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Barrett, J.; Cumming, D.; Hopkins, D.

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Technical Report

TR-2003-28

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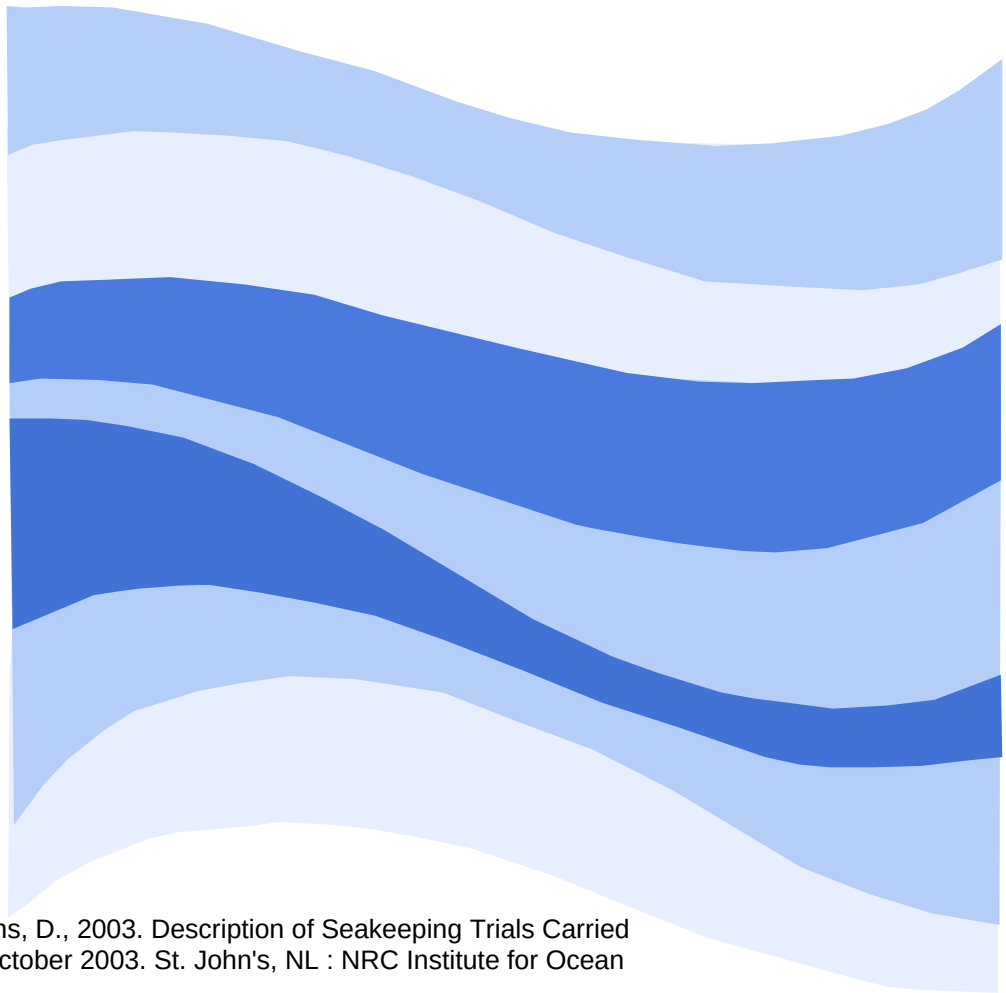
December 2003



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TITLE

DESCRIPTION OF SEAKEEPING TRIALS CARRIED OUT ON CCGA ATLANTIC SWELL – OCTOBER 2003

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SUMMARY

This report describes seakeeping experiments carried out on the 35 ft. (10.67 m) long inshore fishing vessel 'Atlantic Swell' off St. John's, NL October 4, 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.

This document describes the CCGA Atlantic Swell, 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

AC	Alternating Current
CAD	Computer Aided Design
CCG	Canadian Coast Guard
CCGA	Canadian Coast Guard Auxiliary
CG	Center of Gravity
CIHR	Canadian Institutes of Health and Research
cm	centimeter(s)
COG	Course Over Ground
DAS	Data Acquisition System
DC	Direct Current
deg.	degree(s)
DGPS	Differential Global Positioning System
FFT	Fast Fourier Transform
ft	foot, feet
Fwd	Forward
g	acceleration due to gravity
GM_L	Longitudinal Metacentric Height
GM_T	Transverse Metacentric Height
GPS	Global Positioning System
HF	High Frequency
h, hr	hour(s)
hp	horsepower
Hz	Hertz
in	inch(es)
IOT	Institute for Ocean Technology
ITTC	International Towing Tank Conference
kg	kilogram(s)
kHz	kiloHertz
km	kilometre(s)
kt(s)	knot(s)

LIST OF ABBREVIATIONS
(continued)

lb(s)	pound(s)
LCB	Longitudinal Center of Buoyancy
LCF	Longitudinal Center of Flotation
m	metre(s)
mHz	megaHertz
MII(s)	Motion Induced Interrupt(s)
mm	millimetre(s)
MUN	Memorial University of Newfoundland
NIF	New Initiatives Fund
nm	nautical mile(s)
NMEA	National Marine Electronics Association
NSERC	Natural Sciences and Engineering Research Council of Canada
OCC	Oceanic Consulting Corporation
OEB	Offshore Engineering Basin
OSSC	Offshore Safety and Survival Centre
PPT	Parts Per Thousand
RF	Radio Frequency
RPM	Revolutions Per Minute
s, sec.	second(s)
SAR	Search And Rescue
SOG	Speed Over Ground
t	tonne(s)
UHF	Ultra High Frequency
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPS	Uninterruptible Power Supply
V	volt(s)
VCB	Vertical Center of Buoyancy
VHF	very high frequency

1.0 INTRODUCTION

This report describes seakeeping experiments carried out on the 35 ft. (10.67 m) long inshore fishing vessel 'Atlantic Swell' off St. John's, NL October 4, 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. 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 CCGA Atlantic Swell, 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.

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 CCGA ATLANTIC SWELL

The 'Atlantic Swell' (see Figure 1) is a typical 35' fiberglass fishing vessel, built by King's Boat Building of St. Jones Within, NL in 2001, which primarily participates in the inshore snow crab fishery, but has the ability to harvest other species, such as codfish and capelin, when the stocks are available. It has been estimated that this vessel has the capacity of harvesting 20,000 lbs (9,100 kg) of codfish in a single trip, while it may only yield 12,000 lbs (5,450 kg) of snow crab due to the different weight densities and storage methods of each species. The vessel primarily operates out of Fermeuse off the south and east coast of Newfoundland.

One of the goals of this experiment is to measure the motions of the vessel while it is harvesting its catch, therefore a "half loaded" displacement condition was simulated by securing eight water sacks in the fishing hold, each having a capacity of approximately 200 liters, weighing a total of approximately 1,590 kg. Once the vessel was ballasted and most of the outfit items installed, an inclining experiment was performed on October 2nd by Marine Services International Ltd. of St. John's, NL to identify key hydrostatic properties for the trials condition.

The inclining experiment was carried out using standard procedures whereby two pendulums suspended with the weights in an oil bath were deployed to measure roll angle. Static roll angles were induced by the shifting of two steel drums filled with fresh water, weighing 505 lbs (229 kg) each, laterally to various locations on the main deck.

The following is a summary of results:

- Draft: 3' 3" @ stem - 5' 1½" @ transom (0.991 m Forward – 1.562 m Aft)
- Displacement: 16.61 Long Tons (16,876 kg)
- Longitudinal Center of Buoyancy (LCB): 1.17 feet (0.357 m) Fwd. of Midships
- Vertical Center of Buoyancy (VCB): 2.97 feet (0.905 m) above the Keel
- Longitudinal Center of Floatation (LCF): 2.12 feet (0.646 m) Aft of Midships
- Transverse Metacentric Height (GM_T): 4.426 feet (1.349 m)
- Longitudinal Metacentric Height (KM_L): 38.8 feet (11.83 m) above the Keel

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

The 'Atlantic Swell' is a round bilge, single screw (fixed pitch, 4 blade propeller, Figure 2), single flat plate rudder vessel with a large centerline skeg and no

Custom Software:

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

4.2 Rudder Angle Measurement

The rudder angle was measured by winding the cable, with wax string extension, from a 10 inch yo-yo type potentiometer linear displacement transducer around a groove cut in a circular ½ inch (1.27 cm) thick Plexiglas plate. The plate was machined with a steel clamp at its center so that it could be adjusted to any size rudderpost (Figure 6). The transducer was clamped to the aft bulkhead – the cable aligned with the grove cut in the plate.

Rudder angle was calibrated with respect to a protractor, drawn using CAD software, fixed to the top of the circular plate (there was no mechanical rudder angle indicator in the tiller flat) with an estimate of zero degrees rudder angle information provided by the First Mate of the 'Atlantic Swell'.

4.3 Ship's Motion Instrumentation

For the seakeeping trials carried out on October 4th, a MotionPak I was used to measure ship motions with six degrees of freedom. The MotionPak was mounted on a steel bracket fixed to the forward bulkhead in the fish hold of the vessel (Figure 7) 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

Forward, 3.98 m Above the vessel's CG), the system software was initiated by having the vessel perform multiple rotations of 360 degrees 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

4.5 Directional Wave Buoy/Mooring Arrangement

A small (0.75 m diameter, 15.7 kg) discus shaped directional wave buoy manufactured by Neptune Sciences, Inc. of Slidell, Louisiana and procured by MUN for previous sea trials using NSERC funding was used to acquire information on the wave conditions during the seakeeping trials. (Figure 9)

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

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

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

4.6 Propeller Shaft Speed

Propeller shaft speed was measured using an optical sensor acting on a piece of reflective tape on the shaft in the fish hold (Figure 10). 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.

4.7 Wind Anemometer

The "Weather Wizard III", manufactured by Davis Instruments, provides monitoring and logging of essential weather conditions such as temperature, wind direction, wind speed and wind chill (Figure 11). At dockside the directional indicator was aligned to true north with the aid of the vessel's magnetic compass, which was corrected for magnetic declination. Wind speed and direction were logged by hand at the beginning of each run in the seakeeping trials.

4.8 Sea Water Temperature/Density Measurement

To determine whether there are any large variations in water density (which would ultimately change the draft of the vessel) between St. John's harbour where the ship's draft is recorded and the trials area, a YSI model 30 battery powered hand-held salinity, conductivity and temperature meter was used to measure the parameters required to determine ambient water density. The YSI 30 unit, manufactured by YSI of Yellow Springs, Ohio, consists of a hand held display device and a weighted probe with 25 feet of cable connecting the two (Figure 12). The required information, i.e. temperature and salinity, is collected by the probe and presented on the hand held display with an accuracy of ± 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 ~ 0.75 m. The density is then calculated using the Equation of State of Seawater given in Reference 9, which provided density as a function of temperature, salinity, and pressure. Note that 0.75 m depth of water is approximately equivalent to 7.5 kPa of pressure. Additional information on the YSI instrument is provided in Reference 10.

4.9 Propane Generators

Since the 'Atlantic Swell' was not equipped with an AC power supply required to power IOT electronics, a 6.5 hp portable EM3000CC Honda generator, was installed on top of the wheelhouse in a ventilated wooden box designed to

data analysis but corrected before the offline data analysis stage. The draft of the vessel was measured at the bow and stern of the vessel, before departing for the wave buoy location at 47 34.21 North and 52 26.43 West.

Upon arrival at the wave buoy location, the sea conditions were found to be very favorable for the experiment. The significant wave height was recorded at approximately two meters with winds of 10 -12 knots. The data obtained from the wave buoy indicated that the dominant wave direction was 148 degrees True 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 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. The log of the trials events can be found in Appendix F.

Typical Set of Forward Speed Seakeeping Runs:

Each set reflected the recommended ITTC test pattern (Appendix G) and was observed in the following manner for each nominal speed:

- The ship was first positioned in close proximity to the wave buoy.
- After retrieving wave data from the buoy, the dominant head sea direction (degrees magnetic) was corrected using a value of approximately 21 degrees to determine the direction relative to true north.
- The forward speed over the ground and heading were selected such that the vessel was heading directly into the sea (head sea run). The course was set and the throttles adjusted to achieve the desired course and speed. Data acquisition was initiated once steady state conditions were achieved.
- The headings during all runs were maintained by manual steering. It was often difficult to maintain a steady course, particularly at lower speeds, which can be seen from the large rudder deflection angles of up to 20 degrees recorded.
- After 25 minutes had elapsed on a steady course, data acquisition was terminated.
- The vessel was then turned about 180 degrees to complete the "following" sea run where the wave action is essentially pushing the vessel. The shaft RPM was adjusted to maintain a constant speed over ground in order to compare results between runs. This run was scheduled to acquire 40 minutes of data.
- Course adjustment of 135 degrees was selected to correspond with the next section of the test pattern (bow sea run). The shaft RPM was adjusted as necessary.

Figure 16: Surge, Sway, and Heave Displacement vs. Time
Figure 17: Surge, Sway, and Heave Velocity vs. Time
Figure 18: Surge, Sway, and Heave Acceleration vs. Time
Figure 19: Pitch, Roll, and Yaw Angle vs. Time
Figure 20: Pitch, Roll, and Yaw Rates vs. Time
Figure 21: Pitch, Roll, and Yaw Acceleration vs. Time
Figure 22: Shaft Speed and Rudder Angle vs. Time
Figure 23: COG, SOG vs. Time

7.1 Wave Data Analysis

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

More precisely, as a definition:

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

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

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

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

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

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

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

in the electronics lab at IOT, and instrument offsets were recorded. A summary of the calibration file along with the regression equations can be seen in Appendix D.

An unforeseen modification had to be made to the acquired DGPS data when it was discovered that the "Heading" given by the antenna was 180 degrees out of phase. When the antenna was mounted, the longitudinal alignment aid was used in the wrong direction, pointing at the mast of the ship. The raised button on top of the antenna should be pointed in the direction of the bow of the ship. Simple alterations were then made to the DGPS calibration program to remedy the mistake. Additional software modifications were made to eliminate spurious binary code noted in the DGPS data during the trial.

Large variations in the shaft RPM, figure 21, can be attributed to the floating-point math library that was used in the earlier software versions. Originally, the sensor would appear to behave properly upon startup, but over time the measurement would begin to fluctuate due to the accumulation of internal math errors. Only an approximate value of shaft RPM can be found by analyzing the data on a run-to-run basis. Some of the runs fluctuate wildly for a significant portion of the run and then give indications that the software re-zeroed the internal values (e.g. following seas at 4 knots), while others appear to give consistent recordings with the exception of occasional anomalies (e.g. bow seas at 4 knots). This problem was not noted prior to the trial and all shaft speed data is invalid.

After the 'Atlantic Swell' trial, the RPM tachometer was fixed in two ways; the floating-point library used in the microcontroller was changed from a 24 bit to a 32 bit system and the new software re-zeros all internally accumulated quantities approximately every five minutes of continuous measurement.

7.3 Ship Motion Analysis

As part of this experiment, motions were measured at two positions on the vessel, the Master's steering position and the vessel's center of gravity.

Within the software used to analyze MotionPak data, there is the capability to translate the accelerations recorded to any position onboard the vessel. This provided the ability to produce data at the Master's steering position without using sensors at that location.

The following table is a summary of standard deviations at the ship's CG obtained from the experiment. Tables of basic information and statistics (average, standard deviation, minimum and maximum) for each run are provided in Appendix I.

8.0 DISCUSSION & RECOMMENDATIONS

Despite technical difficulties and minor set backs, the seakeeping trial, as a whole, was considered at least a partial success. The following is a series comments on how the trial was executed with recommendations on how to improve the quality of data collected.

Ballasting Efforts:

The decision to use water sacs to ballast the 'Atlantic Swell' proved to be a very effective and efficient method and is recommend for use on small vessels in the future. The use of a garden hose from a shore supply of fresh water made the task of filling the sacs relatively easy because the hose fit snuggly over the valve. After the seakeeping trial was complete, the water was pumped out of the sacs using an electric pump.

Testing Equipment with Calibration Software:

Time constraints put a rush on the instrumentation preparation for the trial, which resulted in incomplete testing of all systems by IOT's electronics staff. On this trial, after system checks were made onboard the vessel, discrepancies were found within the data. Older versions of the calibration software were designed such that it read a voltage range from DaqBoard of ± 10V. This did not coincide with the new signal conditioners used in the electronics lab, which multiplexed all input channels into essentially one channel with a voltage range of ± 5V and was not accounted for in the software. During the sea trial, the slopes of the equations used in the calibration file were divided by two in order to obtain rough estimates of the motions recorded. After completion of the sea trial, the problem was discovered and the acquisition software was remedied.

Use of Salinity Meter:

Salinity and temperature reading were not taken on the day of the seakeeping trial due to the lack of foresight of an intern working at IOT. These readings would have been beneficial to confirm no change in the draft of the vessel due to a change in seawater density. It must now be assumed that the density of the water at the trials area was the same as was measured when the draft was recorded at the dock, which may affect results from model testing in the future.

ITTC Trial Test Pattern:

During the 4 knot set of runs, a steering error was made by the helmsman resulting in selection of the wrong course when turning from bow sea onto a beam sea heading. This resulted in the beam sea run being 180 degrees different than desired and the quartering sea runs being carried out several kilometers from the wave buoy. To prevent this from happening in future, the test

to acquire every half an hour in normal mode at 6:00am October 4th, the wave buoy failed sometime after 10:00am, slightly more than 72 hours after deployment. The wave buoy is equipped with software that monitors and records the status of the buoy. Upon failure, the battery voltage was recorded as 11.67 V. It also states within the wave buoy operation manual, "A Wave Sentry may not operate properly if this value is lower than approximately 9.5 V" (Reference 8). Clearly there is some discrepancy here.

In an attempt to forecast the sea state after the failure of the wave buoy, a trend line was fit to the wave data collected with consideration to visual observations recorded on the day of the seakeeping trial (Figure 25).

Problems with the Honda Generators:

If sea trials are to be done on small vessels not fitted with a reliable supply of AC power in the future, IOT generators should be loaded for an extended period of time to ensure their effectiveness in charging the UPS.

Draft Measurement:

The CCGA Atlantic Swell did not have draft markings painted on its hull, therefore freeboards were measured from both the bow stem and stern of the vessel using a flexible tape measure. Freeboards measured by IOT personnel, which were then translated to drafts with CAD provided by MSI Limited, differ from those quoted by MSI Limited who completed the lines plan and performed the inclining experiment for the vessel. In both instances, the freeboards were measured by standard measuring tapes. The recorded freeboards and resulting drafts are as follows:

MSI Limited: 60 in (Stern) – 90.25 in (Forward, extrapolated from midships)
Resulting Draft: 39in Forward, 62.4in Aft
IOT Personnel: 62 in (Stern) – 96 in (Forward, measured from bow stem)
Resulting Draft: 33.5in Forward, 60.5in Aft

It should be noted that it is possible that gusting winds may have deflected the measuring tape when IOT measured the freeboards and resulted in an overall lighter displacement of the vessel.

9.0 ACKNOWLEDGEMENTS

The authors would like to thank the crew of the CCGA Atlantic Swell, Mike and Patrick Turner, for their enthusiastic support during the trial, the CCG for the loan of survival equipment and permission to berth the 'Atlantic Swell' at the Coast Guard Base (St. John's), Jack Foley of MUN Oceanography for assistance designing the wave buoy mooring and deploying the wave buoy, and IOT technical staff for their efforts throughout the planning and execution of the trial.

Figure 1: CCGA Atlantic Swell

Figure 2: Propeller Arrangement

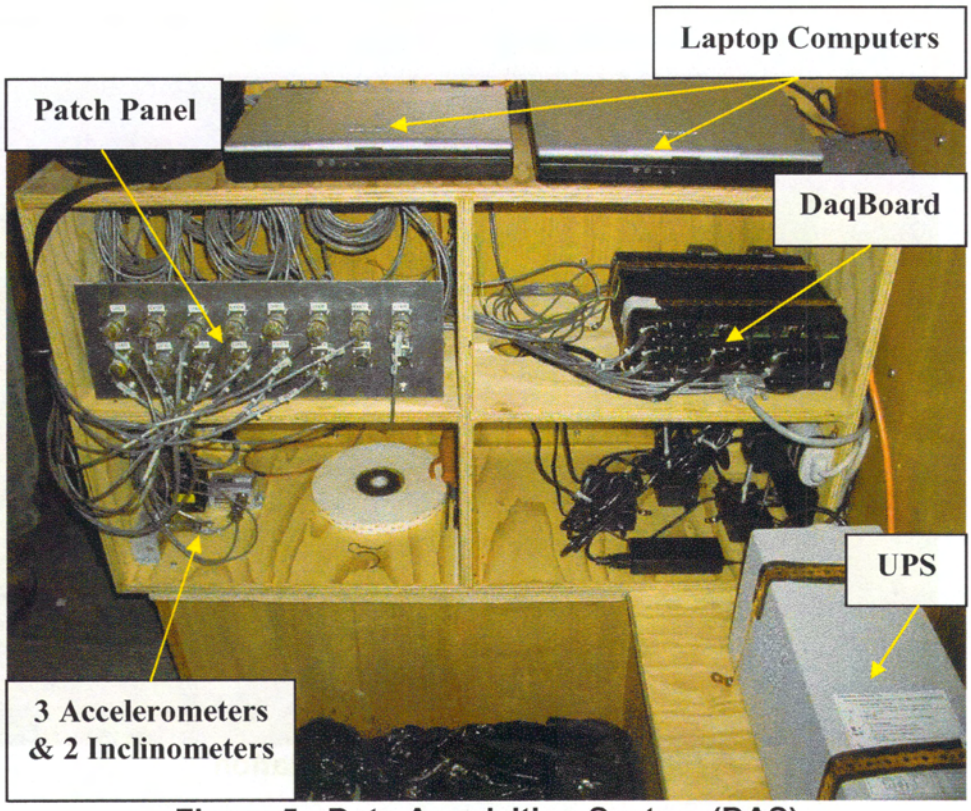


Figure 5: Data Acquisition System (DAS)

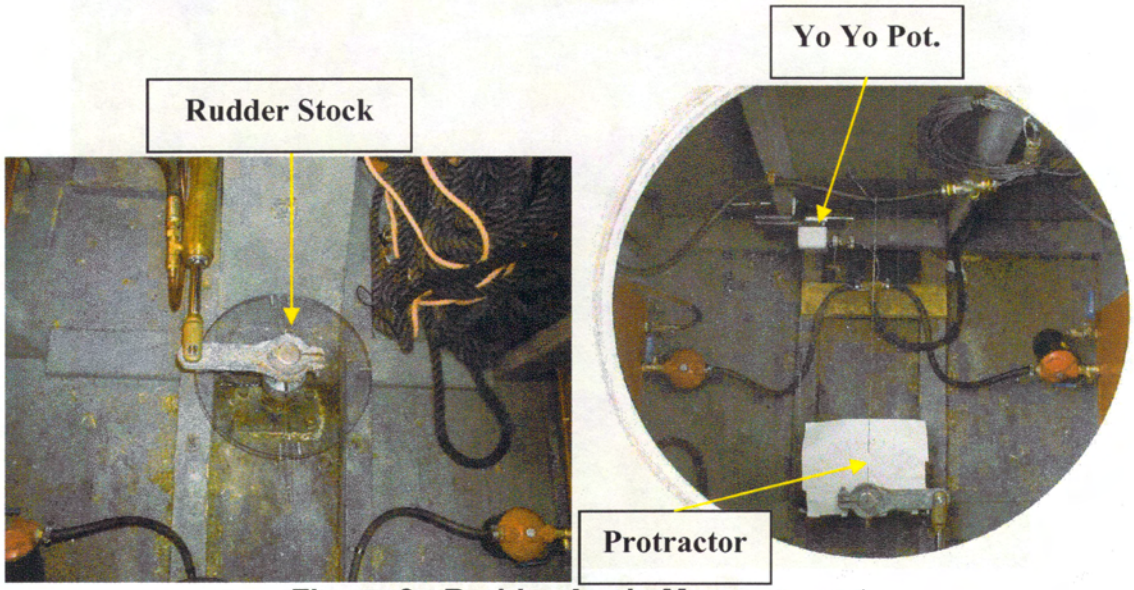


Figure 6: Rudder Angle Measurement

Figure 9: Wave Sentry Buoy, Radar Reflector and Mooring Cable

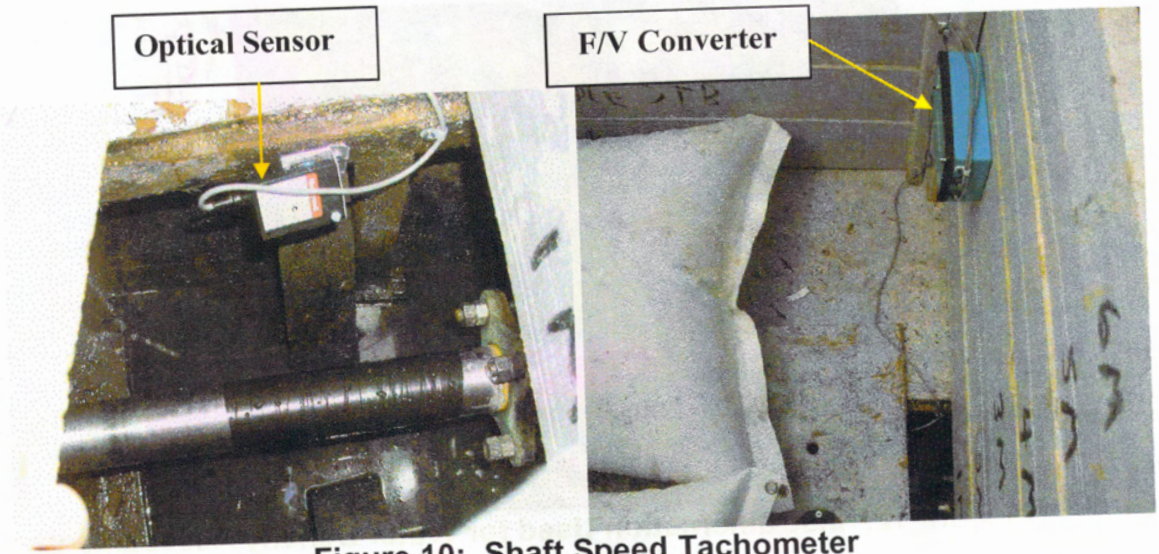


Figure 10: Shaft Speed Tachometer

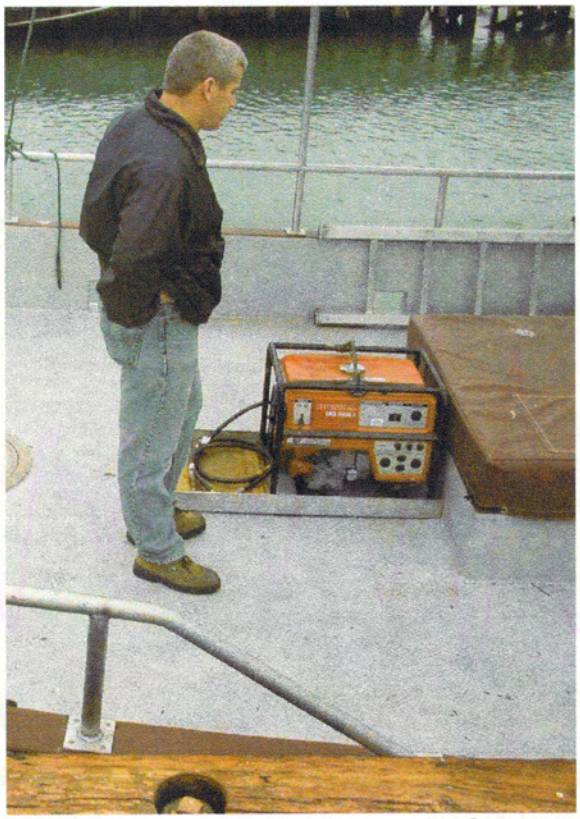


Figure 13: 8 hp Propane Honda Generator

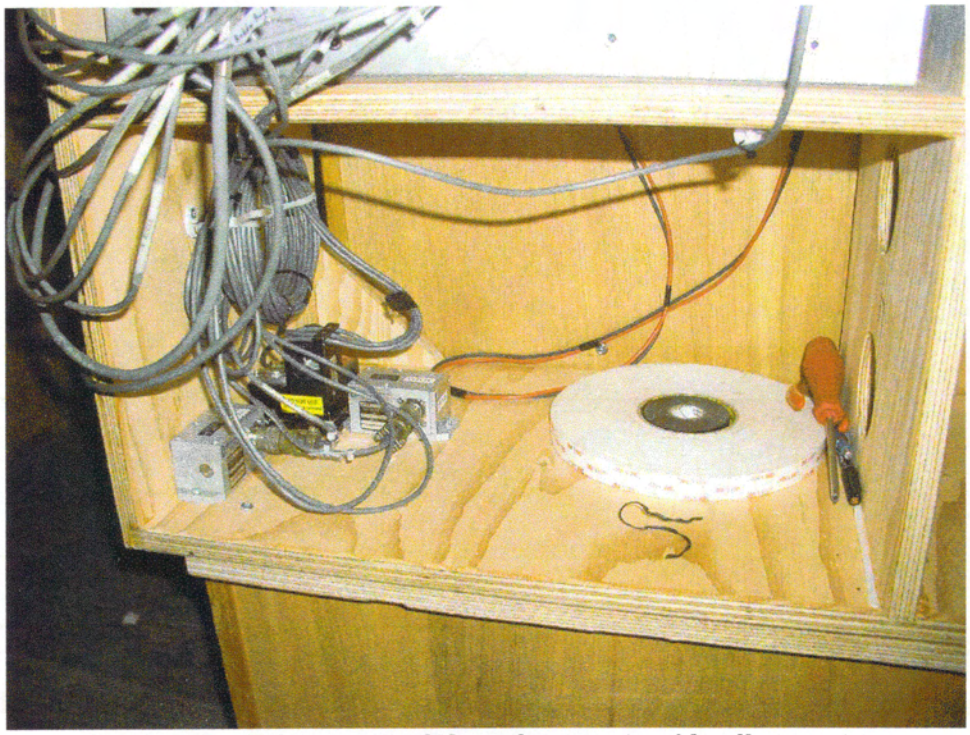


Figure 14: Tri-mounted Accelerometer / Inclinometers

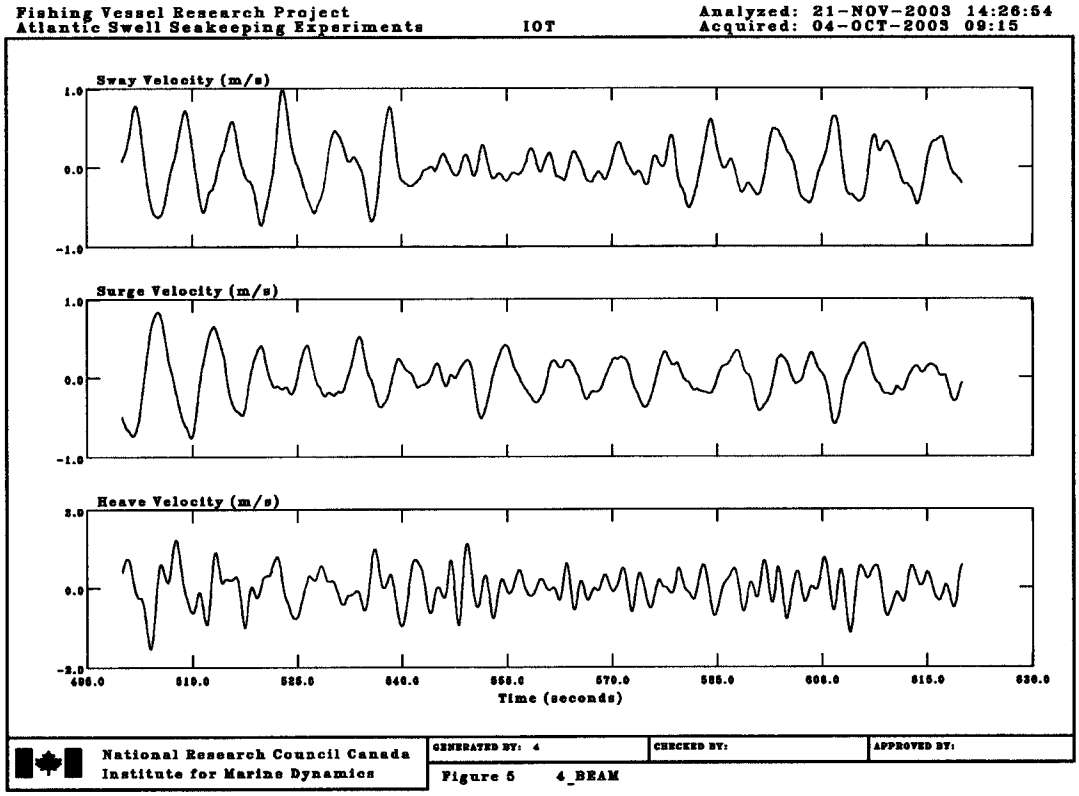


Figure 17: Offline Analysis – Surge, Sway, and Heave Velocity vs. Time

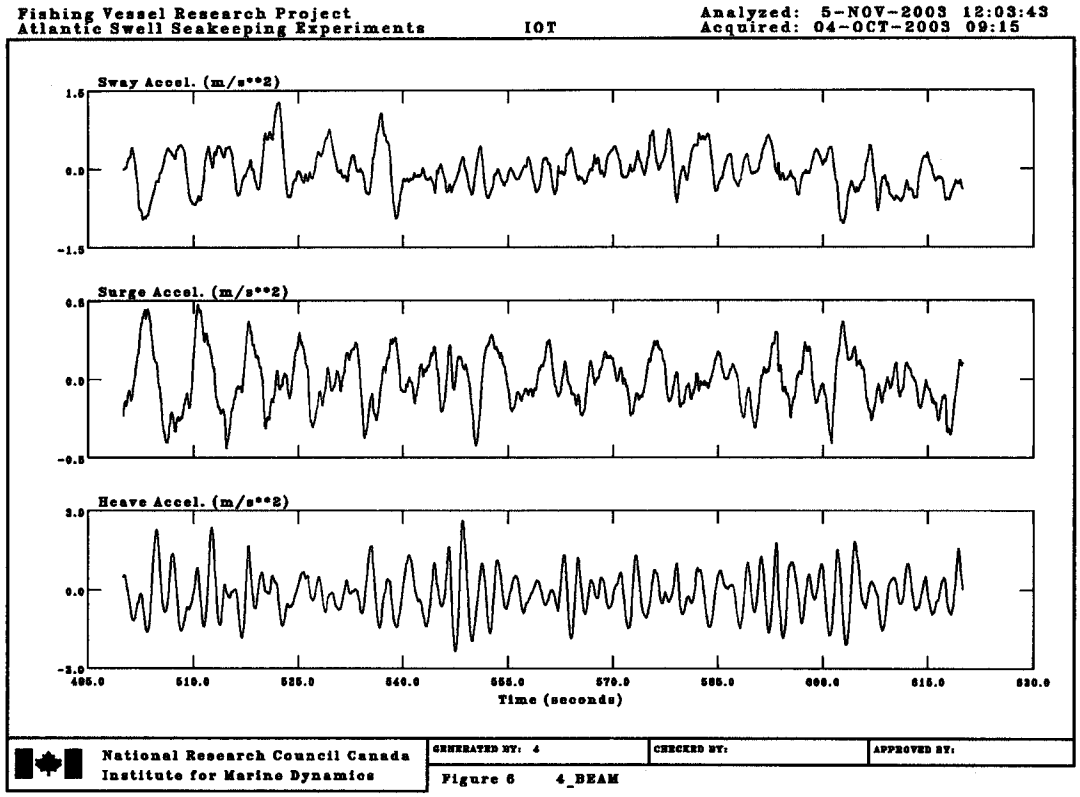


Figure 18: Offline Analysis – Surge, Sway, and Heave Acceleration vs. Time

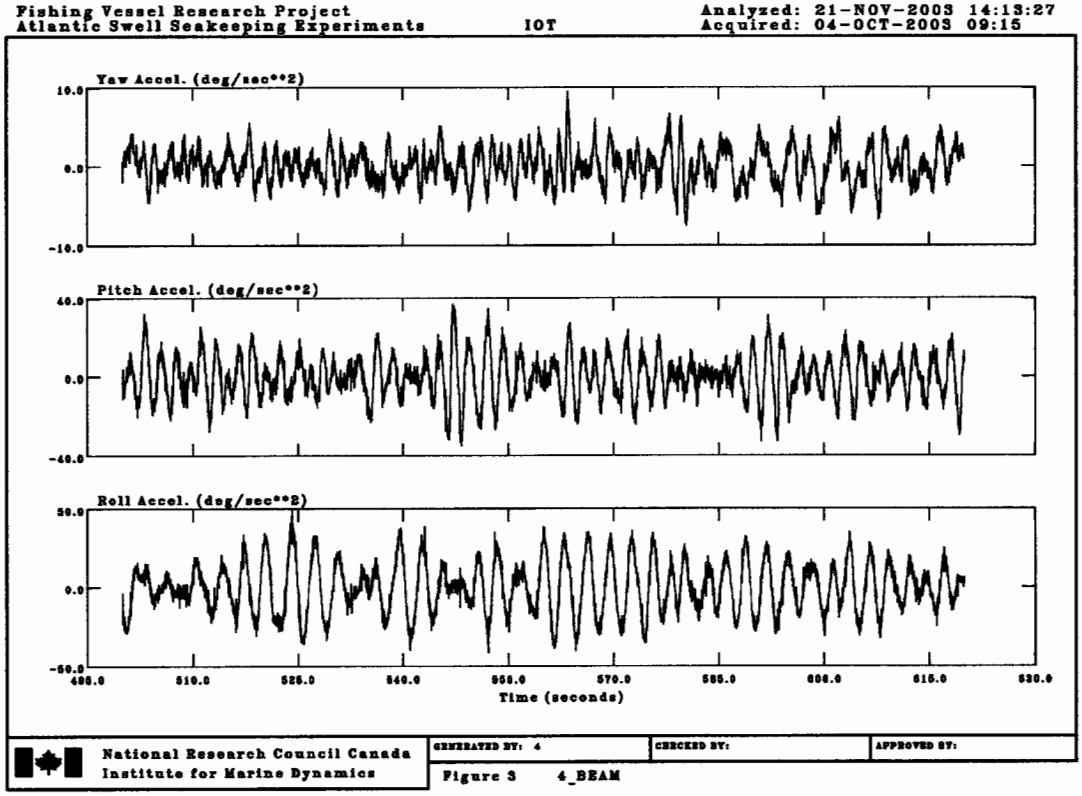


Figure 21: Offline Analysis – Pitch, Roll, and Yaw Acceleration vs. Time

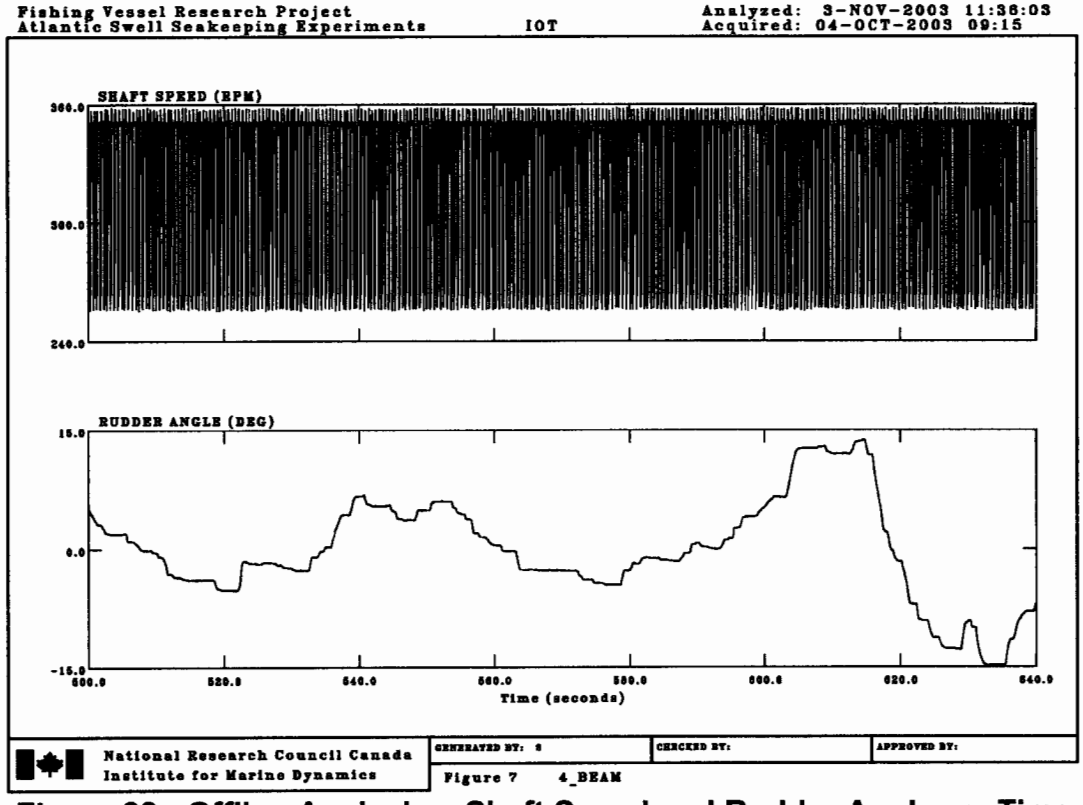
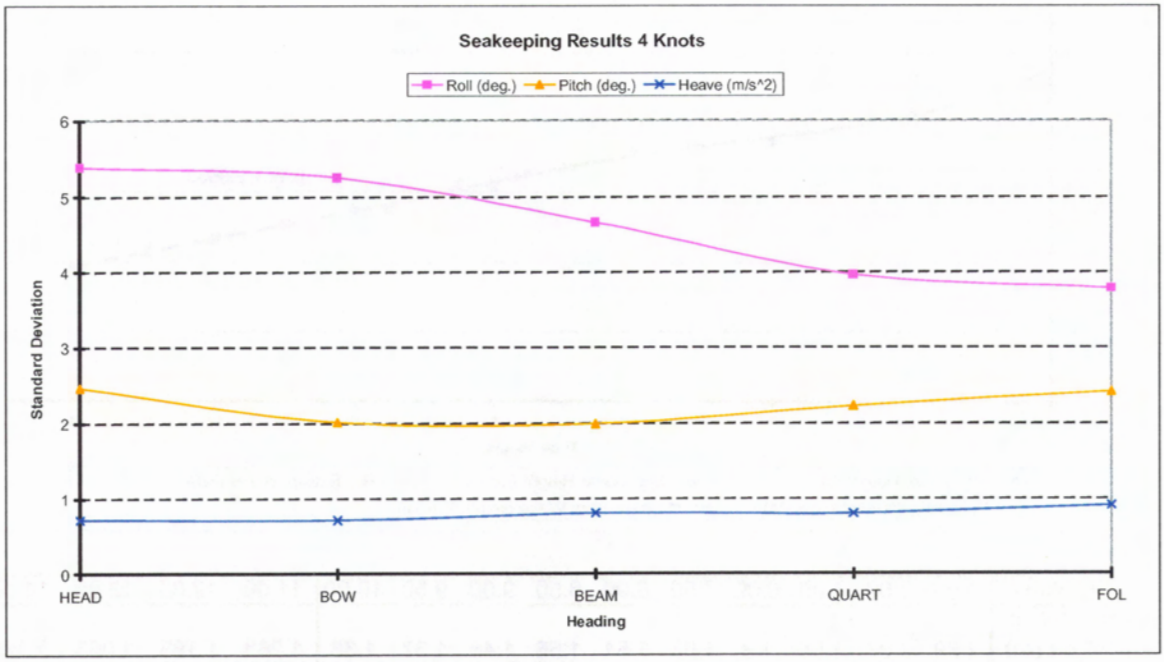


Figure 22: Offline Analysis – Shaft Speed and Rudder Angle vs. Time



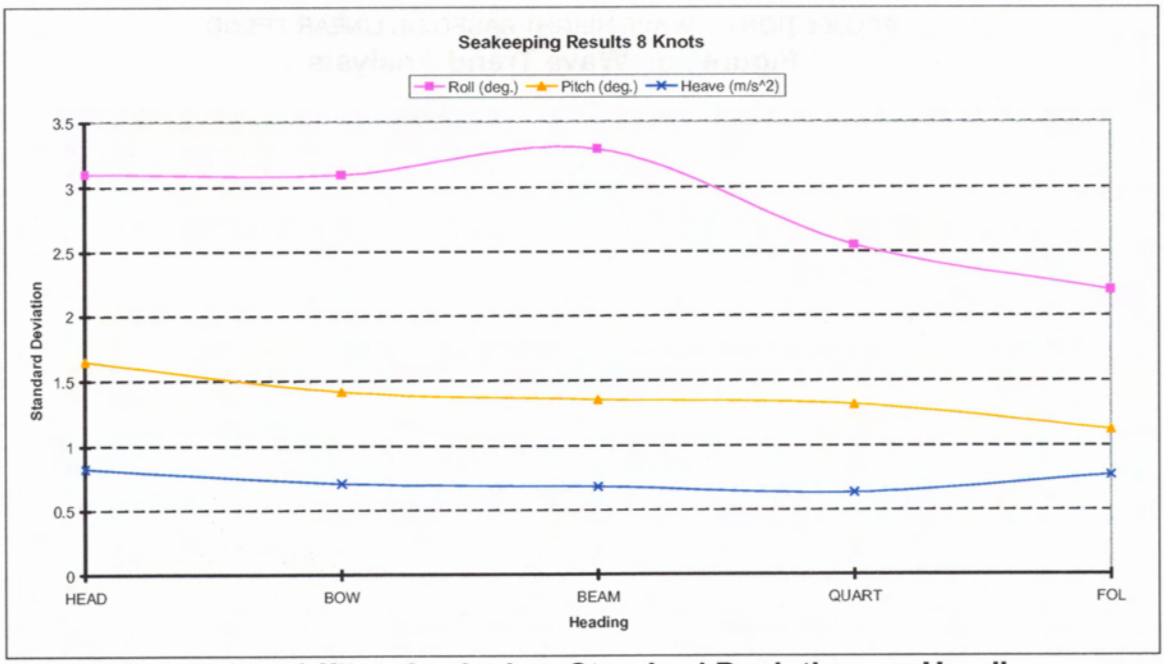


Figure 24: Offline Analysis – Standard Deviation vs. Heading

Appendix A
Inclining Experiment Report

MSI Marine Services International Ltd.

1315 TOPSAIL RD,
P.O. BOX 8274, STN. 'A'
ST JOHN'S , NEWFOUNDLAND
CANADA AIB-3N4

PHONE: 709-782-3355 FAX: 709-782-3335 EMAIL: DMPorter@canship.com

October 9, 2003 Project 535

Dr. Don Bass
Engineering Department
Memorial University.
St. John's NL.

Subject: **2nd Incline Report**

Don

Thank you for the work associated with the Atlantic Swell. Attached please find the report for the second incline experiment.

Also, attached please find the invoice, number 2320, covering the following services.

"To incline the vessel and provide a report

To confirm the lightship and GM,"

Again, thank you for this work MSI looks forward to assisting as required with this project.

Best Regards

David M. Porter

Limit of Liability - MSI limits the liability on any one project to the total fees billed on that project.

Inclining Experiment #2 - Atlantic Swell : Half Load Condition On October 02 2003

Inclining Particulars

Forward Pendulum Details
Length 1720 mm Location: Accommodation Space

After Pendulum Details
Length 1080 mm Location: Lazarett

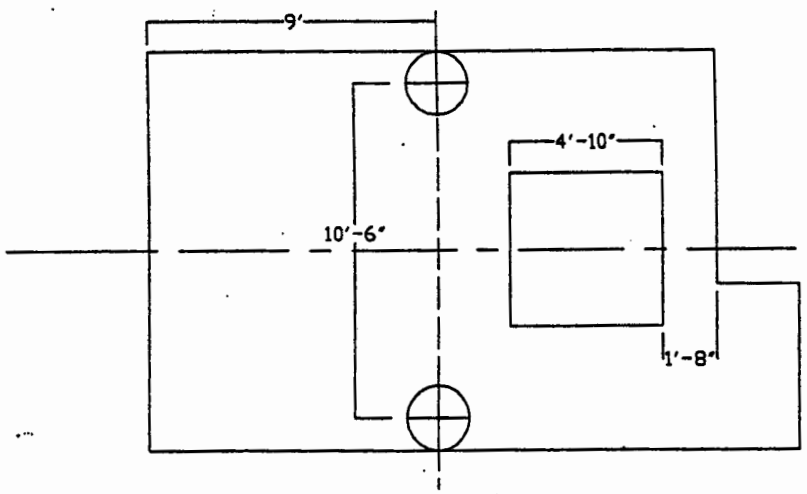
Record of Shifts

Shift Number	Weight Number	Shift Direction	Weight For Shift	Shift Direction	After Pen. Deflection	For. Pen. Deflection
0	1	S - P	505 lbs	10.5 ft	34	63
1	2	P - S	505 lbs	10.5 ft	34	58
2	2	P - S	505 lbs	10.5 ft	29	60
3	1	S - P	505 lbs	10.5 ft	29	60
Averages			505 lbs	10.5 ft	31.5cm	60.25cm

Weight Details

Two plastic drums. Plastic drums taken as 505 lbs each.

Diagram of Shift



Inclining Experiment #2 - Atlantic Swell : Half Load Condition
On October 02 2003

TANK STATUS

Trim: Fwd 0.74/31.69, Heel: zero

Part	Load	SpGr	Weight(LT)	LCG	TCG	VCG	FSM
FOAFT.P	0.980	0.870	0.70	12.89a	3.99p	5.22	0.6
FOAFT.S	0.980	0.870	0.70	12.89a	3.99s	5.22	0.6
Total Tanks---->			1.40	12.89a	0.00	5.22	1.3
Distances in FEET.					Moments in Ft-LT.		

WEIGHT STATUS

Part	Weight(LT)	LCG	TCG	VCG
AS INCLINED	16.61	1.17f	0.00	5.51
Remove All Tanks	-1.40	12.89a	0.00	5.22
Remove Incline Weights	-0.45	5.90a	0.00	8.00
Remove Incline 3 Personnel	-0.22	3.50a	0.00	8.50
Remove Weight Bags	-2.00	2.25	0.00	3.35
Total Light Ship---->	12.53	0.52f	0.00	5.75
Distances in FEET.				

Appendix B
CCGA Atlantic Swell Principle Particulars & List of Outfit Items

CCGA ATLANTIC SWELL

Principal Particulars:

Length Overall	34 ft. 11in.
Length Between Perpendiculars	31 ft. 8.125in.
Breadth	14 ft.
Draft	5 ft.
Displacement	16.6 LT
Cruising Speed	8 knots
Day Trip Crew	4

Machinery Description:

Engine:	Isuzu
Propulsion Power:	154 hp
Maximum Shaft RPM:	660 RPM (11 rps) (nominal)
Maximum Rudder Angle:	± 35 degrees (nominal)

Electrical Inverter, no fuel powered generators

Navigation/Communication Equipment:

Radar	Furuno
GPS Position	Furuno
Depth Sounder	Koden CVS106
VHF Radio	ICOM-M45
Secondary Radio	Raymarine 215E

Magnetic Compass

Barometer

Compact Laptop computer - used to support Electronic Chart Data

Appendix C
Instrumentation Plan

Instrumentation Plan for Fishing Vessel Trials

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

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.

F/V are generally single screw, fixed pitch prop with single flat plate rudder. The smaller vessels may not have an autopilot.

UPS will be required for all trials - some vessels may also require a propane powered generator to supply AC power for instrumentation.

Appendix D
Calibration Information

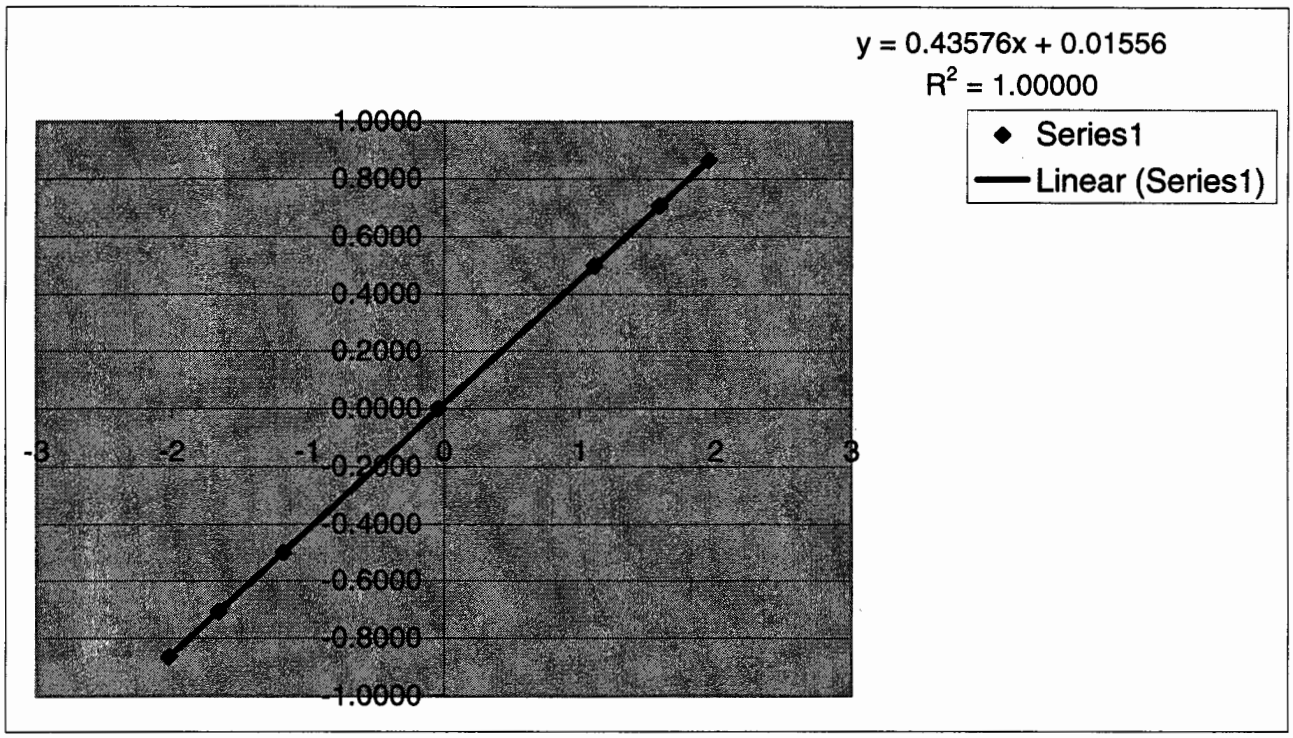
Ch. 01
X Accel, Motion Pak

S/N 0326

Gravity 1

Angle	Sin(angle)	Acceleration	Voltage
0	0	0.0000	-0.038
29.994	0.499909307	0.4999	1.11
45.016	0.707304215	0.7073	1.587
59.9	0.865151421	0.8652	1.952
-59.9	-0.865151421	-0.8652	-2.022
-45.016	-0.707304215	-0.7073	-1.657
-29.994	-0.499909307	-0.4999	-1.182

slope	offset
0.4358	0.0156



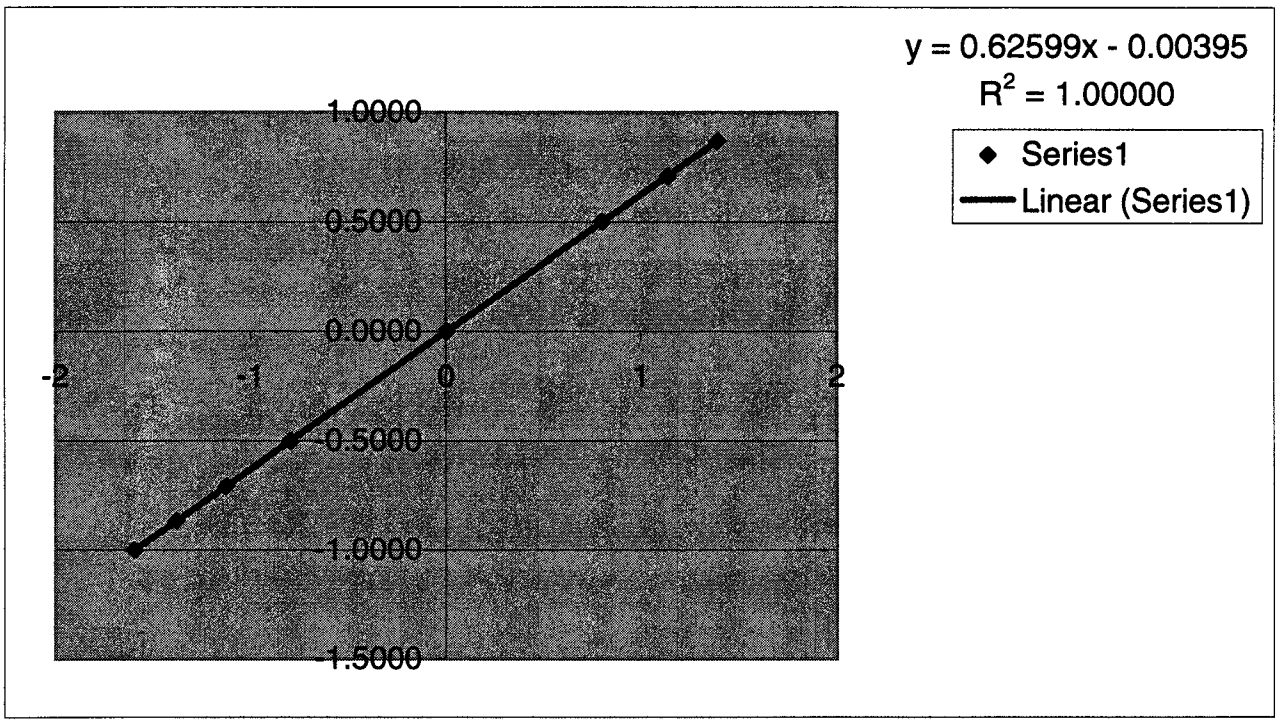
Ch 03
Z Accel, Motion Pak

S/N 0326

Gravity 1

wedge	Angle	-Sin(angle)	Acceleration	Voltage
0	90	-1	-1.0000	-1.592
29.994	60.006	-0.866077759	-0.8661	-1.378
45.016	44.984	-0.706909292	-0.7069	-1.124
59.9	30.1	-0.501510737	-0.5015	-0.792
90	0	0	0.0000	0.008
-59.9	-30.1	0.501510737	0.5015	0.805
-45.016	-44.984	0.706909292	0.7069	1.136
-29.994	-60.006	0.866077759	0.8661	1.39

slope	offset
0.6260	-0.0040



Ch. 05
Pitch Rate, Motion Pak

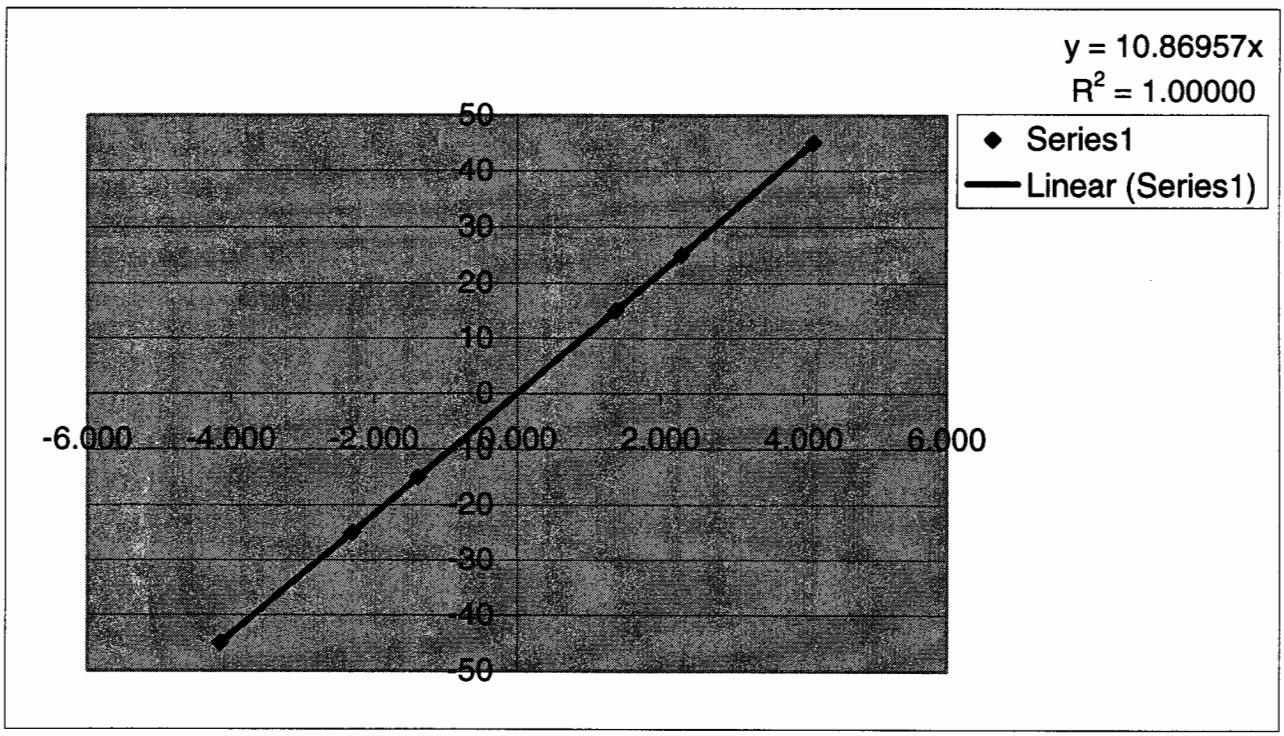
S/N 0326

Scale Factor 49.916 mV/deg/s

Universal Source 169644

Deg/second	Injected voltage, Volts	Output, Volts
45	2.2462	4.140
25	1.2479	2.300
15	0.7487	1.380
-15	-0.7487	-1.380
-25	-1.2479	-2.300
-45	-2.2462	-4.140

slope	offset
10.8696	0.0000

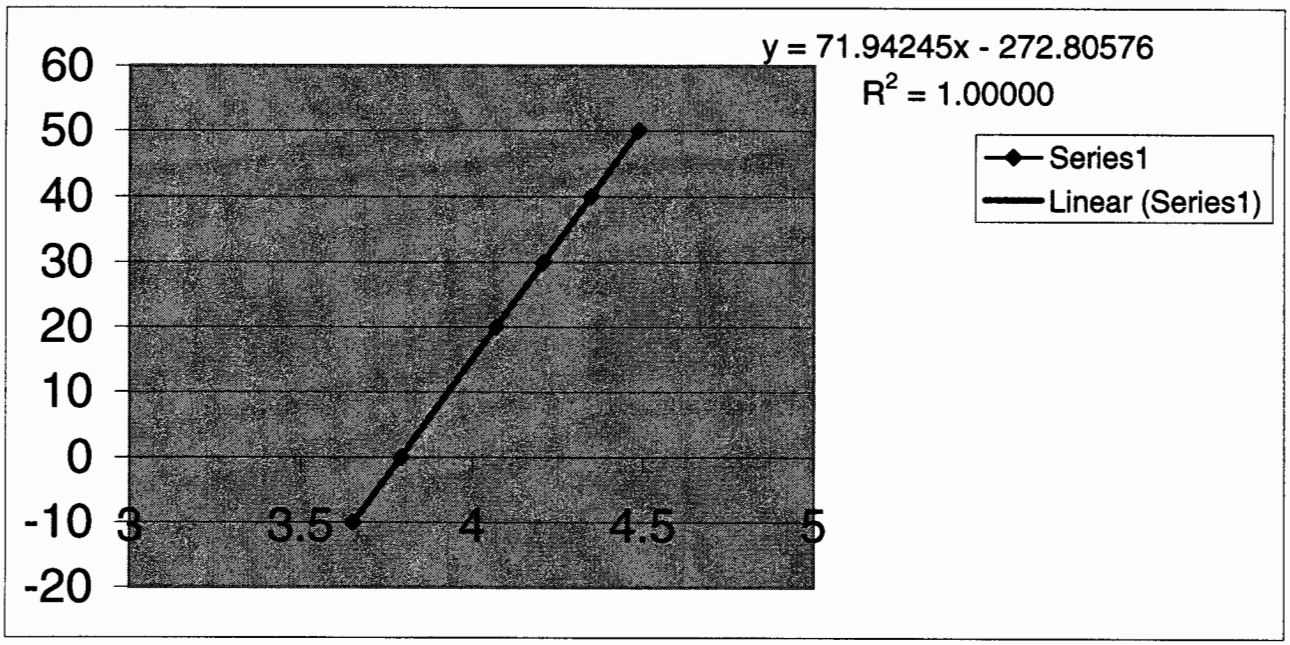


Ch. 07
Temperature, Motion Pak

1.00E-06	A/°K	
13.91	Kohms	

Temperature Celsius	injected voltage V	Output, Volts Volts
-10	0.000	3.653
0	0.000	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	-272.806



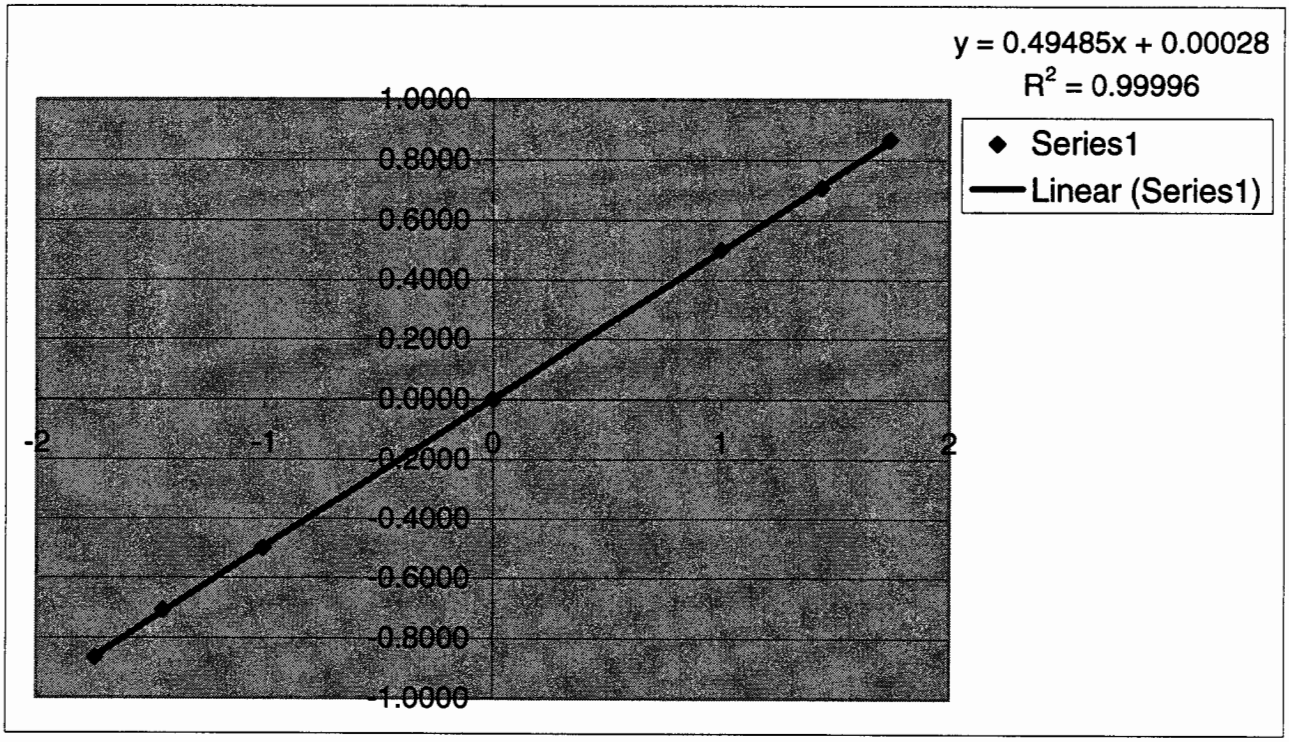
Ch 09
Y Accel (Sway)

Model QA1400
serial # 8710/942

Gravity 1

Angle	Sin(angle)	Acceleration	Voltage
0	0	0.0000	0
29.994	0.499909307	0.4999	1.002
45.016	0.707304215	0.7073	1.442
59.9	0.865151421	0.8652	1.741
-59.9	-0.865151421	-0.8652	-1.743
-45.016	-0.707304215	-0.7073	-1.442
-29.994	-0.499909307	-0.4999	-1.004

slope	offset
0.4948	0.0003



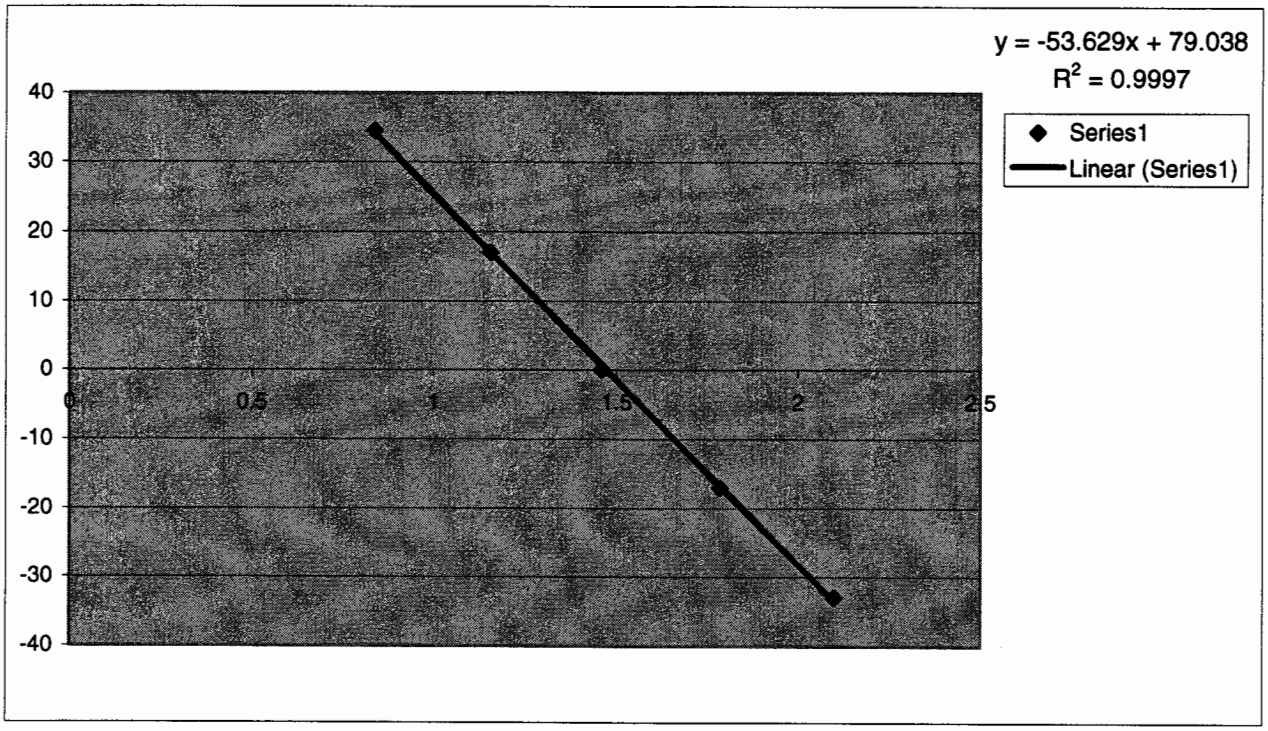
Ch 11
Rudder Angle

Model PT101-0025-111-1110
serial # A10806

Gravity 1

Deflection (deg)	Angle	Voltage
88	0	1.461
105	17	1.157
122.5	34.5	0.838
71	-17	1.786
55	-33	2.099

slope	Intercept
-53.6291	79.0383



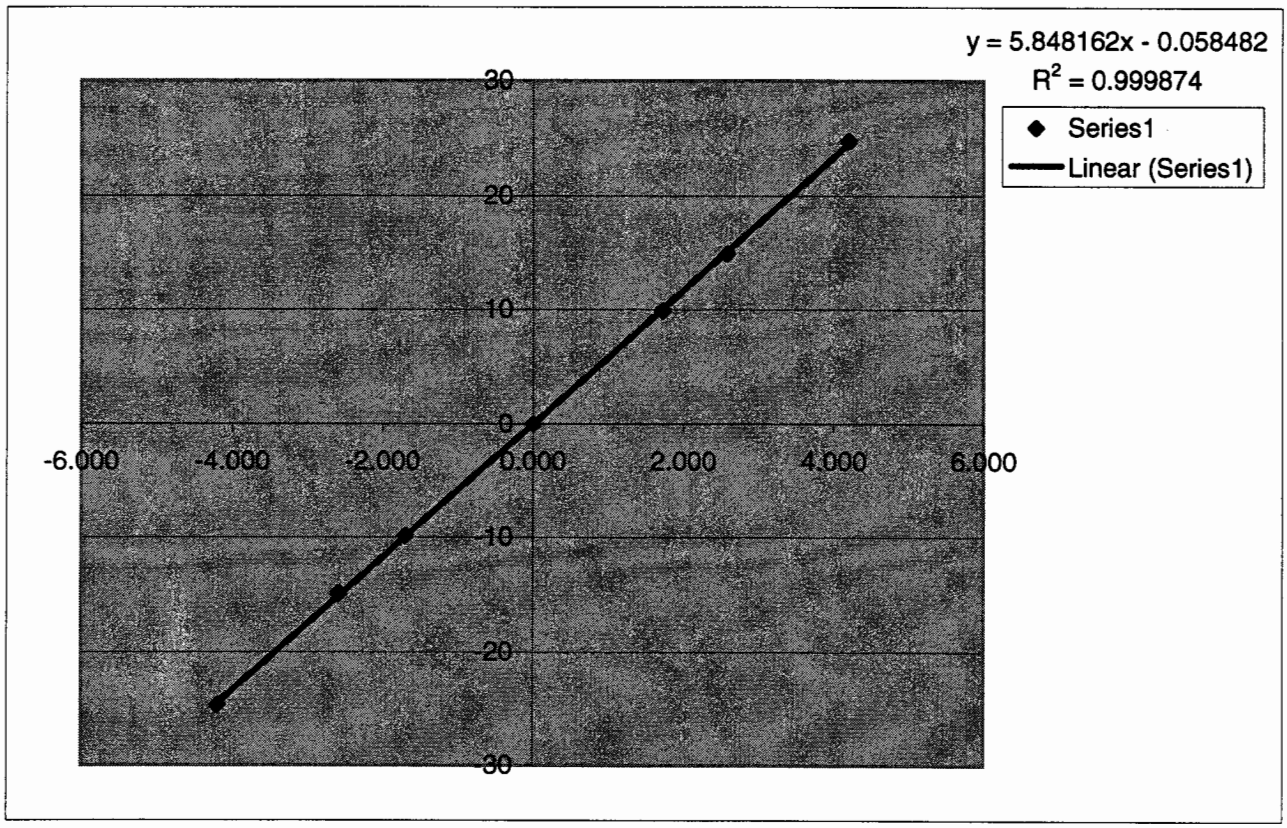
Ch 13
Pitch Angle

Model LSOC-30
serial # 52734

Gravity 1

Angle	Voltage
24.748	4.205
14.868	2.590
9.88	1.728
0	0.008
-9.88	-1.693
-14.868	-2.578
-24.748	-4.190

slope	Intercept
5.8482	-0.0585



Appendix E
Wave Buoy Specifications and Typical Output File

TYPICAL WAVE BUOY OUTPUT FILE

NSI-Neptune Sciences, Inc - Wave Sentry Data Processing Software Version 1.23
Sat Oct 4 06:00:00 2003
VBat = 11.69, Leak = DRY, Temp = 12.1
Significant wave height = 1.80 m
Dominant and average frequency = 0.15 Hz 0.17 Hz
Dominant and average period = 6.87 s 6.06 s

Wave directions are compass headings from which waves approach.
Dominant wave direction = 169.5 deg magnetic
Average wave direction = -155.9 deg magnetic

bnd	cfrq	c11	r1	r2	0	alpha1	alpha2
1	0.038	0	999.9	999.9	0	999.9	999.9
2	0.049	0	999.9	999.9	0	999.9	999.9
3	0.06	0	999.9	999.9	0	999.9	999.9
4	0.07	0.3299	0.3885	0.971	0	260.2	262.2
5	0.081	0.2955	0.2683	0.9643	0	264	257.6
6	0.092	0.7882	0.4297	0.9042	0	255.2	260.2
7	0.103	1.7148	0.5875	0.8518	0	253.3	258.1
8	0.113	1.7287	0.4883	0.6261	0	237.2	246.7
9	0.124	1.5661	0.5122	0.6453	0	237.5	258.2
10	0.135	2.4357	0.5449	0.3036	0	211.5	266.8
11	0.146	3.9363	0.6942	0.2545	0	169.5	144.1
12	0.156	1.5108	0.6213	0.2223	0	157.5	124
13	0.167	0.9978	0.5497	0.3311	0	175.9	123.5
14	0.178	0.728	0.7948	0.5252	0	154.9	145.7
15	0.188	0.4663	0.658	0.1558	0	177	150.7
16	0.199	0.2908	0.4939	0.4529	0	179.2	114.2
17	0.21	0.2432	0.655	0.0769	0	186	153.5
18	0.221	0.3348	0.574	0.1752	0	182.4	223.7
19	0.231	0.1682	0.5771	0.1029	0	182	259.4
20	0.242	0.087	0.3815	0.3539	0	187.9	223.2
21	0.253	0.077	0.3235	0.344	0	243.7	312.5
22	0.264	0.0982	0.3959	0.3716	0	173	251.2
23	0.274	0.1038	0.4363	0.2483	0	221.5	218
24	0.285	0.078	0.2909	0.2366	0	243.7	253.8
25	0.296	0.0455	0.1663	0.2141	0	277.9	210.2
26	0.307	0.048	0.6041	0.0958	0	249	285.1
27	0.317	0.0512	0.347	0.3337	0	356.2	6.1
28	0.328	0.0229	0.2707	0.33	0	74.7	84
29	0.339	0.0345	0.3802	0.3252	0	327.8	3.6
30	0.35	0.0402	0.3815	0.4623	0	351.6	325.5
31	0.36	0.0499	0.6504	0.4888	0	353.3	337.8
32	0.371	0.0401	0.7294	0.6016	0	345.2	338.1
33	0.382	0.0238	0.6276	0.2962	0	9.9	172.3
34	0.393	0.0755	0.7679	0.5661	0	356.4	349.7
35	0.403	0.0764	0.7529	0.6579	0	1.5	175.7
36	0.414	0.0471	0.7464	0.3066	0	357.4	7.6
37	0.425	0.0609	0.8191	0.5963	0	5.6	177.4
38	0.436	0.0444	0.855	0.7432	0	357.4	355.1
39	0.446	0.0256	0.6421	0.5067	0	11.8	1.7
40	0.457	0.031	0.7415	0.2536	0	13	8.1
41	0.468	0.0184	0.5676	0.1889	0	9.6	76.6
42	0.479	0.0232	0.7684	0.4595	0	13.2	15.6
43	0.489	0.0089	0.5808	0.1072	0	7.7	163.1
44	0.5	0.0183	0.7482	0.2797	0	17	16.2

Mean, min, max acc (g) = 0.02 -0.47 0.59
Mean, min, max pitch (deg)= 0.0 -20.1 25.6
Mean, min, max roll (deg) = -0.0 -15.9 16.0
Maximum tilt (deg) = 26.2

- Record length, 4096 samples (17.1 min)

Onboard Computer

Embedded 32-bit processor

Radio Frequency

Spread spectrum, 902-928 MHz

Outputs

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

Accuracies and Ranges

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

Appendix F
Seakeeping Trials Run Log

Run Log for Seakeeping Trial on CCGA Atlantic Swell - Vessel 'A'

Proj. 2017 **Oct. 4, 2003**

Run #	File Name	Start / Finish Time	Course Relative to Incident Waves	Location Start/Finish Latitude	Location Start/Finish Long.	Nominal Wave Height	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	4kt_head_20031004073302_CAL.CSV	7:35 8:00	Head	47 33.36 47 32.22	52 26.13 52 25.12	1.63m	3.8	147	?	?	?	?	One incident of vomiting due to sea-sickness. General motion sickness, incidence of occasional heavy swells.
2	4kt_fol_20031004080310_CAL.CSV	8:05 8:45	Following	47 32.44 47 33.89	52 25.42 52 26.94	1.51m	3.9	320	15-16	320	900	300	Multiple incidences of loss of balance. (Mils)
3	4kt_bow_20031004084312_CAL.CSV	8:45 9:10	Bow	47 23.89 47 33.56	52 26.94 52 24.22	1.56m	3.6	100	10-12	280	850	283	There was an increase in visibility at this time.
4	4kt_beam_20031004091550_CAL.CSV	9:15 9:40	Beam	47 33.59 47 34.41	52 24.21 52 22.59	1.48m	4.0	55	10-12	290	1000	333	Online analysis on beam sea data, it appears to be fine. *Wrong turn in test pattern*, COG should have been 235 deg.
5	4kt_quart_20031004094335_CAL.CSV	9:45 10:10	Quartering	47 34.61 47 36.04	52 22.48 52 22.17	1.37m	4.2	10	5	260	950	317	
6	0_drift_20031004104857_CAL.CSV	10:50 11:10	Beam Drift	47 33.81 47 33.45	52 26.53 52 26.87	*1.38m*	1.2	210	5	60	/	/	Drift test, the wave buoy is unresponsive. Changed generators. Small generator was not charging the
7	8kt_head_20031004113326_CAL.CSV	11:35 12:00	Head	47 33.52 47 31.20	52 26.30 52 23.99	*1.38m*	7.9	147	9	280	1800	600	UPS properly, had to fix the pull cord on the larger generator.
8	8kt_fol_20031004120003_CAL.CSV	12:00 12:30	Following	47 31.20 47 33.25	52 23.99 52 27.65	*1.38m*	7.7	320	12-13	0	1800	600	Sea noticeably calmer (12:00)
9	8kt_bow_20031004123003_CAL.CSV	12:30 12:55	Bow	47 33.36 47 33.25	52 27.65 52 27.65	*1.38m*	7.6	100	12	300	1900	633	
10	8kt_beam_20031004125734_CAL.CSV	13:00 13:25	Beam	47 33.06 47 30.60	52 23.74 52 27.88	*1.38m*	8.2	235	3	0	1700	567	
11	8kt_quart2_20031004132903_CAL.CSV	13:25 13:55	Quartering	47 30.80 47 33.80	52 27.83 52 27.38	*1.38m*	7.0	10	15	320	2000	667	

NOTES: Wind speed/direction is provided relative to the ship's course. The Anemometer was aligned to Magnetic north.
SOG - Speed Over Ground COG - Course Over Ground
No water temp./density readings were taken due to salinity meter accidentally left ashore.
Two AC generators were fitted (one small, one larger) by IMD as 'Atlantic Swell' did not have AC power available for IMD instrumentation.
Trial carried out around moored directional wave buoy nominally 10 nm east of St. John's, NL in 165 m of water @ 47 34.21 North (Lat.) and 52 26.43 West (Long.).
Nominal Draft AP: 1.56m Nominal Draft FP: 0.99m Drafts measured relative to keel line.
No severe slamming was experienced during the initial stages of the trial in heavier seas, which resulted in little water accumulation on deck.
Vessel was not equipped with an autopilot, therefore at lower speeds it was more difficult for the helmsmen to mainttain a steady course.
This may have contributed to the amount of drift experienced.
The sun had risen before the start of the first run. Visability was esitmated at 10 nm and remained so for the duration of the trial.
Nominal loading condition of vessel was approximately at 1800 kg, which was (1/2 load of crab)
Wave buoy failed - no wave data acquired after 10:00

Appendix G
International Tow Tank Conference Test Plan

Test Program for Seakeeping Trials on 35' long Fishing Vessel 'Atlantic Swell' - Vessel A

Proj. 2017 **Sept. 8, 2003** **V1.0**

Assumptions:

1) Vessel is docked in St. John's during trials preparation period & will sail from St. John's during trial.
2) Vessel will carry two crew members and a maximum of two trials personnel.
3) Vessel operator will be responsible for fueling vessel & acquiring required supplies to operate vessel.

Preliminary Preparations:

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

Prior to departing port on day of trial:

1) Check all instrumentation and data acquisition system. Ensure sufficient propane for generator on board for duration of trials.
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

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, generator, ballast from vessel.
5) Return all borrowed lifesaving equipment, cell phone.
6) Arrange to retrieve wave buoy, return mooring equipment to MUN.

NOTE: 180 deg. is defined as a head sea.
The Atlantic Swell vessel does not have an autopilot & thus all data will be collected with the vessel on manual control.
A propane generated will be fitted to the vessel to supply AC power & the fuel tank may have to be changed during trial.

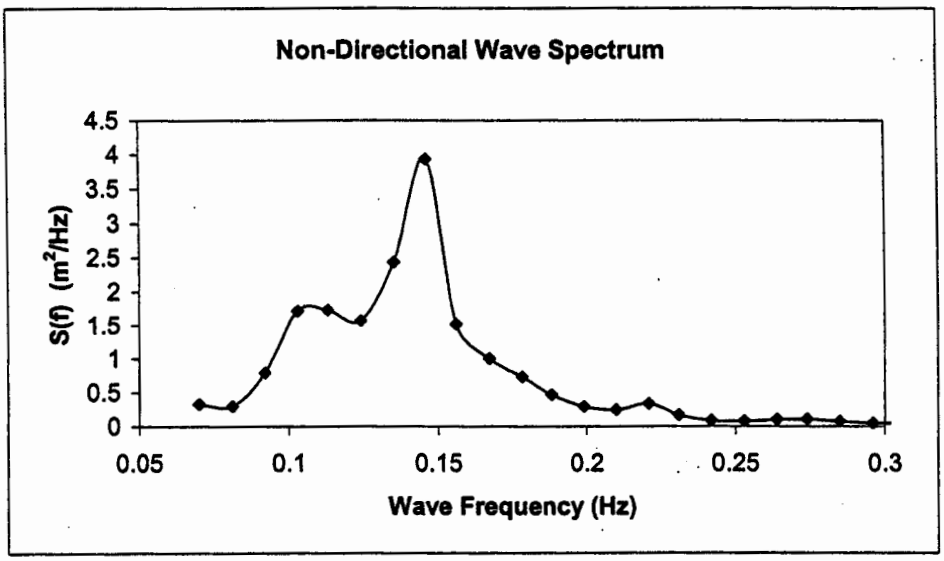
Appendix H
Wave Statistics, Nondimensional Spectrum Plots and Mean Wave Direction Vs. Frequency Plots

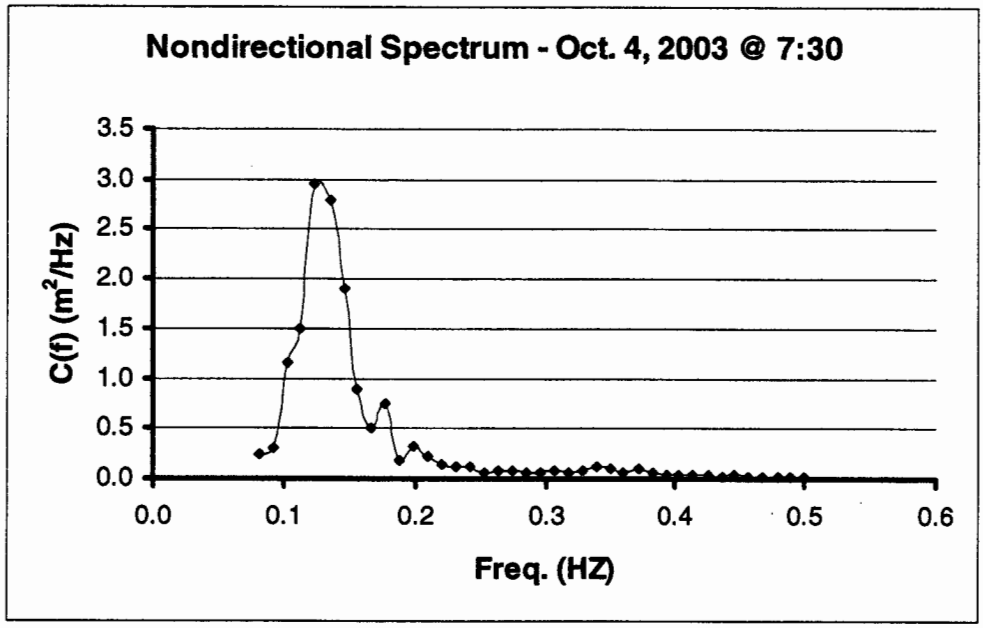
Summary of Wave Statistics Collected Using MUN Directional Wave Buoy

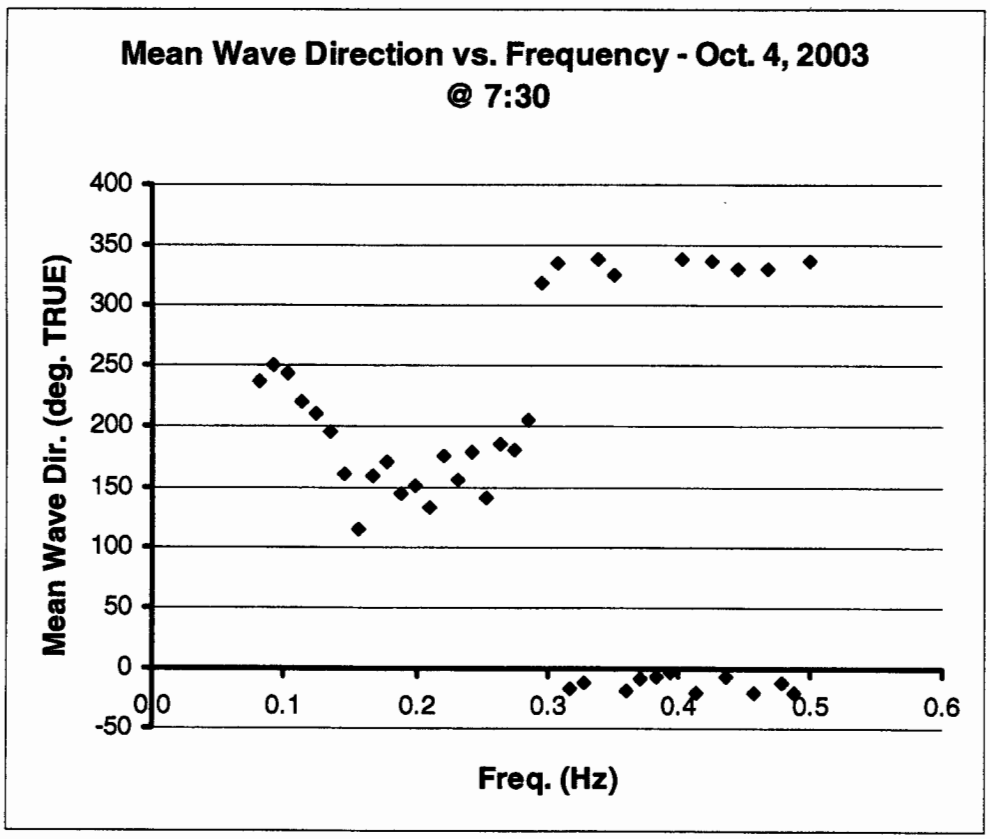
F/V Atlantic Swell **Proj. 2017**
October 4, 2003

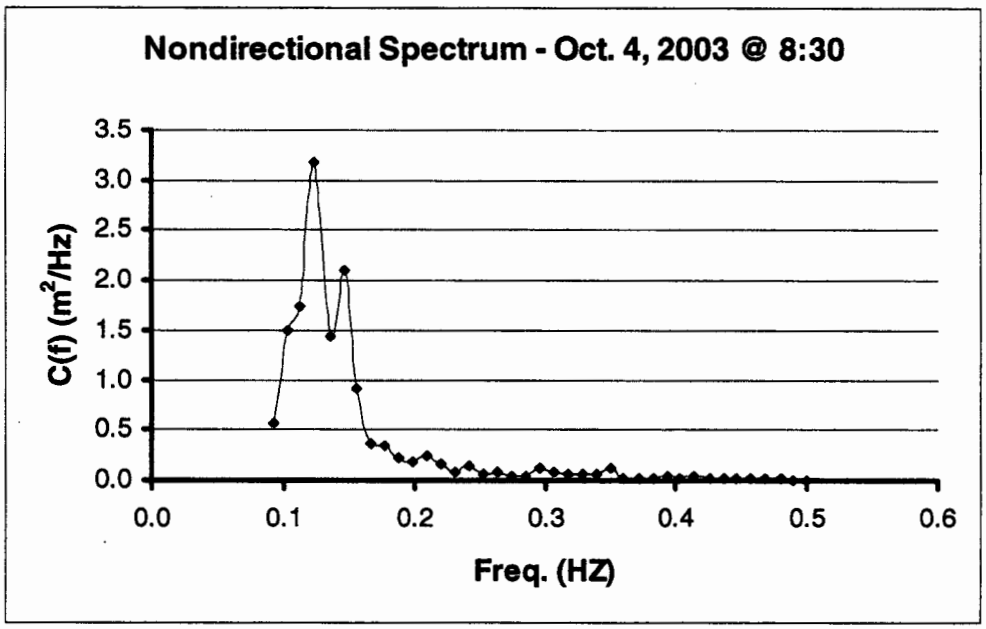
NF Time	Sig. Wave Height (m)	Dominant Wave Freq. (Hz)	Average Wave Freq. (Hz)	Dominant Wave Period (s)	Average Wave Period (s)	Dominant Wave Dir. (deg. mag.)	Average Wave Dir. (deg. mag.)	Dominant Wave Dir. (deg. TRUE)	Average Wave Dir. (deg. TRUE)
0:00	2.39	0.13	0.16	7.42	6.29	176.6	-177.9	155.5	-199
2:00	2.07	0.12	0.16	8.06	6.35	191.7	-171.2	170.6	-192.3
4:00	1.85	0.15	0.17	6.87	6.05	175.1	-165.4	154	-186.5
6:00	1.8	0.15	0.17	6.87	6.06	169.5	-155.9	148.4	-177
7:30	1.63	0.12	0.17	8.06	5.79	231.2	-144.0	210.1	-165.1
8:00	1.51	0.13	0.18	7.42	5.68	183.6	-171.7	162.5	-192.8
8:30	1.56	0.12	0.16	8.06	6.09	239.3	-155.6	218.2	-176.7
9:00	1.48	0.16	0.17	6.4	5.78	151.7	179.9	130.6	158.8
9:30	1.37	0.13	0.17	7.42	5.79	220.8	-143.5	199.7	-164.6
10:00	1.38	0.13	0.16	7.42	6.11	208.9	-152.1	187.8	-173.2

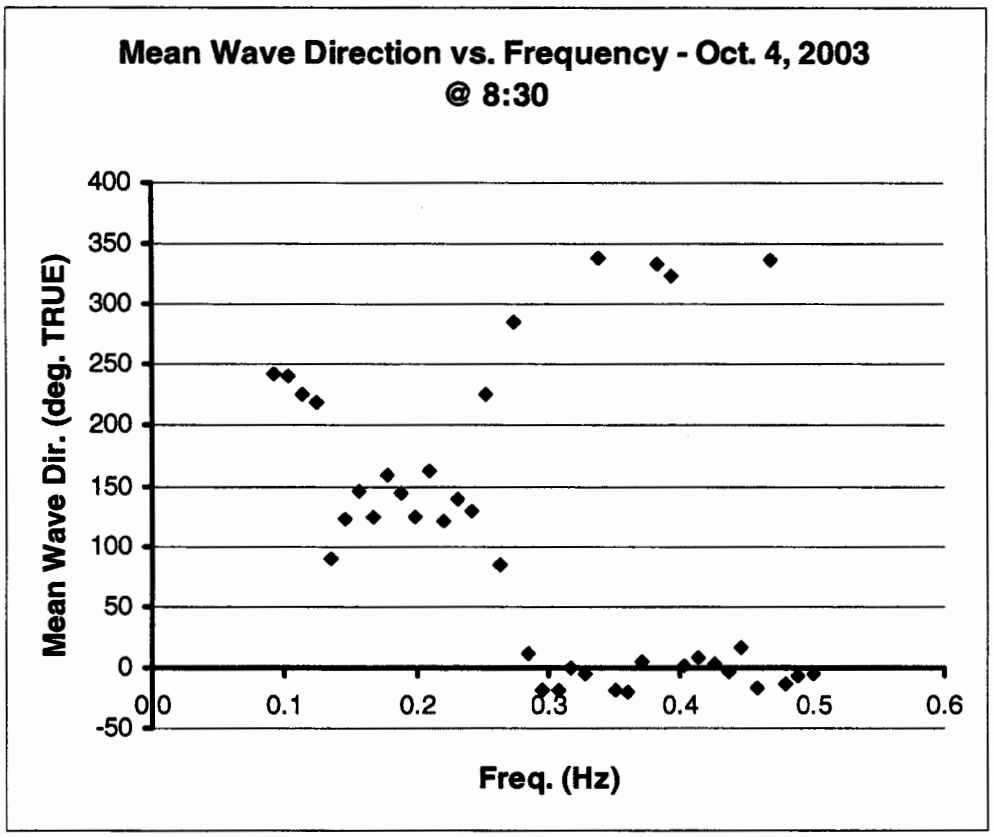
NOTE: The magnetic deviation during the trials time frame was 21.1 degrees West

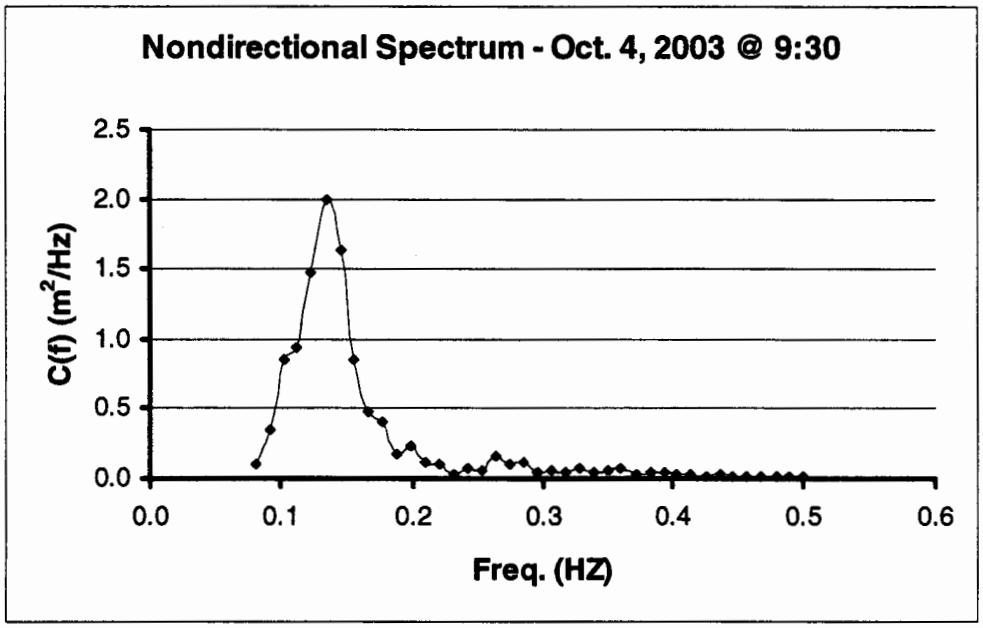


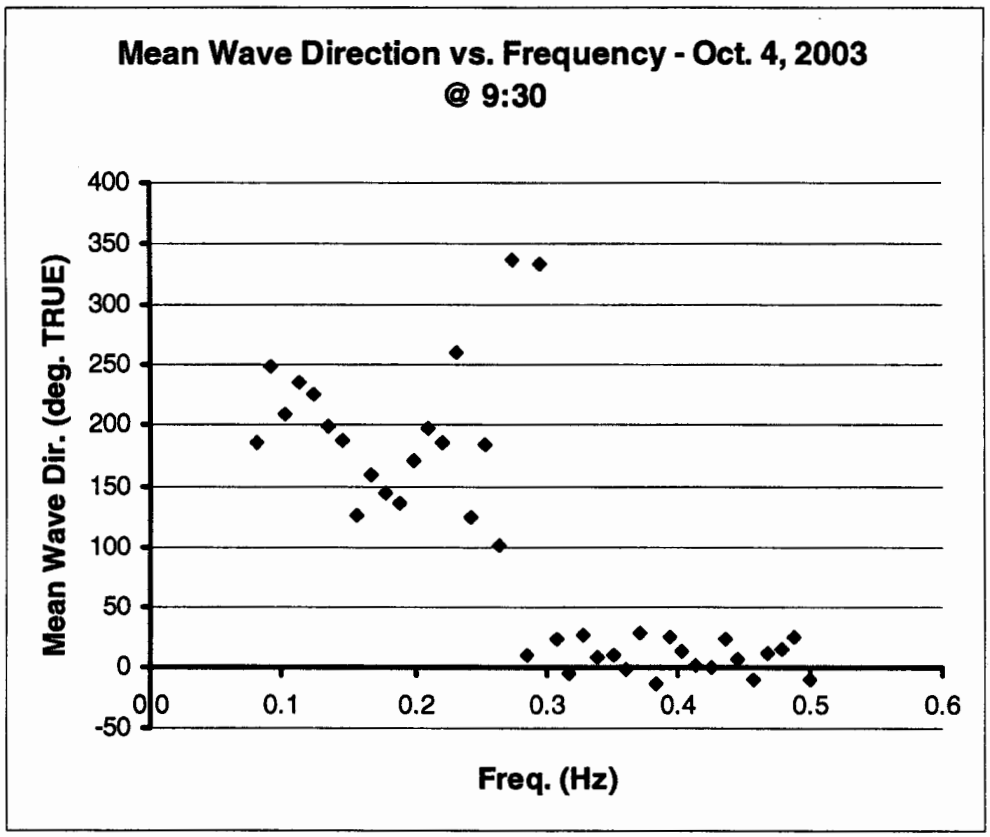

Nondirectional Spectrum - Oct. 4, 2003 @ 7:30
C(f) (m²/Hz)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Freq. (HZ)


Mean Wave Direction vs. Frequency - Oct. 4, 2003
@ 7:30
Mean Wave Dir. (deg. TRUE)
400
350
300
250
200
150
100
50
0
-50
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Freq. (Hz)


Nondirectional Spectrum - Oct. 4, 2003 @ 8:30
C(f) (m²/Hz)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Freq. (HZ)


Mean Wave Direction vs. Frequency - Oct. 4, 2003 @ 8:30
Mean Wave Dir. (deg. TRUE)
400
350
300
250
200
150
100
50
0
-50
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Freq. (Hz)


Nondirectional Spectrum - Oct. 4, 2003 @ 9:30
C(f) (m²/Hz)
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Freq. (HZ)


Mean Wave Direction vs. Frequency - Oct. 4, 2003 @ 9:30
Mean Wave Dir. (deg. TRUE)
400
350
300
250
200
150
100
50
0
-50
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Freq. (Hz)

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

File Name: 4kt_head_20031004073302
Date: October 4, 2003 NF Time: 7:35

Dockside
Location: Pier 31, St. John's
Nominal Draft AP: 1.56 m Nominal Draft FP: 0.99 m

Water Temperature: 11.0 deg. C Water Density: 1020.7 kg/m^3
Closest Stability Booklet Condition: 50% Consumables
Static Stability Info: GM_T(Fluid): 1.35 m

Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: Uncertain Water Density: 1021.0 kg/m^3
Latitude: 47.33'38" North Longitude: 52.26'24" West
Duration of Run: 1560 sec Number of Samples: 15598
Nominal Forward Speed Over the Ground: 4 knots
Nominal Course Over the Ground: 147 (deg. TRUE)
Total Distance Traveled During the Run: 1.61 nautical miles
Nominal Relative Drift Wind Speed: - knots
Nominal Relative Wind Direction: - (deg. TRUE)
Nominal Sea State: 3
Nominal Drift Speed: 0.43 knots Nominal Drift Direction: 290' (deg. True)
Nominal Shaft RPM: 227.4 RPM
Dominant Wave Characteristics: Significant Height: 1.63 m
Direction: 210' (deg. True)
Peak Period: 8.06 s
Peak Response Frequency: Roll: 0.2896 Hz
Pitch: 0.3820 Hz
Heave: 0.1775 Hz

Channel	Average	St. Dev.	Minimum	Maximum
DGPS Antenna				
COG (deg. TRUE)	144.57	16.53	105.31	182.07
SOG (knots)	4.0621	0.3526	2.8890	4.8060
SOG (m/s)	2.0896	0.1814	1.4861	2.4722
Rudder Angle (deg.)	0.888	7.621	-15.245	21.473
Inclinometers				
Roll Angle (deg)	-1.412	6.503	-27.336	20.292
Pitch Angle (deg)	2.694	1.570	-4.665	8.279
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	0.169	5.389	-21.055	19.981
Pitch Angle (deg)	2.005	2.467	-8.003	11.232
Yaw Angle (deg)	-0.041	20.883	-42.208	48.748
Output from Tri-Mounted Accelerometer positioned near DAS				
Surge Acceleration (m/s^2)	0.430	0.257	-0.785	1.349
Sway Acceleration (m/s^2)	0.254	1.064	-3.293	4.506
Heave Acceleration (m/s^2)	9.733	0.803	6.797	12.482

File Name: 4kt_fol_20031004080310
Date: October 4, 2003 NF Time: 8:05

Dockside
Location: Pier 31, St. John's
Nominal Draft AP: 1.56 m Nominal Draft FP: 0.99 m

Water Temperature: 11.0 deg. C Water Density: 1020.7 kg/m^3
Closest Stability Booklet Condition: 50% Consumables
Static Stability Info: GM_T(Fluid): 1.35 m

Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: Uncertain Water Density: 1021.0 kg/m^3
Latitude: 47.32'20" North Longitude: 52.25'15" West
Duration of Run: 2111 sec Number of Samples: 21112
Nominal Forward Speed Over the Ground: 4 knots
Nominal Course Over the Ground: 320 (deg. TRUE)
Total Distance Traveled During the Run: 2.11 nautical miles
Nominal Relative Drift Wind Speed: 15-16 knots
Nominal Relative Wind Direction: 320' (deg. TRUE)
Nominal Sea State: 3
Nominal Drift Speed: 0.31 knots Nominal Drift Direction: 129' (deg. True)
Nominal Shaft RPM: 303.1 RPM
Dominant Wave Characteristics: Significant Height: 1.51 m
Direction: 263' (deg. True)
Peak Period: 7.42 s
Peak Response Frequency: Roll: 0.3069 Hz
Pitch: 0.4465 Hz
Heave: 0.4156 Hz

Channel	Average	St. Dev.	Minimum	Maximum
DGPS Antenna				
COG (deg. TRUE)	319.183	23.822	1.510	358.940
SOG (knots)	3.904	0.406	2.457	5.076
SOG (m/s)	2.008	0.209	1.264	2.611
Rudder Angle (deg.)	0.811	5.009	-13.535	20.622
Inclinometers				
Roll Angle (deg)	-1.242	5.253	-20.764	16.266
Pitch Angle (deg)	2.720	2.984	-9.480	11.562
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	0.359	3.790	-13.099	12.258
Pitch Angle (deg)	2.275	2.416	-6.484	11.287
Yaw Angle (deg)	-0.037	16.686	-45.976	42.033
Output from Tri-Mounted Accelerometer positioned near DAS				
Surge Acceleration (m/s^2)	0.437	0.490	-1.589	1.892
Sway Acceleration (m/s^2)	0.229	0.859	-2.647	3.432
Heave Acceleration (m/s^2)	9.749	1.177	4.733	13.323

File Name: 4kt_bow_20031004084312
Date: October 4, 2003 NF Time: 8:45

Dockside
Location: Pier 31, St. John's
Nominal Draft AP: 1.56 m Nominal Draft FP: 0.99 m

Water Temperature: 11.0 deg. C Water Density: 1020.7 kg/m^3
Closest Stability Booklet Condition: 50% Consumables
Static Stability Info: GM_T(Fluid): 1.35 m

Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: Uncertain Water Density: 1021.0 kg/m^3
Latitude: 47.33'55" North Longitude: 52.27'02" West
Duration of Run: 1707 sec Number of Samples: 17068
Nominal Forward Speed Over the Ground: 4 knots
Nominal Course Over the Ground: 100 (deg. TRUE)
Total Distance Traveled During the Run: 1.74 nautical miles
Nominal Relative Drift Wind Speed: 10-12 knots
Nominal Relative Wind Direction: 280' (deg. TRUE)
Nominal Sea State: 3
Nominal Drift Speed: 0.44 knots Nominal Drift Direction: 253' (deg. True)
Nominal Shaft RPM: 262.3 RPM
Dominant Wave Characteristics: Significant Height: 1.56 m
Direction: 218' (deg. True)
Peak Period: 8.06 s
Peak Response Frequency: Roll: 0.3113 Hz
Pitch: 0.4274 Hz
Heave: 0.3554 Hz

Channel	Average	St. Dev.	Minimum	Maximum
DGPS Antenna				
COG (deg. TRUE)	102.634	18.058	52.790	151.910
SOG (knots)	4.069	0.292	3.040	4.849
SOG (m/s)	2.093	0.150	1.564	2.494
Rudder Angle (deg.)	0.808	5.376	-14.910	17.701
Inclinometers				
Roll Angle (deg)	-0.693	6.349	-24.552	24.618
Pitch Angle (deg)	2.698	1.685	-4.640	8.624
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	0.895	5.257	-19.006	22.340
Pitch Angle (deg)	2.100	2.021	-4.301	8.947
Yaw Angle (deg)	-0.276	18.299	-47.194	56.735
Output from Tri-Mounted Accelerometer positioned near DAS				
Surge Acceleration (m/s^2)	0.437	0.273	-0.773	1.349
Sway Acceleration (m/s^2)	0.137	1.039	-4.013	4.043
Heave Acceleration (m/s^2)	9.741	0.823	6.549	12.790

File Name: 4kt_beam_20031004091550
Date: October 4, 2003 NF Time: 9:15

Dockside
Location: Pier 31, St. John's
Nominal Draft AP: 1.56 m Nominal Draft FP: 0.99 m

Water Temperature: 11.0 deg. C Water Density: 1020.7 kg/m^3
Closest Stability Booklet Condition: 50% Consumables
Static Stability Info: GM_T(Fluid): 1.35 m

Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: Uncertain Water Density: 1021.0 kg/m^3
Latitude: 47.33'31" North Longitude: 52.24'20" West
Duration of Run: 1457 sec Number of Samples: 14572
Nominal Forward Speed Over the Ground: 4 knots
Nominal Course Over the Ground: 55 (deg. TRUE)
Total Distance Traveled During the Run: 1.71 nautical miles
Nominal Relative Drift Wind Speed: 15-16 knots
Nominal Relative Wind Direction: 320' (deg. TRUE)
Nominal Sea State: 3
Nominal Drift Speed: 0.00 knots Nominal Drift Direction: / (deg. True)
Nominal Shaft RPM: 324.8 RPM
Dominant Wave Characteristics: Significant Height: 1.48 m
Direction: 131' (deg. True)
Peak Period: 6.4 s
Peak Response Frequency: Roll: 0.3129 Hz
Pitch: 0.4493 Hz
Heave: 0.4114 Hz

Channel	Average	St. Dev.	Minimum	Maximum
DGPS Antenna				
COG (deg. TRUE)	56.745	38.155	0.340	359.720
SOG (knots)	4.235	0.218	3.326	4.849
SOG (m/s)	2.179	0.112	1.711	2.494
Rudder Angle (deg.)	0.881	5.750	-15.335	16.187
Inclinometers				
Roll Angle (deg)	-0.686	6.131	-22.864	20.568
Pitch Angle (deg)	2.615	2.147	-7.761	10.201
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	0.934	4.669	-15.414	15.514
Pitch Angle (deg)	2.075	1.996	-5.919	8.455
Yaw Angle (deg)	-0.435	21.140	-55.976	50.501
Output from Tri-Mounted Accelerometer positioned near DAS				
Surge Acceleration (m/s^2)	0.424	0.350	-1.229	1.630
Sway Acceleration (m/s^2)	0.137	1.004	-3.347	3.757
Heave Acceleration (m/s^2)	9.746	0.953	5.732	13.052

File Name: 4kt_quart_20031004094335
Date: October 4, 2003 NF Time: 9:45

Dockside
Location: Pier 31, St. John's
Nominal Draft AP: 1.56 m Nominal Draft FP: 0.99 m

Water Temperature: 11.0 deg. C Water Density: 1020.7 kg/m^3
Closest Stability Booklet Condition: 50% Consumables
Static Stability Info: GM_T(Fluid): 1.35 m

Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: Uncertain Water Density: 1021.0 kg/m^3
Latitude: 47.34'34" North Longitude: 52.22'28" West
Duration of Run: 1487 sec Number of Samples: 14875
Nominal Forward Speed Over the Ground: 4 knots
Nominal Course Over the Ground: 10 (deg. TRUE)
Total Distance Traveled During the Run: 1.53 nautical miles
Nominal Relative Drift Wind Speed: 5 knots
Nominal Relative Wind Direction: 260' (deg. TRUE)
Nominal Sea State: 3
Nominal Drift Speed: 0.58 knots Nominal Drift Direction: 186' (deg. True)
Nominal Shaft RPM: 334.6 RPM
Dominant Wave Characteristics: Significant Height: 1.37 m
Direction: 200' (deg. True)
Peak Period: 7.42 s
Peak Response Frequency: Roll: 0.3061 Hz
Pitch: 0.4183 Hz
Heave: 0.4249 Hz

Channel	Average	St. Dev.	Minimum	Maximum
DGPS Antenna				
COG (deg. TRUE)	8.892	25.238	-71.240	68.920
SOG (knots)	4.281	0.241	3.424	5.162
SOG (m/s)	2.202	0.124	1.761	2.656
Rudder Angle (deg.)	0.801	5.375	-16.415	13.961
Inclinometers				
Roll Angle (deg)	-0.760	5.200	-23.085	23.391
Pitch Angle (deg)	2.633	2.436	-8.409	9.958
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	0.835	3.969	-15.296	16.700
Pitch Angle (deg)	2.145	2.233	-8.078	11.961
Yaw Angle (deg)	0.626	24.631	-78.175	54.767
Output from Tri-Mounted Accelerometer positioned near DAS				
Surge Acceleration (m/s^2)	0.427	0.400	-1.454	1.612
Sway Acceleration (m/s^2)	0.151	0.851	-3.816	3.809
Heave Acceleration (m/s^2)	9.757	0.992	5.233	13.065

File Name: 0_drift_20031004104857
Date: October 4, 2003 NF Time: 10:50

Dockside
Location: Pier 31, St. John's
Nominal Draft AP: 1.56 m Nominal Draft FP: 0.99 m

Water Temperature: 11.0 deg. C Water Density: 1020.7 kg/m^3
Closest Stability Booklet Condition: 50% Consumables
Static Stability Info: GM_T(Fluid): 1.35 m

Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: Uncertain Water Density: 1021.0 kg/m^3
Latitude: 47.33'51" North Longitude: 52.26'32" West
Duration of Run: 1349 sec Number of Samples: 13488
Nominal Forward Speed Over the Ground: 0 knots
Nominal Course Over the Ground: 210 (deg. TRUE)
Total Distance Traveled During the Run: 0.54 nautical miles
Nominal Relative Drift Wind Speed: 5 knots
Nominal Relative Wind Direction: 60' (deg. TRUE)
Nominal Sea State: 3
Nominal Drift Speed: 1.44 knots Nominal Drift Direction: 227' (deg. True)
Nominal Shaft RPM: / RPM
Dominant Wave Characteristics: Significant Height: 1.38 m *Note*
Direction: 188' (deg. True) Last wave data
Peak Period: 7.42 s collected @ 10:00
Peak Response Frequency: Roll: 0.3034 Hz
Pitch: 0.4036 Hz
Heave: 0.1461 Hz

Channel	Average	St. Dev.	Minimum	Maximum
DGPS Antenna				
COG (deg. TRUE)	226.624	16.999	163.390	285.690
SOG (knots)	1.559	0.233	1.004	2.560
SOG (m/s)	0.802	0.120	0.517	1.317
Rudder Angle (deg.)	34.269	0.027	34.051	34.476
Inclinometers				
Roll Angle (deg)	-1.559	6.525	-24.386	18.546
Pitch Angle (deg)	2.914	1.269	-1.197	7.596
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	0.016	5.492	-17.595	19.430
Pitch Angle (deg)	2.293	1.970	-3.591	9.196
Yaw Angle (deg)	0.204	14.054	-30.919	30.554
Output from Tri-Mounted Accelerometer positioned near DAS				
Surge Acceleration (m/s^2)	0.461	0.204	-0.185	1.196
Sway Acceleration (m/s^2)	0.273	1.068	-3.026	4.021
Heave Acceleration (m/s^2)	9.725	0.527	7.725	11.800

File Name: 8kt_head_20031004113326
Date: October 4, 2003 NF Time: 11:35

Dockside
Location: Pier 31, St. John's
Nominal Draft AP: 1.56 m Nominal Draft FP: 0.99 m

Water Temperature: 11.0 deg. C Water Density: 1020.7 kg/m^3
Closest Stability Booklet Condition: 50% Consumables
Static Stability Info: GM_T(Fluid): 1.35 m

Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: Uncertain Water Density: 1021.0 kg/m^3
Latitude: 47.33'43" North Longitude: 52.26'32" West
Duration of Run: 1520 sec Number of Samples: 15198
Nominal Forward Speed Over the Ground: 8 knots
Nominal Course Over the Ground: 147 (deg. TRUE)
Total Distance Traveled During the Run: 3.22 nautical miles
Nominal Relative Drift Wind Speed: 9 knots
Nominal Relative Wind Direction: 280' (deg. TRUE)
Nominal Sea State: 3
Nominal Drift Speed: 0.34 knots Nominal Drift Direction: 287' (deg. True)
Nominal Shaft RPM: 541.0 RPM
Dominant Wave Characteristics: Significant Height: 1.38 m *Note*
Direction: 188' (deg. True) Last wave data
Peak Period: 7.42 s collected @ 10:00
Peak Response Frequency: Roll: 0.2995 Hz
Pitch: 0.4348 Hz
Heave: 0.4331 Hz

Channel	Average	St. Dev.	Minimum	Maximum
DGPS Antenna				
COG (deg. TRUE)	143.192	12.519	107.010	187.360
SOG (knots)	7.901	0.272	6.993	8.602
SOG (m/s)	4.064	0.140	3.597	4.425
Rudder Angle (deg.)	0.398	2.023	-8.600	10.949
Inclinometers				
Roll Angle (deg)	-0.154	4.082	-14.087	15.796
Pitch Angle (deg)	2.373	1.799	-5.441	9.007
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	1.354	3.102	-10.406	12.797
Pitch Angle (deg)	1.765	1.650	-4.638	6.792
Yaw Angle (deg)	0.060	14.896	-39.072	53.148
Output from Tri-Mounted Accelerometer positioned near DAS				
Surge Acceleration (m/s^2)	0.392	0.294	-0.870	1.469
Sway Acceleration (m/s^2)	0.053	0.669	-2.576	2.334
Heave Acceleration (m/s^2)	9.778	0.884	5.965	13.077

File Name: 8kt_fol_20031004120003
Date: October 4, 2003 NF Time: 12:00

Dockside
Location: Pier 31, St. John's
Nominal Draft AP: 1.56 m Nominal Draft FP: 0.99 m

Water Temperature: 11.0 deg. C Water Density: 1020.7 kg/m^3
Closest Stability Booklet Condition: 50% Consumables
Static Stability Info: GM_T(Fluid): 1.35 m

Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: Uncertain Water Density: 1021.0 kg/m^3
Latitude: 47.31'09" North Longitude: 52.23'50" West
Duration of Run: 1711 sec Number of Samples: 17111
Nominal Forward Speed Over the Ground: 8 knots
Nominal Course Over the Ground: 320 (deg. TRUE)
Total Distance Traveled During the Run: 3.66 nautical miles
Nominal Relative Drift Wind Speed: 12-13 knots
Nominal Relative Wind Direction: 0 (deg. TRUE)
Nominal Sea State: 3
Nominal Drift Speed: 0.18 knots Nominal Drift Direction: 082' (deg. True)
Nominal Shaft RPM: 574.4 RPM
Dominant Wave Characteristics: Significant Height: 1.38 m *Note*
Direction: 188' (deg. True) Last wave data
Peak Period: 7.42 s collected @ 10:00
Peak Response Frequency: Roll: 0.3045 Hz
Pitch: 0.4578 Hz
Heave: 0.4595 Hz

Channel	Average	St. Dev.	Minimum	Maximum
DGPS Antenna				
COG (deg. TRUE)	314.604	7.067	266.840	336.650
SOG (knots)	7.800	0.219	7.171	9.067
SOG (m/s)	4.012	0.113	3.689	4.664
Rudder Angle (deg.)	0.414	1.689	-6.375	6.981
Inclinometers				
Roll Angle (deg)	-0.649	3.458	-14.707	12.037
Pitch Angle (deg)	2.448	2.268	-7.424	10.648
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	0.894	2.203	-6.854	8.691
Pitch Angle (deg)	1.858	1.125	-2.283	6.336
Yaw Angle (deg)	0.273	6.899	-25.738	18.258
Output from Tri-Mounted Accelerometer positioned near DAS				
Surge Acceleration (m/s^2)	0.401	0.372	-1.221	1.734
Sway Acceleration (m/s^2)	0.136	0.567	-1.938	2.421
Heave Acceleration (m/s^2)	9.782	0.883	6.201	13.448

File Name: 8kt_bow_20031004123003
Date: October 4, 2003 NF Time: 12:30

Dockside
Location: Pier 31, St. John's
Nominal Draft AP: 1.56 m Nominal Draft FP: 0.99 m

Water Temperature: 11.0 deg. C Water Density: 1020.7 kg/m^3
Closest Stability Booklet Condition: 50% Consumables
Static Stability Info: GM_T(Fluid): 1.35 m

Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: Uncertain Water Density: 1021.0 kg/m^3
Latitude: 47.33'45" North Longitude: 52.27'47" West
Duration of Run: 1494 sec Number of Samples: 14943
Nominal Forward Speed Over the Ground: 8 knots
Nominal Course Over the Ground: 100 (deg. TRUE)
Total Distance Traveled During the Run: 3.09 nautical miles
Nominal Relative Drift Wind Speed: 12 knots
Nominal Relative Wind Direction: 300' (deg. TRUE)
Nominal Sea State: 3
Nominal Drift Speed: 0.00 knots Nominal Drift Direction: / (deg. True)
Nominal Shaft RPM: 553.1 RPM
Dominant Wave Characteristics: Significant Height: 1.38 m *Note*
Direction: 188' (deg. True) Last wave data
Peak Period: 7.42 s collected @ 10:00
Peak Response Frequency: Roll: 0.2962 Hz
Pitch: 0.4562 Hz
Heave: 0.4562 Hz

Channel	Average	St. Dev.	Minimum	Maximum
DGPS Antenna				
COG (deg. TRUE)	100.072	15.444	60.910	145.630
SOG (knots)	7.438	0.195	6.988	8.149
SOG (m/s)	3.826	0.100	3.594	4.192
Rudder Angle (deg.)	0.333	2.101	-6.260	8.977
Inclinometers				
Roll Angle (deg)	0.055	3.726	-15.739	13.237
Pitch Angle (deg)	2.405	1.680	-4.507	7.791
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	1.541	3.099	-11.054	11.745
Pitch Angle (deg)	1.811	1.419	-2.632	7.121
Yaw Angle (deg)	-0.026	16.992	-39.410	49.820
Output from Tri-Mounted Accelerometer positioned near DAS				
Surge Acceleration (m/s^2)	0.399	0.275	-0.748	1.280
Sway Acceleration (m/s^2)	0.019	0.611	-2.147	2.598
Heave Acceleration (m/s^2)	9.783	0.775	6.818	12.337

File Name: 8kt_beam_20031004125734
Date: October 4, 2003 NF Time: 13:00

Dockside
Location: Pier 31, St. John's
Nominal Draft AP: 1.56 m Nominal Draft FP: 0.99 m

Water Temperature: 11.0 deg. C Water Density: 1020.7 kg/m^3
Closest Stability Booklet Condition: 50% Consumables
Static Stability Info: GM_T(Fluid): 1.35 m

Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: Uncertain Water Density: 1021.0 kg/m^3
Latitude: 47.33'04" North Longitude: 52.23'19" West
Duration of Run: 1691 sec Number of Samples: 16910
Nominal Forward Speed Over the Ground: 8 knots
Nominal Course Over the Ground: 235 (deg. TRUE)
Total Distance Traveled During the Run: 3.95 nautical miles
Nominal Relative Drift Wind Speed: 3 knots
Nominal Relative Wind Direction: 0' (deg. TRUE)
Nominal Sea State: 3
Nominal Drift Speed: 0.00 knots Nominal Drift Direction: / (deg. True)
Nominal Shaft RPM: 506.2 RPM
Dominant Wave Characteristics: Significant Height: 1.38 m *Note*
Direction: 188' (deg. True) Last wave data
Peak Period: 7.42 s collected @ 10:00
Peak Response Frequency: Roll: 0.3084 Hz
Pitch: 0.4881 Hz
Heave: 0.4900 Hz

Channel	Average	St. Dev.	Minimum	Maximum
DGPS Antenna				
COG (deg. TRUE)	231.252	8.811	194.000	257.760
SOG (knots)	8.404	0.109	8.003	8.726
SOG (m/s)	4.323	0.056	4.117	4.489
Rudder Angle (deg.)	0.184	1.807	-5.155	6.522
Inclinometers				
Roll Angle (deg)	-0.253	3.856	-15.000	14.151
Pitch Angle (deg)	1.972	1.634	-6.065	7.254
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	1.223	3.294	-10.027	13.024
Pitch Angle (deg)	1.406	1.357	-4.158	6.202
Yaw Angle (deg)	0.025	11.431	-48.568	32.591
Output from Tri-Mounted Accelerometer positioned near DAS				
Surge Acceleration (m/s^2)	0.323	0.268	-0.958	1.180
Sway Acceleration (m/s^2)	0.068	0.632	-2.289	2.483
Heave Acceleration (m/s^2)	9.785	0.749	6.941	12.470

File Name: 8kt_quart2_20031004132903
Date: October 4, 2003 NF Time: 13:25

Dockside
Location: Pier 31, St. John's
Nominal Draft AP: 1.56 m Nominal Draft FP: 0.99 m

Water Temperature: 11.0 deg. C Water Density: 1020.7 kg/m^3
Closest Stability Booklet Condition: 50% Consumables
Static Stability Info: GM_T(Fluid): 1.35 m

Trials Site: *Start of the Run*
Trials Location: 10 nautical miles East of St. John's
Water Temperature: Uncertain Water Density: 1021.0 kg/m^3
Latitude: 47.30'53" North Longitude: 52.27'48" West
Duration of Run: 1490 sec Number of Samples: 14896
Nominal Forward Speed Over the Ground: 8 knots
Nominal Course Over the Ground: 10 (deg. TRUE)
Total Distance Traveled During the Run: 2.90 nautical miles
Nominal Relative Drift Wind Speed: 15 knots
Nominal Relative Wind Direction: 320' (deg. TRUE)
Nominal Sea State: 3
Nominal Drift Speed: 0.35 knots Nominal Drift Direction: 172' (deg. True)
Nominal Shaft RPM: 583.3 RPM
Dominant Wave Characteristics: Significant Height: 1.38 m *Note*
Direction: 188' (deg. True) Last wave data
Peak Period: 7.42 s collected @ 10:00
Peak Response Frequency: Roll: 0.3128 Hz
Pitch: 0.4803 Hz
Heave: 0.4788 Hz

Channel	Average	St. Dev.	Minimum	Maximum
DGPS Antenna				
COG (deg. TRUE)	5.959	14.740	-27.380	48.800
SOG (knots)	7.341	0.199	6.674	8.019
SOG (m/s)	3.776	0.102	3.433	4.125
Rudder Angle (deg.)	0.419	2.356	-8.093	7.259
Inclinometers				
Roll Angle (deg)	-0.411	3.578	-15.827	14.051
Pitch Angle (deg)	2.537	1.800	-7.020	7.953
Output from MotionPak positioned at the Center of Gravity				
Roll Angle (deg)	1.100	2.554	-9.541	9.002
Pitch Angle (deg)	1.917	1.319	-2.844	6.050
Yaw Angle (deg)	0.653	15.777	-38.226	43.761
Output from Tri-Mounted Accelerometer positioned near DAS				
Surge Acceleration (m/s^2)	0.419	0.297	-1.195	1.302
Sway Acceleration (m/s^2)	0.097	0.587	-2.282	2.617
Heave Acceleration (m/s^2)	9.785	0.709	7.264	12.183