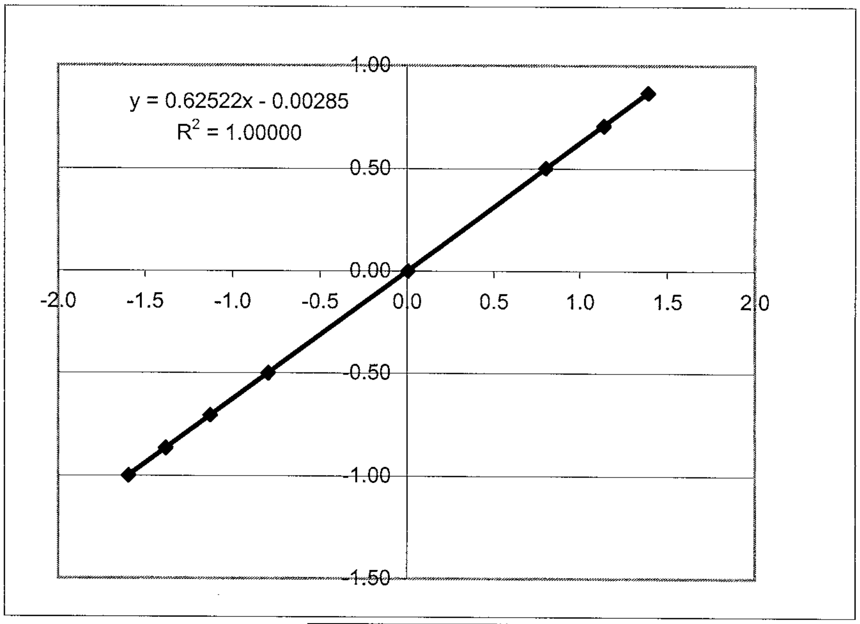


slope	offset
0.4194	-0.0065

Ch 03
Z Accel, Motion Pak
S/N 0326

Gravity 1

wedge	Angle	-Sin(angle)	Acceleration	Voltage
0	90	-1	-1.0000	-1.594
29.994	60.006	-0.866077759	-0.8661	-1.381
45.016	44.984	-0.706909292	-0.7069	-1.128
59.9	30.1	-0.501510737	-0.5015	-0.796
90	0	0	0.0000	0.005
-59.9	-30.1	0.501510737	0.5015	0.804
-45.016	-44.984	0.706909292	0.7069	1.137
-29.994	-60.006	0.866077759	0.8661	1.390



slope	offset
0.6252	-0.0028

slope

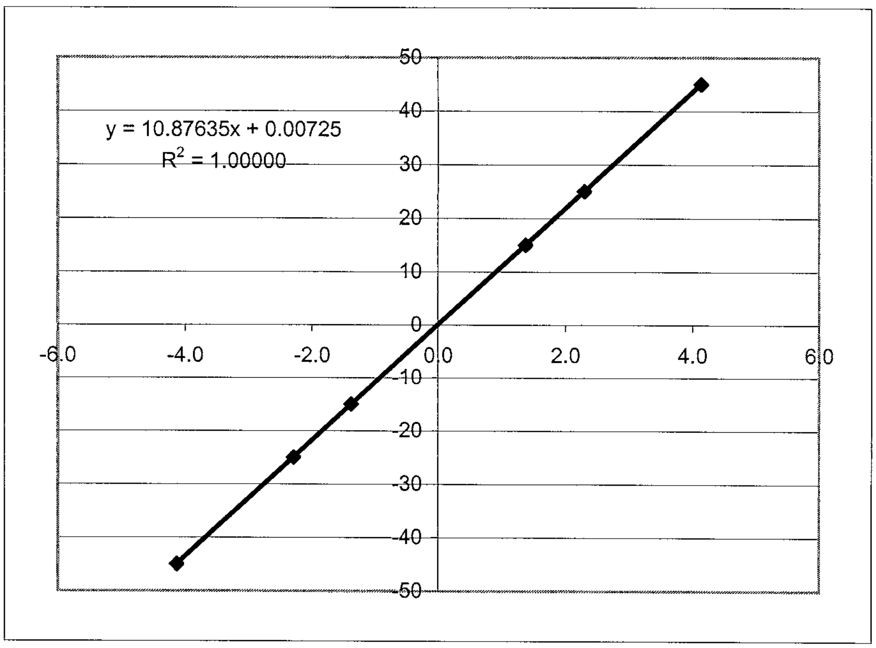
0.6252 -0.0028

Ch. 04
X Rate, Motion Pak
S/N 0326

Scale Factor 50.213 mV/deg/s

Universal Source 169644

Deg/second	injected voltage Volts	Output, Volts
45	2.2596	4.137
25	1.2553	2.298
15	0.7532	1.378
-15	-0.7532	-1.380
-25	-1.2553	-2.299
-45	-2.2596	-4.138

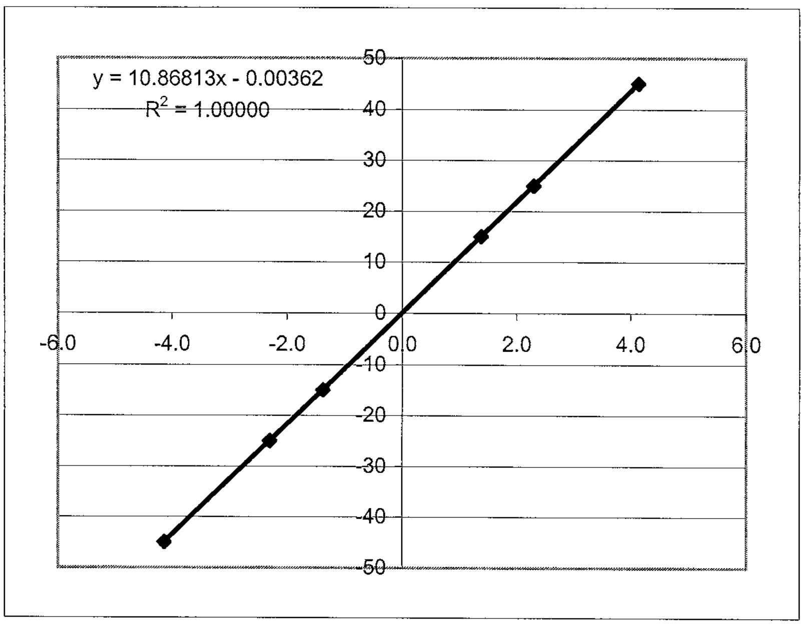


slope	offset
10.8763	0.0073

Ch. 05
Y Rate, Motion Pak
S/N 0326

Scale Factor	49.916 mV/deg/s
Universal Source	169644

Deg/second	injected voltage, V	Output, Volts
45	2.2462	4.141
25	1.2479	2.301
15	0.7487	1.380
-15	-0.7487	-1.380
-25	-1.2479	-2.300
-45	-2.2462	-4.140



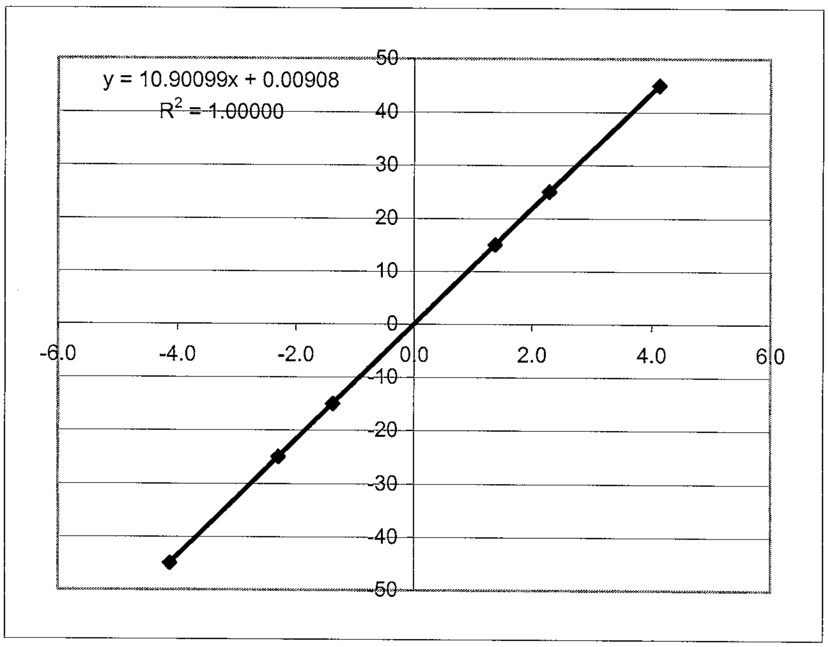
slope	offset
10.8681	-0.0036

Ch. 06
Z Rate, Motion Pak
S/N 0326

Scale Factor 49.889 mV/deg/s

Universal Source 169644

Deg/second	injected voltage	Output, Volts
45	2.2450	4.127
25	1.2472	2.293
15	0.7483	1.375
-15	-0.7483	-1.377
-25	-1.2472	-2.294
-45	-2.2450	-4.129

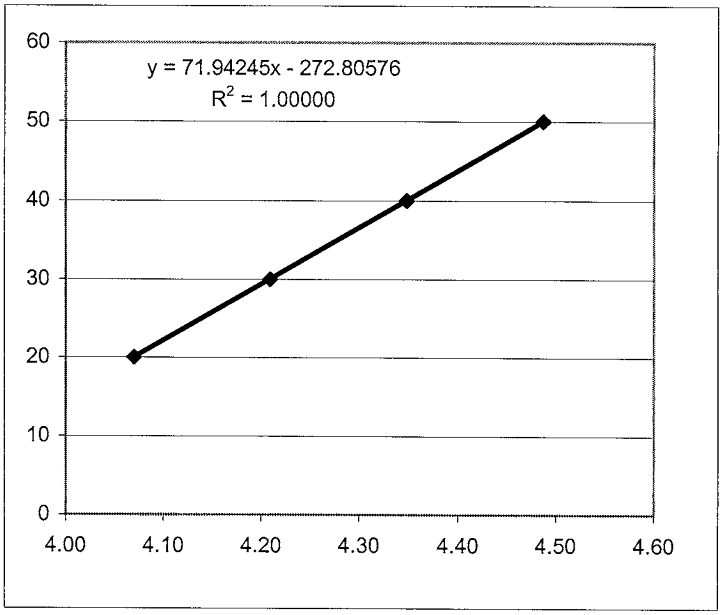


slope	offset
10.9010	0.0091

Ch. 07
Temperature, Motion Pak
S/N 0326

1.00E-06	A/°K
13.91	Kohms

Temperature Celsius	**injected voltage V**	**Output, Volts Volts**
-10	3.660	3.653
0	3.800	**3.793**
20	4.078	4.070
30	4.217	4.209
40	4.356	4.348
50	4.495	4.487



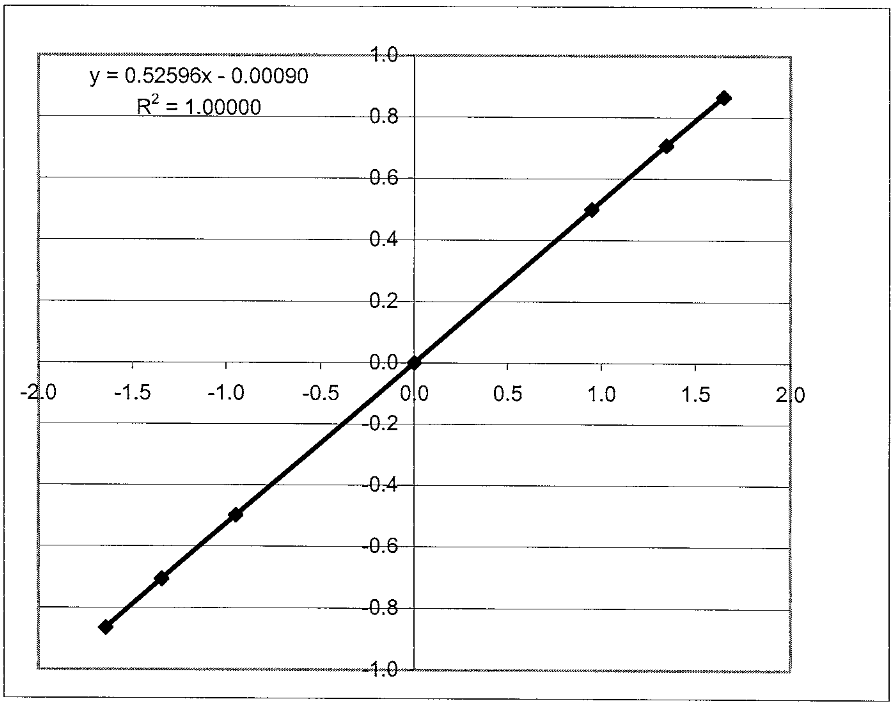
slope	offset
71.9424	-272.8058

Ch 08
X Accel (Surge)

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

Gravity 1

Angle	Sin(angle)	Acceleration	Voltage
0	0	0.0000	0.001
29.994	0.499909307	0.4999	0.949
45.016	0.707304215	0.7073	1.347
59.9	0.865151421	0.8652	1.649
-59.9	-0.865151421	-0.8652	-1.643
-45.016	-0.707304215	-0.7073	-1.342
-29.994	-0.499909307	-0.4999	-0.949

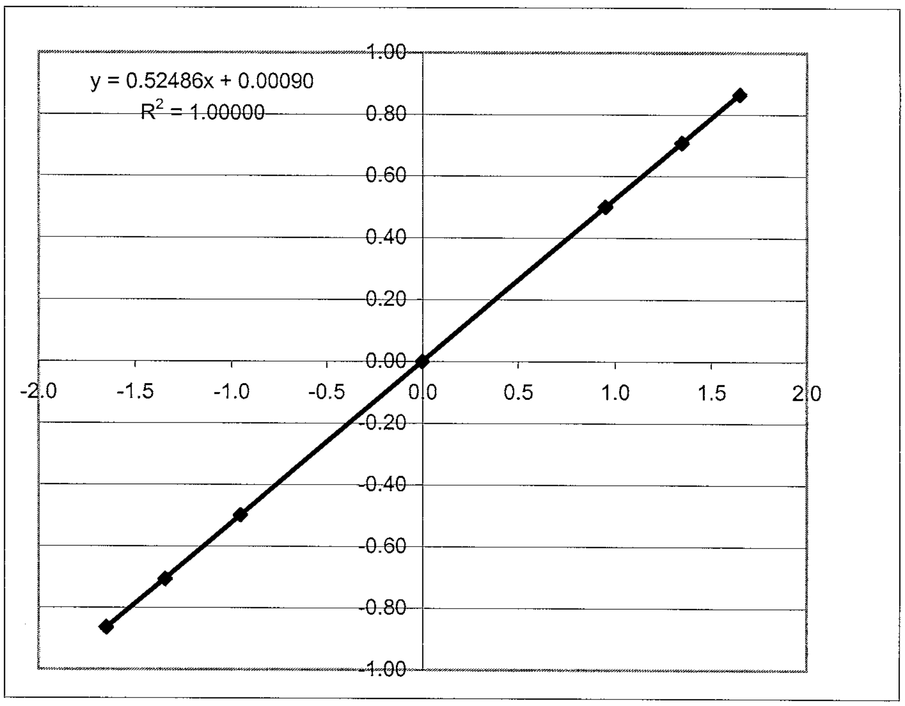


slope	offset
0.5260	-0.0009

Ch 09
Y Accel (Sway)

Model	**QA1400**
serial #	**1103**
Gravity	1

Angle	Sin(angle)	Acceleration	Voltage
0	0	0.0000	-0.002
29.994	0.499909307	0.4999	0.95
45.016	0.707304215	0.7073	1.345
59.9	0.865151421	0.8652	1.648
-59.9	-0.865151421	-0.8652	-1.651
-45.016	-0.707304215	-0.7073	-1.348
-29.994	-0.499909307	-0.4999	-0.954

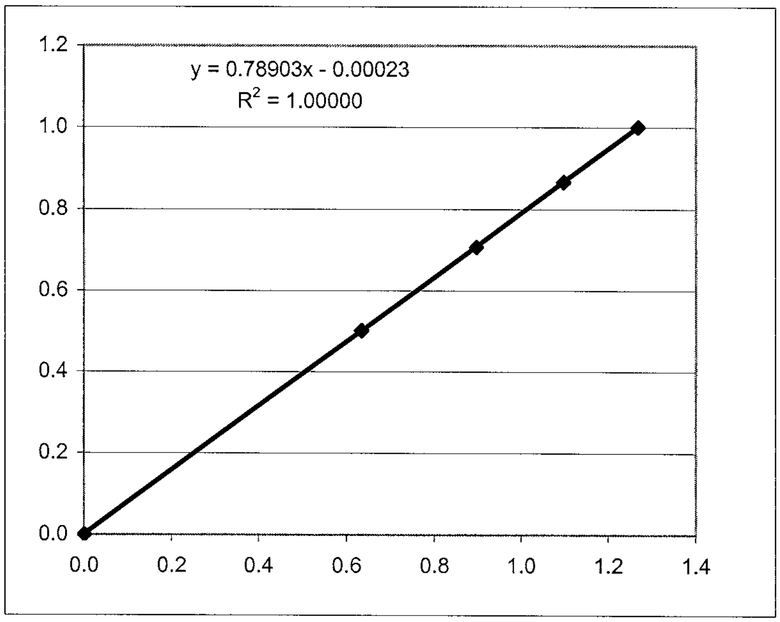


slope	offset
0.5249	0.0009

Ch 10
Z Accel (Heave)
Model QA1400
serial # 1101

Gravity 1

wedge	Angle	SIN(angle)	Acceleration	Voltage
0	90	1	1.0000	1.268
29.994	60.006	0.866077759	0.8661	1.098
45.016	44.984	0.706909292	0.7069	0.897
59.9	30.1	0.501510737	0.5015	0.634
90	0	0	0.0000	0.001



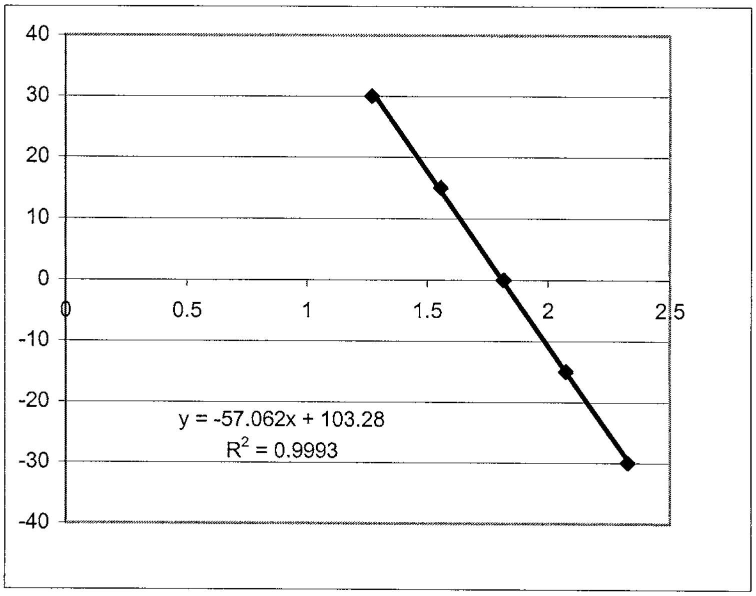
slope	offset
0.7890	-0.0002

Ch 11
Rudder Angle

Model	**PV-25A**
serial #	**0703-20582**

Gravity	1

Angle	Voltage
0	1.818
-15	2.073
-30	2.326
0	1.816
15	1.556
30	1.271

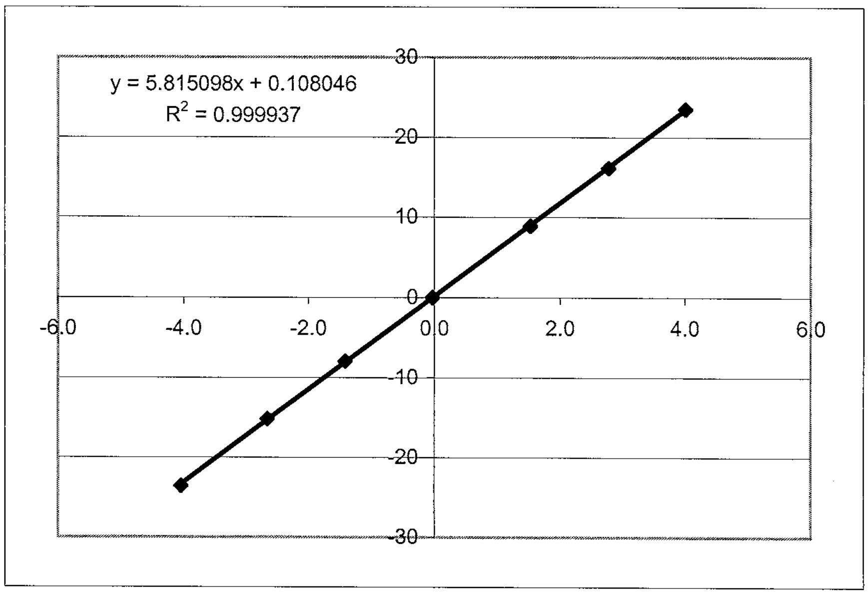


slope	Intercept
-57.0622	103.2826

Ch 12
Roll Angle

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

Angle	Voltage
23.5	4.008
16.1	2.772
8.89	1.529
0	-0.028
-7.98	-1.417
-15.2	-2.654
-23.6	-4.046

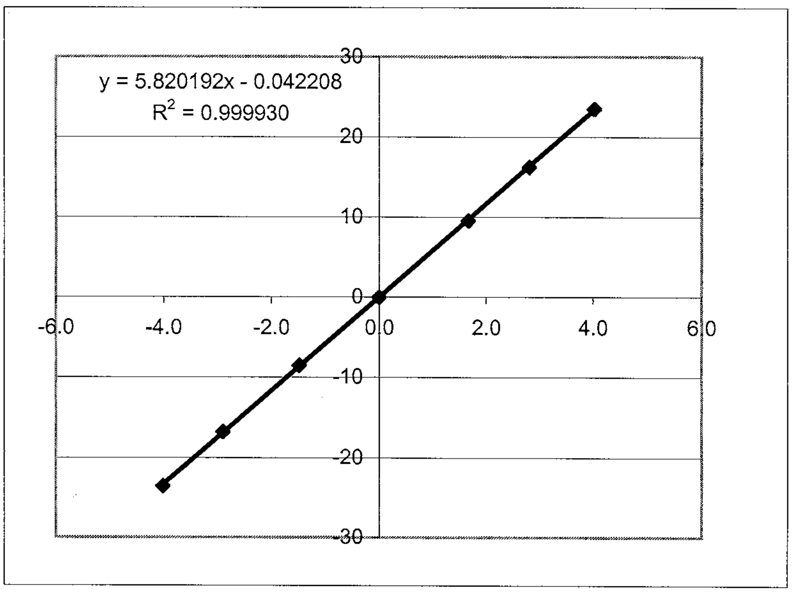


slope	offset
5.8151	0.1080

Ch 13
Pitch Angle

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

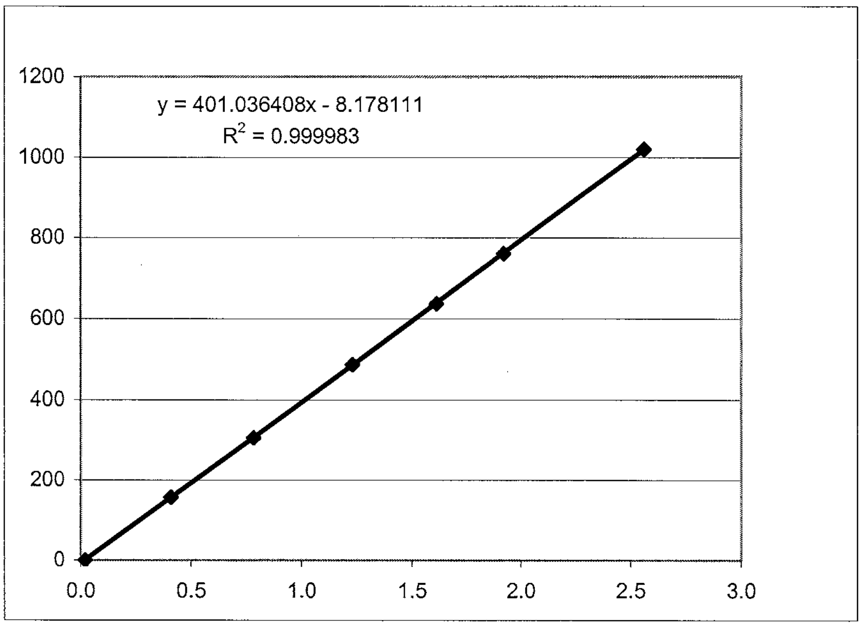
Angle	Voltage
23.50	4.024
16.20	2.811
9.51	1.665
-0.04	-0.003
-8.53	-1.483
-16.80	-2.906
-23.60	-4.016



slope	Offset
5.8202	-0.0422

Ch 14
Shaft RPM
Model **IOT frequency (RPM) to voltage converter**
serial #

rpm	Voltage Out
0	0.021
157	*0.41*
305	*0.782*
487	*1.23*
637	*1.613*
760	*1.92*
1020	*2.56*



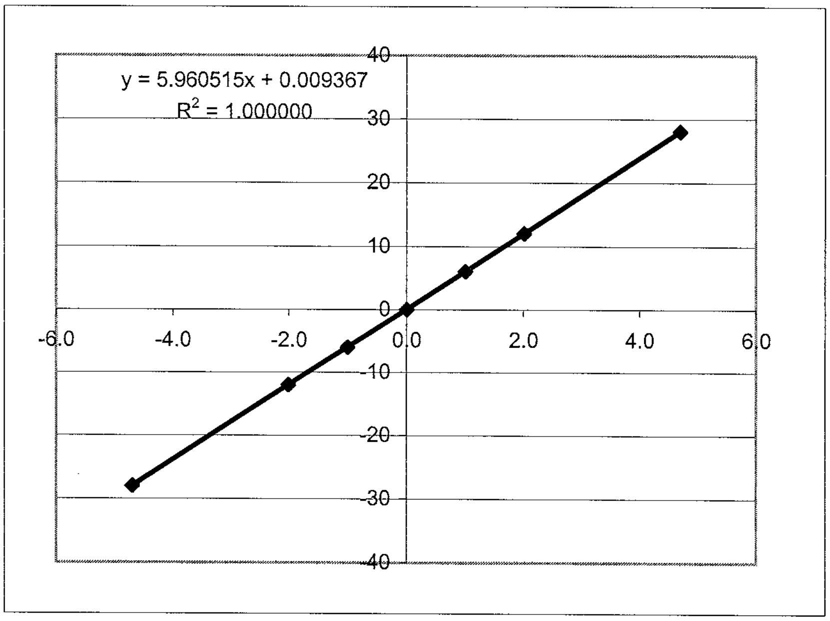
slope	Offset
401.0364	-8.1781

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

Ch 15
Rudder Slew Rate
Model PV-25A
serial # 0703-20582

Gravity 1

in/s	injected voltage	Voltage
28	4.704	4.696
12	2.016	2.012
6	1.008	1.005
0	0	-0.002
-6	-1.008	-1.008
-12	-2.016	-2.015
-28	-4.704	-4.699



slope	Intercept
5.9605	0.0094

83.296
85.984
89.008
90.016
92.704

Appendix E
Wave Buoy Specifications, Mooring Description and Typical Output File

1. General Description of the 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 accepted. 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 CCGS "Shamook" consisted of a passive 3 metre (Kathrein) whip antenna and base mounted on the port side of the forward railing above the wheel house. A coax cable (RG 213 U) was routed from the antenna mount to the wave direction receiver installed in a Wet Lab on the port side of the vessel immediately forward of the back deck. A laptop interfaced to the wave direction receiver for storing and displaying wave data. The receiver was receiving on 38.760 Mhz. A standard 120 volt power supply was used to power the wave direction receiver. OCEANS Ltd. powered both the laptop and directional waverider receiver through a UPS supplied by NRC.

During the trials data was recorded hourly and basic wave information was passed to NRC hourly. These data included the following:

- start time of the data collection in local time
- significant wave height in metres
- mean zero crossing period in seconds
- direction of the maximum wave energy in degrees magnetic
- spread of the maximum wave energy

The directional waverider buoy was deployed in position 47 34.29N 52 26.21W in a water depth of 165 metres. The buoy was deployed at 0945 local and recovered at 1730 local.

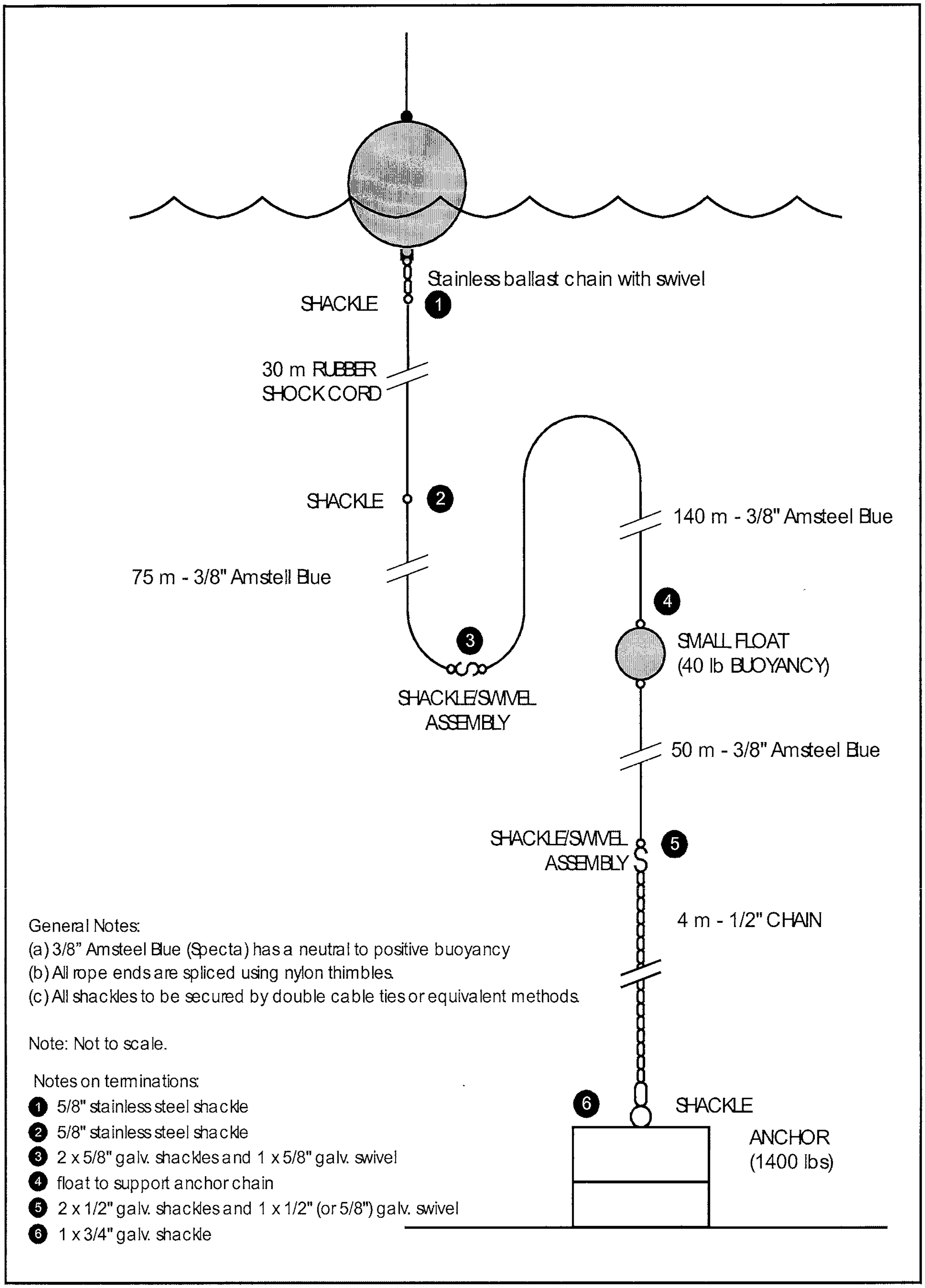


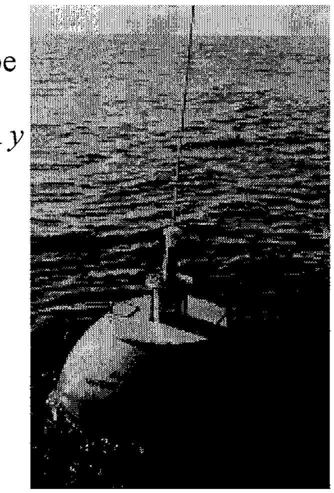
Figure 1 - NRC Directional Waverider Moooring - Water Depth 165 m

NATO TU-WAVES Project: Wave Measurements

Directional Waverider Buoy

(of Datawell b.v.)

Breif Description:



The Datawell directional waverider buoy has been selected for wave measurements of the NATO TU-WAVES Project. The buoy has a spherical shape with 0.9 m diameter and weighs 212 kg. It measures the directional wave spectra. It contains a heave-pitch-roll sensor, three axis fluxgate compass, two fixed *x* and *y* accelerometers, and a micro-processor.

From the accelerations measured in the *x* and *y* directions of 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, FFT is performed every 30 min.

Raw data are compressed to motion vertical, motion north and motion west. Energy density, main direction, directional spread and the normalized second harmonic of the directional distribution for each frequency band (in addition to other sea-state parameters like the significant wave height, H_{mo} and mean wave period, T_z) are computed on-board (called processed data). Both raw and processed data are transmitted.

The buoy is able to detect (measures) wave heights up to 40 m (with a resolution of 1 cm) and periods between 1.6 s and 30 s. Directional resolution is 1.5° and the frequency resolution is 0.005 Hz for frequencies less than 0.1 Hz and 0.01 Hz otherwise. The standard buoy is provided with sea surface water temperature measurement in the range -5°C to +45°C (with an accuracy of 0.2°C).

Unlike the earlier directional wave buoys which measure the wave slopes, the Datawell directional waverider measures the horizontal (north & west) motions. As a consequence, the measurement is independent on buoy roll motions and therefore justifying the small size of the buoy. On the other hand, high current velocities distort the buoy measurements. However, measurements are acceptable in the existence of a current with velocity up to 2.5 m/s.

GO TO:	Turkish N/W	Black-Sea N/W	Wave Gauge	Wave Measurements	**Main Page**

TYPICAL DIRECTIONAL WAVE DATA FILE ACQUIRED DURING CCGS SHAMOOK TRIAL

Fishing Vessel Research Project (Proj. 2017)
Wave data acquired and analyzed by Oceans Ltd., St. John's, NL.

Datawell Mark II Directional Wave Buoy

FILE: 12150953.TXT Acquired Dec. 15, @ 0953 NF Time

3	Current Transmission Number		
201	H_{M0}	(cm)	Significant wave height
6.060606	T_Z	(s)	Mean period time
5.942877	S(m)	(m^2/Hz)	Maximum spectral density
24.95		Reference (dummy) temperature	
2.95	(˚C)	Sea Surface temperature	
7.125		Battery condition (0 - 7) where 7 is fully charged	
1.14125	(m/s^2)	Vertical accelerometer offset	
-0.73375	(m/s^2)	X accelerometer offset	
-0.14625	(m/s^2)	Y accelerometer offset	
60.46875	(deg.)	Compass Heading	
68.11523	(deg.)	Magnetic field inclination	

Frequency (Hz)	Normalized spectral Density S(f) / S(m)	Mean Direction (deg.)	Directional Spread (deg.)	Skewness	Curtosis
0.025	1.85E-04	104.063	73.074	0.41	1.268
0.03	1.26E-03	1.406	66.136	-2.714	2.5
0.035	1.87E-03	5.625	64.01	0.232	2.475
0.04	4.17E-03	28.125	66.808	2.581	2.262
0.045	5.95E-03	75.938	70.053	0.257	1.676
0.05	1.32E-02	11.25	51.7	3.918	3.581
0.055	8.50E-02	16.875	50.358	2.091	4.039
0.06	4.52E-01	14.063	34.467	3.178	5.893
0.065	1.00E+00	16.875	22.717	9.43	17.858
0.07	7.30E-01	21.094	25.626	4.202	14.334
0.075	2.42E-01	23.906	33.572	1.835	7.309
0.08	4.25E-01	12.656	37.712	2.272	5.508
0.085	4.52E-01	26.719	47.336	-5.004	5.089
0.09	2.70E-01	49.219	55.841	2.673	3.341
0.095	2.45E-01	45	73.858	4.883	2.056
0.1	2.50E-01	35.156	41.853	3.338	5.974
0.11	2.38E-01	28.125	44.762	2.125	4.813
0.12	1.80E-01	33.75	40.622	2.395	5.84
0.13	1.32E-01	33.75	45.322	1.917	4.377
0.14	1.44E-01	26.719	41.517	2.888	5.72
0.15	1.56E-01	22.5	33.572	1.728	8.337
0.16	1.21E-01	22.5	27.865	0.289	9.44
0.17	1.07E-01	25.313	30.886	0.355	6.919
0.18	9.49E-02	23.906	28.76	-0.148	7.015
0.19	1.17E-01	15.469	25.738	1.844	12.052
0.2	1.05E-01	16.875	27.641	0.276	6.297
0.21	7.54E-02	12.656	28.76	0.502	7.261

0.22	5.53E-02	21.094	28.088	1.026	7.311
0.23	4.29E-02	19.688	31.334	0.646	5.383
0.24	3.17E-02	19.688	31.781	-0.774	6.852
0.25	4.78E-02	12.656	28.648	-0.299	5.625
0.26	3.40E-02	1.406	36.369	1.058	4.057
0.27	3.54E-02	7.031	30.103	0.823	6.083
0.28	4.53E-02	8.438	28.424	0.465	4.451
0.29	2.64E-02	0	33.684	0	3.398
0.3	3.47E-02	354.375	31.11	1.475	5.253
0.31	3.42E-02	1.406	27.081	1.43	6.556
0.32	1.85E-02	1.406	42.188	-0.388	2.86
0.33	2.33E-02	344.531	36.257	1.123	3.631
0.34	2.35E-02	347.344	33.907	0.306	3.714
0.35	1.55E-02	358.594	35.81	-1.093	4.454
0.36	1.43E-02	345.938	38.831	-0.354	3.247
0.37	1.11E-02	352.969	43.419	-0.213	2.796
0.38	1.22E-02	343.125	39.279	0.356	2.604
0.39	1.36E-02	340.313	34.915	1.004	4.313
0.4	1.03E-02	348.75	33.796	0.798	5.075
0.41	9.23E-03	354.375	36.481	1.515	4.923
0.42	6.54E-03	344.531	43.979	0.6	2.614
0.43	1.01E-02	347.344	33.46	0.302	4.474
0.44	5.17E-03	340.313	45.881	0.785	2.466
0.45	5.60E-03	337.5	47	0.388	1.881
0.46	7.12E-03	331.875	36.705	0.419	3.786
0.47	6.51E-03	338.906	35.362	0.573	4.605
0.48	3.70E-03	348.75	49.91	-0.236	2.714
0.49	3.38E-03	326.25	47.672	-0.326	2.779
0.5	3.66E-03	336.094	43.867	1.178	3.72
0.51	3.64E-03	334.688	46.777	1.129	2.88
0.52	3.40E-03	338.906	44.538	0.994	2.747
0.53	3.64E-03	340.313	40.622	1.073	2.84
0.54	2.11E-03	343.125	52.372	0.799	2.146
0.55	2.61E-03	326.25	46.553	1.368	2.967
0.56	1.65E-03	338.906	46.665	0.868	2.896
0.57	3.07E-03	345.938	42.86	0.459	2.844
0.58	1.85E-03	343.125	49.462	0.672	1.998

Appendix F
Seakeeping Trials Run Log

Run Log for Seakeeping Trial on CCGS Shamook - Vessel 'D'

Fishing Vessel Research Project (Proj. 2017) **Date: Dec 15, 2003**

Run #	File Name	Start / Finish Time	Course Relative to Incident Waves	Location Start/Finish Latitude (deg./min./s)	Long. (deg./min./s)	Nominal SWH (m)	SOG (kts.)	COG (Deg. TRUE)	Wind Speed (kts.)	Wind Direction (Deg. Rel.)	Engine Rpm	Shaft Rpm	**Comments:** Heavy vessel movement, slamming, spray, water accumulation, maintaining balance/seasickness.
1	0driftA_20031215095019_CAL.CSV	9:50:19 10:15:04	Beam Drift	47 34 27 47 34 08	52 26 10 52 26 18	2.01	~1.2 (drift)	~206	N/A	N/A	N/A	N/A	Derive dominant wave direction
2	4head_20031215105129_CAL.CSV	10:51:29 11:16:05	Head	47 34 16 47 35 56	52 26 28 52 26 41	1.86	4.1	356	18	60 (Port)	980	261	
3	4fol_20031215112007_CAL.CSV	11:20:07 11:51:04	Following	47 35 50 47 33 48	52 26 46 52 26 40	1.98	4.0	176	13	90 (Star.)	980	264.2	
4	4bow_20031215115614_CAL.CSV	11:56:14 12:19:37	Bow	47 33 52 47 34 58	52 26 26 52 24 03	1.98	3.9	41	12	110 (Port)	980	262.5	
5	4beam_20031215122555_CAL.CSV	12:25:55 12:51:12	Beam	47 35 14 47 35 00	52 24 48 52 27 14	2.19	4.6	266	16	0	980	263.2	
6	4quart_20031215125501_CAL.CSV	12:55:01 13:20:18	Quartering	47 34 54 47 33 46	52 27 25 52 25 48	2.19	4.2	131	8	180	980	263.9	
7	0driftB_20031215132731_CAL.CSV	13:27:31 13:48:10	Beam Drift	47 34 09 47 33 59	52 26 12 52 26 15	2.19	~1.1 (drift)	~200	8	100 (Port)	N/A	N/A	
8	8head_20031215135155_CAL.CSV	13:51:55 14:17:32	Head	47 34 14 47 37 40	52 26 17 52 25 50	2.19	8.2	6	21	30 (Port)	1070	287.7	New dominant wave direction acquired
9	8fol_20031215142008_CAL.CSV	14:20:08 14:58:54	Following	47 37 37 47 33 48	52 25 54 52 26 35	2.24	8.2	186	8	50 (Star.)	990	258.7	
10	8bow_20031215145914_CAL.CSV	14:59:14 15:25:14	Bow	47 33 44 47 36 03	52 25 50 52 21 49	2.24	8.2	51	12	50 (Port)	1070	288.7	
11	8beam_20031215152901_CAL.CSV	15:29:01 15:54:06	Beam	47 36 16 47 36 35	52 22 08 52 27 05	2.03	8.3	276	10	0	1000	269.7	
12	8quart_20031215155652_CAL.CSV	15:56:52 16:22:03	Quartering	47 36 25 47 33 50	52 27 10 52 24 12	2.03	8.2	141	7	30 (Port)	960	259.3	

NOTES: Wind speed/direction is provided relative to the ship's course, wind acting on the bow of the ship reading zero degrees.
SOG - Speed Over Ground COG - Course Over Ground SWH - Significant Wave Height N/A - not applicable
Trial carried out around moored directional wave buoy nominally 10 nm east of St. John's, NL in 165 m of water approx. @ 47 34 17 North (Lat.) and 52 26 13 West (Long.).
Nominal Draft AP: 2.7923 m Nominal Draft FP: 2.6475 m Drafts measured relative to hydrostatic baseline.
Above drafts were measured during inclining experiment after wave buoy & mooring equipment removed. Drafts were corrected for inclining weights.
CCGS Shamook used a single fin section rudder and a single, 4 bladed, variable pitch propellor. With CP propeller, shaft RPM nominally constant irregardless of forward speed.
Propeller pitch angle not recorded. Rudder azimuth rate signal not available due to equipment failure.
The difference between deg. magnetic and deg. TRUE was approximately 21.1 deg.
From salinity meter readings: St. John's - prior to departure @ 07:45 AM: sea temperature = 3.7 deg. C, salinity = 29.7 ppt, therefore density = 1023.609 kg/m^3
From salinity meter readings: at wave buoy location @ 10:45: sea temperature = 3.0 deg. C, salinity = 31.0 ppt, therefore density = 1024.703 kg/m^3
From salinity meter readings: St. John's - return to port @ 19:10: sea temperature = 3.5 deg. C, salinity = 30.5 ppt, therefore density = 1024.263 kg/m^3
Several cm of water on quarterdeck noted for many runs - especially in beam seas.

Appendix G
International Tow Tank Conference Test Plan

Test Program for Seakeeping Trials on 75' CCGS Shamook - Vessel D

Proj. 2017 **Nov. 20, 2003** **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 has plenty of lifesaving gear for a total of 6 trials staff (MUN Project Engineer, 2 IOT staff, 1 Oceans Ltd. staff and 2 MUN physical education)
3) Vessel operator will be responsible for fueling vessel & acquiring required supplies to operate vessel.

Preliminary Preparations:

1) IOT to fit out vessel with instrumentation as per instrumentation plan.
2) Set displacement condition roughly half load condition - this may require loading ballast - static weights.
   Press up water & fuel tanks to minimize free surface if possible.
3) Poisiden to carry out inclining experiment with all instrumentation (wave buoy & mooring removed), consumables & ballast in place.
4) Select location for trials ~ 10 nm off St. John's. Permission from St. John's Traffic Control may be required.
   Design/compile mooring for wave buoy once water depth is known (R. Fitzgerald/Oceans Ltd.).
5) Decision/arrangements required with respect deploying wave buoy prior to trial
6) CCG to issue Notice to Mariners regarding deployment location (Lat., Long) of wave buoy & buoy identification info
   (color, dimensions, radar beacon, flashing light etc.)
7) Either borrow a cell phone for trials preparation period & sea trial.
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.
   This will require a circles in the harbour to be carried out prior to the trial.

Prior to departing port on day of trial:

1) Check all instrumentation and data acquisition system. No IOT generator will be required for AC power.
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 that 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) 10 minute collection of data with mooring lines slack, engine off
7) For Shamook - wave height of 2-3 m would be ideal.

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

1) Oceans Ltd. personnel supervise deployment of Datawell wave buoy. Oceans Ltd personnel in constant communication with Datawell wave buoy.
Use initial wave buoy data to determine Average Wave Direction.
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.

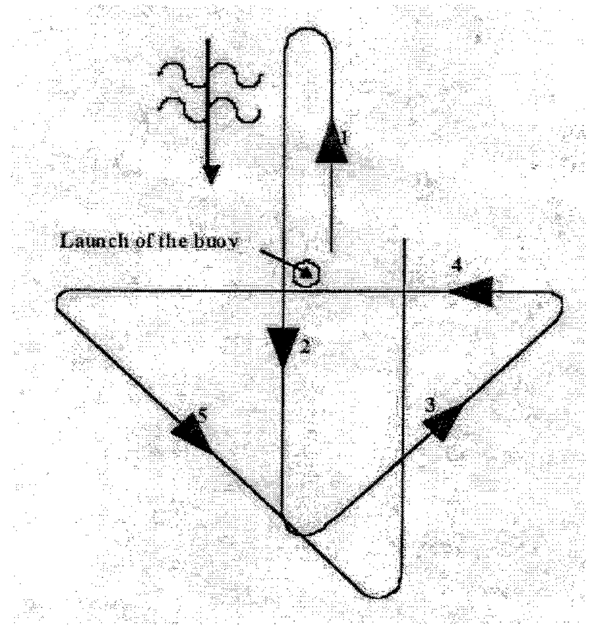
Run 1: Drift A Run: 0 knots, beam seas, 25 minutes

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

Return to wave buoy location.
Run 7: Drift B Run: 0 knots, beam seas, 25 minutes

Run 8: 8 knots, head seas, 25 minutes
Run 9: 8 knots, following seas, 40 minutes
Run 10: 8 knots, bow sea, 25 minutes
Run 11: 8 knots, beam sea, 25 minutes
Run 12: 8 knots, quartering sea, 25 minutes

Return to wave buoy location. Recover wave buoy.



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

After vessel has returned to dock upon completion of trial:

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.
4) Remove all instrumentation, ballast from vessel.
5) Return borrowed cell phone.

NOTE: 180 deg. is defined as a head sea.
The CCGS Shamook has an autopilot & thus all non-zero forward speed runs to be carried out on autopilot.

Appendix H
Wave Statistics, Nondirectional Spectrum Plots and Mean Wave Direction vs. Frequency Plots

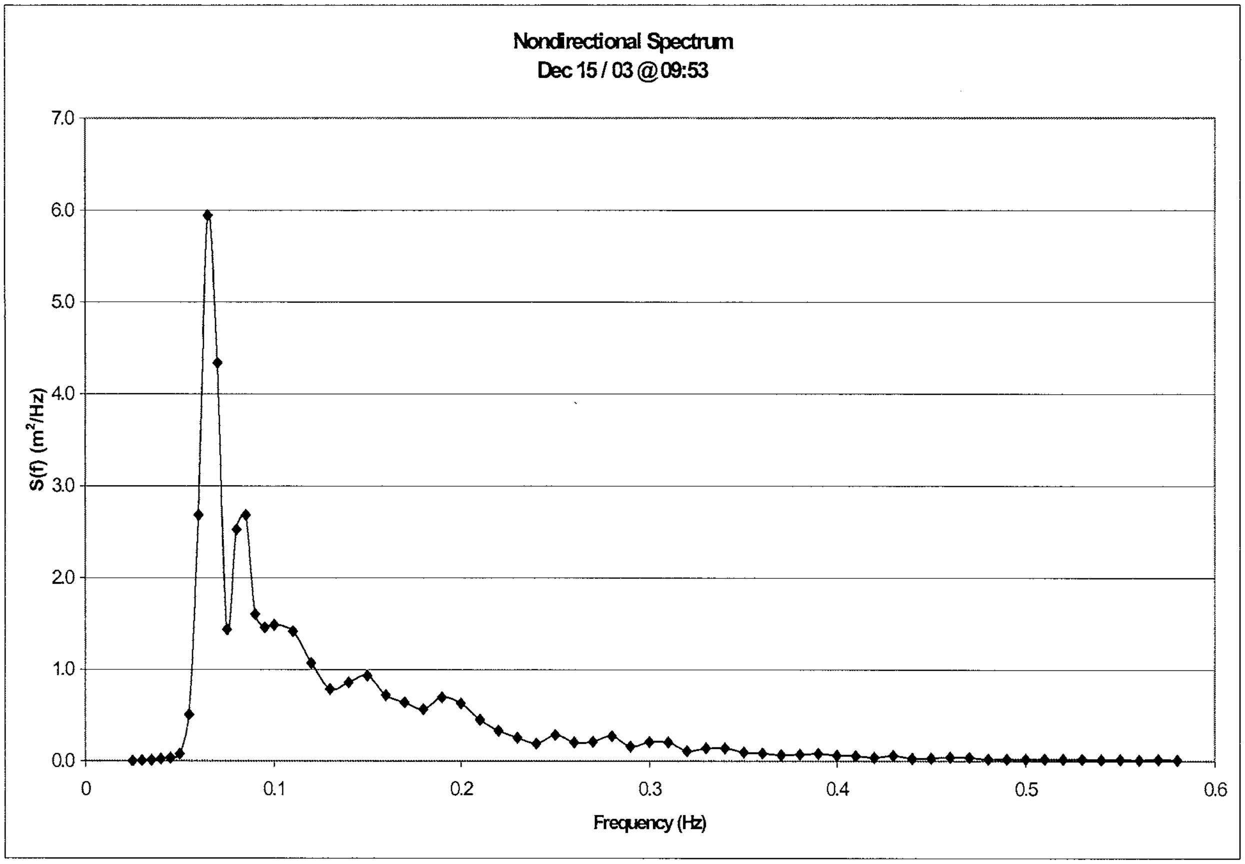
Summary of Wave Statistics Collected Using Oceans Datawell Wave Buoy

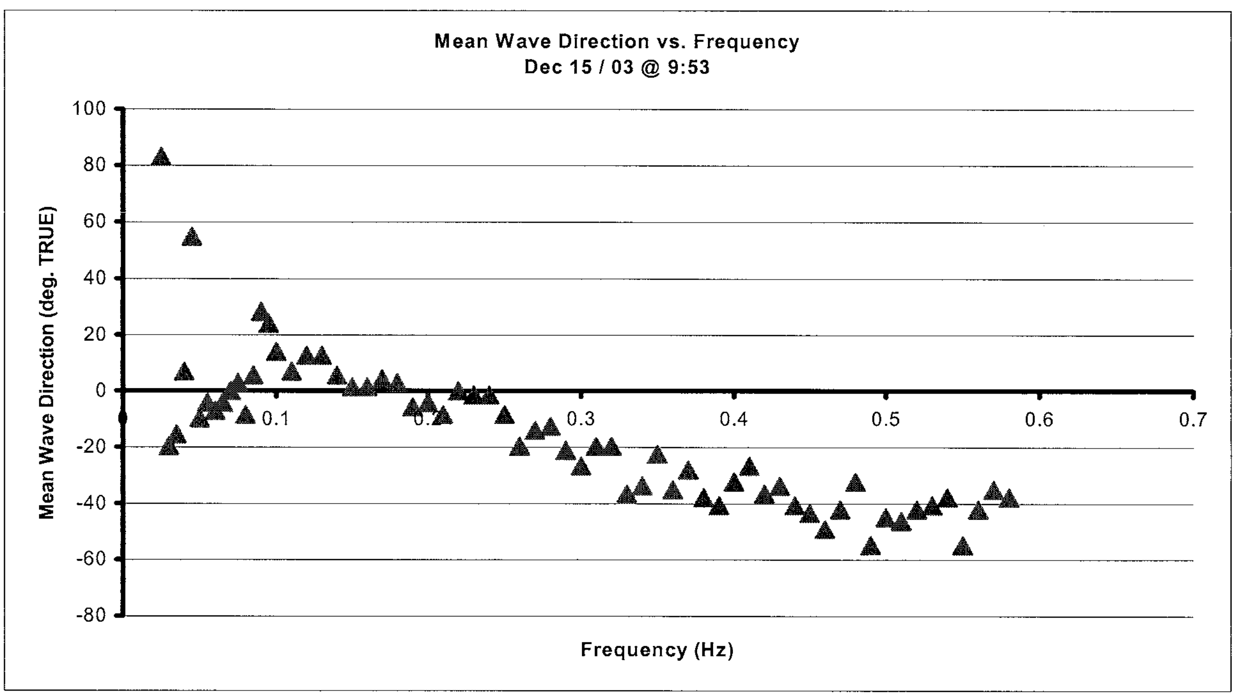
CCGS Shamook
December 15 / 2003

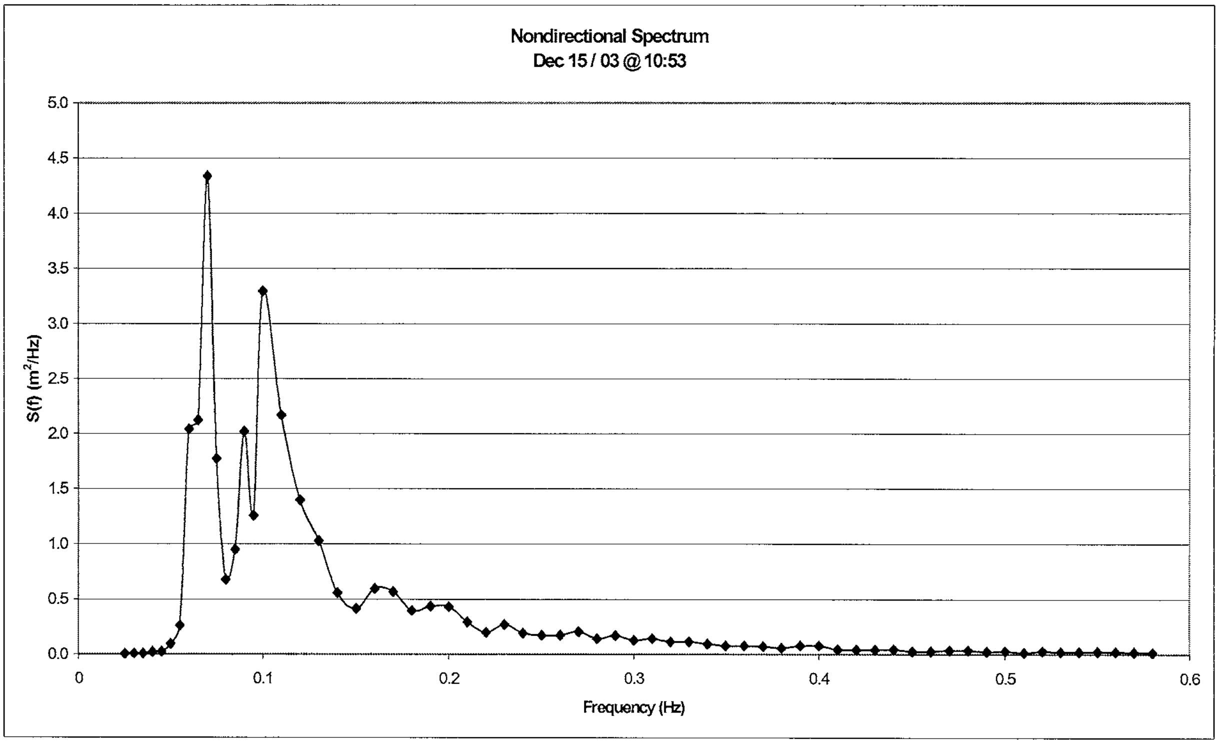
Project: 2017

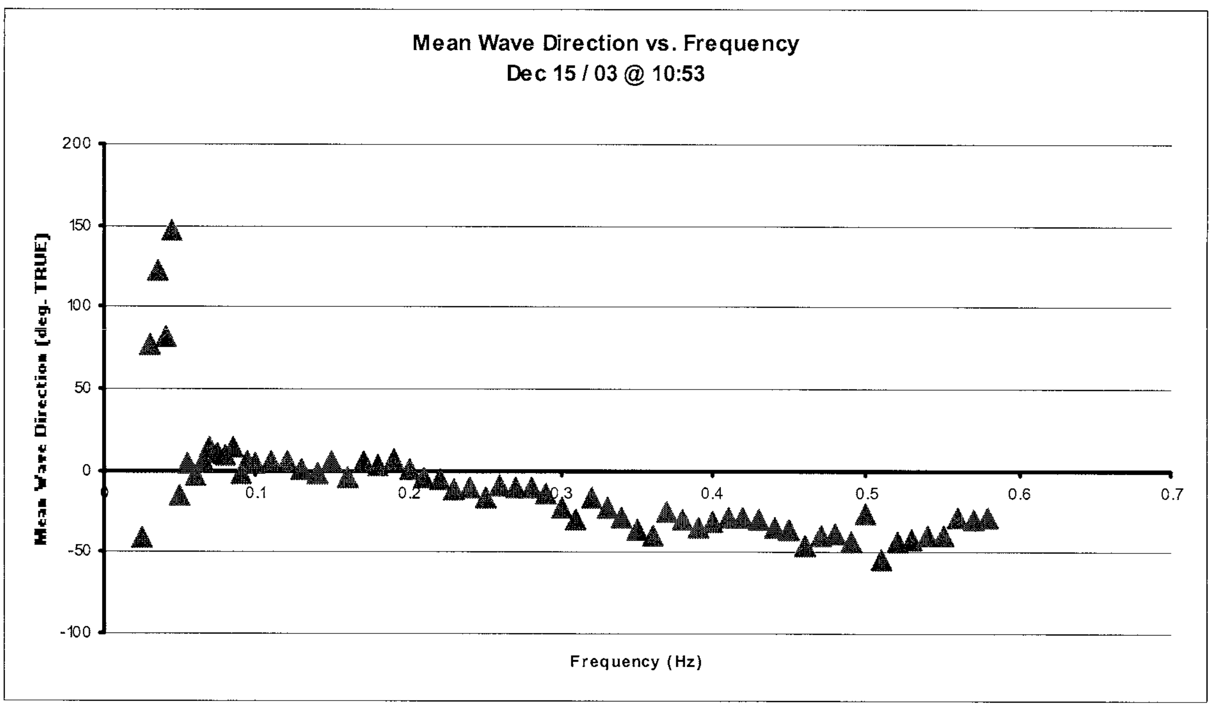
NF Time	Sig. Wave Height (m)	Mean Period (s)	Peak Frequency (Hz)	Directional Spread (deg.)	Mean Wave Direction (deg. Mag.)	Mean Wave Direction (deg. TRUE)
9:53	2.01	6.06	0.065	22.7	16.9	355.8
10:53	1.86	6.06	0.070	28.8	35.2	14.1
11:53	1.98	6.25	0.065	26.1	23.9	2.8
12:53	2.19	6.56	0.070	21.0	26.7	5.6
13:53	2.19	7.02	0.075	20.3	23.9	2.8
14:53	2.24	7.41	0.065	22.2	25.3	4.2
15:53	2.03	7.02	0.075	18.9	25.3	4.2

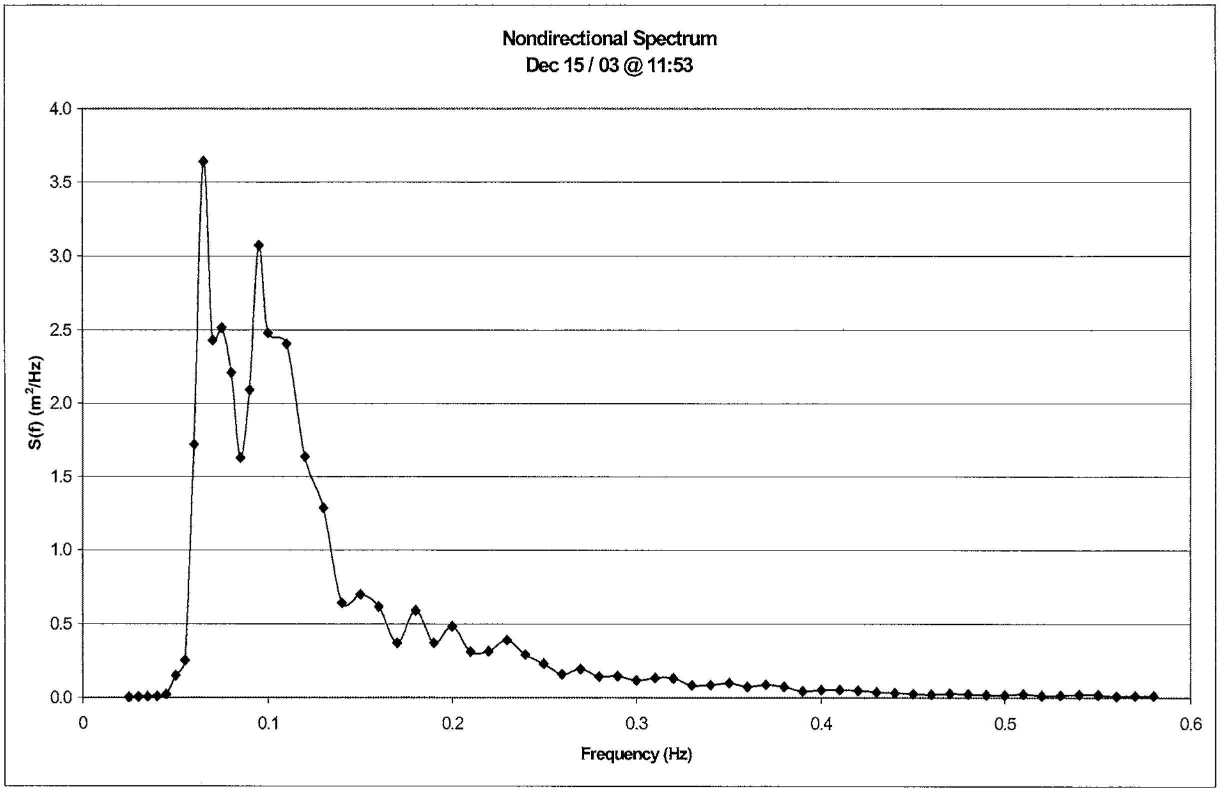
Note: The magnetic deviation during the trials time frame was 21.1 degrees West

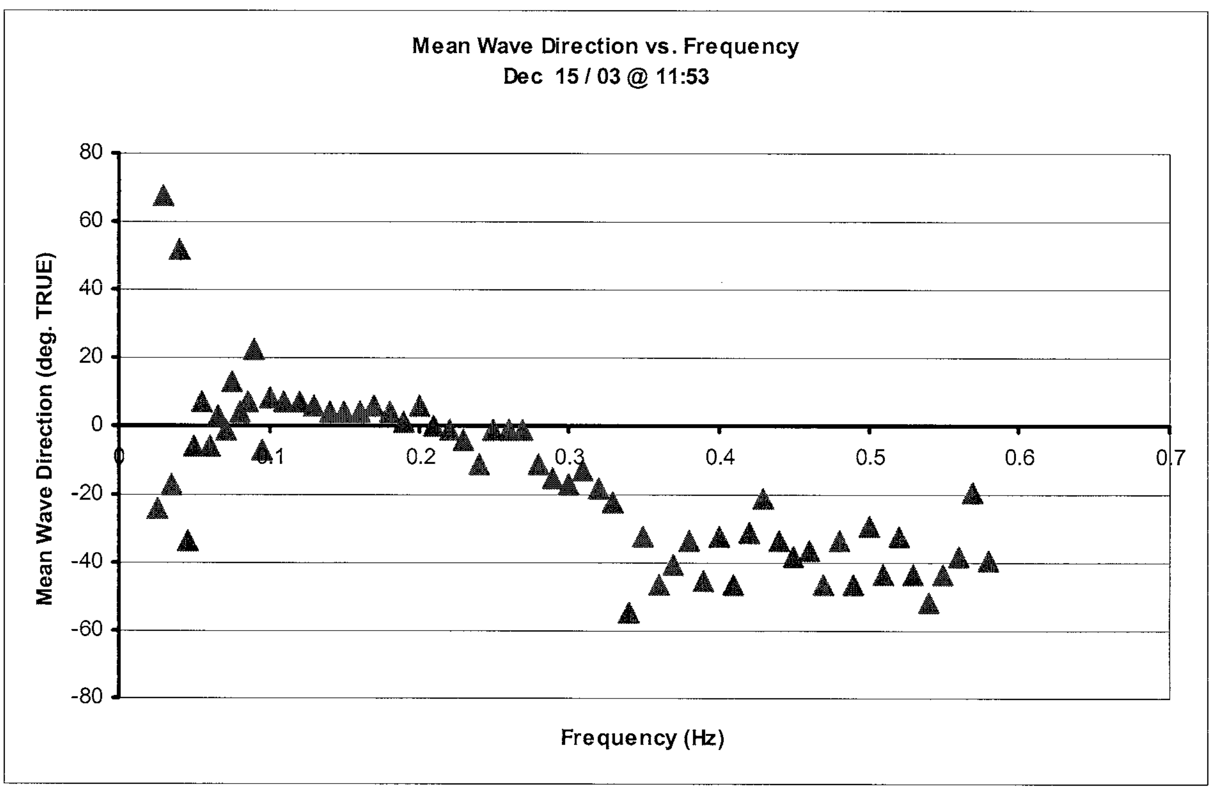

Nondirectional Spectrum
Dec 15 / 03 @ 09:53
S(f) (m²/Hz)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

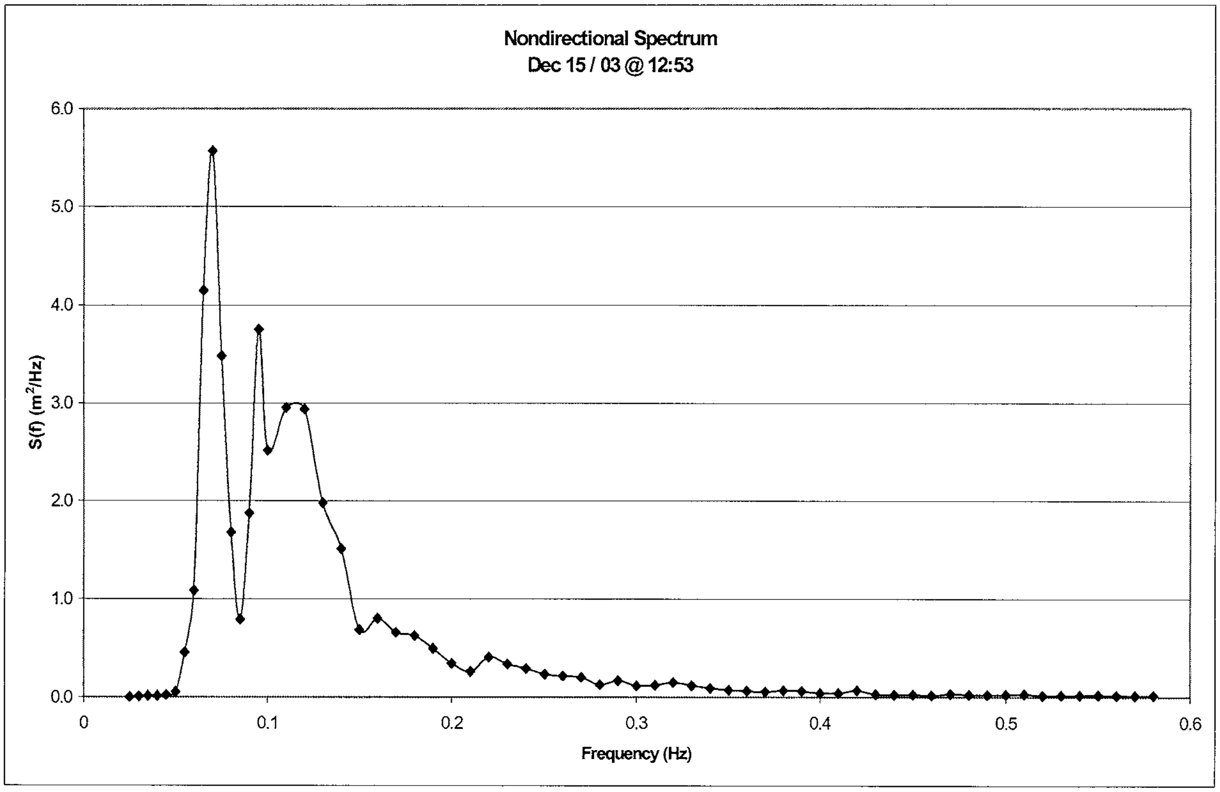

Mean Wave Direction vs. Frequency
Dec 15 / 03 @ 9:53
Mean Wave Direction (deg. TRUE)
100
80
60
40
20
0
-20
-40
-60
-80
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Frequency (Hz)

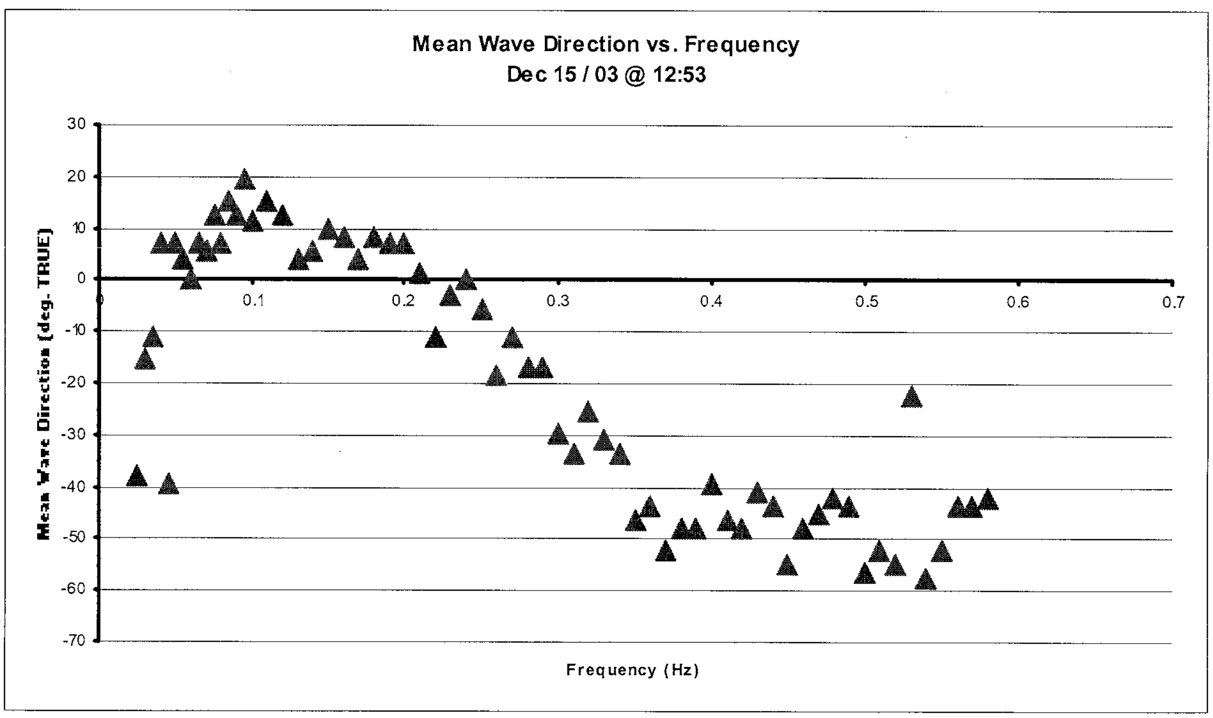

Nondirectional Spectrum
Dec 15 / 03 @ 10:53
S(f) (m²/Hz)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

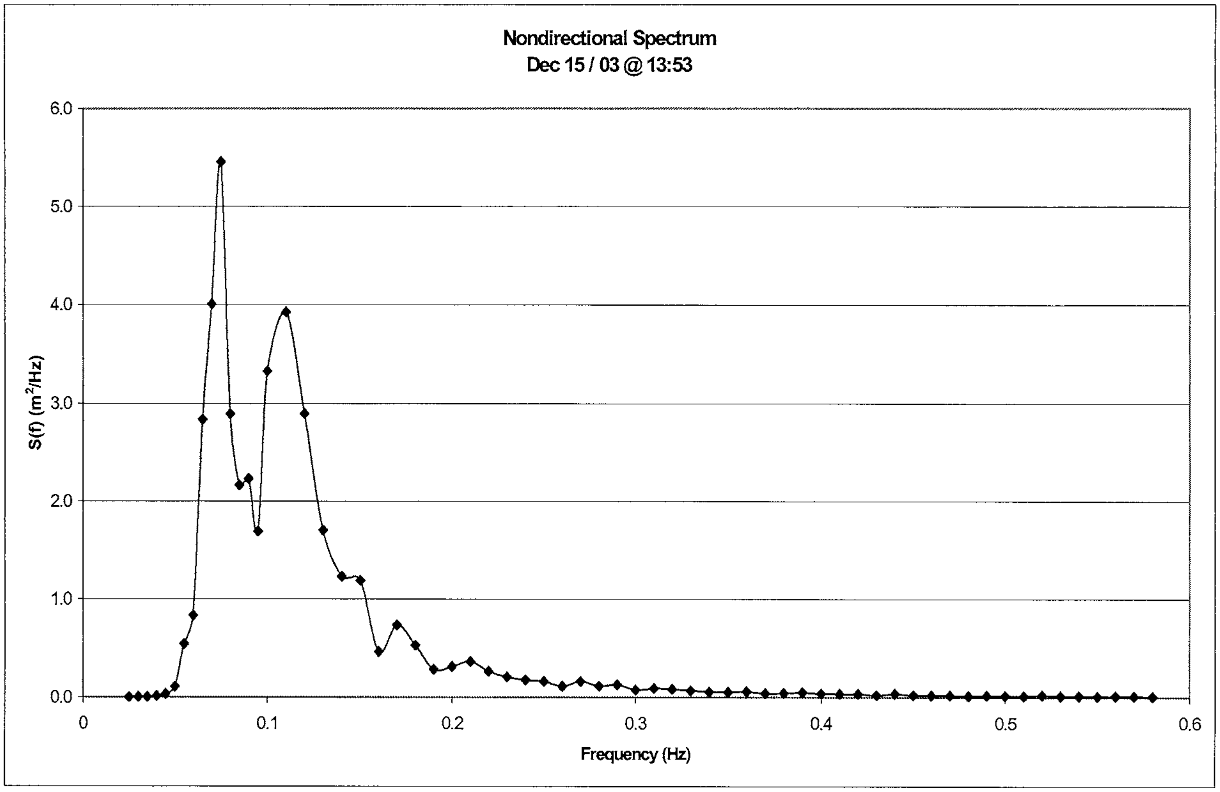

Mean Wave Direction vs. Frequency
Dec 15 / 03 @ 10:53
Mean Wave Direction (deg. TRUE)
200
150
100
50
0
-50
-100
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Frequency (Hz)

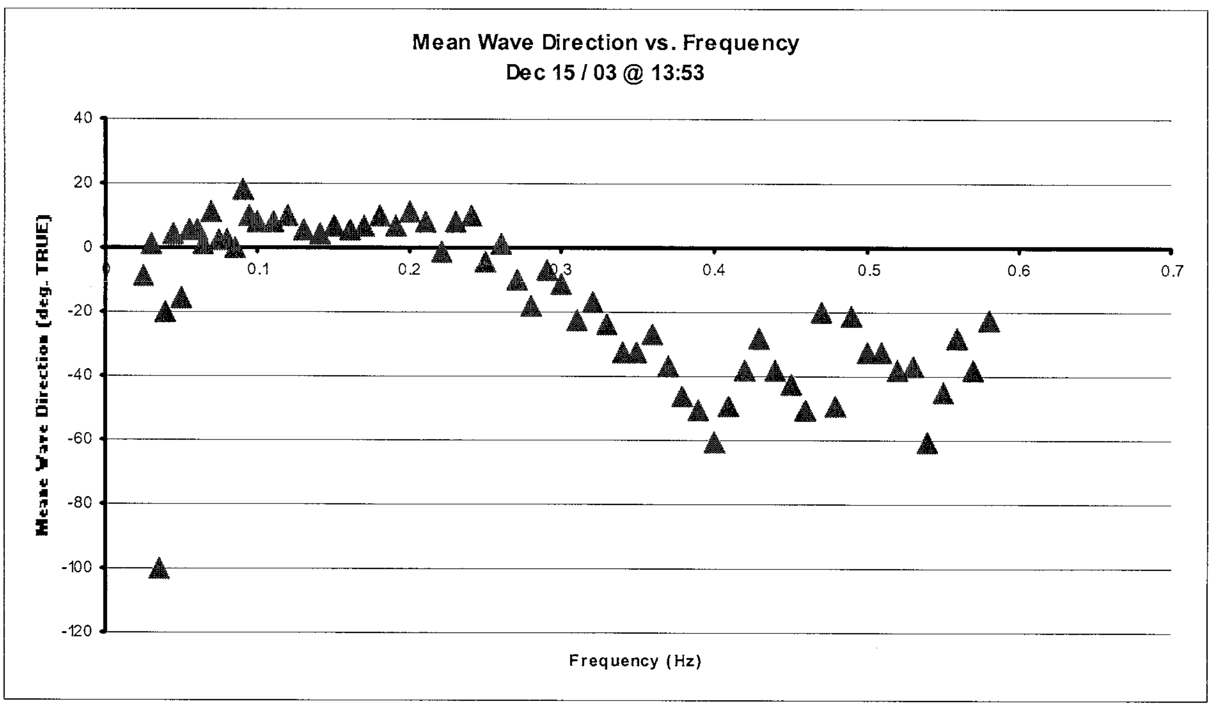

Nondirectional Spectrum
Dec 15 / 03 @ 11:53
S(f) (m²/Hz)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

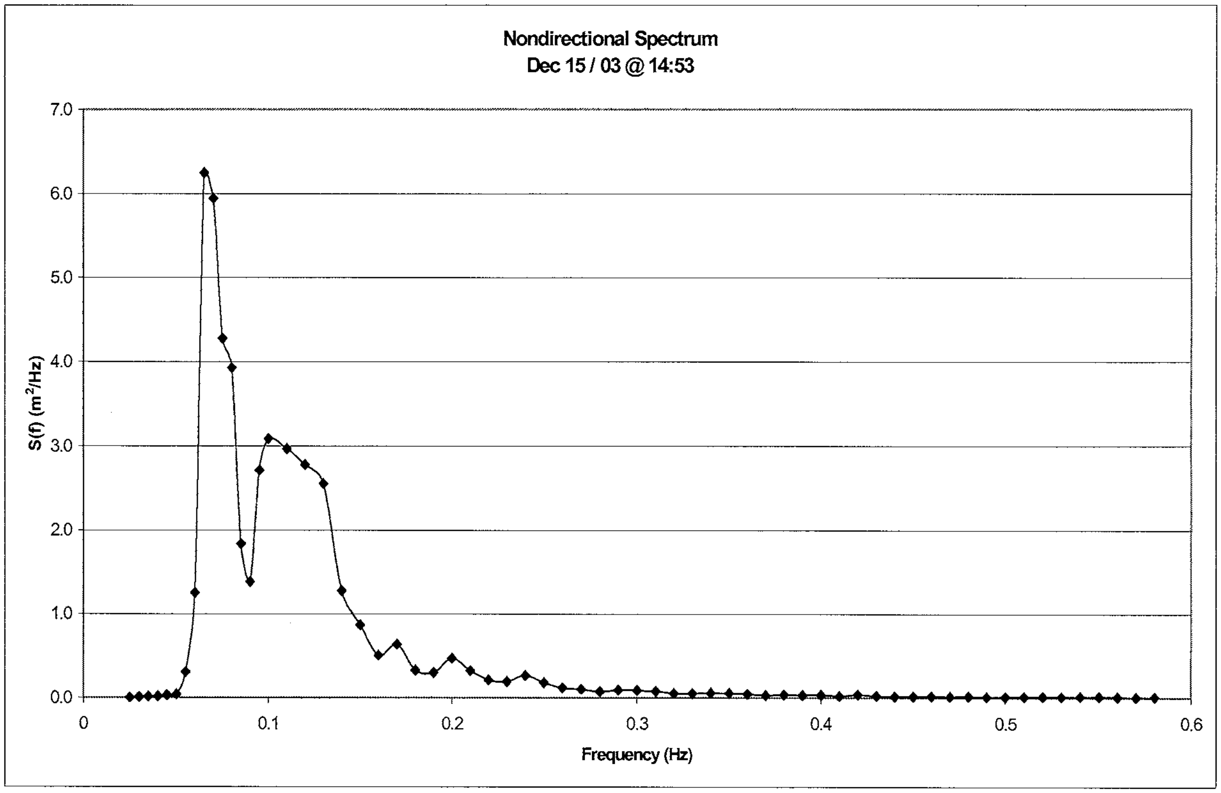

Mean Wave Direction vs. Frequency
Dec 15 / 03 @ 11:53
Mean Wave Direction (deg. TRUE)
80
60
40
20
0
-20
-40
-60
-80
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Frequency (Hz)

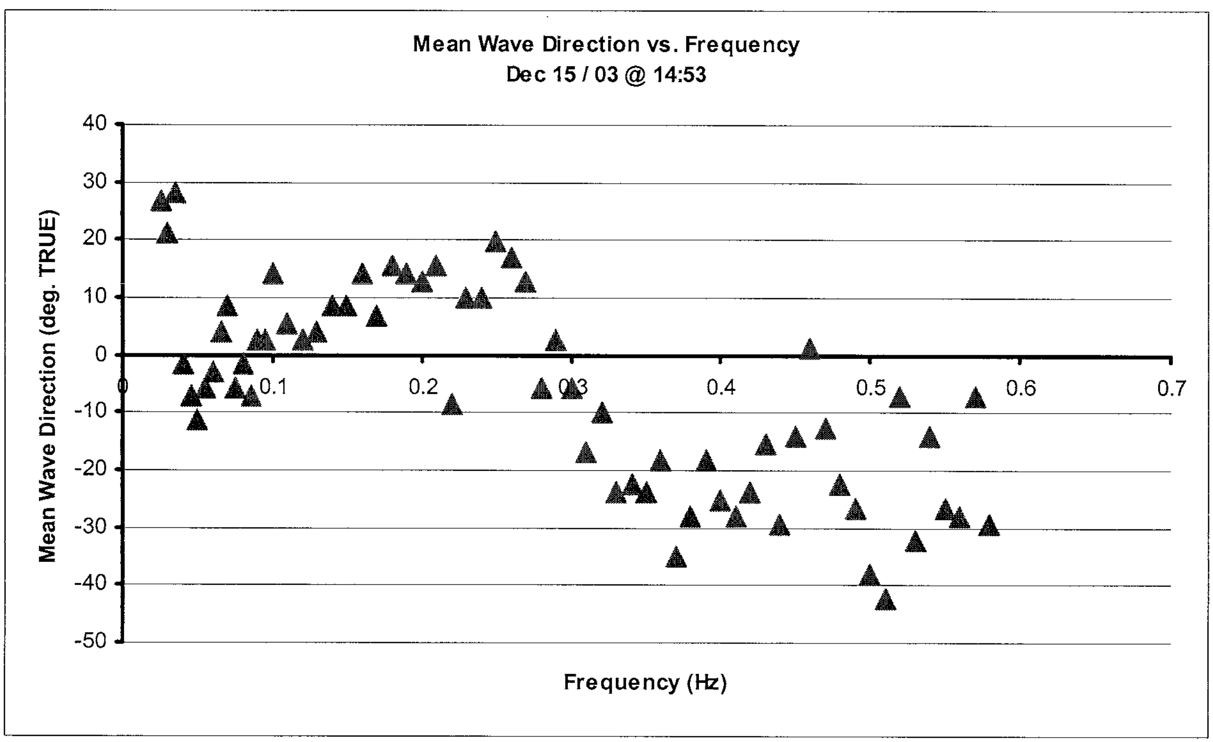

Nondirectional Spectrum
Dec 15 / 03 @ 12:53
S(f) (m^2/Hz)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)

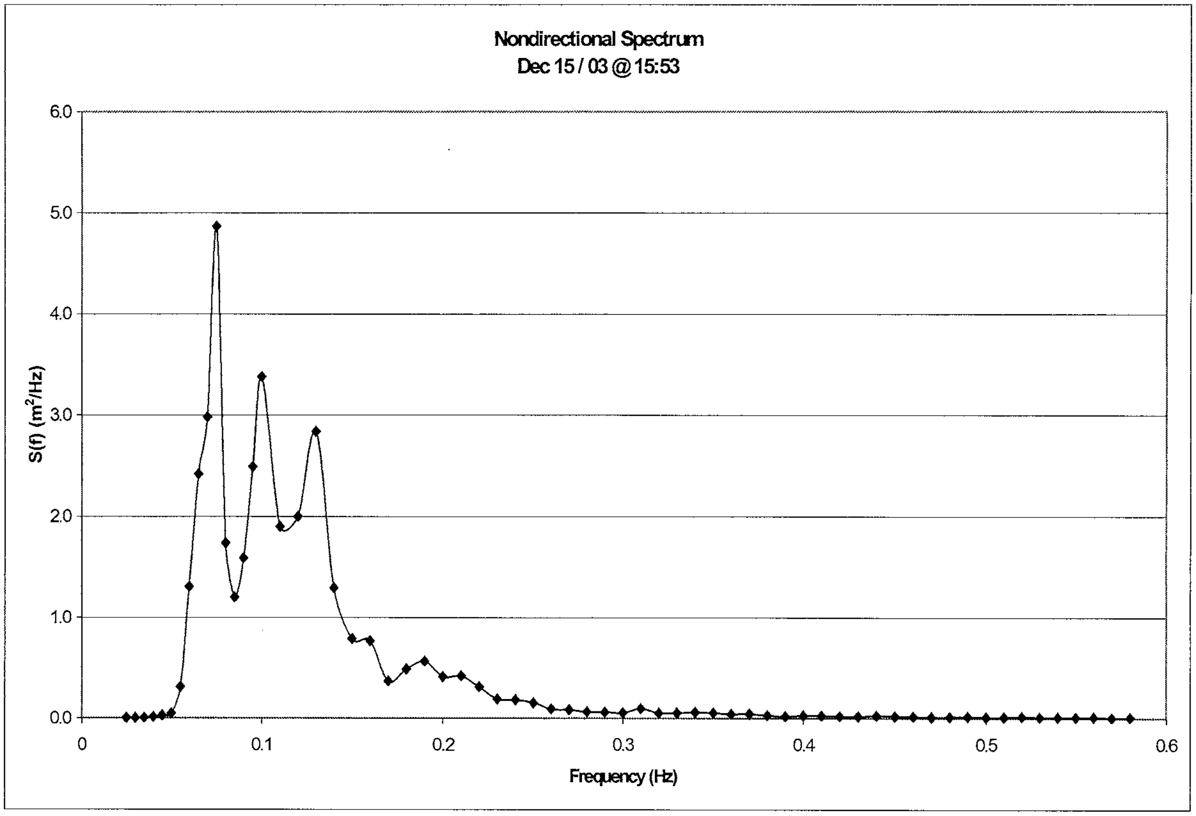

Mean Wave Direction vs. Frequency
Dec 15 / 03 @ 12:53
Mean Wave Direction (deg. TRUE)
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Frequency (Hz)

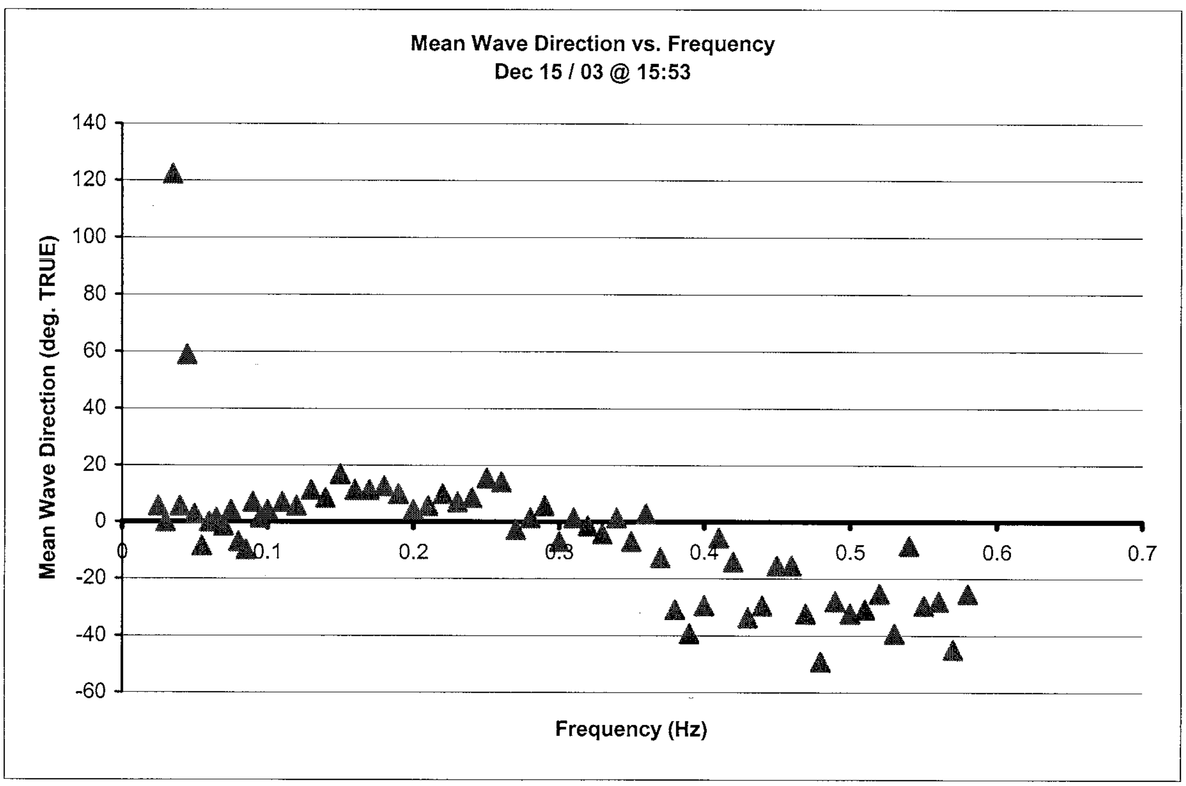

Nondirectional Spectrum
Dec 15 / 03 @ 13:53
6.0
5.0
4.0
3.0
2.0
1.0
0.0
S(f) (m²/Hz)
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)


Mean Wave Direction vs. Frequency
Dec 15 / 03 @ 13:53
40
20
0
-20
-40
-60
-80
-100
-120
Meane Wave Direction (deg. TRUE)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Frequency (Hz)


Nondirectional Spectrum
Dec 15 / 03 @ 14:53
S(f) (m²/Hz)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)


Mean Wave Direction vs. Frequency
Dec 15 / 03 @ 14:53
Mean Wave Direction (deg. TRUE)
40
30
20
10
0
-10
-20
-30
-40
-50
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Frequency (Hz)


Nondirectional Spectrum
Dec 15 / 03 @ 15:53
S(f) (m²/Hz)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
0.1
0.2
0.3
0.4
0.5
0.6
Frequency (Hz)


Mean Wave Direction vs. Frequency
Dec 15 / 03 @ 15:53
Mean Wave Direction (deg. TRUE)
140
120
100
80
60
40
20
0
-20
-40
-60
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Frequency (Hz)

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

File Name: 0DRIFTA_20031215095019_CAL
Date: December 15, 2003 NF Time: 9:50

Dockside

Location:	Pier 31, St. John's Harbour		
Nominal Draft FP:	2.65 m	Nominal Draft AP:	2.79 m
Water Temperature:	3.7 °C	Water Density:	1023.6 kg/m^3
Static Stability Info - GM_T(Fluid):	0.79 m		
Closest Stability Booklet Condition:	Port Departure (98% Consumables)		

Trials Site:

Trials Location:	10 nautical miles East of St. John's		
Water Temperature:	3.0 °C	Water Density:	1024.7 kg/m^3

Start of Run

Latitude:	47° 34' 27" North	Longitude:	52° 26' 10" West
Nominal Forward Speed Over the Ground:		~1.2 knots	(drift)
Nominal Course Over the Ground:		~206 (deg. TRUE)	(drift)
Total Distance Traveled During the Run:		0.32 nautical miles	
Nominal Relative Wind Speed:		Not Recorded knots	
Nominal Relative Wind Direction:		Not Recorded (deg. Rel)	
Nominal Engine RPM:		N/A RPM	
Nominal Sea State:		3	

Duration of Run:	1489 s	Number of Samples:	74443
Drift Speed:	0.79 knots	Drift Direction:	198 (deg. True)

Dominant Wave Characteristics:	Significant Height:	2.01 m
	Direction:	255.8 (deg. True)
	Mean Period:	6.06 s
Peak Response Frequency:	Roll Angle:	0.1679 Hz
	Pitch Angle:	0.1866 Hz
	Heave Accel:	0.1866 Hz

Channel		**Average**	**St. Dev.**	**Minimum**	**Maximum**
DGPS Antenna					
COG	(deg. True)	206.9	36.338	27.1	253.5
SOG	(m/s)	0.634	0.146	0.250	1.231
SOG	(knots)	1.233	0.283	0.486	2.392
Shaft Speed	(RPM)	0.929	4.748	-1.967	50.721
Rudder Angle	(deg.)	-0.115	0.491	-0.850	6.394
Motions Computed for the Centre of Gravity					
Roll Angle	(deg.)	0.336	4.723	-13.690	14.957
Pitch Angle	(deg.)	2.563	1.483	-4.670	7.798
Yaw Angle	(deg.)	0.619	9.285	-27.708	19.725
Surge Displacement	(m)	0.000	0.257	-1.158	0.864
Sway Displacement	(m)	0.000	0.369	-1.267	0.967
Heave Displacement	(m)	0.000	0.483	-1.622	1.937
Surge Acceleration	(m/s^2)	0.000	0.187	-0.647	0.879
Sway Acceleration	(m/s^2)	0.001	0.249	-0.947	0.867
Heave Acceleration	(m/s^2)	-0.012	0.426	-1.854	1.522

File Name: 0DRIFTA_20031215095019_CAL
Date: December 15, 2003 NF Time: 9:50

Channel		Average	St. Dev.	Minimum	Maximum
Output from the MotionPak Accelerometers					
Surge Acceleration	(m/s^2)	0.606	0.137	-0.108	1.258
Sway Acceleration	(m/s^2)	-	-	-	-
Heave Acceleration	(m/s^2)	-9.743	0.427	-11.454	-8.180
Computed for the MotionPak position from the Accelerometers					
Surge Acceleration	(m/s^2)	0.438	0.122	-0.129	0.985
Sway Acceleration	(m/s^2)	-0.043	0.898	-3.095	2.874
Heave Acceleration	(m/s^2)	0.036	0.445	-1.801	1.663
Computed for Wheelsman's Position					
Surge Displacement	(m)	0.000	0.146	-0.497	0.895
Sway Displacement	(m)	0.000	1.038	-2.912	3.416
Heave Displacement	(m)	0.000	0.531	-2.061	2.169
Surge Acceleration	(m/s^2)	0.428	0.285	-1.015	1.664
Sway Acceleration	(m/s^2)	-0.055	1.258	-4.487	3.811
Heave Acceleration	(m/s^2)	0.069	0.563	-2.001	2.457

Notes:
- The draft is referenced to the hydrostatic baseline.
- The wave direction sign convention is stated as where the waves are coming from.
- The engine to shaft speed ratio is 3.75:1.
- Offline analysis showed a glitch in the Sway channel of the MotionPak. Therefore motions were computed using the tri-mounted accelerometers and the MotionPak rates.
- A high-pass filter was used on the MotionPak rates to mitigate any noise caused by engine vibrations.
- The motions of the vessel at the CG were calculated using the earth fixed coordinate system.
- The motions of the vessel at the accelerometers were calculated using the body fixed coordinate system.
- 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 : 0.469 m fwd. Δy : 0.508 m stbd. Δz : 0.344 m below
- The distance to Accelerometers position from MotionPak:
  Δx : 4.686 m fwd. Δy : 0.648 m stbd. Δz : -3.230 m above
- The distance from Accelerometers to Center of Gravity:
  Δx : -4.217 m aft Δy : -0.140 m port Δz : 3.574 m below
- The distance from Accelerometers to Wheelsman's position:
  Δx : 1.2827 m fwd. Δy : 0.000 m Δz : 0.000 m

File Name: 4HEAD_20031215105129_CAL
Date: December 15, 2003 NF Time: 10:51

Dockside
Location: Pier 31, St. John's Harbour
Nominal Draft FP: 2.65 m Nominal Draft AP: 2.79 m
Water Temperature: 3.7 °C Water Density: 1023.6 kg/m^3
Static Stability Info - GM_T(Fluid): 0.79 m
Closest Stability Booklet Condition: Port Departure (98% Consumables)

Trials Site:
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 3.0 °C Water Density: 1024.7 kg/m^3

Start of Run
Latitude: 47° 34' 16" North Longitude: 52° 26' 28" West
Nominal Forward Speed Over the Ground: 4.1 knots
Nominal Course Over the Ground: 356 (deg. TRUE)
Total Distance Traveled During the Run: 1.68 nautical miles
Nominal Relative Wind Speed: 18 knots
Nominal Relative Wind Direction: 300 (deg. Rel)
Nominal Engine RPM: 980 RPM
Nominal Sea State: 3

Duration of Run: 1476 s Number of Samples: 73815
Drift Speed: 0.01 knots Drift Direction: 105 (deg. True)

Dominant Wave Characteristics: Significant Height: 1.86 m
Direction: 14.1 (deg. True)
Mean Period: 6.06 s

Peak Response Frequency: Roll Angle: 0.1693 Hz
Pitch Angle: 0.2371 Hz
Heave Accel.: 0.2747 Hz

Channel		Average	St. Dev.	Minimum	Maximum
DGPS Antenna					
COG	(deg. True)	355.0	1.950	348.5	359.6
SOG	(m/s)	2.119	0.139	1.719	2.469
SOG	(knots)	4.120	0.270	3.343	4.801
Shaft Speed	(RPM)	261.0	0.913	257.9	264.7
Rudder Angle	(deg.)	-0.889	1.226	-4.272	3.495
Motions Computed for the Centre of Gravity					
Roll Angle	(deg.)	0.360	1.592	-5.056	5.539
Pitch Angle	(deg.)	2.537	2.174	-6.240	11.037
Yaw Angle	(deg.)	-0.039	1.509	-4.265	3.612
Surge Displacement	(m)	0.000	0.308	-1.026	1.171
Sway Displacement	(m)	0.000	0.119	-0.428	0.406
Heave Displacement	(m)	-0.001	0.463	-1.484	1.367
Surge Acceleration	(m/s^2)	0.001	0.211	-0.799	0.807
Sway Acceleration	(m/s^2)	0.001	0.124	-0.476	0.525
Heave Acceleration	(m/s^2)	-0.016	0.595	-2.018	2.167

File Name: 4HEAD_20031215105129_CAL
Date: December 15, 2003 NF Time: 10:51

Channel		Average	St. Dev.	Minimum	Maximum
Output from the MotionPak Accelerometers					
Surge Acceleration	(m/s^2)	0.592	0.256	-0.399	1.350
Sway Acceleration	(m/s^2)	-	-	-	-
Heave Acceleration	(m/s^2)	-9.777	0.573	-11.729	-7.648
Computed for the MotionPak position from the Accelerometers					
Surge Acceleration	(m/s^2)	0.426	0.260	-0.579	1.178
Sway Acceleration	(m/s^2)	-0.062	0.312	-1.110	1.028
Heave Acceleration	(m/s^2)	0.000	0.579	-1.919	2.123
Computed for Wheelsman's Position					
Surge Displacement	(m)	0.000	0.234	-0.755	0.991
Sway Displacement	(m)	0.001	0.348	-1.109	1.116
Heave Displacement	(m)	-0.001	0.558	-2.143	1.709
Surge Acceleration	(m/s^2)	0.408	0.547	-1.548	2.132
Sway Acceleration	(m/s^2)	-0.062	0.437	-1.546	1.434
Heave Acceleration	(m/s^2)	0.012	0.959	-3.283	3.400

Notes:

- The draft is referenced to the hydrostatic baseline.
- The wave direction sign convention is stated as where the waves are coming from.
- The engine to shaft speed ratio is 3.75:1.
- Offline analysis showed a glitch in the Sway channel of the MotionPak. Therefore motions were computed using the tri-mounted accelerometers and the MotionPak rates.
- A high-pass filter was used on the MotionPak rates to mitigate any noise caused by engine vibrations.
- The motions of the vessel at the CG were calculated using the earth fixed coordinate system.
- The motions of the vessel at the accelerometers were calculated using the body fixed coordinate system.
- 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 : 0.469 m fwd. Δy : 0.508 m stbd. Δz : 0.344 m below
- The distance to Accelerometers position from MotionPak:
  Δx : 4.686 m fwd. Δy : 0.648 m stbd. Δz : -3.230 m above
- The distance from Accelerometers to Center of Gravity:
  Δx : -4.217 m aft Δy : -0.140 m port Δz : 3.574 m below
- The distance from Accelerometers to Wheelsman's position:
  Δx : 1.2827 m fwd. Δy : 0.000 m Δz : 0.000 m

File Name: 4BOW_20031215115614_CAL
Date: December 15, 2003 NF Time: 11:56

Dockside

Location: Pier 31, St. John's Harbour
Nominal Draft FP: 2.65 m Nominal Draft AP: 2.79 m
Water Temperature: 3.7 °C Water Density: 1023.6 kg/m^3
Static Stability Info - GM_T(Fluid): 0.79 m
Closest Stability Booklet Condition: Port Departure (98% Consumables)

Trials Site:

Trials Location: 10 nautical miles East of St. John's
Water Temperature: 3.0 °C Water Density: 1024.7 kg/m^3

Start of Run

Latitude: 47° 33' 52" North Longitude: 52° 26' 26" West
Nominal Forward Speed Over the Ground: 3.9 knots
Nominal Course Over the Ground: 41 (deg. TRUE)
Total Distance Traveled During the Run: 1.45 nautical miles
Nominal Relative Wind Speed: 12 knots
Nominal Relative Wind Direction: 250 (deg. Rel)
Nominal Engine RPM: 980 RPM
Nominal Sea State: 3

Duration of Run: 1403 s Number of Samples: 70127
Drift Speed: 0.19 knots Drift Direction: 212 (deg. True)

Dominant Wave Characteristics: Significant Height: 1.98 m
Direction: 2.8 (deg. True)
Mean Period: 6.25 s

Peak Response Frequency: Roll Angle: 0.1703 Hz
Pitch Angle: 0.2258 Hz
Heave Accel: 0.2402 Hz

Channel		Average	St. Dev.	Minimum	Maximum
DGPS Antenna					
COG	(deg. True)	40.3	3.080	30.2	50.1
SOG	(m/s)	1.942	0.090	1.672	2.250
SOG	(knots)	3.776	0.175	3.251	4.374
Shaft Speed	(RPM)	262.5	0.631	260.1	264.9
Rudder Angle	(deg.)	-4.500	2.542	-12.509	3.860
Motions Computed for the Centre of Gravity					
Roll Angle	(deg.)	0.490	2.719	-8.302	9.129
Pitch Angle	(deg.)	2.535	1.910	-3.481	8.297
Yaw Angle	(deg.)	-0.005	2.191	-6.701	6.065
Surge Displacement	(m)	0.000	0.300	-1.181	0.891
Sway Displacement	(m)	0.000	0.251	-0.783	0.808
Heave Displacement	(m)	-0.001	0.507	-1.641	1.627
Surge Acceleration	(m/s^2)	0.000	0.201	-0.611	0.774
Sway Acceleration	(m/s^2)	0.001	0.233	-0.812	0.777
Heave Acceleration	(m/s^2)	-0.017	0.617	-1.899	1.954

File Name: 4BOW_20031215115614_CAL
Date: December 15, 2003 NF Time: 11:56

Channel		Average	St. Dev.	Minimum	Maximum
Output from the MotionPak Accelerometers					
Surge Acceleration	(m/s^2)	0.594	0.212	-0.179	1.210
Sway Acceleration	(m/s^2)	-	-	-	-
Heave Acceleration	(m/s^2)	-9.770	0.594	-11.577	-7.877
Computed for the MotionPak position from the Accelerometers					
Surge Acceleration	(m/s^2)	0.428	0.208	-0.362	1.019
Sway Acceleration	(m/s^2)	-0.077	0.549	-1.934	1.652
Heave Acceleration	(m/s^2)	0.006	0.614	-1.867	1.928
Computed for Wheelsman's Position					
Surge Displacement	(m)	0.000	0.202	-0.551	0.722
Sway Displacement	(m)	0.001	0.609	-1.953	1.985
Heave Displacement	(m)	-0.001	0.581	-1.896	1.852
Surge Acceleration	(m/s^2)	0.412	0.455	-1.109	1.833
Sway Acceleration	(m/s^2)	-0.084	0.771	-2.605	2.457
Heave Acceleration	(m/s^2)	0.023	0.895	-2.865	2.775

Notes:
- The draft is referenced to the hydrostatic baseline.
- The wave direction sign convention is stated as where the waves are coming from.
- The engine to shaft speed ratio is 3.75:1.
- Offline analysis showed a glitch in the Sway channel of the MotionPak. Therefore motions were computed using the tri-mounted accelerometers and the MotionPak rates.
- A high-pass filter was used on the MotionPak rates to mitigate any noise caused by engine vibrations.
- The motions of the vessel at the CG were calculated using the earth fixed coordinate system.
- The motions of the vessel at the accelerometers were calculated using the body fixed coordinate system.
- 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 : 0.469 m fwd. Δy : 0.508 m stbd. Δz : 0.344 m below
- The distance to Accelerometers position from MotionPak:
  Δx : 4.686 m fwd. Δy : 0.648 m stbd. Δz : -3.230 m above
- The distance from Accelerometers to Center of Gravity:
  Δx : -4.217 m aft Δy : -0.140 m port Δz : 3.574 m below
- The distance from Accelerometers to Wheelsman's position:
  Δx : 1.2827 m fwd. Δy : 0.000 m Δz : 0.000 m

File Name: 4BEAM_20031215122555_CAL
Date: December 15, 2003 NF Time: 12:26

Dockside

Location:	Pier 31, St. John's Harbour		
Nominal Draft FP:	2.65 m	Nominal Draft AP:	2.79 m
Water Temperature:	3.7 °C	Water Density:	1023.6 kg/m^3
Static Stability Info - GM_T(Fluid):	0.79 m		
Closest Stability Booklet Condition:	Port Departure (98% Consumables)		

Trials Site:

Trials Location:	10 nautical miles East of St. John's		
Water Temperature:	3.0 °C	Water Density:	1024.7 kg/m^3

Start of Run

Latitude:	47° 35' 14" North	Longitude:	52° 24' 48" West
Nominal Forward Speed Over the Ground:	4.6 knots		
Nominal Course Over the Ground:	266 (deg. TRUE)		
Total Distance Traveled During the Run:	1.67 nautical miles		
Nominal Relative Wind Speed:	16 knots		
Nominal Relative Wind Direction:	0 (deg. Rel)		
Nominal Engine RPM:	980 RPM		
Nominal Sea State:	4		
Duration of Run:	1517 s	Number of Samples:	75836
Drift Speed:	0.69 knots	Drift Direction:	106 (deg. True)

Dominant Wave Characteristics:	Significant Height:	2.19 m
	Direction:	5.6 (deg. True)
	Mean Period:	6.56 s
Peak Response Frequency:	Roll Angle:	0.1612 Hz
	Pitch Angle:	0.2344 Hz
	Heave Accel:	0.2125 Hz

Channel		Average	St. Dev.	Minimum	Maximum
DGPS Antenna					
COG	(deg. True)	261.8	3.267	251.9	272.7
SOG	(m/s)	2.094	0.085	1.889	2.436
SOG	(knots)	4.072	0.166	3.672	4.736
Shaft Speed	(RPM)	263.2	0.663	259.6	266.6
Rudder Angle	(deg.)	1.210	2.199	-6.580	8.432
Motions Computed for the Centre of Gravity					
Roll Angle	(deg.)	-0.220	4.717	-16.619	15.147
Pitch Angle	(deg.)	2.507	0.906	-0.325	5.664
Yaw Angle	(deg.)	-0.071	1.899	-5.329	5.497
Surge Displacement	(m)	0.000	0.161	-0.597	0.539
Sway Displacement	(m)	0.000	0.489	-1.666	2.124
Heave Displacement	(m)	0.000	0.517	-1.874	1.510
Surge Acceleration	(m/s^2)	0.000	0.110	-0.372	0.372
Sway Acceleration	(m/s^2)	-0.001	0.297	-1.221	1.060
Heave Acceleration	(m/s^2)	-0.016	0.438	-1.541	1.495

File Name: 4BEAM_20031215122555_CAL
Date: December 15, 2003 NF Time: 12:26

Channel		Average	St. Dev.	Minimum	Maximum
Output from the MotionPak Accelerometers					
Surge Acceleration	(m/s^2)	0.600	0.108	0.155	0.974
Sway Acceleration	(m/s^2)	-	-	-	-
Heave Acceleration	(m/s^2)	-9.750	0.443	-11.278	-8.192
Computed for the MotionPak position from the Accelerometers					
Surge Acceleration	(m/s^2)	0.428	0.108	0.063	0.797
Sway Acceleration	(m/s^2)	0.030	0.808	-2.691	2.813
Heave Acceleration	(m/s^2)	0.022	0.421	-1.437	1.484
Computed for Wheelsman's Position					
Surge Displacement	(m)	0.000	0.095	-0.326	0.355
Sway Displacement	(m)	0.000	0.979	-3.273	3.111
Heave Displacement	(m)	0.000	0.556	-2.053	1.730
Surge Acceleration	(m/s^2)	0.424	0.217	-0.312	1.195
Sway Acceleration	(m/s^2)	0.025	1.129	-3.738	4.000
Heave Acceleration	(m/s^2)	0.049	0.555	-1.934	2.067

Notes:
- The draft is referenced to the hydrostatic baseline.
- The wave direction sign convention is stated as where the waves are coming from.
- The engine to shaft speed ratio is 3.75:1.
- Offline analysis showed a glitch in the Sway channel of the MotionPak. Therefore motions were computed using the tri-mounted accelerometers and the MotionPak rates.
- A high-pass filter was used on the MotionPak rates to mitigate any noise caused by engine vibrations.
- The motions of the vessel at the CG were calculated using the earth fixed coordinate system.
- The motions of the vessel at the accelerometers were calculated using the body fixed coordinate system.
- 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 : 0.469 m fwd. Δy : 0.508 m stbd. Δz : 0.344 m below
- The distance to Accelerometers position from MotionPak:
  Δx : 4.686 m fwd. Δy : 0.648 m stbd. Δz : -3.230 m above
- The distance from Accelerometers to Center of Gravity:
  Δx : -4.217 m aft Δy : -0.140 m port Δz : 3.574 m below
- The distance from Accelerometers to Wheelsman's position:
  Δx : 1.2827 m fwd. Δy : 0.000 m Δz : 0.000 m

File Name: 4QUART_20031215125501_CAL
Date: December 15, 2003 NF Time: 12:55

Dockside
Location: Pier 31, St. John's Harbour
Nominal Draft FP: 2.65 m Nominal Draft AP: 2.79 m
Water Temperature: 3.7 °C Water Density: 1023.6 kg/m^3
Static Stability Info - GM_T(Fluid): 0.79 m
Closest Stability Booklet Condition: Port Departure (98% Consumables)

Trials Site:
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 3.0 °C Water Density: 1024.7 kg/m^3

Start of Run
Latitude: 47° 34' 54" North Longitude: 52° 27' 25" West
Nominal Forward Speed Over the Ground: 4.2 knots
Nominal Course Over the Ground: 131 (deg. TRUE)
Total Distance Traveled During the Run: 1.58 nautical miles
Nominal Relative Wind Speed: 8 knots
Nominal Relative Wind Direction: 180 (deg. Rel)
Nominal Engine RPM: 980 RPM
Nominal Sea State: 4

Duration of Run: 1517 s Number of Samples: 75836
Drift Speed: 0.61 knots Drift Direction: 270 (deg. True)

Dominant Wave Characteristics: Significant Height: 2.19 m
Direction: 5.6 (deg. True)
Mean Period: 6.56 s

Peak Response Frequency: Roll Angle: 0.1720 Hz
Pitch Angle: 0.1261 Hz
Heave Accel: 0.1247 Hz

Channel		Average	St. Dev.	Minimum	Maximum
DGPS Antenna					
COG	(deg. True)	135.6	3.134	122.9	145.3
SOG	(m/s)	1.965	0.075	1.769	2.231
SOG	(knots)	3.820	0.146	3.440	4.336
Shaft Speed	(RPM)	263.9	0.616	261.4	266.8
Rudder Angle	(deg.)	-0.665	2.745	-11.725	8.667
Motions Computed for the Centre of Gravity					
Roll Angle	(deg.)	0.143	4.463	-14.153	15.520
Pitch Angle	(deg.)	2.463	1.264	-1.426	7.041
Yaw Angle	(deg.)	0.027	2.211	-7.927	6.393
Surge Displacement	(m)	-0.001	0.331	-1.169	1.025
Sway Displacement	(m)	-0.001	0.354	-1.140	1.531
Heave Displacement	(m)	-0.001	0.453	-1.715	1.633
Surge Acceleration	(m/s^2)	0.000	0.186	-0.710	0.626
Sway Acceleration	(m/s^2)	-0.001	0.211	-0.850	0.823
Heave Acceleration	(m/s^2)	-0.016	0.325	-1.277	1.096

File Name: 4QUART_20031215125501_CAL
Date: December 15, 2003 NF Time: 12:55

Channel		Average	St. Dev.	Minimum	Maximum
Output from the MotionPak Accelerometers					
Surge Acceleration	(m/s^2)	0.592	0.085	0.299	0.865
Sway Acceleration	(m/s^2)	-	-	-	-
Heave Acceleration	(m/s^2)	-9.759	0.325	-10.851	-8.631
Computed for the MotionPak position from the Accelerometers					
Surge Acceleration	(m/s^2)	0.422	0.083	0.117	0.712
Sway Acceleration	(m/s^2)	-0.016	0.711	-2.510	2.601
Heave Acceleration	(m/s^2)	0.015	0.341	-1.215	1.115
Computed for Wheelsman's Position					
Surge Displacement	(m)	0.000	0.111	-0.360	0.366
Sway Displacement	(m)	0.001	0.921	-2.971	3.079
Heave Displacement	(m)	0.000	0.480	-1.799	1.709
Surge Acceleration	(m/s^2)	0.417	0.179	-0.212	1.020
Sway Acceleration	(m/s^2)	-0.024	0.992	-3.341	3.659
Heave Acceleration	(m/s^2)	0.038	0.412	-1.585	1.502

Notes:
- The draft is referenced to the hydrostatic baseline.
- The wave direction sign convention is stated as where the waves are coming from.
- The engine to shaft speed ratio is 3.75:1.
- Offline analysis showed a glitch in the Sway channel of the MotionPak. Therefore motions were computed using the tri-mounted accelerometers and the MotionPak rates.
- A high-pass filter was used on the MotionPak rates to mitigate any noise caused by engine vibrations.
- The motions of the vessel at the CG were calculated using the earth fixed coordinate system.
- The motions of the vessel at the accelerometers were calculated using the body fixed coordinate system.
- 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 : 0.469 m fwd. Δy : 0.508 m stbd. Δz : 0.344 m below
- The distance to Accelerometers position from MotionPak:
  Δx : 4.686 m fwd. Δy : 0.648 m stbd. Δz : -3.230 m above
- The distance from Accelerometers to Center of Gravity:
  Δx : -4.217 m aft Δy : -0.140 m port Δz : 3.574 m below
- The distance from Accelerometers to Wheelsman's position:
  Δx : 1.2827 m fwd. Δy : 0.000 m Δz : 0.000 m

File Name: 4FOL_20031215112007_CAL
Date: December 15, 2003 NF Time: 11:20

Dockside
Location: Pier 31, St. John's Harbour
Nominal Draft FP: 2.65 m Nominal Draft AP: 2.79 m
Water Temperature: 3.7 °C Water Density: 1023.6 kg/m^3
Static Stability Info - GM_T(Fluid): 0.79 m
Closest Stability Booklet Condition: Port Departure (98% Consumables)

Trials Site:
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 3.0 °C Water Density: 1024.7 kg/m^3

Start of Run
Latitude: 47° 35' 50" North Longitude: 52° 26' 46" West
Nominal Forward Speed Over the Ground: 4 knots
Nominal Course Over the Ground: 176 (deg. TRUE)
Total Distance Traveled During the Run: 2.03 nautical miles
Nominal Relative Wind Speed: 13 knots
Nominal Relative Wind Direction: 90 (deg. Rel)
Nominal Engine RPM: 980 RPM
Nominal Sea State: 3

Duration of Run: 1857 s Number of Samples: 92828
Drift Speed: 0.24 knots Drift Direction: 283 (deg. True)

Dominant Wave Characteristics: Significant Height: 1.98 m
Direction: 2.8 (deg. True)
Mean Period: 6.25 s

Peak Response Frequency: Roll Angle: 0.1706 Hz
Pitch Angle: 0.1347 Hz
Heave Accel: 0.1333 Hz

Channel		Average	St. Dev.	Minimum	Maximum
DGPS Antenna					
COG	(deg. True)	178.2	2.362	169.6	185.4
SOG	(m/s)	2.038	0.106	1.667	2.367
SOG	(knots)	3.962	0.206	3.240	4.601
Shaft Speed	(RPM)	264.2	0.655	261.5	267.0
Rudder Angle	(deg.)	2.487	2.339	-6.492	10.608
Motions Computed for the Centre of Gravity					
Roll Angle	(deg.)	-0.130	2.444	-7.058	6.415
Pitch Angle	(deg.)	2.478	1.560	-3.069	7.408
Yaw Angle	(deg.)	-0.133	2.269	-7.824	6.258
Surge Displacement	(m)	0.000	0.481	-1.621	1.582
Sway Displacement	(m)	0.000	0.155	-0.489	0.522
Heave Displacement	(m)	0.001	0.411	-1.396	1.260
Surge Acceleration	(m/s^2)	0.000	0.230	-0.774	0.751
Sway Acceleration	(m/s^2)	-0.002	0.114	-0.439	0.360
Heave Acceleration	(m/s^2)	-0.016	0.233	-0.772	0.735

File Name: 4FOL_20031215112007_CAL
Date: December 15, 2003 NF Time: 11:20

Channel		Average	St. Dev.	Minimum	Maximum
Output from the MotionPak Accelerometers					
Surge Acceleration	(m/s^2)	0.595	0.077	0.298	0.849
Sway Acceleration	(m/s^2)	-	-	-	-
Heave Acceleration	(m/s^2)	-9.775	0.230	-10.506	-9.064
Computed for the MotionPak position from the Accelerometers					
Surge Acceleration	(m/s^2)	0.424	0.075	0.147	0.677
Sway Acceleration	(m/s^2)	0.022	0.405	-1.190	1.213
Heave Acceleration	(m/s^2)	-0.002	0.234	-0.779	0.758
Computed for Wheelsman's Position					
Surge Displacement	(m)	0.000	0.144	-0.434	0.507
Sway Displacement	(m)	0.000	0.512	-1.453	1.572
Heave Displacement	(m)	0.000	0.450	-1.481	1.458
Surge Acceleration	(m/s^2)	0.420	0.168	-0.216	0.945
Sway Acceleration	(m/s^2)	0.020	0.576	-1.739	1.693
Heave Acceleration	(m/s^2)	0.008	0.319	-0.943	1.157

Notes:
- The draft is referenced to the hydrostatic baseline.
- The wave direction sign convention is stated as where the waves are coming from.
- The engine to shaft speed ratio is 3.75:1.
- Offline analysis showed a glitch in the Sway channel of the MotionPak. Therefore motions were computed using the tri-mounted accelerometers and the MotionPak rates.
- A high-pass filter was used on the MotionPak rates to mitigate any noise caused by engine vibrations.
- The motions of the vessel at the CG were calculated using the earth fixed coordinate system.
- The motions of the vessel at the accelerometers were calculated using the body fixed coordinate system.
- 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 : 0.469 m fwd. Δy : 0.508 m stbd. Δz : 0.344 m below
- The distance to Accelerometers position from MotionPak:
  Δx : 4.686 m fwd. Δy : 0.648 m stbd. Δz : -3.230 m above
- The distance from Accelerometers to Center of Gravity:
  Δx : -4.217 m aft Δy : -0.140 m port Δz : 3.574 m below
- The distance from Accelerometers to Wheelsman's position:
  Δx : 1.2827 m fwd. Δy : 0.000 m Δz : 0.000 m

File Name: 0DRIFTB_20031215132731_CAL
Date: December 15, 2003 NF Time: 13:27

Dockside
Location: Pier 31, St. John's Harbour
Nominal Draft FP: 2.65 m Nominal Draft AP: 2.79 m
Water Temperature: 3.5 °C Water Density: 1024.3 kg/m^3
Static Stability Info - GM_T(Fluid): 0.79 m
Closest Stability Booklet Condition: Port Departure (98% Consumables)

Trials Site:
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 3.0 °C Water Density: 1024.7 kg/m^3

Start of Run
Latitude: 47° 34' 09" North Longitude: 52° 26' 12" West
Nominal Forward Speed Over the Ground: ~1.1 knots (drift)
Nominal Course Over the Ground: ~200 (deg. TRUE) (drift)
Total Distance Traveled During the Run: 0.17 nautical miles
Nominal Relative Wind Speed: 8 knots
Nominal Relative Wind Direction: 260 (deg. Rel)
Nominal Engine RPM: N/A RPM
Nominal Sea State: 4

Duration of Run: 1239 s Number of Samples: 61971
Drift Speed: 0.50 knots Drift Direction: 195 (deg. True)

Dominant Wave Characteristics: Significant Height: 2.19 m
Direction: 2.8 (deg. True)
Mean Period: 7.02 s

Peak Response Frequency: Roll Angle: 0.1748 Hz
Pitch Angle: 0.1927 Hz
Heave Accel: 0.1927 Hz

Channel		Average	St. Dev.	Minimum	Maximum
DGPS Antenna					
COG	(deg. True)	211.6	18.619	135.1	266.6
SOG (knots)	(m/s)	0.454	0.129	0.194	0.967
SOG	(knots)	0.883	0.250	0.378	1.879
Shaft Speed	(RPM)	1.204	8.469	-2.395	64.490
Rudder Angle	(deg.)	-0.562	0.054	-0.763	-0.345
Motions Computed for the Centre of Gravity					
Roll Angle	(deg.)	-0.059	4.405	-14.142	13.441
Pitch Angle	(deg.)	2.560	1.519	-2.269	6.955
Yaw Angle	(deg.)	0.317	13.784	-25.686	27.468
Surge Displacement	(m)	0.000	0.296	-1.182	1.005
Sway Displacement	(m)	0.000	0.322	-1.070	0.929
Heave Displacement	(m)	0.001	0.469	-1.298	1.529
Surge Acceleration	(m/s^2)	0.000	0.186	-0.748	0.640
Sway Acceleration	(m/s^2)	-0.001	0.226	-0.714	0.861
Heave Acceleration	(m/s^2)	-0.013	0.355	-1.350	1.142

File Name: 0DRIFTB_20031215132731_CAL
Date: December 15, 2003 NF Time: 13:27

Channel		Average	St. Dev.	Minimum	Maximum
Output from the MotionPak Accelerometers					
Surge Acceleration	(m/s^2)	0.608	0.132	0.198	1.019
Sway Acceleration	(m/s^2)	-	-	-	-
Heave Acceleration	(m/s^2)	-9.753	0.347	-11.051	-8.531
Computed for the MotionPak position from the Accelerometers					
Surge Acceleration	(m/s^2)	0.437	0.129	0.018	0.842
Sway Acceleration	(m/s^2)	0.005	0.754	-2.728	2.210
Heave Acceleration	(m/s^2)	0.023	0.337	-1.244	1.165
Computed for Wheelsman's Position					
Surge Displacement	(m)	0.000	0.157	-0.444	0.566
Sway Displacement	(m)	0.001	0.878	-3.128	2.556
Heave Displacement	(m)	0.000	0.516	-1.655	1.843
Surge Acceleration	(m/s^2)	0.430	0.285	-0.488	1.269
Sway Acceleration	(m/s^2)	0.003	1.041	-3.654	3.163
Heave Acceleration	(m/s^2)	0.048	0.497	-1.491	1.644

Notes:
- The draft is referenced to the hydrostatic baseline.
- The wave direction sign convention is stated as where the waves are coming from.
- The engine to shaft speed ratio is 3.75:1.
- Offline analysis showed a glitch in the Sway channel of the MotionPak. Therefore motions were computed using the tri-mounted accelerometers and the MotionPak rates.
- A high-pass filter was used on the MotionPak rates to mitigate any noise caused by engine vibrations.
- The motions of the vessel at the CG were calculated using the earth fixed coordinate system.
- The motions of the vessel at the accelerometers were calculated using the body fixed coordinate system.
- 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 : 0.469 m fwd. Δy : 0.508 m stbd. Δz : 0.344 m below
- The distance to Accelerometers position from MotionPak:
  Δx : 4.686 m fwd. Δy : 0.648 m stbd. Δz : -3.230 m above
- The distance from Accelerometers to Center of Gravity:
  Δx : -4.217 m aft Δy : -0.140 m port Δz : 3.574 m below
- The distance from Accelerometers to Wheelsman's position:
  Δx : 1.2827 m fwd. Δy : 0.000 m Δz : 0.000 m

File Name: 8HEAD_20031215135155_CAL
Date: December 15, 2003 NF Time: 13:52

<u>Dockside</u>

Location:	Pier 31, St. John's Harbour		
Nominal Draft FP:	2.65 m	Nominal Draft AP:	2.79 m
Water Temperature:	3.5 °C	Water Density:	1024.3 kg/m^3
Static Stability Info - GM_T(Fluid):	0.79 m		
Closest Stability Booklet Condition:	Port Departure (98% Consumables)		

<u>Trials Site:</u>

Trials Location:	10 nautical miles East of St. John's		
Water Temperature:	3.0 °C	Water Density:	1024.7 kg/m^3

Start of Run

Latitude:	47° 34' 14" North	Longitude:	52° 26' 17" West
Nominal Forward Speed Over the Ground:	8.2 knots		
Nominal Course Over the Ground:	6 (deg. TRUE)		
Total Distance Traveled During the Run:	3.46 nautical miles		
Nominal Relative Wind Speed:	21 knots		
Nominal Relative Wind Direction:	330 (deg. Rel)		
Nominal Engine RPM:	1070 RPM		
Nominal Sea State:	4		
Duration of Run:	1537 s	Number of Samples:	76854
Drift Speed:	0.84 knots	Drift Direction:	203 (deg. True)

Dominant Wave Characteristics:	Significant Height:	2.19 m
	Direction:	2.8 (deg. True)
	Mean Period:	7.02 s
Peak Response Frequency:	Roll Angle:	0.1663 Hz
	Pitch Angle:	0.2783 Hz
	Heave Accel:	0.2783 Hz

Channel		Average	St. Dev.	Minimum	Maximum
DGPS Antenna					
COG	(deg. True)	5.1	1.478	1.6	9.1
SOG	(m/s)	4.182	0.109	3.706	4.447
SOG	(knots)	8.129	0.212	7.204	8.645
Shaft Speed	(RPM)	287.7	4.131	176.8	650.6
Rudder Angle	(deg.)	-0.430	1.034	-3.698	3.660
Motions Computed for the Centre of Gravity					
Roll Angle	(deg.)	0.026	1.304	-4.364	4.426
Pitch Angle	(deg.)	2.274	2.072	-4.165	9.381
Yaw Angle	(deg.)	-0.047	0.955	-2.706	2.827
Surge Displacement	(m)	0.000	0.268	-0.886	1.081
Sway Displacement	(m)	0.000	0.100	-0.432	0.343
Heave Displacement	(m)	0.000	0.532	-2.367	2.048
Surge Acceleration	(m/s^2)	0.001	0.196	-0.649	0.699
Sway Acceleration	(m/s^2)	0.000	0.133	-0.497	0.623
Heave Acceleration	(m/s^2)	-0.017	0.855	-2.812	3.257

File Name: 8HEAD_20031215135155_CAL
Date: December 15, 2003 NF Time: 13:52

Channel		Average	St. Dev.	Minimum	Maximum
Output from the MotionPak Accelerometers					
Surge Acceleration	(m/s^2)	0.549	0.304	-0.563	1.482
Sway Acceleration	(m/s^2)	-	-	-	-
Heave Acceleration	(m/s^2)	-9.779	0.843	-12.507	-6.549
Computed for the MotionPak position from the Accelerometers					
Surge Acceleration	(m/s^2)	0.378	0.305	-0.707	1.273
Sway Acceleration	(m/s^2)	-0.004	0.274	-1.076	0.944
Heave Acceleration	(m/s^2)	-0.003	0.841	-2.726	3.228
Computed for Wheelsman's Position					
Surge Displacement	(m)	0.000	0.229	-0.697	0.814
Sway Displacement	(m)	0.000	0.292	-1.042	1.096
Heave Displacement	(m)	0.000	0.623	-2.766	2.188
Surge Acceleration	(m/s^2)	0.360	0.617	-1.812	2.267
Sway Acceleration	(m/s^2)	-0.004	0.383	-1.514	1.273
Heave Acceleration	(m/s^2)	0.009	1.213	-3.986	4.689

Notes:

- The draft is referenced to the hydrostatic baseline.
- The wave direction sign convention is stated as where the waves are coming from.
- The engine to shaft speed ratio is 3.75:1.
- Offline analysis showed a glitch in the Sway channel of the MotionPak. Therefore motions were computed using the tri-mounted accelerometers and the MotionPak rates.
- A high-pass filter was used on the MotionPak rates to mitigate any noise caused by engine vibrations.
- The motions of the vessel at the CG were calculated using the earth fixed coordinate system.
- The motions of the vessel at the accelerometers were calculated using the body fixed coordinate system.
- 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 : 0.469 m fwd. Δy : 0.508 m stbd. Δz : 0.344 m below
- The distance to Accelerometers position from MotionPak:
  Δx : 4.686 m fwd. Δy : 0.648 m stbd. Δz : -3.230 m above
- The distance from Accelerometers to Center of Gravity:
  Δx : -4.217 m aft Δy : -0.140 m port Δz : 3.574 m below
- The distance from Accelerometers to Wheelsman's position:
  Δx : 1.2827 m fwd. Δy : 0.000 m Δz : 0.000 m

File Name: 8BOW_20031215145914_CAL
Date: December 15, 2003 NF Time: 14:59

Dockside
Location: Pier 31, St. John's Harbour
Nominal Draft FP: 2.65 m Nominal Draft AP: 2.79 m
Water Temperature: 3.5 °C Water Density: 1024.3 kg/m^3
Static Stability Info - GM_T(Fluid): 0.79 m
Closest Stability Booklet Condition: Port Departure (98% Consumables)

Trials Site:
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 3.0 °C Water Density: 1024.7 kg/m^3

Start of Run
Latitude: 47° 33' 44" North Longitude: 52° 25' 50" West
Nominal Forward Speed Over the Ground: 8.2 knots
Nominal Course Over the Ground: 51 (deg. TRUE)
Total Distance Traveled During the Run: 3.57 nautical miles
Nominal Relative Wind Speed: 12 knots
Nominal Relative Wind Direction: 310 (deg. Rel)
Nominal Engine RPM: 1070 RPM
Nominal Sea State: 4

Duration of Run: 1560 s Number of Samples: 77981
Drift Speed: 0.69 knots Drift Direction: 246 (deg. True)

Dominant Wave Characteristics: Significant Height: 2.24 m
Direction: 4.2 (deg. True)
Mean Period: 7.41 s

Peak Response Frequency: Roll Angle: 0.1603 Hz
Pitch Angle: 0.2885 Hz
Heave Accel: 0.2885 Hz

Channel		Average	St. Dev.	Minimum	Maximum
DGPS Antenna					
COG	(deg. True)	49.6	1.427	45.4	54.6
SOG	(m/s)	4.255	0.079	4.017	4.464
SOG	(knots)	8.272	0.154	7.808	8.678
Shaft Speed	(RPM)	288.7	1.051	283.1	292.6
Rudder Angle	(deg.)	-1.145	1.594	-7.755	4.748
Motions Computed for the Centre of Gravity					
Roll Angle	(deg.)	0.131	3.234	-9.930	9.353
Pitch Angle	(deg.)	2.235	1.588	-3.153	7.423
Yaw Angle	(deg.)	-0.060	1.290	-4.924	3.252
Surge Displacement	(m)	0.000	0.243	-0.727	0.718
Sway Displacement	(m)	0.001	0.307	-0.928	1.125
Heave Displacement	(m)	0.000	0.554	-1.800	1.647
Surge Acceleration	(m/s^2)	0.000	0.170	-0.664	0.547
Sway Acceleration	(m/s^2)	0.000	0.259	-0.902	0.989
Heave Acceleration	(m/s^2)	-0.016	0.791	-2.778	2.885

File Name: 8BOW_20031215145914_CAL
Date: December 15, 2003 NF Time: 14:59

Channel		Average	St. Dev.	Minimum	Maximum
Output from the MotionPak Accelerometers					
Surge Acceleration	(m/s^2)	0.547	0.235	-0.398	1.372
Sway Acceleration	(m/s^2)	-	-	-	-
Heave Acceleration	(m/s^2)	-9.768	0.781	-12.502	-6.811
Computed for the MotionPak position from the Accelerometers					
Surge Acceleration	(m/s^2)	0.377	0.235	-0.579	1.198
Sway Acceleration	(m/s^2)	-0.008	0.608	-2.012	2.063
Heave Acceleration	(m/s^2)	0.008	0.797	-2.735	3.079
Computed for Wheelsman's Position					
Surge Displacement	(m)	0.000	0.179	-0.555	0.675
Sway Displacement	(m)	0.000	0.701	-2.262	2.279
Heave Displacement	(m)	0.000	0.599	-1.962	1.837
Surge Acceleration	(m/s^2)	0.365	0.476	-1.544	2.070
Sway Acceleration	(m/s^2)	-0.011	0.849	-2.745	2.934
Heave Acceleration	(m/s^2)	0.027	1.027	-3.717	3.643

Notes:
- The draft is referenced to the hydrostatic baseline.
- The wave direction sign convention is stated as where the waves are coming from.
- The engine to shaft speed ratio is 3.75:1.
- Offline analysis showed a glitch in the Sway channel of the MotionPak. Therefore motions were computed using the tri-mounted accelerometers and the MotionPak rates.
- A high-pass filter was used on the MotionPak rates to mitigate any noise caused by engine vibrations.
- The motions of the vessel at the CG were calculated using the earth fixed coordinate system.
- The motions of the vessel at the accelerometers were calculated using the body fixed coordinate system.
- 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 : 0.469 m fwd. Δy : 0.508 m stbd. Δz : 0.344 m below
- The distance to Accelerometers position from MotionPak:
  Δx : 4.686 m fwd. Δy : 0.648 m stbd. Δz : -3.230 m above
- The distance from Accelerometers to Center of Gravity:
  Δx : -4.217 m aft Δy : -0.140 m port Δz : 3.574 m below
- The distance from Accelerometers to Wheelsman's position:
  Δx : 1.2827 m fwd. Δy : 0.000 m Δz : 0.000 m

File Name: 8BEAM_20031215152901_CAL
Date: December 15, 2003 NF Time: 15:29

Dockside
Location: Pier 31, St. John's Harbour
Nominal Draft FP: 2.65 m Nominal Draft AP: 2.79 m
Water Temperature: 3.5 °C Water Density: 1024.3 kg/m^3
Static Stability Info - GM_T(Fluid): 0.79 m
Closest Stability Booklet Condition: Port Departure (98% Consumables)

Trials Site:
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 3.0 °C Water Density: 1024.7 kg/m^3

Start of Run
Latitude: 47° 36' 16" North Longitude: 52° 22' 08" West
Nominal Forward Speed Over the Ground: 8.3 knots
Nominal Course Over the Ground: 276 (deg. TRUE)
Total Distance Traveled During the Run: 3.36 nautical miles
Nominal Relative Wind Speed: 10 knots
Nominal Relative Wind Direction: 0 (deg. Rel)
Nominal Engine RPM: 1000 RPM
Nominal Sea State: 4

Duration of Run: 1505 s Number of Samples: 75266
Drift Speed: 0.26 knots Drift Direction: 80 (deg. True)

Dominant Wave Characteristics: Significant Height: 2.03 m
Direction: 4.2 (deg. True)
Mean Period: 7.02 s

Peak Response Frequency: Roll Angle: 0.1772 Hz
Pitch Angle: 0.1063 Hz
Heave Accel: 0.2746 Hz

Channel		Average	St. Dev.	Minimum	Maximum
DGPS Antenna					
COG	(deg. True)	275.5	1.654	270.3	280.7
SOG	(m/s)	4.165	0.065	3.956	4.325
SOG	(knots)	8.096	0.126	7.690	8.408
Shaft Speed	(RPM)	269.7	3.639	170.2	587.3
Rudder Angle	(deg.)	0.745	1.726	-5.160	7.805
Motions Computed for the Centre of Gravity					
Roll Angle	(deg.)	-0.161	4.084	-14.211	16.448
Pitch Angle	(deg.)	2.203	0.871	-0.756	5.445
Yaw Angle	(deg.)	0.022	1.120	-3.417	4.365
Surge Displacement	(m)	0.000	0.194	-0.655	0.554
Sway Displacement	(m)	-0.001	0.454	-1.724	1.812
Heave Displacement	(m)	0.000	0.542	-1.923	1.805
Surge Acceleration	(m/s^2)	0.000	0.112	-0.415	0.436
Sway Acceleration	(m/s^2)	0.001	0.283	-0.963	1.157
Heave Acceleration	(m/s^2)	-0.018	0.509	-1.573	1.961

File Name: 8BEAM_20031215152901_CAL
Date: December 15, 2003 NF Time: 15:29

Channel		Average	St. Dev.	Minimum	Maximum
Output from the MotionPak Accelerometers					
Surge Acceleration	(m/s^2)	0.548	0.116	0.120	0.999
Sway Acceleration	(m/s^2)	-	-	-	-
Heave Acceleration	(m/s^2)	-9.763	0.515	-11.851	-7.661
Computed for the MotionPak position from the Accelerometers					
Surge Acceleration	(m/s^2)	0.376	0.116	-0.074	0.835
Sway Acceleration	(m/s^2)	0.020	0.695	-3.053	2.390
Heave Acceleration	(m/s^2)	0.010	0.493	-1.549	2.025
Computed for Wheelsman's Position					
Surge Displacement	(m)	0.000	0.096	-0.368	0.402
Sway Displacement	(m)	0.001	0.869	-3.079	3.404
Heave Displacement	(m)	0.000	0.566	-2.141	1.839
Surge Acceleration	(m/s^2)	0.373	0.223	-0.473	1.217
Sway Acceleration	(m/s^2)	0.017	0.957	-4.363	3.227
Heave Acceleration	(m/s^2)	0.029	0.579	-1.872	2.320

Notes:

- The draft is referenced to the hydrostatic baseline.
- The wave direction sign convention is stated as where the waves are coming from.
- The engine to shaft speed ratio is 3.75:1.
- Offline analysis showed a glitch in the Sway channel of the MotionPak. Therefore motions were computed using the tri-mounted accelerometers and the MotionPak rates.
- A high-pass filter was used on the MotionPak rates to mitigate any noise caused by engine vibrations.
- The motions of the vessel at the CG were calculated using the earth fixed coordinate system.
- The motions of the vessel at the accelerometers were calculated using the body fixed coordinate system.
- 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 : 0.469 m fwd. Δy : 0.508 m stbd. Δz : 0.344 m below
- The distance to Accelerometers position from MotionPak:
  Δx : 4.686 m fwd. Δy : 0.648 m stbd. Δz : -3.230 m above
- The distance from Accelerometers to Center of Gravity:
  Δx : -4.217 m aft Δy : -0.140 m port Δz : 3.574 m below
- The distance from Accelerometers to Wheelsman's position:
  Δx : 1.2827 m fwd. Δy : 0.000 m Δz : 0.000 m

File Name: 8QUART_20031215155652_CAL
Date: December 15, 2003 NF Time: 15:57

Dockside
Location: Pier 31, St. John's Harbour
Nominal Draft FP: 2.65 m Nominal Draft AP: 2.79 m
Water Temperature: 3.5 °C Water Density: 1024.3 kg/m^3
Static Stability Info - GM_T(Fluid): 0.79 m
Closest Stability Booklet Condition: Port Departure (98% Consumables)

Trials Site:
Trials Location: 10 nautical miles East of St. John's
Water Temperature: 3.0 °C Water Density: 1024.7 kg/m^3

Start of Run
Latitude: 47° 36' 25" North Longitude: 52° 27' 10" West
Nominal Forward Speed Over the Ground: 8.2 knots
Nominal Course Over the Ground: 141 (deg. TRUE)
Total Distance Traveled During the Run: 3.27 nautical miles
Nominal Relative Wind Speed: 7 knots
Nominal Relative Wind Direction: 330 (deg. Rel)
Nominal Engine RPM: 960 RPM
Nominal Sea State: 4

Duration of Run: 1511 s Number of Samples: 75545
Drift Speed: 0.50 knots Drift Direction: 288 (deg. True)

Dominant Wave Characteristics: Significant Height: 2.03 m
Direction: 4.2 (deg. True)
Mean Period: 7.02 s

Peak Response Frequency: Roll Angle: 0.1655 Hz
Pitch Angle: 0.1030 Hz
Heave Accel: 0.2206 Hz

Channel		Average	St. Dev.	Minimum	Maximum
DGPS Antenna					
COG	(deg. True)	141.9	1.567	135.8	145.5
SOG	(m/s)	4.018	0.097	3.722	4.325
SOG	(knots)	7.812	0.189	7.236	8.408
Shaft Speed	(RPM)	259.3	3.279	167.5	531.3
Rudder Angle	(deg.)	-0.180	2.438	-8.129	9.067
Motions Computed for the Centre of Gravity					
Roll Angle	(deg.)	0.288	2.549	-9.865	8.720
Pitch Angle	(deg.)	2.190	1.235	-2.060	5.735
Yaw Angle	(deg.)	0.023	1.439	-4.796	4.161
Surge Displacement	(m)	0.000	0.549	-1.585	1.651
Sway Displacement	(m)	0.000	0.361	-1.293	1.195
Heave Displacement	(m)	0.000	0.467	-1.610	1.318
Surge Acceleration	(m/s^2)	0.000	0.197	-0.615	0.736
Sway Acceleration	(m/s^2)	0.000	0.172	-0.519	0.625
Heave Acceleration	(m/s^2)	-0.017	0.306	-1.167	1.021

File Name: 8QUART_20031215155652_CAL
Date: December 15, 2003 NF Time: 15:57

Channel		Average	St. Dev.	Minimum	Maximum
Output from the MotionPak Accelerometers					
Surge Acceleration	(m/s^2)	0.543	0.072	0.175	0.807
Sway Acceleration	(m/s^2)	-	-	-	-
Heave Acceleration	(m/s^2)	-9.780	0.302	-10.900	-8.702
Computed for the MotionPak position from the Accelerometers					
Surge Acceleration	(m/s^2)	0.376	0.070	0.072	0.661
Sway Acceleration	(m/s^2)	-0.048	0.412	-1.464	1.794
Heave Acceleration	(m/s^2)	-0.004	0.312	-1.177	1.081
Computed for Wheelsman's Position					
Surge Displacement	(m)	0.000	0.114	-0.364	0.374
Sway Displacement	(m)	0.001	0.670	-2.334	2.352
Heave Displacement	(m)	0.000	0.506	-2.045	1.474
Surge Acceleration	(m/s^2)	0.372	0.140	-0.205	0.894
Sway Acceleration	(m/s^2)	-0.050	0.556	-1.956	2.381
Heave Acceleration	(m/s^2)	0.003	0.366	-1.285	1.285

Notes:

- The draft is referenced to the hydrostatic baseline.
- The wave direction sign convention is stated as where the waves are coming from.
- The engine to shaft speed ratio is 3.75:1.
- Offline analysis showed a glitch in the Sway channel of the MotionPak. Therefore motions were computed using the tri-mounted accelerometers and the MotionPak rates.
- A high-pass filter was used on the MotionPak rates to mitigate any noise caused by engine vibrations.
- The motions of the vessel at the CG were calculated using the earth fixed coordinate system.
- The motions of the vessel at the accelerometers were calculated using the body fixed coordinate system.
- 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 : 0.469 m fwd. Δy : 0.508 m stbd. Δz : 0.344 m below
- The distance to Accelerometers position from MotionPak:
  Δx : 4.686 m fwd. Δy : 0.648 m stbd. Δz : -3.230 m above
- The distance from Accelerometers to Center of Gravity:
  Δx : -4.217 m aft Δy : -0.140 m port Δz : 3.574 m below
- The distance from Accelerometers to Wheelsman's position:
  Δx : 1.2827 m fwd. Δy : 0.000 m Δz : 0.000 m

File Name: 8FOL_20031215142008_CAL
Date: December 15, 2003 NF Time: 14:20

Dockside

Location:	Pier 31, St. John's Harbour		
Nominal Draft FP:	2.65 m	Nominal Draft AP:	2.79 m
Water Temperature:	3.5 °C	Water Density:	1024.3 kg/m^3
Static Stability Info - GM_T(Fluid):	0.79 m		
Closest Stability Booklet Condition:	Port Departure (98% Consumables)		

Trials Site:

Trials Location:	10 nautical miles East of St. John's		
Water Temperature:	3.0 °C	Water Density:	1024.7 kg/m^3

Start of Run

Latitude:	47° 37' 37" North	Longitude:	52° 25' 54" West
Nominal Forward Speed Over the Ground:	8.2 knots		
Nominal Course Over the Ground:	186 (deg. TRUE)		
Total Distance Traveled During the Run:	3.85 nautical miles		
Nominal Relative Wind Speed:	8 knots		
Nominal Relative Wind Direction:	50 (deg. Rel)		
Nominal Engine RPM:	990 RPM		
Nominal Sea State:	4		
Duration of Run:	1726 s	Number of Samples:	86321
Drift Speed:	0.40 knots	Drift Direction:	310 (deg. True)

Dominant Wave Characteristics:	Significant Height:	2.24 m
	Direction:	4.2 (deg. True)
	Mean Period:	7.41 s
Peak Response Frequency:	Roll Angle:	0.1770 Hz
	Pitch Angle:	0.0901 Hz
	Heave Accel:	0.2864 Hz

Channel		**Average**	**St. Dev.**	**Minimum**	**Maximum**
DGPS Antenna					
COG	(deg. True)	187.1	1.377	181.3	190.5
SOG	(m/s)	4.135	0.126	3.792	4.583
SOG	(knots)	8.039	0.244	7.371	8.910
Shaft Speed	(RPM)	258.7	3.181	165.4	531.3
Rudder Angle	(deg.)	0.268	1.870	-6.641	6.838
Motions Computed for the Centre of Gravity					
Roll Angle	(deg.)	-0.015	1.475	-5.912	6.136
Pitch Angle	(deg.)	2.175	1.248	-2.435	6.035
Yaw Angle	(deg.)	-0.087	1.604	-6.879	4.463
Surge Displacement	(m)	-0.001	0.710	-2.461	2.291
Sway Displacement	(m)	0.000	0.171	-0.638	0.700
Heave Displacement	(m)	-0.001	0.448	-1.644	1.444
Surge Acceleration	(m/s^2)	0.000	0.191	-0.629	0.692
Sway Acceleration	(m/s^2)	0.000	0.093	-0.352	0.396
Heave Acceleration	(m/s^2)	-0.016	0.228	-0.756	0.947

File Name: 8FOL_20031215142008_CAL
Date: December 15, 2003 NF Time: 14:20

Channel		Average	St. Dev.	Minimum	Maximum
Output from the MotionPak Accelerometers					
Surge Acceleration	(m/s^2)	0.542	0.073	0.269	0.837
Sway Acceleration	(m/s^2)	-	-	-	-
Heave Acceleration	(m/s^2)	-9.784	0.223	-10.515	-8.828
Computed for the MotionPak position from the Accelerometers					
Surge Acceleration	(m/s^2)	0.373	0.074	0.109	0.664
Sway Acceleration	(m/s^2)	0.003	0.254	-1.138	1.061
Heave Acceleration	(m/s^2)	-0.008	0.227	-0.757	0.939
Computed for Wheelsman's Position					
Surge Displacement	(m)	0.000	0.147	-0.514	0.486
Sway Displacement	(m)	0.000	0.394	-1.638	1.306
Heave Displacement	(m)	-0.001	0.462	-1.653	1.403
Surge Acceleration	(m/s^2)	0.371	0.145	-0.147	0.913
Sway Acceleration	(m/s^2)	0.003	0.340	-1.509	1.460
Heave Acceleration	(m/s^2)	-0.005	0.300	-1.003	1.233

Notes:

- The draft is referenced to the hydrostatic baseline.
- The wave direction sign convention is stated as where the waves are coming from.
- The engine to shaft speed ratio is 3.75:1.
- Offline analysis showed a glitch in the Sway channel of the MotionPak. Therefore motions were computed using the tri-mounted accelerometers and the MotionPak rates.
- A high-pass filter was used on the MotionPak rates to mitigate any noise caused by engine vibrations.
- The motions of the vessel at the CG were calculated using the earth fixed coordinate system.
- The motions of the vessel at the accelerometers were calculated using the body fixed coordinate system.
- 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 : 0.469 m fwd. Δy : 0.508 m stbd. Δz : 0.344 m below
- The distance to Accelerometers position from MotionPak:
  Δx : 4.686 m fwd. Δy : 0.648 m stbd. Δz : -3.230 m above
- The distance from Accelerometers to Center of Gravity:
  Δx : -4.217 m aft Δy : -0.140 m port Δz : 3.574 m below
- The distance from Accelerometers to Wheelsman's position:
  Δx : 1.2827 m fwd. Δy : 0.000 m Δz : 0.000 m