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REGIONAL COASTAL PROCESSES NUMERICAL MODELING SYSTEM

Report 1

RCPWAVE—A LINEAR WAVE PROPAGATION MODEL FOR ENGINEERING USE

by

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empirical method is used to predict wave transformation. This method is based on a hydraulic jump representation of the entire surf zone. The model is verified using laboratory and field data.

A user's manual section is provided to aid potential users. This documentation contains two examples illustrating application of the model. These examples describe job control language files, job submission procedures, sample input and output files, and execution costs.

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PREFACE

The model development documented here was authorized as part of the Civil Works Research and Development Program of the Office, Chief of Engineers (OCE), US Army. The research work unit funding this work, Regional Coastal Processes Numerical Modeling System, is part of the Shore Protection and Restoration Program. Messrs. John H. Lockhart and John G. Housley were the OCE Technical Monitors during preparation and publication of this report.

The study was conducted under the direction of Dr. James R. Houston, Chief, Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station (WES); Mr. Charles C. Calhoun, Jr., Assistant Chief, CERC; and Mr. H. Lee Butler, Chief, Research Division. The report was prepared by Mr. Bruce A. Ebersole, Research Hydraulic Engineer; Mrs. Mary A. Cialone, Hydraulic Engineer; and Mr. Mark D. Prater, Research Hydraulic Engineer. The prototype data used in the model verification procedure were supplied by members of the staff of CERC's Field Research Facility, particularly Messrs. William A. Birkemeier and H. Carl Miller. This report was edited by Ms. Shirley A. J. Hanshaw, Publications and Graphic Arts Division, WES.

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REGIONAL COASTAL PROCESSES NUMERICAL MODELING SYSTEM

RCPWAVE--A LINEAR WAVE PROPAGATION MODEL FOR ENGINEERING USE

PART I: INTRODUCTION

1. The "Regional Coastal Processes Numerical Modeling System" research work unit is part of the US Army Corps of Engineers (Corps) Shore Protection and Restoration research program. Its goal is the development of a modeling system that can predict coastal processes on a regional scale so that coastal changes resulting from natural forces and man-made structures and modifications can be determined on a regional basis. All important physical processes that determine coastal changes over a region will be considered in the system's development. Long-wave (e.g. tide and storm surge) hydrodynamics, short-wave (e.g. swell and wind sea) propagation, and associated currents and setup/setdown will be addressed. These wave phenomena will be used as forcing functions to drive models which calculate alongshore and on- offshore sediment transport. Sediment sources and sinks such as sediment discharge from rivers, dredging gains or losses, and dune erosion will be considered in the sediment models. The modeling system will provide a tool for predicting coastal erosion and deposition, paths of sediment movement, and ultimate fates of coastal sediments.

2. All component models comprising the system must be capable of performing regional scale simulations in a cost-effective manner. Regional scale implies an area of interest with horizontal length scales of up to tens of miles and simulation times ranging from days to years. These requirements impose severe restrictions on candidate models. Individual models must also be compatible so that they can interface with one another in an efficient manner. Some examples of compatibility are (a) solutions from different models computed at identical spatial locations and (b) input/output information common to different models retrieved/stored using identical formats.

3. A philosophy for development of the modeling system has been adopted which provides direction to the work unit research. The aim is to develop (and/or obtain) and link a series of models so that all important physical processes are simulated to a predetermined level of sophistication. This

milestone will occur approximately 2 years before the scheduled conclusion of the work unit. Component models comprising the initial system are determined by: (a) available models within the Coastal Engineering Research Center (CERC) addressing the important physical processes, (b) other (outside CERC) state-of-the-art methods for modeling these processes on a regional scale, and (c) the need for having a field oriented product in the near future. The framework designed for linking these models into a usable system will allow for integration of more sophisticated models when they become available. Research addressing perceived weaknesses in the system models will be conducted concurrently with work done to bring the system to its initial level of sophistication.

4. Any technology created as an interim product, which can immediately aid Corps field engineers and can be easily transferred to them, will be made available. This report documents such a product. The Regional Coastal Processes Wave (RCPWAVE) Propagation Model can be used to predict linear, plane wave propagation over a "regional" area of arbitrary bathymetry. This model currently forms the initial level of sophistication for the short-wave modeling component of the regional system.

Background Information

5. Linear wave theory was chosen as the initial level of sophistication for the short-wave modeling component because, historically, it has been shown to yield fairly accurate first order solutions to wave propagation problems. Considering both accuracy and cost, it is currently the most feasible way to model waves on a regional scale. Modeling short-wave processes using either a fully two-dimensional nonlinear wave theory or a two-dimensional spectral representation of irregular waves is presently impractical for the types of applications anticipated for this modeling system.

6. Much of the early work addressing the problem of linear, monochromatic wave propagation was based on wave ray methods and the manual construction of refraction diagrams (see Johnson, O'Brien, and Issacs (1948); Dunham (1951); and Pierson, Neumann, and James (1952) for examples). During the 1960's and early 1970's the refraction problem was solved in a more efficient way through the use of the computer (for examples see Harrison and Wilson (1964), Dobson (1967), Noda et al. (1974), and Rabe (1975). Refraction theory fails in regions of complex bathymetry where waves are strongly convergent or divergent. Crossing wave rays results in the computation of erroneously large wave height estimates. Strongly divergent wave fields manifest themselves in regions of unusually small wave heights. Laboratory and prototype observations show that refraction theory is inadequate under these conditions (Whalin 1971 and 1972).

7. Inclusion of diffractive effects into the equations governing wave propagation allows wave energy to be diffused from regions of convergence to regions of divergence. Berkhoff (1972 and 1976) derived an elliptic equation approximating the complete wave transformation process for linear waves over an arbitrary bathymetry constrained only to have mild bottom slopes (hence the designation "mild slope equation" (Smith and Sprinks 1975)). The mild slope equation can be expressed in the form

$$\frac{\partial}{\partial x} \left(c c_g \frac{\partial \phi}{\partial x} \right) + \frac{\partial}{\partial y} \left(c c_g \frac{\partial \phi}{\partial y} \right) + \sigma^2 \frac{c_g}{c} \phi = 0 \quad (1)$$

where

x and y = two orthogonal horizontal coordinate directions

$c(x,y)$ = the wave celerity ($= \sigma/k$)

σ = angular wave frequency (defined to be $2\pi/T$)

$k(x,y)$ = wave number given by the dispersion relation,

$$\sigma^2 = gk \tanh(kh)$$

T = wave period

$c_g(x,y)$ = group velocity ($= \partial\sigma/\partial k$)

$\phi(x,y)$ = complex velocity potential

g = acceleration due to gravity

$h(x,y)$ = still-water depth

8. Numerical solution of this equation for the velocity potential field is an effective means for solving the complete wave propagation problem. The equation can be solved using either finite element (Berkhoff 1972 and Houston 1981) or finite difference methods (William, Darbyshire, and Holmes 1980). Since transmission and reflection boundary conditions are easily implemented into these solution schemes, this approach is a popular one for modeling tsunami propagation and for solving problems involving the response of harbors to short and long waves. This method becomes computationally infeasible for large scale, open coast, short-wave problems because of its great expense. Numerical solutions of Equation 1 are only practical, as a rough rule of thumb, when the dimensions of the spatial area of interest are no more than 10 times the length scale of the wave lengths being considered (Berkhoff, Booy, and Radder 1982).

9. An alternative method based upon a simplification of this equation has recently been developed. This method alleviates the computational burden imposed by a direct solution of Equation 1. The velocity potential can be separated into a forward scattered and a reflected component. By neglecting the reflected part and assuming that diffractive effects in the direction of propagation are much less than those perpendicular to the direction of wave advance, the following equation for the forward scattered wave can be derived:

$$\frac{\partial \phi}{\partial x} = \left[ik - \frac{1}{2kcc_g} \frac{\partial}{\partial x} (kcc_g) \right] \phi + \frac{1}{2kcc_g} \frac{\partial}{\partial y} \left(cc_g \frac{\partial \phi}{\partial y} \right) \quad (2)$$

where $i = \sqrt{-1}$ and x is now defined as the principal direction of propagation. Here, the velocity potential describes only the forward scattered wave field. The assumption made above, concerning the relative magnitude of the diffractive effects, changes the character of the governing equation from elliptic to parabolic. Very efficient computational techniques exist for solving this type of equation. Candel (1979), Radder (1979), Lozano and Liu (1980), Tsay and Liu (1982), Berkhoff, Booij, and Radder (1982), Booij (1981), and Kirby (1983) all applied this approach to study the problem of wave propagation over complex bathymetries using finite difference solution techniques.

10. The "parabolic approximation" method, as it is called, has the following disadvantage. It requires that one grid coordinate be approximately parallel to the predominant wave direction. This requirement can conceivably result in erroneous solutions to problems involving complex bathymetries where a dominant wave direction may not be clearly defined. Booij (1981) examined errors associated with the application of different parabolic approximations to solve the problem of oblique wave incidence over a horizontal bottom. To date, nothing has been documented concerning errors which may result from using this method to model wave incidence over arbitrary bathymetry. This directional restriction also implies that more than one grid system may be required in order to simulate a wide range of incident wave directions. The parabolic approximation method is a powerful tool for predicting linear wave transformations, but, it does have some deficiencies. These unaddressed problems currently preclude its incorporation into the regional modeling system, as it is envisioned.

11. The model presented in this report, RCPWAVE, is an alternative approach for solving the open coast wave propagation problem. It addresses both processes, refraction and diffraction, and can be applied on a regional basis quite economically. The model also contains an algorithm which estimates wave conditions inside the surf zone. This wave breaking model is an extension of the work of Dally, Dean, and Dalrymple (1984) to two horizontal dimensions. Kirby (1983) implemented their one-dimensional breaking model into his parabolic approximation model. Any short-wave propagation model integrated into the regional system must address the problem of wave transformation within the surf zone where many of the physical processes interact and move sediment.

Theoretical Basis

12. The velocity potential function for linear, monochromatic, plane waves can be represented by the expression

$$\phi = ae^{is} \quad (3)$$

where

$a(x,y)$ = wave amplitude function equal to $gH(x,y)/2\sigma$

$H(x,y)$ = wave height

$s(x,y)$ = wave phase function

Here again, the velocity potential function only describes the forward scattered wave field. No considerations are given to wave reflections. By substituting this expression for the velocity potential into Equation 1 and solving the real and imaginary parts separately, two equations can be derived (Berkhoff 1976), namely,

$$\frac{1}{a} \left\{ \frac{\partial^2 a}{\partial x^2} + \frac{\partial^2 a}{\partial y^2} + \frac{1}{cc_g} \left[\nabla a \cdot \nabla (cc_g) \right] \right\} + k^2 - |\nabla s|^2 = 0 \quad (4)$$

$$\nabla \cdot (a^2 cc_g \nabla s) = 0 \quad (5)$$

where the symbol ∇ denotes the horizontal gradient operation.

13. Together, these equations describe the combined refraction and diffraction process. Diffraction is often erroneously described as the propagation of energy along wave crests which are defined to be perpendicular to the wave phase function gradient ∇s . Equation 5 shows energy is still propagated in a direction perpendicular to the wave crest. Diffractive effects do change the phase function as a result of significant wave height gradients and curvatures. These changes cause the local wave direction to vary. If diffractive effects are neglected, Equations 4 and 5 reduce to those describing pure refraction in which the wave number represents the magnitude of the phase function gradient.

14. Linear wave theory assumes irrotationality of the wave phase function gradient. This property can be expressed mathematically as

$$\nabla x(\nabla s) = 0 \quad (6)$$

The phase function gradient can be written in vector notation as

$$\nabla s = |\nabla s| \cos \theta \vec{i} + |\nabla s| \sin \theta \vec{j} \quad (7)$$

where $\vec{i}$ and $\vec{j}$ are unit vectors in the x- and y-directions, respectively, and $\theta(x,y)$ is the local wave direction. Equations 6 and 7 can be combined to yield the following expression:

$$\frac{\partial}{\partial x} (|\nabla s| \sin \theta) - \frac{\partial}{\partial y} (|\nabla s| \cos \theta) = 0 \quad (8)$$

If the magnitude of the wave phase gradient is known, local wave angles can be calculated from Equation 8. Similarly, Equation 7 can be substituted into Equation 5 to yield

$$\frac{\partial}{\partial x} \left(a_{ccg}^2 |\nabla s| \cos \theta \right) + \frac{\partial}{\partial y} \left(a_{ccg}^2 |\nabla s| \sin \theta \right) = 0 \quad (9)$$

This form of the energy equation can be solved for the wave amplitude function a once the wave phase characteristics ∇s and θ are known. The wave height can be determined and is proportional to the amplitude function, since wave frequency is constant.

15. Equations 4, 8, and 9, along with the dispersion relation, describe the combined refraction and diffraction process for linear plane waves subject to the restrictions that the bottom slopes are small, wave reflections are negligible, and any energy losses are very small and can be neglected. The numerical solution scheme used to solve these equations is presented in the next section. These equations are assumed to be valid outside the surf zone. The method used to determine wave characteristics inside the surf zone is described later.

Numerical solution

16. The three governing equations (Equations 4, 8, and 9) are solved using numerical methods. Partial derivatives within the equations are approximated using finite difference operators. Finite difference solution methods require the construction of a computational grid system or mesh. Solution accuracy is directly related to resolution within the grid system. Discussion

throughout the text will refer only to grid systems comprised of constant sized, rectangular cells. RCPWAVE is capable of computing solutions on variably sized, rectilinear grid systems. Technology for creating variably sized grids, which are compatible with the wave model, exists at CERC.

17. Figure 1 shows nine rectangular cells which make up a small part of a larger mesh. Each cell has a length equal to Δx in the x-direction and Δy in the y-direction. The maximum values of i and j are M and N , respectively.

Figure 1. Definition of coordinate system and grid cell conventions used in the model

18. All variables which vary as a function of space are defined at the cell centers. For any dependent variable F , the following finite difference operators are used to approximate certain partial derivatives of F at the position (i, j) :

$$\frac{\partial^2 F}{\partial x^2} = \frac{2F_{i,j} - 5F_{i+1,j} + 4F_{i+2,j} - F_{i+3,j}}{(\Delta x)^2} \quad (10)$$

$$\frac{\partial^2 F}{\partial y^2} = \frac{F_{i,j+1} - 2F_{i,j} + F_{i,j-1}}{(\Delta y)^2} \quad (11)$$

$$\frac{\partial F}{\partial x} = \frac{-3F_{i,j} + 4F_{i+1,j} - F_{i+2,j}}{2\Delta x} \quad (12)$$

$$\frac{\partial F}{\partial y} = \frac{F_{i,j+1} - F_{i,j-1}}{2\Delta y} \quad (13)$$

Equations 11 and 13 are central differences, and Equations 10 and 12 are backward differences. All four expressions have the same order of accuracy.

19. The magnitude of the wave phase function gradient at any point (i,j) is computed from the following expression,

$$\begin{aligned} |\nabla s|_{i,j}^2 = & k_{i,j}^2 + \frac{1}{a_{i,j}} \left\{ \left[\frac{2a_{i,j} - 5a_{i+1,j} + 4a_{i+2,j} - a_{i+3,j}}{(\Delta x)^2} \right] \right. \\ & + \left[\frac{a_{i,j+1} - 2a_{i,j} + a_{i,j-1}}{(\Delta y)^2} \right] + \frac{1}{cc_{g_{i,j}}} \\ & \times \left[\left(\frac{-3a_{i,j} + 4a_{i+1,j} - a_{i+2,j}}{2\Delta x} \right) \left(\frac{-3cc_{g_{i,j}} + 4cc_{g_{i+1,j}} - cc_{g_{i+2,j}}}{2\Delta x} \right) \right. \\ & \left. \left. + \left(\frac{a_{i,j+1} - a_{i,j-1}}{2\Delta y} \right) \left(\frac{cc_{g_{i,j+1}} - cc_{g_{i,j-1}}}{2\Delta y} \right) \right] \right\} \quad (14) \end{aligned}$$

This equation was derived by approximating the partial derivatives in Equation 4 using the finite difference operators given in Equations 10 through 13. The reason for selecting backward finite differences to approximate the x-derivatives, specifically the curvature, will be discussed later in this section.

20. Equations 8 and 9 can both be expressed in the following general form:

$$\frac{\partial F}{\partial x} + \frac{\partial G}{\partial y} = 0 \quad (15)$$

If partial derivatives in both the x- and y-directions are estimated using central differences about the point $i-1/2, j$, then an approximate form of Equation 15 can be written as

$$\frac{F_{i,j} - F_{i-1,j}}{\Delta x} + W \left(\frac{G_{i-1,j+1} - G_{i-1,j-1}}{2\Delta y} \right) + (1 - W) \left(\frac{G_{i,j+1} - G_{i,j-1}}{2\Delta y} \right) = 0 \quad (16)$$

The partial derivative $\partial G / \partial y$ at position $i-1/2, j$ has been represented as a weighted average of its values at locations i, j and $i-1, j$. The value of the weighting factor W used in RCPWAVE is 1.0. This choice implies that an implicit solution of the equation is required. One additional approximation is made by using the following weighted sum:

$$F_{i,j} = \alpha F_{i,j+1} + (1 - 2\alpha) F_{i,j} + \alpha F_{i,j-1} \quad (17)$$

to represent the variable F at position i, j . Here α is another weighting parameter. The value of α is set to 0.167 in RCPWAVE. This "dissipative interface" (Abbott 1975) is used to enhance the stability of the numerical scheme. Substitution of Equation 17 into Equation 16 results in the following expression:

$$F_{i-1,j} = \alpha F_{i,j+1} + (1 - 2\alpha) F_{i,j} + \alpha F_{i,j-1} + \Delta x \left[W \left(\frac{G_{i-1,j+1} - G_{i-1,j-1}}{2\Delta y} \right) + (1 - W) \left(\frac{G_{i,j+1} - G_{i,j-1}}{2\Delta y} \right) \right] \quad (18)$$

The finite difference formulation of Equations 8 and 9, which will be described next, is identical to that used by Perlin and Dean (1983). Their choices for W and α were 1.0 and 0.25, respectively.

21. The finite difference form of Equation 8 is derived by substituting the following expressions for F and G into Equation 18:

$$F = |v_s| \sin \theta \quad (19)$$

$$G = -|vs| \cos \theta \quad (20)$$

These substitutions result in the following equation in which the sine of the local wave angle at the location $i-1, j$ is the quantity to be determined, thus

$$\begin{aligned} \sin \theta_{i-1, j} = \frac{1}{|vs|_{i-1, j}} & \left[\left(\alpha |vs|_{i, j+1} \sin \theta_{i, j+1} + (1 - 2\alpha) |vs|_{i, j} \sin \theta_{i, j} \right. \right. \\ & + \alpha |vs|_{i, j-1} \sin \theta_{i, j-1} \Big) - \frac{W\Delta x}{2\Delta y} \left(|vs|_{i-1, j+1} \cos \theta_{i-1, j+1} \right. \\ & - |vs|_{i-1, j-1} \cos \theta_{i-1, j-1} \Big) - \frac{(1 - W)\Delta x}{2\Delta y} \left(|vs|_{i, j+1} \cos \theta_{i, j+1} \right. \\ & \left. \left. - |vs|_{i, j-1} \cos \theta_{i, j-1} \right) \right] \end{aligned} \quad (21)$$

22. Similarly, using the substitutions

$$F = a^2 A \quad (22)$$

$$G = a^2 B \quad (23)$$

where

$$A = cc_g |vs| \cos \theta \quad (24)$$

$$B = cc_g |vs| \sin \theta \quad (25)$$

the finite difference form of Equation 9 becomes

$$\begin{aligned}
a_{i-1,j}^2 = & \frac{1}{A_{i-1,j}} \left[\left(\alpha a_{i,j+1}^2 A_{i,j+1} + (1 - 2\alpha) a_{i,j}^2 A_{i,j} + \alpha a_{i,j-1}^2 A_{i,j-1} \right) \right. \\
& + \frac{W \Delta x}{2 \Delta y} \left(a_{i-1,j+1}^2 B_{i-1,j+1} - a_{i-1,j-1}^2 B_{i-1,j-1} \right) \\
& \left. + \frac{(1-W) \Delta x}{2 \Delta y} \left(a_{i,j+1}^2 B_{i,j+1} - a_{i,j-1}^2 B_{i,j-1} \right) \right]
\end{aligned} \tag{26}$$

This equation can be solved for the wave amplitude function, and subsequently the wave height, at the location $i-1, j$. The remainder of this section describes the procedure used to solve the set of approximate Equations 14, 21, and 26.

23. Model input (described in detail in Part IV) includes values of the deepwater height H_o , direction θ_o , and period T of waves to be simulated. It also includes specification of the bottom bathymetry throughout the grid. The wave number, which is related to the wave period and the local water depth through the dispersion relation, is computed at every cell. Wave number is used as an initial guess for the magnitude of the wave phase function gradient. The wave celerity c and the group velocity c_g are functions of the wave period and wave number. Therefore these variables can be calculated at each cell.

24. From Snell's law,

$$\frac{\sin \theta}{c} = \frac{\sin \theta_o}{c_o} \tag{27}$$

where c_o is the deepwater wave celerity (defined to be $gT/2\pi$), an estimate of the local wave angle is calculated everywhere. This estimate assumes that the bottom contours are parallel with the y -axis. If the bottom bathymetric contours make a known nonzero angle with the y -axis, a better first guess for the wave angles can be computed. The new approximation is

$$\theta = \pi - \sin^{-1} \left(\frac{\sin (\theta_o - \theta_c)}{\frac{c_o}{c}} \right) + \theta_c \tag{28}$$

where θ_c defines the contour angle. The local wave angle, deepwater wave angle, and contour angle follow the angle convention shown in Figure 2. The contour angle is an input parameter into RCPWAVE.

Figure 2. Definition of angle conventions used in the model

25. Wave heights at each cell are estimated as the product of the deep-water wave height, a shoaling coefficient κ_s , and a refraction coefficient κ_r , thus

$$H = H_o \kappa_r \kappa_s \quad (29)$$

where

$$\kappa_r = \left(\frac{\cos \theta_o}{\cos \theta} \right)^{1/2} \quad (30)$$

and

$$\kappa_s = \left[\frac{1}{\left(1 + \frac{2kh}{\sinh(2kh)}\right) \tanh(kh)} \right]^{1/2} \quad (31)$$

The dispersion relation, Snell's law, and this simple estimator of the wave height allow an initial guess to be made for the variables of interest throughout the grid system.

26. The solution scheme implements the following marching procedure once initial guesses for the variables of interest have been made. Starting at the offshore row designated by $i=M-3$, Equations 21 and 26 are used to compute wave angles and then heights along the entire row (from $j=2$ to $j=N-1$). Wave height is used interchangeably with amplitude function since one is directly proportional to the other.

27. Wave angle and height solutions along a given row are solved iteratively because of the implicit differencing formulation used. Calculations of the wave angle (actually the sine of the wave angle) and the wave amplitude function are reiterated until the average change (along a row) in each variable from one iteration to the next is less than some tolerance. These convergence criteria, 0.0005 for wave sines and 0.001 ft* (or a metric equivalent) for wave heights, are suggested values for prototype applications. They can be easily changed by modifying the source code using the method outlined in Part IV.

28. This solution considers only refraction since the wave number k is used as an estimate of the magnitude of the phase function gradient. Equation 14 is then used to compute the true magnitude of the wave phase gradient. This new wave number accounts for the effects of diffraction. Backwards differences are used to approximate the x-derivatives because they require only information which has already been computed. Next, Equations 21 and 26 are again solved in order to compute the wave angles and heights using these new wave numbers. This procedure is repeated along the row under consideration until the change in new wave number, from one iteration to the next, is less than 0.5 percent of the newly computed value. This condition must be met at each cell along the row. As a row of new wave numbers is computed, the values are filtered in the y-direction using the method of Sheng, Segur, and Lewellen

* To convert feet to metres use a conversion factor of 0.3048.

(1978). This filter removes cell-to-cell oscillations introduced as a result of the differencing scheme used to compute the new wave numbers. Row-by-row marching proceeds until solutions are computed along row $i=2$.

29. Lateral boundary conditions for a row are specified at the conclusion of calculations for that row. The value of all variables at cells $j=N$ and $j=1$ are set equal to their values at cells $j=N-1$ and $j=2$, respectively. This boundary condition implies that the change in the variable in the y -direction is zero. The condition is most valid when the bathymetric contours are nearly straight and parallel to the y -axis. For this reason it is recommended that users orient their grid system so that the y -axis is nearly parallel to bottom contours along the lateral boundaries.

30. Boundary conditions along the seaward extent of the grid are used to initiate the shoreward marching algorithm. They are computed from deep-water wave input supplied by the user along with the following assumption. Bottom contours extending from the offshore grid row $i=M$ out to deep water are assumed to be straight and parallel to a line making an angle of θ_c with the y -axis. In other words, Snell's law is assumed to be valid from deep water to the outer boundary of the grid system. No inshore boundary conditions (along row $i=1$) are required because of the forward marching solution scheme.

Wave Transformation Inside the Surf Zone

Theoretical basis

31. Waves approaching the very nearshore zone tend to steepen and eventually break because of decreasing water depths. Shoreward of this breaking point dissipative energy losses due to turbulence strongly influence the wave height. Linear theory does not allow for prediction of the breaker location nor for wave transformation across the surf zone. Instead, empirical and approximate methods must be used to describe the breaking process.

32. The first aspect to consider in surf zone transformation of waves is incipient wave breaking. Iwata and Sawaragi (1982) reviewed many criteria for determining wave characteristics at the breaking point. One which is appealing because of its basis on wave physics defines breaking as the point when the particle velocity at the wave crest exceeds the wave celerity. The following formulas:

$$H_b = 0.78h_b \quad (32)$$

and

$$H_b = 0.142L_b \tanh \left(\frac{2\pi h_b}{L_b} \right) \quad (33)$$

where

H_b = breaking wave height

h_b = water depth at breaking

L_b = wave length at breaking

by McCowan (1891) and Miche (1944), respectively, are based on this criterion. Equations 32 and 33 were derived for solitary and periodic shallow-water waves, respectively, in water of uniform depth (Iwata and Sawaragi 1982). A breaking height predictor based on wave energy flux was developed by Komar and Gaughan (1972) and is given by

$$H_b = \kappa^* (g)^{1/5} (TH_o^2) \quad (34)$$

where κ^* is a dimensional coefficient equal to 0.39. Field and laboratory data have shown this predictor to be quite accurate. Other incipient breaking criteria have been developed by fitting empirical relationships to breaking wave data. These methods are not derived from any theoretical considerations of wave physics, yet results derived using them agree very well with observed data. The most widely used of these criteria are those developed in Equations 35, 36, and 37 by Le Méhauté and Koh (1967), Goda (1970), and Weggel (1972), respectively. These criteria are as follows:

$$H_b = 0.76 H_o \left(\frac{H_o}{L_o} \right)^{-1/4} m^{1/7} \quad (35)$$

where

L_o = deepwater wave length

m = bottom slope

$$H_b = 0.17L_o \left\{ 1 - \exp \left[-1.5\pi \frac{h_b}{L_o} (1 + 15(m))^{4/3} \right] \right\} \quad (36)$$

and

$$H_b = \frac{\bar{b}h_b}{1 + \frac{\bar{b}a}{gT^2}} \quad (37)$$

where

$$\begin{aligned} \bar{a} &= 43.75 \left[1 - e^{(-19m)} \right] \\ \bar{b} &= 1.56 / \left[1 + e^{(-19.5m)} \right] \end{aligned}$$

33. All of these empirical methods give reasonable approximations of the incipient breaking wave height. In choosing a criterion for inclusion into RCPWAVE, the following factors were considered. The criterion should account for bottom slope and wave period since field and laboratory tests show these parameters to be important (Iwata and Sawaragi 1982). It should not depend on deepwater parameters alone because the transformation algorithm must be capable of modeling multiple breaking and reformation. The Weggel (1972) and Goda (1970) criteria satisfy both requirements. The former was selected for inclusion into RCPWAVE.

34. Once the incipient breaking point is defined, a mechanism is needed to transform the breaking wave across the surf zone. Historically the wave height has been assumed to be proportional to the local water depth throughout the surf zone. The constant of proportionality was assumed to be about 0.8. Field and laboratory data have shown that this approximation consistently overestimates actual wave heights within the surf zone (Dally 1980 and Thornton and Guza 1982). Other formulations have been developed and applied successfully by researchers to calculate surf zone wave heights. Most are of the following form:

$$\frac{\partial(Ec_g)}{\partial x} = -\delta \quad (38)$$

where Ec_g is the energy flux associated with the breaking wave and δ is a term representing the rate of energy lost due to bottom friction, turbulence, and other dissipative processes.

35. Divoky, Le Méhauté, and Lin (1970) considered the dissipation in a breaking wave to resemble that in a hydraulic jump. They assumed that the change in energy flux could be approximated by

$$\frac{\partial(Ec_g)}{\partial x} = \rho g Q \left[\frac{(Y_1 - Y_2)^3}{4Y_1 Y_2} \right] \quad (39)$$

where

ρ = water density

Q = flow across the jump

Y_1 = water depth on the high end of the jump

Y_2 = water depth on the low end of the jump

For water of uniform depth, they assumed that $Y_2 = h + H$ and $Y_1 = h + \beta H$

where β is a coefficient related to the percentage of the wave height covered by foam. Battjes and Janssen (1978) also used a hydraulic jump representation of wave breaking. They used the following expression:

$$\frac{\partial(Ec_g)}{\partial x} = \alpha^* \rho g Q \frac{H^2}{4T} \quad (40)$$

where α^* is a coefficient of order one. Mizuguchi (1980) modeled surf zone energy loss as,

$$\frac{\partial(Ec_g)}{\partial x} = 2\rho g v_e \left(\frac{kH}{2} \right)^2 \quad (41)$$

where v_e is a coefficient of turbulent eddy viscosity. Results derived from this model compared quite well with experimental data, but any physical reasoning behind the use of the eddy viscosity formulation is, as Mizuguchi (1980) states, obscure. Horikawa and Kuo (1966) developed an analytical scheme using second order solitary wave theory and theoretical expressions for dissipation due to bottom friction and turbulence. Their governing equation contained two coefficients, one for each dissipative mechanism.

36. The transformation algorithm selected for use in RCPWAVE (Dally, Dean, and Dalrymple 1984) uses the same energy flux basis as the models mentioned above. However, instead of using a hydraulic jump to represent energy loss in a single breaking wave, the form of the hydraulic jump energy loss is used to approximate losses across the entire surf zone. Through analogy with energy flux in a channel, the following equation is postulated:

$$\frac{\partial(Ec_g)}{\partial x} = \frac{-\kappa}{h} \left[Ec_g - (Ec_g)_s \right] \quad (42)$$

where

κ = rate of energy dissipation coefficient (set equal to 0.2 in RCPWAVE)

$(E c_g)_s$ = stable level of energy flux that the transformation process seeks to attain

The right-hand side of Equation 42 is simply a dissipation term. The subscript s is used to denote the stable level of some quantity. Substituting the linear wave theory estimate for E ($E = 0.125 \rho g H^2$) into Equation 42 results in the following expression:

$$\frac{\partial(H^2 c_g)}{\partial x} = \frac{-\kappa}{h} (H^2 c_g)_s \quad (43)$$

37. Various field (Thornton and Guza 1982) and laboratory (Horikawa and Kuo 1966) experiments have shown that, well into the surf zone, the wave height tends toward a stable value which is proportional to the local water depth. This relationship can be expressed as

$$H_s = \gamma h$$

where

H_s = stable wave height

γ = proportionality coefficient (set equal to 0.4 in RCPWAVE)

Equation 43 can now be rewritten as

$$\frac{\partial(H^2 c_g)}{\partial x} = \frac{-\kappa}{h} \left[H^2 c_g - (\gamma^2 h^2 c_g)_s \right] = D \quad (45)$$

38. This surf zone wave transformation model can be incorporated into the conservation of wave energy equation (Equation 5) by simply adding the dissipation term D to the right-hand side. The function D must now represent dissipation in the direction of wave propagation. Also for dimensional consistency, the term D must be multiplied by the wave celerity and the magnitude of the wave phase gradient, and the wave height must be replaced by the wave amplitude function. In vector notation, the energy equation becomes

$$\nabla \cdot (a^2 c c_g \nabla s) = \frac{-\kappa}{h} \left\{ a^2 c c_g |\nabla s| - \left[\left(\frac{g}{2\sigma} \right)^2 \gamma^2 h^2 c c_g |\nabla s| \right]_s \right\} \quad (46)$$

This equation can be thought of as being valid both inside and outside the surf zone. Outside, the coefficient κ is zero, and the equation reduces to Equation 5.

39. Discussion relating to wave transformation within the surf zone has addressed the problem of determining wave heights. The problem of wave phase must be addressed also. Diffraction effects are assumed to be negligible inside the surf zone. Therefore, the wave number k is assumed to accurately represent the magnitude of the wave phase function gradient. The linear wave theory assumption that the waves are irrotational also will be assumed to remain valid inside the surf zone. Consequently, wave angles inside the surf zone are computed in the same manner that was used outside the surf zone.

Numerical solution

40. The numerical procedure for computing wave angles inside and outside the surf zone is the same. This section documents only the solution scheme used to determine breaking wave heights. The finite difference form of the wave energy equation outside the surf zone (Equation 26) can be expressed in the following form:

$$a_{i-1,j}^2 = \frac{\bar{F} + \Delta x \bar{G}}{A_{i-1,j}} \quad (47)$$

where

$$\bar{F} = \alpha a_{i,j+1}^2 A_{i,j+1} + (1 - 2\alpha) a_{i,j}^2 A_{i,j} + \alpha a_{i,j-1}^2 A_{i,j-1}$$

$$\begin{aligned} \bar{G} = (1 - W) & \left(\frac{a_{i,j+1}^2 B_{i,j+1} - a_{i,j-1}^2 B_{i,j-1}}{2\Delta y} \right) \\ & + W \left(\frac{a_{i-1,j+1}^2 B_{i-1,j+1} - a_{i-1,j-1}^2 B_{i-1,j-1}}{2\Delta y} \right) \end{aligned}$$

$$B = c c_g |v_s| \sin \theta$$

$$A = c c_g |v_s| \cos \theta$$

With the inclusion of the dissipative term, Equation 47 becomes

$$a_{i-1,j}^2 = \frac{\bar{F} + \Delta x \bar{G}}{A_{i-1,j}} + \frac{\Delta x D^*}{A_{i-1,j}} \quad (48)$$

where D^* represents the finite difference form of the dissipation term on the right-hand side of Equation 46. Reiterating, the dissipation term is an average value along the wave path. The wave path is determined by the local wave angle at the position $i-1,j$ which has already been computed. Therefore, the average along the path is an average of information at cell $i-1,j$ and another cell whose position is denoted by $ikey,jkey$. The procedure used for determining the location of this cell will be presented later.

41. The term D can be written in finite difference form as

$$D^* = \frac{\kappa}{\bar{h}} \left\{ \left[\frac{(a_{cc_g}^2 |vs|)_{ikey,jkey} + (a_{cc_g}^2 |vs|)_{i-1,j}}{2} \right] - \left(\frac{g}{2\sigma} \right)^2 \left(\frac{\gamma^2 h_{cc_g}^2 |vs|_{ikey,jkey} + \gamma^2 h_{cc_g}^2 |vs|_{i-1,j}}{2} \right) \right\} \quad (49)$$

where

$$\bar{h} = \frac{h_{i-1,j} + h_{ikey,jkey}}{2}$$

With some algebra, Equation 48 can be reorganized so that the amplitude function at the position $i-1,j$ only appears on the left-hand side of the equation. Therefore, the energy equation inside the surf zone can be numerically solved using the same procedure which was used to solve it outside the surf zone.

42. The location of the cell denoted $ikey,jkey$ is found using the following procedure. "Areas of influence" are determined by extending lines from the center of the cell $i-1,j$ to the midpoints between the surrounding cell centers (Figure 3). Angles are computed from the x-axis to these radial lines. The local wave angle calculated at cell $i-1,j$ is compared to each of these angles in order to determine the nearest, prior cell along the wave path. For example (refer to Figure 3), if the local wave angle is greater than θ_2 but less than θ_1 , then cell $i,j+1$ is the cell of influence and $ikey = i$ and $jkey = j+1$.

43. A flow chart describing the wave height computation is shown in

Figure 3. Schematic drawing showing cell of influence conventions used in the wave breaking scheme

Figure 4. The wave amplitude function is computed from the energy equation assuming no dissipation. The amplitude function is converted to wave height and compared to the stable wave height γh . If the wave is less than or equal to this stable level, the wave is either inside the surf zone, having been transformed to a state below the stable level, or it is outside the surf zone. In either case, no further transformation is needed. If the wave height is greater than γh , then additional wave transformation may occur. The cell of influence is located and tested to determine whether or not the wave has experienced prior breaking. If the wave is undergoing transformation in the cell of influence, it continues to be transformed. If the wave in the cell of influence is not being transformed, the local wave height is checked against the incipient breaking height criterion. If the height exceeds the allowable value, wave dissipation begins. The accuracy of the surf zone wave transformation model has been verified using laboratory data of Horikawa and Kuo (1966) and Izumiya (1984). Comparisons between model results and these data are described in Part III.

Figure 4. Flow chart of the wave breaking scheme

General Comments

44. Comparisons between model results and observed data were used to verify the model. Both laboratory and field data were used in these tests. The ability of RCPWAVE to simulate wave transformation outside the surf zone was checked using data collected during a laboratory experiment conducted by Berkhoff, Booy, and Radder (1982) and using prototype data obtained during a field experiment at the CERC Field Research Facility (FRF) in Duck, North Carolina. The next two sections describe these comparisons in detail. Figures pertaining to the laboratory and field verification are located in Appendixes A and B, respectively. Only laboratory data were used to verify the surf zone wave transformation part of the model. These data were collected during one-dimensional flume tests performed by Horikawa and Kuo (1966) and Izumiya (1984). Both experiments considered only breaking of monochromatic, plane waves. The former experiment investigated wave transformation on a plane beach only; the latter involved tests using plane, stepped, and barred beaches. These comparisons are discussed in the last section. Figures pertaining to the wave breaking verification are located in Appendix C.

Elliptical Shoal Case: Comparison with Laboratory Data

45. Berkhoff, Booy, and Radder (1982) performed a wave tank experiment in which wave conditions resulting from the propagation of a monochromatic, plane wave train over complex bathymetry were measured. The bathymetry consisted of an elliptical shoal superimposed on a plane beach. This geometry is shown in Figure A1. The shoal acts as a lens and focuses incoming wave energy into a strong convergence zone. This experiment provided a set of data which could be used to verify the ability of RCPWAVE to compute accurate solutions to problems where refraction theory breaks down. Wave height data were collected at many locations within this zone along the eight cross sections shown in Figure A1. RCPWAVE was used to simulate the same experiment. Simulated wave heights were then compared with observed data.

46. A finite difference grid mesh, which measured 25 m in the x-direction and 20 m in the y-direction was constructed. Rectangular grid

cells measuring 0.25 and 0.20 m in the x- and y-directions, respectively, were used for the simulation. The center of the shoal was located at the point with x- and y-coordinates of 15 and 10 m, respectively. The equation describing the outer extent of the shoal is given by

$$\left(\frac{y'}{3}\right)^2 + \left(\frac{x'}{4}\right)^2 = 1 \quad (50)$$

where x' and y' denote a local coordinate system whose origin is located at the center of the shoal. Also this coordinate system is rotated 20 deg in the clockwise direction relative to the x- and y-coordinate system. All length scales for both coordinate systems are measured in metres. Water depths, denoted by h and measured in metres, were calculated from the following three equations,

$$h = 0.45 \quad \text{for } y' \geq 5.84 \quad (51)$$

$$h = 0.45 - 0.02 (5.84 - y') \quad (\text{outside the shoal boundary}) \quad (52)$$

$$h = 0.45 - 0.02 (5.84 - y') + 0.3 - 0.5 \left[1 - \left(\frac{x'}{5}\right)^2 - \left(\frac{y'}{3.75}\right)^2 \right]^{1/2} \quad (53)$$

(inside the shoal boundary)

An incident wave with a period of 1.00 sec, a height of 1.06 cm, and a direction of approach parallel to the x-axis was used as the deepwater boundary condition for the simulation.

47. Figures A2 through A4 show comparisons between the experimental data (open circles) and model results (solid line) for all eight profiles. Results are presented as profiles of relative wave height (observed wave height divided by incident wave height). A refraction analysis (presented in Berkhoff, Booy, and Radder (1982)) shows that a caustic occurs at a point between profiles 2 and 3. Results show that the model is quite capable of accurately simulating diffractive effects at, and beyond, the caustic location. Consequently, it is a much more powerful tool for simulating wave transformation than refraction theory alone. Berkhoff, Booy, and Radder (1982) and Kirby (1983) also numerically simulated this experiment in order to test their parabolic approximation models. Accuracy of their model results, using linear wave theory, is comparable to that obtained using RCPWAVE. Results obtained

by Kirby (1983) are shown also in the figures (as a dashed line). Kirby showed that much of the discrepancy between simulated and observed data could be eliminated if a nonlinear wave theory were incorporated into the model. He incorporated Stokes' second order theory (which he showed was valid for this experiment) into his model, and the results also showed that nonlinear effects became increasingly important after the waves pass profile 3.

48. An interesting aspect of the RCPWAVE results is evident in profiles 3, 4, and 5. The lobed features in the wave height variation are smoothed by the model. The cause of this smoothing is not known. It may be caused by the dissipative interface or the point-to-point filter used in the numerical scheme. The side lobes seem to be related to the occurrence of an amphidromic point where the wave phase becomes multivalued and the wave height variation contains a discontinuity. The solution scheme forces the magnitude of the phase function gradient to be single valued. This may also cause the local smoothing. The model is intended for use in open coast, prototype applications. For these types of problems, this smoothing property of the model can certainly be tolerated.

CERC's FRF Cases: Comparisons with Prototype Data

49. In addition to the laboratory verification, RCPWAVE also was verified using field data collected at CERC's FRF in Duck, North Carolina. Bottom bathymetric contours in the area are generally straight and parallel to the coastline except in the immediate vicinity of the research pier. The pier's presence has caused the formation of a deep scour hole along much of its length. The complicated bathymetry, which has resulted from this hole, was one reason for selecting the FRF for field verification. Hubertz (1981) showed that a ray model using refraction theory alone proved incapable of simulating observed conditions. Hubertz (1982) also showed that a short wave model which includes diffractive effects in its governing equations (the System 21 Mark 8 proprietary model developed by the Danish Hydraulic Institute) could accurately simulate wave propagation in the vicinity of the pier up to the breaking point.

50. Another reason for selecting the FRF was the availability of wave data, both offshore and along the pier. During October 1982, an extensive, 1-month field data collection program was undertaken. Two storms

occurred during the month, one lasting from 10-13 October and the other from 23-26 October. The latter was the more severe event. Prototype data collected during this month included bathymetric surveys conducted on October 16 and 27, continuous and synchronous wave data from six Baylor gages along the pier and an offshore Waverider buoy, radar imagery of the sea surface, and continuous tide elevation data. All wave data were available in a spectral form (energy density as a function of frequency). Estimates of significant height and peak period were provided also. Wave directions could be determined from the radar imagery. The availability of clear radar pictures was ultimately the discriminating factor in selecting which time periods were considered for verification purposes.

51. Six cases, or time periods, were ultimately chosen using the following process. As stated above, only those times were considered when clear radar imagery was available. The number of candidate times were further reduced by requiring that wave data be available within approximately 1 hr of the time the image was taken. Next, the wave spectrum from the offshore gage was checked for spectral shape. Only times with single-peaked, fairly narrow banded spectra were considered. Six cases which met all the criteria are shown in Table 1.

Table 1
Summary of Field Data Used to Verify RCPWAVE

Test Case Number	Date	Time G.m.t.*	H_o m	T sec	θ_o deg	Tide m	Time of Radar Imagery G.m.t.	Bathymetry Survey Date
1	10-13-82	1300	1.95	13.21	-23	0.12	1115	10-16-82
2	10-13-82	1400	1.87	14.22	-25	-0.18	1115	10-16-82
3	10-15-82	1210	0.78	12.34	-25	0.78	1130	10-16-82
4	10-17-82	1200	1.56	6.87	43	0.91	1120	10-16-82
5	10-25-82	1900	3.10	12.34	-25	0.68	1950	10-27-82
6	10-25-82	2000	2.95	12.34	-25	0.63	1950	10-27-82

* G.m.t. denotes Greenwich mean time.

52. For each case the date and time of the recorded wave data are shown. The parameters H_o , T, and θ_o are the deepwater wave characteristics used as input into RCPWAVE. The value of T was chosen to be the best

estimate of the peak spectral period and was made using data from the Wave-rider buoy and the seaward-most Baylor gage located at the end of the pier. The deepwater wave angle was computed using this peak period and a wave direction estimated from the radar imagery. The time at which the radar image was taken also is given. Inherent in the procedure used to calculate the wave parameters in deep water is the assumption that the bottom contours seaward of the pier are straight and parallel. This assumption is quite reasonable for this stretch of coastline. The deepwater wave height represents a significant height and was computed using the peak period, deepwater angle, and the significant height recorded by the offshore Waverider buoy. The recorded wave spectra at the offshore gage are shown for all six cases in Figure B1.

53. Bottom bathymetry is required as model input. The total water depth matrix, used in the model, is computed by simply adding some tidal elevation to each depth value. Depth values were taken from one of two surveys shown in Figure B2. The particular survey used for each verification case is shown in Table 1. The tidal elevation (relative to mean sea level (MSL)) also is given in Table 1. The areal extent of each survey is identical, covering 1,200 m in the y-direction and 900 m in the x-direction. The orientation of the survey axes was adopted for use in constructing the model grid system. The x-axis is parallel to the FRF pier. Actual depth values (relative to MSL) were provided for each cell of a grid comprised of 75 cells in the x-direction and 50 cells in the y-direction. This grid completely encompasses the surveyed region. Cell dimensions are 12 and 24 m in the x- and y-directions, respectively.

54. Comparisons between simulated and observed significant wave heights along the pier are shown for each case in Figures B3 and B4. For these tests, the model is being used to propagate some amount of energy (here, designated by the significant height) with a single frequency and some mean direction. By requiring that the radar imagery be clear and contain only a unidirectional wave train, only waves which are nearly planar (long-crested) are being considered. Since most of the wave spectra are narrow-banded (with the exception of Case 4), the cases being considered represent nearly monochromatic conditions. Therefore, assumptions inherent in the model's governing equations are essentially upheld, and the model should be able to simulate these conditions. Results show that RCPWAVE accurately predicts wave propagation for these types of wave conditions over a complex bottom. In all cases the scour hole causes

wave energy to be propagated away from the hole causing a reduction in wave height along the pier. Results from Hubertz (1982) substantiate this observation. The trend of the wave height variation along the pier for Case 4 also is accurately simulated. The magnitude of the simulated significant height consistently underestimates observed data by about 0.1 m. The closeness of fit for this case, which involves a wider spectral bandwidth, suggests that the model may provide a useful method for predicting spectral wave transformations if the waves have a small directional spread. More research is needed to test this hypothesis.

Verification of the Wave Breaking Scheme: Comparisons with Laboratory Data

55. A number of numerical simulations were performed in order to verify the capability of RCPWAVE to predict wave breaking and surf zone wave transformation. Model results were compared with data from laboratory experiments. Two sources of data were used. The first source was the original work of Horikawa and Kuo (1966) along with additional information concerning that work found in Dally (1980) and Dally, Dean, and Dalrymple (1984). Horikawa and Kuo studied the transformation of waves in the surf zone using two wave tanks and four different uniform bottom slopes. Two slopes, 1:20 and 1:30, were tested in a wave tank 17 m long and 0.6 m deep. The remaining slopes, 1:65 and 1:80, were tested using a larger tank which measured 75 m in length and 1.2 m in depth. The second source of experimental data was the dissertation work of Izumiya (1984), who used a smaller wave tank for his tests. All water depths considered in the experiments were less than 0.3 m, and all breaking wave data were collected within 7 m of the dry "beach." He investigated wave transformation over three different bottom configurations: a plane beach, a stepped beach, and a barred beach. All slopes were 1:20, including the back slope on the barred beach.

56. Wave and bathymetry conditions for each laboratory test used in the model verification process are shown in Table 2. The table shows the data source, an arbitrarily assigned test case number, the type of beach considered, and the beach slope. The following wave parameters for each test are given also: (a) the wave period, (b) the deepwater wave height (if it were available), (c) the incipient breaking wave height, and (d) the water depth at breaking.

Table 2

Summary of Laboratory Data Used to Verify the Wave Breaking Scheme

<u>Test Case</u>	<u>Bathymetry</u>	<u>Slope</u>	<u>T</u> <u>sec</u>	<u>H_o</u> <u>cm</u>	<u>H_b</u> <u>cm</u>	<u>h_b</u> <u>cm</u>
Horikawa and Kuo 1	Plane beach	1:20	1.40	--	13.2	15.5
Horikawa and Kuo 2	Plane beach	1:30	2.20	--	9.1	10.8
Horikawa and Kuo 3	Plane beach	1:30	2.20	--	12.2	16.4
Horikawa and Kuo 4	Plane beach	1:65	1.56	14.4	17.2	19.4
Horikawa and Kuo 5	Plane beach	1:65	1.56	24.7	27.1	35.2
Horikawa and Kuo 6	Plane beach	1:80	1.40	--	17.7	25.0
Izumiya 7	Plane beach	1:20	1.19	6.0	7.7	9.4
Izumiya 8	Stepped beach	1:20	0.96	7.9	8.5	9.7
Izumiya 9	Barred beach	1:20	0.95	6.3	6.9	8.3

57. Two series of verification tests were conducted. The first series involved model simulations which were initiated at the break point determined from the data in Table 2. The purpose of these tests was to check the validity of the surf zone transformation part of the breaking scheme. Figures C1 through C6 show plots comparing simulated results with Horikawa and Kuo's data. The horizontal and vertical scales vary from plot to plot. Model results generally show good agreement with observed data. The model tends to underpredict the wave heights very close to shore because the model does not consider the effects of wave setup. Setup would increase the total water depth here and allow for larger simulated wave heights (Dally 1980). Horikawa and Kuo Test 2, having data points 1.0 and 0.5 m from shore, clearly illustrate this model deficiency. However, neglecting wave setup has little effect on model accuracy in the remainder of the surf zone. Steep slopes, 1:20 and 1:30, produce a much more rapid decrease in wave height across the breaking zone than do the milder slopes, 1:65 and 1:80. Qualitatively, this is what is usually observed in the field. Plunging waves are more likely to occur on steep slopes and spilling breakers on mild slopes. Results suggest that the breaking model is applicable under both types of breaking conditions.

58. Figures C7 through C9 show comparisons between model results and Izumiya's data, again for surf zone transformation only. Test 7, a plane beach case, shows very good agreement. The wave height variation across the

surf zone is characterized by a strong gradient, typical of steep slopes. Test 8 was conducted using a stepped beach. The model reproduces the same general wave height variation exhibited by the data but not as accurately as in the plane beach cases. The data show a more rapid decay immediately inside the break point, and the decay seems to be toward a stable height less than that predicted by the model. Some oscillations appear in the data, possibly from reflections, which make an estimation of the stable height difficult. The values of κ and γ used in the model's breaking scheme were selected to provide a "best" fit to both data sets. Better agreement could have been obtained for individual data sets by using some other values. There is also evidence that the values of κ and γ are dependent upon the beach slope (Dally, Dean, and Dalrymple 1984). For simplicity, a constant value for both parameters is used in the model. The final comparison is for the barred beach case. Again, good agreement is obtained for the overall shape of the wave height decay. The model miscalculates the location of the second break point by about 0.3 m, but the simulated decay after this point closely parallels the data.

59. A second series of comparisons, using the same laboratory data, were made. Results from these comparisons are provided to show the capability of the model to simulate the entire shoaling and breaking process, including a determination of the break point. Previously, only the accuracy of the decay mechanism was examined. RCPWAVE was used to simulate wave propagation from generation through to breaking. These simulations were performed for those cases in which the deepwater wave height was given by the authors or could be computed. The deepwater wave height is used as model input. Figure C10 shows the model results from Horikawa and Kuo Test 5. The model could not shoal the wave up to the observed incipient breaking height; however, the simulated surf zone transformation matches well with observed data.

60. Results from similar comparisons between model results and laboratory data for the Izumiya Tests 7, 8, and 9 are shown in Figures C11 through C13. In all cases the model failed to reproduce the wave shoaling peak immediately prior to breaking. The model does decay the wave correctly for Tests 7 and 8. In Test 9 the model misses the first break point entirely. This case was included to illustrate the dependency of accurate surf zone simulations on the validity of the incipient breaking criterion used.

61. For the monochromatic wave conditions considered in this

verification, and probably narrow-banded spectra as well, the model is incapable of predicting the full extent of the shoaling peak prior to breaking, probably due to the use of linear wave theory. This limitation, coupled with any errors in the incipient breaking criterion, may cause the location of the break point to be erroneously specified (e.g., Izumiya Test 9). However, the surf zone transformation part of the model seems to be very accurate for plane beaches and quite reasonable for stepped and barred bathymetry. Consequently, the model is usually capable of simulating the general form of the wave height variation across the breaker zone even though there may be a slight horizontal shift between observed and simulated distributions. This is substantiated by the results presented above. Inclusion of this breaking scheme into the model, despite its shortcomings, is an obvious improvement over methods which specify the surf zone wave height to be proportional to the local water depth everywhere, especially for complex bathymetry involving stepped or barred beaches. The accuracy of this model for use in predicting surf zone characteristics under wide-banded spectral wave conditions is questionable. The model assumes wave breaking begins at a well defined point. This assumption is most valid under extremely narrow-banded spectral conditions but is violated otherwise.

PART IV: MODEL EXECUTION ON THE CONTROL DATA
CORPORATION COMPUTING SYSTEM

General Comments

62. The RCPWAVE model can be run in a remote batch mode on the Control Data Corporation (CDC) computing system. Batch jobs comprised of job control language (JCL) allow users to instruct the computer to perform a series of tasks including file manipulation, compilation, and execution. RCPWAVE can be run on two CDC computers, the CYBER 865 and CYBER 205. Costs are less expensive on the CYBER 865 machine (cost comparisons will be given in Part V); however, available memory within this computer limits its use to applications involving fewer than 9,025 grid cells. The CYBER 205 has more available memory, but it is more expensive to use. It is recommended that users restrict their use of the CYBER 205 to model applications where the total number of grid cells exceeds 9,025.

63. JCL used to run the wave model on the CYBER 865 differs from that used to run it on the CYBER 205. The next two sections explain CYBER 865 JCL and CYBER 205 JCL, respectively. Then the following procedures are explained: submitting batch jobs on both machines, checking job status, and accessing job output. The last two sections give a general description of necessary input files and all output files which are generated in the course of job execution. Part V of the text covers examples of actual applications of RCPWAVE run on both CDC machines, and it includes specific examples of the aforementioned files.

64. It is essential for the user to be familiar with XEDIT* or another text editor available on the CDC system. This knowledge is required in order to make any changes to the JCL files or to examine an output file in a text editor mode. The text editor also is required to create input data files. A limited knowledge of the "UPDATE"* method for making changes to the model source code also is recommended. Discussion concerning modifications to the source code and examples documenting this procedure are given in subsequent sections.

* Cybernet services manuals are available from CDC titled "XEDIT, Extended Text Editor," Manual No. 76071000C, and "UPDATE, Version 1 Reference Manual," Manual No. 60449900B.

CYBER 865 Job Control Language

65. An example of JCL used to run RCPWAVE on the CYBER 865 is given in Figure 5. The file containing this JCL can be obtained by logging into the CDC computing system and typing

```
GET,RCP865J/UN=CERØQ2      .
```

This action will create a local file called RCP865J on the user's work space. In order to save the file permanently, type

```
SAVE,RCP865J      .
```

Each line or "card image" of RCP865J contains a specific instruction to the computer. Note the brief description of important input and output files under the "COMMENT" section. These files will be discussed in greater detail later in Part IV, and specific examples will be given in Part V. At this point, it is only important to know what each file contains. A line-by-line description of the JCL in RCP865J is given in Appendix D.

Submitting the CYBER 865 Batch Job

66. A series of commands (JCL) has been assembled into a batch job that instructs the computer to gather input, compile and execute the wave model, and save output. The computer is actually given this batch of commands by using the following form of the SUBMIT command:

```
SUBMIT,<JCL FILENAME>,T      .
```

The <JCL filename> of the file shown in Figure 5 is RCP865J; therefore the following command is given:

```
SUBMIT,RCP865J,T      .
```

The parameter T tells the computer to return certain output to the user's terminal once the job is completed. When a batch job is submitted, the computer responds by giving the job an identifier similar to the one shown below:

```
15.21.05. SUBMIT COMPLETE.  JOBNAME IS AKQBRMA      .
```

```

*****
/ JOB
JOB, P3, T1000, CM377000,
/USER
/CHARGE
GET, SR=RCRWAVE, UN=CER002,
    GET, UPDL=RCRPUPOT,
    GET, TAPE7=RCRDATA,
    GET, TAPE8=RCRDPT,
        (SEE **NOTE** BELOW) BATHMETRY OBTAINED
UPDATE (I=SR, N=NEWL IB, F, L=0)
FINS, I=NEAPLUS, B=BIN, L=OUTPUT,
LOAD, BIN,
EXECUTE,
REWIND, TAPE6, OUTPUT,
REPLACE, TAPE6=RCRPNT,
REPLACE, OUTPUT=RCRPOTPT,
COST,
DAYFILE, L=RCRDAYF,
REPLACE, RCPDAYF,
EXIT,
REWIND, OUTPUT,
REPLACE, OUTPUT=RCRPOTPT,
REPLACE, TAPE6=RCRPNT,
COST,
DAYFILE, L=RCRDAYF,
REPLACE, RCPDAYF,
EXIT,
DAYFILE, L=RCRDAYF,
REPLACE, RCPDAYF,
*****
RESOURCE LIMITS SPECIFIED
*****
COMMENT.* *****
COMMENT.* COMMENTS CONCERNING FILES REQUIRED BY
COMMENT.* THE ABOVE JOB CONTROL LANGUAGE (JCL)
COMMENT.* *****
COMMENT.* *****
COMMENT.* *****
RCRWAVE: SOURCE CODE FOR THE WAVE PROPAGATION MODEL.
COMMENT.
RCRPUPOT: UPDATE FILE CONTAINING MODIFICATIONS TO
            THE SOURCE CODE.
COMMENT.
RCRDATA: DATA FILE SPECIFYING GRID GEOMETRY AND WAVE
          CHARACTERISTICS CONSIDERED,
          ((LOGICAL UNIT DEVICE TAPE7))
COMMENT.
RCRDPT: DATA FILE CONTAINING BATHMETRY
         ((LOGICAL UNIT DEVICE TAPE8))
COMMENT.
**NOTE** IF THE BATHMETRY IS GENERATED WITH FORTRAN CODE IN
          THE UPDATE FILE AND NOT READ IN EXPLICITLY, THE JCL
          LINE WHICH ACCESSES THE BATHMETRY FILE IS NOT
          REQUIRED AND MUST BE REMOVED.
COMMENT.
RCRDAYF: DAYFILE OR DIARY OF JOB EXECUTION EVENTS.
COMMENT.
RCRPNT: OUTPUT FILE CONTAINING THE RESULTS OF THE
        WAVE MODEL RUN. ((LOGICAL DEVICE UNIT TAPE6))
COMMENT.
RCRPOTPT: OUTPUT FILE CONTAINING A LISTING OF THE PROGRAM
          COMPILATION AND ABORTED JOB INFORMATION.
COMMENT.* *****
/EDIT

```

Figure 5. File RCP865J, JCL to execute RCPWAVE on the CYBER 865 computer

The job identifier (or job name) is denoted by a sequence of seven letters or numbers, here AKQBRMA. The first four characters are uniquely associated with a particular user number. The last three characters identify the job which was submitted.

67. In order to check the progress of a batch job submitted to the CYBER 865, the user can issue the following command:

```
ENQUIRE,JN=RMA      .
```

The computer will respond in one of the following ways:

- a. AKQBRMA IN INPUT QUEUE--This means that the batch job AKQBRMA is in the input queue; i.e., the job has not begun execution.
- b. AKQBRMA EXECUTING--This means that the batch job AKQBBQF is executing; i.e., the computer is processing the JCL commands.
- c. AKQBRMA IN PRINT - TERMINAL QUEUE--This means that the job AKQBRMA is in the PRINT-TERMINAL queue; i.e., the batch job has been completed, and the output is available to the user.

68. By using the T parameter on the SUBMIT command, certain information concerning the batch job is returned to the terminal upon its completion. This information includes, in the following order, a copy of the diary of events, actual user cost information, CDC scheduling information, a compiled listing of RCPWAVE, and abnormal execution information. The following QGET command is used to look at this information:

```
QGET,XYZ      .
```

The user must specify only the last three letters of the computer-generated job name (xyz). For example, if the batch job AKQBRMA is in the PRINT-TERMINAL QUEUE, the following command would be entered:

```
QGET,RMA      .
```

The computer would respond with

```
AKQBRMA ATTACHED      .
```

Then, the text editor could be used to look at this output by typing

```
XEDIT,AKQBRMA      .
```

69. The same information accessed with the QGET command resides on the permanent files RCPDAYF and RCPOTPT. These permanent files can be viewed in

three different ways. They can be accessed with a GET command and then examined via the text editor with the following information:

GET,RCPDAYF

XEDIT,RCPDAYF

and

GET,RCPOTPT

XEDIT,RCPOTPT .

Alternatively, the files can be listed at the user's terminal by typing the following commands:

OLD,RCPDAYF

LIST

and

OLD,RCPOTPT

LIST .

The files can be listed also at a remote printer site by entering

ROUTE,RCPDAYF,DC=PR,UN=SC

and

ROUTE,RCPOTPT,DC=PR,UN=SC

where SC is the site code of the device which is to receive the printed file. The printed output file RCPPRNT and the input files RCPDATA, RCPUPDT, and RCPDEPT also can be listed in any of these three ways.

CYBER 205 Job Control Language

70. Running RCPWAVE on the CYBER 205 is both more complicated and expensive than on the CYBER 865. Before work can be done on the CYBER 205 a separate CYBER 205 user number and password must be obtained. Additionally, a direct access file must be created on the user's account which contains validation information (USER and CHARGE cards for his/her CYBER 205, and CYBER 865 accounts). This file will be called AF205.

71. An example of JCL which creates this file is shown in Figure 6. The file containing this JCL can be copied onto the user's local file space and then saved permanently by typing in the following commands:

```
GET,AFJCL/UN=CERØQ2
```

```
SAVE,AFJCL      .
```

```
SENDJOB.  
USER(U=<205 USER NAME>,PA=<205 PASSWORD>)>ADY  
RESOURCE(JCAT=P3,TL=200)  
CHARGE(<CHARGE NO.>,<PROJECT NAME>)  
TV,10+.  
PURGE(AF205)  
TV,4+.  
COPY,INPUT,AF205.  
DEFINE,AF205.  
USER(<865 USER>,<865 PASSWORD>,<KOE>  
CHARGE(<CHARGE NO.>,<PROJECT NAME>)
```

Figure 6. File AFJCL, JCL to create validation information for CYBER 205 usage

By submitting this JCL file for execution, the file AF205 will be created. Certain information must be entered into this file before it is submitted: the user's CYBER 205 user number and password (<205 USERNAME> and <205 PASSWORD>, respectively), the user's charge information (<CHARGE NUMBER> and <PROJECT NAME>) with which he/she logged in, and the user's CYBER 865 user number and password (<865 USERNAME> and <865 PASSWORD>, respectively). Once these changes have been made, the JCL file can be submitted with the following command:

```
SUBMIT,AFJCL,T      .
```

Successful completion of this batch job creates the file AF205 which is required in some of the CYBER 205 commands.

72. An example of JCL used to run RCPWAVE on the CYBER 205 is given in Figure 7. The file containing this JCL can be permanently saved on the user's file space by typing the following commands:

```
GET,RCP205J/UN=CERØQ2
```

```
SAVE,RCP205J      .
```

```

/JOB
JOB:P3,T1000,CH377000.
/USER
/CHARGE
    GET,SR=RCPWAVE/UN=CER002.
    GET,UPOFL=RCPUPTOT.
    UPDATE,I=SR,N=NEWLIB,F,L=0.
    UPDATE,P=NEWLIB,I=UPOFL,C=NEWPLUS,L=0.F.
    REPLACE,NEWPLUS.
    *
    *
    COPYVR,INPUT,SENDJOB,I.
    SUBMIT,SENDJOB,I.
    DAYFILE,L=RCPDAYF.
    REPLACE,RCPDAYF.
    EXIT.
    DAYFILE,L=RCPDAYF.
    REPLACE,RCPDAYF.
    /EOR
JOB205.
USER(U=(205 USERNAME),PA=(205 PASSWORD))ADY
RESOURCE(JCAT=P3,TL=2000)
/CHARGE
    LINK,GET,NEWPLUS/DD=C6,UN=(CYBER 865 USERNAME),FM=KOE,AF=AF205.
    LINK,GET,TAPE7=RCPIATA/DD=C6,UN=(CYBER 865 USERNAME),FM=KOE,AF=AF205.
    LINK,GET,TAPE6=RCPIEPT/DD=C6,UN=(CYBER 865 USERNAME),FM=KOE,AF=AF205.
    FORTRAN,I=NEWPLUS.
    LOAD,CN=60/600,L=N205,GRLLPALL= .
    GO.
    LINK,REPLACE,TAPE6=RCPPRINT/UN=(CYBER 865 USERNAME),FM=KOE,DD=C6,AF=AF205.
    SUMMARY.
    EXIT.
    LINK,REPLACE(TAPE6=RCPPRINT/UN=(CYBER 865 USERNAME),FM=KOE,DD=C6,AF=AF205)
    SUMMARY.
    EXIT.
    /EOF

COMMENT.*****
COMMENT.*
COMMENT.*      COMMENTS CONCERNING FILES REQUIRED BY
COMMENT.*      THE ABOVE JOB CONTROL LANGUAGE (JCL)
COMMENT.*
COMMENT.*
COMMENT.*
COMMENT.*      RCPWAVE: SOURCE CODE FOR THE WAVE PROPAGATION MODEL.
COMMENT.
COMMENT.
COMMENT.      RCPUPUT: UPDATE FILE CONTAINING MODIFICATIONS TO
COMMENT.      THE SOURCE CODE.
COMMENT.
COMMENT.      RCPDATA: DATA FILE SPECIFYING GRID GEOMETRY AND WAVE
COMMENT.      CHARACTERISTICS CONSIDERED.
COMMENT.      (LOGICAL UNIT DEVICE TAPE7)
COMMENT.
COMMENT.      RCPREPT: DATA FILE CONTAINING BATHYMETRY
COMMENT.      (LOGICAL UNIT DEVICE TAPE8)
COMMENT.      **NOTE** IF THE BATHYMETRY IS GENERATED WITH FORTRAN CODE IN
COMMENT.      THE UPDATE FILE AND NOT READ IN EXPLICITLY, THE JCL
COMMENT.      LINE WHICH ACCESSES THE BATHYMETRY FILE IS NOT
COMMENT.      REQUIRED AND MUST BE REMOVED.
COMMENT.
COMMENT.      RCPDAYF: DAYFILE OR DIARY OF JOB EXECUTION EVENTS.
COMMENT.
COMMENT.      RCPPRINT: OUTPUT FILE CONTAINING THE RESULTS OF THE
COMMENT.      WAVE MODEL RUN. (LOGICAL DEVICE UNIT TAPE6)
COMMENT.
COMMENT.      RCPOTPT: DOES NOT EXIST ON THE CYBER205.
COMMENT.
COMMENT.*****
/EOF

```

Figure 7. File RCP205J, JCL to execute RCPWAVE on the CYBER 205 computer

This JCL for running RCPWAVE on the CYBER 205 must first pass through the CYBER 865 front-end computer. The first section of lines in the JCL deals with preparation of the program RCPWAVE on the front end and the subsequent relay to the CYBER 205. All JCL is described in detail in Appendix E.

Submitting the CYBER 205 Batch Job

73. The procedure for submitting a batch job for processing on the CYBER 205 is identical to that used for the CYBER 865. The following command sends the JCL shown in Figure 7 to the front-end CYBER 865 and ultimately to the CYBER 205:

```
SUBMIT,RCP205J,T      .
```

Computer response to the SUBMIT command informs the user of the computer generated job name (AKQBRUD in this case).

74. Status of the job sent to the front-end CYBER 865 is checked in the same manner as was presented before, using the ENQUIRE command:

```
ENQUIRE,JN=RUD      .
```

When the job AKQBRUD is in the PRINT-TERMINAL QUEUE, as shown below,

```
AKQBRUD IN PRINT - TERMINAL QUEUE
```

then a job should have been routed to the CYBER 205. Whether or not this occurred can be determined by checking the diary of events by typing

```
OLD,RCPDAYF
```

```
LIST
```

or by typing

```
QGET,RUD
```

```
XEDIT,AKQBRUD
```

and then using the editor to locate the diary of events in this file. The dayfile should contain the following lines, including the seven-letter jobname given to the file SENDJOB by the computer:

```
13.40.08.SUBMIT,SENDJOB,T.
```

```
13.40.08. SUBMIT COMPLETE.  JOBNAME IS AKQBRUZ.
```

If this line is not found, errors have occurred in the batch job processing; and the job has not been relayed to the CYBER 205 machine.

75. Assuming the job has been successfully sent from the front end to the CYBER 205, the status of the CYBER 205 job can be checked with the following command:

```
LINK,ENQUIRE,JN=JOB205      .
```

The computer will respond with

```
STATUS FOR CERØQ2/KOE
```

DATE MMDD	TIME HHMM	USER JOB NAME	SYSTEM JOB NAME	FILE TYPE	FILE STATUS
0326	1547	JOB205	AKQBRUZ	TO	ROUTING INITIATED TO ADY
0326	1547	JOB205	JOB2RVB	TO	ARRIVED AT ADY
LINK COMPLETE.					

When the job status reads

```
STATUS FOR CERØQ2/KOE
```

DATE MMDD	TIME HHMM	USER JOB NAME	SYSTEM JOB NAME	FILE TYPE	FILE STATUS
0326	1547	JOB205	AKQBRUZ	TO	ROUTING INITIATED TO ADY
0326	1547	JOB205	JOB2RVB	TO	ARRIVED AT ADY
0326	1555	JOB205	AKQBRUZ	WT	OUTPUT AVAILABLE AT KOE/T

then the batch job has been completed, and output is available to the user.

76. In order to get a compiled version of RCPWAVE and a dayfile containing execution information and a summary of actual cost information from the CYBER 205, the following QGET command must be used:

```
QGET,RUZ
```

```
XEDIT,AKQBRUZ      .
```

The text editor can then be used to locate and print the desired information. Notice that the output file RCPOTPT is absent from the CYBER 205 JCL. Currently it is not possible to have this information saved as a permanent file within the JCL as was done on the CYBER 865.

77. All other permanent files used or created by the JCL can be accessed and viewed in any of the three ways given previously. For example, file RCPPRNT could be viewed by typing

GET,RCPPRNT

XEDIT,RCPPRNT

or

OLD,RCPPRNT

LIST .

or

GET,RCPPRNT

ROUTE,RCPPRNT,DC=PR,UN=SC

where SC is the site code of the device which is to receive the printed file.

Input Files

78. The model source code RCPWAVE is the first file retrieved in the course of JCL processing. Both JCL files RCP865J and RCP205J obtain the source code from the permanent file space assigned to the user number CERØQ2. Users are discouraged from copying the source code onto their file space, making their own permanent modifications, and running their own model version. CERC personnel will support only the source code residing on this user number.

79. A compiler-generated listing of the entire source code, which includes a main program and nine subroutines, is provided in Appendix F. Users are encouraged to read comments within the program listing which explain important variables and input parameters as well as those comments which describe what is being performed in each subroutine. Another important feature contained in the listing is the line identifier to the far right of each FORTRAN statement. The following example of the sixth statement,

```
PROGRAM RCPWAVE (INPUT,OUTPUT,TAPE7,TAPE6,TAPE8,TAPE3)          MAIN          2
```

has as its identifier "MAIN 2" . "MAIN" denotes the main program, and "2" denotes the second line. The identifier associated with each subroutine is the subroutine name itself, and, again, the numbers correspond to line numbers within each subroutine. These identifiers are required when making changes to the model source code using the "Update" method and ensure correct placement of changes.

80. Three additional input files are accessed by RCP865J and RCP205J. They must reside on the user's permanent file space. These files contain information describing grid characteristics and wave conditions to be simulated, data controlling the amount of printed output, bottom bathymetry for each grid cell, and any changes to the model source code. The general format of each of these files is independent of the CDC machine being used to execute the wave model. However, one additional source code modification must be made when running on the CYBER 205. It will be discussed later in this section. In the following text, all three input files will be addressed using the names given to them in Figures 5 and 7--RCPDATA, RCPDEPT, and RCPUPDT.

81. RCPDATA contains grid information, specifically the size and number of cells in the grid. It contains deepwater wave characteristics (height, period, and direction) describing wave conditions to be simulated, and it contains data which control the volume of printed output. These, along with all other input parameters, are described below. Following each parameter, in parentheses, is its corresponding value taken from the sample input data file shown in Figure 8.

```

FIELD RESEARCH FACILITY (DUCK , NC) EXAMPLE
  75      12.0  50      24.0   9.800      0.0  2      0.90
    2.00    12.00   20.00
    1.50     8.00  -35.00
  1  50   1  11  41
  1

```

Figure 8. Sample input data file for a wave model application

82. A detailed description of the input parameters follows:

a. CARD 1 - FORMAT (7A10).

LTITLE - A 70-character array describing the model application being considered.

(FIELD RESEARCH FACILITY (DUCK, NC) EXAMPLE)

b. CARD 2 - FORMAT (I5, F10.4, I5, F10.4, 2F10.2, I5, F10.2).

M	- Number of grid cells in the x-direction	(75)
DX	- Cell size in the x-direction	(12.0)
N	- Number of cells in the y-direction	(50)
DY	- Cell size in the y-direction	(24.0)
G	- Gravitational acceleration constant	(9.800)

Note: The parameter G controls the units of all input and output variables. The choice shown above (9.800)

requires that all input be in the kilograms, metres, and seconds unit system. All output will also be in these units. Other options for G are 32.2 (pounds, feet, and seconds) and 980.0 (grams, centimetres, and seconds).

CNTRANG - Angle between bathymetric contours and the y axis (0.0)

Note: If the bottom contours deviate from a line parallel to the y axis by a well defined angle, inclusion of this variable may result in faster iterative convergence toward a solution. The angle convention adopted for CNTRANG is shown in Figure 2. All angles are measured in degrees. If a well defined angle does not exist, or if there is doubt, set this parameter to zero.

NCASES - Number of individual wave conditions to be simulated (2)

DLEVEL - Constant added to the entire water depth matrix which adjusts the water level datum (0.90)

c. CARDS 3a, 3b, ... - FORMAT (3F10.3).

There must be one card for each wave condition considered.

HDEEP - Deepwater wave height (2.00 for case 1, 1.50 for case 2)

TDEEP - Wave period (12.00 for case 1, 8.00 for case 2)

ZDEEP - Deepwater wave angle (20.00 for case 1, -35.00 for case 2)

Note: See Figure 2 for the wave angle convention. All wave angles in both input and output files are given in degrees.

d. CARD 4 - FORMAT (5I5).

IP1 - Wave model output starts at this "I" row number (1)

IP2 - Wave model output ends at this "I" row number (50)

INC - Row by row output is incremented by this number of lines (1)

JP1 - Wave model output starts at this "J" column number (11)

JP2 - Wave model output ends at this "J" column number (41)

Note: Column by column output is always incremented by one.

e. CARD 5 - FORMAT (2I5).

IREF - Flag for instructing the model to consider refraction only or combined refraction and diffraction (1)

= 0 refraction only

= 1 combined refraction and diffraction

Note: Users should set this parameter to one.

IGRID - Flag for indicating what type of grid system is
being used (omitted)

Note: This must be set to zero or omitted.

83. The model can be run using either constant, or variably sized, rectangular grid cells. This model documentation discusses only applications involving grids with constant sized cells. As stated earlier, technology for creating variable sized grids which are compatible with RCPWAVE does exist at CERC.

84. Bottom bathymetry for each grid cell must be supplied to the model. The source code is written such that bathymetric data are read from the file RCPDEPT in the following format. Depths along the entire row I=1 (from J=1 to J=N) are read using a 10F8.2 format. Depths along row I=2 are read next, and the procedure is repeated until depths along the offshore row I=M have been read. An example of a bathymetric grid with 10 cells in the x-direction (I coordinate) and 24 cells in the y-direction (J coordinate) is shown in Figure 9. A depth file containing this data set, and written in 10F8.2 format, is also shown. It is a trivial matter to change this section of the source code which reads the bathymetry (in subroutine DEPTH) to some other, more convenient format. Such a modification will be illustrated later in this section.

85. The wave model considers only positive, nonzero water depths in its computations. All grid cells which occupy dry land can be designated by negative depths or zeros in the input file, but the model will internally assign a small water depth of 1.0 ft (or a metric equivalent) to each of these cells. Depths in water cells that are less than 1.0 ft will be increased to this minimum value. Bathymetric input data are modified within the program in one other way. Along each row, depths in columns J=1 and J=N are replaced by the depths in columns J=2 and J=N-1, respectively. These changes are consistent with the lateral boundary conditions used in the model.

86. The third input file obtained by the JCL is the file RCPUPDT which contains necessary or desired corrections to the source code via the "Update" method. Figure 10 shows an example of an "Update" file. It is used to illustrate certain points pertaining to this correction method. The first statement in the file

*ID MODS

identifies all subsequent changes to be made with the identifier "MODS." This

Figure 9. Sample bathymetry grid and input file for a wave model application

line must be the first in any update file like RCPUPDT. The next two lines,

```
*D PARAM.3
```

and

```
PARAMETER (IQ=75,JQ=50)
```

delete the line identified by "PARAM.3" everywhere in the program and replace it with the new PARAMETER statement. This action changes the limits on all arrays within the program to match the number of cells in the grid mesh. The quantity IQ must be set greater than or equal to the number of rows, M, and JQ must be greater than or equal to the number of columns, N. These first three "Update" lines are the only ones required for model applications run on the CYBER 865 machine. For jobs sent to the CYBER 205, two additional lines must be included,

```
*D MAIN.2
```

```
PROGRAM RCPWAVE (INPUT,OUTPUT,TAPE7=TAPE7,TAPE6=TAPE6,TAPE8=TAPE8  
*,TAPE3=TAPE3)
```

These are required because the PROGRAM statement format is different for each machine's compiler. They are shown also in Figure 10.

```
ID MODS  
D PARAM.3  
    PARAMETER (IQ=75,JQ=50)  
D DEPTH.23,DEPTH.26  
    DO 14 J=1,N  
        READ(8,60) (D(I,J),I=1,M)  
        DO 315 I=1,M  
            D(I,J)=-D(I,J)  
315 CONTINUE  
60 FORMAT(5X/(15F8.2))  
14 CONTINUE  
D MAIN.203  
    DMULT=10.0  
D MAIN.2  
    PROGRAM RCPWAVE (INPUT,OUTPUT,TAPE7=TAPE7,TAPE6=TAPE6,TAPE8=TAPE8  
*,TAPE3=TAPE3)
```

Figure 10. Sample "Update" file for
a wave model application

87. The "Update" modification,

```
*D DEPTH.23,DEPTH.26  
    DO 14 J=1,N  
        READ(8,60) (D(I,J),I=M)  
    DO 315 I=1,M
```

```

      D(I,J)=-D(I,J)
315  CONTINUE
    60  FORMAT(5X/(15F8.2))
    14  CONTINUE

```

and the seven subsequent lines of FORTRAN code delete the statements identified by "DEPTH.23" through "DEPTH.26" in subroutine DEPTH and replace them with the seven new lines. These modifications alter the format used to read bottom bathymetry data; and, since the water depths on the file happen to be negative numbers, a sign change is programmed into the procedure. The "Update" correction

```

*D MAIN.203
  DMULT=10.0

```

replaces the line in the main program identified by "MAIN.203" with the subsequent new line of code. This correction changes the accuracy of the depth matrix in the printed output from whole metres (or other units) to tenths of metres (or other units). As it is written, the model prints out water depths to the nearest whole foot (metre or centimetre), wave heights to the nearest tenth foot (metre or centimetre), and wave angles to the nearest degree. Changes in output accuracy must be made via "Update" corrections. Users are referred to the statements "MAIN.194" through "MAIN.206" in Appendix F for further explanation.

88. These "Update" corrections have illustrated the use of the DELETE (*D) command which deletes line(s) of text. Other frequently used "Update" commands are the INSERT (*I) command, which inserts text after a certain line, and the BEFORE (*B) command which inserts text before a line. Users interested in making source code changes should first consult the "Update" manual referenced earlier.

Output Files

89. Two permanent output files are generated during the course of model execution on the CYBER 205. These same two files plus one additional file are generated during the course of execution on the front end (CYBER 865). Output file names given in Figure 7 will be used in this discussion. Information contained on the printed output file RCPFRNT is independent of the choice of

machines, but the diary of events RCPDAYF is machine dependent. The file RCPOTPT is generated only by the front-end machine. At some point in the future, RCPOTPT will be generated also by the CYBER 205.

90. The RCPPRNT file summarizes all model input such as grid characteristics, wave conditions considered, and bathymetry for that window of the grid mesh defined by the parameters IP1, IP2, INC, JP1, and JP2. For each wave condition simulated, a listing of the following wave characteristics is printed for the two-dimensional field defined by the above parameters: (a) breaker indices defining the location of the surf zone (zeros denote cells where no breaking is occurring), (b) wave angles, (c) wave heights, and (d) the magnitude of the wave phase function gradient (in the absence of appreciable diffractive effects this is approximately the wave number, e.g., it is a function of the wave length). Specific examples of this file will not be presented here but rather in Part V, the sample application section.

91. For jobs run on the CYBER 865, a short file (RCPDAYF) is created which summarizes the steps performed during the course of JCL processing. Any errors encountered during compilation and/or execution are indicated on this file. Estimated costs are given also, but these are not the costs which are actually billed to the user's account. Even though this "dayfile" indicates any errors which have caused abnormal job termination, it provides little detail for locating the problem. These details are provided on the file RCPOTPT.

92. This rather large file contains a compiled listing of the model, any compilation errors which may have occurred, and a short variable map. Because of its length, an example is not printed. Any of these output files can be viewed using one of the three methods mentioned previously. It should be noted that the job output returned to the users terminal with the T parameter on the SUBMIT command is very useful and can be viewed using the QGET command. This file contains: (a) the entire RCPDAYF file, (b) actual costs (including the Corps of Engineers discount), and (c) the entire RCPOTPT file.

93. For CYBER 205 model execution the "dayfile," RCPDAYF, contains only those steps actually processed on the front-end CYBER 865 machine. The QGET command must be used to obtain job output from the CYBER 205. This output includes: (a) a file equivalent to the front-end RCPOTPT file (compiled listing and any compilation errors), (b) the diary of events which occurred during CYBER 205 processing, and (c) computer usage and actual cost information.

General Comments

94. General guidance concerning RCPWAVE applications is provided in this section. Two model applications are given to demonstrate the different scales of prototype problems for which the model can be applied successfully. The next two sections explain each example in greater detail. Listings of JCL files used to run each simulation are provided, as are listings of input files and printed output. Comparisons between model execution costs incurred on both CDC computers are given in the last section.

95. Whenever RCPWAVE is a candidate for solving a wave propagation problem, the area of interest is well defined, and wave conditions to be simulated are known. The user must create a finite difference grid system encompassing the area. Grid characteristics determine the success of the application, so they should be given considerable thought. Two factors completely define the grid, orientation of the axes, and cell resolution.

96. Users should construct the grid system so that the y-axis runs as parallel to the coastline as possible. This causes the x-axis to be directed offshore and probably somewhat perpendicular to the bottom contours. The lateral boundary conditions used in the model are most accurate when this axis configuration is adopted. The boundary conditions assume that the variation of the bathymetry, and wave parameters, in the y-direction is small. The assumption is most accurate when the y-direction is essentially the longshore direction. Ideally this axis configuration also results in the offshore bathymetry having fairly straight and parallel contours and the offshore rows of cells having the greatest depths. The procedure of applying Snell's law to propagate wave information from deep water to the seaward boundary of the model is more accurate if these conditions exist.

97. Waves will generally attempt to advance in directions parallel to the x-axis as a result of the recommended orientation. The model tends to produce erroneous results if computed waves attempt to propagate parallel to the y-axis (wave angles near plus or minus 90 deg). Even with this axis configuration, problems may arise due to very irregular bottom bathymetry and/or very oblique wave incidence. These errors manifest themselves via large local wave angles and occurrences of very large and very small wave heights in

alternating cells. An artificial limit on the absolute value of the wave angle, 86 deg, is written into the model. Problems of this nature can sometimes be eliminated by using finer grid resolution.

98. Cell size is the second factor defining the grid system. Accuracy of model solutions computed using finite difference approximations is dependent upon cell size; smaller cells result in less error. Diffractive effects can become important on spatial scales with orders of magnitude smaller than the wave lengths being considered. In modeled regions of interest where diffraction is important (very complicated bathymetry) cell sizes may need to be some fraction of the wavelength in order to simulate wave propagation accurately. Fine resolution is not a requirement for model applications where the bathymetry is very regular. The physical processes of importance, whether it be refraction or a combination of refraction and diffraction, dictate cell sizes which should be used.

99. The examples in the next two sections represent two different kinds of problems. Example I deals with wave propagation over a rather small region with complex bathymetry. Diffraction was presumed to be an important physical process; therefore, finer grid resolution was used in an attempt to represent this effect more accurately. Example II illustrates the applicability of RCPWAVE for propagating waves over a very large area dominated by very regular bathymetry. Assuming that refractive effects would dominate wave transformation throughout the region, cell sizes were increased to a value on the same order of magnitude as the wave length. These two examples show the diversification of problems which can be addressed using the model.

Example I: FRF Pier, Duck, North Carolina

100. Bathymetry in the vicinity of CERC's research pier at Duck, North Carolina, is quite complex as seen in Figures 11 and B2. Figure 11 was plotted using similar bathymetric data digitized onto the rectangular grid system comprised of 75 cells in the offshore (x) direction and 50 cells in the longshore (y) direction. Again, cell sizes are 12 and 24 m in the x- and y-directions, respectively. All depths on the bathymetric file are given in metres below MSL. A constant tidal elevation of 0.90 m is added to the bathymetric data. Two wave conditions are considered: (a) 2-m-deep water wave height, 12-sec wave period, and +20 deg deepwater incident angle (refer

Figure 11. Bathymetry used in the FRF pier, Duck, North Carolina sample application

to the angle convention in Figure 2) and (b) 1.5-m deepwater wave height, 8-sec period, and -35 deg deepwater incident angle.

101. All files associated with this example are listed in Appendix G. Files are arranged in the following sequence:

- a. JCL file to run this application on the CYBER 865, DUCK865 (Figure G1)
- b. JCL file to run this application on the CYBER 205, DUCK205 (Figure G2)
- c. Input data file , DUCKDAT (Figure G3)
- d. Source code correction file for the CYBER 865 run, DUCKUPD (Figure G4)
- e. Source code correction file for the CYBER 205 run, DUCKUP2 (Figure G5)

- f. A sample of the bathymetric data file , DUCKDEP
(Figure G6)
- g. Printed output file , RCPPRNT
(Figure G7)

Two-dimensional fields of total water depth, breaker index, wave angle, wave height, and wave number (more precisely, the wave phase gradient) are printed for a portion of the grid extending from rows I=1 to I=50 and from columns J=11 to J=41. Figure 11 shows the extent of this region relative to the entire grid system.

Example II: Homer Spit, Alaska

102. Bathymetry for this application (see Figure 12) is digitized onto a grid with 96 rows in the offshore (x) direction and 83 cells in the longshore (y) direction. Cell dimensions are approximately 417 ft in the x-direction and 833 ft in the y-direction (about 10 times the resolution used in the Duck, North Carolina, examples. One wave condition is considered in

Figure 12. Bathymetry used in the Homer Spit, Alaska, sample application

the simulation. The deepwater wave height is 8 ft, the period is 10 sec, and the deepwater wave angle is -45 deg (see Figure 2 for the wave angle convention). Bathymetry is given in fathoms below mean low water so depths are converted to feet via a correction to the source code. No water level datum adjustment is applied.

103. All files associated with this example are listed in Appendix H. Files are arranged in the following sequence:

- a. JCL file to run this application on the CYBER 865, HOMR865 (Figure H1)
- b. JCL file to run this application on the CYBER 205, HOMR205 (Figure H2)
- c. Input data file , HOMRDAT (Figure H3)
- d. Source code correction file for the CYBER 865 run, HOMRUPD (Figure H4)
- e. Source code correction file for the CYBER 205 run, HOMRUP2 (Figure H5)
- f. A sample of the bathymetric data file , HOMRDEP (Figure H6)
- g. Printed output file , RCPPRNT (Figure H7)

Two-dimensional fields of water depth and wave parameters are given also in Appendix H for the subgrid region denoted in Figure 12.

Cost Comparisons

104. The following tabulation shows cost comparisons between simulations run on both CDC machines. Costs in dollars are shown for Examples I and II which represent the FRF pier and Homer Spit, respectively.

	<u>Priority</u>	<u>CYBER 865 Cost in Dollars</u>	<u>CYBER 205 Cost in Dollars</u>
Example I	P4	2.24	6.09
	P3	0.86	4.74
	P2	0.17	1.68
Example II	P4	2.51	6.40
	P3	0.96	4.98
	P2	0.19	3.25

These are actual costs to the user and include the Corps' fiscal year 1985 (FY 85) discount of 45 percent. Example I was run on a 75 by 50 grid. Two wave conditions were simulated. One wave condition was considered in Example II, but the grid was larger, 96 by 83.

105. The CYBER 865 is a cheaper, easier computer to work on. It does have central memory limitations. Comparisons show that costs incurred during simulations using the CYBER 205 are not excessive. Users should not sacrifice modeling accuracy simply to avoid using the CYBER 205.

PART VI: GRID INTERPOLATION PROGRAM (INTPRCP)

General Comments

106. Bathymetry at every cell of the finite difference grid mesh is required as input into RCPWAVE. Since digitization of bathymetric data from survey or nautical charts is both tedious and time consuming, it is desirable to limit the number of times one must perform this task. The grid interpolation program INTPRCP provides a method for determining bathymetry on a "new" grid using depth data from an "old" grid. The origin of the new grid can be rotated and/or translated relative to the old grid origin. This capability for interpolation ensures that the bulk of the digitization is done only once. The program is useful when:

- a. A coarse grid containing bathymetry is available but finer resolution is desired or required.
- b. The axis orientation of the available grid is different from the desired orientation.
- c. The region to be modeled is a subset of the available grid.

A compiled listing of the program is given in Appendix I.

107. The program uses a fairly simple interpolational scheme. For each new grid cell, a search is done for the nearest old depth value in each of the four 90 deg quadrants relative to the new cell center. A weighted average of these four values is used to compute a new depth. The weighting functions are based on relative distances from the new grid center to the cell centers defining the positions of the four old depth values.

108. JCL is available to run the program on the CDC CYBER 205 machine only. The next section briefly describes the procedures performed in the course of job execution. It also explains how an interpolational job is submitted. The third section documents, in detail, all required input files and includes some examples. It also describes the output files created during program execution. A complete example illustrating the use of INTPRCP is presented in the last section.

Executing INTPRCP on the CDC Computing System

109. The interpolation program is run on the CYBER 205 machine in a

remote batch mode just like the wave model. This machine was chosen instead of the CYBER 865 because it has more available central memory. As a result, users are not limited by the number of grid cells contained in either the old or new grids. A CYBER 205 user number and password must be obtained before attempting to run INTRPCP. The direct access file AF205, mentioned in Part IV, must exist on the user's file space. This file contains validation information for the user's CYBER 205 and CYBER 865 accounts. Refer to Part IV for details concerning these requirements.

110. The JCL file called INTRCPJ, used to run INTRPCP, is shown in Figure 13. A copy of this file can be obtained by logging into the CDC computing system and typing

```
GET,INTRCPJ/UN=CEROQ2      .
```

This action creates a local file called INTRCPJ on the user's work space. To save the file permanently, type the following command:

```
SAVE,INTRCPJ      .
```

The JCL file for executing the interpolation program on the CYBER 205 must first pass through the front-end machine. The first section of JCL commands deals with compilation of the program on the front end and the subsequent relay to the CYBER 205. Commands in the CYBER 205 JCL instruct the computer to gather old and new grid information, retrieve bathymetry data for the old grid, compile and execute the program, and save the new grid bathymetry. The "COMMENT" section of the JCL briefly describes required input data files and output files generated in the course of program execution. Before submitting this JCL file, the user must make a few changes. Users must replace the "<205 USERNAME>," "<205 PASSWORD>," and "<CYBER 865 USERNAME>" with the passwords and user numbers associated with their account.

111. The front-end machine is given the entire batch of commands contained in INTRCPJ by using the SUBMIT command in the following way:

```
SUBMIT,INTRCPJ,T      .
```

The T parameter instructs the computer to return certain output to the user's terminal. The procedure for checking job status and accessing output is identical to that presented in Part IV. No further discussion addressing these points is given.


```

/JOB
JOB,P3,T1000,CMK377000.
/USER
/CHARGE
GET,SR=INTPROP/UNE=CE022.
SET,UPDFL=INTPUD.
UPDATE,I=SR,N=NEWLJB,F,L=0.
UPDATE,P=NEWLJB,I=UPDFL,C=NEWPLUS,L=0,F.
REPLACE,NEWPLUS.
COMMENT.
COMMENT.
COPYBR,INPUT,SENDJOB=1.
COMMENT.
SUBMIT,SENDJOB.1.
DAYFILE,L=INTPAY.
REPLACE,INTPAY.
EXXIT.
DAYFILE,L=INTPAY.
REPLACE,INTPAY.
/END
JOB205.
USER,U=(205 USERNAME),PA=(205 PASSWORD),ADV
RESOURCE,JCAT=P3,TL=2000.
/CHARGE
RESOURCE LIMITS CARD
LINLN,GET,NEWPLUS/DD=C6,UN=(CYBER 865 USERNAME),FM=XOE,AF=AF205.
LINLN,GET,TAPE7=INTP60/DD=C6,UN=(CYBER 865 USERNAME),FM=XOE,AF=AF205.
LINLN,GET,TAPE7=INTP60/DD=C6,UN=(CYBER 865 USERNAME),FM=XOE,AF=AF205.
FORTN,TAPE7=INTP60/DD=C6,UN=(CYBER 865 USERNAME),FM=XOE,AF=AF205.
LOAD,CN=60/6000,L=M205,6RLPALL= .
GO.
LINLN,REPLACE,TAPE6=INTPUD/UN=(CYBER 865 USERNAME),FM=XOE,DD=C6,AF=AF205.
LINLN,REPLACE,TAPE7=INTP60/UN=(CYBER 865 USERNAME),FM=XOE,DD=C6,AF=AF205.
LINLN,REPLACE,TAPE7=INTP60/UN=(CYBER 865 USERNAME),FM=XOE,DD=C6,AF=AF205.
/END

```

Figure 13. File INTRCPJ, JCL to execute INTPRCP, the interpolation program, on the CYBER 205 machine

Input and Output Files

112. The interpolation program reads input data from two files, INTDEPO and INTPGRD. Old grid bathymetry is contained in INTDEPO. The procedure for reading bathymetry into this program is the same as that used in RCPWAVE. The row of depths corresponding to I=1 are read first in "10F8.2" format. A row includes values from J=1 to J=N. The row-by-row procedure is repeated until the offshore row (I=M) has been read. An example of a depth file in this format was shown in Figure 9.

113. Input data contained in INTPGRD are geometric parameters which define the grid characteristics of the old and new grids. The format used by the program to read this information and a description of each parameter are given here. The value for each input parameter, taken from the sample input file shown in Figure 14, is also given in parentheses after the description.

```
35 30 50 40. 10.0 0.5 0.5
0 0
0.20 0.20
0.14 0.15
```

Figure 14. Sample input data file
for grid interpolation

a. CARD 1 - FORMAT (4I5, 3F10.5).

M	- Number of grid cells in the x-direction for the old grid	(35)
N	- Number of grid cells in the y-direction for the old grid	(30)
N2	- Number of grid cells in the x-direction for the new grid	(50)
M2	- Number of grid cells in the y-direction for the new grid	(40)
ANG	- Angle of rotation measured from the old grid to the new grid (positive angles are measured counterclockwise, negative angles are measured clockwise)	(10.0)
XSHIFT	- Offset from the old grid to the new grid in the x-direction (positive offsets indicate that the new grid origin is below the old origin, negative offsets indicate that the new grid origin is above the old grid origin)	(0.5)

YSHIFT - Offset from the old grid to the new grid in the y-direction (positive offsets indicate that the new grid origin is to the right of the old origin, negative offsets indicate that the new grid origin is to the left of the old grid origin) (0.5)

Note: The conventions for ANG, XSHIFT, and YSHIFT are shown in Figure 15.

Figure 15. "Old" and "new" grid conventions used in the interpolation program

b. CARD 2 - FORMAT (2I5).

GRDTYP1 - Old grid type (must be set to zero) (0)

GRDTYP2 - New grid type (must be set to zero) (0)

c. CARD 3 - FORMAT (2F10.5).

DX - Old grid cell size in x-direction (0.2)

DY - Old grid cell size in the y-direction (0.2)

d. CARD 4 - FORMAT (2F10.5).

DX2 - New grid cell size in the x-direction (0.14)

DY2 - New grid cell size in the y-direction (0.15)

Note: The parameters DX, DY, DX2, and DY2 must all have consistent units.

114. In addition to bathymetry and grid information, one other input file is required. This is the file INTPUPD which contains any source code changes and must include information specifying the number of cells contained in both the old and new grids. An example of this file is shown in Figure 16. Variables in the PARAMETER statements are defined here; and their values, taken from the example, are shown in parentheses:

IQ - Number of cells in the x-direction for the old grid (35)

JQ - Number of cells in the y-direction for the old grid (30)

IQ2 - Number of cells in the x-direction for the new grid (50)

JQ2 - Number of cells in the y-direction for the new grid (40)

KQ - Larger of the two products IQ*JQ or IQ2*JQ2 (2000)

Modifications to change the procedure or format for reading the bathymetry into the program should be included in this file. Figure 16 shows an example of such changes. Here, a format different from the one in the program was desired. The section of source code which reads old grid bathymetry is contained in the lines designated by "INTERPO.15" through "INTERPO.18" in Appendix I.

```
*ID MODS
*ID PARAM.3,PARAM.5
   PARAMETER(IQ=35,JQ=30)
   PARAMETER(IQ2=50,JQ2=40)
   PARAMETER(KQ=2000)
*ID INTERPO.18
  11 FORMAT(15F5.0)
```

Figure 16. Sample
"Update" file for
grid interpolation

115. There are three output files created as a result of running the program. The file INTPDAY is a dayfile containing a diary of events which occurred on the front-end CYBER 865 machine. This is saved as a permanent file on the user's file space. A file called INTPOUT is created on the CYBER 205 and is saved permanently. It contains a compile listing, execution information, and printed output created during the run. The printed output

includes a listing of both old and new grids and the grid characteristics of each. The file INTDEPN contains the bathymetry for the new grid. This file is written using the same procedure and format as those used for reading the old depth data (row by row in 10F8.2 format).

Grid Interpolation Example

116. The example problem involves interpolating bathymetry from an old grid with square cells to a new grid with smaller, rectangular-shaped cells. The new grid system is translated and rotated relative to the old grid. Original grid cell dimensions are 0.2 and 0.2 in the x- and y-directions, respectively. The new grid requires 50 cells in the x-direction, each 0.14 in length, and 40 cells in the y-direction, each 0.15 in length. The new grid is shifted by 0.5 in both coordinate directions and rotated 10 deg in the counterclockwise direction relative to the old grid. The input files used in this example, INTPGRD, INTDEPO, and INTPUPD are shown in Appendix J. The order in which the files are listed is:

- a. Input data file ,INTPGRD (Figure J1)
- b. Source code correction file ,INTPUPD (Figure J2)
- c. Sample of the input bathymetric file ,INTDEPO (Figure J3)
- d. Sample of the output bathymetric file ,INTDEPN (Figure J4)

Figure 17 shows both grids and contour plots of the original and interpolated bathymetry.

— ORIGINAL BATHYMETRIC CONTOURS
- - - INTERPOLATED BATHYMETRIC CONTOURS

Figure 17. Comparison between original and interpolated bathymetry for the sample grid interpolation application

PART VII: CONCLUSIONS AND RECOMMENDATIONS

117. The model presented in this report is capable of simulating wave propagation over arbitrary, and potentially complex, bathymetry. The governing equations are theoretically applicable to linear, monochromatic plane wave propagation only. Comparisons between model results and laboratory data showed good agreement, indicating that the model is quite accurate if the above conditions are satisfied. The results also showed the model's ability to simulate not only wave refraction but also bottom-induced diffraction. Comparisons between model results and field data indicated the model is capable of accurately simulating the transformation of single-peaked, narrow-banded, wave spectra. Results from one test suggest potential model use for solving problems involving propagation of wider-banded spectra, if a clearly defined wave direction exists. This hypothesis has not been substantiated in this report.

118. The wave breaking scheme incorporated into the model is a vast improvement over those wave propagation models which assume proportionality between wave height and water depth throughout the surf zone. Comparisons between model results and laboratory data showed the model to be reasonably accurate for a variety of bottom profiles, including plane, stepped, and barred beaches. Since the breaking scheme assumes that all waves break at the same location, the model is most valid for monochromatic waves and very narrow-banded wave spectra. No field data were used to verify the wave breaking aspects of the model.

119. The user's manual portion of the documentation and the sample applications presented show the model's ease of application. Users are reminded to pay close attention to comments made concerning relationships between model accuracy and grid resolution. The problems of interest and the perceived physical processes of importance should dictate cell sizes. Also, the user should remember assumptions inherent in the model's governing equations. Applications in which these assumptions are violated may yield erroneous results.

120. The model provides a tool which can be used by field personnel to solve many types of wave problems in a quantitative way and at a very low cost. If all assumptions inherent in the model development are essentially met, very accurate results can be obtained. Even if the model is applied to

problems in which some of the model assumptions are violated, it may still yield informative results, at least qualitatively if not quantitatively.

121. The JCL files used to execute the wave model and the interpolation program on the CDC computing system utilize commands and procedures which are currently operative (at the time the report is being written). CERC personnel are not responsible for any changes implemented by the CDC which may render these files inoperative. However, CERC personnel will attempt to maintain usable JCL files with the same names as those given in the text.

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APPENDIX A: VERIFICATION OF MODEL RESULTS USING THE
ELLIPTICAL SHOAL LABORATORY TEST DATA

Figure A1. Geometry used in the model simulation of the elliptical shoal case

Figure A2. Comparisons between model results and observed data for the elliptical shoal case (profiles 1, 2, and 3)

Figure A3. Comparisons between model results and observed data for the elliptical shoal case (profiles 4 and 5)

Figure A4. Comparisons between model results and observed data for the elliptical shoal case (profiles 6, 7, and 8)

APPENDIX B: VERIFICATION OF MODEL RESULTS USING FIELD
RESEARCH FACILITY (FRF) PROTOTYPE DATA

Figure B1. Observed offshore wave spectra during field verification, Cases 1 through 6

Figure B2. Bathymetry around the FRF pier measured on 16 October 1982 and 27 October 1982

Figure B3. Comparisons between model results and observed data for field verification, Cases 1, 2, and 3

Figure B4. Comparisons between model results and observed data for field verification, Cases 4, 5, and 6

APPENDIX C: VERIFICATION OF MODEL RESULTS USING BREAKING
WAVE DATA COLLECTED IN LABORATORY EXPERIMENTS

Figure C1. Comparisons between model results and observed data for wave breaking verification, Test 1 (surf zone transformation only)

Figure C2. Comparisons between model results and observed data for wave breaking verification, Test 2 (surf zone transformation only)

Figure C3. Comparisons between model results and observed data for wave breaking verification, Test 3 (surf zone transformation only)

Figure C4. Comparisons between model results and observed data for wave breaking verification, Test 4 (surf zone transformation only)

Figure C5. Comparisons between model results and observed data for wave breaking verification, Test 5 (surf zone transformation only)

Figure C6. Comparisons between model results and observed data for wave breaking verification, Test 6 (surf zone transformation only)

Figure C7. Comparisons between model results and observed data for wave breaking verification, Test 7 (surf zone transformation only)

Figure C8. Comparisons between model results and observed data for wave breaking verification, Test 8 (surf zone transformation only)

Figure C9. Comparisons between model results and observed data for wave breaking verification, Test 9 (surf zone transformation only)

Figure C10. Comparisons between model results and observed data for wave breaking verification, Test 5 (incipient breaking and surf zone transformation)

Figure C11. Comparisons between model results and observed data for wave breaking verification, Test 7 (incipient breaking and surf zone transformation)

Figure C12. Comparisons between model results and observed data for wave breaking verification, Test 8 (incipient breaking and surf zone transformation)

Figure C13. Comparisons between model results and observed data for wave breaking verification, Test 9 (incipient breaking and surf zone transformation)

APPENDIX D: LINE-BY-LINE DESCRIPTION OF JOB CONTROL LANGUAGE
FOR EXECUTING RCPWAVE ON THE CYBER 865 COMPUTER

(1) /JOB

The job card tells the computer that this is a batch job.

(2) JOB,P3,T1000,CM37000.

The resource card informs the computer of the priority (P) of the batch job, the execution time (T), and central memory (CM) limits.

<u>Priority</u>	<u>Meaning</u>	<u>Guaranteed Response Time, hr</u>	<u>Cost/ SBU* dollars</u>
P1	Weekend run	<48	0.01
P2	Overnight run	<24+	0.01
P3	Slower than default	<4+	0.04
P4	Default	<2+	0.12
P6	Faster than default	<1/2+	0.13

* Current Control Data Corporation (CDC) costs (FY 85).

+ Excluding execution time.

T: SBU account block limit.

This is the job execution time limit (in seconds).

CM: Central memory field length limit is the maximum amount of memory you can use for your batch job (in octal words).

(3) /USER

This form of the user card specifies that the user identification number being used in the current session will be assigned to this batch job.

(4) /CHARGE

The charge card identifies the charge code being used for the current session and bills that charge account for the cost of the batch job.

****Important****

The following "GET" commands instruct the computer to access certain permanent files. Using this form of the "GET" command assumes that all files, except RCPWAVE, reside in the file space assigned to the user number being used in the current session.

The following statements instruct the computer to:

- (5) GET,SR=RCPWAVE/UN=CERØQ2. Get the permanent file RCPWAVE from user number CERØQ2 file space and give it the local file name SR for this batch job.
- (6) GET,UPDFL=RCPUPDT. Get the permanent file RCPUPDT and give it the local file name UPDFL for this batch job.
- (7) GET,TAPE7=RCPDATA. Get the permanent file RCPDATA and give it the local file name TAPE7 for this batch job.
- (8) GET,TAPE8=RCPDEPT. Get the permanent file RCPDEPT and give it the local file name TAPE8 for this batch job.
- (9) UPDATE(I=SR,N=NEWLIB,F,L=Ø) Take the local file SR and create a full (F), new program library NEWLIB from it, but do not list (L=Ø) the file NEWLIB.
- (10) UPDATE(P=NEWLIB,I=UPDFL, C=NEWPLUS,L=Ø,F). Take the program library NEWLIB and add to it the update information contained in file UPDFL. Do not list the full combined program library called NEWPLUS.
- (11) FTN5,I=NEWPLUS,B=BIN,L=OUTPUT. Compile the file NEWPLUS. Save the relocatable binary code in a local file BIN and the compiled listing in a local file OUTPUT.
- (12) LOAD,BIN. Load the local file BIN.
- (13) EXECUTE. Run the program BIN.
- (14) REWIND,TAPE6,OUTPUT. Rewind the local files TAPE6 and OUTPUT which generated during compilation and execution of the program.
- (15) REPLACE,TAPE6=RCPPRNT. Take the information from local file TAPE6 and save it in the permanent file RCPPRNT. If a permanent file RCPPRNT already exists, it will be replaced with this new information.
- (16) REPLACE,OUTPUT=RCPOTPT. Take the information from local file OUTPUT and save it in the permanent file RCPOTPT. If a permanent file RCPOTPT already exists, it will be replaced with this new information.
- The following statements instruct the computer to:
- (17) COST. Estimate the cost of this batch job. This cost excludes the CDC discount to US Army Corps of Engineers users.

(18) DAYFILE,L=RCPDAYF.

Create a diary of events for this batch job and give the diary a local file name RCPDAYF.

(19) REPLACE,RCPDAYF.

Save RCPDAYF as a permanent file. If a permanent file RCPDAYF already exists, it will be replaced with this new information.

(20) EXIT.

Stop processing information if no errors have occurred. If errors have occurred prior to reaching line 20, the system jumps to this line then continues downward in what is called "error processing." Processing beyond this point consists of saving output and diary files as was done in lines 14 through 19.

APPENDIX E: LINE-BY-LINE DESCRIPTION OF JOB CONTROL LANGUAGE
FOR EXECUTING RCPWAVE ON THE CYBER 205 COMPUTER

(1) /JOB	The job card tells the computer that this is a batch job.
(2) JOB,P3,T1000,CM377000.	The resource card informs the computer of the priority (P) of your batch job, and the execution time (T) and central memory (CM) limits.
(3) /USER	This form of the user card specifies that the user identification number being used in the current session will be assigned to this batch job.
(4) /CHARGE	The charge card identifies the charge code being used for the current session and bills that charge account for the cost of the batch job.
Important	The following "GET" commands instruct the computer to access certain permanent files. Using this form of the "GET" command assumes that all files, except RCPWAVE, reside in the file space assigned to the user number being used in the current session. <u>The following statements instruct the computer to:</u>
(5) GET,SR=RCPWAVE/UN=CERØQ2.	Get the permanent file RCPWAVE from user number CERØQ2 file space and give it the local file name <u>SR</u> for this batch job.
(6) GET,UPDFL=RCPPUPDT.	Get the permanent file RCPUPDT and give it the local file name <u>UPDFL</u> for this batch job.
(7) UPDATE,I=SR,N=NEWLIB,F,L=0.	Take the local file <u>SR</u> and create a full (F) new program library <u>NEWLIB</u> from it. Do not list (L=0) the file <u>NEWLIB</u> .
(8) UPDATE,P=NEWLIB,I=UPDFL,
C=NEWPLUS,L=0,F.	Take the program library <u>NEWLIB</u> and add in the update information contained in file <u>UPDFL</u> . Do not list the full combined program library <u>NEWPLUS</u> .
(9) REPLACE,NEWPLUS.	Save <u>NEWPLUS</u> as a permanent file. If a permanent file <u>NEWPLUS</u> already exists, it will be replaced with this new information.
(10) COPYBR,INPUT,SENDJOB,1.	Copy one record from the local file <u>INPUT*</u> to the local file <u>SENDJOB</u> .
- *INPUT begins after the EOR card (card 19). One record is defined as all the cards in INPUT until a /EOR or /EOF is encountered (Card 35).

The following statements instruct the computer to:

- (13) SUBMIT,SENDJOB,T. Give the CYBER 205 the batch of commands in file SENDJOB.
- (14) DAYFILE,L=RCPDAYF. Create a diary of events for this batch job and give the diary a local file name RCPDAYF.
- (15) REPLACE,RCPDAYF. Save RCPDAYF as a permanent file. If a permanent file RCPDAYF already exists, it will be replaced with this new information.
- (16) EXIT. Stop processing information if no errors have occurred. If errors occur prior to reaching the EXIT card, the system jumps to this line then continues downward in what is called "error processing." Processing beyond this point consists of saving the diary file as was done in lines 14 and 15.
- (19) /EOR End of record card. All cards following card 19 are part of local file INPUT.
- (20) JOB205. The job card tells the computer that this is a batch job.
- (21) USER(U=<205 USERNAME>, PA=<205 PASSWORD>)ADY. The user card identifies the CYBER 205 user for billing purposes.
- (22) RESOURCE(JCAT=P3,TL=2000). The resource card informs the computer of the priority (P) and time (TL) of the batch job.

<u>Priority</u>	<u>Meaning</u>	<u>Guaran- teed Response Time, hr</u>	<u>Cost SBU* dollars</u>
P2	Overnight run	<24+	0.08
P3	Slower than default	<4+	0.12
P4	Default	<2+	0.15
P6	Faster than default	<1/2+	0.18

* Current Control Data Corporation (CDC) costs (FY 85).

+ Excluding execution time.

- T: SBU account block limit. This is the job execution time limit (in seconds).
- (23) /CHARGE
- The charge card identifies the charge being used for the current session and bills that charge account for the batch job.
- The following statements instruct the computer to:
- (24) LINK,GET,NEWPLUS/DD=C6,
UN=<CYBER 865 USERNAME>
,FM=KOE,AF=AF205.
- Get the permanent file NEWPLUS from the CYBER 865 user account. AF205 is your direct access file containing validation information.
- (25) LINK,GET,TAPE7=RCPDATA/DD=C6
UN=<CYBER 865 USERNAME>
,FM=KOE,AF=AF205.
- Get the permanent file RCPDATA from the CYBER 865 user account and give it the local file name TAPE7.
- (26) LINK,GET,TAPE8=RCPDEPT/DD=C6,UN=<CYBER 865 USERNAME>
,FM=KOE,AF=AF205.
- Get the permanent file RCPDEPT from the CYBER 865 user account and give it the local file name TAPE8.
- (27) FORTRAN,I=NEWPLUS.
- Compile the file NEWPLUS. The relocatable LGO by default, and the compiled listing is on local file OUTPUT by default.
- (28) LOAD,ON=GO/6000,L=M205,
GRLPALL=.
- Load the relocatable binary code.
- (29) GO.
- Run the program.
- (30) LINK,REPLACE(TAPE6=RCPPRNT/
UN=<CYBER 865 USERNAME>
,FM=KOE,DD=C6,AF=AF205)
- Take the information on TAPE6 and save it in the permanent file RCPPRNT. If a permanent file RCPPRNT already exists, it will be replaced with this new information.
- (31) SUMMARY.
- The summary card tells the computer to list out all system usage (i.e., blocks, disks, SBU's) for this batch job.
- (33) /EOF
- End of file marker.

APPENDIX F: RCPWAVE PROGRAM LISTING

1	PROGRAM RCPWAVE(INPUT,OUTPUT,TAPE7,TAPE6,TAPE8,TAPE3)	MAIN	2
2	CAAA	MAIN	3
3	C	MAIN	4
4	CA* NOTE ** 'IQ' AND 'JQ' DEFINE THE LENGTH OF THE ONE AND TWO	MAIN	5
5	C DIMENSIONAL ARRAYS USED IN THE PROGRAM. 'IQ' CORRESPONDS	MAIN	6
6	C TO THE X DIRECTION (ON-OFFSHORE) AND 'JQ' TO THE Y	MAIN	7
7	C DIRECTION (LONGSHORE)	MAIN	8
8	C	MAIN	9
9	CAAA	MAIN	10
10	C	MAIN	11
11	C	PARAM	2
12	PARAMETER(IQ=95,JQ=95)	PARAM	3
13	C	PARAM	4
14	C	MAIN	13
15	CA* NOTE ** THE PRODUCT IQ * JQ MUST BE LESS THAN 9025 IF THE MODEL	MAIN	14
16	C APPLICATION IS TO BE RUN ON THE FRONT END CYBER 863	MAIN	15
17	C MACHINE. ANYTHING LARGER MUST BE RUN ON THE CYBER 305.	MAIN	16
18	C	MAIN	17
19	CAAA	MAIN	18
20	C	MAIN	19
21	CA* DEFINITION OF IMPORTANT VARIABLE ARRAYS USED THROUGHOUT THE PROGRAM	MAIN	20
22	C	MAIN	21
23	C Z - WAVE ANGLE	MAIN	22
24	C SI - SIN(Z)	MAIN	23
25	C CO - COS(Z)	MAIN	24
26	C H - FUNCTION OF THE WAVE AMPLITUDE	MAIN	25
27	C CCG - PRODUCT OF THE WAVE CELERITY AND THE GROUP VELOCITY	MAIN	26
28	C D - TOTAL WATER DEPTH RELATIVE TO SOME DATUM	MAIN	27
29	C RKA - WAVE NUMBER DEFINED BY THE DISPERSION RELATION	MAIN	28
30	C GRC - GRADIENT OF THE WAVE PHASE FUNCTION	MAIN	29
31	C XMUC - SCALE FACTOR RELATING REAL SPACE X GRID DISTANCES	MAIN	30
32	C TO MAPPED SPACE X GRID DISTANCES AND DEFINED AT THE	MAIN	31
33	C GRID CENTER	MAIN	32
34	C XMUS - SCALE FACTOR RELATING REAL SPACE X GRID DISTANCES	MAIN	33
35	C TO MAPPED SPACE X GRID DISTANCES AND DEFINED AT THE	MAIN	34
36	C GRID SIDES	MAIN	35
37	C YMUC - SCALE FACTOR RELATING REAL SPACE Y GRID DISTANCES	MAIN	36
38	C TO MAPPED SPACE Y GRID DISTANCES AND DEFINED AT THE	MAIN	37
39	C GRID CENTER	MAIN	38
40	C YMUS - SCALE FACTOR RELATING REAL SPACE Y GRID DISTANCES	MAIN	39
41	C TO MAPPED SPACE Y GRID DISTANCES AND DEFINED AT THE	MAIN	40
42	C GRID SIDES	MAIN	41
43	C XX - REAL SPACE X GRID DISTANCES MEASURED FROM THE GRID	MAIN	42
44	C ORIGIN TO THE GRID CENTER	MAIN	43
45	C YY - REAL SPACE Y GRID DISTANCES MEASURED FROM THE GRID	MAIN	44
46	C ORIGIN TO THE GRID CENTER	MAIN	45
47	C	MAIN	46
48	CAAA	MAIN	47
49	C	MAIN	48
50	CA* DEFINITIONS OF INPUT DATA TO BE READ INTO THE PROGRAM **	MAIN	49
51	C	MAIN	50
52	C ITITLE - ARRAY CONTAINING THE APPLICATION TITLE (70	MAIN	51
53	C CHARACTERS OR LESS)	MAIN	52
54	C M - NUMBER OF GRID CELLS IN THE X DIRECTION	MAIN	53
55	C DX - GRID SIZE IN THE X DIRECTION	MAIN	54
56	C N - NUMBER OF GRID CELLS IN THE Y DIRECTION	MAIN	55
57	C DY - GRID SIZE IN THE Y DIRECTION	MAIN	56
58	C **NOTE** G - GRAVITATIONAL CONSTANT WHICH DETERMINES THE UNITS OF	MAIN	57

59	C	ALL THE INPUT AND OUTPUT VARIABLES	MAIN	58
60	C	CNTRANG - APPROXIMATE ANGLE THE OFFSHORE CONTOURS MAKE WITH	MAIN	59
61	C	THE Y AXIS (AIDS IN A BETTER INITIAL GUESS OF THE	MAIN	60
62	C	SOLUTION COMPUTED USING SNELL'S LAW)	MAIN	61
63	C	NCASES - NUMBER OF INDIVIDUAL DEEP WATER HEIGHT-PERIOD-	MAIN	62
64	C	DIRECTION CONDITIONS CONSIDERED	MAIN	63
65	C	DLEVEL - CONSTANT WATER LEVEL ADDED TO OR SUBTRACTED FROM	MAIN	64
66	C	THE ENTIRE DEPTH MATRIX	MAIN	65
67	C	HDEEP - DEEP WATER WAVE HEIGHT INPUT CONDITIONS	MAIN	66
68	C	TDEEP - DEEP WATER WAVE PERIOD INPUT CONDITIONS	MAIN	67
69	C	ZDEEP - DEEP WATER WAVE DIRECTION INPUT CONDITIONS	MAIN	68
70	C	IP1 - STARTING VALUE OF I FOR THE PRINTED OUTPUT	MAIN	69
71	C	IP2 - ENDING VALUE OF I FOR THE PRINTED OUTPUT	MAIN	70
72	C	INC - INCREMENT OF I FOR THE PRINTED OUTPUT	MAIN	71
73	C	JPI - STARTING VALUE OF J FOR THE PRINTED OUTPUT	MAIN	72
74	C	JP2 - ENDING VALUE OF J FOR THE PRINTED OUTPUT	MAIN	73
75	C	(THE J INCREMENT IS ALWAYS 1)	MAIN	74
76	C	IGRID - =0 IF CONSIDERING A CONSTANT SIZED RECTANGULAR GRID	MAIN	75
77	C	=1 IF CONSIDERING A VARIABLY SIZED RECTANGULAR GRID	MAIN	76
78	C	GENERATED USING THE MAPIT PROCEDURE IN CMSGRID.	MAIN	77
79	C	***NOTE** FOR ADDITIONAL INFORMATION ABOUT THE VARIABLY SIZED	MAIN	78
80	C	GRID INPUT SEE THE COMMENTS IN 'SUBROUTINE GRID'	MAIN	79
81	C	IREF - =1 DIFFRACTIVE EFFECTS INCLUDED	MAIN	80
82	C	=0 DIFFRACTIVE EFFECTS IGNORED(PURE REFRACTION)	MAIN	81
83	C		MAIN	82
84	C	*****	MAIN	83
85	C		MAIN	84
86		COMMON/ANGLES/Z(IQ,JQ),SI(IQ,JQ),CO(IQ,JQ)	MAIN	85
87		COMMON/WVH/H(IQ,JQ),CCG(IQ,JQ)	MAIN	86
88		COMMON/DEPTHS/D(IQ,JQ)	MAIN	87
89		COMMON/WAVNUM/KKA(IQ,JQ),GRDK(IQ,JQ)	MAIN	88
90		COMMON/CONST/ G,P1,P12,KAD,HCONVR,SCONVR,DX,DY,DX2,DY2,T,OMEG,	MAIN	89
91		AM,N,M1,M2,MH1,MH2,IWET,IDRY,IWETP1,CNTRANG,HEACT,DLEVEL	MAIN	90
92		COMMON/PRINTC/IP1,IP2,INC,JPI,JP2,DMULT,HMULT,ZMULT,RKMULT	MAIN	91
93		COMMON/CONS2/IGRID,IREF,ITAMX,ITMHX,IDIFF	MAIN	92
94		COMMON/MUSC/XMUC(IQ),XMUS(IQ),YMUC(JQ),YMUS(JQ)	MAIN	93
95		COMMON/COORD/XX(IQ),YY(JQ)	MAIN	94
96		COMMON /TRANE/ DECAY,STABL,IBKK(JQ),IBRKH(JQ)	MAIN	95
97		DIMENSION HDEEP(200),IDEEP(200),ZDEEP(200),LTITLE(9)	MAIN	96
98	C		MAIN	97
99	C	***** READ INPUT DATA FROM FILE CODE 7	MAIN	98
100	C		MAIN	99
101		READ(7,601) (LTITLE(L),L=1,9)	MAIN	100
102		601 FORMAT(9A8)	MAIN	101
103		READ(7,100)M,DX,N,DY,G,CNTRANG,NCASES,DLEVEL	MAIN	102
104		100 FORMAT(15,F10.4,15,F10.4,2F10.2,15,F10.2)	MAIN	103
105		DO 602 L=1,NCASES	MAIN	104
106		READ(7,103)HDEEP(L),TDEEP(L),ZDEEP(L)	MAIN	105
107		103 FORMAT(3F10.2)	MAIN	106
108		602 CONTINUE	MAIN	107
109		READ(7,101)IP1,IP2,INC,JPI,JP2	MAIN	108
110		101 FORMAT(5I5)	MAIN	109
111		READ(7,102)IREF,IGRID	MAIN	110
112		102 FORMAT(2I5)	MAIN	111
113	C		MAIN	112
114	C	***** WRITE OUT INPUT DATA ON FILE CODE 6	MAIN	113
115	C		MAIN	114
116		WRITE(6,15)	MAIN	115
117		15 FORMAT(////,2X,'R E G I O N A L C O A S T A L',3X,	MAIN	116

118	*' PROCESSES WAVE TRANSFORMATION',	MAIN	117
119	A3X,'MODEL',/43X,'(RCP WAVE)',////)	MAIN	118
120	WRITE(6,609)(LTITLE(L),L=1,9)	MAIN	119
121	609 FORMAT(25X,9A8,////)	MAIN	120
122	WRITE(6,55)	MAIN	121
123	55 FORMAT(/,1X,'MODEL INPUT:',//)	MAIN	122
124	IF(IGRID.GT.0)GO TO 300	MAIN	123
125	WRITE(6,41)	MAIN	124
126	41 FORMAT(1X,'UNIFORMLY SIZED, RECTILINEAR GRID MESH',/)	MAIN	125
127	GO TO 301	MAIN	126
128	300 WRITE(6,42)	MAIN	127
129	42 FORMAT(1X,'VARIABLY SIZED, RECTILINEAR GRID MESH',/)	MAIN	128
130	301 WRITE(6,5)N,DX,N,DY	MAIN	129
131	5 FORMAT(5X,'X - DIRECTION (ON-OFFSHORE)',5X,15,' CELLS, EACH',	MAIN	130
132	A'F10.2,' IN LENGTH',/,5X,'Y - DIRECTION (LONGSHORE) ',5X,15,	MAIN	131
133	A' CELLS, EACH ,F10.2,' IN LENGTH',/)	MAIN	132
134	WRITE(6,43)G	MAIN	133
135	43 FORMAT(1X,'THE ACCELERATION OF GRAVITY IS',F8.2,'. THESE UNITS ,	MAIN	134
136	A'DETERMINE THE UNITS OF ALL INPUT AND OUTPUT VARIABLES ',/)	MAIN	135
137	DO 604 L=1,NCASES	MAIN	136
138	WRITE(6,44)L,HDEEP(L),TDEEP(L),ZDEEP(L)	MAIN	137
139	604 CONTINUE	MAIN	138
140	44 FORMAT(' THE DEEP WATER WAVE PARAMETERS FOR CASE',I3,' ARE:',	MAIN	139
141	A5X,'HEIGHT=',E7.3,5X,'PERIOD=',E7.3,5X,'ANGLE=',E8.3)	MAIN	140
142	WRITE(6,45)CNTRANG	MAIN	141
143	45 FORMAT(/,1X,'THE OFFSHORE CONTOURS MAKE AN ANGLE OF',E7.2,	MAIN	142
144	A' DEGREES WITH THE Y AXIS',/)	MAIN	143
145	WRITE(6,19)	MAIN	144
146	19 FORMAT(1X,'THE BATHYMETRY MATRIX IS VARIABLE IN BOTH HORIZONTAL'	MAIN	145
147	A', DIRECTIONS AND WAS READ FROM FILE CODE 8',/)	MAIN	146
148	WRITE(6,20)BLEVEL	MAIN	147
149	20 FORMAT(1X,'A WATER LEVEL CHANGE OF',E7.2,' WAS ADDED TO THE '	MAIN	148
150	A' ENTIRE BATHYMETRY MATRIX')	MAIN	149
151	C	MAIN	150
152	C***** CONSTANTS USED IN THE PROGRAM	MAIN	151
153	C	MAIN	152
154	PI=3.1415927	MAIN	153
155	PI2=PI A2.0	MAIN	154
156	KAD=180.0/PI	MAIN	155
157	CNTRANG=CNTRANG/RAD	MAIN	156
158	M2=M-2	MAIN	157
159	M1=M-1	MAIN	158
160	NM1=N-1	MAIN	159
161	NM2=N-2	MAIN	160
162	DX2=DXA2.	MAIN	161
163	DY2=DYA2.	MAIN	162
164	WTA=1.0	MAIN	163
165	WTH=1.0	MAIN	164
166	TAU=0.167	MAIN	165
167	BETA=0.167	MAIN	166
168	IDRY=1	MAIN	167
169	IWET=2	MAIN	168
170	IWETP1=IWET+1	MAIN	169
171	C	MAIN	170
172	C***** 'STABL' AND 'DECAY' ARE USED IN THE WAVE BREAKING	MAIN	171
173	C***** ROUTINE	MAIN	172
174	C	MAIN	173
175	STABL=0.4	MAIN	174
176	DECAY=0.2	MAIN	175

177	C	MAIN	176
178	C***** 'HCONVR' AND 'SCONVR' ARE THE CONVERGENCE CRITERIA USED IN	MAIN	177
179	C***** THE HEIGHT AND ANGLE ITERATIVE SOLUTION SCHEMES	MAIN	178
180	C	MAIN	179
181	HCONVR=0.0005	MAIN	180
182	SCONVR=0.00025	MAIN	181
183	IF(G.GT.9.7.AND.G.LT.9.9)HCONVR=HCONVR*0.3048	MAIN	182
184	IF(G.GT.970.0.AND.G.LT.990.0)HCONVR=HCONVR*30.48	MAIN	183
185	C	MAIN	184
186	C***** 'ITHMX' AND 'ITAMX' CONTROL THE MAXIMUM NUMBER OF ITERATIONS	MAIN	185
187	C***** ALLOWED IN THE WAVE HEIGHT AND ANGLE SOLUTION SCHEMES	MAIN	186
188	C***** 'IDIFF' CONTROLS THE NUMBER OF ITERATIONS ALLOWED IN THE	MAIN	187
189	C***** ITERATIVE DIFFRACTION SCHEME	MAIN	188
190	C	MAIN	189
191	ITHMX=50	MAIN	190
192	ITAMX=50	MAIN	191
193	IDIFF=15	MAIN	192
194	C	MAIN	193
195	C***** THE FOLLOWING MULTIPLICATION FACTORS CONTROL THE ACCURACY	MAIN	194
196	C***** OF THE PRINTED OUTPUT(NOT THE ACTUAL COMPUTATION).	MAIN	195
197	C***** DEPTH (D) - DMULT	MAIN	196
198	C***** WAVE HEIGHT (H) - HMULT	MAIN	197
199	C***** WAVE ANGLE (Z) - ZMULT	MAIN	198
200	C***** WAVE NUMBER (GRADK) - RKMULT	MAIN	199
201	C***** THE VARIABLES ARE FIRST MULTIPLIED BY THE SCALE FACTORS	MAIN	200
202	C***** BELOW, THEN PRINTED OUT IN INTEGER FORM	MAIN	201
203	C	MAIN	202
204	DMULT=1.0	MAIN	203
205	HMULT=10.0	MAIN	204
206	ZMULT=1.0	MAIN	205
207	RKMULT=1000.0	MAIN	206
208	C	MAIN	207
209	C***** DEFINE THE GRID SCALE FACTORS AND DISTANCES FOR A CONSTANT	MAIN	208
210	C***** SIZED RECTANGULAR GRID	MAIN	209
211	C	MAIN	210
212	DO 3 I=1,M	MAIN	211
213	XMUC(I)=1.0	MAIN	212
214	YMUS(I)=1.0	MAIN	213
215	XX(I)=DX*(I-0.5)	MAIN	214
216	2 CONTINUE	MAIN	215
217	DO 3 J=1,N	MAIN	216
218	XMUC(J)=1.0	MAIN	217
219	YMUS(J)=1.0	MAIN	218
220	YY(J)=DY*(J-0.5)	MAIN	219
221	3 CONTINUE	MAIN	220
222	C	MAIN	221
223	C***** CALL SUBROUTINE GRID TO READ IN THE VARIABLE GRID MAPPING	MAIN	222
224	C***** INFORMATION FROM FILE CODE 3 (X DIRECTION FIRST, THEN Y)	MAIN	223
225	C***** GENERATE THE VARIABLE GRID SCALE FACTORS AND DISTANCES	MAIN	224
226	C	MAIN	225
227	IF(IGRID.EQ.1)CALL GRID	MAIN	226
228	C	MAIN	227
229	C***** CALL SUBROUTINE DEPTH TO GENERATE THE WATER DEPTH MATRIX	MAIN	228
230	C	MAIN	229
231	CALL DEPTH	MAIN	230
232	C	MAIN	231
233	C***** ADD DLEVEL TO ALL THE WATER DEPTHS AND THEN REQUIRE	MAIN	232
234	C***** ALL DEPTHS BE GREATER THAN THE MINIMUM DEPTH 'DMIN'	MAIN	233
235	C***** WHERE 'DMIN' IS 1.0 FEET OR A METRIC EQUIVALENT	MAIN	234

236	C	MAIN	235
237	DMIN=1.0	MAIN	236
238	IF(G.GT.9.7.AND.G.LT.9.9)DMIN=0.3048	MAIN	237
239	IF(G.GT.970.0.AND.G.LT.990.0)DMIN=30.48	MAIN	238
240	DO 87 I=1,M	MAIN	239
241	DO 87 J=1,N	MAIN	240
242	D(I,J)=D(I,J)+DLEVEL	MAIN	241
243	IF(D(I,J).LT.DMIN)D(I,J)=DMIN	MAIN	242
244	87 CONTINUE	MAIN	243
245	C-	MAIN	244
246	C***** SET THE BOUNDARY CONDITIONS FOR THE WATER DEPTHS	MAIN	245
247	C	MAIN	246
248	DO 86 I=1,M	MAIN	247
249	D(I,1)=D(I,2)	MAIN	248
250	D(I,N)=D(I,NM1)	MAIN	249
251	86 CONTINUE	MAIN	250
252	CALL QNBC(D)	MAIN	251
253	C	MAIN	252
254	C***** PRINT THE TOTAL WATER DEPTH MATRIX (ALL DEPTHS MULTIPLIED BY D	MAIN	253
255	C	MAIN	254
256	CALL POUT(IP1,IP2,INC,JP1,JP2,' WATER DEPTHS ',D,DAULT)	MAIN	255
257	C	MAIN	256
258	C***** ITERATE OVER THE NUMBER OF WAVE CONDITIONS CONSIDERED	MAIN	257
259	C	MAIN	258
260	DO 605 L=1,NCASES	MAIN	259
261	HO=HDEEP(L)	MAIN	260
262	T=TDEEP(L)	MAIN	261
263	OMEG=PI/T	MAIN	262
264	HFACT=2.0*OMEG/G	MAIN	263
265	C	MAIN	264
266	C***** 'HFACT' IS A FACTOR TO CONVERT FROM WAVE HEIGHT TO THE	MAIN	265
267	C***** AMPLITUDE FUNCTION 'H'	MAIN	266
268	C	MAIN	267
269	A=ZDEEP(L)	MAIN	268
270	WRITE(6,606)L	MAIN	269
271	606 FORMAT('////',' W A V E C O N D I T I O N ',IS,')	MAIN	270
272	WRITE(6,44)L,HO,T,A	MAIN	271
273	A=A+180.0	MAIN	272
274	DO 607 J=1,M	MAIN	273
275	IBRK(J)=0	MAIN	274
276	IBRKM(J)=0	MAIN	275
277	607 CONTINUE	MAIN	276
278	CALL REEDIE(A,HO,WT,TAU,WT,WT,BETA)	MAIN	277
279	605 CONTINUE	MAIN	278
280	C	MAIN	279
281	99 STOP	MAIN	280
282	END	MAIN	281
1	C*****	REEDIE	2
2	C	REEDIE	3
3	SUBROUTINE REEDIE(THETA0,HH,WT,TAU,WT,WT,BETA)	REEDIE	4
4	C	REEDIE	5
5	C*****	REEDIE	6
6	C	REEDIE	7
7	C THIS SUBROUTINE CONTROLS THE ITERATIVE SOLUTION SCHEME AND	REEDIE	8
8	C PRINTING OF THE WAVE INFORMATION	REEDIE	9
9	C	REEDIE	10
10	C*****	REEDIE	11
11	C	PARAM	2
12	PARAMETER(IQ=95,JO=95)	PARAM	3

13	C	PARAM	4
14	COMMON/ANGLES/Z(IQ,JQ),SI(IQ,JQ),CO(IQ,JQ)	REDFIE	13
15	COMMON/WVH/H(IQ,JQ),CCG(IQ,JQ)	REDFIE	14
16	COMMON/DEPTHS/D(IQ,JQ)	REDFIE	15
17	COMMON/WAVNUM/RKA(IQ,JQ),GRKD(IQ,JQ)	REDFIE	16
18	COMMON/CONST/ G,PI,PIC,RAD,HCONVR,SCONVR,DX,DY,DX2,DY2,T,OMEG,	REDFIE	17
19	*M,N,M1,M2,NM1,NM2,IWET,IDRY,IWETP1,CONTRANG,HEACT,DLEVEL	REDFIE	18
20	COMMON/PRINTC/IP1,IP2,INC,JP1,JP2,DMULT,HMULT,EMULT,RKMULT	REDFIE	19
21	COMMON/CONSC/IGRID,IREF,ITAM,ITHMX,IDIEF	REDFIE	20
22	COMMON /TRAVE/ DECAY,STABL,IBRK(JQ),IBRKH(JQ)	REDFIE	21
23	DIMENSION DUM1(IQ,JQ),GRDOLD(JQ)	REDFIE	22
24	C	REDFIE	23
25	***** CALL SUBROUTINE SNELL TO OBTAIN AN INITIAL GUESS OF THE	REDFIE	24
26	***** WAVE HEIGHTS AND ANGLES USING SNELLS LAW	REDFIE	25
27	C	REDFIE	26
28	CALL SNELL ((THETAO/RAD),HH)	REDFIE	27
29	CALL ONBC(H)	REDFIE	28
30	CALL ONBC(Z)	REDFIE	29
31	CALL ONBC(CO)	REDFIE	30
32	CALL ONBC(SI)	REDFIE	31
33	CALL ONBC(RKA)	REDFIE	32
34	CALL ONBC(GRKD)	REDFIE	33
35	CALL ONBC(CCG)	REDFIE	34
36	C	REDFIE	35
37	***** REMOVE THE /GO TO 122 STATEMENT TO PRINT OUT THE SNELL S LAW	REDFIE	36
38	***** SOLUTION	REDFIE	37
39	C	REDFIE	38
40	GO TO 122	REDFIE	39
41	177 CONTINUE	REDFIE	40
42	DO 13 I=1,M	REDFIE	41
43	DO 13 J=1,N	REDFIE	42
44	DUM3=Z(I,J)-PI	REDFIE	43
45	DUM1(I,J)=DUM3*RAD	REDFIE	44
46	13 CONTINUE	REDFIE	45
47	C	REDFIE	46
48	***** ANGLES,HEIGHTS, AND WAVE NUMBERS ARE MULTIPLIED BY EMULT,	REDFIE	47
49	***** HMULT, AND RKMULT RESPECTIVELY IN THE PRINT OUT. THESE MUST BE	REDFIE	48
50	***** CHANGED INTERNALLY WITHIN THE MAIN PROGRAM IF OTHER VALUES	REDFIE	49
51	***** ARE DESIRED	REDFIE	50
52	C	REDFIE	51
53	CALL POUT(IP1,IP2,INC,JP1,JP2,' WAVE ANGLES (DEG ,DUM1,	REDFIE	52
54	*EMULT)	REDFIE	53
55	DO 79 I=1,M	REDFIE	54
56	DO 79 J=1,N	REDFIE	55
57	DUM1(I,J)=H(I,J)*HEACT	REDFIE	56
58	79 CONTINUE	REDFIE	57
59	CALL POUT(IP1,IP2,INC,JP1,JP2,' WAVE HEIGHTS ,DUM1,	REDFIE	58
60	HMULT)	REDFIE	59
61	CALL POUT(IP1,IP2,INC,JP1,JP2,' WAVE NUMBER ,RKA,	REDFIE	60
62	*RKMULT)	REDFIE	61
63	122 CONTINUE	REDFIE	62
64	C	REDFIE	63
65	***** ROW BY ROW MARCHING LOOP	REDFIE	64
66	C	REDFIE	65
67	DO 10 IL=M2,IWETP1,-1	REDFIE	66
68	ILM1=IL-1	REDFIE	67
69	C	REDFIE	68
70	***** COMPUTE THE WAVE ANGLES ALONG A ROW	REDFIE	69
71	C	REDFIE	70

72	CALL ANGLE(IL, IL, ITAMX, WTA, TAU, SCONVR)	REEDIF	71
73	C	REEDIF	72
74	C***** COMPUTE THE WAVE HEIGHTS ALONG A ROW	REEDIF	73
75	C	REEDIF	74
76	CALL HEIGHT(IL, IL, ITMX, WTH, BETA, HCONVR)	REEDIF	75
77	C	REEDIF	76
78	IF(IREF.EQ.0) GO TO 114	REEDIF	77
79	DO 119 J=1,N	REEDIF	78
80	GRDOLD(J)=GRDK(ILM1,J)	REEDIF	79
81	119 CONTINUE	REEDIF	80
82	DO 110 LLL=1, IDIFF	REEDIF	81
83	C	REEDIF	82
84	C***** COMPUTE NEW GRADIENT OF THE WAVE PHASE FUNCTION ALONG A ROW	REEDIF	83
85	C	REEDIF	84
86	CALL GRADK(ILM1, ILM1)	REEDIF	85
87	EPSK=0.5	REEDIF	86
88	DO 112 J=1,N	REEDIF	87
89	GRDK(ILM1,J)=EPSK*GRDK(ILM1,J)+(1.0-EPSK)*GRDOLD(J)	REEDIF	88
90	112 CONTINUE	REEDIF	89
91	IFLAG=1	REEDIF	90
92	DO 111 J=1,N	REEDIF	91
93	IF(ABS(GRDK(ILM1,J)-GRDOLD(J)).GT.0.0025*ABS(GRDK(ILM1,J)))	REEDIF	92
94	ATILAG=0	REEDIF	93
95	111 CONTINUE	REEDIF	94
96	DO 113 J=1,N	REEDIF	95
97	GRDOLD(J)=GRDK(ILM1,J)	REEDIF	96
98	113 CONTINUE	REEDIF	97
99	C	REEDIF	98
100	C***** RECOMPUTE THE WAVE ANGLES ALONG A ROW	REEDIF	99
101	C	REEDIF	100
102	CALL ANGLE(IL, IL, ITAMX, WTA, (TAU*1.0), SCONVR)	REEDIF	101
103	C	REEDIF	102
104	C***** RECOMPUTE THE WAVE HEIGHTS ALONG A ROW	REEDIF	103
105	C	REEDIF	104
106	CALL HEIGHT(IL, IL, ITMX, WTH, (BETA*1.0), HCONVR)	REEDIF	105
107	IF(IELAG.EQ.1) GO TO 114	REEDIF	106
108	110 CONTINUE	REEDIF	107
109	WRITE(6,117) ILM1	REEDIF	108
110	117 FORMAT(1X, 'CONVERGENCE TOWARD A SOLUTION FAILED ON ROW', I5)	REEDIF	109
111	114 CONTINUE	REEDIF	110
112	C	REEDIF	111
113	C***** UPDATE BREAKER INDEX	REEDIF	112
114	C	REEDIF	113
115	DO 115 J=1,N	REEDIF	114
116	IBRK(J)=IBRK(J)	REEDIF	115
117	DUM1(ILM1,J)=IBRK(J)	REEDIF	116
118	IBRK(J)=0	REEDIF	117
119	115 CONTINUE	REEDIF	118
120	C	REEDIF	119
121	10 CONTINUE	REEDIF	120
122	CALL ONBC(GRDK)	REEDIF	121
123	CALL ONBC(H)	REEDIF	122
124	CALL ONBC(Z)	REEDIF	123
125	CALL ONBC(CD)	REEDIF	124
126	CALL ONBC(SI)	REEDIF	125
127	C	REEDIF	126
128	C***** PRINT WAVE INFORMATION	REEDIF	127
129	C	REEDIF	128
130	C***** BREAKER INDEX (0=NON-BREAKING , 11=BREAKING)	REEDIF	129

131	C		REFDIF	130
132		DO 219 J=1,M	REFDIF	131
133		DUM1(1,J)=DUM1(2,J)	REFDIF	132
134		DUM1(M,J)=0.0	REFDIF	133
135		DUM1(M1,J)=0.0	REFDIF	134
136		DUM1(M2,J)=0.0	REFDIF	135
137		DO 219 I=1,M	REFDIF	136
138		IF(DUM1(I,J).EQ.1.0)DUM1(I,J)=11.0	REFDIF	137
139		219 CONTINUE	REFDIF	138
140		CALL POUT(IP1,IP2,INC,JP1,JP2,' BREAKER INDEX ',DUM1,1.0)	REFDIF	139
141		CAAAAAAA ANGLES,HEIGHTS, AND WAVE NUMBERS ARE MULTIPLIED BY ZMULT,	REFDIF	140
142		CAAAAAAA HMULT. AND RKMULT RESPECTIVELY IN THE PRINT OUT. THESE MUST	REFDIF	141
143		CAAAAAAA BE CHANGED INTERNALLY WITHIN THE MAIN PROGRAM IF OTHER VALUES	REFDIF	142
144		CAAAAAAA ARE DESIRED	REFDIF	143
145	C		REFDIF	144
146		DO 23 I=1,M	REFDIF	145
147		DO 23 J=1,N	REFDIF	146
148		DUM3=Z(I,J)-PI	REFDIF	147
149		DUM1(I,J)=DUM3*RAD	REFDIF	148
150		23 CONTINUE	REFDIF	149
151		CALL POUT(IP1,IP2,INC,JP1,JP2,' WAVE ANGLES (DEG)',DUM1,	REFDIF	150
152		*ZMULT)	REFDIF	151
153	C		REFDIF	152
154		CAAAAAAA CONVERT FROM AMPLITUDE FUNCTION TO WAVE HEIGHT	REFDIF	153
155	C		REFDIF	154
156		DO 81 I=1,M	REFDIF	155
157		DO 81 J=1,N	REFDIF	156
158		DUM1(I,J)=H(I,J)*HFACT	REFDIF	157
159		81 CONTINUE	REFDIF	158
160		CALL POUT(IP1,IP2,INC,JP1,JP2,' WAVE HEIGHTS ',DUM1,	REFDIF	159
161		1*HMULT)	REFDIF	160
162		CALL POUT(IP1,IP2,INC,JP1,JP2,' WAVE NUMBER ',GRDK,	REFDIF	161
163		*RKMULT)	REFDIF	162
164		99 RETURN	REFDIF	163
165		END	REFDIF	164
1		CAAA	GRADK	2
2	C		GRADK	3
3		SUBROUTINE GRADK(ISTART,IEND)	GRADK	4
4	C		GRADK	5
5		CAAA	GRADK	6
6	C		GRADK	7
7	C	THIS SUBROUTINE COMPUTES THE UPDATED VALUES OF THE GRADIENT	GRADK	8
8	C	OF THE WAVE PHASE FUNCTION ALONG A GIVEN ROW	GRADK	9
9	C		GRADK	10
10		CAAA	GRADK	11
11	C		PARAM	2
12		PARAMETER(IQ=95,JQ=95)	PARAM	3
13	C		PARAM	4
14		COMMON/ANGLES/Z(IQ,JQ),SI(IQ,JQ),CD(IQ,JQ)	GRADK	13
15		COMMON/DEPTHS/D(IQ,JQ)	GRADK	14
16		COMMON/WVH/H(IQ,JQ),CCG(IQ,JQ)	GRADK	15
17		COMMON/WAVNUM/RKA(IQ,JQ),GRDK(IQ,JQ)	GRADK	16
18		COMMON/CONST/ G,PI,P12,RAD,HCONVR,SCONVR,DX,DY,DX2,DY2,I,OMEGA,	GRADK	17
19		AM,N,M1,M2,NM1,NM2,IWET,IDRY,IWETP1,CNTRANG,HFACT,DLEVEL	GRADK	18
20		COMMON/CONST/IGRID,IREF,ITANX,ITHMN,IDIEF	GRADK	19
21		COMMON/HUSC/XMUC(IQ),XMUS(IQ),YMUC(JQ),YMUS(JQ)	GRADK	20
22		COMMON /TRANE/ DECAY,STABL,IBRK(JQ),IBRKM(JQ)	GRADK	21
23		DIMENSION DUM1(IQ,JQ),X(IQ)	GRADK	22
24	C		GRADK	23

25	C***** COMPUTE THE DIFFRACTIVE TERMS	GRADK	24
26	C	GRADK	25
27	C***** USE 4 POINT BACKWARDS DIFFERENCE FOR THE X CURVATURE OF 'H'	GRADK	26
28	C***** USE 3 POINT BACKWARDS DIFFERENCE FOR THE X GRADIENT OF 'H,CCG'	GRADK	27
29	C***** USE CENTRAL DIFFERENCES FOR THE Y CURVATURE OF 'H'	GRADK	28
30	C***** USE CENTRAL DIFFERENCES FOR THE Y GRADIENT OF 'H,CCG'	GRADK	29
31	C	GRADK	30
32	DO 2 I=ISTART,IEND	GRADK	31
33	DLX2=DX2*XMUC(I)	GRADK	32
34	DLXSQ=(DLX2*0.5)**2	GRADK	33
35	DO 2 J=2,NM1	GRADK	34
36	DLY2=DY2*YMUC(J)	GRADK	35
37	DLYSQ=(DLY2*0.5)**2	GRADK	36
38	CCG1J=CCG(I,J)	GRADK	37
39	H1J=H(I,J)	GRADK	38
40	HJ1=H(I,J+1)	GRADK	39
41	HJ1=H(I,J-1)	GRADK	40
42	H1P1=H(I+1,J)	GRADK	41
43	H1P2=H(I+2,J)	GRADK	42
44	DUM6=(-3.0*H1J+4.0*H1P1-H1P2)/DLX2	GRADK	43
45	DUM4=(2.0*H1J-5.0*H1P1+4.0*H1P2-H(I+3,J))/DLXSQ	GRADK	44
46	DUM4=DUM4-0.5*DUM6*(XMUC(I+1)-XMUC(I-1))/((XMUC(I)**2)*DX)	GRADK	45
47	DUM2=(-3.0*CCG1J+4.0*CCG(I+1,J)-CCG(I+2,J))/DLY2	GRADK	46
48	DUM7=(HJ1-HJ1)/DLY2	GRADK	47
49	DUM5=(HJ1-2.0*H1J+HJ1)/DLYSQ	GRADK	48
50	DUM5=DUM5-0.5*DUM7*(YMUC(J+1)-YMUC(J-1))/((YMUC(J)**2)*DY)	GRADK	49
51	DUM3=(CCG(I,J+1)-CCG(I,J-1))/DLY2	GRADK	50
52	DUM1(I,J)=(DUM4+DUM5+(DUM2*DUM6+DUM3*DUM7)/CCG1J)/H1J	GRADK	51
53	CONTINUE	GRADK	52
54	C	GRADK	53
55	C***** CHECK FOR POINT TO POINT OSCILLATIONS IN WAVE PHASE GRADIENT	GRADK	54
56	C	GRADK	55
57	DO 410 I=ISTART,IEND	GRADK	56
58	DUM1(I,1)=DUM1(I,2)	GRADK	57
59	DUM1(I,N)=DUM1(I,NM1)	GRADK	58
60	SHU=4.0	GRADK	59
61	SBETA=0.25	GRADK	60
62	DO 409 J=1,N	GRADK	61
63	X(J)=DUM1(I,J)	GRADK	62
64	409 CONTINUE	GRADK	63
65	DO 408 J=3,NM2	GRADK	64
66	DUM2=ABS(X(J+1)-X(J))	GRADK	65
67	DUM3=ABS(X(J)-X(J-1))	GRADK	66
68	DUM4=ABS(X(J+1)-X(J-1))*0.5	GRADK	67
69	IF((DUM2+DUM3).LT.(SHU*DUM4))GO TO 408	GRADK	68
70	DUM5=X(J+1)-2.0*X(J)+X(J-1)	GRADK	69
71	DUM6=X(J+2)-2.0*X(J+1)+X(J)	GRADK	70
72	DUM7=X(J)-2.0*X(J-1)+X(J-2)	GRADK	71
73	IF((DUM5*DUM6).GE.0.0.AND.(DUM5*DUM7).GE.0.0)GO TO 408	GRADK	72
74	DUM1(I,J)=X(J)+SBETA*(X(J+1)-2.0*X(J)+X(J-1))	GRADK	73
75	408 CONTINUE	GRADK	74
76	410 CONTINUE	GRADK	75
77	C	GRADK	76
78	DO 17 I=ISTART,IEND	GRADK	77
79	DO 17 J=2,NM1	GRADK	78
80	C	GRADK	79
81	C***** DO NOT INCLUDE DIFFRACTIVE EFFECTS INSIDE OR IMMEDIATELY	GRADK	80
82	C***** ADJACENT TO THE BREAKER ZONE	GRADK	81
83	C	GRADK	82

84	IBTEST=IBRKM(J-1)+IBRKM(J)+IBRKM(J+1)+IBRK(J-1)+IBRK(J)+	GRADK	83
85	IBRK(J+1)	GRADK	84
86	IF(IBTEST.GT.0) GO TO 17	GRADK	85
87	C	GRADK	86
88	***** LIMIT THE CHANGE IN THE GRADIENT OF THE WAVE PHASE FUNCTION	GRADK	87
89	***** FROM THE DISPERSION RELATION WAVE NUMBER TO 50 PERCENT	GRADK	88
90	C	GRADK	89
91	RKOLD=RKA(I,J)	GRADK	90
92	RKADD=0.25*RKOLD	GRADK	91
93	RKARG=RKOLD**2+DUM1(I,J)	GRADK	92
94	IF(RKARG.LE.0.0) RKARG=((OMEGA**2/G)**2)	GRADK	93
95	RKNEW=SQRT(RKARG)	GRADK	94
96	RKDIFF=RKNEW-RKOLD	GRADK	95
97	IF(ABS(RKDIFF).LT.(0.0025*RKOLD))GO TO 17	GRADK	96
98	IF(ABS(RKDIFF).LE.RKADD)GO TO 341	GRADK	97
99	IF(RKDIFF.LT.0.0)RKNEW=RKOLD-RKADD	GRADK	98
100	IF(RKDIFF.GE.0.0)RKNEW=RKOLD+RKADD	GRADK	99
101	341 GRDK(I,J)=RKNEW	GRADK	100
102	17 CONTINUE	GRADK	101
103	C	GRADK	102
104	***** SET LATERAL BOUNDARY CONDITIONS FOR THE GRADIENT OF THE WAVE	GRADK	103
105	***** PHASE FUNCTION	GRADK	104
106	C	GRADK	105
107	DO 38 I=ISTART,IEND	GRADK	106
108	GRDK(I,1)=GRDK(I,2)	GRADK	107
109	GRDK(I,N)=GRDK(I,NM1)	GRADK	108
110	38 CONTINUE	GRADK	109
111	RETURN	GRADK	110
112	END	GRADK	111
1	*****	HEIGHT	2
2	C	HEIGHT	3
3	SUBROUTINE HEIGHT(ISTART,IEND,ITMAX,IT,ALPHA,HCONV)	HEIGHT	4
4	C	HEIGHT	5
5	*****	HEIGHT	6
6	C	HEIGHT	7
7	C THIS SUBROUTINE ITERATES TO SOLVE FOR THE WAVE HEIGHTS	HEIGHT	8
8	C ALONG A GIVEN ROW	HEIGHT	9
9	C	HEIGHT	10
10	*****	HEIGHT	11
11	C	PARAM	2
12	PARAMETER(IQ=95,JQ=95)	PARAM	3
13	C	PARAM	4
14	COMMON/ANGLES/Z(IQ,JQ),SI(IQ,JQ),CO(IQ,JQ)	HEIGHT	13
15	COMMON/WVH/H(IQ,JQ),CCS(IQ,JQ)	HEIGHT	14
16	COMMON/DEPTHS/D(IQ,JQ)	HEIGHT	15
17	COMMON/WAVNUM/RKA(IQ,JQ),GRDK(IQ,JQ)	HEIGHT	16
18	COMMON/CONST/ G,P1,P12,RAD,HCONVR,SCONVR,DX,DY,DX2,DY2,T,OMEG.	HEIGHT	17
19	AM,N,M1,M2,NM1,NM2,IWET,IDRY,IWETPI,CNTRANG,HEACT,DLEVEL	HEIGHT	18
20	COMMON/CONS2/IGRID,IREF,ITAMX,ITIMX,IDIFF	HEIGHT	19
21	COMMON/HUSC/XMUC(IQ),XMUS(IQ),YMUC(JQ),YMUS(JQ)	HEIGHT	20
22	COMMON/COORD/XX(IQ),YY(JQ)	HEIGHT	21
23	COMMON /TRANE/ DECAY,STABL,IBRK(JQ),IBRKM(JQ)	HEIGHT	22
24	DIMENSION DWB(JQ),SLOPE(JQ)	HEIGHT	23
25	C	HEIGHT	24
26	***** SOLVE DIFFERENCED FORM OF CONSERVATION OF WAVE ACTION EQUATION	HEIGHT	25
27	C	HEIGHT	26
28	DO 500 I=IEND,ISTART,-1	HEIGHT	27
29	IM=I-1	HEIGHT	28
30	DO 450 IT=1,ITMAX	HEIGHT	29

31	C		HEIGHT	30
32		DO 200 J=2,NM1	HEIGHT	31
33		JP=J+1	HEIGHT	32
34		JM=J-1	HEIGHT	33
35		DM1=CCG(IM,JP)*GRDK(IM,JP)*SI(IM,JP)	HEIGHT	34
36		DM2=CCG(IM,JM)*GRDK(IM,JM)*SI(IM,JM)	HEIGHT	35
37		DM3=CCG(I,JP)*GRDK(I,JP)*SI(I,JP)	HEIGHT	36
38		DM4=CCG(I,JM)*GRDK(I,JM)*SI(I,JM)	HEIGHT	37
39		DM6=(WT*(DM1*H(IM,JP)**2-DM2*H(IM,JM)**2)	HEIGHT	38
40	-	/(DY2*YMUC(J)))+(1.0-WT)*DM3*H(I,JP)**2-DM4*	HEIGHT	39
41	-	H(I,JM)**2)/(DY2*YMUC(J))	HEIGHT	40
42	C		HEIGHT	41
43		DM1=(CCG(I,J)*GRDK(I,J)*CO(I,J))*H(I,J)*H(I,J)	HEIGHT	42
44		DM2=(CCG(I,JM)*GRDK(I,JM)*CO(I,JM))*H(I,JM)*H(I,JM)	HEIGHT	43
45		DM3=(CCG(I,JP)*GRDK(I,JP)*CO(I,JP))*H(I,JP)*H(I,JP)	HEIGHT	44
46		DM4=CCG(IM,J)*GRDK(IM,J)*CO(IM,J)	HEIGHT	45
47		DM5=((DM6)*(DX*XMUS(IM))+ALPHA*DM2+	HEIGHT	46
48	-	(1.0-2.0*ALPHA)*DM1+ALPHA*DM3)/DM4	HEIGHT	47
49	C		HEIGHT	48
50		C***** CONVERT AMPLITUDE FUNCTION TO WAVE HEIGHT	HEIGHT	49
51	C		HEIGHT	50
52		DM7=DM5*(HEACTAHEACT)	HEIGHT	51
53	C		HEIGHT	52
54		C***** CHECK FOR WAVE HEIGHTS LESS THAN ZERO	HEIGHT	53
55	C		HEIGHT	54
56		IF(DM7.LT.0.00001) DM7=0.00001	HEIGHT	55
57		DM7=SQRT(DM7)	HEIGHT	56
58	C		HEIGHT	57
59		C***** CHECK FOR WAVE BREAKING OR WAVE TRANSFORMATION	HEIGHT	58
60	C		HEIGHT	59
61		IF(DM7.GT.STABLD(IM,J)) THEN	HEIGHT	60
62	C		HEIGHT	61
63		C***** CALCULATE ANGLES AND CELLS OF INFLUENCE	HEIGHT	62
64	C		HEIGHT	63
1 65		THETA=Z(IM,J)-PI	HEIGHT	64
1 66		IF(THETA.GE.0.) THEN	HEIGHT	65
3 67		X1=0.5*(XX(IM)+XX(I))-XX(IM)	HEIGHT	66
2 68		X2=XX(I)-XX(IM)	HEIGHT	67
2 69		Y1=YY(J+1)-YY(J)	HEIGHT	68
2 70		Y2=0.5*(YY(J)+YY(J+1))-YY(J)	HEIGHT	69
2 71		ANG1=ATAN2(Y1,X1)	HEIGHT	70
2 72		ANG2=ATAN2(Y2,X2)	HEIGHT	71
2 73	C		HEIGHT	72
2 74		IF(THETA.GT.ANG1) THEN	HEIGHT	73
3 75		KEY=IBRK(J+1)	HEIGHT	74
3 76		IKEY=IM	HEIGHT	75
3 77		JKEY=J+1	HEIGHT	76
3 78		ELSE IF(THETA.GT.ANG2) THEN	HEIGHT	77
3 79		KEY=IBRK(J+1)	HEIGHT	78
3 80		IKEY=I	HEIGHT	79
3 81		JKEY=J+1	HEIGHT	80
3 82		ELSE	HEIGHT	81
3 83		KEY=IBRK(J)	HEIGHT	82
3 84		IKEY=I	HEIGHT	83
3 85		JKEY=J	HEIGHT	84
3 86		ENDIF	HEIGHT	85
3 87	C		HEIGHT	86
2 88		ELSE	HEIGHT	87
2 89		X3=XX(I)-XX(IM)	HEIGHT	88

2	90	X4=0.5*(XX(IM)+XX(I))-XX(IM)	HEIGHT	89
2	91	Y3=0.5*(YY(J)+YY(J-1))-YY(J)	HEIGHT	90
2	92	Y4=YY(J-1)-YY(J)	HEIGHT	91
2	93	ANG3=ATAN2(Y3,X3)	HEIGHT	92
2	94	ANG4=ATAN2(Y4,X4)	HEIGHT	93
2	95	C	HEIGHT	94
2	96	IF(THETA.GT.ANG3) THEN	HEIGHT	95
3	97	KEY=IBRKM(J)	HEIGHT	96
3	98	IKEY=I	HEIGHT	97
3	99	JKEY=J	HEIGHT	98
3	100	ELSE IF(THETA.GT.ANG4) THEN	HEIGHT	99
3	101	KEY=IBRKM(J-1)	HEIGHT	100
3	102	IKEY=I	HEIGHT	101
3	103	JKEY=J-1	HEIGHT	102
3	104	ELSE	HEIGHT	103
3	105	KEY=IBRK(J-1)	HEIGHT	104
3	106	IKEY=IM	HEIGHT	105
3	107	JKEY=J-1	HEIGHT	106
3	108	ENDIF	HEIGHT	107
2	109	ENDIF	HEIGHT	108
2	110	C	HEIGHT	109
2	111	C***** COMPUTE INCIPIENT BREAKING WAVE HEIGHT USING METHOD FROM	HEIGHT	110
2	112	C***** THE SHORE PROTECTION MANUAL (WEGGEL'S EMPIRICAL METHOD)	HEIGHT	111
2	113	C	HEIGHT	112
1	114	JJ=(J+(JKEY-J-1)/2)	HEIGHT	113
1	115	DIST=SQRT((FLOAT(IKEY-IM)*DX*XMUS(IM))**2+	HEIGHT	114
1	116	(FLOAT(JKEY-J)*DY*XMUS(JJ))**2)	HEIGHT	115
1	117	SLOPE(J)=(D(IKEY,JKEY)-D(IM,J))/DIST	HEIGHT	116
1	118	SLOPE(J)=AMAX1(0.0,SLOPE(J))	HEIGHT	117
1	119	HSIG=1.0*DM7	HEIGHT	118
1	120	A1=43.75*(1.0-EXP(-19.0*SLOPE(J)))	HEIGHT	119
1	121	B1=1.56/(1.0+EXP(-19.5*SLOPE(J)))	HEIGHT	120
1	122	DEPBK=HSIG/(B1-(A1*HSIG/(6*AT)))	HEIGHT	121
1	123	IF(DEPBK.GT.D(IM,J)) KEY=I	HEIGHT	122
1	124	C	HEIGHT	123
1	125	C***** CHECK WHETHER TO ACTUALLY TRANSFORM WAVE	HEIGHT	124
1	126	C	HEIGHT	125
1	127	IF(KEY.EQ.1) THEN	HEIGHT	126
2	128	IBRK(J)=1	HEIGHT	127
2	129	DM1=0.5*(D(IKEY,JKEY)+D(IM,J))	HEIGHT	128
2	130	DM2=CCG(IKEY,JKEY)*GRDK(IKEY,JKEY)*(H(IKEY,JKEY)**2-	HEIGHT	129
2	131	(STABLD(IKEY,JKEY)/HEACT)**2)-CCG(IM,J)*GRDK(IM,J)*	HEIGHT	130
2	132	(STABLD(IM,J)/HEACT)**2	HEIGHT	131
2	133	DM3=DX*XMUS(IM)*DECAY/(2.0*DM1*DM4)	HEIGHT	132
2	134	DM5=(DM5+DM3*DM2)/(1.0-CCG(IM,J)*GRDK(IM,J)*DM3)	HEIGHT	133
2	135	DM7=DM5*(HEACT*HEACT)	HEIGHT	134
2	136	IF(DM7.LT.((STABLD(IM,J))**2)) DM7=(STABLD(IM,J))**2	HEIGHT	135
2	137	DM7=SQRT(DM7)	HEIGHT	136
2	138	ENDIF	HEIGHT	137
1	139	ENDIF	HEIGHT	138
1	140	C	HEIGHT	139
1	141	DM8(J)=DM7	HEIGHT	140
1	142	C	HEIGHT	141
1	143	200 CONTINUE	HEIGHT	142
1	144	C	HEIGHT	143
1	145	C***** CHECK FOR WAVE HEIGHT CONVERGENCE	HEIGHT	144
1	146	C	HEIGHT	145
1	147	SUM=0.0	HEIGHT	146
1	148	DO 400 J=2,NM1	HEIGHT	147

149	DM7=DM8(J)	HEIGHT	148
150	HM2=H(IM,J)*HFACT	HEIGHT	149
151	C	HEIGHT	150
152	C***** UPDATE THE WAVE HEIGHT	HEIGHT	151
153	C	HEIGHT	152
154	EPSZ=0.5	HEIGHT	153
155	DM7=EPSZ*DM7+(1.0-EPSZ)*HM2	HEIGHT	154
156	SUM=SUM+ABS(DM7-HM2)	HEIGHT	155
157	C	HEIGHT	156
158	C***** CONVERT HEIGHT BACK TO AMPLITUDE FUNCTION	HEIGHT	157
159	C	HEIGHT	158
160	H(IM,J)=DM7/HFACT	HEIGHT	159
161	400 CONTINUE	HEIGHT	160
162	C	HEIGHT	161
163	C***** SET LATERAL BOUNDARY CONDITIONS FOR WAVE HEIGHT	HEIGHT	162
164	C	HEIGHT	163
165	H(IM,1)=H(IM,2)	HEIGHT	164
166	H(IM,N)=H(IM,NM1)	HEIGHT	165
167	C	HEIGHT	166
168	C***** TEST FOR CONVERGENCE	HEIGHT	167
169	C	HEIGHT	168
170	IF(SUM.LT.(FLOAT(NM2)*HCONV)) GO TO 500	HEIGHT	169
171	450 CONTINUE	HEIGHT	170
172	C	HEIGHT	171
173	IF(IREF.EQ.1)GO TO 500	HEIGHT	172
174	WRITE(6,475) IM	HEIGHT	173
175	475 FORMAT(IX,'RELAXATION FOR WAVE HEIGHTS FAILED ON ROW =',I4)	HEIGHT	174
176	C	HEIGHT	175
177	500 CONTINUE	HEIGHT	176
178	RETURN	HEIGHT	177
179	END	HEIGHT	178
1	C*****	SNELL	2
2	C	SNELL	3
3	SUBROUTINE SNELL (THETA0,HH)	SNELL	4
4	C	SNELL	5
5	C*****	SNELL	6
6	C	SNELL	7
7	C THIS SUBROUTINE COMPUTES THE SNELLS LAW SOLUTION OVER THE ENTIRE	SNELL	8
8	C GRID	SNELL	9
9	C	SNELL	10
10	C*****	SNELL	11
11	C	PARAM	2
12	PARAMETER(IQ=95,JQ=95)	PARAM	3
13	C	PARAM	4
14	COMMON/ANGLES/Z(IQ,JQ),SI(IQ,JQ),CO(IQ,JQ)	SNELL	13
15	COMMON/WH/H(IQ,JQ),CC6(IQ,JQ)	SNELL	14
16	COMMON/DEPTHS/D(IQ,JQ)	SNELL	15
17	COMMON/WAVNUM/RKA(IQ,JQ),GRDK(IQ,JQ)	SNELL	16
18	COMMON/CONST/ G,PI,P12,RAD,HCONVR,SCONVR,DX,DY,DX2,DY2,T,OMEG,	SNELL	17
19	AM,N,M1,M2,MH1,MH2,IWET,IDRY,IWETP1,CNTRANG,HFACT,DLEVEL	SNELL	18
20	COMMON/PRINTC/IP1,IP2,INC,JP1,JP2,DMULT,MMULT,ZMULT,BKMULT	SNELL	19
21	COMMON/CONSD/IGRID,IBEF,ITAMX,ITMHX,IDIFF	SNELL	20
22	C	SNELL	21
23	C***** COMPUTE THE WAVE NUMBERS USING THE PADE APPROXIMATION	SNELL	22
24	C***** (SEE THE COASTAL ENGINEERING NOTEBOOK)	SNELL	23
25	C	SNELL	24
26	DO 1 I=IWET,M	SNELL	25
27	DO 1 J=1,N	SNELL	26
28	DD=D(I,J)	SNELL	27

29	DUM1=(OMEGA**2)*ADD/G	SNELL	28
30	DUM2=DUM1+1.0/(1.0+0.6522*DUM1+0.4622*	SNELL	29
31	A*(DUM1**2)+0.0864*(DUM1**4)+0.0675*(DUM1**5))	SNELL	30
32	DUM3=IASORT(GADD/DUM2)	SNELL	31
33	RKNUM=PI2/DUM3	SNELL	32
34	RKA(I,J)=RKNUM	SNELL	33
35	GRDK(I,J)=RKNUM	SNELL	34
36	C	SNELL	35
37	C***** COMPUTE THE HEIGHTS AND ANGLES USING SNELL'S LAW	SNELL	36
38	C***** COMPUTE SIGMA AND CCG	SNELL	37
39	C	SNELL	38
40	DUM1=RKNUM*ADD	SNELL	39
41	DUM2=2.0*DUM1	SNELL	40
42	DUM3=TANH(DUM1)	SNELL	41
43	DUM4=SINH(DUM2)	SNELL	42
44	SINE=SIN(THETA0-CNTRANG)*DUM3	SNELL	43
45	ZANG=PI-ASIN(SINE)+CNTRANG	SNELL	44
46	Z(I,J)=ZANG	SNELL	45
47	SI(I,J)=SIN(ZANG)	SNELL	46
48	CO(I,J)=COS(ZANG)	SNELL	47
49	DUM5=SQRT(COS(THETA0-CNTRANG)/COS(ZANG-CNTRANG))	SNELL	48
50	H(I,J)=HHADUM5*ASORT(0.5/(0.5*(1.0+DUM2/DUM4)	SNELL	49
51	**DUM3))	SNELL	50
52	CCG(I,J)=0.5*(1.0+(DUM2/DUM4))*OMEGA**2)/	SNELL	51
53	A*(RKNUM**2)	SNELL	52
54	1 CONTINUE	SNELL	53
55	C	SNELL	54
56	C***** CHECK FOR WAVE BREAKING	SNELL	55
57	C	SNELL	56
58	DO 600 I=IWET,M	SNELL	57
59	DO 604 J=1,M	SNELL	58
60	DUM5=H(I,J)	SNELL	59
61	HBRK=0.78*D(I,J)	SNELL	60
62	IF(DUM5.GE.HBRK) DUM5=HBRK	SNELL	61
63	C	SNELL	62
64	C*****CONVERT HEIGHTS TO AMPLITUDE FUNCTION (HAG/ZASIGMA)	SNELL	63
65	C	SNELL	64
66	H(I,J)=DUM5/HEACT	SNELL	65
67	604 CONTINUE	SNELL	66
68	600 CONTINUE	SNELL	67
69	RETURN	SNELL	68
70	END	SNELL	69
1	C*****	ANGLE	2
2	C	ANGLE	3
3	SUBROUTINE ANGLE(ISTART,IEND,ITMAX,WT,ALPHA,SCNV)	ANGLE	4
4	C	ANGLE	5
5	C*****	ANGLE	6
6	C	ANGLE	7
7	C THIS SUBROUTINE ITERATES TO SOLVE FOR THE WAVE ANGLES	ANGLE	8
8	C ALONG A GIVEN ROW	ANGLE	9
9	C	ANGLE	10
10	C*****	ANGLE	11
11	C	PARAM	2
12	PARAMETER(IQ=95,JQ=95)	PARAM	3
13	C	PARAM	4
14	COMMON/ANGLES/Z(IQ,JQ),SI(IQ,JQ),CO(IQ,JQ)	ANGLE	13
15	COMMON/DEPTHS/D(IQ,JQ)	ANGLE	14
16	COMMON/WAVNUM/RKA(IQ,JQ),GRDK(IQ,JQ)	ANGLE	15
17	COMMON/CONST/ G,PI,PI2,RAD,HCONVR,SCONVR,DX,DY,DX2,DY2,T,OMEG,	ANGLE	16

18	AM,N,M1,M2,NM1,NM2,IWET,IDRY,IWETP1,CNTRANG,HEACT,DLEVEL	ANGLE	17
19	COMMON/CONS/IGRID,IREF,ITAMX,IHMX,IDIEF	ANGLE	18
20	COMMON/MUSC/XMUC(IQ),XMUS(IQ),YMUC(JQ),YMUS(JQ)	ANGLE	19
21	DIMENSION DUM1(IQ,JQ),X(JQ)	ANGLE	20
22	C	ANGLE	21
23	C***** SOLVE THE DIFFERENCED FORM OF THE IRROTATIONALITY OF THE	ANGLE	22
24	C***** GRADIENT OF THE WAVE PHASE FUNCTION EQUATION	ANGLE	23
25	C	ANGLE	24
26	DO 1 I=IEND,ISTART,-1	ANGLE	25
27	IM=I-1	ANGLE	26
28	DO 4 IT=1,ITMAX	ANGLE	27
29	DO 2 J=2,NM1	ANGLE	28
30	DUM6=ALPHA*(GRDK(I,J+1)*SI(I,J+1))	ANGLE	29
31	*+(1.0-2.0*ALPHA)*(GRDK(I,J)*SI(I,J))	ANGLE	30
32	*+ALPHA*(GRDK(I,J-1)*SI(I,J-1))	ANGLE	31
33	DUM2=WT*(GRDK(I-1,J+1)*CO(I-1,J+1)-GRDK(I-1,J-1)*	ANGLE	32
34	*CO(I-1,J-1))/(DY2*YMUC(J))	ANGLE	33
35	*+(1.0-WT)*(GRDK(I,J+1)*CO(I,J+1)-GRDK(I,J-1)*	ANGLE	34
36	*CO(I,J-1))/(DY2*YMUC(J))	ANGLE	35
37	DUM3=DUM6-(DX*XMUS(I-1))*DUM2	ANGLE	36
38	DUM4=DUM3/GRDK(I-1,J)	ANGLE	37
39	DUM1(I,J)=DUM4	ANGLE	38
40	2 CONTINUE	ANGLE	39
41	SUM=0.0	ANGLE	40
42	DO 22 J=2,NM1	ANGLE	41
43	DUM4=DUM1(I,J)	ANGLE	42
44	DUM5=Z(I-1,J)	ANGLE	43
45	DUM3=SIN(DUM5)	ANGLE	44
46	C	ANGLE	45
47	C***** UPDATE THE SINES	ANGLE	46
48	C	ANGLE	47
49	EPSZ=0.5	ANGLE	48
50	DUM4=EPSZ*DUM4+(1.0-EPSZ)*DUM3	ANGLE	49
51	C	ANGLE	50
52	C***** LIMIT OBLIQUE WAVE ANGLES	ANGLE	51
53	C	ANGLE	52
54	IF(DUM4.GE.0.997)DUM4=0.997	ANGLE	53
55	IF(DUM4.LE.-0.997)DUM4=-0.997	ANGLE	54
56	DUM6=PI-ASIN(DUM4)	ANGLE	55
57	SUM=SUM+ABS(DUM6-Z(IM,J))	ANGLE	56
58	Z(IM,J)=DUM6	ANGLE	57
59	SI(IM,J)=DUM4	ANGLE	58
60	CO(IM,J)=COS(DUM6)	ANGLE	59
61	22 CONTINUE	ANGLE	60
62	C	ANGLE	61
63	C***** SET LATERAL BOUNDARY CONDITIONS FOR WAVE ANGLES,SINES,AND	ANGLE	62
64	C***** COSINES	ANGLE	63
65	C	ANGLE	64
66	Z(IM,1)=Z(IM,2)	ANGLE	65
67	CO(IM,1)=CO(IM,2)	ANGLE	66
68	SI(IM,1)=SI(IM,2)	ANGLE	67
69	Z(IM,N)=Z(IM,NM1)	ANGLE	68
70	CO(IM,N)=CO(IM,NM1)	ANGLE	69
71	SI(IM,N)=SI(IM,NM1)	ANGLE	70
72	C	ANGLE	71
73	C***** CHECK FOR ANGLE CONVERGENCE	ANGLE	72
74	C	ANGLE	73
75	IF(SUM.LT.(NM2*SCNV))GO TO 1	ANGLE	74
76	4 CONTINUE	ANGLE	75

77	IF(IREF.EQ.1)GO TO 1	ANGLE	76
78	WRITE(6,643)IM	ANGLE	77
79	643 FORMAT(IX,'RELAXATION FOR WAVE ANGLES FAILED ON ROW =',I4)	ANGLE	78
80	1 CONTINUE	ANGLE	79
81	99 RETURN	ANGLE	80
82	END	ANGLE	81
1	C*****	DEPTH	2
2	C	DEPTH	3
3	SUBROUTINE DEPTH	DEPTH	4
4	C	DEPTH	5
5	C*****	DEPTH	6
6	C	DEPTH	7
7	C THIS SUBROUTINE GENERATES THE WATER DEPTH MATRIX	DEPTH	8
8	C	DEPTH	9
9	C*****	DEPTH	10
10	C	PARAM	2
11	PARAMETER(IQ=95,JQ=95)	PARAM	3
12	C	PARAM	4
13	COMMON/DEPTHS/D(IQ,JQ)	DEPTH	12
14	COMMON/CONST/ G,PI,PI2,RAD,HCONVR,SCONVR,DX,DY,DX2,DY2,I,OMEG.	DEPTH	13
15	AM,N,M1,M2,NM1,NM2,IWET,IDRY,IWETP1,CNTRANG,HFACT,DLEVEL	DEPTH	14
16	COMMON/CONS2/IGRID,IREF,ITAMX,ITHMX,IDIFF	DEPTH	15
17	COMMON/MUSC/XMUC(IQ),XMUS(IQ),YHUC(JQ),YHUS(JQ)	DEPTH	16
18	COMMON/COORD/XX(IQ),YY(JQ)	DEPTH	17
19	C	DEPTH	18
20	C***** READ IN VARIABLE BATHYMETRY FROM FILE CODE 8. FIRST READ	DEPTH	19
21	C***** IN THE 'ALONGSHORE' ROW CLOSEST TO SHORE, THEN PROCEED	DEPTH	20
22	C***** ROW BY ROW IN THE OFFSHORE DIRECTION	DEPTH	21
23	C	DEPTH	22
24	DO 14 I=1,M	DEPTH	23
25	READ(8,50)(D(I,J),J=1,N)	DEPTH	24
26	14 CONTINUE	DEPTH	25
27	50 FORMAT(10F8.2)	DEPTH	26
28	99 RETURN	DEPTH	27
29	END	DEPTH	28
1	C*****	POUT	2
2	C	POUT	3
3	SUBROUTINE POUT(I11,I12,IVAL,JSTART,JEND,ITITLE,DUM1,FACT)	POUT	4
4	C	POUT	5
5	C*****	POUT	6
6	C	POUT	7
7	C THIS SUBROUTINE PRINTS OUT SELECTED VALUES OF A PARTICULAR ARRAY	POUT	8
8	,DUM1, WHICH ARE SCALED BY THE VALUE OF 'FACT'	POUT	9
9	C	POUT	10
10	C*****	POUT	11
11	C	PARAM	2
12	PARAMETER(IQ=95,JQ=95)	PARAM	3
13	C	PARAM	4
14	COMMON/CONST/ G,PI,PI2,RAD,HCONVR,SCONVR,DX,DY,DX2,DY2,I,OMEG,	POUT	13
15	AM,N,M1,M2,NM1,NM2,IWET,IDRY,IWETP1,CNTRANG,HFACT,DLEVEL	POUT	14
16	COMMON/CONS2/IGRID,IREF,ITAMX,ITHMX,IDIFF	POUT	15
17	INTEGER IX(JQ*31),ITITLE(3)	POUT	16
18	DIMENSION DUM1(IQ,JQ)	POUT	17
19	C	POUT	18
20	NC=31	POUT	19
21	WRITE(6,100)ITITLE,FACT	POUT	20
22	100 FORMAT(///,3A10,5X,'(MULTIPLIED BY ',F6.0,')')	POUT	21
23	J1=JSTART	POUT	22
24	J2=JSTART+NC-1	POUT	23

25	1 IF(J2.GT.JEND)J2=JEND	POUT	24
26	WRITE(6,102)(J,J=J1,J2)	POUT	25
27	102 FORMAT(/,3X,'I/J:',3I14)	POUT	26
28	WRITE(6,103)	POUT	27
29	103 FORMAT(1X,'-----',	POUT	28
30	* '-----',	POUT	29
31	* '-----')	POUT	30
32	DO 2 I=I11,I12,IVAL	POUT	31
33	DO 3 J=J1,J2	POUT	32
34	RND=0.5	POUT	33
35	IF(DUM1(I,J).LT.0.0)RND=-0.5	POUT	34
36	3 IX(J)=INT(EACTADUM1(I,J)+RND)	POUT	35
37	2 WRITE(6,104)I,(IX(J),J=J1,J2)	POUT	36
38	104 FORMAT(1X,I3,2X,':',3I14)	POUT	37
39	J1=J1+NC	POUT	38
40	J2=J2+NC	POUT	39
41	IF(J1.LE.JEND)GO TO 1	POUT	40
42	WRITE(6,101)	POUT	41
43	101 FORMAT(//)	POUT	42
44	RETURN	POUT	43
45	END	POUT	44
1	CAAA	GRID	2
2	C	GRID	3
3	SUBROUTINE GRID	GRID	4
4	C	GRID	5
5	CAAA	GRID	6
6	C	GRID	7
7	C THIS SUBROUTINE READS THE VARIABLE GRID MAPPING INFORMATION FROM	GRID	8
8	C FILE CODE 3 (X REGION FIRST,THEN Y) AND GENERATES THE VARIABLE	GRID	9
9	C GRID SCALE FACTORS AND DISTANCES TO THE GRID CENTERS	GRID	10
10	C	GRID	11
11	C WHEN GENERATING A VARIABLY SIZED GRID IT IS RECCOMENDED THAT THE	GRID	12
12	C MAPPING BE DONE IN MAP INCENES FROM SOME BATHYMETRIC CHART OF A	GRID	13
13	C KNOWN SCALE. THE 'DX' AND 'DY' USED AS INPUT INTO THE MODEL ARE	GRID	14
14	C THEN SIMPLY THE NUMBER OF FEET OR METERS PER MAP INCH. IF MAP	GRID	15
15	C INCHES ARE NOT USED IN THE MAPPING, THE VALUES OF 'XSCALE' AND	GRID	16
16	C 'YSCALE' CAN BE SET TO SOMETHING OTHER THAN 1.0 (IN CONJUNCTION	GRID	17
17	C WITH THE CHOICE OF 'DX' AND 'DY') TO CONVERT FROM THE MAPPED	GRID	18
18	C SPACE INTO REAL SPACE	GRID	19
19	C	GRID	20
20	CAAA	GRID	21
21	C	GRID	22
22	C **DEFINITIONS OF VARIABLE GRID MAPPING INPUT REQUIRED BY THE MODEL	GRID	23
23	C	GRID	24
24	C NREG(X,Y) - IS THE NUMBER OF MAPPING REGIONS IN THE X OR Y	GRID	25
25	C DIRECTION	GRID	26
26	C NA(X,Y) - IS THE NUMBER OF GRID CELLS IN A PARTICULAR MAPPING	GRID	27
27	C REGION IN THE X OR Y DIRECTION	GRID	28
28	C A(X,Y),B(X,Y),C(X,Y) - ARE THE MAPPING COEFFICIENTS FOR A	GRID	29
29	C PARTICULAR REGION IN THE X OR Y DIRECTION	GRID	30
30	C	GRID	31
31	CAAA	GRID	32
32	C	PARAM	3
33	PARAMETER(IO=95,JQ=95)	PARAM	4
34	C	PARAM	5
35	COMMON/CONST/ G,PI,PI2,RAD,HCONVR,SCONVR,DX,DY,DX2,DY2,T,ONES,	GRID	34
36	*M,N,M1,M2,MN1,MN2,IWET,IDRY,IWETP1,CNTRANG,HEACT,DLEVEL	GRID	35
37	COMMON/CONS2/IGRID,IREF,I1AMX,I1HMX,IDIEF	GRID	36
38	COMMON/MUSC/XMUC(IO),XMUS(IO),YMUC(JQ),YMUS(JQ)	GRID	37

39	COMMON/COOR/XX(IQ),YY(JQ)	GRID	38
40	DIMENSION AX(50),BX(50),CX(50),MAX(50)	GRID	39
41	DIMENSION AY(50),BY(50),CY(50),NAY(50)	GRID	40
42	CHARACTER*1 STR	GRID	41
43	C	GRID	42
44	XSCALE=1.0	GRID	43
45	YSCALE=1.0	GRID	44
46	C	GRID	45
47	C***** READ MAPPING INFORMATION	GRID	46
48	C	GRID	47
49	J=1	GRID	48
50	I=1	GRID	49
51	21 CONTINUE	GRID	50
52	READ(3,31,END=999) STR,NST,NEND,A1,B1,C1	GRID	51
53	31 FORMAT(A1,7X,2I8,3G16.11)	GRID	52
54	NEND=NEND-1	GRID	53
55	IF(STR.EQ,'Y') GO TO 20	GRID	54
56	AX(I)=A1	GRID	55
57	BX(I)=B1	GRID	56
58	CX(I)=C1	GRID	57
59	DO 201 LLC=NST,NEND	GRID	58
60	LL=LLC+1	GRID	59
61	ALPHC=LL-0.5	GRID	60
62	ALPHS=LL	GRID	61
63	XMUS(LL-1)=(B1*C1*(ALPHS*(C1-1.0)))*XSCALE	GRID	62
64	XMUC(LL-1)=(B1*C1*(ALPHC*(C1-1.0)))*XSCALE	GRID	63
65	XX(LL-1)=(A1+B1*(ALPHC*(C1-1.0)))*XSCALE*DX	GRID	64
66	201 CONTINUE	GRID	65
67	MAX(I)=NEND+1-NST	GRID	66
68	NXREG=I	GRID	67
69	I=I+1	GRID	68
70	GO TO 21	GRID	69
71	20 CONTINUE	GRID	70
72	AY(J)=A1	GRID	71
73	BY(J)=B1	GRID	72
74	CY(J)=C1	GRID	73
75	DO 203 LLC=NST,NEND	GRID	74
76	LL=LLC+1	GRID	75
77	ALPHC=LL-0.5	GRID	76
78	ALPHS=LL	GRID	77
79	YMUS(LL-1)=(B1*C1*(ALPHS*(C1-1.0)))*YSCALE	GRID	78
80	YMUC(LL-1)=(B1*C1*(ALPHC*(C1-1.0)))*YSCALE	GRID	79
81	YY(LL-1)=(A1+B1*(ALPHC*(C1-1.0)))*YSCALE*DY	GRID	80
82	203 CONTINUE	GRID	81
83	NAY(J)=NEND+1-NST	GRID	82
84	NYREG=J	GRID	83
85	J=J+1	GRID	84
86	GO TO 21	GRID	85
87	999 CONTINUE	GRID	86
88	C	GRID	87
89	C***** WRITE THE VARIABLE GRID INFORMATION ON FILE CODE 6	GRID	88
90	C	GRID	89
91	WRITE(6,9)	GRID	90
92	9 FORMAT(///,20X,'VARIABLE WAVE GRID INFORMATION',///)	GRID	91
93	WRITE(6,23)*XSCALE,YSCALE	GRID	92
94	23 FORMAT(///,'EXPANSION COEFFICIENT SCALE FACTORS',/,	GRID	93
95	A*XSCALE=',F10.3,5X,'YSCALE=',F10.3,//)	GRID	94
96	WRITE(6,5)	GRID	95
97	5 FORMAT(1X,'X EXPANSION COEFS(A,B,C) AND GRIDS PER REGION',//)	GRID	96

98	WRITE(6,4)(I,AX(I),BX(I),CX(I),MAX(I),I=1,MXREG)	GRID	97
99	4 FORMAT(110,3E20.7,110)	GRID	98
100	WRITE(6,6)	GRID	99
101	6 FORMAT(///,1X,'Y EXPANSION COEES(A,B,C) AND GRIDS PER REGION',//)	GRID	100
102	WRITE(6,4)(I,AY(I),BY(I),CY(I),MAY(I),I=1,MYREG)	GRID	101
103	WRITE(6,7)	GRID	102
104	7 FORMAT(///,1X,'X SCALE FACTORS (XMUC,XMUS)',//)	GRID	103
105	WRITE(6,2)(I,XMUC(I),XMUS(I),I=1,M)	GRID	104
106	WRITE(6,8)	GRID	105
107	8 FORMAT(///,1X,'Y SCALE FACTORS (YMUC,YMUS)',//)	GRID	106
108	WRITE(6,2)(I,YMUC(I),YMUS(I),I=1,N)	GRID	107
109	2 FORMAT(5(15,2F10.5))	GRID	108
110	WRITE(6,10)	GRID	109
111	10 FORMAT(///,1X,'X CENTER DISTANCES',//)	GRID	110
112	WRITE(6,11)(I,XX(I),I=1,M)	GRID	111
113	11 FORMAT(8(14,F12.3))	GRID	112
114	WRITE(6,12)	GRID	113
115	12 FORMAT(///,1X,'Y CENTER DISTANCES',//)	GRID	114
116	WRITE(6,11)(J,YY(J),J=1,N)	GRID	115
117	RETURN	GRID	116
118	END	GRID	117
1	C*****	ONBC	2
2	C	ONBC	3
3	SUBROUTINE ONBC(DUM1)	ONBC	4
4	C	ONBC	5
5	C*****	ONBC	6
6	C	ONBC	7
7	C THIS SUBROUTINE SETS THE ONSHORE BOUNDARY CONDITION .	ONBC	8
8	C THIS BOUNDARY CONDITION IS NOT USED IN THE COMPUTATIONAL SCHEME	ONBC	9
9	C SINCE IT PROCEEDS FROM OFFSHORE TOWARDS ONSHORE.	ONBC	10
10	C	ONBC	11
11	C*****	ONBC	12
12	C	PARAM	2
13	PARAMETER(IQ=95,JQ=95)	PARAM	3
14	C	PARAM	4
15	COMMON/CONST/ 6,PI,P12,RAD,HCONVR,SCONVR,DX,DY,DX2,DY2,I,OMEG.	ONBC	14
16	AM,N,M1,M2,NM1,NM2,IWET,IDRY,IWETP1,CNTRANG,HEACT,DLEVEL	ONBC	15
17	COMMON/CONS2/IGRID,IREF,ITAMX,ITHMV,IDIFF	ONBC	16
18	DIMENSION DUM1(IQ,JQ)	ONBC	17
19	DO 1 I=1,IDRY	ONBC	18
20	DO 1 J=1,N	ONBC	19
21	DUM1(I,J)=DUM1(IWET,J)	ONBC	20
22	1 CONTINUE	ONBC	21
23	RETURN	ONBC	22
24	END	ONBC	23

APPENDIX G: SAMPLE FILES--FIELD RESEARCH FACILITY PIER,
DUCK, NORTH CAROLINA, WAVE PROPAGATION EXAMPLE

FIELD RESEARCH FACILITY (DUCK , NC) EXAMPLE

75	12.0	50	24.0	9.800	0.0	2	0.90
	2.00	12.00	20.00				
	1.50	8.00	-35.00				
1	50	1	11	41			
1							

Figure G3. DUCKDAT

```

ID MODS
D PARAM.3
  PARAMETER(IQ=75,JQ=50)
D DEPTH.23,DEPTH.26
  DO 14 J=1,N
    READ(8,60) (D(I,J),I=1,M)
    DO 315 I=1,M
      D(I,J)=-D(I,J)
315 CONTINUE
  60 FORMAT(5X/(15F8.2))
  14 CONTINUE
D MAIN.203
  DMULT=10.0

```

Figure G4. DUCKUPD

```

ID MODS
D PARAM.3
  PARAMETER(IQ=75,JQ=50)
D DEPTH.23,DEPTH.26
  DO 14 J=1,N
    READ(8,60) (D(I,J),I=1,M)
    DO 315 I=1,M
      D(I,J)=-D(I,J)
315 CONTINUE
  60 FORMAT(5X/(15F8.2))
  14 CONTINUE
D MAIN.203
  DMULT=10.0
D MAIN.2
  PROGRAM RCPWAVE(INPUT,OUTPUT,TAPE7=TAPE7,TAPE6=TAPE6,TAPE8=TAPE8
*,TAPE3=TAPE3)

```

Figure G5. DUCKUP2

1	5.76	6.05	3.13	2.59	1.18	-0.13	-1.62	-1.90	-1.03	-0.92	-1.20	-1.44	-1.86	-2.29	-2.78
	-3.08	-3.54	-3.83	-4.02	-4.08	-4.05	-3.99	-3.88	-3.81	-3.69	-3.67	-3.69	-3.75	-3.84	-3.93
	-4.05	-4.22	-4.33	-4.45	-4.53	-4.69	-4.76	-4.94	-5.03	-5.12	-5.24	-5.37	-5.51	-5.64	-5.72
	-5.82	-5.92	-5.97	-6.10	-6.22	-6.28	-6.40	-6.52	-6.60	-6.70	-6.74	-6.80	-6.88	-6.96	-7.01
	-7.04	-7.16	-7.28	-7.31	-7.36	-7.41	-7.56	-7.62	-7.68	-7.74	-7.86	-7.92	-8.07	-8.14	-8.19
2	5.61	4.95	3.49	2.23	1.06	-0.23	-1.22	-1.55	-1.34	-1.14	-1.24	-1.53	-1.83	-2.38	-2.87
	-3.23	-3.53	-3.83	-4.05	-4.11	-4.08	-4.00	-3.89	-3.80	-3.72	-3.68	-3.70	-3.75	-3.83	-3.92
	-4.07	-4.23	-4.34	-4.43	-4.53	-4.65	-4.78	-4.92	-5.01	-5.11	-5.22	-5.35	-5.49	-5.61	-5.69
	-5.78	-5.90	-5.99	-6.07	-6.16	-6.28	-6.39	-6.48	-6.58	-6.67	-6.74	-6.80	-6.88	-6.94	-6.99
	-7.05	-7.15	-7.25	-7.30	-7.34	-7.43	-7.53	-7.61	-7.67	-7.74	-7.84	-7.93	-8.03	-8.09	-8.14
3	5.45	4.77	3.65	2.27	1.14	-0.13	-1.02	-1.38	-1.43	-1.36	-1.40	-1.61	-1.89	-2.47	-3.01
	-3.37	-3.67	-3.94	-4.15	-4.20	-4.17	-4.06	-3.91	-3.81	-3.74	-3.70	-3.71	-3.75	-3.83	-3.91
	-4.05	-4.20	-4.31	-4.40	-4.51	-4.62	-4.75	-4.87	-4.97	-5.09	-5.18	-5.28	-5.42	-5.53	-5.62
	-5.72	-5.85	-5.94	-6.03	-6.12	-6.24	-6.36	-6.44	-6.55	-6.62	-6.72	-6.78	-6.86	-6.91	-6.96
	-7.02	-7.13	-7.21	-7.26	-7.30	-7.40	-7.50	-7.59	-7.65	-7.71	-7.81	-7.89	-7.98	-8.01	-8.06
4	5.66	4.90	3.67	2.44	1.32	-0.00	-0.91	-1.30	-1.50	-1.55	-1.56	-1.66	-1.94	-2.55	-3.10
	-3.50	-3.83	-4.08	-4.25	-4.29	-4.27	-4.17	-3.95	-3.84	-3.76	-3.71	-3.70	-3.74	-3.82	-3.89
	-4.02	-4.15	-4.27	-4.36	-4.47	-4.58	-4.69	-4.79	-4.90	-5.05	-5.14	-5.23	-5.35	-5.46	-5.56
	-5.67	-5.78	-5.88	-6.00	-6.10	-6.21	-6.31	-6.40	-6.51	-6.59	-6.69	-6.75	-6.84	-6.88	-6.93
	-6.99	-7.11	-7.17	-7.22	-7.26	-7.37	-7.47	-7.56	-7.63	-7.70	-7.78	-7.84	-7.91	-7.95	-7.99
5	6.39	5.24	3.49	2.59	1.52	.02	-0.91	-1.30	-1.55	-1.68	-1.66	-1.59	-1.92	-2.59	-3.13
	-3.57	-3.93	-4.16	-4.32	-4.35	-4.33	-4.25	-4.02	-3.84	-3.77	-3.69	-3.67	-3.73	-3.79	-3.88
	-3.98	-4.12	-4.23	-4.34	-4.43	-4.55	-4.64	-4.73	-4.86	-5.01	-5.11	-5.20	-5.32	-5.44	-5.55
	-5.65	-5.75	-5.85	-5.98	-6.07	-6.20	-6.29	-6.38	-6.49	-6.58	-6.66	-6.76	-6.82	-6.87	-6.91
	-6.98	-7.08	-7.16	-7.19	-7.24	-7.35	-7.46	-7.53	-7.62	-7.70	-7.77	-7.81	-7.87	-7.93	-7.98
6	6.37	5.24	3.51	2.60	1.54	.06	-0.88	-1.28	-1.54	-1.69	-1.67	-1.60	-1.94	-2.60	-3.14
	-3.58	-3.95	-4.17	-4.33	-4.36	-4.33	-4.24	-4.00	-3.83	-3.76	-3.68	-3.67	-3.72	-3.79	-3.88
	-3.97	-4.11	-4.23	-4.33	-4.42	-4.53	-4.63	-4.71	-4.84	-4.99	-5.09	-5.20	-5.31	-5.43	-5.53
	-5.64	-5.74	-5.84	-5.98	-6.07	-6.20	-6.28	-6.38	-6.49	-6.59	-6.67	-6.76	-6.83	-6.88	-6.92
	-6.99	-7.09	-7.16	-7.20	-7.25	-7.36	-7.47	-7.54	-7.63	-7.70	-7.77	-7.81	-7.87	-7.93	-7.97

Figure G6. DUCKDEP

REGIONAL COASTAL PROCESSES WAVE TRANSFORMATION MODEL
(R C P W A V E)

FIELD RESEARCH FACILITY (DUCK , NC) EXAMPLE

MODEL INPUT:

UNIFORMLY SIZED, RECTILINEAR GRID MESH

X - DIRECTION (ON-OFFSHORE)	75 CELLS, EACH	12.00 IN LENGTH
Y - DIRECTION (LONGSHORE)	50 CELLS, EACH	24.00 IN LENGTH

THE ACCELERATION OF GRAVITY IS 9.80. THESE UNITS DETERMINE THE UNITS OF ALL INPUT AND OUTPUT VARIABLES

THE DEEP WATER WAVE PARAMETERS FOR CASE 1 ARE:	HEIGHT= 2.000	PERIOD= 12.000	ANGLE= 20.000
THE DEEP WATER WAVE PARAMETERS FOR CASE 2 ARE:	HEIGHT= 1.500	PERIOD= 8.000	ANGLE= -35.000

THE OFFSHORE CONTOURS MAKE AN ANGLE OF .00 DEGREES WITH THE Y AXIS

THE BATHYMETRY MATRIX IS VARIABLE IN BOTH HORIZONTAL DIRECTIONS AND WAS READ FROM FILE CODE 8

A WATER LEVEL CHANGE OF .90 WAS ADDED TO THE ENTIRE BATHYMETRY MATRIX

Figure G7. RCPPRNT

WATER DEPTHS

(MULTIPLIED BY 10.)

I/J:	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1 :	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2 :	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3 :	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4 :	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4
5 :	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	8	9	13	15	14	15	14
6 :	14	13	11	10	7	5	3	3	3	3	3	3	3	3	3	3	10	10	16	16	18	19	19	21	20
7 :	22	21	19	21	16	19	13	11	8	6	5	5	7	6	8	10	16	15	17	18	20	20	22	21	23
8 :	25	24	23	23	20	22	18	19	15	15	14	13	14	15	16	15	16	17	21	21	22	22	25	27	26
9 :	24	24	22	19	20	18	18	17	17	16	16	16	16	17	16	17	18	19	23	24	25	26	28	29	29
10 :	24	23	22	20	20	18	19	19	18	17	17	17	17	17	18	19	20	21	24	25	27	28	30	31	31
11 :	25	24	23	22	21	20	20	20	19	17	18	18	18	19	18	20	20	22	25	26	28	29	31	33	32
12 :	26	26	25	24	23	22	22	20	20	18	18	18	19	19	19	21	21	24	28	28	29	29	31	33	32
13 :	29	29	28	28	27	27	26	24	23	21	21	21	21	21	22	24	25	27	30	31	31	31	32	29	33
14 :	33	33	33	33	33	32	32	30	28	25	25	25	25	27	26	28	28	31	35	35	36	36	36	35	36
15 :	36	36	37	36	37	37	38	38	36	31	30	30	32	33	30	32	34	36	40	41	41	41	42	42	42
16 :	41	41	41	41	42	43	45	49	43	37	35	35	38	36	35	38	39	41	44	44	45	45	46	46	46
17 :	45	45	46	46	48	49	50	52	47	41	40	40	44	42	40	43	44	45	48	48	47	47	48	49	48
18 :	48	48	49	50	52	55	53	54	50	48	46	46	50	47	47	48	48	50	49	49	48	47	48	49	49
19 :	49	49	50	51	53	56	55	56	54	52	51	51	54	54	50	52	50	52	50	49	47	46	47	47	48
20 :	46	47	49	50	52	54	54	56	55	56	55	56	58	56	53	54	53	51	48	48	46	45	46	46	47
21 :	43	43	46	46	50	53	53	52	55	58	58	58	61	60	56	56	54	51	47	46	45	45	45	45	46
22 :	42	42	44	44	48	51	51	52	55	59	59	60	62	62	58	57	52	51	46	46	45	44	44	44	45
23 :	41	41	42	42	45	47	49	52	54	58	60	61	63	62	64	58	52	50	46	46	45	44	44	44	45
24 :	42	42	41	41	44	45	48	50	53	57	59	62	64	63	65	58	49	49	47	46	45	45	45	44	45
25 :	42	42	42	42	43	43	46	48	51	55	59	61	64	63	61	57	49	49	47	47	46	45	45	45	45
26 :	43	43	42	42	43	42	45	47	50	54	57	60	64	64	59	57	49	50	48	48	47	46	46	46	46
27 :	44	44	43	42	43	42	45	47	50	53	56	59	65	64	57	57	51	51	49	49	48	47	47	47	47
28 :	45	45	44	43	44	43	45	47	50	53	55	59	65	63	57	57	52	52	51	50	49	48	48	47	47
29 :	46	46	45	45	45	43	46	47	50	53	56	60	65	64	59	57	52	52	51	51	50	49	49	48	48
30 :	48	47	47	46	46	45	47	48	50	54	57	61	66	64	58	58	53	53	52	52	51	50	50	49	49
31 :	49	49	49	49	48	46	48	49	52	55	58	63	68	66	61	60	54	54	53	53	52	51	51	50	51
32 :	50	50	51	51	50	49	50	51	54	57	60	64	69	67	60	61	56	55	55	54	53	53	52	52	52
33 :	51	52	53	53	52	53	53	56	59	61	65	70	69	62	62	56	56	55	55	54	53	53	53	53	53
34 :	53	53	55	56	55	54	55	57	58	61	63	66	72	71	63	64	59	57	56	55	55	54	54	54	54
35 :	54	55	57	58	57	57	58	58	61	63	65	69	74	73	67	66	59	58	57	57	56	56	55	55	55
36 :	55	56	59	60	60	59	61	62	64	66	68	73	78	74	69	67	61	59	58	58	57	56	56	56	56
37 :	57	58	61	63	63	63	65	65	67	68	70	74	79	75	67	67	60	60	59	58	58	57	57	57	57
38 :	58	60	64	66	66	67	67	68	69	72	73	76	80	77	68	68	61	61	60	60	59	58	58	58	59
39 :	60	61	66	67	69	70	71	72	73	75	76	79	82	78	73	70	63	62	61	61	60	59	60	59	60
40 :	61	62	67	69	71	74	74	76	77	78	79	81	84	79	70	71	63	63	63	62	61	61	61	61	61
41 :	62	64	69	71	74	77	77	79	79	80	81	83	86	80	71	71	64	64	64	63	63	62	62	62	62
42 :	64	65	71	73	76	79	79	81	81	82	82	83	86	82	76	72	65	65	65	63	63	63	63	63	63
43 :	65	67	72	75	77	80	80	82	82	83	83	84	86	82	74	73	66	66	66	66	65	65	64	64	64
44 :	67	68	73	76	79	83	81	82	82	83	83	84	87	82	73	74	69	68	67	67	66	66	66	65	65
45 :	68	69	74	76	79	82	82	82	82	83	83	84	88	85	78	75	70	69	68	68	67	67	67	66	66

Figure G8. RCPPRNT

(Sheet 1 of 9)

ANGLE= 20.000

[illegible]

Figure G8. (Sheet 2 of 9)

WAVE HEIGHTS

(MULTIPLIED BY 10.)

I/J:	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1 :	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2 :	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3 :	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4 :	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	5	4	5
5 :	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	6	6	7	7	7	8	8
6 :	8	8	7	10	6	7	4	1	1	1	1	1	1	1	1	3	6	6	7	7	8	8	9	9	10
7 :	10	9	9	9	8	7	7	8	6	5	5	5	5	5	6	6	7	7	8	9	9	10	10	11	11
8 :	10	10	9	8	8	7	7	7	6	6	6	6	6	7	7	7	7	8	9	10	10	11	12	12	12
9 :	10	10	9	9	8	7	8	7	7	7	7	7	7	7	7	8	8	9	10	11	12	12	13	13	13
10 :	12	11	11	10	9	9	9	8	8	7	7	7	7	8	8	8	9	10	12	13	13	14	14	15	15
11 :	14	14	14	13	12	12	11	10	9	8	8	8	8	8	9	10	11	13	15	16	16	16	17	17	16
12 :	19	19	19	19	18	17	16	15	13	12	10	10	10	11	12	13	14	17	20	22	22	21	21	20	20
13 :	27	27	27	27	26	25	24	24	23	15	15	14	15	16	16	18	20	21	30	30	30	29	27	27	26
14 :	26	27	26	26	26	25	23	22	22	22	21	21	20	21	24	26	28	29	29	29	28	28	27	26	25
15 :	26	26	26	26	25	24	23	21	21	21	21	20	19	21	23	25	27	28	28	28	27	27	26	25	24
16 :	25	25	25	25	24	24	23	21	20	20	20	19	19	20	22	24	26	27	28	27	27	26	25	24	24
17 :	24	24	24	24	24	23	22	21	20	20	19	19	18	19	21	23	26	27	27	27	26	25	25	24	24
18 :	23	23	23	24	24	23	23	21	20	19	19	18	18	19	21	23	25	27	27	26	26	25	25	24	24
19 :	23	23	23	23	23	23	23	22	20	19	18	18	18	19	21	23	25	27	27	26	26	25	25	24	24
20 :	23	23	23	23	23	23	23	22	21	19	18	18	18	19	21	23	25	26	27	26	26	25	25	24	24
21 :	23	23	23	24	24	23	23	21	19	18	18	18	18	21	23	25	26	27	26	25	25	25	24	24	24
22 :	23	23	23	24	24	23	23	21	20	19	18	18	19	20	23	25	26	27	26	25	25	25	24	24	24
23 :	23	23	23	23	24	24	24	23	22	20	19	18	18	19	20	23	26	26	26	26	25	25	25	24	24
24 :	23	23	23	23	24	24	24	23	22	21	19	18	18	19	20	23	26	26	26	26	25	25	24	24	24
25 :	23	23	23	23	24	24	23	22	21	20	19	18	19	21	23	26	26	26	26	25	25	24	24	24	24
26 :	23	23	23	23	24	24	23	22	21	20	19	18	19	21	23	26	26	26	26	25	25	24	24	24	24
27 :	23	23	22	23	24	24	23	23	22	20	19	19	19	20	22	24	25	26	25	25	24	24	24	24	24
28 :	23	23	22	22	23	24	24	23	23	22	21	19	19	20	22	24	25	26	25	24	24	24	24	24	24
29 :	23	23	22	22	23	23	23	23	23	22	21	20	19	20	22	24	25	25	25	24	24	24	24	24	23
30 :	23	23	22	22	23	23	23	23	23	22	21	20	19	20	22	24	25	25	25	24	24	24	24	24	23
31 :	23	23	22	22	23	23	23	23	23	22	21	20	19	20	22	23	25	25	24	24	24	23	23	23	23
32 :	23	23	22	22	23	23	23	23	23	22	21	20	19	20	22	23	25	25	24	24	23	23	23	23	23
33 :	23	23	22	22	22	22	23	22	22	21	20	20	20	22	23	24	24	24	23	23	23	23	23	23	23
34 :	23	23	22	21	22	22	22	22	22	22	21	20	20	20	22	23	24	24	24	23	23	23	23	23	23
35 :	23	23	22	21	22	22	22	22	22	22	21	20	20	20	22	23	24	24	23	23	23	23	23	23	23
36 :	23	23	22	21	21	22	22	22	22	22	21	20	20	21	22	23	24	24	23	23	23	23	23	23	23
37 :	23	22	22	21	21	21	22	22	22	22	21	20	20	20	22	23	24	24	23	23	23	23	23	23	23
38 :	23	22	22	21	21	21	21	22	22	21	21	20	20	20	22	23	24	23	23	23	23	23	23	23	22
39 :	22	22	21	21	21	21	21	21	21	21	21	21	20	20	22	22	23	23	23	22	22	22	22	22	22
40 :	23	22	22	21	21	21	21	21	21	21	21	21	20	20	21	22	22	23	23	23	22	22	22	23	22
41 :	22	22	21	21	21	21	21	21	21	21	21	21	20	20	21	22	22	23	23	22	22	22	22	22	22
42 :	22	22	21	21	21	21	21	21	21	21	21	21	20	21	22	22	23	23	22	22	22	22	22	22	22
43 :	22	22	21	21	21	21	21	21	21	21	21	21	21	21	22	22	23	23	22	22	22	22	22	22	22
44 :	22	22	21	21	21	21	21	21	21	21	21	21	21	20	20	21	22	22	22	22	22	22	22	22	22
45 :	22	22	21	21	21	21	21	21	21	21	21	21	20	20	21	22	22	22	22	22	22	22	22	22	22

Figure G8. (Sheet 4 of 9)

WAVE NUMBER

(MULTIPLIED BY 1000.)

I/J:	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	
1	:	303	303	303	303	300	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	
2	:	303	303	303	303	300	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	
3	:	303	303	303	303	245	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	
4	:	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	253	275	
5	:	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	303	182	176	148	136	144	139	142
6	:	142	146	163	165	205	230	303	303	303	303	303	303	303	303	303	303	172	170	134	134	127	122	122	116	120
7	:	114	116	121	116	132	122	150	158	184	210	230	235	207	213	182	168	134	138	129	125	121	119	114	116	111
8	:	108	109	112	111	119	115	127	123	137	139	144	146	140	137	132	138	135	128	118	116	114	113	107	103	105
9	:	108	109	115	121	120	127	125	130	129	132	133	134	133	131	133	128	126	121	112	110	107	105	102	100	100
10	:	110	112	114	119	120	128	123	122	126	131	130	130	128	128	125	124	120	116	108	107	103	101	98	96	97
11	:	108	109	112	114	117	120	120	120	124	128	128	127	124	124	125	121	118	113	108	105	101	100	96	93	95
12	:	104	105	108	109	111	114	114	120	119	125	125	124	122	122	122	117	116	110	102	101	100	99	96	94	95
13	:	100	100	101	102	103	103	106	109	112	116	117	118	116	115	113	110	107	103	97	96	96	96	94	98	94
14	:	93	93	93	94	93	94	95	99	101	106	107	108	107	104	106	101	101	96	91	91	90	90	90	91	90
15	:	89	89	88	89	88	87	87	88	91	97	98	98	96	94	98	95	93	90	86	85	84	84	84	83	84
16	:	84	85	84	84	83	83	81	78	83	89	91	91	88	90	91	88	86	84	81	81	81	81	81	80	80
17	:	82	82	81	80	78	78	77	76	79	85	86	85	82	84	86	83	81	80	79	79	79	79	78	78	78
18	:	79	79	78	78	76	73	74	75	78	78	80	81	77	79	80	79	78	78	77	77	78	79	78	78	78
19	:	78	78	77	76	75	72	73	73	74	76	76	76	75	74	77	76	76	76	77	77	79	80	79	79	78
20	:	79	79	77	77	75	74	74	71	73	74	74	73	73	74	74	74	74	75	77	78	80	80	80	80	79
21	:	83	82	80	79	76	74	74	74	73	72	72	72	71	71	73	73	74	75	79	79	80	81	81	81	80
22	:	83	83	82	81	78	76	76	75	74	71	71	71	70	70	73	72	75	76	79	80	81	81	81	81	81
23	:	84	84	83	83	80	78	77	75	73	71	71	71	69	70	69	71	74	76	80	80	81	82	81	82	81
24	:	84	84	84	84	82	80	78	76	74	72	71	70	69	69	68	71	76	76	79	80	80	81	81	81	81
25	:	83	83	84	84	82	82	79	78	76	73	71	70	69	70	70	71	77	77	79	79	80	80	80	81	81
26	:	83	83	83	83	83	82	80	79	77	74	72	70	70	69	71	72	77	77	78	78	79	79	80	80	80
27	:	81	82	83	83	82	83	81	79	76	74	72	71	69	69	71	72	76	76	77	77	78	79	79	79	79
28	:	80	81	82	82	82	82	80	79	77	74	73	71	68	69	73	72	74	75	76	77	78	78	78	79	79
29	:	79	80	81	81	81	82	80	79	77	75	73	70	68	69	70	72	75	75	76	76	77	77	78	78	78
30	:	78	79	80	80	80	80	79	78	76	74	72	70	68	68	72	71	74	74	75	75	76	76	77	77	77
31	:	77	77	78	78	78	79	78	77	75	73	71	69	67	67	68	70	73	73	74	75	75	76	76	76	76
32	:	77	76	77	76	77	78	76	75	74	71	70	69	67	68	70	72	73	74	74	75	75	75	75	75	75
33	:	76	75	75	75	75	75	74	73	71	70	67	66	67	69	70	73	73	73	73	74	74	74	74	74	74
34	:	75	74	73	73	73	74	73	72	71	70	69	67	65	65	69	69	70	72	73	73	73	74	74	74	74
35	:	74	73	72	71	72	72	71	71	70	68	67	67	65	64	67	67	71	71	72	72	73	73	73	73	73
36	:	73	73	71	71	70	71	69	69	68	67	66	64	63	64	65	66	69	71	72	72	72	73	73	73	73
37	:	72	72	70	69	69	69	68	67	66	66	65	64	62	64	67	67	70	70	71	71	72	72	72	72	72
38	:	71	70	68	67	67	67	67	66	66	64	64	63	62	64	67	67	69	70	71	71	71	71	71	71	71
39	:	70	69	67	67	66	66	65	65	64	63	63	62	62	63	64	65	69	69	70	70	71	71	71	71	70
40	:	70	69	67	66	65	64	64	63	63	62	62	61	60	62	65	65	68	68	69	69	70	70	70	70	70
41	:	69	68	66	65	64	63	62	62	62	61	61	61	59	61	65	64	68	68	68	69	69	69	69	69	69
42	:	68	68	65	64	63	62	62	61	61	61	61	61	59	60	62	64	67	67	68	68	68	69	69	69	69
43	:	68	67	65	63	62	62	61	61	61	61	60	60	61	61	64	64	67	67	67	68	68	68	68	68	68
44	:	67	66	64	63	62	60	61	61	61	61	60	60	61	63	65	64	66	66	67	67	67	67	67	67	67
45	:	66	66	64	63	62	61	61	61	61	61	61	60	60	61	62	63	65	66	66	67	67	67	67	67	67

Figure G8. (Sheet 5 of 9)

WAVE CONDITION 2

THE DEEP WATER WAVE PARAMETERS FOR CASE 2 ARE:

HEIGHT= 1.500

PERIOD= 8.000

ANGLE= -35.000

BREAKER	INDEX															(MULTIPLIED BY 1.)														
I/J:	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38					
1 :	0	0	0	0	0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	0	0	0	0					
2 :	0	0	0	0	0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	0	0	0	0					
3 :	0	0	0	0	0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11					
4 :	0	0	0	0	0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11					
5 :	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11					
6 :	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11					
7 :	0	11	11	11	11	11	11	0	11	11	11	11	11	11	11	11	11	11	0	0	0	0	0	0	0					
8 :	0	11	11	11	11	11	11	0	11	11	11	11	11	11	0	0	0	0	0	0	0	0	0	0	0					
9 :	0	11	11	11	11	11	11	0	11	11	11	11	11	11	0	0	0	0	0	0	0	0	0	0	0					
10 :	0	11	11	11	11	11	11	0	11	11	11	11	11	11	0	0	0	0	0	0	0	0	0	0	0					
11 :	0	0	0	0	0	11	0	11	11	11	11	11	11	0	0	0	0	0	0	0	0	0	0	0	0					
12 :	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
13 :	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
14 :	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
15 :	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
16 :	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
17 :	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
18 :	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
19 :	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
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21 :	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
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Figure G8. (Sheet 6 of 9)

WAVE ANGLES	(DEG)										(MULTIPLIED BY										1.)									
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2 :	-4	-6	-7	-8	-9	-9	-8	-7	-7	-6	-5	-3	-2	-1	1	3	4	4	3	0	-2	-3	-3	-4	-5					
3 :	-5	-7	-8	-9	-9	-9	-8	-7	-7	-6	-5	-3	-2	-1	1	3	4	5	3	0	-2	-4	-3	-4	-5					
4 :	-4	-6	-7	-7	-8	-9	-8	-7	-7	-6	-5	-3	-2	-1	1	3	4	5	4	-1	-2	-4	-3	-4	-5					
5 :	-4	-6	-7	-7	-8	-9	-9	-7	-7	-6	-5	-2	-1	-1	0	4	4	6	8	-3	-4	-10	-11	-11	-11					
6 :	-9	-14	-12	-14	-12	-12	-9	-6	-7	-6	-5	-2	-1	-1	-1	5	8	-1	-2	-8	-10	-12	-12	-14	-13					
7 :	-15	-16	-14	-14	-10	-11	-11	-11	-12	-9	-6	-2	-2	-2	-2	-2	-3	-5	-6	-10	-12	-13	-14	-14	-15					
8 :	-17	-16	-15	-13	-11	-10	-9	-10	-11	-9	-7	-5	-4	-5	-7	-7	-6	-5	-8	-12	-14	-15	-15	-17	-16					
9 :	-17	-16	-14	-11	-10	-8	-7	-9	-10	-9	-7	-5	-5	-7	-7	-8	-7	-10	-14	-16	-17	-17	-18	-17	-18					
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38 :	-14	-13	-13	-14	-15	-16	-17	-18	-19	-20	-20	-20	-22	-26	-27	-28	-27	-25	-23	-22	-21	-20	-20	-20	-19	-18				
39 :	-15	-14	-14	-14	-15	-17	-18	-19	-20	-21	-21	-21	-23	-26	-27	-28	-27	-24	-23	-22	-21	-20	-20	-20	-20	-19				
40 :	-15	-14	-14	-15	-16	-17	-19	-20	-21	-22	-22	-23	-26	-27	-28	-27	-26	-24	-22	-21	-21	-20	-20	-20	-20	-19				
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45 :	-17	-17	-18	-18	-19	-20	-21	-22	-23	-23	-23	-23	-24	-25	-25	-25	-24	-22	-21	-21	-21	-21	-21	-21	-21	-20				

WAVE HEIGHTS

(MULTIPLIED BY 10.)

I/J:	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
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5 :	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	2	4	5	6	7	9	8	9	9
6 :	10	9	8	8	6	8	1	2	1	1	1	1	2	1	1	5	5	6	13	13	15	11	11	12	13
7 :	17	11	9	9	8	9	12	8	6	5	5	5	3	4	6	5	12	12	12	13	15	16	17	19	19
8 :	18	12	10	9	8	9	12	8	7	7	6	7	12	13	12	13	12	12	12	13	14	16	17	18	19
9 :	18	12	10	9	9	9	14	9	7	7	7	7	12	13	12	12	12	12	12	13	14	16	17	18	19
10 :	19	14	13	12	11	11	15	10	8	8	7	8	13	13	12	12	12	12	12	13	14	16	17	18	19
11 :	19	19	19	19	18	12	17	11	10	10	9	9	13	13	12	12	12	12	12	13	15	16	17	18	19
12 :	18	19	19	18	18	17	16	16	16	16	16	15	13	12	12	12	12	12	12	13	15	17	18	19	19
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Figure G8. (Sheet 8 of 9)

WAVE NUMBER

(MULTIPLIED BY 1000.)

I/J:	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	: 454	454	455	455	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456
2	: 454	454	455	455	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456
3	: 404	405	415	415	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456
4	: 456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	380	414
5	: 456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	456	275	266	223	206	218	210
6	: 215	221	245	249	309	347	456	456	456	456	456	456	456	456	456	456	260	256	203	203	192	186	185	176	182
7	: 174	177	184	177	202	185	227	238	278	316	347	353	311	321	275	254	203	208	195	190	183	181	173	177	168
8	: 164	166	170	169	180	174	192	186	208	210	218	221	212	206	200	210	204	194	179	177	173	172	164	157	160
9	: 165	166	174	184	183	192	189	197	195	199	201	203	202	199	202	195	192	184	171	168	163	161	156	153	153
10	: 167	170	173	180	183	193	187	186	192	198	198	197	194	194	190	188	182	177	165	163	157	155	151	147	148
11	: 164	166	169	173	177	182	182	182	188	194	193	192	189	187	189	183	179	172	164	161	155	152	147	143	145
12	: 159	160	163	165	169	173	173	182	181	189	189	188	184	184	186	178	175	167	156	154	152	151	145	142	144
13	: 152	153	164	174	184	183	192	189	176	169	176	177	179	177	175	172	166	158	149	148	148	147	141	135	144
14	: 143	144	143	144	143	144	146	150	154	162	163	164	162	158	161	155	154	147	140	139	138	138	137	139	137
15	: 137	137	136	137	135	135	134	134	138	148	150	150	145	144	150	145	142	138	132	131	129	129	129	127	128
16	: 129	130	130	130	128	127	124	120	127	136	140	139	134	137	139	135	133	130	126	125	124	124	123	123	122
17	: 125	124	123	123	121	120	119	116	122	129	131	131	126	129	131	123	126	124	122	121	121	121	121	120	120
18	: 120	121	120	119	117	114	115	115	118	120	123	123	119	122	122	122	122	121	119	119	120	121	121	120	120
19	: 120	120	118	117	115	113	114	113	115	116	117	117	114	115	118	117	118	119	119	119	122	122	122	122	121
20	: 122	122	120	119	117	115	114	112	113	113	113	113	112	113	115	115	116	117	120	121	123	124	123	123	122
21	: 127	126	123	122	118	115	116	116	114	111	111	111	109	109	113	113	115	117	122	122	124	124	124	124	123
22	: 128	126	126	126	121	118	117	116	114	110	110	109	108	108	112	112	116	117	122	123	124	125	125	125	124
23	: 129	129	128	128	124	121	119	117	114	111	110	109	107	108	107	111	116	118	123	123	125	126	125	126	125
24	: 129	129	129	129	126	124	121	118	116	112	110	108	107	107	106	111	119	119	122	123	124	125	125	125	125
25	: 128	128	128	129	127	126	123	120	117	113	110	108	107	107	109	111	119	119	121	122	123	124	124	124	124
26	: 127	127	128	128	127	128	124	122	118	115	112	109	107	107	110	112	119	119	120	121	122	123	123	123	123
27	: 125	126	127	127	127	128	125	122	118	115	113	110	106	106	111	112	118	117	119	120	121	121	122	122	122
28	: 124	124	126	126	126	126	124	122	119	116	113	110	106	107	112	112	116	117	118	118	120	120	121	122	121
29	: 122	123	124	124	125	126	123	122	119	116	113	109	106	107	110	111	116	116	117	117	118	119	120	120	120
30	: 121	121	122	123	123	124	122	120	118	115	112	109	105	107	112	111	115	115	116	116	118	118	119	119	119
31	: 120	120	120	120	121	123	120	119	117	114	111	107	104	105	108	110	114	114	115	115	116	117	118	118	118
32	: 118	118	118	118	119	120	118	117	115	111	109	107	103	104	109	109	113	113	114	114	115	116	116	117	117
33	: 117	117	115	115	116	117	116	115	113	110	108	105	103	103	108	108	112	113	113	114	115	115	115	116	116
34	: 116	115	114	113	114	115	113	112	111	109	107	104	101	102	107	106	110	112	112	113	114	114	114	115	115
35	: 115	114	112	111	111	112	111	111	109	107	105	103	100	101	105	105	110	110	111	112	113	113	113	114	113
36	: 113	113	110	109	109	110	108	108	106	105	104	100	98	100	103	105	108	110	111	111	112	113	113	113	113
37	: 112	111	108	107	107	107	106	106	104	103	102	100	98	99	104	104	109	109	110	111	111	111	112	112	112
38	: 111	109	106	105	105	104	104	104	103	101	100	99	97	99	104	104	108	108	109	110	110	111	111	111	110
39	: 110	108	105	104	103	102	102	101	100	100	99	97	96	98	100	103	107	108	108	109	110	110	110	110	109
40	: 109	108	104	103	102	100	100	99	98	98	97	96	95	97	102	102	107	107	108	108	109	109	109	109	109
41	: 108	107	103	102	100	99	98	97	97	97	96	96	94	97	102	102	106	106	107	107	107	108	108	108	108
42	: 107	106	102	101	99	97	97	96	97	96	96	95	94	96	99	101	105	106	106	106	107	107	107	107	107
43	: 105	105	101	100	98	97	97	96	96	96	95	95	94	96	100	101	105	105	105	105	106	106	106	106	106
44	: 104	104	100	99	98	98	96	96	96	95	95	95	94	96	101	100	103	104	104	104	105	105	105	106	105
45	: 104	103	100	99	97	96	96	96	96	96	96	95	94	95	98	99	102	103	104	104	104	104	105	105	105

Figure G8. (Sheet 9 of 9)

APPENDIX H: SAMPLE FILES--HOMER SPIT, ALASKA,
WAVE PROPAGATION EXAMPLE

[illegible]

Figure H1. HOMR865


```

/ JOB
JOB,P3,T1000,CX37000.
/USER
/CHARGE
  GET,SR=RCPMWAVE/UN=CER002,
  GET,I=UPDL=HOMRUP2,
  UPDATE,I=SR=HMEMLIB,F,I=0,
  UPDATE,P=HMEMLIB,I=UPDL,C=HMEMPLUS,I=0,F,
  *
  *
  COPYR,INPUT,SENDJOB,I,
  SUBMIT,SENDJOB,T,
  DAYFILE,I=RCPDAYF,
  REPLACE,RCPDAYF,
  EXIT,
  DAYFILE,I=RCPDAYF,
  REPLACE,RCPDAYF,
  /EOR
JOB205,
USER(U= ,PA= )ADY
RESOURCE(JCAT=P3,TL=2000)
/CHARGE
  LINK,GET,HMEMPLUS/DD=C6,UN= ,FM=10E,AF=AF205,
  LINK,GET,TAPE7=HOMRUP2/DD=C6,UN= ,FM=10E,AF=AF205,
  LINK,GET,I=TAPE8=HOMRUP2/DD=C6,UN= ,FM=10E,AF=AF205,
  FORTRAN,I=HMEMPLUS,
  LOAD,CN=50/5000,I=H205,GRUPALL= ,
  GO,
  LINK,REPLACE,TAPE6=RCPPRINT/UN= ,FM=10E,DD=C6,AF=AF205,
  SUMMARY,
  EXIT,
  LINK,REPLACE(TAPE6=RCPPRINT/UN= ,FM=10E,DD=C6,AF=AF205)
  SUMMARY,
  EXIT,
  /EOR

```

```

*****
COMMENT,*****
COMMENT,*
COMMENT,* COMMENTS CONCERNING FILES REQUIRED BY
COMMENT,* THE ABOVE JOB CONTROL LANGUAGE (JCL)
COMMENT,*
COMMENT,*
*****
COMMENT,*****
COMMENT,* RCPMVAE: SOURCE CODE FOR THE WAVE PROPAGATION MODEL,
COMMENT,*
COMMENT,* HOMRUP2: UPDATE FILE CONTAINING MODIFICATIONS TO
COMMENT,* THE SOURCE CODE.
COMMENT,*
COMMENT,* HOMRUP2: DATA FILE SPECIFYING GRID GEOMETRY AND WAVE
COMMENT,* CHARACTERISTICS CONSIDERED,
COMMENT,* (LOGICAL UNIT DEVICE TAPE7)
COMMENT,*
COMMENT,* HOMRUP2: DATA FILE CONTAINING BATHYMETRY
COMMENT,* (LOGICAL UNIT DEVICE TAPE8)
COMMENT,*
COMMENT,* **NOTE** IF THE BATHYMETRY IS GENERATED WITH FORTRAN CODE IN
COMMENT,* THE UPDATE FILE AND NOT READ IN EXPLICITLY,THE JCL
COMMENT,* LINE WHICH ACCESSES THE BATHYMETRY FILE IS NOT
COMMENT,* REQUIRED AND MUST BE REMOVED.
COMMENT,*
COMMENT,* RCPDAYF: DAYFILE OR DIARY OF JOB EXECUTION EVENTS.
COMMENT,*
COMMENT,* RCPPRINT: OUTPUT FILE CONTAINING THE RESULTS OF THE
COMMENT,* WAVE MODEL RUN. (LOGICAL DEVICE UNIT TAPE6)
COMMENT,*
COMMENT,* RCPPTPT: DOES NOT EXIST ON THE CYBER205.
COMMENT,*
COMMENT,*
*****
/EOF

```

Figure H2. HOMR205

```

HOMER SPIT , ALASKA EXAMPLE
  96    416.7   83    833.3   32.200    0.0   1    0.00
    8.00    10.00   -45.00
  1    50    1    25    55
  0

```

Figure H3. HOMRDAT

```

*ID MODS
*D PARAM.3
  PARAMETER(IQ=96,JQ=83)
*I DEPTH.26
  DO 10 I=1,M
  DO 10 J=1,N
  D(I,J)=D(I,J)*6.0
  10 CONTINUE

```

Figure H4. HOMRUPD

```

*ID MODS
*D PARAM.3
  PARAMETER(IQ=96,JQ=83)
*I DEPTH.26
  DO 10 I=1,M
  DO 10 J=1,N
  D(I,J)=D(I,J)*6.0
  10 CONTINUE
*D MAIN.2
  PROGRAM RCPWAVE(INPUT,OUTPUT,TAPE7=TAPE7,TAPE6=TAPE6,TAPE8=TAPE8
*,TAPE3=TAPE3)

```

Figure H5. HOMRUP2

REGIONAL COASTAL PROCESSES WAVE TRANSFORMATION MODEL
(RCPWAVE)

HOMER SPIT , ALASKA EXAMPLE

MODEL INPUT:

UNIFORMLY SIZED, RECTILINEAR GRID MESH

X - DIRECTION (ON-OFFSHORE)	96 CELLS, EACH	416.70 IN LENGTH
Y - DIRECTION (LONGSHORE)	83 CELLS, EACH	833.30 IN LENGTH

THE ACCELERATION OF GRAVITY IS 32.20. THESE UNITS DETERMINE THE UNITS OF ALL INPUT AND OUTPUT VARIABLES

THE DEEP WATER WAVE PARAMETERS FOR CASE 1 ARE: HEIGHT= 8.000 PERIOD= 10.000 ANGLE= -45.000

THE OFFSHORE CONTOURS MAKE AN ANGLE OF .00 DEGREES WITH THE Y AXIS

THE BATHYMETRY MATRIX IS VARIABLE IN BOTH HORIZONTAL DIRECTIONS AND WAS READ FROM FILE CODE 8

A WATER LEVEL CHANGE OF .00 WAS ADDED TO THE ENTIRE BATHYMETRY MATRIX

Figure H7. RCPPRINT

WATER DEPTHS

(MULTIPLIED BY 1.)

I/J:	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
1 :	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2 :	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3 :	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4 :	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5 :	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6 :	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7 :	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8 :	1	1	1	1	1	1	2	2	2	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1
9 :	1	1	1	1	1	2	3	3	3	3	3	3	3	3	3	3	2	2	1	1	1	1	1	1	1
10 :	1	1	2	2	2	3	4	4	5	5	6	5	5	5	5	5	5	4	3	2	2	1	1	1	1
11 :	1	3	4	4	4	6	6	6	6	7	7	7	7	7	7	7	7	5	4	3	3	3	2	2	1
12 :	2	4	6	7	8	8	8	7	8	9	9	9	9	10	9	9	8	7	6	5	5	5	4	3	2
13 :	4	6	9	10	11	9	9	9	10	11	11	11	12	12	11	10	9	8	7	7	6	6	6	4	3
14 :	7	8	10	11	11	11	10	11	11	12	13	13	13	13	12	11	10	9	9	9	8	8	7	6	5
15 :	8	8	10	11	12	12	12	13	13	13	14	14	14	14	13	12	11	11	10	10	9	8	7	6	5
16 :	8	8	9	11	12	11	12	13	14	14	15	16	16	15	14	13	13	12	12	12	12	11	10	9	8
17 :	9	8	9	10	11	11	12	13	14	14	15	16	16	15	14	14	14	14	14	14	14	13	11	10	9
18 :	8	8	9	10	11	11	12	13	14	14	15	16	16	15	14	15	15	15	15	16	15	15	13	12	11
19 :	7	8	9	11	12	12	13	13	13	14	14	14	14	14	15	16	16	15	15	16	17	16	15	14	13
20 :	7	8	10	11	13	13	14	13	14	14	14	13	12	13	15	16	16	16	16	16	17	16	16	16	15
21 :	7	8	10	11	13	15	15	14	14	15	15	14	14	14	15	16	17	16	16	16	16	16	17	18	18
22 :	8	8	10	11	13	16	16	15	15	16	16	16	16	16	16	17	17	17	16	16	16	16	17	18	19
23 :	7	8	10	13	15	17	16	16	16	17	17	17	17	17	17	17	17	17	16	16	16	17	19	20	20
24 :	8	8	11	15	18	18	18	17	17	17	17	17	17	17	17	17	17	17	16	16	16	16	18	19	21
25 :	10	10	12	16	19	19	19	18	17	17	18	18	18	18	17	17	17	17	17	16	16	16	18	20	21
26 :	11	11	12	15	18	19	20	19	19	19	19	18	18	19	19	18	18	19	18	17	16	16	18	20	22
27 :	13	12	14	16	18	20	20	19	19	20	20	20	20	20	21	21	21	20	19	18	17	17	18	20	22
28 :	15	15	15	17	19	20	21	20	20	21	21	21	21	21	22	22	22	21	20	20	19	20	20	21	22
29 :	17	16	17	18	20	21	22	21	21	21	21	21	22	22	22	22	22	21	21	21	21	22	22	21	21
30 :	18	18	18	19	20	22	23	22	22	21	21	21	21	21	22	22	22	21	21	22	22	23	22	21	21
31 :	19	19	20	20	21	22	23	23	23	22	21	21	21	21	22	22	22	21	21	22	22	23	22	20	20
32 :	20	20	21	21	22	23	23	23	23	23	22	22	21	21	23	23	22	21	21	21	21	22	22	20	20
33 :	21	21	21	22	22	23	23	22	23	24	24	22	22	22	22	22	23	24	23	22	22	22	22	21	21
34 :	21	21	21	22	23	24	23	22	22	24	25	24	24	24	25	25	24	24	23	23	22	22	21	22	22
35 :	22	21	22	22	24	25	25	24	24	26	27	28	27	28	27	26	26	25	25	25	25	24	23	22	23
36 :	22	22	22	23	24	25	26	26	27	28	29	29	28	27	27	26	26	26	26	26	25	24	23	22	23
37 :	24	24	24	24	25	26	27	27	28	29	30	29	29	28	27	26	26	26	26	26	25	24	22	21	22
38 :	25	27	27	26	27	28	29	30	31	31	32	31	30	29	27	27	26	25	25	25	24	23	22	23	23
39 :	26	28	29	29	29	29	30	30	31	32	32	31	30	28	27	27	27	26	26	26	25	23	23	23	24
40 :	26	28	29	30	30	31	31	31	32	33	33	33	31	28	27	28	28	27	27	28	26	23	22	23	24
41 :	26	28	30	31	32	32	32	32	33	34	34	34	32	29	27	27	27	26	27	28	27	23	21	22	23
42 :	27	29	32	33	34	34	34	34	33	33	33	33	31	28	26	26	26	26	26	26	27	24	23	22	22
43 :	28	31	33	34	35	36	36	34	33	33	32	31	29	27	26	26	26	26	26	26	26	25	24	22	21
44 :	28	31	33	34	35	36	36	34	33	33	32	31	29	27	26	26	26	26	26	26	26	25	24	22	21
45 :	30	32	34	35	36	37	36	35	34	34	34	33	31	27	26	26	26	26	25	26	25	24	23	22	22

Figure H8. RCPPRNT output

(Sheet 1 of 5)

THE DEEP WATER WAVE PARAMETERS FOR CASE 1 ARE: HEIGHT= 8.000 PERIOD= 10.000 ANGLE= -45.000

Figure H8. (Sheet 2 of 5)

WAVE ANGLES				(DEG)		(MULTIPLIED BY		1.)																		
I/J:	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	
1 :	8	10	10	10	10	8	5	1	-3	-4	-4	-3	-4	-6	-8	-9	-10	-11	-12	-13	-13	-13	-14	-16	-17	
2 :	8	10	10	10	10	8	5	1	-3	-4	-4	-3	-4	-6	-8	-9	-10	-11	-12	-13	-13	-13	-14	-16	-17	
3 :	9	10	10	10	10	9	6	1	-3	-5	-4	-3	-4	-7	-8	-9	-10	-11	-13	-13	-13	-13	-14	-16	-17	
4 :	9	11	10	10	10	9	6	1	-4	-6	-3	-2	-4	-7	-9	-9	-10	-11	-13	-13	-13	-13	-14	-16	-18	
5 :	10	11	10	10	10	10	7	1	-5	-6	-3	-2	-4	-7	-9	-9	-10	-12	-13	-14	-13	-13	-14	-16	-18	
6 :	10	12	10	9	10	11	8	2	-6	-7	-3	-1	-4	-8	-9	-9	-10	-12	-14	-14	-13	-13	-14	-16	-18	
7 :	11	12	10	9	10	11	10	3	-10	-9	-2	0	-4	-10	-10	-9	-10	-12	-14	-14	-13	-13	-15	-17	-19	
8 :	12	13	9	8	11	11	6	0	-5	-6	-1	0	-6	-10	-9	-8	-10	-12	-15	-14	-12	-13	-15	-17	-19	
9 :	13	14	9	8	11	12	2	-1	-1	-2	-4	-6	-8	-9	-11	-13	-15	-17	-18	-14	-12	-13	-15	-18	-20	
10 :	15	18	11	8	9	5	0	-2	-1	-2	-7	-9	-10	-11	-13	-16	-19	-21	-20	-18	-14	-15	-16	-18	-20	
11 :	15	25	13	8	6	2	-3	-4	-3	-4	-8	-10	-11	-13	-16	-19	-21	-21	-18	-17	-15	-16	-21	-23	-21	
12 :	12	16	14	10	4	-1	-4	-4	-4	-6	-9	-11	-13	-16	-19	-20	-20	-20	-18	-17	-16	-18	-22	-25	-26	
13 :	5	10	13	10	3	-2	-3	-4	-6	-8	-11	-13	-15	-18	-20	-21	-20	-19	-19	-18	-18	-20	-22	-23	-21	
14 :	-1	6	12	10	4	-1	-3	-5	-8	-10	-12	-14	-17	-19	-20	-20	-19	-19	-19	-19	-20	-21	-22	-21	-20	
15 :	-5	4	11	10	4	-1	-4	-7	-10	-12	-13	-15	-18	-20	-20	-19	-19	-20	-20	-20	-22	-23	-22	-21	-19	
16 :	-6	2	10	10	4	-1	-4	-8	-11	-12	-14	-17	-19	-20	-19	-19	-20	-21	-21	-21	-23	-24	-23	-21	-19	
17 :	-6	2	9	9	4	-2	-5	-9	-11	-13	-15	-18	-20	-20	-18	-18	-20	-22	-22	-23	-24	-25	-23	-20	-19	
18 :	-5	3	8	8	3	-2	-7	-11	-12	-14	-16	-19	-20	-19	-18	-19	-21	-23	-23	-24	-26	-25	-22	-20	-19	
19 :	-4	3	7	7	3	-3	-9	-12	-13	-14	-16	-18	-18	-18	-18	-19	-22	-24	-24	-25	-26	-25	-22	-20	-20	
20 :	-4	2	6	6	2	-4	-10	-14	-14	-15	-17	-18	-17	-17	-18	-20	-23	-24	-25	-26	-27	-25	-21	-19	-20	
21 :	-6	0	5	5	2	-5	-12	-15	-14	-15	-17	-18	-19	-19	-20	-21	-23	-25	-26	-27	-27	-24	-20	-19	-20	
22 :	-8	-2	4	4	0	-6	-12	-15	-15	-16	-18	-19	-20	-21	-22	-23	-24	-25	-27	-28	-27	-23	-20	-19	-21	
23 :	-10	-4	3	3	-2	-8	-13	-16	-17	-17	-18	-19	-21	-22	-22	-23	-24	-26	-27	-28	-26	-23	-20	-20	-21	
24 :	-11	-5	1	1	-5	-10	-14	-16	-17	-17	-18	-20	-21	-22	-23	-24	-24	-26	-28	-28	-26	-23	-21	-21	-22	
25 :	-12	-8	-3	-3	-6	-10	-14	-17	-18	-18	-19	-21	-22	-22	-23	-24	-25	-26	-28	-27	-25	-23	-22	-22	-23	
26 :	-13	-9	-6	-5	-7	-11	-15	-18	-18	-19	-20	-21	-22	-23	-24	-25	-26	-28	-29	-27	-25	-23	-23	-24	-24	
27 :	-13	-11	-8	-7	-8	-12	-16	-18	-18	-19	-21	-22	-23	-24	-25	-27	-28	-30	-29	-27	-25	-24	-24	-26	-25	
28 :	-14	-12	-10	-9	-10	-13	-16	-18	-19	-20	-21	-23	-25	-26	-26	-27	-29	-30	-29	-27	-26	-26	-28	-28	-26	
29 :	-15	-13	-11	-11	-11	-14	-17	-19	-20	-21	-22	-24	-25	-26	-27	-28	-29	-30	-29	-28	-27	-28	-30	-29	-25	
30 :	-15	-13	-12	-12	-13	-15	-18	-20	-21	-21	-22	-24	-25	-26	-27	-28	-29	-30	-29	-28	-28	-29	-30	-29	-25	
31 :	-14	-13	-13	-13	-14	-16	-18	-20	-21	-21	-23	-24	-26	-27	-27	-28	-30	-30	-29	-28	-28	-29	-30	-28	-24	
32 :	-14	-13	-13	-14	-15	-17	-19	-21	-21	-21	-23	-25	-27	-27	-27	-29	-30	-30	-29	-28	-27	-29	-29	-27	-23	
33 :	-14	-14	-14	-14	-15	-17	-19	-21	-21	-21	-24	-25	-27	-28	-29	-30	-31	-30	-29	-28	-28	-29	-29	-26	-23	
34 :	-14	-14	-14	-15	-16	-18	-20	-21	-21	-22	-24	-26	-28	-30	-31	-32	-32	-31	-29	-28	-28	-29	-28	-26	-23	
35 :	-14	-14	-14	-15	-17	-18	-21	-22	-22	-24	-26	-28	-30	-32	-32	-33	-32	-31	-29	-28	-29	-29	-29	-26	-23	
36 :	-13	-14	-15	-16	-17	-19	-21	-23	-24	-26	-27	-29	-31	-32	-33	-33	-32	-31	-29	-29	-29	-30	-30	-29	-26	-22
37 :	-14	-14	-16	-18	-19	-20	-22	-24	-25	-27	-28	-30	-31	-33	-33	-33	-32	-30	-29	-28	-29	-30	-28	-25	-21	
38 :	-14	-15	-17	-19	-20	-21	-24	-25	-27	-28	-29	-31	-32	-34	-33	-32	-31	-30	-28	-28	-29	-29	-27	-24	-22	
39 :	-15	-16	-18	-20	-21	-23	-25	-27	-28	-29	-30	-31	-32	-33	-33	-32	-31	-30	-28	-28	-29	-29	-27	-24	-22	
40 :	-16	-16	-18	-20	-22	-24	-26	-28	-29	-30	-30	-31	-33	-33	-32	-32	-31	-30	-28	-28	-29	-28	-26	-24	-22	
41 :	-17	-17	-19	-21	-23	-25	-27	-30	-31	-31	-31	-31	-33	-33	-32	-31	-30	-29	-28	-27	-28	-27	-25	-23	-21	
42 :	-17	-18	-21	-23	-24	-26	-29	-31	-32	-31	-30	-30	-31	-32	-31	-30	-30	-29	-27	-27	-27	-27	-25	-23	-20	
43 :	-18	-20	-22	-24	-25	-27	-30	-32	-32	-30	-29	-29	-30	-31	-30	-30	-30	-29	-27	-26	-26	-26	-25	-23	-20	
44 :	-19	-21	-23	-25	-26	-28	-31	-32	-31	-30	-28	-28	-29	-30	-30	-30	-30	-29	-28	-27	-26	-26	-25	-24	-21	-19
45 :	-21	-23	-25	-26	-27	-29	-31	-32	-31	-29	-28	-28	-30	-31	-30	-30	-30	-29	-28	-26	-26	-25	-24	-22	-20	-19

WAVE HEIGHTS

(MULTIPLIED BY 10.)

I/J:	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
1 :	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
2 :	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
3 :	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
4 :	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5 :	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
6 :	4	4	4	4	4	4	4	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
7 :	4	4	4	4	4	4	6	8	7	4	4	4	5	5	4	4	4	4	4	4	4	4	4	4	4
8 :	4	4	4	4	4	5	7	8	8	6	4	7	7	6	4	5	4	4	4	4	4	4	4	4	4
9 :	4	4	4	4	5	10	13	13	13	12	13	13	13	13	13	11	11	8	6	4	4	4	4	4	4
10 :	4	5	7	7	11	15	16	17	19	23	24	23	22	22	21	23	19	17	12	10	7	6	5	4	4
11 :	4	12	17	20	18	23	28	25	27	27	28	27	29	33	30	27	22	18	15	13	13	9	7	4	4
12 :	9	15	22	29	60	61	32	30	30	67	68	70	71	76	38	38	31	22	22	22	20	20	18	12	7
13 :	17	28	57	58	57	59	62	64	65	65	66	67	69	72	79	39	38	34	31	26	25	26	22	19	13
14 :	35	34	56	58	57	58	60	61	63	64	65	66	69	72	75	81	40	37	35	38	34	30	29	24	20
15 :	33	34	57	60	58	58	59	60	62	64	65	66	68	72	75	76	77	79	85	42	39	42	33	31	27
16 :	32	34	59	62	59	59	59	60	62	64	65	66	69	72	74	74	75	78	80	82	93	44	45	36	32
17 :	31	34	61	64	62	60	60	61	64	65	65	66	69	73	74	73	74	77	79	82	87	100	46	46	39
18 :	30	33	62	66	63	61	60	63	65	66	66	68	70	73	74	73	74	76	79	81	87	94	102	48	43
19 :	30	33	63	67	63	60	60	63	66	67	68	70	72	73	74	73	74	77	79	82	88	94	95	93	91
20 :	30	34	64	68	64	60	61	64	67	68	69	72	74	74	74	74	75	77	80	84	89	94	93	89	88
21 :	30	35	66	70	65	60	61	65	67	68	69	71	73	74	75	75	75	77	80	85	91	93	91	87	86
22 :	30	34	68	72	66	61	61	64	67	68	68	70	72	73	75	75	76	78	81	87	92	93	89	86	85
23 :	30	33	71	72	65	62	61	64	67	68	69	70	72	73	75	76	77	78	83	88	92	92	88	85	85
24 :	32	32	74	71	64	62	62	64	67	68	69	70	72	74	76	77	78	79	84	90	92	90	86	85	86
25 :	40	42	76	73	65	62	62	64	67	68	69	70	72	74	76	77	78	80	85	91	92	89	86	85	87
26 :	43	42	83	74	67	62	62	64	67	68	69	71	73	74	75	77	78	81	86	90	91	88	85	85	88
27 :	92	89	81	73	67	63	62	65	67	68	69	71	72	74	75	76	77	82	86	89	89	87	85	87	89
28 :	89	85	78	72	66	63	63	65	67	68	69	70	72	74	76	76	78	82	86	87	86	84	84	88	91
29 :	86	82	76	70	66	63	63	65	67	69	70	71	73	75	76	77	79	83	86	86	84	82	84	89	91
30 :	84	79	74	69	66	63	63	65	68	69	71	73	75	76	77	78	80	84	86	86	84	82	85	90	90
31 :	83	77	72	68	65	64	64	66	68	69	71	73	76	77	78	78	81	84	86	86	84	82	85	90	90
32 :	81	75	70	67	65	64	64	66	68	69	71	74	76	78	78	79	81	85	86	86	84	83	86	89	88
33 :	79	74	69	67	65	64	65	67	69	70	72	75	77	78	79	80	82	84	86	85	83	83	86	88	86
34 :	78	73	69	66	65	64	65	68	69	70	73	75	77	78	79	81	82	84	85	84	83	84	86	87	84
35 :	76	72	68	66	65	65	65	67	69	71	73	76	77	78	80	81	82	83	82	82	82	83	86	86	82
36 :	75	70	67	66	66	65	65	67	69	72	75	77	78	79	80	81	82	83	83	81	81	83	85	85	81
37 :	73	69	66	66	66	66	66	67	70	73	76	78	79	79	80	81	81	82	82	81	81	83	85	84	79
38 :	72	67	65	66	66	66	66	68	71	74	78	79	79	80	80	81	82	82	81	81	83	84	82	78	78
39 :	71	67	65	66	66	66	67	69	72	76	79	80	79	80	80	80	79	79	81	82	81	81	82	82	76
40 :	70	66	65	66	66	66	67	70	74	77	80	80	79	80	80	78	79	80	81	80	80	82	81	78	75
41 :	69	66	65	66	67	67	68	71	75	79	81	80	79	79	79	78	79	80	81	80	80	81	80	78	74
42 :	68	66	65	67	67	67	68	72	77	80	81	80	78	78	78	78	79	81	81	80	79	79	77	77	73
43 :	67	66	66	68	68	68	69	74	78	81	82	80	78	78	77	77	78	81	82	80	79	78	77	75	72
44 :	67	66	67	69	69	69	71	75	79	81	81	79	78	77	77	77	79	81	81	80	78	77	76	74	71
45 :	66	67	68	69	69	70	72	76	80	81	80	78	77	77	76	76	79	81	81	79	78	76	74	72	69

Figure H8. (Sheet 4 of 5)

WAVE NUMBER

(MULTIPLIED BY 1000.)

I/J:	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
1	:	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111
2	:	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111
3	:	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111
4	:	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111
5	:	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111
6	:	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111
7	:	111	111	111	111	111	111	95	78	80	110	111	107	101	101	111	111	111	111	111	111	111	111	111	111
8	:	111	111	111	111	111	101	86	77	80	101	111	93	87	95	111	111	111	111	111	111	111	111	111	111
9	:	111	111	111	111	101	72	64	64	64	64	64	63	62	62	65	69	75	82	95	111	111	111	111	111
10	:	111	99	86	86	73	61	56	55	52	48	47	48	49	49	49	49	51	55	63	75	89	95	111	111
11	:	107	65	56	57	53	46	45	47	46	43	42	43	43	42	41	41	44	49	55	58	62	64	73	91
12	:	82	58	47	42	39	39	40	41	38	37	37	37	37	37	38	41	44	47	50	51	50	54	63	83
13	:	55	45	38	36	35	37	38	38	37	35	33	33	33	33	34	36	38	39	41	44	45	45	47	53
14	:	42	39	36	34	34	35	35	35	33	33	32	32	31	31	32	34	36	37	38	39	40	41	43	46
15	:	40	39	36	34	33	33	33	32	31	31	31	30	30	30	31	33	34	34	35	35	36	37	39	41
16	:	39	39	37	35	33	34	33	31	31	30	30	29	29	30	30	31	32	32	33	33	33	34	36	38
17	:	38	39	38	36	34	34	33	32	31	30	29	28	29	30	30	30	31	31	31	30	31	32	34	35
18	:	40	40	38	36	34	34	33	32	31	30	29	29	29	30	30	30	30	30	29	29	29	30	31	33
19	:	41	40	37	35	33	32	32	32	31	31	30	31	31	30	30	29	29	29	28	28	28	28	28	29
20	:	41	39	36	34	32	31	31	31	31	30	31	32	32	31	30	29	28	29	29	28	28	28	28	29
21	:	41	39	36	34	31	30	29	31	31	29	29	30	31	30	29	29	28	28	29	28	28	28	28	27
22	:	41	39	36	34	31	29	28	29	30	29	28	28	29	29	29	28	28	28	28	28	28	28	28	27
23	:	41	40	36	32	29	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	26
24	:	40	40	35	29	27	27	28	28	28	28	28	28	28	28	28	28	28	28	29	29	28	27	26	25
25	:	36	36	33	29	27	26	27	27	27	27	27	27	27	27	28	28	28	28	28	29	29	29	27	26
26	:	35	35	32	29	27	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	25
27	:	32	32	31	29	27	26	26	26	26	26	26	26	26	26	25	25	25	25	25	25	25	25	25	25
28	:	29	30	29	28	26	26	25	26	26	25	25	25	25	25	25	25	25	25	25	26	26	26	26	25
29	:	28	28	28	27	26	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
30	:	27	27	26	26	25	24	25	25	25	25	25	25	25	25	25	25	25	25	25	25	24	24	25	25
31	:	26	26	26	26	25	24	24	24	24	25	25	25	25	25	25	25	25	25	25	25	25	24	25	26
32	:	26	26	25	25	25	24	24	24	24	24	24	25	25	25	25	24	24	25	25	25	25	25	25	26
33	:	25	25	25	25	25	24	24	25	24	24	24	24	25	25	24	24	24	24	25	25	25	25	25	25
34	:	25	25	25	25	24	24	24	25	24	24	23	24	24	24	24	24	24	24	24	24	25	25	25	25
35	:	25	25	25	25	24	23	23	24	24	23	22	22	22	23	23	23	23	23	23	24	24	25	25	24
36	:	25	25	24	24	24	23	23	23	23	22	22	22	22	22	23	23	23	23	23	23	23	24	24	25
37	:	24	24	24	24	23	23	23	22	22	22	22	22	22	22	23	23	23	23	23	23	23	24	25	25
38	:	23	23	22	23	22	22	22	22	22	21	21	21	22	22	22	23	23	23	23	23	23	24	25	24
39	:	23	22	22	22	22	22	22	22	22	21	21	21	22	22	23	23	23	23	23	23	23	24	24	24
40	:	23	22	22	22	21	21	21	21	21	21	21	21	21	22	23	22	22	22	22	22	23	24	25	24
41	:	23	22	22	21	21	21	21	21	21	21	21	21	21	22	23	23	23	23	23	22	23	24	25	24
42	:	23	22	21	21	20	20	20	20	21	21	21	21	21	22	23	23	23	23	23	23	23	24	25	25
43	:	22	21	21	20	20	20	20	20	21	21	21	21	21	22	23	23	23	23	23	23	23	24	25	25
44	:	22	21	21	20	20	20	20	20	21	21	21	21	21	22	23	23	23	23	23	23	23	24	25	25
45	:	22	21	20	20	20	20	20	20	20	20	20	21	21	22	23	23	23	23	23	23	23	24	24	25

Figure H8. (Sheet 5 of 5)

APPENDIX I: INTPRCP PROGRAM LISTING

*****	*COMDECK PARAM	PARAM	1
	C	PARAM	2
	PARAMETER(IQ=95, JQ=95)	PARAM	3
	PARAMETER(IQ2=95, JQ2=95)	PARAM	4
	PARAMETER(KQ=IQ*JQ)	PARAM	5
	C	PARAM	6
*****	*DECK MAIN	MAIN	1
	PROGRAM GRID(TAPE1=TAPE1, TAPE2=TAPE2, TAPE3=TAPE3, TAPE4=TAPE4,	MAIN	2
	1 TAPE6=TAPE6, TAPE7=TAPE7)	MAIN	3
*****	*CALL PARAM	MAIN	4
	C*****	MAIN	5
	C	MAIN	6
	C DOCUMENTATION	MAIN	7
	C	MAIN	8
	C*****	MAIN	9
	C	MAIN	10
	C THIS PROGRAM PROVIDES A METHOD FOR INTERPOLATING BATHYMETRY	MAIN	11
	C FROM ONE GRID TO ANOTHER. THE NEW GRID ORIGIN CAN BE	MAIN	12
	C TRANSLATED AND/OR ROTATED RELATIVE TO THE OLD GRID ORIGIN	MAIN	13
	C	MAIN	14
	C*****	MAIN	15
	C	MAIN	16
	C INPUT DATA (TAPE7)	MAIN	17
	C	MAIN	18
	C*****	MAIN	19
	C	MAIN	20
	C READ(7,500) M,N,M2,ANG,XSHIFT,YSHIFT	MAIN	21
	C 500 FORMAT(4I5,3F10.5)	MAIN	22
	C	MAIN	23
	C M= NUMBER OF GRID CELLS IN THE X-DIRECTION ON THE OLD GRID	MAIN	24
	C N= NUMBER OF GRID CELLS IN THE Y-DIRECTION ON THE OLD GRID	MAIN	25
	C M2= NUMBER OF GRID CELLS IN THE X-DIRECTION ON THE NEW GRID	MAIN	26
	C N2= NUMBER OF GRID CELLS IN THE Y-DIRECTION ON THE NEW GRID	MAIN	27
	C	MAIN	28
	C ANG=THE ANGLE OF ROTATION MEASURED	MAIN	29
	C FROM THE OLD GRID TO THE NEW GRID	MAIN	30
	C +COUNTER-CLOCKWISE	MAIN	31
	C -CLOCKWISE	MAIN	32
	C	MAIN	33
	C XSHIFT=THE X OFFSET FROM THE OLD GRID TO THE NEW GRID	MAIN	34
	C + NEW GRID ORIGIN IS BELOW THE OLD ORIGIN	MAIN	35
	C - NEW GRID ORIGIN IS ABOVE THE OLD ORIGIN	MAIN	36
	C YSHIFT=THE Y OFFSET FROM THE OLD GRID TO THE NEW GRID	MAIN	37
	C + NEW GRID ORIGIN IS TO THE RIGHT OF THE OLD ORIGIN	MAIN	38
	C - NEW GRID ORIGIN IS TO THE LEFT OF THE OLD ORIGIN	MAIN	39
	C	MAIN	40
	C****	MAIN	41
	C	MAIN	42
	C READ(7,505) GRDTYP1,GRDTYP2	MAIN	43
	C 505 FORMAT(2I5)	MAIN	44
	C	MAIN	45
	C GRDTYP1=OLD GRID TYPE	MAIN	46
	C 0 = CONSTANT SIZED, RECTILINEAR	MAIN	47

C	1 = VARIABLY SIZED, RECTILINEAR	MAIN	48
C		MAIN	49
C	GRDTP2=NEW GRID TYPE	MAIN	50
C	0 = CONSTANT SIZED, RECTILINEAR	MAIN	51
C	1 = VARIABLY SIZED, RECTILINEAR	MAIN	52
C		MAIN	53
C****		MAIN	54
C		MAIN	55
C	IF: GRDTP1=0 THEN:	MAIN	56
C		MAIN	57
C	READ(7,501) DX,DY	MAIN	58
C	501 FORMAT(2F10.5)	MAIN	59
C		MAIN	60
C****		MAIN	61
C		MAIN	62
C	IF: GRDTP2=0 THEN:	MAIN	63
C		MAIN	64
C	READ(7,501) DX2,DY2	MAIN	65
C	501 FORMAT(2F10.5)	MAIN	66
C		MAIN	67
C****		MAIN	68
C		MAIN	69
C	IF: GRDTP1=0 & GRDTP2=0 THEN:	MAIN	70
C		MAIN	71
C	READ(7,501) DX,DY	MAIN	72
C	READ(7,501) DX2,DY2	MAIN	73
C	501 FORMAT(2F10.5)	MAIN	74
C		MAIN	75
C	DX=CELL LENGTH IN THE X DIRECTION (OLD GRID) IN MAP INCHES OR CM	MAIN	76
C	DY=CELL LENGTH IN THE Y DIRECTION (OLD GRID) IN MAP INCHES OR CM	MAIN	77
C	DX2=CELL LENGTH IN THE X DIRECTION (NEW GRID) IN MAP INCHES OR CM	MAIN	78
C	DY2=CELL LENGTH IN THE Y DIRECTION (NEW GRID) IN MAP INCHES OR CM	MAIN	79
C		MAIN	80
C*****		MAIN	81
C		MAIN	82
C	INPUT DATA (TAPE3)	MAIN	83
C	-OLD GRID-	MAIN	84
C		MAIN	85
C*****		MAIN	86
C		MAIN	87
C	**NOTE**	MAIN	88
C	ONLY USE TAPE3 IF GRDTP1=1	MAIN	89
C		MAIN	90
C*****		MAIN	91
C		MAIN	92
C	IF GRDTP1=1 THEN:	MAIN	93
C		MAIN	94
C		MAIN	95
C	READ(3,31,END=999) STR,NST,NEND,A1,B1,C1	MAIN	96
C		MAIN	97
C	STR=X OR Y STRETCHING DIRECTION	MAIN	98
C	NST=STARTING CELL NUMBER FOR THE REGION	MAIN	99
C	NEND-NST=NUMBER OF CELLS IN THE REGION	MAIN	100
C	A1,B1,C1=STRETCHING COEFFICIENTS FOR THE REGION	MAIN	101

C		MAIN	102
C	31 FORMAT(A1,7X,218,3616.11)	MAIN	103
C		MAIN	104
C	*****	MAIN	105
C		MAIN	106
C	INPUT DATA (TAPE4)	MAIN	107
C	-NEW GRID-	MAIN	108
C		MAIN	109
C	*****	MAIN	110
C		MAIN	111
C	**NOTE**	MAIN	112
C	ONLY USE TAPE4 IF GRDTYP2=1	MAIN	113
C		MAIN	114
C	*****	MAIN	115
C	IF GRDTYP2=1 THEN:	MAIN	116
C		MAIN	117
C	READ(4,31,END=998) STR,NST,NEND,A1,B1,C1	MAIN	118
C		MAIN	119
C	STR=X OR Y STRETCHING DIRECTION	MAIN	120
C	NST=STARTING CELL NUMBER FOR THE REGION	MAIN	121
C	NEND-NST=NUMBER OF CELLS IN THE REGION	MAIN	122
C	A1,B1,C1=STRETCHING COEFFICIENTS FOR THE REGION	MAIN	123
C		MAIN	124
C	31 FORMAT(A1,7X,218,3616.11)	MAIN	125
C		MAIN	126
C		MAIN	127
C		MAIN	128
C	*****	MAIN	129
C		MAIN	130
C	INPUT DATA (TAPE1)	MAIN	131
C		MAIN	132
C	*****	MAIN	133
C		MAIN	134
C	DO 10 I=1,M	MAIN	135
C	READ(1,11) (DD(I,J),J=1,N)	MAIN	136
C	10 CONTINUE	MAIN	137
C	11 FORMAT(10F8.2)	MAIN	138
C		MAIN	139
C	DD(I,J)=DEPTH AT EACH CELL OF THE OLD GRID	MAIN	140
C		MAIN	141
C	*****	MAIN	142
	COMMON/CONST/M,N,M2,N2,DX,DY	MAIN	143
	COMMON/COORD/XX(IQ),YY(JQ)	MAIN	144
	COMMON/COORD2/XX2(IQ2),YY2(JQ2)	MAIN	145
	COMMON/COORD3/XOWRTN(IQ,JQ),YOWRTN(IQ,JQ)	MAIN	146
	COMMON/DEPTHS/D(IQ2,JQ2),DD(IQ,JQ)	MAIN	147
	CHARACTER*1 STR	MAIN	148
	READ(7,500) M,N,M2,N2,ANG,XSHIFT,YSHIFT	MAIN	149
	ANG=-1.0*(ANG)	MAIN	150
	READ(7,505) GRDTYP1,GRDTYP2	MAIN	151
505	FORMAT(215)	MAIN	152
500	FORMAT(415,3F10.5)	MAIN	153
	ANG=ANG*3.1415927/180.0	MAIN	154
	SCALE=1.0	MAIN	155

	XSHIFT=XSHIFT*SCALE	MAIN	156
	YSHIFT=YSHIFT*SCALE	MAIN	157
	IF (GRDTYP1.EQ.0) GO TO 506	MAIN	158
21	CONTINUE	MAIN	159
	READ(3,31,END=999) STR,NST,NEND,A1,B1,C1	MAIN	160
31	FORMAT(A1,7X,2I8,36I6.11)	MAIN	161
	NEND=NEND-1	MAIN	162
	IF (STR.EQ.'Y') GO TO 20	MAIN	163
	DO 201 LLC=NST,NEND	MAIN	164
	LL=LLC+1	MAIN	165
	ALPHC=LL-0.5	MAIN	166
	ALPHS=LL	MAIN	167
	XX(LL-1)=(A1+B1*(ALPHC**C1))*SCALE	MAIN	168
201	CONTINUE	MAIN	169
	GO TO 21	MAIN	170
20	CONTINUE	MAIN	171
	DO 203 LLC=NST,NEND	MAIN	172
	LL=LLC+1	MAIN	173
	ALPHC=LL-0.5	MAIN	174
	ALPHS=LL	MAIN	175
	YY(LL-1)=(A1+B1*(ALPHC**C1))*SCALE	MAIN	176
203	CONTINUE	MAIN	177
	GO TO 21	MAIN	178
999	CONTINUE	MAIN	179
506	CONTINUE	MAIN	180
	WRITE(6,9)	MAIN	181
	9 FORMAT(////,20X,'VARIABLE WAVE GRID INFORMATION',///)	MAIN	182
	WRITE(6,23)SCALE	MAIN	183
	23 FORMAT(///,'EXPANSION COEFFICIENT SCALE FACTOR',/,	MAIN	184
	*'SCALE=',F10.3,//)	MAIN	185
	IF (GRDTYP1.EQ.0) GO TO 507	MAIN	186
	GO TO 513	MAIN	187
507	READ(7,501) DX,DY	MAIN	188
501	FORMAT(2F10.5)	MAIN	189
	DO 511 L=1,M	MAIN	190
	XX(L)=(L-0.5)*DX*SCALE	MAIN	191
511	CONTINUE	MAIN	192
	DO 512 L=1,N	MAIN	193
	YY(L)=(L-0.5)*DY*SCALE	MAIN	194
512	CONTINUE	MAIN	195
513	CONTINUE	MAIN	196
	WRITE(6,10)	MAIN	197
	10 FORMAT(///,1X,'X CENTER DISTANCES',//)	MAIN	198
	WRITE(6,11) (I,XX(I),I=1,M)	MAIN	199
	11 FORMAT(8(I4,F12.3))	MAIN	200
	WRITE(6,12)	MAIN	201
	12 FORMAT(///,1X,'Y CENTER DISTANCES',//)	MAIN	202
	WRITE(6,11) (J,YY(J),J=1,N)	MAIN	203
	IF (GRDTYP2.EQ.0) GO TO 539	MAIN	204
28	CONTINUE	MAIN	205
	READ(4,31,END=998) STR,NST,NEND,A1,B1,C1	MAIN	206
	NEND=NEND-1	MAIN	207
	IF (STR.EQ.'Y') GO TO 27	MAIN	208
	DO 271 LLC=NST,NEND	MAIN	209

LL=LLC+1	MAIN	210
ALPHC=LL-0.5	MAIN	211
ALPHS=LL	MAIN	212
XX2(LL-1)=(A1+B1*(ALPHC*C1))*SCALE	MAIN	213
271 CONTINUE	MAIN	214
GO TO 28	MAIN	215
27 CONTINUE	MAIN	216
DO 273 LLC=NST,NEND	MAIN	217
LL=LLC+1	MAIN	218
ALPHC=LL-0.5	MAIN	219
ALPHS=LL	MAIN	220
YY2(LL-1)=(A1+B1*(ALPHC*C1))*SCALE	MAIN	221
273 CONTINUE	MAIN	222
GO TO 28	MAIN	223
998 CONTINUE	MAIN	224
GO TO 560	MAIN	225
539 CONTINUE	MAIN	226
READ(7,555) DX2,DY2	MAIN	227
555 FORMAT(2F10.5)	MAIN	228
560 CONTINUE	MAIN	229
WRITE(6,19)	MAIN	230
19 FORMAT(////,20X,'VARIABLE SECOND GRID INFORMATION',//)	MAIN	231
WRITE(6,23) SCALE	MAIN	232
IF(GRDTYP2.EQ.0) GO TO 515	MAIN	233
GO TO 525	MAIN	234
515 CONTINUE	MAIN	235
DO 520 L=1,M2	MAIN	236
XX2(L)=(L-0.5)*DX2*SCALE	MAIN	237
520 CONTINUE	MAIN	238
DO 524 L=1,N2	MAIN	239
YY2(L)=(L-0.5)*DY2*SCALE	MAIN	240
524 CONTINUE	MAIN	241
525 CONTINUE	MAIN	242
WRITE(6,40)	MAIN	243
40 FORMAT(///,1X,'X2 CENTER DISTANCES',//)	MAIN	244
WRITE(6,11) (I,XX2(I), I=1,M2)	MAIN	245
WRITE(6,42)	MAIN	246
42 FORMAT(///,1X,'Y2 CENTER DISTANCES',//)	MAIN	247
WRITE(6,11) (J,YY2(J), J=1,N2)	MAIN	248
DO 26 JJ=1,N	MAIN	249
DO 26 II=1,M	MAIN	250
XOMRTN(II,JJ)=(XX(II)-XSHIFT)*COS(ANG)+(YSHIFT	MAIN	251
1-YY(JJ))*SIN(ANG)	MAIN	252
YOMRTN(II,JJ)=(XX(II)-XSHIFT)*SIN(ANG)+(YY(JJ)	MAIN	253
1-YSHIFT)*COS(ANG)	MAIN	254
26 CONTINUE	MAIN	255
CALL INTERPO	MAIN	256
99 STOP	MAIN	257
END	MAIN	258
***** *DECK INTERPO	INTERPO	1
C*****	INTERPO	2
C*	INTERPO	3
SUBROUTINE INTERPO	INTERPO	4
C*	INTERPO	5

C*****	INTERPO	6
***** *CALL PARAM	INTERPO	7
COMMON/CONST/M,N,M2,N2,DX,DY	INTERPO	8
COMMON/COORD/XX(IQ),YY(JQ)	INTERPO	9
COMMON/COORD2/XX2(IQ2),YY2(JQ2)	INTERPO	10
COMMON/COORD3/XOWRTN(IQ,JQ),YOWRTN(IQ,JQ)	INTERPO	11
COMMON/DEPTHS/D(IQ2,JQ2),DD(IQ,JQ)	INTERPO	12
DIMENSION R(KQ),IVAL(KQ),JVAL(KQ),DIST(KQ)	INTERPO	13
INTEGER MD2,ND2	INTERPO	14
DO 10 I=1,M	INTERPO	15
READ(1,11) (DD(I,J),J=1,N)	INTERPO	16
10 CONTINUE	INTERPO	17
11 FORMAT(10F8.2)	INTERPO	18
CALL POUT(1,M,1,1,N,'OLD DEPTHS (X,1)',DD,1.0,IQ,JQ)	INTERPO	19
DO 1 I=1,M2	INTERPO	20
DO 1 J=1,N2	INTERPO	21
XD=XX2(I)	INTERPO	22
YD=YY2(J)	INTERPO	23
K=0	INTERPO	24
IF(I.EQ.1.AND.J.EQ.1) GO TO 601	INTERPO	25
IF(J.NE.1) GO TO 550	INTERPO	26
I1FP=I1FM+30	INTERPO	27
DO 599 I1=I1FM,I1FP	INTERPO	28
IF(I1.LE.0.OR.I1.GT.M) GO TO 599	INTERPO	29
DO 5 JJ=1,N	INTERPO	30
K=K+1	INTERPO	31
DIST(K)=SQRT((XOWRTN(I1,JJ)-XD)**2+(YOWRTN(I1,JJ)-YD)**2)	INTERPO	32
	INTERPO	33
CS=XOWRTN(I1,JJ)-XD	INTERPO	34
SN=YOWRTN(I1,JJ)-YD	INTERPO	35
IF(CS.GE.0.0.AND.SN.GE.0.0)R(K)=1.0	INTERPO	36
IF(CS.LT.0.0.AND.SN.GE.0.0)R(K)=2.0	INTERPO	37
IF(CS.LT.0.0.AND.SN.LT.0.0)R(K)=3.0	INTERPO	38
IF(CS.GE.0.0.AND.SN.LT.0.0)R(K)=4.0	INTERPO	39
IF(CS.EQ.0.0.AND.SN.EQ.0.0) GO TO 603	INTERPO	40
IVAL(K)=I1	INTERPO	41
JVAL(K)=JJ	INTERPO	42
IF(K.GT.1) GO TO 565	INTERPO	43
DMIN=DIST(1)	INTERPO	44
I1=IVAL(1)	INTERPO	45
J1=JVAL(1)	INTERPO	46
K1=1	INTERPO	47
565 IF(DIST(K).GE.DMIN) GO TO 5	INTERPO	48
DMIN=DIST(K)	INTERPO	49
K1=K	INTERPO	50
5 CONTINUE	INTERPO	51
599 CONTINUE	INTERPO	52
I1=IVAL(K1)	INTERPO	53
J1=JVAL(K1)	INTERPO	54
R1=R(K1)	INTERPO	55
I1FM=I1-15	INTERPO	56
GO TO 552	INTERPO	57
601 MD2=(M*1.0)	INTERPO	58
ND2=(N*1.0)	INTERPO	59

DO 602 II=1,MD2	INTERPO	60
DO 602 JJ=1,ND2	INTERPO	61
K=K+1	INTERPO	62
DIST(K)=SQRT((XOWRTN(II,JJ)-XD)**2+(YOWRTN(	INTERPO	63
II,JJ)-YD)**2)	INTERPO	64
CS=XOWRTN(II,JJ)-XD	INTERPO	65
SN=YOWRTN(II,JJ)-YD	INTERPO	66
IF(CS.GE.0.0.AND.SN.GE.0.0)R(K)=1.0	INTERPO	67
IF(CS.LT.0.0.AND.SN.GE.0.0)R(K)=2.0	INTERPO	68
IF(CS.LT.0.0.AND.SN.LT.0.0)R(K)=3.0	INTERPO	69
IF(CS.GE.0.0.AND.SN.LT.0.0)R(K)=4.0	INTERPO	70
IF(CS.EQ.0.0.AND.SN.EQ.0.0) GO TO 603	INTERPO	71
IVAL(K)=II	INTERPO	72
JVAL(K)=JJ	INTERPO	73
IF(K.GT.1) GO TO 610	INTERPO	74
DMIN=DIST(1)	INTERPO	75
II=II	INTERPO	76
J1=JJ	INTERPO	77
K1=1	INTERPO	78
610 IF(DIST(K).GE.DMIN) GO TO 602	INTERPO	79
DMIN=DIST(K)	INTERPO	80
K1=K	INTERPO	81
602 CONTINUE	INTERPO	82
II=IVAL(K1)	INTERPO	83
J1=JVAL(K1)	INTERPO	84
R1=R(K1)	INTERPO	85
I1FM=I1-15	INTERPO	86
GO TO 552	INTERPO	87
603 II=IVAL(K)	INTERPO	88
J1=JVAL(K)	INTERPO	89
I1FM=I1-15	INTERPO	90
609 D(I,J)=DD(I1,J1)	INTERPO	91
GO TO 717	INTERPO	92
613 SUM1=DMIN+DMIN2	INTERPO	93
SUM2=SUM1/DMIN+SUM1/DMIN2	INTERPO	94
SF1=SUM1/(DMIN*SUM2)	INTERPO	95
SF2=SUM1/(DMIN2*SUM2)	INTERPO	96
D(I,J)=SF1*DD(I1,J1)+SF2*DD(I2,J2)	INTERPO	97
GO TO 717	INTERPO	98
614 SUM1=DMIN+DMIN2+DMIN3	INTERPO	99
SUM2=SUM1/DMIN+SUM1/DMIN2+SUM1/DMIN3	INTERPO	100
SF1=SUM1/(DMIN*SUM2)	INTERPO	101
SF2=SUM1/(DMIN2*SUM2)	INTERPO	102
SF3=SUM1/(DMIN3*SUM2)	INTERPO	103
D(I,J)=SF1*DD(I1,J1)+SF2*DD(I2,J2)+SF3*DD(I3,J3)	INTERPO	104
GO TO 717	INTERPO	105
550 I1M4=I1-4	INTERPO	106
I1P4=I1+4	INTERPO	107
J1M4=J1-4	INTERPO	108
J1P4=J1+4	INTERPO	109
DO 551 II=I1M4,I1P4	INTERPO	110
IF(II.LE.0.OR.II.GT.M) GO TO 551	INTERPO	111
DO 553 JJ=J1M4,J1P4	INTERPO	112
IF(JJ.LE.0.OR.JJ.GT.N) GO TO 553	INTERPO	113

K=K+1	INTERPO	114
DIST(K)=SQRT((XOWRTN(II,JJ)-XD)**2+(YOWRTN(II,JJ)-YD)**2)	INTERPO	115
CS=XOWRTN(II,JJ)-XD	INTERPO	116
SN=YOWRTN(II,JJ)-YD	INTERPO	117
IF(CS.GE.0.0.AND.SN.GE.0.0)R(K)=1.0	INTERPO	118
IF(CS.LT.0.0.AND.SN.GE.0.0)R(K)=2.0	INTERPO	119
IF(CS.LT.0.0.AND.SN.LT.0.0)R(K)=3.0	INTERPO	120
IF(CS.GE.0.0.AND.SN.LT.0.0)R(K)=4.0	INTERPO	121
IF(CS.EQ.0.0.AND.SN.EQ.0.0) GO TO 603	INTERPO	122
IVAL(K)=II	INTERPO	123
JVAL(K)=JJ	INTERPO	124
IF(K.GT.1) GO TO 560	INTERPO	125
DMIN=DIST(1)	INTERPO	126
I1=IVAL(1)	INTERPO	127
J1=JVAL(1)	INTERPO	128
K1=1	INTERPO	129
560 IF(DIST(K).GE.DMIN) GO TO 553	INTERPO	130
DMIN=DIST(K)	INTERPO	131
K1=K	INTERPO	132
553 CONTINUE	INTERPO	133
551 CONTINUE	INTERPO	134
I1=IVAL(K1)	INTERPO	135
J1=JVAL(K1)	INTERPO	136
R1=R(K1)	INTERPO	137
552 CONTINUE	INTERPO	138
DO 700 III=1,K	INTERPO	139
R2=R(III)	INTERPO	140
IF(R2.EQ.R1) GO TO 700	INTERPO	141
K2=III	INTERPO	142
I2=IVAL(III)	INTERPO	143
J2=JVAL(III)	INTERPO	144
DMIN2=DIST(III)	INTERPO	145
GO TO 701	INTERPO	146
700 CONTINUE	INTERPO	147
IF(R2.EQ.R1) GO TO 609	INTERPO	148
701 CONTINUE	INTERPO	149
DO 570 L=III,K	INTERPO	150
IF(L.EQ.K1) GO TO 570	INTERPO	151
IF(R(L).EQ.R1) GO TO 570	INTERPO	152
IF(DIST(L).GE.DMIN2) GO TO 570	INTERPO	153
DMIN2=DIST(L)	INTERPO	154
K2=L	INTERPO	155
570 CONTINUE	INTERPO	156
R2=R(K2)	INTERPO	157
I2=IVAL(K2)	INTERPO	158
J2=JVAL(K2)	INTERPO	159
DO 703 JJJ=1,K	INTERPO	160
R3=R(JJJ)	INTERPO	161
IF(R3.EQ.R1.OR.R3.EQ.R2) GO TO 703	INTERPO	162
K3=JJJ	INTERPO	163
I3=IVAL(JJJ)	INTERPO	164
J3=JVAL(JJJ)	INTERPO	165
DMIN3=DIST(JJJ)	INTERPO	166
GO TO 704	INTERPO	167

703	CONTINUE	INTERPO	168
	IF (R3.EQ.R2.OR.R3.EQ.R1) GO TO 613	INTERPO	169
704	CONTINUE	INTERPO	170
	DO 580 LL=JJJ,K	INTERPO	171
	IF (LL.EQ.K1.OR.LL.EQ.K2) GO TO 580	INTERPO	172
	IF (R(LL).EQ.R1.OR.R(LL).EQ.R2) GO TO 580	INTERPO	173
	IF (DIST(LL).GE.DMIN3) GO TO 580	INTERPO	174
	DMIN3=DIST(LL)	INTERPO	175
	K3=LL	INTERPO	176
580	CONTINUE	INTERPO	177
	I3=IVAL(K3)	INTERPO	178
	J3=JVAL(K3)	INTERPO	179
	R3=R(K3)	INTERPO	180
	DO 588 III=1,K	INTERPO	181
	R4=R(III)	INTERPO	182
	IF (R4.EQ.R3.OR.R4.EQ.R2.OR.R4.EQ.R1) GO TO 588	INTERPO	183
	K4=III	INTERPO	184
	I4=IVAL(III)	INTERPO	185
	J4=JVAL(III)	INTERPO	186
	DMIN4=DIST(III)	INTERPO	187
	GO TO 589	INTERPO	188
588	CONTINUE	INTERPO	189
	IF (R4.EQ.R3.OR.R4.EQ.R2.OR.R4.EQ.R1) GO TO 614	INTERPO	190
589	CONTINUE	INTERPO	191
	DO 590 LLL=III,K	INTERPO	192
	IF (LLL.EQ.K1.OR.LLL.EQ.K2) GO TO 590	INTERPO	193
	IF (LLL.EQ.K3) GO TO 590	INTERPO	194
	IF (DIST(LLL).GE.DMIN4) GO TO 590	INTERPO	195
	IF (R(LLL).EQ.R1.OR.R(LLL).EQ.R2.OR.R(LLL).EQ.R3) GO TO 590	INTERPO	196
	DMIN4=DIST(LLL)	INTERPO	197
	K4=LLL	INTERPO	198
590	CONTINUE	INTERPO	199
	I4=IVAL(K4)	INTERPO	200
	J4=JVAL(K4)	INTERPO	201
	R4=R(K4)	INTERPO	202
	D1=DMIN	INTERPO	203
	D2=DMIN2	INTERPO	204
	D3=DMIN3	INTERPO	205
	D4=DMIN4	INTERPO	206
	SUM1=D1+D2+D3+D4	INTERPO	207
	SUM2=SUM1/D1+SUM1/D2+SUM1/D3+SUM1/D4	INTERPO	208
	SF1=SUM1/(D1*SUM2)	INTERPO	209
	SF2=SUM1/(D2*SUM2)	INTERPO	210
	SF3=SUM1/(D3*SUM2)	INTERPO	211
	SF4=SUM1/(D4*SUM2)	INTERPO	212
	D(I,J)=SF1*DD(I1,J1)+SF2*DD(I2,J2)+SF3*DD(I3,J3)+SF4*DD(I4,J4)	INTERPO	213
717	CONTINUE	INTERPO	214
1	CONTINUE	INTERPO	215
	CALL POUT(1,M2,1,1,N2,'NEW DEPTHS (X,1)',D,1.0,IQ2,JQ2)	INTERPO	216
	DO 1112 I=1,M2	INTERPO	217
	WRITE(2,1113) (D(I,J),J=1,N2)	INTERPO	218
1112	CONTINUE	INTERPO	219
1113	FORMAT(10F8.2)	INTERPO	220
	RETURN	INTERPO	221

APPENDIX J: SAMPLE FILES--GRID INTERPOLATION EXAMPLE

35	30	50	40	10.0	0.5	0.5
0	0					
		0.20	0.20			
		0.14	0.15			

Figure J1. INTPGRD

```

*ID MOOS
*ID PARAM.3,PARAM.5
    PARAMETER(IQ=35,JQ=30)
    PARAMETER(IQ2=50,JQ2=40)
    PARAMETER(KQ=2000)
*ID INTERPD.18
    11 FORMAT(15F5.0)

```

Figure J2. INTPUPD

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	4.0	5.0	5.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	5.0	5.0	6.0	6.5	6.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	5.0	5.0	6.0	6.5	7.0	7.5	7.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0	5.0	5.0	7.0	7.0	7.0	7.5	8.0	9.0	9.0	
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	4.0
4.0	4.0	4.5	4.5	5.0	5.0	6.0	7.0	8.0	8.0	8.5	9.0	9.0	10.0	10.0	
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	4.0	5.0	5.0	6.0
6.0	6.0	5.5	6.5	7.5	7.0	7.0	8.0	9.0	9.0	9.0	10.0	10.0	11.0	11.0	
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	5.0	5.0	7.5	10.0	10.0	
10.0	10.0	10.0	10.0	10.0	9.5	9.0	9.0	10.0	10.0	11.0	11.0	11.5	12.0	12.0	
0.0	0.0	0.0	0.0	0.0	0.0	1.0	4.0	4.0	5.0	7.5	7.5	10.0	11.5	12.0	
12.0	11.5	11.0	11.0	10.5	10.5	11.0	11.0	11.0	11.0	11.5	11.5	12.0	12.5	12.5	
0.0	1.0	3.0	4.0	5.0	5.0	5.0	6.0	6.0	7.0	9.5	10.0	11.0	13.0	13.5	
14.0	13.5	13.0	13.0	12.0	12.0	11.5	11.5	11.5	11.5	12.0	12.0	12.5	13.0	13.0	
3.0	4.0	5.0	5.0	6.0	6.0	7.0	7.0	8.0	9.0	10.0	11.0	12.0	14.0	15.0	
15.0	15.0	15.0	14.0	14.0	13.0	12.0	12.0	12.0	12.0	12.5	12.5	13.0	13.5	13.5	
5.0	6.0	6.0	7.0	8.0	8.0	9.0	9.0	10.0	11.0	11.0	12.0	13.0	15.0	16.0	
16.0	16.0	16.0	16.0	15.0	14.0	13.0	13.0	13.0	13.0	13.0	13.0	14.0	14.0	14.0	
6.0	7.0	8.0	9.0	9.0	9.0	10.0	11.0	11.0	11.5	12.0	13.0	15.0	16.0	17.0	
17.0	17.0	17.0	17.0	16.0	15.0	14.0	14.0	14.0	14.0	14.0	14.0	15.0	15.0	15.0	
7.0	8.0	9.0	10.0	10.0	11.0	11.0	11.5	11.5	12.0	13.0	14.0	15.5	17.0	18.0	
18.0	18.0	18.0	18.0	17.0	17.0	17.0	16.0	15.0	15.0	15.0	15.5	15.5	15.5	15.5	
9.0	10.0	11.0	11.0	11.0	11.5	11.5	12.0	12.0	13.0	14.0	15.0	16.0	18.0	18.0	
19.0	19.0	19.0	19.0	18.0	18.0	18.0	17.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	
11.0	11.0	11.5	11.5	11.5	12.0	12.0	13.0	13.0	14.0	15.0	16.0	17.0	18.0	18.0	
19.0	20.0	20.0	20.0	19.0	18.5	18.5	18.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	
11.5	11.5	12.0	12.0	12.0	12.5	13.0	14.0	14.0	15.0	15.5	16.5	17.5	18.0	18.5	
19.0	20.0	21.0	21.0	20.0	19.0	19.0	18.5	18.0	17.5	17.5	17.5	17.5	17.5	17.5	
12.0	12.0	12.5	12.5	13.0	13.0	14.0	15.0	15.0	15.5	16.0	17.0	18.0	18.5	18.5	
19.0	20.5	21.0	21.5	21.0	20.0	19.5	19.0	18.5	18.0	18.0	18.0	18.0	18.0	18.0	
13.0	12.5	13.0	13.0	14.0	14.0	15.0	15.5	15.5	16.0	16.5	17.5	18.0	18.5	19.0	
20.0	20.5	21.0	21.5	22.0	21.0	20.0	19.5	19.0	18.5	18.5	18.5	18.5	18.5	18.5	
14.0	13.5	14.0	14.5	15.0	15.0	15.5	16.0	16.5	16.5	17.0	17.5	18.0	19.0	19.0	
20.0	20.5	21.0	22.0	23.0	22.0	21.0	20.5	20.0	19.0	19.0	19.0	19.0	19.0	19.0	
14.5	14.0	15.0	15.0	15.5	15.5	16.0	16.5	17.0	17.0	17.5	18.0	18.5	19.0	20.0	
20.5	21.0	22.0	23.0	24.0	23.0	22.0	21.0	20.5	20.0	20.0	19.5	19.5	19.5	19.5	
15.5	16.0	15.5	15.5	16.0	16.0	17.0	17.0	17.5	18.0	18.0	18.5	19.0	19.0	20.0	

Figure J3. INTDEPO

.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.49	1.00	1.00	1.00	1.00
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.49	1.00	1.00	1.00	1.00
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.51	1.00	1.00	1.00	1.00
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.14	.22	.86	.52	.45	.54	.82	.72	.67	.63
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.24	1.04
.70	1.11	1.75	2.76	2.93	2.76	2.71	2.85	2.91	2.93
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.29	.28	.28	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.24	1.06	1.31	1.93	2.71
3.66	3.44	4.25	5.28	5.54	5.25	5.53	5.66	5.70	5.71
.00	.00	.00	.00	.00	.00	.00	.00	.15	.19
.84	.99	1.57	1.27	1.64	1.91	1.47	1.34	.67	.00
.00	.00	.24	1.10	1.67	2.09	2.52	4.10	3.62	4.51
5.61	5.70	6.08	6.60	6.46	6.31	5.85	5.76	5.75	5.74
.00	.00	.00	.00	.00	.15	.23	.36	.28	1.12
1.92	2.99	3.59	3.31	4.10	4.66	3.86	3.68	2.67	2.58
2.36	2.00	2.22	2.35	4.81	3.67	4.79	6.11	5.93	6.18
6.59	6.53	6.95	6.96	7.09	6.75	6.98	6.98	6.99	6.99
.00	.00	.00	.25	.90	.64	1.09	.67	1.70	3.26
3.94	5.28	6.23	5.51	5.97	5.30	5.27	5.04	4.96	5.11
5.29	5.17	4.67	4.51	5.79	5.88	6.77	7.38	6.94	6.98
6.94	7.33	7.69	7.97	8.15	7.66	8.14	8.19	8.21	8.22
2.22	2.06	1.38	1.92	2.44	2.95	2.97	2.95	4.41	5.93
5.65	6.50	7.38	8.62	8.31	8.06	7.78	7.22	6.76	6.41
6.18	6.62	6.25	6.24	6.79	7.25	7.96	8.00	7.80	7.91
8.11	8.33	8.70	9.02	8.92	8.28	8.32	8.27	8.25	8.25
4.94	4.47	4.44	3.69	4.32	5.02	5.16	5.36	7.02	7.48
7.47	8.27	9.87	10.83	10.77	10.68	9.77	9.03	9.00	8.46
8.59	8.47	7.89	7.77	7.59	7.92	8.42	8.58	8.62	8.79

Figure J4. INTDEPN

APPENDIX K: NOTATION

a or $a(x,y)$	Wave amplitude function
$\bar{a}$	Function of the bottom slope
A	Function of dependent variables
$\bar{b}$	Function of the bottom slope
B	Function of dependent variables
c or $c(x,y)$	Wave celerity
c_g or $c_g(x,y)$	Group velocity
c_o	Deepwater wave celerity
D	Energy dissipation function
D*	Energy dissipation function
E	Wave energy
F	Function of dependent variables
$\bar{F}$	Function of dependent variables
g	Gravitational acceleration constant
G	Function of dependent variables
$\bar{G}$	Function of dependent variables
h or $h(x,y)$	Water depth
h_b	Water depth at incipient breaking
H or $H(x,y)$	Wave height
H_b	Wave height at incipient breaking
H_o	Deepwater wave height
i	Arbitrary subscript designating the x-direction
$\vec{i}$	Complex number equal to $\sqrt{-1}$
i	Unit vector in the x-direction
ikey	Specific subscript designating the x-direction
j	Arbitrary subscript designating the y-direction
$\vec{j}$	Unit vector in the y-direction
jkey	Specific subscript designating the y-direction
k or $k(x,y)$	Wave number
L_b	Wave length at incipient breaking
L_o	Deepwater wave length
m	Bottom slope
M	Total number of grid cells in the x-direction
N	Total number of grid cells in the y-direction
Q	Flow across a hydraulic jump

s or $s(x,y)$	Wave phase function
s	Subscript denoting stable wave conditions
T	Wave period
W	Weighting factor
x	Coordinate direction
x'	Coordinate direction
y	Coordinate direction
y'	Coordinate direction
Y_1	Water depth on the high end of a hydraulic jump
Y_2	Water depth on the low end of a hydraulic jump
α	Weighting factor
α^*	Coefficient
β	Coefficient
γ	Coefficient
δ	Rate of energy loss
Δx	Grid size in the x-direction
Δy	Grid size in the y-direction
θ	Wave angle
θ_c	Contour angle
θ_o	Deepwater wave angle
κ	Rate of energy dissipation coefficient
κ^*	Coefficient
κ_r	Refraction coefficient
κ_s	Shoaling coefficient
ν_e	Coefficient
ρ	Water density
σ	Angular wave frequency
ϕ	Velocity potential function

Mathematical symbols

∂	Partial differentiation
∇	Horizontal gradient operator
$\cdot$	Vector dot product
$\times$	Vector cross product
$ $	Absolute value