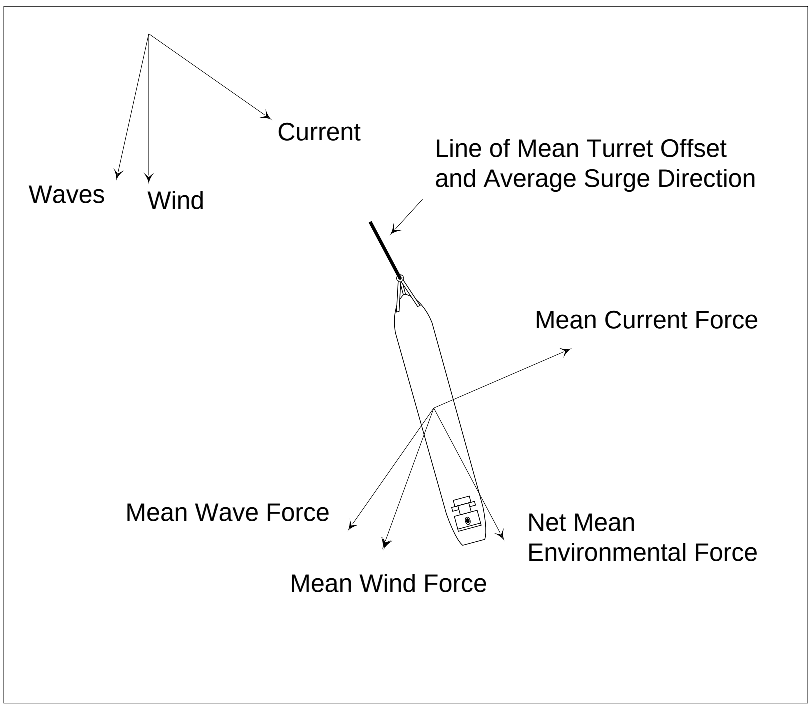
Slowsim®

Analysis of Slowly Varying Environmental Forces from SeaSoft® Systems

User Manual

April, 2005



Slowsim

Analysis of Slowly Varying Environmental Forces from SeaSoft Systems

User Manual

http://www.seasoftsys.com

Phone: (805) 683-3002 E-mail: seasoft@west.net Fax: (805) 683-0440

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About the SeaSoft Library

The SeaSoft family of software products for the offshore industry has been developed in response to a need for high quality, easy to use analytical tools for numerical simulation of the dynamic and static characteristics of a wide variety of offshore vessels and mooring structures.

The variety of computing platforms now used in engineering and naval architectural environments requires that offshore engineering software be easily transportable to a wide variety of computers (Macintosh, Unix, Windows, etc.) so that software tools can easily be moved to new computing facilities as the need arises. The SeaSoft program library was developed with these considerations in mind.

SeaSoft's products are capable, in most circumstances, of exceeding the physical modeling capabilities of older, operationally more complex codes while far surpassing them in terms of versatility and ease of use. Benchmark efforts by the DeepStar Committee (http://www.deepstar.org), using high-quality model test data as simulation quality arbiter, have shown unequivocally that the quality of the SeaSoft simulations surpasses all other available mooring tools, be they time-domain, frequency-domain or hybrid.

In the development of this suite of programs, the principal objectives have been (1) to deliver state of the art computational abilities to the offshore industry in packages that would permit their utilization by any technically trained individual with a need for the information, and (2) to insure that the quality and robustness of the underlying physical and analytical modeling are second to none.

The software is oriented specifically towards the practicing marine/offshore engineer and naval architect. In order to be of maximum utility to this audience, the software has been designed so that first-time or infrequent users can produce meaningful results.

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Chapter 1

Introduction

Background

Slowsim is a member of the SeaSoft family of software packages for the offshore industry. These programs have been developed to provide easy to use, state of the art analytical tools for simulation of dynamic and static characteristics of a wide variety of offshore vessels and structures.

Objectives

The central objective in the development of Slowsim has been to open a "window" into the various vessel environmental load models built into CALMsim, Moorsim, SPMsim, SALMsim, TLPsim and Towsim; these are the so-called "comprehensive" SeaSoft simulations which model static and low-frequency system behavior in addition to wave-frequency vessel dynamics. During the course of each comprehensive simulation, static and slowly-varying environmental forces are evaluated and used for vessel and mooring system performance estimation. A variety of user-selectable environmental representations can be brought into play, including an exhaustive collection of built-in wind and current forcing models. In fact, the option list is not static but grows with time as more and more capabilities are added to the software. Because the central focus of each "comprehensive" simulation is overall mooring performance, the output streams of these simulations lack details of the environmental force models used. Slowsim has been created in order to gain direct access to environmental forcing functions and their spectral characteristics.

Although Slowsim was created to support other SeaSoft simulations, its power as a stand-alone utility should be self-evident. For better or worse, much engineering analysis done in the offshore industry remains limited to static and "quasi-static" studies, to which Slowsim is directly applicable. And of course in the final analysis a *thorough* understanding of the mean forces and offsets relevant to an offshore system and environment is the essential bedrock upon which all dynamical understanding is built.

Details of the full complement of static and slowly-varying environmental forcing functions have been made available in Slowsim's output stream, including angle- and frequency-dependent wave drift force coefficients, angle-dependent wind and current force coefficients, low-frequency wind, current and wave-drift forcing spectra, and so forth.

Support of Related Simulations

Because of Slowsim's role as a support utility for the comprehensive SeaSoft simulations, it is intimately related to all of these and designed to work seamlessly with them. It is expected that the primary application of Slowsim will be to evaluate environmental force coefficients of vessels already contained within other simulation data files. The most common source of data, then, for Slowsim will be existing Moorsim, CALMsim, SPMsim, etc. data files. These data files (MOORDAT, CALMDAT, SPMDAT, etc.) can be "imported" directly into the Slowsim working directory, renamed SLOWDAT, and loaded directly into Slowsim for evaluation.

Note:

The LOWDAT file, if present, must be imported in addition to the main data file. Thus, for example, the sample problem of this manual resulted from importation of *both* SPMDAT and LOWDAT from a valid SPMsim simulation.

Frequently Asked Questions (FAQ)

A database of "Frequently Asked Questions", or "FAQ", is maintained at the SeaSoft web site (http://www.seasoftsys.com) which contains a wealth of detailed real-life explanations and problem resolutions that supplements the User Manual, particularly for advanced users. In addition, the FAQ is updated more frequently than the user manuals and therefore may contain information pertinent to recent changes or additions that have not yet migrated into the manuals. The FAQ can be freely downloaded and searched by keyword(s); it is an invaluable resource for obtaining quick guidance on a wide range of issues from the mundane to the highly technical.

Chapter 2

Program Package Contents

The Slowsim package comprises the user manual, the machine-executable program units, and support services provided by SeaSoft. The latter include bug reports, corrections and support of possible bug-related problems encountered during program execution.

Program Files

The disk files involved in a Slowsim execution are of three generic types: binary program files, binary data files and formatted data files.

The sole executable binary program file is Slowsim (the "Simulator"), which interacts dynamically (without user intervention) with a suite of binary overlay modules that are operating-system specific.

In addition to these executable modules, which are supplied with the package and which cannot be altered in any way by the user, a number of data files are created during the simulation process. These data files comprise two types, binary files usable as input (SLOWDAT, SLOWBAK and LASTBAK) and formatted output data files (SLOWIN.stxt, SLOWOUT.stxt) containing input documentation and simulation output. Management and recommended archival procedures for these files are discussed in Appendix D.

The User Interface

The User Interface, an integral part of Slowsim, is used to create and modify the input data file required for execution (called the "SLOWDAT" file). This input file contains physical information necessary for the simulation such as water depths, vessel physical characteristics, and so on. The file is the result of an interactive session between the user and Slowsim (see Appendix B and Chapter 4 for a sample session and Chapter 7 of the SPMsim/Moorsim user manual, hereafter referred to as the "SPMsim" user manual, for further discussion of the Interface). The Interface is also used to *modify* previously created data files when vessel characteristics, site or environmental conditions require changes. Note that the input file is in machine-readable format and cannot be viewed or modified without the Simulation.

User Manual Overview

The Slowsim user manual, in conjunction with the SPMsim user manual, constitutes the major tutorial tool provided with the program package. To derive maximum benefit, these manuals should be thoroughly reviewed on two occasions: Upon initial package acquisition (before and during the first few simulation executions), and again after perhaps ten to twenty weeks of use. The second review, carried out after practical experience has been gained in the use of the program, is of inestimable value in sharpening the user's understanding of the program, its workings and its capabilities. The manual includes a reasonably extensive glossary and an index, which, along with the table of contents and internal cross-references should permit quick location of specific topics.

Chapter 3 discusses the various classes of input data required and provides some details regarding special features and limitations of the simulation. It complements Chapter 4 and SPMsim Chapter 7 by providing additional information on items of special importance and is therefore a valuable cross-reference point for the material in Chapter 4 and SPMsim Chapter 7.

Chapter 4 and SPMsim Chapter 7 give a Screen-by-Screen description of all input items required for Slowsim and serves as a "super index" which can be used to answer most of the day-to-day operational questions that arise during Slowsim execution. Cross-references to other portions of the user manual are given at appropriate points in Chapter 4 and SPMsim Chapter 7.

Chapter 5 discusses in detail the Slowsim output stream. It too is an important cross-reference point for Chapter 4, complementing the description of the output controls given there.

A collection of appendices provide a potpourri of miscellaneous useful information including file archive recommendations, a discussion of error messages, a glossary, a comprehensive sample problem (with input and output) and a limited discussion of theoretical issues.

Program Capabilities

The environmental vessel loading models integral to the comprehensive SeaSoft simulations comprise the fundamental wind, wave and current forcing coefficients in dimensionless form and a variety of dimensional realizations for the specified environmental intensities. That is, the *dimensionless* coefficients are by their nature independent of the actual environmental strengths. Slowsim goes on to apply the dimensionless coefficients to the specified environmental conditions and produces a collection of summaries of the resulting environmental force estimates as a function of environmental angle relative to the vessel. The forcing summaries are not limited to the *internal* SeaSoft forcing models but are also available when user-specified dimensionless coefficients are in use.

Automatic Backup of Input Files

When the Simulation is executed, it first inspects the Slowsim's local directory to see if any file with the name SLOWDAT is resident there. If so, a backup file named SLOWBAK is produced from the pre-existing SLOWDAT file while any pre-existing SLOWBAK file is copied to a file named LASTBAK. Any pre-existing LASTBAK file is lost. In this way, two generations of data files are maintained to protect against inadvertent data loss. This is discussed further under "file management" in Appendix D.

Chapter 3

Input Data Requirements

Like the "comprehensive" SeaSoft simulations, Slowsim requires for its execution data of three distinct generic types: (1) site data consisting of water depth and density, (2) physical data on mass, hydrostatic and geometrical properties of vessel, and (3) environmental data comprising principally the wind, current and wave conditions desired for simulation. This data is then used to evaluate the static and quasi-static environmental force characteristics requested by the user.

Data File Importation

As discussed in the Introduction, it is expected that the primary function of Slowsim will be to evaluate static and low-frequency properties of vessels already described within other SeaSoft simulation data files. There will only rarely, then, be a data file "C"reation session for Slowsim; rather most data will be already resident in existing Moorsim, CALMsim, SPMsim, etc. data files. These data files (MOORDAT, CALMDAT, SPMDAT, etc.) can be copied directly into the Slowsim working directory, renamed SLOWDAT and "M"odified in the usual way; all necessary vessel and environmental data contained in the imported file will thereby be automatically brought into Slowsim. Note that any applicable LOWDAT file must also be brought into the Slowsim directory as well.

Note: Care must be taken to *copy* rather than *move* the data files as Slowsim will modify these files and export of these modified files *back* to their original simulations is not recommended..

The Slowsim user interface is identical in all respects to those of other comprehensive SeaSoft simulations with regard to definition of vessel and environment; only the output options differ. Naturally, since environmental forces acting on a vessel do not "know" about mooring structures, input relative to a mooring system is not relevant and mooring data contained within an imported file will be invisible to the Slowsim user *but is not lost*.

Data File Exportation not Recommended

Although possible, it is nonetheless unwise to *export* a Slowsim data file back to its original application once imported into Slowsim and modified. The reason for this is that Slowsim alters data locations in the file that are unused in co-current versions of other SeaSoft simulations but which *may* come into use in future versions; in that event unexpected and unanticipated conflicts may develop when updating old data files using the automatic data updating algorithms built into future SeaSoft simulations.

Use of Related User Manuals

A detailed explanation of portions of the user interface common to comprehensive simulations such as Moorsim or SPMsim will not be presented. Only user-selectable output stream options unique to Slowsim will be considered in detail in this manual. Refer to the relevant manuals (e.g., Moorsim) for supplementary documentation.

Refer to Appendix B for a sample problem. This sample problem resulted from an importation of the SPMDAT and LOWDAT files used for the SPMsim user manual sample problem; that manual may therefore be consulted to provide further user interface information. Printed images of output selection Screen presentations produced by the Editor and additional details are included in the SPMsim manual, Chapter 7.

Chapter 4

User Interface Description

This chapter is devoted to a truncated description of the user interface to Slowsim (the "Editor") which is employed for creation of new data files and editing of existing files. Because the specification of vessel and environment is identical for all SeaSoft simulations, only the Slowsim output selection page, which is the only Editor page unique to Slowsim, will be described in detail; we shall however repeat sufficient information on the introductory Screen and "help" Screens to bridge to the supplemental information contained in the SPMsim manual. The user should study the SPMsim manual for details of vessel and environment specification. Since all options are represented by Editor selections, this chapter and the corresponding SPMsim chapter comprise an itemization of capabilities, input/output cross-reference and tutorial combined. All responses typed by the user at the console are in ***bold*** typeset, both on Screen images and in the text of this chapter. User-typed carriage returns are indicated by ***<c/r>***. Note that a carriage return (designated as "***Return***" on most keyboards but as "***Enter***" on some) is required as the last keystroke of *any* input to the console; thus, when we speak of "Entering the value 3", we in fact mean the keystroke combination "***3<c/r>***". (Quotation marks are included here and below *only* for readability; they are *never* to be used for data entry in the Editor.)

Screens are numbered sequentially according to the order of their appearance; unnumbered SubScreens that are subordinate to the main Screen but overlay it are designated by letter. Thus SubScreen 3a would be the first SubScreen of Screen 3.

General Editing Information

The editing session is largely self-explanatory; editing alternatives consist of several simple, fundamental types:

1. The "toggle": Many editing items are configured as toggles between two possible values; selection of these items will require no further data input from the user. For example, selection of "units of measure" on Screen 1 below will cause the selected units to toggle between "English" and "metric". All items displaying a value of "yes" or "no" are of the toggle type.

2. Single datum input: Most selections in the Editor require input or modification of a single item on a Screen. To change a particular item, input the item number followed by a carriage return (***<c/r>***) at the "Enter number of selection:" prompt, and an appropriate prompt line requesting the new input value will appear at the Screen bottom. It is not necessary to input decimal points for floating point numbers without fractional parts (i.e. 10.0 can be input as 10). When more that one input value is required on an input line, the values should be separated by commas. A simple

<c/r> in response to a request for data will leave the existing value of the data unchanged.

3. Expanded data input: For situations in which many numbers must be entered, or a choice more complicated than a simple datum input is involved, the Editor will produce a "SubScreen" subordinate to the active Screen to accomplish the input operation. For example, a SubScreen is used to permit semi-automatic input of the regular wave period array, the input of which one period at a time would be laborious.

4. Screen access "Help" menu: Entering "H" (*without* quotation marks) at any "Enter number of selection:" prompt will produce the Screen access Help menu displayed after console Screen 1 below. These paging options, which, like the "H" command, can be given at any "Enter number of selection:" prompt, are designed to permit ease of access to any Screen of the Editor from any other Screen. Both upper and lower case letters can be used.

The following mechanisms for paging through the Editor should be noted: To page forward to the next sequential Screen, press the carriage return at the "Enter selection number" prompt; to page ***B***ackwards to the previous Screen, enter "***B<c/r>***"; the ***F***irst and ***L***ast input Screens can be accessed from any numbered Screen in the Editor by entering, respectively, "***F<c/r>***" or "***L<c/r>***"; one can ***S***kip a Screen by entering "***S<c/r>***" or ***J***ump to Screen "n" by entering "***Jn<c/r>***" (for example, ***J5<c/r>*** will produce a jump to Screen 5 from any numbered Screen in the Editor).

5. Help with specific items: Concise descriptions of many input items can be obtained on-line by entering "***?n<c/r>***" at any "Enter selection number" prompt; n is the item number of interest on the current Screen. Entering "***?<c/r>***" will cause all help text associated with the Screen presently in view to scroll by.

Editor Screen Images

Note that with the exception of the "Welcome" Screen, Screen 1 and the paging help Screen, which are included to establish continuity with the SPMsim manual, only Screen images unique to Slowsim are displayed in this chapter. For a detailed review of other Slowsim Screens, please refer to the SPMsim user manual; the images in this manual and the sample problem of Appendix B correspond to the SPMsim manual sample problem.

```
          +=========================================================+
          |                                                         |
          |               **   Welcome to Slowsim   **              |
          |                                                         |
          |                                                         |
          |                    Slowsim  Version 5.11                |
          |                                                         |
          |          Copyright (C) 2005 by SeaSoft Systems          |
          |                                                         |
          +=========================================================+

-----------------------------------------------------------------------------

(M) Modify existing data file, (C) Create a new file, (E) Execute simulation
Enter letter of selection: M<c/r>
```

Title page: This Screen presents options to Modify (***M***) an existing Data file, Create (***C***) a wholly new one or Execute (***E***) the Simulation using an existing Data file. No response but "***M***", "***m***", "***C***", "***c***", "***E***" or "***e***" will be accepted. If either (***M***) or (***C***) are entered, any first or second generation Data files in the current directory will be copied to backup files to avoid inadvertent loss of data. Thus, the two most recent generations of data files are automatically preserved. At the end of the Editor session, a Data file with the new or modified data will be created in the current directory in addition to the two generations of backup files. Appendix D discusses file management recommendations.

```
                   ****  Screen 1: Site conditions  ****


    Two-line Identification for this simulation:

1) [Moorsim/SPMsim Manual Sample Problem                                    ]
2) [Turret moored 150,000 DWT tanker                                        ]

3) Units of measure: English

4) Site water depth:          450.00 feet
5) Water density:              64.00 lbs/cubic foot

Enter number of selection: H<c/r>
```

Screen 1: This Screen contains necessary site data and other miscellaneous information. The units of measure can be toggled between English and metric by selecting item 3. Input of new numerical data (e.g., item 4) or character string data (e.g., item 1) is accomplished by selecting the relevant numbered item and responding appropriately to the ensuing prompts. Note: a request for "H"elp has been issued at the "Enter number of selection" prompt.

```
(F)  First page
(L)  Last page
(S)  Skip ahead a page
(E)  Execute program
(B)  Back a page
(Jn) Jump to page "n"
(?)  Help summary for current page
(?n) Help on current page for selection "n"

Press <RETURN> to continue: <c/r>
```

Help Screen: This Screen contains instructions for access to various interface Screens and on-line help. The described actions are accomplished by entering the appropriate letter (uppercase or lowercase), followed by a carriage return, at an "Enter number of selection:" prompt on any page-numbered Screen.

```
******************  Screen 14:  Slowsim Output Options 1 *****************

              *** Wave <<Reflection>> Forces and Moments ***

 1) Dimensionless regular wave force/moment coefficients ............. Yes
 2) Mean irregular wave force/moment frequency distribution .......... Yes
 3) Mean irregular wave forces/moments ............................... Yes
 4) Low-frequency variable force/moment spectral densities ........... Yes

              *** Wave <<Absorption>> Forces and Moments ***

 5) Dimensionless regular wave force/moment coefficients ............. Yes
 6) Mean irregular wave force/moment frequency distribution .......... Yes
 7) Mean irregular wave forces/moments ............................... Yes
 8) Low-frequency variable force/moment spectral densities ........... Yes

                          *** Wave Spectrum ***

 9) Specified wave spectrum .......................................... Yes
10) Specified wave group spectrum .................................... Yes
11) Specified swell spectrum ......................................... Yes
12) Specified swell group spectrum ................................... Yes

Enter number of selection:
```

See Also pp 16 ff

Screen 14: This Screen, and Screen 15 below, are the only Slowsim Screen Images not duplicated in the SPMsim manual. Screen 14 consists of yes/no toggles to turn on/off various output options. See the output stream discussion in Chapter 5 for an expanded description of many of these items.

Item 1: Dimensionless wave reflection force and moment coefficients Cx, Cy and Cz at wave frequency ω (radians/sec) and wave angle θ are related to the associated dimensional forces (Fx,Fy) and moment Mz by:

$$Fx(\omega,\theta) = Cx(\omega,\theta)*[.5*Dw*B*a^2]$$
$$Fy(\omega,\theta) = Cy(\omega,\theta)*[.5*Dw*L*a^2]$$
$$Mz(\omega,\theta) = Cz(\omega,\theta)*[.5*Dw*L^2*a^2]$$

Here Dw is *weight* density of water, a is regular wave amplitude, B and L are vessel Beam and Length. Fx, Fy and Mz are the forces and moment acting at vessel cg due to re-direction of a portion of the incident momentum (i.e., "refraction" or "reflection") of a regular wave of circular frequency ω and approach angle θ. The expression in brackets for Fx and Fy is the force exerted by such a wave on a section of length L (or B) of an infinite, fixed breakwater. In magnitude, Cx or Cy comprises the ratio between the actual wave reflection force and the wave reflection force acting on a comparable length of fixed breakwater; Cx and Cy are therefore generally less than unity. For example in the short-wave or "geometrical optics" limit (infinite ω), Cx = 1 and Cy = Cz = 0 for waves incident frontally on a box-shaped barge. Selection of Item 1 produces a table of drift force and moment coefficients (Cx, Cy, Cz) for each requested wave frequency and direction.

Item 2: This item produces, for each requested wave direction, a "spectral" distribution table for the wave reflection forces and moments. The table comprises the product of appropriate dimensionless regular wave reflection force coefficients with the specified wave spectrum.

Item 3: This item produces output values of mean dimensional irregular wave reflection forces and moments acting on the vessel for each requested wave direction. These forces and moments comprise the integral over frequency of the "product spectrum" of cg-relative dimensionless regular wave reflection coefficients times the wave spectrum, transferred if necessary to the requested off-cg longitudinal moment calculation point. The *untransferred* (cg-relative) product spectrum we have called "Mean irregular wave force/moment frequency distribution" and included as output item 2 on this page.

Item 4: The "low-frequency" spectral density of wave reflection forces and moments is a direct measure of the *variable* part of wave reflection forces which are responsible for low-frequency oscillations in the moor. The low-frequency vessel motion variance contributed by such variability is approximately proportional to this quantity. The oscillation frequency of interest must be specified. Moments are referred to the requested off-cg longitudinal moment calculation point.

Item 5: Dimensionless wave *absorption* force and moment coefficients Cx, Cy and Cz at wave frequency ω (radians/sec) and wave angle Theta are defined by:

$$Fx(\omega,\theta) = Cx(\omega,\theta)*[.5*Dm*B*(\omega^2)*(a^3)]$$
$$Fy(\omega,\theta) = Cy(\omega,\theta)*[.5*Dm*L*(\omega^2)*(a^3)]$$
$$Mz(\omega,\theta) = Cz(\omega,\theta)*[.5*Dm*(L^2)*(\omega^2)*(a^3)]$$

Here Dm is *mass* density of water, a is regular wave amplitude, B and L are vessel Beam and Length. Fx, Fy and Mz are the forces and moment acting at vessel cg due to partial dissipation (or "absorption") of a regular wave of circular frequency ω. This represents the dissipative analog to the wave "reflection" coefficients.

Item 6: This item produces, for each requested wave direction, a spectral distribution table for the wave *absorption* forces and moments. The table comprises the product of appropriate dimensionless regular wave absorption force coefficients with the specified wave spectrum.

Item 7: This item produces output values of mean dimensional irregular wave *absorption* forces and moments acting on the vessel for each requested wave direction. These forces and moments comprise the integral over frequency of the "product spectrum" of cg-relative dimensionless regular wave absorption coefficients times the wave spectrum, transferred if necessary to the requested off-cg longitudinal moment calculation point. The untransferred (cg-relative) product spectrum we have called "Mean irregular wave force/moment frequency distribution".

Item 8: The "low-frequency" spectral density of wave *absorption* forces and moments is a direct measure of the *variable* part of wave absorption forces which are responsible for low-frequency oscillations in the moor. The low-frequency vessel motion variance contributed by such variability is approximately proportional to this quantity. The oscillation frequency of interest must be specified. Moments are referred to the requested off-cg longitudinal moment calculation point.

Item 9: This item produces an output table of irregular wave spectral density.

Items 10 & 12: The wave (or swell) "group spectrum" G(ω) is defined as eight (8) times the integral on $[0, \infty]$ of $[S(q)*S(q+\omega)dq]$ where S is the usual first-order wave (or swell) energy spectrum, q is the wave frequency (rad/sec) and ω is the group frequency (rad/sec). Simply related to the spectrum of the wave crest/trough envelope, G(ω) is an important qualitative measure of low-frequency second-order wave exciting forces.

Item 11: This item produces an output table of swell spectral density.

```
******************  Screen 15:  Slowsim Output Options 2 *****************

                      *** Wind Forces and Moments ***

 1) Dimensionless wind force/moment coefficients .................... Yes
 2) Mean wind forces/moments ........................................ Yes
 3) Wind force spectral density (fixed frequency, variable angle) .... Yes
 4) Wind speed spectral density (variation with frequency) ........... No

                     *** Current Forces and Moments ***

 5) Dimensionless current force/moment <<coefficients>> ............. Yes
 6) Mean current forces/moments ..................................... Yes
 7) Current force spectral density (fixed frequency, variable angle) . Yes
 8) Current speed spectral density (variation with frequency) ........ No
 9) Use "Legacy" current-wave drift force interaction model .......... Yes

                          *** Net Load Tables ***

10) Net environmental moment and load tables ........................ Yes
11) Exclude wave drag from net loads tables .......................... No

                       *** Angular Grid Controls ***

12) Number of angular offsets for evaluation ........................   9
13) Uniform angular offset increments (toggle to specify array)

14) Azimuthal angular increment (deg) ...............................  20.00
15) Starting angle (deg) ............................................    .00

                       *** Miscellaneous Controls ***

17) Offset from CG for moment calculations (feet) ...................    .00
18) Frequency of "low-frequency" oscillations (radians/sec) ..........  .0000

19) Use vessel-relative <<attack angles>> for environment in output tables

20) Output goes to   ................................................ Disk
21) Debug option is  ................................................ off
```

See Also pp 16 ff

Screen 15: Additional Slowsim output options; this is a logical continuation of Screen 14.

Items 1 & 5: The *dimensionless* wind and current force and moment coefficients [Cx,Cy,Cz] are related to the *dimensional* forces and moment [Fx,Fy,Mz] by

$$Fx(\theta) = Cx(\theta)*[.5*Dm*Ah*V^2]$$
$$Fy(\theta) = Cy(\theta)*[.5*Dm*Ab*V^2]$$
$$Mz(\theta) = Cz(\theta)*[.5*Dm*Ab*L*V^2]$$

Here, $Fx(\theta)$, etc., represents the net *dimensional* force/moment *acting at vessel cg*, "Dm" is the relevant fluid mass density (e.g., slugs/ft^3), "Ah", "Ab" are vessel projected areas (head-on or beam-on), V is wind or current speed (ft/sec or m/sec) and L is vessel waterline length. For head-on conditions, therefore, Cx(θ) is simply the (dimensionless) ratio of the force on the vessel to that acting on a flat plate with drag coefficient 1.0 and appropriate projected area. Item 1 will produce an output table of the dimensionless coefficients at each requested relative angle between vessel and environment.

Items 2 & 6: These items produce output values of net dimensional wind and current forces and moments acting on the vessel for each requested environment direction, in a format analogous to that for net dimensional wave drift forces. Moments are referred to the requested off-cg longitudinal moment calculation point.

Items 3 & 7: The "low-frequency" spectral density of wind or current forces and moment is a direct measure of the *variable* part of the wind and current contribution to environmental forces responsible for low-frequency oscillations in the moor. The low-frequency vessel motion variance associated with wind or current variability is approximately proportional to this quantity. The oscillation frequency of interest must be specified. Moments are referred to the requested off-cg longitudinal moment calculation point.

Items 4 & 8: The spectral density of wind or current *speed* is another measure of the variable contribution to environmental forces responsible for low-frequency oscillations in the moor. This quantity depends only on the specified spectrum and is independent of vessel particulars; values are given as a function of frequency and are analogous to the wave group spectral density.

Item 9: In order to reproduce the "Legacy" current-wave drift force interaction in effect prior to version 4.4, set this flag to "Yes". In general, this feature should only be used with one of the "Legacy" vessel models (e.g., Legacy Semisubmersible or Legacy Tanker).

Item 10: This option produces output of *net* environmental loads and moments comprising, at each requested vessel angle, combined effects of wind, wave, current and imposed external forces and moments.

Item 11: This flag, when set to "yes", will cause wave "drag" (or "absorption") effects to be omitted in the net loads tables even when wave absorption coefficients have been requested. It can be used to isolate purely reflective net forces from the purely absorptive forces and the combined (reflective + absorptive) wave "drift" forces.

Item 12: The number of desired relative angles between environment and vessel centerline is specified in this item. There are no restrictions on the number of angles specified.

Item 13: This toggle permits either (1) an array of uniform angular offsets or (2) an arbitrary array of environmental angles to be selected for processing.

Item 14: The angular increment in degrees between sequential vessel centerline orientations (relative to the fixed environment) is specified in this item whenever the "Uniform angular offset increments" toggle is set. There are no restrictions on the size or sign of this item.

Item 15: The starting angle for the "Uniform angular offset increments" option is set using this item.

Item 16: When the Item 13 toggle is set to "Specify angular array", this item appears to facilitate angular array entry.

Item 17: The longitudinal location of the *centerline* point about which moment values are to be reported must be specified. Positive values are towards the bow. For moments about the cg, enter zero.

Item 18: The circular frequency of oscillations (in radians/second) must be specified whenever "low-frequency" spectral densities have been requested. Normally, this will be a very small value, corresponding to periods of 100-10,000 or more seconds. In particular, a frequency of identically zero is usually used as a "benchmark" value for wave drift oscillatory forces and the simulation therefore permits a value of zero for this quantity.

Item 19: The output tables produced for each requested relative vessel-environment angle will use vessel-relative *headings* or *attack angles* according to the state of this toggle. In general,

attack angle = relative heading - 180.

For example, a vessel-relative heading of 180 degrees corresponds to an attack angle of 0 degrees and a vessel-relative heading of 225 degrees corresponds to an attack angle of 45 degrees.

Item 20: All output data can be vectored to the console or disk at the user's discretion. For printing, many users find it convenient to vector output to disc so that the powerful formatting, printing and editing capabilities of dedicated editors or word processors can be utilized.

Item 21: When the debug option is "on", a stream of debugging information is vectored to the Screen during program execution. This information may be useful during telephone support discussions with SeaSoft to pinpoint execution problems.

Chapter 5

Output Stream Description

Output Description by Output Section

The following discussion relates to the sample problem output pages in Appendix Z.

Note: With the exception of globally-resolved forces in Output Section X, all forces in the output stream are decomposed in the SeaSoft vessel-based coordinate system with X forward, Y to port and Z vertical upwards.

Wave-Related Output

Wave Drift Force Terminology Note

As a result of the introduction into the simulations of nonlinear wave "drag" estimates for all vessel types (previous to version 5.0 these estimates were only available for semisubmersible-type vessels), we have adopted a more suggestive and logically consistent terminology when discussing wave "drift" forces.

Historically, the designations "wave drift force" and "wave drift coefficient" have been applied to the wave-energy conserving second-order process of momentum transfer from waves to vessel via diffraction and reflection. In SeaSoft's simulations, these energy-conserving forces and coefficients derive either from built-in models, or from user-supplied text files, the latter usually being produced from the output of three-dimensional diffraction codes.

Notwithstanding historical conventions, from a purely logical perspective wave "drift" forces actually comprise *two* components, the above-mentioned energy-conserving component, which we now call the "reflective" component, and a "dissipative" (or "absorptive") component. The dissipative component will on occasion be called the "drag" component, which use is also in keeping with our "legacy" terminology for the same effects as applied to semisubmersibles.

Because of the long (and misleading) historical association of "wave drift force" with the energy-conserving component (which we now call the "wave reflection force"), there will be times when we lapse into historical usage and say or write "wave drift force" when we actually mean the *reflective* component only of the total drift force. In case of such lapses, the context of the remarks should serve to clarify whether we are in fact speaking of the reflective component or the *combined* reflective and dissipative components. A reference to the "wave drag force" always refers to the dissipative component.

Dimensionless Wave Drift Coefficients; Section I

This section presents the wave-frequency drift force coefficients (reflective component in Section Ia and absorptive component in Section Ib) associated with *regular* waves of each specified period and angle relative to the vessel.

Wave Reflection Coefficients

The *reflection* force coefficients are scaled by the drift force acting on an appropriate length of infinitely deep and long breakwater, which causes perfect and total reflection of the incoming wave. *Dimensionless* regular wave drift force and moment coefficients [Cx, Cy, Cz] at (circular) wave frequency ω are related to the *dimensional* forces and moment [Fx, Fy, Mz] by

$$Fx(\omega) = Cx(\omega)*[.5*Dw*B*a^2]$$
$$Fy(\omega) = Cy(\omega)*[.5*Dw*L*a^2]$$
$$Mz(\omega) = Cz(\omega)*[.5*Dw*L^2*a^2]$$

Here Dw is weight density of water, a is regular wave amplitude, B and L are vessel Beam and Length. Fx(ω), Fy(ω) and Mz(ω) are lateral forces and moment *acting at vessel cg* due to refraction and reflection of a regular wave of circular frequency ω. The expression in brackets is the force exerted by the same wave on a section of length L (or B) of an infinite breakwater. In magnitude, Cx(ω) comprises the ratio between the vessel head-on wave reflection force to that acting on a comparable length of breakwater. For example, in the short-wave (infinite ω) limit, Cx = 1 and Cy = Cz = 0 for waves incident frontally on a box-shaped barge.

Notes:

- Cx, Cy and Cz are dimensionless and therefore independent of the units (metric or English) of the simulation. They are, however, *signed.* That is, they contain the sign of the wave force along the indicated axis resolved in the usual vessel coordinate system. The moment sign is interpreted using the vessel coordinate system and the engineering "right-hand" rule.

- It is physically possible to realize reflection force coefficients greater than unity; these can be caused by a favorable phasing of vessel motions with the incoming wave.

- In this section, dimensional moments derived from these formulae are referred to the vessel center of gravity rather than the user-specified origin.

- This section gives *shallow water corrected* wavelength and wave slope for the requested wave height (or correct wavelength and wave height for the requested wave slope).

Wave Absorption Coefficients

The *absorption* force coefficients derive from square-law dissipative forces arising from the orbital motion of water particles acting on surface-piercing objects. These forces are scaled by the theoretical maximum wave drag force acting per unit length of wave front and integrated upwards from the mean water level to the wave crest. *Dimensionless* regular wave absorption force and moment coefficients [C'x, C'y, C'z] at (circular) wave frequency ω are thus related to the *dimensional* forces and moment [Fx, Fy, Mz] by

$$Fx(\omega) = C'x(\omega)*[.5*Dm*B*(\omega^2)*(a^3)]$$
$$Fy(\omega) = C'y(\omega)*[.5*Dm*L*(\omega^2)*(a^3)]$$
$$Mz(\omega) = C'z(\omega)*[.5*Dm*L^2*(\omega^2)*(a^3)]$$

Here Dm is the *mass* density of water.

Mean Drift Force Frequency Distribution; Section II

This section presents, for each requested wave direction, a "spectral distribution" table for the mean wave drift force (reflective component in Section IIa and absorptive component in Section IIb) associated with a specified wave spectra. These tables comprise simply the product of the dimensionless regular wave drift force/moment coefficients and the appropriate wave spectrum (irregular sea and/or swell as required). They provide an important measure of the most influential wave frequencies with respect to low-frequency and static wave forcing, which depend on *both* wave spectrum and vessel properties.

Notes:

- As in Output Section I, dimensional moments in these tables are referred to vessel center of gravity rather than the user-specified origin.

- The *signs* of these spectra correspond to those of the drift force and moment coefficients in Output Section I.

- These "spectral" quantities are related to the mean wave drift forces themselves in the same qualitative way as the wave spectrum is related to the wave variance (the square of the r.m.s. wave elevation).

Mean Wave Drift Forces & Moments; Section III

This table provides estimates of *mean* irregular wave drift forces (Fx, Fy) and moment (Mz) acting on the vessel for each requested wave direction (reflective component in Section IIIa and absorptive component in Section IIIb). These forces and moment comprise simply the integral over frequency of the "Mean Drift Force Frequency Distribution", discussed above, with moments transferred to the user-requested moment calculation point located a distance "Vx" from vessel cg.

"Low-Frequency" Drift Force & Moment Densities: Section IV

Unfortunately the terminology here may be confusing. The "low-frequency" spectral density of wave drift forces and moment is a direct measure of the *variable* part of wave drift forces which are responsible for low- frequency oscillations in the moor. It is wholly distinct and only remotely related to the wave drift spectral densities presented in Output Section II above, which comprise the spectral decomposition of the *mean* wave forces and are unrelated to force *variations*.

The low-frequency vessel *motion* variance (i.e., the square of the r.m.s. low-frequency motion) associated with wave force variability is approximately proportional to these spectral densities; the densities are a function of a user-specified system "oscillation" frequency which is simply an (approximate) substitute for the anticipated natural frequency of mooring oscillations.

Notes:

- As in other wave drift force tabulations, the reflective component can found in Section IVa and the absorptive component in Section IVb.

- The "oscillation" frequency must be supplied by the user because, absent mooring information, there is no way for Slowsim to estimate the natural mooring period(s) internally; the frequency dependence is generally weak and it is common to use a frequency of zero for this "guesstimate".

- Moments in this section are referred to the requested off-cg longitudinal moment calculation point Vx.

- This table represents the theoretical "groupiness" of the specified spectrum assuming truly random phases of the individual regular wave components comprising the irregular wave spectrum. See related discussion in Appendix C.

- More formally, these values comprise, at the *single* user-specified frequency, the diagonal part of the second-order "quadratic transfer function" discussed by Pinkster[1]; although these values represent a formally incomplete description of second-order wave drift forces acting on the vessel, they nonetheless contain the most important features of these forces and are commonly used in engineering estimates of variable wave-drift effects.

Wind- and Current-Related Output

Dimensionless Wind and Current Coefficients; Section V

The *dimensionless* wind and current force and moment coefficients [Cx, Cy, Cz] are related to the *dimensional* forces and moment [Fx, Fy, Mz] by

$$Fx(\theta) = Cx(\theta)*[.5*Dm*Ah*V^2].$$
$$Fy(\theta) = Cy(\theta)*[.5*Dm*Ab*V^2].$$
$$Mz(\theta) = Cz(\theta)*[.5*Dm*Ab*L*V^2].$$

[1] J. A. Pinkster, "Low Frequency Second Order Wave Exciting Forces on Floating Structures", Marin Publication No. 600, Wageningen, The Netherlands, 1980.

Here, θ is relative angle between wind or current and vessel bow, [Fx(θ), Fy(θ), Mz(θ)] represents the net dimensional force and moment *acting at vessel cg*, "Dm" is the relevant mass density (wind -> air, current -> water), "Ah", "Ab" are vessel projected areas (head-on or beam-on), V is wind or current speed (ft/sec or m/sec) and L is vessel waterline length (or Lpp). In head-on conditions, for example, Cx(θ) is the (dimensionless) ratio of the head-on force on the vessel [Fx(θ)] to that acting on a flat plate with drag coefficient 1.0 and projected area Ab. Note that these coefficients are *signed* quantities just as for wave drift coefficients.

Mean Wind and Current Forces & Moments; Section VI

These tables provide estimates of *mean* dimensional wind and current forces and moments acting on the vessel for each requested environment direction, in a format analogous to that for mean dimensional wave drift forces. As usual, moments are referred to the user-specified off-cg longitudinal moment calculation point Vx.

"Low-Frequency" Wind/Current Spectral Densities; Section VII

The "low-frequency" spectral density of wind or current forces and moment is a direct measure of the *variable* part of the wind and current contribution to environmental forces responsible for low-frequency oscillations in the moor. (See also the comments on the analogous wave-drift quantity above.) The low-frequency vessel motion variances associated with wind or current variability are approximately proportional to these quantities. The oscillation frequency of interest must be specified. Moments are referred to the requested off-cg longitudinal moment calculation point.

Irregular Wave Spectral Values; Section VIII

These tables provide visualization of the specified irregular wave and swell spectra along with a summary of miscellaneous wave spectral characteristics.

Notes:

- "Requested" and "calculated" wave heights seldom match exactly. This is because "calculated" heights include only wave energy contained in the user-specified range of regular wave periods; there will usually be at least some wave energy outside the short- or long-period boundaries of this range and therefore missing from the spectral integration.

- The "Spectrum characteristic wind speed" is the wind speed which would, if acting for an infinite period of time in deep water with no fetch limitations, create waves of the specified height. This is also the wind speed associated with a (single-parameter) Pierson-Moskowitz fully-developed wave spectrum for the specified height. It is a useful measure of the wind severity associated with specified sea conditions but *is unrelated to the user-specified wind speed.* Note that because there is no wind associated with swell conditions, no useful "Swell characteristic wind speed" can be defined.

- The Spectrum or Swell "characteristic wave slope" is the slope associated with the "Significant" wave, by which we mean simply a *regular* wave of period equal to the spectrum peak period and height equal to the specified significant wave height. It is a simple measure of wave slope magnitude associated with the larger waves.

- The "Wave height for slope calculation" (or "Wave slope for height calculation") is a recapitulation of the user-specified constant height (or slope) to be used in various regular wave analyses.

- Wave lengths and wave slopes given have been corrected for shallow water.

- In the presence of current, it is assumed the requested wave spectrum is one that would be measured in an *earth-fixed* frame. In a frame co-moving with the fluid, the waves would experience a Doppler shift requiring an analytical adjustment to the frequency values. Furthermore, a spectrum generated in an earth-fixed frame and propagated *into* a region containing current will be modified in general, depending on the details of the current profile with depth and the abruptness of the transition from still water to running water.

- The wave "group spectrum" G(ω) is defined as eight (8) times the integral on [0, ∞] of [S(q)*S(q+ω)dq] where S is the usual first-order wave (or swell) energy spectrum, q is the wave frequency (rad/sec) and ω is the group frequency (rad/sec). Simply related to the spectrum of the wave crest/trough envelope, G(ω) is an important qualitative measure of low-frequency second-order wave exciting forces.

Net Environmental Forces & Moments; Section IX

Mean environmental forces and moments are categorized by component and environmental source and presented. Output Section IX comprises three pages, one each for the X force, Y force and Z moment acting on the vessel.

Environmental Force & Moment Summary; Section X

Combined mean environmental forces and moments are summarized in a slightly different single-table format combining the effects of wind, wave, swell, current and any specified external forces.

Notes:

- Forces are broken out in both the "Vessel" and "Global" coordinate systems.

- The "Angle" in these tables is the angle of the net force relative to the appropriate X-axis (Vx for vessel, Gx for Global). As always in the SeaSoft framework, angles are measured positive in a counter-clockwise direction from the x-axes, consistent with the "right-hand rule".

- The moments, which are always the same in Vessel and Global systems because these systems differ only by a rotation about the (vertical) Z axis, are given about the indicated user-specified moment offset point.

Appendix A

Glossary

added mass	Refers to the enhancement of inertial properties of a body undergoing accelerated motion in a surrounding fluid.
angular wedge	The basic unit of angle used in numerical integrations involving angular-dependent quantities, such as wave amplitude spectra, for short-crested ("azimuthally spread") irregular waves.
Auto Repeat	A feature permitting rapid input of a long string of equally spaced input variables, such as regular wave periods.
azimuthal spreading	Refers to irregular sea conditions in which waves approach simultaneously from many directions; i.e., appear short-crested.
background swell	A long-period, long-crested wave underlying, and often obscured by, locally generated wind driven seas.
ballasted	Refers to a condition of partial load for a VLCC or ULCC which represents the smallest practical operational displacement. Normally definition is in terms of freeboard (with ballast condition freeboard typically defined as approximately three to four times full load freeboard); in this manual it refers to any tanker load condition, substantially less than full, which is more appropriately represented by characteristics of a lightly loaded vessel than a fully loaded one.
bilge	The area at the bottom of a vessel where the nearly flat bottom turns upwards to form the nearly vertical side.
bilge keel	A protuberance, situated near the bilge, whose function is to create turbulence in the surrounding fluid during rolling motions, thereby dissipating roll energy and reducing the magnitude of roll excursions.
block coefficient	The displacement of a vessel at a given waterline divided by the product of its molded beam, length, and draft; a measure of the "boxiness" of the hull form (symbolized by Cb).
bracketing	This refers to the procedure of selecting regular wave periods for a simulation of vessel performance in irregular waves; in particular the highest and lowest regular wave periods selected must "bracket" the periods in which the irregular waves, as characterized by the wave spectrum, possess

substantial wave energy.

Bretschneider	A widely used two-parameter wave spectrum specified by the significant wave height and the spectral peak period.
Cargo Weight	The difference between "Displacement" and "Lightship Weight".
characteristic period	The ratio of the r.m.s. value to the r.m.s. rate of a particular dynamical variable.
characteristic wind speed	The wind speed which would, if acting for an infinite period of time in deep water with no fetch limitations, create waves of the height specified in an irregular wave analysis request. It is a measure of severity of environmental conditions associated with specified sea conditions.
conventional bow	Refers to a conventional tanker bow design with prominent bulbous protrusion and a deeply notched profile; this bow is generally more sharply pointed in plan view than the contrasting "cylindrical" bow shape.
coordinate convention	In this document, x is positive forward, y positive to port (left when facing forward), z positive upwards; origin at vessel baseline directly below the center of gravity.
crossed sea	Simultaneous occurrence of two or more distinct and identifiable wave systems from different sources.
custom spectrum	A user-specified irregular wave spectrum for which values of wave spectral densities are individually specified at each wave period rather than computed from Simulation-resident formulas.
cylindrical bow	Refers to a tanker bow configuration which, viewed from the side, is indented to such a small degree that it appears almost cylindrical; when viewed from the top, this bow type is considerably more blunt and rounded that the contrasting "conventional" type.
Davenport	A widely used wind gust spectrum which is completely defined by the mean wind speed and a surface roughness factor.
deadweight (DWT)	Formally, the deadweight is simply cargo weight and comprises the difference between displacement and lightship weight; it is therefore a continuous function of mean vessel draft condition. However, for our purposes DWT refers to the design maximum deadweight, which corresponds to the maximum cargo carrying capacity of a VLCC and is commonly used as a standard measure of tanker size.
diffraction theory	A method for computing wave forces and torques on a body in waves which utilizes potential (ideal) fluid theory

	in conjunction with a finite lattice of fluid sources and sinks distributed about the body so that the boundary condition of zero velocity component normal to the body surface is approximately satisfied.
displacement RAOs	These characterize the motion of selected points on the vessel. They include contributions from all six degrees of freedom, combined with proper phase to produce three components (vertical, lateral and forward) of displacement at the indicated point. Coordinates are specified in the vessel-fixed frame, as are the components of motion.
dry weight	Refers to the weight of an object out of water, in contrast to the submerged, or "wet" weight which is influenced by the buoyancy of the displaced fluid.
dynamic pressure	One-half of the mass density of a flowing fluid times the square of the flow speed.
dynamical variable	Any of the forces, torques, accelerations, velocities or motions that might be selected for dynamic analysis.
dynamically similar box	A special construct whose most important dynamical properties, including all mass, added mass and hydrostatic properties, are chosen to closely approximate those of the simulated vessel. The selection process insures, in particular, that the important natural periods of roll, pitch and heave are properly modeled.
enhancement factor	A multiplicative coefficient that can be assigned by the user to increase or decrease the relative importance of wind, wave and current forces on the vessel.
floating point	Refers to a numerical variable in Fortran which is used and stored in memory in exponential format as opposed to simple integer ("fixed point") format.
frequency spectrum	A spectral density function whose independent variable is frequency, as opposed to period or wavelength or otherwise.
Full Load Draft	The design maximum draft of a vessel corresponding to the design maximum load for seagoing operations. This is sometimes known as Maximum Draft, Design Draft, Loaded Draft, Summer Draft, or in England as the Summer Draught.
fully-developed	The limiting sea condition associated with a given wind speed and fetch corresponding to an infinite duration of the specified wind conditions.
global coordinates	Any coordinate system fixed to the earth which provides a suitable reference system for definition of environmental forces and directions. The origin is at the mooring centroid.
GM	The vertical distance between the center of gravity and

	metacenter. Equal to KM minus KG. Transverse and longitudinal values are associated respectively with KMT and KML.
gyradius	The square root of the ratio between the mass moment of inertia of a body about its center of gravity and its mass. A measure of the angular inertia of a body.
high-frequency	Refers to frequencies contained within the bandwidth of naturally-occurring surface waves; for practical purposes, the range of periods indicated by this qualifier is three to twenty seconds.
high-speed	In this document, high-speed refers to speeds comparable to the phase speed of waves of primary interest to operations, namely six to sixteen seconds or so, which corresponds to deep water phase speeds of thirty to eighty feet per second.
Hull Area	The above- or below-water projected area of the hull, neglecting contribution from any superstructure such as deck houses or production equipment, subject to hydrodynamic forces of wind or current.
in-plane	Refers to points lying in a vertical aligned with the mean offset direction from the quiescent-condition mooring centroid to the displaced (environmentally-determined) mean mooring centroid.
input file	File produced by the Editor containing input data.
JONSWAP	The JOint North Sea WAve Project. A systematic study of North Sea wave conditions carried out in response to the high level of petroleum exploration and development activities there.
KB, KG, KML, KMT	The vertical positions of the center of buoyancy, center of gravity, and longitudinal and transverse metacenters, all measured from the keel baseline.
kgw	Kilogram weight; a unit of weight equal to 1/1000 of a metric ton.
kip	The unit of weight used when English units are selected. Equal to 1000 pounds.
Lightship Weight	The weight of vessel and machinery without crew, cargo or consumables such as stores or fuel.
long crested	Refers to naturally occurring waves, such as swell, which are highly unidirectional and possess long, unbroken wave crests and troughs.
low-frequency	In this manual this refers to oscillations whose period is much greater than periods associated with naturally occurring

waves. In particular, the natural periods of oscillation of moored vessels fall in this category, these being typically from one to ten minutes.

Lpp, LBP — The "length between perpendiculars" is a common measure of vessel length that is generally quite close to the length of the waterline at maximum draft condition. It is usually about 5% less than the overall vessel length (LOA).

machine-readable — Data files which remain in machine-encoded format and which cannot be easily interpreted without a computer program equipped to display them, such as the Editor.

mainframe — A large data processing machine with special floating point mathematics processors, high speed circuitry and core addressing capabilities measured in hundreds of megabytes.

metric ton — The unit of weight used when metric units are selected. Equal to the weight of 1000 kilograms at a nominal gravitational acceleration of 9.8 meters/second**2, or roughly 2205 pounds.

moulded depth — For practical purposes, this is the profile height of the hull from keel to main deck level; it is by definition draft plus freeboard in this document.

N.A. — Not Applicable.

natural period — The period with which a vessel will oscillate in a particular degree of freedom, once displaced from equilibrium. For unmoored vessels, this only applies to degrees of freedom (roll, pitch, heave) which experience static restoring forces upon displacement from equilibrium. For highly asymmetric vessels, well-defined natural periods for roll, pitch and heave may not exist due to coupling between the degrees of freedom.

nonlinear damping — The damping associated with the finite viscosity of water is of the "square law" type for conditions of relevance. This means that response characteristics do not scale linearly with wave amplitude. For practical purposes, nonlinear effects can usually be ignored except near system resonances, where natural linear damping contributions, for instance those arising from wave radiation, are small.

paging — The facility in the Editor which permits progress through the input file in either the forward (with a "carriage return") or backward (by inputting a "B") directions.

period spectrum — A spectral density function using wave period as the independent variable, as opposed to wave frequency.

phase — The property of a dynamical variable such as the force or torque which, in the presence of a regular wave, indicates the timing of the maximum of that variable with respect to

	the occurrence of the wave crest at a prescribed datum, usually the waterplane centroid. A positive phase angle indicates that the maximum of the variable occurs in advance of ("leads") the arrival of the wave crest.
phase speed	The advance speed of a wave crest.
Pierson-Moskowitz	A widely used one-parameter wave spectrum which is completely specified by significant wave height and is characteristic of a fully-developed sea condition in deep water with an infinite fetch.
quasi-linear	This refers to a method of linearization of non-linear phenomenon, such as roll damping, which is accomplished by choosing a linear variable which behaves, in most important respects, like the nonlinear variable to be modeled. In the case of roll damping, this amounts to choosing a linear damping coefficient that produces the same dissipation per regular wave cycle at a given wave height as the true nonlinear roll damping. Unlike a linear damping coefficient, the "quasi-linear" coefficient will depend on the value of wave height selected.
quasi-static	This refers to dynamic phenomena which occur on a time scale which is so long that the system is at each instant very near to an equilibrium configuration; in particular acceleration, damping and other quantities which depend explicitly upon time derivatives of dynamical variables can be considered negligible.
RAO	The Response Amplitude Operator; in practical usage, this refers to the amplitude of the transfer function from wave height (or amplitude, or slope) to force, torque, or motion variables. Formally, however, the RAO includes both the amplitude and the phase of the transfer function.
scale factor	The force and torque RAOs produced are presented in dimensionless form; except for yaw, these tend to a constant, non-zero value at long wavelengths in the deep water limit. (This constant value is 1 for heave, pitch and roll; for surge and sway the constant value may be greater than one.) The scale factors used to non-dimensionalize the force/torque RAOs are given in the force- and torque-specific printouts. For each degree of freedom, the physical force or torque is determined from the RAO value, the wave amplitude (or slope), and the scale factor by multiplying these three quantities together. The forces and torques for all degrees of freedom except heave scale with wave slope; heave scales with wave amplitude. The units of the scale factors indicate whether to use wave slope or amplitude as a multiplier in determining the dimensional force or torque.
shallow water	Shallow here refers to bottom influence on the phase speed and vertical pressure distribution of waves. For most practical

	purposes, water can be considered "deep" whenever its depth exceeds 1/4 of the wavelength. The effects of shallow water wave characteristics on vessel performance are taken into account.
sigma	The square root of the variance of a time history such as low-frequency surge motions or wave-frequency loads. It corresponds to the root-mean-square (r.m.s.) value (the standard deviation) of the variable. For many processes, the "significant" value is nearly equal to twice the sigma value.
significant	In most discussions of statistical properties of wave-excited motion or load variables, the significant value is defined as the average of the one-third highest occurrences of the variable in a particular record. For a narrow-banded process whose peaks are distributed according to a Rayleigh distribution, which for practical purposes includes most processes of interest to the offshore industry, the significant value is very nearly equal to twice the root-mean-square (r.m.s.) value of the variable.
significant rate	This is a slight misnomer; in this manual it is twice the r.m.s. value of the time derivative of a particular dynamical variable.
significant value	Formally, this is the average of the one-third largest excursions of a dynamical variable; in this manual it is taken to be twice the r.m.s. value of that variable.
significant wave height	The average of the one-third largest waves in a particular sample of water surface elevations. For spectra of interest in offshore operations, this is very closely equal to four times the square root of the variance of the wave amplitude spectrum, which is also four times the root-mean-square deviation of the water surface from the calm water level.
significant wave period	The average period of the one-third largest waves in a particular statistical sample.
Simulation Draft	The mean draft associated with the desired partial loading condition for the target vessel.
single amplitude	This refers to the use of "single amplitude" (S.A.), or mean-to-maximum of variables in quoting RAOs or statistical measures of motions and loads. This is to be compared with "double amplitude" (D.A.) measure which is a measure of peak-to-trough, or maximum to minimum, values of a motion or load variable. The former is exactly one-half the latter, except that S.A./S.A. RAOs are exactly the same as D.A./D.A. RAOs, because the factors of one-half cancel out of the ratio.
spectrum peak period	The period corresponding to the highest spectral density value of a particular frequency spectrum. For well-behaved

	spectra, this is very close to the "significant period"; or the average period of the significant waves. This contrasts with the "average" wave period which is generally considerably smaller than the significant period and is therefore of limited value in the practical characterization of wave periods.
strip theory	This is a theory of the "diffraction" type which is particularized to the case of long, slender vessels and short wave periods.
toggle	This is a generic mechanism used to change an input variable having two possible values, such as metric versus English units specification.
ULCC	"Ultra Large Crude Carrier".
variance	The total area under a spectral plot; it corresponds to the squared root-mean-square fluctuations of the spectral variable about its mean value.
velocity RAOs	These characterize the velocity of selected points on the vessel relative to an inertially fixed coordinate system. Note, however, that both point coordinates and velocity components are resolved in the vessel-fixed frame.
vessel-fixed	This refers, in particular, to a coordinate system fixed with respect to the vessel with x-axis forward, y-axis to port and z-axis vertical. The origin of this system is generally taken to be at keel level below the plan-view centroid of the waterplane area.
waterplane coefficient	The waterplane area of a vessel at a given waterline divided by the product of its waterline beam and length; a measure of the rectangularity of the waterplane (symbolized by Cwp).
wave amplitude	Because waves are not symmetrical about the still water position, the "wave amplitude" as such is not a well defined quantity. This expression, where it occurs, refers to the vertical amplitude of water particle excursions at the surface. This value is equal to one-half of the wave height for waves satisfying the usual assumption of linearity (i.e. wave height "small" compared to wave length).
wave drift force	This "second order" force, acting on a floating body in the presence of waves, is proportional in strength to the square of the wave amplitude; in an irregular sea it has a frequency spectrum with significant components at zero frequency (static force) and very low frequency. The low-frequency components, sometimes called "slowly variable wave-drift forces" contribute to the excitation of long-period oscillations in moored systems.
wave heading	This is the direction which the waves are actually heading. Thus a 180 degree wave heading is associated with waves

	impinging on the bow; that is, they are "head waves".
wave height	The elevation as measured from a wave crest to the immediately adjacent trough.
wave slope	The tangent of the angle which a regular wave surface, viewed in profile, makes to the horizontal at the point of maximum slope (near the still-water line).
wave spreading index	The exponent of cosine in the analytical description of angular distribution of wave energy used in the Simulation. The short-crested sea spectrum is assumed to be representable in the form f(a)S(w) where a is the angle relative to the direction of maximum seas, f(a) is a power of the cosine of that angle, and S(w) is the frequency spectrum of the wave amplitudes.

Appendix B

Sample Problem

As a tutorial aid in the use of Slowsim, this appendix includes the data required to carry out a complete evaluation of environmental loads on a typical fully loaded 150,000 DWT tanker, turret moored at the bow. This sample problem uses the same vessel and environment as the SPMsim sample problem in the SPMsim manual, which should be consulted for additional details. The data required for Slowsim comprises only a subset of the information required for execution of SPMsim; the required vessel and environment information is duplicated here for convenience. The output stream appears in Appendix Z.

Input Data

Vessel Particulars:

1. Displacement.. 407000 k. lbs
2. Length .... 929.0 feet
3. Beam .... 146.6 feet
4. Draft .... 64.0 feet
5. KMT... 61.0 feet
6. KML... 1225.0 feet
7. VKB .... 34.0 feet
8. VKG... 36.0 feet
9. Water plane area... 126000 square feet
10. Pitch gyradius... 232.0 feet
11. Roll gyradius .... 51.2 feet
12. Yaw gyradius .... 235.0 feet
13. Bilge radius .... 5.0 feet
14. Head-on wind area .... 7400 square feet
15. Beam-on wind area .... 23000 square feet
16. Head-on current area....................................... 9600 square feet

17. Beam-on current area..................................... 61000 square feet
18. Beam-on current area centroid....................... 50 feet
19. Conventional bow (OCIMF '77 definition)
20. Full load condition ("100% loaded")
21. Computed pitch and roll damping coefficients
22. User-specified heave damping of 16%.
23. Computed pitch and heave periods
24. User-specified roll period of 14 seconds.
25. Computed surge and low sway/yaw ("sway") damping coefficients
26. User-specified high sway/yaw ("yaw") damping coefficients of 33%.

Environment Particulars:

Wind:

- Davenport spectrum with mean speed of 60 knots.
- Wind heading 150 degrees.
- Wind enhancement factor = 1.0 (default).
- Wind force coefficients according to the OCIMF '77 standard.

Current:

- Steady 2.0 knot current heading 180 degrees.
- Current profile with depth according to 1/7 th power law.
- Current force enhancement factor = 1.0 (default).
- Current Cx coefficients user specified as the COSINE of the attack angle [= COS(q)].
- Current Cy coefficients according to the NSMB '91 standard with bow shape interpolated midway on (with bulb, no bulb).
- Current Cz coefficients according to the SeaSoft barge model.

Irregular waves:

- Bretschneider wave spectrum with significant height 20 feet and peak period 13.0 seconds; long-crested irregular wave model.

- Irregular wave heading 180 degrees
- Swell with significant wave height 10 feet, peak period 16 seconds and default bandwidth.
- Swell heading 210 degrees
- Default "Tanker 2001" wave drift and absorption coefficients
- Storm duration 6 hours

Regular waves:

- Constant wave height of 14 feet; periods 6 to 18.5 seconds; .5 second intervals

Appendix C

Theoretical Considerations

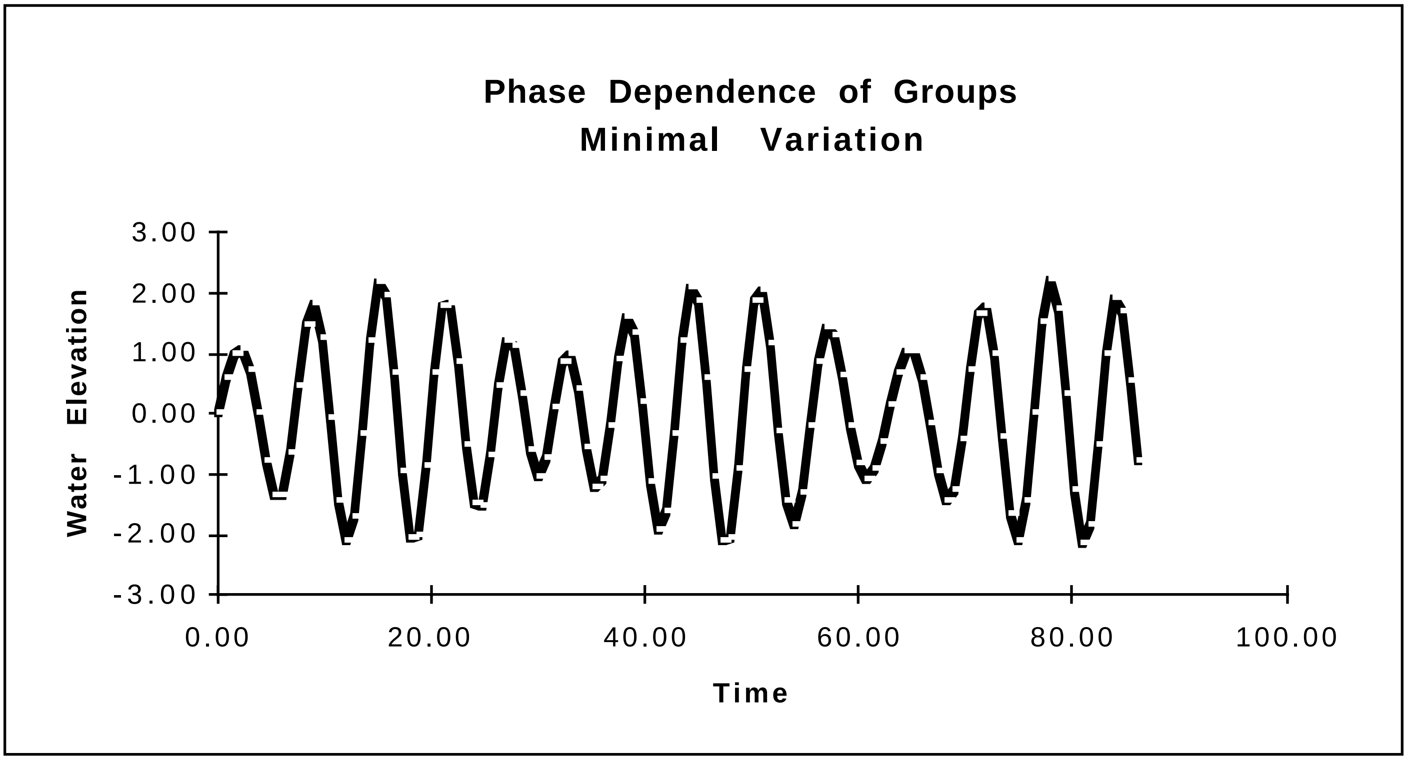
Thinking in Terms of Wave Groups; Wave-Basin Caveats

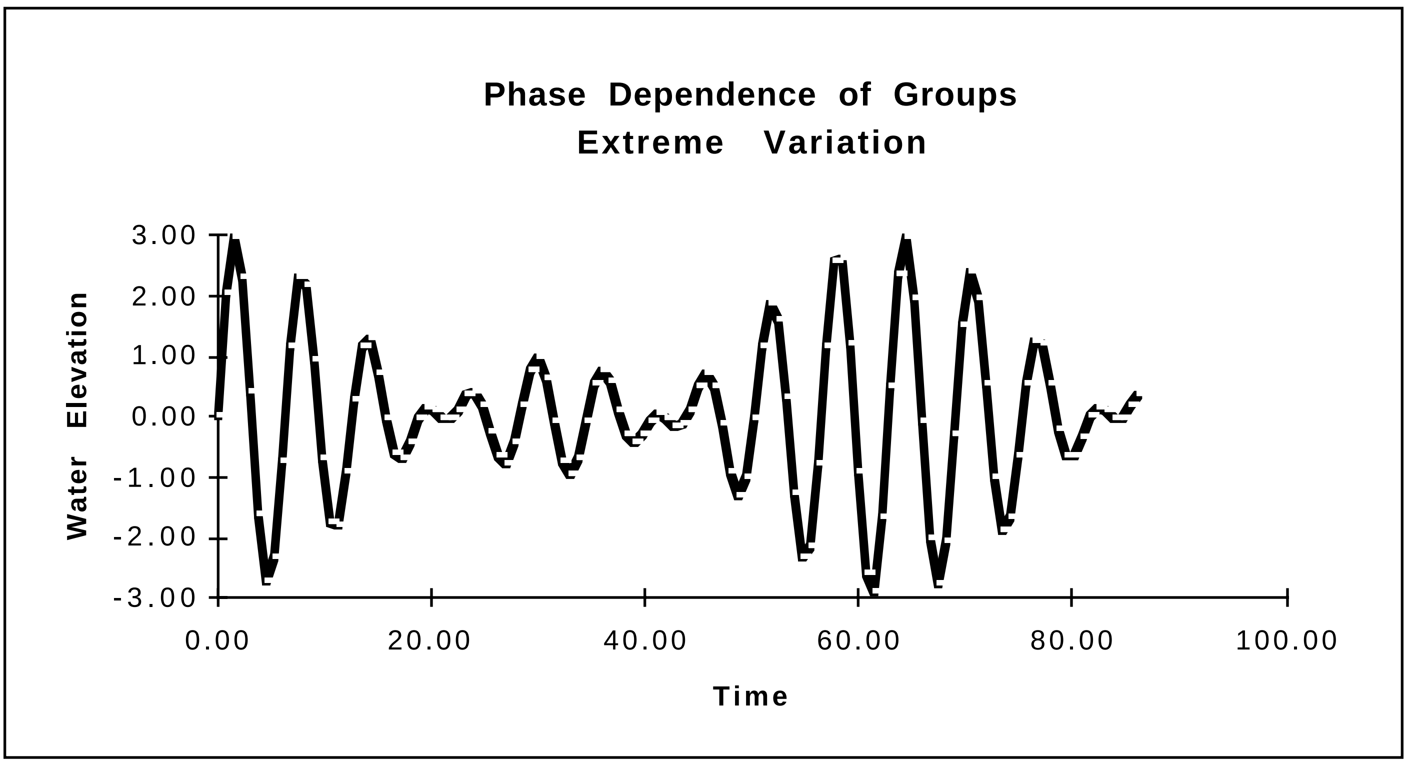
The "low-frequency wave spectral density" responsible for wave-induced long-period oscillations of a moored vessel can be thought of simply as the spectrum of the *envelope* of the waves, or equivalently as the spectrum of wave *groups*. It is extremely important to realize that it is mathematically (and physically) impossible to define without ambiguity the group spectrum from a specified wave spectrum. This fact is illustrated below. The spectral values produced in Output Section IV by Slowsim relate to a "perfectly random" phase relationship between the regular wave components comprising the irregular wave train. Because a physically realizable (but negligibly probable in nature) phase map for the component waves can produce a vastly different low-frequency spectral density than the one predicted by Slowsim, much care must be taken when comparing simulation results with wave-basin measurements. Because all wave basins are designed by humans, and humans often have difficulty producing truly random inputs, the group spectra produced in a wave basin can be horribly unrealistic and can result in vessel low-frequency motions and mooring loads substantially larger or smaller than will be realized in "nature's laboratory".

This problem is similar to the familiar "statistical paradox" that the Second Law of Thermodynamics does not really speak to physical *impossibilities*, but rather to hopelessly remote *improbabilities*. For example, no physical law denies the formal possibility that at some moment all the air will rush from the room in which you sit, creating for an instant a perfect vacuum (and producing a moment of discomfort). Such events, though physically possible, are so fantastically unlikely that no human or any other creature anywhere is likely to witness such an occurrence in the entire history of the universe. However, by careful control of the phase of individual regular wave components in an irregular wave field, we *can* produce group spectra that are hopelessly improbable in nature.

Simple Three-Wave Demonstration

A simple composite "sea" consisting of three regular waves of slightly different period and equal amplitudes illustrates qualitatively (and clearly) the problem. We plot below the water surface elevation for the three wave composite using two different phase relationships between the component waves, one *favorable* for "groupiness", the other *unfavorable*. The difference is readily apparent; these two examples have the *same* "spectrum" and the *same* "wave energy" or "significant wave height" or more accurately, the same wave variance. This phase freedom and its consequent effect on group spectra applies to *all* wave spectra regardless how complex.


Phase Dependence of Groups
Minimal Variation
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
Water Elevation
0.00
20.00
40.00
60.00
80.00
100.00
Time


Phase Dependence of Groups
Extreme Variation
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
Water Elevation
0.00
20.00
40.00
60.00
80.00
100.00
Time

Appendix D

File Management

File Requirements

As discussed earlier, the Editor produces an unformatted binary input file called SLOWDAT containing particulars of a given simulation including vessel, site and environmental characteristics. If any *user-input* environmental coefficients have been specified, these are saved in a binary input file called LOWDAT. Once a satisfactory SLOWDAT (and, possibly, LOWDAT) file has been produced, as determined by satisfactory output from Slowsim, these input file(s) should be *archived* for possible later use by giving them more meaningful names and placing copies in an archive area along with a descriptive note. A copy of the archived file(s) can then, at any later time, be copied to the Slowsim working area on the disk, renamed to SLOWDAT (and, *if applicable*, LOWDAT), and reworked as necessary for the new simulation. The same procedure should be used to archive a satisfactory copy of all *formatted* output for future reference. It is important to use meaningful names for the archival copies so that they may be easily identified. The entire input/output package can be compressed with any of a number of widely available compression and archival utilities and saved for later reference.

Importance of Archiving SLOWIN.stxt

It is *essential* to archive, along with the binary SLOWDAT/LOWDAT file(s), the SLOWIN.stxt formatted data file produced at runtime. This is important because it is impossible to view the data in binary files without the Editor. Although it is SeaSoft policy to provide upgrade paths for data files as the Simulation's data structures change over time, these changes may in unusual circumstances make reading very old SLOWDAT files problematic. In such cases it may be advantageous to create a new data file manually from a SLOWIN archive. Also, because creation and/or alteration of a LOWDAT file will be a relatively infrequent occurrence (because of the comprehensive collection of built-in environmental coefficient options), it is possible that LOWDAT will be overlooked occasionally at archive time. A lost LOWDAT can be rebuilt, if necessary, from the formatted SLOWIN file.

Appendix Z

Sample Problem Output

This appendix contains output generated by Slowsim as a result of a simulation execution using input data presented in Appendix B. Note that the Screen images presented in Chapter 4 and in Chapter 7 of the SPMsim manual correspond to the same sample problem.

SeaSoft Systems Simulation Library

Volume 16

SeaSoft Quasi-Static Environmental Characteristics

Slowsim Version 5.11

Moorsim/SPMsim Manual Sample Problem
Turret moored 150,000 DWT tanker

Executed at 13:44 on 4/5/05

********* Ia. Dimensionless Regular Wave Reflection Coefficients *********

Attack Angle Relative to Vessel = -.00 degrees
Current Angle Relative to Waves = .00 degrees

>>> NOTE: Dimensional regular wave reflection forces & moments are defined by:

Head-on force = .5*B*Dw*g*(a^2)*Cx
Beam-on force = .5*L*Dw*g*(a^2)*Cy
Moment at CG = .5*(L^2)*Dw*g*(a^2)*Cz

a = wave amplitude = .5*(wave height)

L = 929.00 ft
B = 146.60 ft
Dw*g = 64.00 lbs/(ft^3)

Wave force model: Tanker (Legacy)
Bow-on shape factor = 1.00
Effective included bow angle = 73.74 degrees

>>> Wave height for slope calculation = 14.00 ft

Wave Period (sec)	Wave Frequency (rad/sec)	Wave Length (ft)	Wave slope (deg)	Cx	Cy	Cz
6.000	1.0472	184.217	13.679	-.50619	.00000	-.00000
6.500	.9666	216.200	11.656	-.49891	.00000	-.00000
7.000	.8976	250.740	10.050	-.49607	.00000	-.00000
7.500	.8378	287.840	8.755	-.50004	.00000	-.00000
8.000	.7854	327.498	7.695	-.51518	.00000	-.00000
8.500	.7392	369.714	6.816	-.54884	.00000	-.00000
9.000	.6981	414.488	6.080	-.61298	.00000	-.00000
9.500	.6614	461.818	5.457	-.72653	.00000	-.00000
10.000	.6283	511.699	4.925	-.75115	.00000	-.00000
10.500	.5984	564.116	4.467	-.74519	.00000	-.00000
11.000	.5712	619.042	4.071	-.69330	.00000	-.00000
11.500	.5464	676.426	3.725	-.58016	.00000	-.00000
12.000	.5236	736.190	3.423	-.48988	.00000	-.00000
12.500	.5027	798.216	3.157	-.41726	.00000	-.00000
13.000	.4833	862.347	2.922	-.35836	.00000	-.00000
13.500	.4654	928.389	2.714	-.31022	.00000	-.00000
14.000	.4488	996.116	2.530	-.27055	.00000	-.00000
14.500	.4333	1065.282	2.366	-.23757	.00000	-.00000
15.000	.4189	1135.630	2.219	-.20993	.00000	-.00000
15.500	.4054	1206.911	2.088	-.18656	.00000	-.00000
16.000	.3927	1278.888	1.970	-.16664	.00000	-.00000
16.500	.3808	1351.350	1.865	-.14952	.00000	-.00000
17.000	.3696	1424.111	1.770	-.13470	.00000	-.00000
17.500	.3590	1497.015	1.683	-.12178	.00000	-.00000
18.000	.3491	1569.933	1.605	-.11045	.00000	-.00000
18.500	.3396	1642.762	1.534	-.10046	.00000	-.00000

```
*********  Ia. Dimensionless Regular Wave Reflection Coefficients  *********

               Attack Angle Relative to Vessel =    20.00 degrees
               Current Angle Relative to Waves =      .00 degrees

>>> NOTE: Dimensional regular wave reflection forces & moments are defined by:

          Head-on force = .5*B*Dw*g*(a^2)*Cx
          Beam-on force = .5*L*Dw*g*(a^2)*Cy
          Moment at CG  = .5*(L^2)*Dw*g*(a^2)*Cz

          a = wave amplitude = .5*(wave height)

          L    =  929.00 ft
          B    =  146.60 ft
          Dw*g =   64.00 lbs/(ft^3)


          Wave force model: Tanker (Legacy)
          Bow-on shape factor            =   1.00
          Effective included bow angle   =  73.74 degrees

    >>> Wave height for slope calculation =  14.00 ft
```

Wave Period (sec)	Wave Frequency (rad/sec)	Wave Length (ft)	Wave slope (deg)	Cx	Cy	Cz
6.000	1.0472	184.217	13.679	-.55224	-.13549	-.03814
6.500	.9666	216.200	11.656	-.54430	-.13328	-.03759
7.000	.8976	250.740	10.050	-.54120	-.13196	-.03738
7.500	.8378	287.840	8.755	-.54554	-.13191	-.03767
8.000	.7854	327.498	7.695	-.56205	-.13386	-.03882
8.500	.7392	369.714	6.816	-.59877	-.13903	-.04135
9.000	.6981	414.488	6.080	-.66875	-.14947	-.04618
9.500	.6614	461.818	5.457	-.79263	-.16842	-.05474
10.000	.6283	511.699	4.925	-.81950	-.17081	-.05659
10.500	.5984	564.116	4.467	-.81299	-.16707	-.05614
11.000	.5712	619.042	4.071	-.75638	-.15443	-.05224
11.500	.5464	676.426	3.725	-.63294	-.13031	-.04371
12.000	.5236	736.190	3.423	-.53445	-.11011	-.03691
12.500	.5027	798.216	3.157	-.45522	-.09320	-.03144
13.000	.4833	862.347	2.922	-.39097	-.07912	-.02700
13.500	.4654	928.389	2.714	-.33845	-.06746	-.02337
14.000	.4488	996.116	2.530	-.29516	-.05786	-.02038
14.500	.4333	1065.282	2.366	-.25919	-.04995	-.01790
15.000	.4189	1135.630	2.219	-.22903	-.04342	-.01582
15.500	.4054	1206.911	2.088	-.20353	-.03801	-.01406
16.000	.3927	1278.888	1.970	-.18180	-.03349	-.01256
16.500	.3808	1351.350	1.865	-.16312	-.02969	-.01127
17.000	.3696	1424.111	1.770	-.14695	-.02646	-.01015
17.500	.3590	1497.015	1.683	-.13286	-.02370	-.00918
18.000	.3491	1569.933	1.605	-.12050	-.02132	-.00832
18.500	.3396	1642.762	1.534	-.10960	-.01925	-.00757

```
*********  Ia. Dimensionless Regular Wave Reflection Coefficients  *********

               Attack Angle Relative to Vessel =    40.00 degrees
               Current Angle Relative to Waves =      .00 degrees

>>> NOTE: Dimensional regular wave reflection forces & moments are defined by:

          Head-on force = .5*B*Dw*g*(a^2)*Cx
          Beam-on force = .5*L*Dw*g*(a^2)*Cy
          Moment at CG  = .5*(L^2)*Dw*g*(a^2)*Cz

          a = wave amplitude = .5*(wave height)

          L    =  929.00 ft
          B    =  146.60 ft
          Dw*g =   64.00 lbs/(ft^3)


          Wave force model: Tanker (Legacy)
          Bow-on shape factor            =   1.00
          Effective included bow angle   =  73.74 degrees

    >>> Wave height for slope calculation =  14.00 ft
```

Wave Period (sec)	Wave Frequency (rad/sec)	Wave Length (ft)	Wave slope (deg)	Cx	Cy	Cz
6.000	1.0472	184.217	13.679	-.66466	-.43422	-.05843
6.500	.9666	216.200	11.656	-.65511	-.42619	-.05759
7.000	.8976	250.740	10.050	-.65137	-.42005	-.05726
7.500	.8378	287.840	8.755	-.65660	-.41611	-.05772
8.000	.7854	327.498	7.695	-.67647	-.41514	-.05947
8.500	.7392	369.714	6.816	-.72066	-.41854	-.06335
9.000	.6981	414.488	6.080	-.80489	-.42883	-.07076
9.500	.6614	461.818	5.457	-.95399	-.45030	-.08386
10.000	.6283	511.699	4.925	-.98632	-.44354	-.08671
10.500	.5984	564.116	4.467	-.97849	-.42416	-.08602
11.000	.5712	619.042	4.071	-.91035	-.38800	-.08003
11.500	.5464	676.426	3.725	-.76179	-.33181	-.06697
12.000	.5236	736.190	3.423	-.64325	-.28070	-.05655
12.500	.5027	798.216	3.157	-.54789	-.23522	-.04816
13.000	.4833	862.347	2.922	-.47056	-.19587	-.04137
13.500	.4654	928.389	2.714	-.40735	-.16274	-.03581
14.000	.4488	996.116	2.530	-.35525	-.13544	-.03123
14.500	.4333	1065.282	2.366	-.31195	-.11325	-.02742
15.000	.4189	1135.630	2.219	-.27565	-.09533	-.02423
15.500	.4054	1206.911	2.088	-.24497	-.08088	-.02154
16.000	.3927	1278.888	1.970	-.21881	-.06919	-.01924
16.500	.3808	1351.350	1.865	-.19633	-.05967	-.01726
17.000	.3696	1424.111	1.770	-.17687	-.05186	-.01555
17.500	.3590	1497.015	1.683	-.15991	-.04540	-.01406
18.000	.3491	1569.933	1.605	-.14503	-.04000	-.01275
18.500	.3396	1642.762	1.534	-.13191	-.03546	-.01160

```
 *********  Ia. Dimensionless Regular Wave Reflection Coefficients  *********

                Attack Angle Relative to Vessel =    60.00 degrees
                Current Angle Relative to Waves =      .00 degrees

>>> NOTE: Dimensional regular wave reflection forces & moments are defined by:

          Head-on force = .5*B*Dw*g*(a^2)*Cx
          Beam-on force = .5*L*Dw*g*(a^2)*Cy
          Moment at CG  = .5*(L^2)*Dw*g*(a^2)*Cz

          a = wave amplitude = .5*(wave height)

          L    =  929.00 ft
          B    =  146.60 ft
          Dw*g =   64.00 lbs/(ft^3)


          Wave force model: Tanker (Legacy)
          Bow-on shape factor            =   1.00
          Effective included bow angle   =  73.74 degrees

    >>> Wave height for slope calculation =  14.00 ft
```

Wave Period (sec)	Wave Frequency (rad/sec)	Wave Length (ft)	Wave slope (deg)	Cx	Cy	Cz
6.000	1.0472	184.217	13.679	-.58449	-.88640	-.05138
6.500	.9666	216.200	11.656	-.57609	-.86929	-.05064
7.000	.8976	250.740	10.050	-.57281	-.85524	-.05036
7.500	.8378	287.840	8.755	-.57740	-.84424	-.05076
8.000	.7854	327.498	7.695	-.59488	-.83661	-.05230
8.500	.7392	369.714	6.816	-.63374	-.83326	-.05571
9.000	.6981	414.488	6.080	-.70781	-.83619	-.06222
9.500	.6614	461.818	5.457	-.83892	-.84931	-.07375
10.000	.6283	511.699	4.925	-.86736	-.82423	-.07625
10.500	.5984	564.116	4.467	-.86047	-.77892	-.07564
11.000	.5712	619.042	4.071	-.80055	-.70848	-.07038
11.500	.5464	676.426	3.725	-.66991	-.61027	-.05889
12.000	.5236	736.190	3.423	-.56567	-.51661	-.04973
12.500	.5027	798.216	3.157	-.48181	-.43056	-.04236
13.000	.4833	862.347	2.922	-.41380	-.35474	-.03638
13.500	.4654	928.389	2.714	-.35821	-.29042	-.03149
14.000	.4488	996.116	2.530	-.31240	-.23740	-.02746
14.500	.4333	1065.282	2.366	-.27432	-.19457	-.02412
15.000	.4189	1135.630	2.219	-.24241	-.16034	-.02131
15.500	.4054	1206.911	2.088	-.21542	-.13311	-.01894
16.000	.3927	1278.888	1.970	-.19242	-.11142	-.01692
16.500	.3808	1351.350	1.865	-.17265	-.09408	-.01518
17.000	.3696	1424.111	1.770	-.15554	-.08012	-.01367
17.500	.3590	1497.015	1.683	-.14062	-.06880	-.01236
18.000	.3491	1569.933	1.605	-.12754	-.05953	-.01121
18.500	.3396	1642.762	1.534	-.11600	-.05188	-.01020

```
 *********  Ia. Dimensionless Regular Wave Reflection Coefficients  *********

                Attack Angle Relative to Vessel =    80.00 degrees
                Current Angle Relative to Waves =      .00 degrees

>>> NOTE: Dimensional regular wave reflection forces & moments are defined by:

          Head-on force = .5*B*Dw*g*(a^2)*Cx
          Beam-on force = .5*L*Dw*g*(a^2)*Cy
          Moment at CG  = .5*(L^2)*Dw*g*(a^2)*Cz

          a = wave amplitude = .5*(wave height)

          L    =  929.00 ft
          B    =  146.60 ft
          Dw*g =   64.00 lbs/(ft^3)


          Wave force model: Tanker (Legacy)
          Bow-on shape factor            =   1.00
          Effective included bow angle   =  73.74 degrees

    >>> Wave height for slope calculation =  14.00 ft
```

Wave Period (sec)	Wave Frequency (rad/sec)	Wave Length (ft)	Wave slope (deg)	Cx	Cy	Cz
6.000	1.0472	184.217	13.679	-.23083	-1.24232	-.02029
6.500	.9666	216.200	11.656	-.22752	-1.21803	-.02000
7.000	.8976	250.740	10.050	-.22622	-1.19772	-.01989
7.500	.8378	287.840	8.755	-.22803	-1.18106	-.02005
8.000	.7854	327.498	7.695	-.23494	-1.16801	-.02065
8.500	.7392	369.714	6.816	-.25028	-1.15903	-.02200
9.000	.6981	414.488	6.080	-.27954	-1.15558	-.02457
9.500	.6614	461.818	5.457	-.33132	-1.16116	-.02913
10.000	.6283	511.699	4.925	-.34255	-1.12132	-.03011
10.500	.5984	564.116	4.467	-.33983	-1.05540	-.02987
11.000	.5712	619.042	4.071	-.31616	-.95809	-.02779
11.500	.5464	676.426	3.725	-.26457	-.82734	-.02326
12.000	.5236	736.190	3.423	-.22340	-.70051	-.01964
12.500	.5027	798.216	3.157	-.19028	-.58274	-.01673
13.000	.4833	862.347	2.922	-.16342	-.47837	-.01437
13.500	.4654	928.389	2.714	-.14147	-.38959	-.01244
14.000	.4488	996.116	2.530	-.12338	-.31643	-.01085
14.500	.4333	1065.282	2.366	-.10834	-.25742	-.00952
15.000	.4189	1135.630	2.219	-.09573	-.21043	-.00842
15.500	.4054	1206.911	2.088	-.08508	-.17320	-.00748
16.000	.3927	1278.888	1.970	-.07599	-.14372	-.00668
16.500	.3808	1351.350	1.865	-.06818	-.12029	-.00599
17.000	.3696	1424.111	1.770	-.06143	-.10155	-.00540
17.500	.3590	1497.015	1.683	-.05553	-.08646	-.00488
18.000	.3491	1569.933	1.605	-.05037	-.07420	-.00443
18.500	.3396	1642.762	1.534	-.04581	-.06416	-.00403

```
*********  Ia. Dimensionless Regular Wave Reflection Coefficients  *********

               Attack Angle Relative to Vessel =   100.00 degrees
               Current Angle Relative to Waves =      .00 degrees

>>> NOTE: Dimensional regular wave reflection forces & moments are defined by:

          Head-on force = .5*B*Dw*g*(a^2)*Cx
          Beam-on force = .5*L*Dw*g*(a^2)*Cy
          Moment at CG  = .5*(L^2)*Dw*g*(a^2)*Cz

          a = wave amplitude = .5*(wave height)

          L    =  929.00 ft
          B    =  146.60 ft
          Dw*g =   64.00 lbs/(ft^3)


          Wave force model: Tanker (Legacy)
          Bow-on shape factor            =   1.00
          Effective included bow angle   =  73.74 degrees

    >>> Wave height for slope calculation =  14.00 ft
```

Wave Period (sec)	Wave Frequency (rad/sec)	Wave Length (ft)	Wave slope (deg)	Cx	Cy	Cz
6.000	1.0472	184.217	13.679	.23083	-1.24232	.02029
6.500	.9666	216.200	11.656	.22752	-1.21803	.02000
7.000	.8976	250.740	10.050	.22622	-1.19772	.01989
7.500	.8378	287.840	8.755	.22803	-1.18106	.02005
8.000	.7854	327.498	7.695	.23494	-1.16801	.02065
8.500	.7392	369.714	6.816	.25028	-1.15903	.02200
9.000	.6981	414.488	6.080	.27954	-1.15558	.02457
9.500	.6614	461.818	5.457	.33132	-1.16116	.02913
10.000	.6283	511.699	4.925	.34255	-1.12132	.03011
10.500	.5984	564.116	4.467	.33983	-1.05540	.02987
11.000	.5712	619.042	4.071	.31616	-.95809	.02779
11.500	.5464	676.426	3.725	.26457	-.82734	.02326
12.000	.5236	736.190	3.423	.22340	-.70051	.01964
12.500	.5027	798.216	3.157	.19028	-.58274	.01673
13.000	.4833	862.347	2.922	.16342	-.47837	.01437
13.500	.4654	928.389	2.714	.14147	-.38959	.01244
14.000	.4488	996.116	2.530	.12338	-.31643	.01085
14.500	.4333	1065.282	2.366	.10834	-.25742	.00952
15.000	.4189	1135.630	2.219	.09573	-.21043	.00842
15.500	.4054	1206.911	2.088	.08508	-.17320	.00748
16.000	.3927	1278.888	1.970	.07599	-.14372	.00668
16.500	.3808	1351.350	1.865	.06818	-.12029	.00599
17.000	.3696	1424.111	1.770	.06143	-.10155	.00540
17.500	.3590	1497.015	1.683	.05554	-.08646	.00488
18.000	.3491	1569.933	1.605	.05037	-.07420	.00443
18.500	.3396	1642.762	1.534	.04581	-.06416	.00403

```
*********  Ia. Dimensionless Regular Wave Reflection Coefficients  *********

               Attack Angle Relative to Vessel =   120.00 degrees
               Current Angle Relative to Waves =      .00 degrees

>>> NOTE: Dimensional regular wave reflection forces & moments are defined by:

          Head-on force = .5*B*Dw*g*(a^2)*Cx
          Beam-on force = .5*L*Dw*g*(a^2)*Cy
          Moment at CG  = .5*(L^2)*Dw*g*(a^2)*Cz

          a = wave amplitude = .5*(wave height)

          L    =  929.00 ft
          B    =  146.60 ft
          Dw*g =   64.00 lbs/(ft^3)


          Wave force model: Tanker (Legacy)
          Bow-on shape factor            =   1.00
          Effective included bow angle   =  73.74 degrees

    >>> Wave height for slope calculation =  14.00 ft
```

Wave Period (sec)	Wave Frequency (rad/sec)	Wave Length (ft)	Wave slope (deg)	Cx	Cy	Cz
6.000	1.0472	184.217	13.679	.58449	-.88640	.05138
6.500	.9666	216.200	11.656	.57609	-.86929	.05064
7.000	.8976	250.740	10.050	.57281	-.85524	.05036
7.500	.8378	287.840	8.755	.57740	-.84424	.05076
8.000	.7854	327.498	7.695	.59488	-.83661	.05230
8.500	.7392	369.714	6.816	.63374	-.83326	.05571
9.000	.6981	414.488	6.080	.70781	-.83619	.06222
9.500	.6614	461.818	5.457	.83892	-.84931	.07375
10.000	.6283	511.699	4.925	.86736	-.82423	.07625
10.500	.5984	564.116	4.467	.86047	-.77892	.07564
11.000	.5712	619.042	4.071	.80055	-.70848	.07038
11.500	.5464	676.426	3.725	.66991	-.61027	.05889
12.000	.5236	736.190	3.423	.56567	-.51661	.04973
12.500	.5027	798.216	3.157	.48181	-.43056	.04236
13.000	.4833	862.347	2.922	.41380	-.35474	.03638
13.500	.4654	928.389	2.714	.35821	-.29042	.03149
14.000	.4488	996.116	2.530	.31240	-.23740	.02746
14.500	.4333	1065.282	2.366	.27432	-.19457	.02412
15.000	.4189	1135.630	2.219	.24241	-.16034	.02131
15.500	.4054	1206.911	2.088	.21542	-.13311	.01894
16.000	.3927	1278.888	1.970	.19242	-.11142	.01692
16.500	.3808	1351.350	1.865	.17265	-.09408	.01518
17.000	.3696	1424.111	1.770	.15554	-.08012	.01367
17.500	.3590	1497.015	1.683	.14062	-.06880	.01236
18.000	.3491	1569.933	1.605	.12754	-.05953	.01121
18.500	.3396	1642.762	1.534	.11600	-.05188	.01020

```
 *********  Ia. Dimensionless Regular Wave Reflection Coefficients  *********

               Attack Angle Relative to Vessel =   140.00 degrees
               Current Angle Relative to Waves =      .00 degrees

>>> NOTE: Dimensional regular wave reflection forces & moments are defined by:

          Head-on force = .5*B*Dw*g*(a^2)*Cx
          Beam-on force = .5*L*Dw*g*(a^2)*Cy
          Moment at CG  = .5*(L^2)*Dw*g*(a^2)*Cz

          a = wave amplitude = .5*(wave height)

          L    =  929.00 ft
          B    =  146.60 ft
          Dw*g =   64.00 lbs/(ft^3)


          Wave force model: Tanker (Legacy)
          Bow-on shape factor            =   1.00
          Effective included bow angle   =  73.74 degrees

    >>> Wave height for slope calculation =  14.00 ft
```

Wave Period (sec)	Wave Frequency (rad/sec)	Wave Length (ft)	Wave slope (deg)	Cx	Cy	Cz
6.000	1.0472	184.217	13.679	.66466	-.43422	.05843
6.500	.9666	216.200	11.656	.65511	-.42619	.05759
7.000	.8976	250.740	10.050	.65137	-.42005	.05726
7.500	.8378	287.840	8.755	.65660	-.41611	.05772
8.000	.7854	327.498	7.695	.67647	-.41514	.05947
8.500	.7392	369.714	6.816	.72066	-.41854	.06335
9.000	.6981	414.488	6.080	.80489	-.42883	.07076
9.500	.6614	461.818	5.457	.95399	-.45030	.08386
10.000	.6283	511.699	4.925	.98632	-.44354	.08671
10.500	.5984	564.116	4.467	.97849	-.42416	.08602
11.000	.5712	619.042	4.071	.91035	-.38800	.08003
11.500	.5464	676.426	3.725	.76179	-.33180	.06697
12.000	.5236	736.190	3.423	.64325	-.28070	.05655
12.500	.5027	798.216	3.157	.54789	-.23522	.04816
13.000	.4833	862.347	2.922	.47056	-.19587	.04137
13.500	.4654	928.389	2.714	.40735	-.16274	.03581
14.000	.4488	996.116	2.530	.35525	-.13544	.03123
14.500	.4333	1065.282	2.366	.31195	-.11325	.02742
15.000	.4189	1135.630	2.219	.27565	-.09533	.02423
15.500	.4054	1206.911	2.088	.24497	-.08088	.02154
16.000	.3927	1278.888	1.970	.21881	-.06919	.01924
16.500	.3808	1351.350	1.865	.19633	-.05967	.01726
17.000	.3696	1424.111	1.770	.17687	-.05186	.01555
17.500	.3590	1497.015	1.683	.15991	-.04540	.01406
18.000	.3491	1569.933	1.605	.14503	-.04000	.01275
18.500	.3396	1642.762	1.534	.13191	-.03546	.01160

```
 *********  Ia. Dimensionless Regular Wave Reflection Coefficients  *********

               Attack Angle Relative to Vessel =   160.00 degrees
               Current Angle Relative to Waves =      .00 degrees

>>> NOTE: Dimensional regular wave reflection forces & moments are defined by:

          Head-on force = .5*B*Dw*g*(a^2)*Cx
          Beam-on force = .5*L*Dw*g*(a^2)*Cy
          Moment at CG  = .5*(L^2)*Dw*g*(a^2)*Cz

          a = wave amplitude = .5*(wave height)

          L    =  929.00 ft
          B    =  146.60 ft
          Dw*g =   64.00 lbs/(ft^3)


          Wave force model: Tanker (Legacy)
          Bow-on shape factor            =   1.00
          Effective included bow angle   =  73.74 degrees

    >>> Wave height for slope calculation =  14.00 ft
```

Wave Period (sec)	Wave Frequency (rad/sec)	Wave Length (ft)	Wave slope (deg)	Cx	Cy	Cz
6.000	1.0472	184.217	13.679	.55224	-.13549	.03814
6.500	.9666	216.200	11.656	.54430	-.13328	.03759
7.000	.8976	250.740	10.050	.54120	-.13196	.03738
7.500	.8378	287.840	8.755	.54554	-.13191	.03767
8.000	.7854	327.498	7.695	.56205	-.13386	.03882
8.500	.7392	369.714	6.816	.59877	-.13903	.04135
9.000	.6981	414.488	6.080	.66875	-.14947	.04618
9.500	.6614	461.818	5.457	.79263	-.16842	.05474
10.000	.6283	511.699	4.925	.81950	-.17081	.05659
10.500	.5984	564.116	4.467	.81299	-.16707	.05614
11.000	.5712	619.042	4.071	.75638	-.15443	.05224
11.500	.5464	676.426	3.725	.63294	-.13031	.04371
12.000	.5236	736.190	3.423	.53445	-.11011	.03691
12.500	.5027	798.216	3.157	.45522	-.09320	.03144
13.000	.4833	862.347	2.922	.39097	-.07912	.02700
13.500	.4654	928.389	2.714	.33845	-.06746	.02337
14.000	.4488	996.116	2.530	.29516	-.05786	.02038
14.500	.4333	1065.282	2.366	.25919	-.04995	.01790
15.000	.4189	1135.630	2.219	.22903	-.04342	.01582
15.500	.4054	1206.911	2.088	.20353	-.03801	.01406
16.000	.3927	1278.888	1.970	.18180	-.03349	.01256
16.500	.3808	1351.350	1.865	.16312	-.02969	.01127
17.000	.3696	1424.111	1.770	.14695	-.02646	.01015
17.500	.3590	1497.015	1.683	.13286	-.02370	.00918
18.000	.3491	1569.933	1.605	.12050	-.02132	.00832
18.500	.3396	1642.762	1.534	.10960	-.01925	.00757

```
********    IIa. Mean Reflection Force Frequency Distribution     ********

                Attack Angle Relative to Vessel =     -.00 degrees
                Current Angle Relative to Waves =      .00 degrees

                Wave force model: Tanker (Legacy)
                Bow-on shape factor            =     1.00
                Effective included bow angle   =    73.74 degrees

>>> NOTE: Moments in this table are computed about the center of gravity
```

Wave	--------	Wave Data	--------	--------	Swell Data	--------
Period	S(Fx)	S(Fy)	S(Mz)	S(Fx)	S(Fy)	S(Mz)
(sec)	<--- k.lbs*sec --->		(kip-ft*sec)	<--- k.lbs*sec --->		(kip-ft*sec)
6.00	-0.243E+02	0.000E+00	-0.000E+00	-0.000E+00	0.000E+00	-0.000E+00
6.50	-0.350E+02	0.000E+00	-0.000E+00	-0.000E+00	0.000E+00	-0.000E+00
7.00	-0.491E+02	0.000E+00	-0.000E+00	-0.000E+00	0.000E+00	-0.000E+00
7.50	-0.675E+02	0.000E+00	-0.000E+00	-0.000E+00	0.000E+00	-0.000E+00
8.00	-0.922E+02	0.000E+00	-0.000E+00	-0.592E-19	0.000E+00	-0.000E+00
8.50	-0.127E+03	0.000E+00	-0.000E+00	-0.406E-14	0.000E+00	-0.000E+00
9.00	-0.178E+03	0.000E+00	-0.000E+00	-0.267E-10	0.000E+00	-0.000E+00
9.50	-0.257E+03	0.000E+00	-0.000E+00	-0.296E-07	0.000E+00	-0.000E+00
10.00	-0.317E+03	0.000E+00	-0.000E+00	-0.682E-05	0.000E+00	-0.000E+00
10.50	-0.365E+03	0.000E+00	-0.000E+00	-0.489E-03	0.000E+00	-0.000E+00
11.00	-0.385E+03	0.000E+00	-0.000E+00	-0.135E-01	0.000E+00	-0.000E+00
11.50	-0.355E+03	0.000E+00	-0.000E+00	-0.164E+00	0.000E+00	-0.000E+00
12.00	-0.322E+03	0.000E+00	-0.000E+00	-0.113E+01	0.000E+00	-0.000E+00
12.50	-0.286E+03	0.000E+00	-0.000E+00	-0.493E+01	0.000E+00	-0.000E+00
13.00	-0.249E+03	0.000E+00	-0.000E+00	-0.149E+02	0.000E+00	-0.000E+00
13.50	-0.213E+03	0.000E+00	-0.000E+00	-0.333E+02	0.000E+00	-0.000E+00
14.00	-0.177E+03	0.000E+00	-0.000E+00	-0.581E+02	0.000E+00	-0.000E+00
14.50	-0.144E+03	0.000E+00	-0.000E+00	-0.829E+02	0.000E+00	-0.000E+00
15.00	-0.114E+03	0.000E+00	-0.000E+00	-0.100E+03	0.000E+00	-0.000E+00
15.50	-0.872E+02	0.000E+00	-0.000E+00	-0.106E+03	0.000E+00	-0.000E+00
16.00	-0.649E+02	0.000E+00	-0.000E+00	-0.993E+02	0.000E+00	-0.000E+00
16.50	-0.466E+02	0.000E+00	-0.000E+00	-0.851E+02	0.000E+00	-0.000E+00
17.00	-0.323E+02	0.000E+00	-0.000E+00	-0.675E+02	0.000E+00	-0.000E+00
17.50	-0.215E+02	0.000E+00	-0.000E+00	-0.502E+02	0.000E+00	-0.000E+00
18.00	-0.138E+02	0.000E+00	-0.000E+00	-0.355E+02	0.000E+00	-0.000E+00
18.50	-0.845E+01	0.000E+00	-0.000E+00	-0.240E+02	0.000E+00	-0.000E+00

```
********    IIa. Mean Reflection Force Frequency Distribution     ********

                Attack Angle Relative to Vessel =    20.00 degrees
                Current Angle Relative to Waves =      .00 degrees

                Wave force model: Tanker (Legacy)
                Bow-on shape factor            =     1.00
                Effective included bow angle   =    73.74 degrees

>>> NOTE: Moments in this table are computed about the center of gravity
```

Wave	--------	Wave Data	--------	--------	Swell Data	--------
Period	S(Fx)	S(Fy)	S(Mz)	S(Fx)	S(Fy)	S(Mz)
(sec)	<--- k.lbs*sec --->		(kip-ft*sec)	<--- k.lbs*sec --->		(kip-ft*sec)
6.00	-0.265E+02	-0.412E+02	-0.108E+05	-0.000E+00	-0.000E+00	-0.000E+00
6.50	-0.382E+02	-0.592E+02	-0.155E+05	-0.000E+00	-0.000E+00	-0.000E+00
7.00	-0.535E+02	-0.827E+02	-0.218E+05	-0.000E+00	-0.000E+00	-0.000E+00
7.50	-0.737E+02	-0.113E+03	-0.300E+05	-0.000E+00	-0.000E+00	-0.000E+00
8.00	-0.101E+03	-0.152E+03	-0.409E+05	-0.646E-19	-0.975E-19	-0.263E-16
8.50	-0.138E+03	-0.203E+03	-0.562E+05	-0.443E-14	-0.652E-14	-0.180E-11
9.00	-0.194E+03	-0.274E+03	-0.787E+05	-0.291E-10	-0.412E-10	-0.118E-07
9.50	-0.281E+03	-0.378E+03	-0.114E+06	-0.322E-07	-0.434E-07	-0.131E-04
10.00	-0.346E+03	-0.457E+03	-0.141E+06	-0.744E-05	-0.982E-05	-0.302E-02
10.50	-0.398E+03	-0.519E+03	-0.162E+06	-0.533E-03	-0.695E-03	-0.217E+00
11.00	-0.420E+03	-0.543E+03	-0.171E+06	-0.147E-01	-0.190E-01	-0.598E+01
11.50	-0.387E+03	-0.505E+03	-0.157E+06	-0.178E+00	-0.233E+00	-0.725E+02
12.00	-0.351E+03	-0.458E+03	-0.143E+06	-0.123E+01	-0.161E+01	-0.500E+03
12.50	-0.312E+03	-0.405E+03	-0.127E+06	-0.538E+01	-0.698E+01	-0.219E+04
13.00	-0.272E+03	-0.349E+03	-0.111E+06	-0.162E+02	-0.208E+02	-0.661E+04
13.50	-0.232E+03	-0.293E+03	-0.943E+05	-0.363E+02	-0.458E+02	-0.148E+05
14.00	-0.193E+03	-0.240E+03	-0.785E+05	-0.634E+02	-0.787E+02	-0.258E+05
14.50	-0.157E+03	-0.192E+03	-0.638E+05	-0.904E+02	-0.110E+03	-0.368E+05
15.00	-0.124E+03	-0.149E+03	-0.504E+05	-0.109E+03	-0.131E+03	-0.444E+05
15.50	-0.952E+02	-0.113E+03	-0.387E+05	-0.115E+03	-0.136E+03	-0.468E+05
16.00	-0.708E+02	-0.826E+02	-0.288E+05	-0.108E+03	-0.126E+03	-0.440E+05
16.50	-0.509E+02	-0.587E+02	-0.207E+05	-0.928E+02	-0.107E+03	-0.377E+05
17.00	-0.353E+02	-0.402E+02	-0.143E+05	-0.736E+02	-0.840E+02	-0.299E+05
17.50	-0.235E+02	-0.266E+02	-0.956E+04	-0.548E+02	-0.620E+02	-0.223E+05
18.00	-0.150E+02	-0.169E+02	-0.612E+04	-0.387E+02	-0.434E+02	-0.157E+05
18.50	-0.922E+01	-0.103E+02	-0.375E+04	-0.262E+02	-0.292E+02	-0.107E+05

******** IIa. Mean Reflection Force Frequency Distribution ********

Attack Angle Relative to Vessel = 40.00 degrees
Current Angle Relative to Waves = .00 degrees

Wave force model: Tanker (Legacy)
Bow-on shape factor = 1.00
Effective included bow angle = 73.74 degrees

>>> NOTE: Moments in this table are computed about the center of gravity

Wave Period (sec)	Wave Data S(Fx) (k.lbs*sec)	Wave Data S(Fy) (k.lbs*sec)	Wave Data S(Mz) (kip-ft*sec)	Swell Data S(Fx) (k.lbs*sec)	Swell Data S(Fy) (k.lbs*sec)	Swell Data S(Mz) (kip-ft*sec)
6.00	-0.319E+02	-0.132E+03	-0.165E+05	-0.000E+00	-0.000E+00	-0.000E+00
6.50	-0.460E+02	-0.189E+03	-0.238E+05	-0.000E+00	-0.000E+00	-0.000E+00
7.00	-0.644E+02	-0.263E+03	-0.333E+05	-0.000E+00	-0.000E+00	-0.000E+00
7.50	-0.887E+02	-0.356E+03	-0.459E+05	-0.000E+00	-0.000E+00	-0.000E+00
8.00	-0.121E+03	-0.471E+03	-0.627E+05	-0.777E-19	-0.302E-18	-0.402E-16
8.50	-0.166E+03	-0.612E+03	-0.861E+05	-0.533E-14	-0.196E-13	-0.276E-11
9.00	-0.233E+03	-0.787E+03	-0.121E+06	-0.351E-10	-0.118E-09	-0.181E-07
9.50	-0.338E+03	-0.101E+04	-0.175E+06	-0.388E-07	-0.116E-06	-0.201E-04
10.00	-0.416E+03	-0.119E+04	-0.215E+06	-0.895E-05	-0.255E-04	-0.463E-02
10.50	-0.480E+03	-0.132E+04	-0.248E+06	-0.642E-03	-0.176E-02	-0.332E+00
11.00	-0.505E+03	-0.136E+04	-0.261E+06	-0.177E-01	-0.478E-01	-0.916E+01
11.50	-0.466E+03	-0.129E+04	-0.241E+06	-0.215E+00	-0.593E+00	-0.111E+03
12.00	-0.422E+03	-0.117E+04	-0.218E+06	-0.148E+01	-0.410E+01	-0.767E+03
12.50	-0.375E+03	-0.102E+04	-0.194E+06	-0.648E+01	-0.176E+02	-0.335E+04
13.00	-0.327E+03	-0.863E+03	-0.169E+06	-0.196E+02	-0.516E+02	-0.101E+05
13.50	-0.279E+03	-0.706E+03	-0.144E+06	-0.437E+02	-0.111E+03	-0.226E+05
14.00	-0.232E+03	-0.562E+03	-0.120E+06	-0.763E+02	-0.184E+03	-0.395E+05
14.50	-0.189E+03	-0.434E+03	-0.977E+05	-0.109E+03	-0.250E+03	-0.563E+05
15.00	-0.149E+03	-0.327E+03	-0.772E+05	-0.131E+03	-0.288E+03	-0.681E+05
15.50	-0.115E+03	-0.240E+03	-0.593E+05	-0.139E+03	-0.290E+03	-0.717E+05
16.00	-0.852E+02	-0.171E+03	-0.441E+05	-0.130E+03	-0.261E+03	-0.675E+05
16.50	-0.612E+02	-0.118E+03	-0.317E+05	-0.112E+03	-0.215E+03	-0.578E+05
17.00	-0.424E+02	-0.789E+02	-0.220E+05	-0.886E+02	-0.165E+03	-0.459E+05
17.50	-0.283E+02	-0.509E+02	-0.146E+05	-0.660E+02	-0.119E+03	-0.341E+05
18.00	-0.181E+02	-0.317E+02	-0.937E+04	-0.466E+02	-0.815E+02	-0.241E+05
18.50	-0.111E+02	-0.189E+02	-0.574E+04	-0.315E+02	-0.537E+02	-0.163E+05

******** IIa. Mean Reflection Force Frequency Distribution ********

Attack Angle Relative to Vessel = 60.00 degrees
Current Angle Relative to Waves = .00 degrees

Wave force model: Tanker (Legacy)
Bow-on shape factor = 1.00
Effective included bow angle = 73.74 degrees

>>> NOTE: Moments in this table are computed about the center of gravity

Wave Period (sec)	Wave Data S(Fx) (k.lbs*sec)	Wave Data S(Fy) (k.lbs*sec)	Wave Data S(Mz) (kip-ft*sec)	Swell Data S(Fx) (k.lbs*sec)	Swell Data S(Fy) (k.lbs*sec)	Swell Data S(Mz) (kip-ft*sec)
6.00	-0.281E+02	-0.270E+03	-0.145E+05	-0.000E+00	-0.000E+00	-0.000E+00
6.50	-0.404E+02	-0.386E+03	-0.209E+05	-0.000E+00	-0.000E+00	-0.000E+00
7.00	-0.567E+02	-0.536E+03	-0.293E+05	-0.000E+00	-0.000E+00	-0.000E+00
7.50	-0.780E+02	-0.723E+03	-0.404E+05	-0.000E+00	-0.000E+00	-0.000E+00
8.00	-0.107E+03	-0.949E+03	-0.551E+05	-0.684E-19	-0.609E-18	-0.354E-16
8.50	-0.146E+03	-0.122E+04	-0.757E+05	-0.469E-14	-0.391E-13	-0.243E-11
9.00	-0.205E+03	-0.153E+04	-0.106E+06	-0.308E-10	-0.231E-09	-0.160E-07
9.50	-0.297E+03	-0.191E+04	-0.154E+06	-0.341E-07	-0.219E-06	-0.177E-04
10.00	-0.366E+03	-0.220E+04	-0.189E+06	-0.787E-05	-0.474E-04	-0.407E-02
10.50	-0.422E+03	-0.242E+04	-0.218E+06	-0.565E-03	-0.324E-02	-0.292E+00
11.00	-0.444E+03	-0.249E+04	-0.230E+06	-0.156E-01	-0.872E-01	-0.805E+01
11.50	-0.410E+03	-0.236E+04	-0.212E+06	-0.189E+00	-0.109E+01	-0.977E+02
12.00	-0.371E+03	-0.215E+04	-0.192E+06	-0.130E+01	-0.754E+01	-0.674E+03
12.50	-0.330E+03	-0.187E+04	-0.171E+06	-0.569E+01	-0.322E+02	-0.295E+04
13.00	-0.288E+03	-0.156E+04	-0.149E+06	-0.172E+02	-0.934E+02	-0.890E+04
13.50	-0.245E+03	-0.126E+04	-0.127E+06	-0.384E+02	-0.197E+03	-0.199E+05
14.00	-0.204E+03	-0.984E+03	-0.106E+06	-0.671E+02	-0.323E+03	-0.347E+05
14.50	-0.166E+03	-0.746E+03	-0.859E+05	-0.957E+02	-0.430E+03	-0.495E+05
15.00	-0.131E+03	-0.550E+03	-0.679E+05	-0.116E+03	-0.485E+03	-0.598E+05
15.50	-0.101E+03	-0.394E+03	-0.521E+05	-0.122E+03	-0.477E+03	-0.630E+05
16.00	-0.749E+02	-0.275E+03	-0.388E+05	-0.115E+03	-0.421E+03	-0.593E+05
16.50	-0.538E+02	-0.186E+03	-0.279E+05	-0.982E+02	-0.339E+03	-0.508E+05
17.00	-0.373E+02	-0.122E+03	-0.193E+05	-0.779E+02	-0.254E+03	-0.403E+05
17.50	-0.249E+02	-0.771E+02	-0.129E+05	-0.580E+02	-0.180E+03	-0.300E+05
18.00	-0.159E+02	-0.471E+02	-0.824E+04	-0.410E+02	-0.121E+03	-0.212E+05
18.50	-0.976E+01	-0.277E+02	-0.505E+04	-0.277E+02	-0.786E+02	-0.144E+05

******** IIa. Mean Reflection Force Frequency Distribution ********

Attack Angle Relative to Vessel = 80.00 degrees
Current Angle Relative to Waves = .00 degrees

Wave force model: Tanker (Legacy)
Bow-on shape factor = 1.00
Effective included bow angle = 73.74 degrees

>>> NOTE: Moments in this table are computed about the center of gravity

Wave Period (sec)	-------- Wave Data S(Fx)	S(Fy) <--- k.lbs*sec --->	-------- S(Mz) (kip-ft*sec)	-------- Swell Data S(Fx)	S(Fy) <--- k.lbs*sec --->	-------- S(Mz) (kip-ft*sec)
6.00	-0.111E+02	-0.378E+03	-0.574E+04	-0.000E+00	-0.000E+00	-0.000E+00
6.50	-0.160E+02	-0.541E+03	-0.826E+04	-0.000E+00	-0.000E+00	-0.000E+00
7.00	-0.224E+02	-0.751E+03	-0.116E+05	-0.000E+00	-0.000E+00	-0.000E+00
7.50	-0.308E+02	-0.101E+04	-0.159E+05	-0.000E+00	-0.000E+00	-0.000E+00
8.00	-0.421E+02	-0.133E+04	-0.218E+05	-0.270E-19	-0.850E-18	-0.140E-16
8.50	-0.578E+02	-0.170E+04	-0.299E+05	-0.185E-14	-0.543E-13	-0.958E-12
9.00	-0.810E+02	-0.212E+04	-0.419E+05	-0.122E-10	-0.319E-09	-0.630E-08
9.50	-0.117E+03	-0.261E+04	-0.607E+05	-0.135E-07	-0.299E-06	-0.698E-05
10.00	-0.145E+03	-0.300E+04	-0.748E+05	-0.311E-05	-0.645E-04	-0.161E-02
10.50	-0.167E+03	-0.328E+04	-0.862E+05	-0.223E-03	-0.439E-02	-0.115E+00
11.00	-0.175E+03	-0.337E+04	-0.908E+05	-0.614E-02	-0.118E+00	-0.318E+01
11.50	-0.162E+03	-0.321E+04	-0.837E+05	-0.746E-01	-0.148E+01	-0.386E+02
12.00	-0.147E+03	-0.291E+04	-0.759E+05	-0.514E+00	-0.102E+02	-0.266E+03
12.50	-0.130E+03	-0.253E+04	-0.675E+05	-0.225E+01	-0.436E+02	-0.116E+04
13.00	-0.114E+03	-0.211E+04	-0.588E+05	-0.679E+01	-0.126E+03	-0.351E+04
13.50	-0.969E+02	-0.169E+04	-0.502E+05	-0.152E+02	-0.265E+03	-0.785E+04
14.00	-0.807E+02	-0.131E+04	-0.418E+05	-0.265E+02	-0.431E+03	-0.137E+05
14.50	-0.656E+02	-0.987E+03	-0.339E+05	-0.378E+02	-0.569E+03	-0.196E+05
15.00	-0.518E+02	-0.722E+03	-0.268E+05	-0.457E+02	-0.636E+03	-0.236E+05
15.50	-0.398E+02	-0.513E+03	-0.206E+05	-0.481E+02	-0.621E+03	-0.249E+05
16.00	-0.296E+02	-0.355E+03	-0.153E+05	-0.453E+02	-0.543E+03	-0.234E+05
16.50	-0.213E+02	-0.238E+03	-0.110E+05	-0.388E+02	-0.434E+03	-0.201E+05
17.00	-0.147E+02	-0.154E+03	-0.763E+04	-0.308E+02	-0.322E+03	-0.159E+05
17.50	-0.983E+01	-0.970E+02	-0.509E+04	-0.229E+02	-0.226E+03	-0.119E+05
18.00	-0.629E+01	-0.587E+02	-0.325E+04	-0.162E+02	-0.151E+03	-0.838E+04
18.50	-0.385E+01	-0.342E+02	-0.199E+04	-0.110E+02	-0.972E+02	-0.567E+04

******** IIa. Mean Reflection Force Frequency Distribution ********

Attack Angle Relative to Vessel = 100.00 degrees
Current Angle Relative to Waves = .00 degrees

Wave force model: Tanker (Legacy)
Bow-on shape factor = 1.00
Effective included bow angle = 73.74 degrees

>>> NOTE: Moments in this table are computed about the center of gravity

Wave Period (sec)	-------- Wave Data S(Fx)	S(Fy) <--- k.lbs*sec --->	-------- S(Mz) (kip-ft*sec)	-------- Swell Data S(Fx)	S(Fy) <--- k.lbs*sec --->	-------- S(Mz) (kip-ft*sec)
6.00	0.111E+02	-0.378E+03	0.574E+04	0.000E+00	-0.000E+00	0.000E+00
6.50	0.160E+02	-0.541E+03	0.826E+04	0.000E+00	-0.000E+00	0.000E+00
7.00	0.224E+02	-0.751E+03	0.116E+05	0.000E+00	-0.000E+00	0.000E+00
7.50	0.308E+02	-0.101E+04	0.159E+05	0.000E+00	-0.000E+00	0.000E+00
8.00	0.421E+02	-0.133E+04	0.218E+05	0.270E-19	-0.850E-18	0.140E-16
8.50	0.578E+02	-0.170E+04	0.299E+05	0.185E-14	-0.543E-13	0.958E-12
9.00	0.810E+02	-0.212E+04	0.419E+05	0.122E-10	-0.319E-09	0.630E-08
9.50	0.117E+03	-0.261E+04	0.607E+05	0.135E-07	-0.299E-06	0.698E-05
10.00	0.145E+03	-0.300E+04	0.748E+05	0.311E-05	-0.645E-04	0.161E-02
10.50	0.167E+03	-0.328E+04	0.862E+05	0.223E-03	-0.439E-02	0.115E+00
11.00	0.175E+03	-0.337E+04	0.908E+05	0.614E-02	-0.118E+00	0.318E+01
11.50	0.162E+03	-0.321E+04	0.837E+05	0.746E-01	-0.148E+01	0.386E+02
12.00	0.147E+03	-0.291E+04	0.759E+05	0.514E+00	-0.102E+02	0.266E+03
12.50	0.130E+03	-0.253E+04	0.675E+05	0.225E+01	-0.436E+02	0.116E+04
13.00	0.114E+03	-0.211E+04	0.588E+05	0.679E+01	-0.126E+03	0.351E+04
13.50	0.969E+02	-0.169E+04	0.502E+05	0.152E+02	-0.265E+03	0.785E+04
14.00	0.807E+02	-0.131E+04	0.418E+05	0.265E+02	-0.431E+03	0.137E+05
14.50	0.656E+02	-0.987E+03	0.339E+05	0.378E+02	-0.569E+03	0.196E+05
15.00	0.518E+02	-0.722E+03	0.268E+05	0.457E+02	-0.636E+03	0.236E+05
15.50	0.398E+02	-0.513E+03	0.206E+05	0.481E+02	-0.621E+03	0.249E+05
16.00	0.296E+02	-0.355E+03	0.153E+05	0.453E+02	-0.543E+03	0.234E+05
16.50	0.213E+02	-0.238E+03	0.110E+05	0.388E+02	-0.434E+03	0.201E+05
17.00	0.147E+02	-0.154E+03	0.763E+04	0.308E+02	-0.322E+03	0.159E+05
17.50	0.983E+01	-0.970E+02	0.509E+04	0.229E+02	-0.226E+03	0.119E+05
18.00	0.629E+01	-0.587E+02	0.325E+04	0.162E+02	-0.151E+03	0.838E+04
18.50	0.385E+01	-0.342E+02	0.199E+04	0.110E+02	-0.972E+02	0.567E+04

******** IIa. Mean Reflection Force Frequency Distribution ********

Attack Angle Relative to Vessel = 120.00 degrees
Current Angle Relative to Waves = .00 degrees

Wave force model: Tanker (Legacy)
Bow-on shape factor = 1.00
Effective included bow angle = 73.74 degrees

>>> NOTE: Moments in this table are computed about the center of gravity

Wave Period (sec)	-------- Wave Data S(Fx) <--- k.lbs*sec	S(Fy) --->	-------- S(Mz) (kip-ft*sec)	-------- Swell Data S(Fx) <--- k.lbs*sec	S(Fy) --->	-------- S(Mz) (kip-ft*sec)
6.00	0.281E+02	-0.270E+03	0.145E+05	0.000E+00	-0.000E+00	0.000E+00
6.50	0.404E+02	-0.386E+03	0.209E+05	0.000E+00	-0.000E+00	0.000E+00
7.00	0.567E+02	-0.536E+03	0.293E+05	0.000E+00	-0.000E+00	0.000E+00
7.50	0.780E+02	-0.723E+03	0.404E+05	0.000E+00	-0.000E+00	0.000E+00
8.00	0.107E+03	-0.949E+03	0.551E+05	0.684E-19	-0.609E-18	0.354E-16
8.50	0.146E+03	-0.122E+04	0.757E+05	0.469E-14	-0.391E-13	0.243E-11
9.00	0.205E+03	-0.153E+04	0.106E+06	0.308E-10	-0.231E-09	0.160E-07
9.50	0.297E+03	-0.191E+04	0.154E+06	0.341E-07	-0.219E-06	0.177E-04
10.00	0.366E+03	-0.220E+04	0.189E+06	0.787E-05	-0.474E-04	0.407E-02
10.50	0.422E+03	-0.242E+04	0.218E+06	0.565E-03	-0.324E-02	0.292E+00
11.00	0.444E+03	-0.249E+04	0.230E+06	0.156E-01	-0.872E-01	0.805E+01
11.50	0.410E+03	-0.236E+04	0.212E+06	0.189E+00	-0.109E+01	0.977E+02
12.00	0.371E+03	-0.215E+04	0.192E+06	0.130E+01	-0.754E+01	0.674E+03
12.50	0.330E+03	-0.187E+04	0.171E+06	0.569E+01	-0.322E+02	0.295E+04
13.00	0.288E+03	-0.156E+04	0.149E+06	0.172E+02	-0.934E+02	0.890E+04
13.50	0.245E+03	-0.126E+04	0.127E+06	0.384E+02	-0.197E+03	0.199E+05
14.00	0.204E+03	-0.984E+03	0.106E+06	0.671E+02	-0.323E+03	0.347E+05
14.50	0.166E+03	-0.746E+03	0.859E+05	0.957E+02	-0.430E+03	0.495E+05
15.00	0.131E+03	-0.550E+03	0.679E+05	0.116E+03	-0.485E+03	0.598E+05
15.50	0.101E+03	-0.394E+03	0.521E+05	0.122E+03	-0.477E+03	0.630E+05
16.00	0.749E+02	-0.275E+03	0.388E+05	0.115E+03	-0.421E+03	0.593E+05
16.50	0.538E+02	-0.186E+03	0.279E+05	0.982E+02	-0.339E+03	0.508E+05
17.00	0.373E+02	-0.122E+03	0.193E+05	0.779E+02	-0.254E+03	0.403E+05
17.50	0.249E+02	-0.771E+02	0.129E+05	0.580E+02	-0.180E+03	0.300E+05
18.00	0.159E+02	-0.471E+02	0.824E+04	0.410E+02	-0.121E+03	0.212E+05
18.50	0.976E+01	-0.277E+02	0.505E+04	0.277E+02	-0.786E+02	0.144E+05

******** IIa. Mean Reflection Force Frequency Distribution ********

Attack Angle Relative to Vessel = 140.00 degrees
Current Angle Relative to Waves = .00 degrees

Wave force model: Tanker (Legacy)
Bow-on shape factor = 1.00
Effective included bow angle = 73.74 degrees

>>> NOTE: Moments in this table are computed about the center of gravity

Wave Period (sec)	-------- Wave Data S(Fx) <--- k.lbs*sec	S(Fy) --->	-------- S(Mz) (kip-ft*sec)	-------- Swell Data S(Fx) <--- k.lbs*sec	S(Fy) --->	-------- S(Mz) (kip-ft*sec)
6.00	0.319E+02	-0.132E+03	0.165E+05	0.000E+00	-0.000E+00	0.000E+00
6.50	0.460E+02	-0.189E+03	0.238E+05	0.000E+00	-0.000E+00	0.000E+00
7.00	0.644E+02	-0.263E+03	0.333E+05	0.000E+00	-0.000E+00	0.000E+00
7.50	0.887E+02	-0.356E+03	0.459E+05	0.000E+00	-0.000E+00	0.000E+00
8.00	0.121E+03	-0.471E+03	0.627E+05	0.777E-19	-0.302E-18	0.402E-16
8.50	0.166E+03	-0.612E+03	0.861E+05	0.533E-14	-0.196E-13	0.276E-11
9.00	0.233E+03	-0.787E+03	0.121E+06	0.351E-10	-0.118E-09	0.181E-07
9.50	0.338E+03	-0.101E+04	0.175E+06	0.388E-07	-0.116E-06	0.201E-04
10.00	0.416E+03	-0.119E+04	0.215E+06	0.895E-05	-0.255E-04	0.463E-02
10.50	0.480E+03	-0.132E+04	0.248E+06	0.642E-03	-0.176E-02	0.332E+00
11.00	0.505E+03	-0.136E+04	0.261E+06	0.177E-01	-0.478E-01	0.916E+01
11.50	0.466E+03	-0.129E+04	0.241E+06	0.215E+00	-0.593E+00	0.111E+03
12.00	0.422E+03	-0.117E+04	0.218E+06	0.148E+01	-0.410E+01	0.767E+03
12.50	0.375E+03	-0.102E+04	0.194E+06	0.648E+01	-0.176E+02	0.335E+04
13.00	0.327E+03	-0.863E+03	0.169E+06	0.196E+02	-0.516E+02	0.101E+05
13.50	0.279E+03	-0.706E+03	0.144E+06	0.437E+02	-0.111E+03	0.226E+05
14.00	0.232E+03	-0.562E+03	0.120E+06	0.763E+02	-0.184E+03	0.395E+05
14.50	0.189E+03	-0.434E+03	0.977E+05	0.109E+03	-0.250E+03	0.563E+05
15.00	0.149E+03	-0.327E+03	0.772E+05	0.131E+03	-0.288E+03	0.681E+05
15.50	0.115E+03	-0.240E+03	0.593E+05	0.139E+03	-0.290E+03	0.717E+05
16.00	0.852E+02	-0.171E+03	0.441E+05	0.130E+03	-0.261E+03	0.675E+05
16.50	0.612E+02	-0.118E+03	0.317E+05	0.112E+03	-0.215E+03	0.578E+05
17.00	0.424E+02	-0.789E+02	0.220E+05	0.886E+02	-0.165E+03	0.459E+05
17.50	0.283E+02	-0.509E+02	0.146E+05	0.660E+02	-0.119E+03	0.341E+05
18.00	0.181E+02	-0.317E+02	0.937E+04	0.466E+02	-0.815E+02	0.241E+05
18.50	0.111E+02	-0.189E+02	0.574E+04	0.315E+02	-0.537E+02	0.163E+05

******** IIa. Mean Reflection Force Frequency Distribution ********

Attack Angle Relative to Vessel = 160.00 degrees
Current Angle Relative to Waves = .00 degrees

Wave force model: Tanker (Legacy)
Bow-on shape factor = 1.00
Effective included bow angle = 73.74 degrees

>>> NOTE: Moments in this table are computed about the center of gravity

Wave Period (sec)	Wave Data S(Fx) k.lbs*sec	Wave Data S(Fy) k.lbs*sec	Wave Data S(Mz) (kip-ft*sec)	Swell Data S(Fx) k.lbs*sec	Swell Data S(Fy) k.lbs*sec	Swell Data S(Mz) (kip-ft*sec)
6.00	0.265E+02	-0.412E+02	0.108E+05	0.000E+00	-0.000E+00	0.000E+00
6.50	0.382E+02	-0.592E+02	0.155E+05	0.000E+00	-0.000E+00	0.000E+00
7.00	0.535E+02	-0.827E+02	0.218E+05	0.000E+00	-0.000E+00	0.000E+00
7.50	0.737E+02	-0.113E+03	0.300E+05	0.000E+00	-0.000E+00	0.000E+00
8.00	0.101E+03	-0.152E+03	0.409E+05	0.646E-19	-0.975E-19	0.263E-16
8.50	0.138E+03	-0.203E+03	0.562E+05	0.443E-14	-0.652E-14	0.180E-11
9.00	0.194E+03	-0.274E+03	0.787E+05	0.291E-10	-0.412E-10	0.118E-07
9.50	0.281E+03	-0.378E+03	0.114E+06	0.322E-07	-0.434E-07	0.131E-04
10.00	0.346E+03	-0.457E+03	0.141E+06	0.744E-05	-0.982E-05	0.302E-02
10.50	0.398E+03	-0.519E+03	0.162E+06	0.533E-03	-0.695E-03	0.217E+00
11.00	0.420E+03	-0.543E+03	0.171E+06	0.147E-01	-0.190E-01	0.598E+01
11.50	0.387E+03	-0.505E+03	0.157E+06	0.178E+00	-0.233E+00	0.725E+02
12.00	0.351E+03	-0.458E+03	0.143E+06	0.123E+01	-0.161E+01	0.500E+03
12.50	0.312E+03	-0.405E+03	0.127E+06	0.538E+01	-0.698E+01	0.219E+04
13.00	0.272E+03	-0.349E+03	0.111E+06	0.162E+02	-0.208E+02	0.661E+04
13.50	0.232E+03	-0.293E+03	0.943E+05	0.363E+02	-0.458E+02	0.148E+05
14.00	0.193E+03	-0.240E+03	0.785E+05	0.634E+02	-0.787E+02	0.258E+05
14.50	0.157E+03	-0.192E+03	0.638E+05	0.904E+02	-0.110E+03	0.368E+05
15.00	0.124E+03	-0.149E+03	0.504E+05	0.109E+03	-0.131E+03	0.444E+05
15.50	0.952E+02	-0.113E+03	0.387E+05	0.115E+03	-0.136E+03	0.468E+05
16.00	0.708E+02	-0.826E+02	0.288E+05	0.108E+03	-0.126E+03	0.440E+05
16.50	0.509E+02	-0.587E+02	0.207E+05	0.928E+02	-0.107E+03	0.377E+05
17.00	0.353E+02	-0.402E+02	0.143E+05	0.736E+02	-0.840E+02	0.299E+05
17.50	0.235E+02	-0.266E+02	0.956E+04	0.548E+02	-0.620E+02	0.223E+05
18.00	0.150E+02	-0.169E+02	0.612E+04	0.387E+02	-0.434E+02	0.157E+05
18.50	0.922E+01	-0.103E+02	0.375E+04	0.262E+02	-0.292E+02	0.107E+05

************* III. Mean Wave Reflection Forces & Moments *************

---- Wave Characteristics ----

Wave Spectral Type -- Bretschneider; Long-crested seas

Requested Significant wave height .... 20.00 ft
Calculated Significant wave height ... 19.41 ft
Spectrum peak period .... 13.00 seconds

+++ Background Swell Data +++

Requested Significant swell height ... 10.00 ft
Swell period .... 16.00 seconds
Swell spectral bandwidth .... .10

Wave force model .... Tanker (Legacy)
Bow-on shape factor 1.00
Effective included bow angle .... 73.74 degrees

>>> NOTE: Moments in this table are computed about Xves = .00 ft
Current Angle Relative to Waves = .00 degrees

Angle of Attack (deg)	Wave Data Fx (k.lbs)	Wave Data Fy (k.lbs)	Wave Data Mz (kip-ft)	Swell Data Fx (k.lbs)	Swell Data Fy (k.lbs)	Swell Data Mz (kip-ft)
-.0	-1.062E+02	0.000E-01	0.000E-01	-1.004E+01	0.000E-01	0.000E-01
20.0	-1.159E+02	-1.559E+02	-4.713E+04	-1.095E+01	-1.303E+01	-4.454E+03
40.0	-1.395E+02	-4.159E+02	-7.220E+04	-1.318E+01	-2.804E+01	-6.824E+03
60.0	-1.227E+02	-7.837E+02	-6.349E+04	-1.159E+01	-4.650E+01	-6.000E+03
80.0	-4.845E+01	-1.071E+03	-2.508E+04	-4.579E+00	-6.070E+01	-2.370E+03
100.0	4.845E+01	-1.071E+03	2.508E+04	4.579E+00	-6.070E+01	2.370E+03
120.0	1.227E+02	-7.837E+02	6.349E+04	1.159E+01	-4.650E+01	6.000E+03
140.0	1.395E+02	-4.159E+02	7.220E+04	1.318E+01	-2.804E+01	6.824E+03
160.0	1.159E+02	-1.559E+02	4.713E+04	1.095E+01	-1.303E+01	4.454E+03

```
  **  IV. "Low-Frequency" Wave Reflection Force & Moment Spectral Densities  **

    ----  Wave Characteristics  ----

    Wave Spectral Type -- Bretschneider; Long-crested seas

         Requested Significant wave height ....     20.00 ft
         Calculated Significant wave height ...     19.41 ft
         Spectrum peak period ................     13.00 seconds

         +++ Background Swell Data +++

         Requested Significant swell height ...     10.00 ft
         Swell period .........................     16.00 seconds
         Swell spectral bandwidth .............       .10

         Wave force model .....................  Tanker (Legacy)
         Bow-on shape factor ..................      1.00
         Effective included bow angle .........     73.74 degrees
         Variable reflection enhancement factor      1.00

>>> NOTE: Moments in this table are computed about Xves =      .00 ft
          Frequency of "low-frequency" oscillations     =     .000 rad/sec
          Current Angle Relative to Waves               =      .00 degrees
```

Angle of Attack (deg)	Wave Data SFx <-- [k.lbs]^2*s	Wave Data SFy [k.lbs]^2*s -->	Wave Data SMz [kip-ft]^2*s	Swell Data SFx <-- [k.lbs]^2*s	Swell Data SFy [k.lbs]^2*s -->	Swell Data SMz [kip-ft]^2*s
-.0	5.196E+04	0.000E-01	0.000E-01	1.531E+03	0.000E-01	0.000E-01
20.0	6.185E+04	1.079E+05	1.022E+10	1.823E+03	2.568E+03	3.013E+08
40.0	8.959E+04	7.340E+05	2.400E+10	2.640E+03	1.184E+04	7.072E+08
60.0	6.928E+04	2.555E+06	1.856E+10	2.042E+03	3.261E+04	5.469E+08
80.0	1.081E+04	4.745E+06	2.894E+09	3.185E+02	5.565E+04	8.530E+07
100.0	1.081E+04	4.745E+06	2.894E+09	3.185E+02	5.565E+04	8.530E+07
120.0	6.928E+04	2.555E+06	1.856E+10	2.042E+03	3.261E+04	5.469E+08
140.0	8.959E+04	7.340E+05	2.400E+10	2.640E+03	1.184E+04	7.072E+08
160.0	6.185E+04	1.079E+05	1.022E+10	1.823E+03	2.568E+03	3.013E+08

```
  *********   V. Dimensionless Wind and Current Coefficients   ************

>>> NOTE: Dimensional wind/current forces & moments are defined by:

           Head-on force = .5*Ah*Df*(V^2)*Cx
           Beam-on force = .5*Ab*Df*(V^2)*Cy
           Moment at CG  = .5*L*Ab*Df*(V^2)*Cz

           V  = Relevant (wind or current) speed

           Ah = Head-On Projected Area
           Ab = Beam-On Projected Area
           L  = Vessel Length
           Df = Relevant (air or water) mass density

           Wind force model ..................  OCIMF Tanker '77 (extended)
           Above-Water Bow Shape .............  Conventional
           Freeboard-Based Load ..............  100.00 Percent
           Tanker Deadweight .................  300000 kips

           Head-on Current Coefficients (Cx) ..  User-Specified LOWDAT
           Beam-on Current Coefficients (Cy) ..  NSMB Tanker '91
           Current Moment Coefficients  (Cz) ..  Barge (SeaSoft)
           Below-Water Bow Shape .............  Interpolated
           Bow Interpolation Factor ..........     .50
           Draft-Based Load ..................  100.00 Percent
           Water depth/draft ratio ...........    7.03
           Water depth/draft parameter .......    7.03
```

Angle of Attack (deg)	Wind Cx	Wind Cy	Wind Cz	Current Cx	Current Cy	Current Cz
-.0	-.90315	.00000	.00000	1.00000	.00000	.00000
20.0	-.78898	-.18567	.01411	.94000	-.15210	.00000
40.0	-.59541	-.43805	.04242	.76700	-.32748	.00000
60.0	-.33535	-.63595	.06934	.50000	-.47551	.00000
80.0	-.07412	-.71191	.09335	.17400	-.56968	.00000
100.0	.13383	-.71963	.11746	-.17400	-.58302	-.00000
120.0	.28873	-.68052	.15289	-.50000	-.48985	-.00000
140.0	.50594	-.54365	.15183	-.76700	-.34078	-.00000
160.0	.71634	-.27921	.09470	-.94000	-.15708	-.00000

```
************   VI. Mean Wind and Current Forces & Moments   ***********

         Wind force model ..................  OCIMF Tanker '77 (extended)
         Above-Water Bow Shape .............  Conventional
         Freeboard-Based Load ..............  100.00 Percent
         Tanker Deadweight .................  300000 kips

         Head-on Current Coefficients (Cx) ..  User-Specified LOWDAT
         Beam-on Current Coefficients (Cy) ..  NSMB Tanker '91
         Current Moment Coefficients  (Cz) ..  Barge (SeaSoft)
         Below-Water Bow Shape .............  Interpolated
         Bow Interpolation Factor ..........      .50
         Draft-Based Load ..................  100.00 Percent
         Water depth/draft ratio ...........    7.03
         Water depth/draft parameter ........    7.03

>>> NOTE: Moments in this table are computed about Xves =      .00 ft
```

Angle of Attack (deg)	Wind Fx (k.lbs)	Wind Fy (k.lbs)	Wind Mz (kip-ft)	Current Cx (k.lbs)	Current Cy (k.lbs)	Current Cz (kip-ft)
-.0	-8.335E+01	0.000E-01	0.000E-01	1.064E+02	0.000E-01	0.000E-01
20.0	-7.282E+01	-5.326E+01	3.761E+03	1.000E+02	-1.029E+02	0.000E-01
40.0	-5.495E+01	-1.257E+02	1.130E+04	8.164E+01	-2.215E+02	0.000E-01
60.0	-3.095E+01	-1.824E+02	1.848E+04	5.322E+01	-3.216E+02	0.000E-01
80.0	-6.841E+00	-2.042E+02	2.488E+04	1.852E+01	-3.853E+02	0.000E-01
100.0	1.235E+01	-2.064E+02	3.130E+04	-1.852E+01	-3.943E+02	0.000E-01
120.0	2.665E+01	-1.952E+02	4.074E+04	-5.322E+01	-3.313E+02	0.000E-01
140.0	4.669E+01	-1.559E+02	4.046E+04	-8.164E+01	-2.305E+02	0.000E-01
160.0	6.611E+01	-8.009E+01	2.524E+04	-1.000E+02	-1.062E+02	0.000E-01

```
***  VII. "Low-Frequency" Wind/Current Force & Moment Spectral Densities  ***

>>> NOTE: Moments in this table are computed about Xves =      .00 ft
          Frequency of "low-frequency" oscillations     =     .000 rad/sec
```

Angle of Attack (deg)	Wind Data SFx [k.lbs]^2*s	Wind Data SFy [k.lbs]^2*s	Wind Data SMz [kip-ft]^2*s	Current Data SFx [k.lbs]^2*s	Current Data SFy [k.lbs]^2*s	Current Data SMz [kip-ft]^2*s
-.0	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01
20.0	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01
40.0	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01
60.0	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01
80.0	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01
100.0	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01
120.0	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01
140.0	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01
160.0	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01

**************** VIII. Irregular Wave Spectral Values *****************

---- Wave Characteristics ----

Wave Spectral Type -- Bretschneider; Long-crested seas

Requested Significant wave height .... 20.00 ft
Calculated Significant wave height ... 19.41 ft
Spectrum peak period .... 13.00 seconds
Spectrum characteristic wind speed ... 59.02 feet/sec
Spectrum characteristic wave slope ... 4.17 degrees
Direction of maximum seas .... 180.00 degrees

+++ Background Swell Data +++

Requested Significant swell height ... 10.00 ft
Swell direction .... 210.00 degrees
Swell period .... 16.00 seconds
Swell spectral bandwidth .... .10
Swell characteristic wave slope ...... 1.41 degrees

>>> Wave height for slope calculation = 14.00 ft

Wave Period (Sec)	Wave Frequency (rad/sec)	Wave Length (ft)	Wave slope (deg)	Wave Spectrum <-- (ft^2/[rad/sec])	Swell Spectrum -->
6.000	1.047	184.217	13.679	5.1187	.0000
6.500	.967	216.200	11.656	7.4761	.0000
7.000	.898	250.740	10.050	10.5413	.0000
7.500	.838	287.840	8.755	14.3948	.0000
8.000	.785	327.498	7.695	19.0825	0.0000
8.500	.739	369.714	6.816	24.5988	0.0000
9.000	.698	414.488	6.080	30.8706	0.0000
9.500	.661	461.818	5.457	37.7434	0.0000
10.000	.628	511.699	4.925	44.9745	0.0000
10.500	.598	564.116	4.467	52.2337	.0001
11.000	.571	619.042	4.071	59.1175	.0021
11.500	.546	676.426	3.725	65.1762	.0300
12.000	.524	736.190	3.423	69.9535	.2455
12.500	.503	798.216	3.157	73.0371	1.2598
13.000	.483	862.347	2.922	74.1119	4.4292
13.500	.465	928.389	2.714	73.0094	11.4302
14.000	.449	996.116	2.530	69.7419	22.8862
14.500	.433	1065.282	2.366	64.5148	37.1834
15.000	.419	1135.630	2.219	57.7098	50.8417
15.500	.405	1206.911	2.088	49.8418	60.2746
16.000	.393	1278.888	1.970	41.4930	63.4936
16.500	.381	1351.350	1.865	33.2380	60.6443
17.000	.370	1424.111	1.770	25.5725	53.4063
17.500	.359	1497.015	1.683	18.8604	43.9737
18.000	.349	1569.933	1.605	13.3073	34.2489
18.500	.340	1642.762	1.534	8.9634	25.4793

************* VIIIp. Irregular Wave Group Spectral Values **************

---- Wave Characteristics ----

Wave Spectral Type -- Bretschneider; Long-crested seas

Requested Significant wave height .... 20.00 ft
Calculated Significant wave height ... 19.41 ft
Spectrum peak period .... 13.00 seconds
Spectrum characteristic wind speed ... 59.02 feet/sec
Spectrum characteristic wave slope ... 4.17 degrees
Direction of maximum seas .... 180.00 degrees

+++ Background Swell Data +++

Requested Significant swell height ... 10.00 ft
Swell direction .... 210.00 degrees
Swell period .... 16.00 seconds
Swell spectral bandwidth .... .10
Swell characteristic wave slope ...... 1.41 degrees

Group Frequency (rad/sec)	Group Period (Sec)	Wave InterGroup Spacing (ft)	Swell InterGroup Spacing (ft)	Wave Group Spectrum <-- (ft^4/[rad/sec])	Swell Group Spectrum -->
.0000	Infinity	Infinity	Infinity	9.30E+03	2.22E+03
.0025	2513.27	84909.98	111116.60	9.27E+03	2.13E+03
.0050	1256.64	42454.99	55558.29	9.26E+03	2.12E+03
.0075	837.76	28303.32	37038.86	9.25E+03	2.10E+03
.0100	628.32	21227.49	27779.14	9.24E+03	2.08E+03
.0125	502.65	16982.00	22223.31	9.23E+03	2.07E+03
.0150	418.88	14151.66	18519.43	9.21E+03	2.04E+03
.0175	359.04	12130.00	15873.80	9.20E+03	2.02E+03
.0200	314.16	10613.75	13889.57	9.17E+03	1.94E+03
.0225	279.25	9434.44	12346.29	9.16E+03	1.92E+03
.0250	251.33	8491.00	11111.66	9.14E+03	1.88E+03
.0275	228.48	7719.09	10101.51	9.12E+03	1.84E+03
.0300	209.44	7075.83	9259.71	9.10E+03	1.79E+03
.0325	193.33	6531.54	8547.43	9.07E+03	1.74E+03
.0350	179.52	6065.00	7936.90	9.04E+03	1.69E+03
.0375	167.55	5660.67	7407.77	9.01E+03	1.64E+03
.0400	157.08	5306.87	6944.79	8.94E+03	1.43E+03
.0425	147.84	4994.70	6536.27	8.90E+03	1.39E+03
.0450	139.63	4717.22	6173.14	8.86E+03	1.35E+03
.0475	132.28	4468.95	5848.24	8.81E+03	1.30E+03
.0500	125.66	4245.50	5555.83	8.77E+03	1.26E+03
.0525	119.68	4043.33	5291.26	8.72E+03	1.20E+03
.0550	114.24	3859.54	5050.75	8.68E+03	1.15E+03
.0575	109.27	3691.74	4831.15	8.63E+03	1.10E+03
.0600	104.72	3537.92	4629.86	8.55E+03	9.53E+02
.0625	100.53	3396.40	4444.66	8.50E+03	9.06E+02
.0650	96.66	3265.77	4273.71	8.45E+03	8.61E+02
.0675	93.08	3144.81	4115.43	8.40E+03	8.18E+02
.0700	89.76	3032.50	3968.45	8.34E+03	7.77E+02
.0725	86.66	2927.93	3831.61	8.29E+03	7.36E+02
.0750	83.78	2830.33	3703.89	8.23E+03	6.96E+02
.0775	81.07	2739.03	3584.41	8.17E+03	6.56E+02
.0800	78.54	2653.44	3472.39	8.11E+03	6.16E+02
.0825	76.16	2573.03	3367.17	7.99E+03	4.28E+02
.0850	73.92	2497.35	3268.13	7.93E+03	4.00E+02
.0875	71.81	2426.00	3174.76	7.87E+03	3.73E+02
.0900	69.81	2358.61	3086.57	7.81E+03	3.48E+02
.0925	67.93	2294.86	3003.15	7.74E+03	3.23E+02
.0950	66.14	2234.47	2924.12	7.68E+03	3.00E+02
.0975	64.44	2177.18	2849.14	7.62E+03	2.78E+02
.1000	62.83	2122.75	2777.91	7.55E+03	2.56E+02
.1025	61.30	2070.98	2710.16	7.49E+03	2.38E+02
.1050	59.84	2021.67	2645.63	7.42E+03	2.20E+02
.1075	58.45	1974.65	2584.11	7.32E+03	1.61E+02
.1100	57.12	1929.77	2525.38	7.25E+03	1.48E+02

.1125	55.85	1886.89	2469.26	7.18E+03	1.36E+02
.1150	54.64	1845.87	2415.58	7.12E+03	1.24E+02
.1175	53.47	1806.60	2364.18	7.05E+03	1.13E+02
.1200	52.36	1768.96	2314.93	6.98E+03	1.02E+02
.1225	51.29	1732.86	2267.69	6.92E+03	9.35E+01
.1250	50.27	1698.20	2222.33	6.85E+03	8.51E+01
.1275	49.28	1664.90	2178.76	6.78E+03	7.71E+01
.1300	48.33	1632.88	2136.86	6.71E+03	6.97E+01
.1325	47.42	1602.08	2096.54	6.55E+03	3.15E+01
.1350	46.54	1572.41	2057.72	6.49E+03	2.82E+01
.1375	45.70	1543.82	2020.30	6.42E+03	2.49E+01
.1400	44.88	1516.25	1984.23	6.36E+03	2.24E+01
.1425	44.09	1489.65	1949.41	6.29E+03	2.04E+01
.1450	43.33	1463.97	1915.80	6.23E+03	1.86E+01
.1475	42.60	1439.15	1883.33	6.16E+03	1.67E+01
.1500	41.89	1415.17	1851.94	6.10E+03	1.50E+01
.1525	41.20	1391.97	1821.58	6.03E+03	1.35E+01
.1550	40.54	1369.52	1792.20	5.97E+03	1.21E+01
.1575	39.89	1347.78	1763.76	5.90E+03	1.07E+01
.1600	39.27	1326.72	1736.20	5.79E+03	5.95E+00
.1625	38.67	1306.31	1709.49	5.68E+03	5.26E+00
.1650	38.08	1286.52	1683.59	5.62E+03	4.69E+00
.1675	37.51	1267.31	1658.46	5.56E+03	4.14E+00
.1700	36.96	1248.68	1634.07	5.50E+03	3.62E+00
.1725	36.42	1230.58	1610.39	5.43E+03	3.12E+00
.1750	35.90	1213.00	1587.38	5.37E+03	2.65E+00
.1775	35.40	1195.92	1565.02	5.31E+03	2.21E+00
.1800	34.91	1179.31	1543.29	5.25E+03	1.80E+00
.1825	34.43	1163.15	1522.15	5.19E+03	1.58E+00
.1850	33.96	1147.43	1501.58	5.13E+03	1.41E+00

**************** IX. Net Environmental Forces & Moments ***************

Global Heading of Wind = 150.00 deg
Global Heading of Current = 180.00 deg
Global Heading of Waves = 180.00 deg
Global Heading of Swell = 210.00 deg

>>> NOTE: Moments in this table are computed about Xves = .00 ft

------------------- Vessel-Based X Forces ------------------- (k.lbs)

Vessel Heading (deg)	Wave	Wind	Current	Swell	External	NET
-.0	-1.062E+02	-6.460E+01	1.064E+02	-1.202E+01	0.000E-01	-7.643E+01
20.0	-1.159E+02	-4.322E+01	1.000E+02	-1.030E+01	0.000E-01	-6.939E+01
40.0	-1.395E+02	-1.893E+01	8.164E+01	-1.030E+01	0.000E-01	-8.711E+01
60.0	-1.227E+02	4.061E+00	5.322E+01	-1.202E+01	0.000E-01	-7.743E+01
80.0	-4.845E+01	1.921E+01	1.852E+01	-1.321E+01	0.000E-01	-2.393E+01
100.0	4.845E+01	3.562E+01	-1.852E+01	-8.623E+00	0.000E-01	5.692E+01
120.0	1.227E+02	5.843E+01	-5.322E+01	0.000E-01	0.000E-01	1.279E+02
140.0	1.395E+02	6.750E+01	-8.164E+01	8.623E+00	0.000E-01	1.340E+02
160.0	1.159E+02	6.750E+01	-1.000E+02	1.321E+01	0.000E-01	9.658E+01

```
 ****************  IX. Net Environmental Forces & Moments   ***************

                    Global Heading of Wind    =  150.00 deg
                    Global Heading of Current =  180.00 deg
                    Global Heading of Waves   =  180.00 deg
                    Global Heading of Swell   =  210.00 deg

>>> NOTE: Moments in this table are computed about Xves =      .00 ft

           -------------------   Vessel-Based Y Forces   -------------------
                                        (k.lbs)
 Vessel
Heading     Wave        Wind        Current     Swell      External      NET
 (deg)

   -.0   0.000E-01   8.710E+01   0.000E-01  -2.046E+01   0.000E-01   6.664E+01
  20.0   1.559E+02   1.594E+02   1.029E+02  -6.326E+00   0.000E-01   4.118E+02
  40.0   4.159E+02   1.965E+02   2.215E+02   6.326E+00   0.000E-01   8.402E+02
  60.0   7.837E+02   2.067E+02   3.216E+02   2.046E+01   0.000E-01   1.332E+03
  80.0   1.071E+03   2.038E+02   3.853E+02   3.743E+01   0.000E-01   1.698E+03
 100.0   1.071E+03   1.791E+02   3.943E+02   5.565E+01   0.000E-01   1.700E+03
 120.0   7.837E+02   1.229E+02   3.313E+02   6.364E+01   0.000E-01   1.302E+03
 140.0   4.159E+02   3.689E+01   2.305E+02   5.565E+01   0.000E-01   7.389E+02
 160.0   1.559E+02  -3.689E+01   1.062E+02   3.743E+01   0.000E-01   2.626E+02
```

```
 ****************  IX. Net Environmental Forces & Moments   ***************

                    Global Heading of Wind    =  150.00 deg
                    Global Heading of Current =  180.00 deg
                    Global Heading of Waves   =  180.00 deg
                    Global Heading of Swell   =  210.00 deg

>>> NOTE: Moments in this table are computed about Xves =      .00 ft

           -------------------   Vessel-Based Z Moments   -------------------
                                        (kip-ft)
 Vessel
Heading     Wave        Wind        Current     Swell      External      NET
 (deg)

   -.0  -2.276E-02  -7.105E+03   0.000E-01  -6.013E+03   0.000E-01  -1.312E+04
  20.0   4.713E+04  -1.510E+04   0.000E-01  -2.375E+03   0.000E-01   2.965E+04
  40.0   7.220E+04  -2.193E+04   0.000E-01   2.375E+03   0.000E-01   5.264E+04
  60.0   6.349E+04  -2.741E+04   0.000E-01   6.013E+03   0.000E-01   4.209E+04
  80.0   2.508E+04  -3.663E+04   0.000E-01   6.837E+03   0.000E-01  -4.717E+03
 100.0  -2.508E+04  -4.197E+04   0.000E-01   4.463E+03   0.000E-01  -6.258E+04
 120.0  -6.349E+04  -3.523E+04   0.000E-01   0.000E-01   0.000E-01  -9.873E+04
 140.0  -7.220E+04  -1.257E+04   0.000E-01  -4.463E+03   0.000E-01  -8.923E+04
 160.0  -4.713E+04   1.257E+04   0.000E-01  -6.837E+03   0.000E-01  -4.140E+04
```

```
****************  X. Environmental Force & Moment Summary   ***************

                  Global Heading of Wind    =  150.00 deg
                  Global Heading of Current =  180.00 deg
                  Global Heading of Waves   =  180.00 deg
                  Global Heading of Swell   =  210.00 deg
```

Vessel Heading (deg)	--- Vessel System --- VFx (k.lbs)	VFy (k.lbs)	Angle (deg)	--- Global System --- GFx (k.lbs)	GFy (k.lbs)	Angle (deg)	Net Force (k.lbs)	Net Moment (kip-ft)
-.0	-76.4	66.6	138.9	-76.4	66.6	138.9	101.4	-1.31E+04
20.0	-69.4	411.8	99.6	-206.1	363.3	119.6	417.6	2.97E+04
40.0	-87.1	840.2	95.9	-606.8	587.7	135.9	844.7	5.26E+04
60.0	-77.4	1332.4	93.3	-1192.6	599.2	153.3	1334.7	4.21E+04
80.0	-23.9	1697.6	90.8	-1676.0	271.2	170.8	1697.8	-4.72E+03
100.0	56.9	1700.2	88.1	-1684.2	-239.2	-171.9	1701.1	-6.26E+04
120.0	127.9	1301.5	84.4	-1191.1	-540.0	-155.6	1307.8	-9.87E+04
140.0	134.0	738.9	79.7	-577.6	-479.9	-140.3	751.0	-8.92E+04
160.0	96.6	262.6	69.8	-180.6	-213.8	-130.2	279.8	-4.14E+04

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