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SEAPUP UPDATE VERSION 5.1: A COMPUTER PROGRAM FOR ESTIMATING DISCOVERY AND PRODUCTION OF CRUDE OIL FROM UNDISCOVERED ACCUMULATIONS

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CONTENTS

SUMMARY

Version 4.0 of program SEAPUP (Hinde, 1988a) was designed to simulate repeated drilling of the petroleum traps within a model of Australian petroleum traps and to estimate production of crude oil during each year from 1987 to 2000 and to estimate the average amount of crude oil discovered in each year and in the fourteen years period. The revised version of the program, SEAPUP 5.1, carries out the same task and in addition it provides estimates of the number of wells drilled, the number of oil discoveries, the amount of oil discovered, success and discovery rates, number of accumulations brought into production, and oil production, both for each year and for the 14 year period, as well as estimates of the accumulation sizes in their simulated order of discovery. The program also produces an assessment of Australia's undiscovered crude oil resources. The full range of estimates may be obtained for all of onshore and offshore Australia or for any basin.

These changes have necessitated a revised format for some of the input data and a more comprehensive set of output data. The input data are compatible with version 5.1 of program VALAL (Hinde, 1986).

INTRODUCTION

The SEAPUP program (Forman & Hinde, 1989) is made up of six sub-models (Figure 1) each of which consists of one or more stochastic equations relating the input variables and the required output variable. Because exact values cannot be estimated for the variables in each equation, they are input as distributions of possible values which are sampled during the running of the program.

The input data include the Australian petroleum traps model and the computer program incorporates the method for assessing undiscovered petroleum resources using area of closure and resources per unit area (Forman & others, 1988) so that the program will simulate the discovery of all Australia's undiscovered crude oil resources and will supply a probabilistic assessment. Such an assessment requires none of the other input data for the SEAPUP program, such as efficiency of exploration, economic accumulation sizes, lead times, or production rates, that are needed to estimate future rates of discovery and production of crude oil.

The outputs from the program are presented as cumulative probability distributions showing estimates of the number of wells drilled, the number of discoveries made, success and discovery rates, the number of accumulations brought into production, and crude oil production rates, both for each year and for the 14 year period, as well as estimates of undiscovered crude oil resources and the sizes of the discoveries in their simulated order of discovery. The estimates can be made either for any basin or combination of basins or for all of Australia.

Part of Australia's future production from undiscovered oil accumulations will depend on the timing and results of negotiations with Indonesia over future arrangements for exploration in the so-called Timor Gap area. The estimate of possible future production from this area has been prepared using a number of special assumptions:

- when drilling and discovery of an accumulation could occur;
- the minimum economic accumulation size in the area; and
- the percentage of the total production that may be included in the Australian estimate.

The amounts of economic and subeconomic oil that may be discovered onshore and offshore Australia between 1987 and 2000 and the amount that might be brought into production during that period are also estimated probabilistically.

INPUT DATA

Input data are read by the program from a file prepared and named by expert committees. Many of the relevant historical data are contained in BMR's AUSTRES database (within the PEDIN system) and preliminary processing, sorting, plotting, and statistical analysis are carried out using the ASPBO and ASLIN programs (Hinde, 1988b), before final examination by the committees.

General data

The following general data are read in:

- title;
- whether estimate is for oil, gas, or condensate;
- the number of iterations for the Monte Carlo simulation;
- start year of the production profile;
- an optional basin to which the output will refer.

Annual drilling model

The number of new-field wildcat wells drilled during each year from 1960 to 1986 has been characterized by uptrends and downtrends with a high degree of autocorrelation from one year to the next and a variable time lag between the peaks and troughs of the profiles for onshore and offshore Australia. Our preferred annual drilling model provides probabilistic estimates of the number of new-field wildcat wells that could be drilled during each year from 1987 to 2000 either in onshore and offshore Australia or in any combination of basins, assuming that trends and lags similar to those of the past will occur in the future. It includes the possibility of low drilling in early years and high drilling in later years and vice versa. It also takes into account the limitations on increasing well numbers from one year to the next and the number of years for which an uptrend or downtrend is likely to last.

The number of years in each offshore trend and the lag time (l_t) between the start of each offshore trend and the corresponding onshore trend are selected by random sampling of input distributions. The number of years (y) in an onshore trend (t) is then given by the equation:

$$y_t = y_t - l_{t-1} + l_t, \qquad l_o = 0 \qquad (1)$$

The number of wells (N_i) to be drilled in a particular year (i) of a trend (t) is given by the equation:

$$N_i = N_{i-1} + n_i, \qquad 1 < i \leqslant y_t \qquad (2)$$

where N_{i-1} is the number of new-field wildcat wells drilled in the previous year, n_i is the increase (or decrease) in the number of wells drilled during year i, and y_t is the number of years for which trend (t) continues before changing to the opposite trend. Some modification to the basic equation is needed to determine the length and duration of the initial downtrend that began in 1985.

The input data for the program include distributions for the values of n_i, y_t, and l_t and upper and lower limits to the likely level of annual drilling (N_i) which were subjectively determined by an expert committee. Subroutine FDRILL calculates a new drilling profile for onshore and offshore Australia for each iteration by substituting values for n_i, y_t, and l_t chosen by random selections from the probability distributions, into the equations and by repeating the process for each succeeding downtrend or uptrend until the year 2000 is reached. The program also provides cumulative probability distributions showing the estimate of annual new-field wildcat drilling for each year from 1987 to 2000 and for the whole 14 years period.

Alternative drilling models may be used in the subroutine - the number of wells to be drilled onshore and offshore in each year of the estimate may be specified as a triangular distribution.

Australian petroleum traps model

The information within the Australian petroleum traps model has previously been used to assess Australia's undiscovered petroleum resources using the methods outlined by Forman & Hinde (1986), BMR (1988), and Forman & others (1988). SEAPUP uses the data to prepare an assessment of undiscovered crude oil resources as well as the estimates of future discovery and production of crude oil. The amount of recoverable oil (V) that each trap could contain is calculated using the equation:

$$V = A_{clos} V_A P_o \qquad (3)$$

where A_{clos} is the area of closure of the trap, V_A is the volume of recoverable oil and oil equivalent gas per unit area of closure, and P_o is the proportion of oil to oil plus gas.

Another use of the petroleum traps model is to estimate the risked average amount of petroleum that each petroleum trap could contain; referred to as the risked average trap size (R.A.T.S)

$$(R.A.T.S) = [\sum_{i=1}^{N_{iter}} V_{ij} d_{ij} c_{ij}] E_r / N_{iter} \qquad (4)$$

where N_{iter} is the number of iterations, V_{ij} is the simulated volume of recoverable oil and oil equivalent gas in trap j during iteration i, d_{ij} is either 0 or 1 depending on whether a random number is greater or less than a random value chosen for iteration i from the distribution for the success rate, c_{ij} is either 0 or 1 depending on whether V_{ij} is smaller or larger than the random value chosen for iteration i from the distribution for the smallest size of accumulation to be included as a resource, and E_r is the estimated probability that hydrocarbon resources occur in at least one trap in the play or independent petroleum system (as defined by Ulmishek, 1986).

The following data are read in for each trap type in each independent petroleum system:

- basin and sub-basin, whether offshore or onshore, trap type, sequence level;
- the number of future wells to be drilled;
- a triangular distribution for the success rate;
- the probability (one minus the risk) that hydrocarbons have been generated within or have migrated into the stratigraphic sequence;
- the probability that traps of the type specified contain petroleum;
- the proportion of oil, gas, and oil and gas accumulations and a triangular distribution for the proportion of oil to oil plus gas in the accumulations containing both oil and gas;
- the triangular distribution for the conversion factor, G_{moe}, used to convert gas to the equivalent volume of oil in the reservoir.
- a triangular distribution for the ratio of condensate to gas;
- the parameters of the linear model of log area closure (ln A) versus drilling sequence number (N): slope; intercept; standard deviation of the residuals; lambda; standard deviation of lambda; the number of data points within the model; and the drilling sequence number at which the simulation is to start. The intercept is input as a value in km^2 and the slope is calculated by dividing the change in ln A by the corresponding change in drilling sequence number.
  If the value of lambda is ommitted (and the slope is non-zero, the computer will calculate and use an average value; this value is the smallest allowed by the model. When the value for the standard deviation of lambda is ommitted, the program uses the value $1/N^{1/2}$;
- the parameters of the linear model of log resources per unit area (ln V_A) versus discovery sequence number (N_d): slope; intercept in metres; standard deviation of the residuals; lambda; standard deviation of lambda; the number of data points within the model; and the discovery sequence number at which the simulation is to start. Resources per unit area (V_A) is given in metres of oil equivalent;
- a cut-off for the closure area (A). This is specified as a maximum value for the next well to be tested and the values for subsequent wells are determined using the logarithm of this value as the intercept (at the next well) of a line with slope parallel to that of the simulated slope of the ln A plot. When values greater than the cut-off are generated, another value is generated to replace it. All values of A are allowed if no cut-off is specified;

- a cut-off for the values of resources per unit area of closure (V_A). This is specified as a maximum value for the next discovery number and the values for subsequent discoveries are determined using the logarithm of this value as the intercept (at the next discovery number) of a line with slope parallel to that of the simulated slope of the ln V_A versus discovery sequence number plot. When values greater than the cut-off are generated, they are replaced with the cut-off (this results in a truncated lognormal distribution with a spike at the truncation point for V_A). A default value of 6 is used, if no cut-off is specified;
- a triangular distribution for the intercept of the cut-off line for ln V_A. If not specified, The default value of 6 is used if a distribution is not specified.
- cut-offs specifying the smallest size of accumulation to be included as a resource and the maximum accumulation size to be accepted in the Monte Carlo simulation. When an accumulation larger than the maximum cut-off is generated, another accumulation size is selected to replace it. The maximum accumulation size cut-off may be left blank as cut-offs on area of closure and resources per unit area normally achieve the same purpose;

Efficiency of exploration model

The efficiency of exploration model (subroutine FDISC) is designed to ensure that the values of lambda for the simulated order of discovery of the undiscovered fields fall within a range established by an expert committee after examination of the historic trends visible in the plot of log accumulation size (ln V) versus discovery sequence number and consideration of likely future trends. The task is complicated firstly because the expert committee cannot assess the values of lambda directly and secondly because the program does not use field size and lambda but instead determines the probability (P_j) of drilling a trap next using the equation

$$P_j = \{[\sum_{i+1}^{N_{iter}} V_{ij} d_{ij} c_{ij}] E_r / N_{iter}\}^{\alpha} \text{constant} \qquad (5)$$

where the first factor on the right hand side of the equation is the risked average trap size, obtained from the petroleum traps model, raised to the power alpha (α). Alpha is an adjustable parameter of the model which gives the program a tendency to simulate early drilling of the most prospective traps.

Determining the order of drilling:

The program stores the cumulative values of risked average trap size, raised to the power alpha, W_i, in an array, for each trap, i

$$W_i = \sum_{j=1}^{i} P_j, \; W_0 = 0, \qquad 0 < i < N \qquad (6)$$

where N is the total number of traps in the onshore of offshore petroleum traps model.

During each step of the ordering process, the program selects a uniform random number, T, lying between zero and the maximum value of W_i (W_N). Starting from i=1, the first trap with a value of W_i greater than or equal to T is placed next in order, that is when

$$W_{i-1} < T \leqslant W_i \qquad (7)$$

The trap selected is removed from the array, and the cumulative values, W_i, recalculated and the process repeated for the next trap.

This method is time consuming and has been modified in the program in two ways (programmed by D. Downie, BMR). First, the array of cumulative risked average trap sizes, raised to the power alpha, W_i, is replaced by a number of smaller cumulative arrays or blocks, and the maximum cumulative value for each block is stored cumulatively in a separate array. The number of blocks is chosen to be the nearest integer to the square root of the number of traps, N, so that there are approximately the same number of elements in each block as there are number of blocks.

Second, the search for each trap to be ordered is carried out by a 'binary search' method. In this method, the array of cumulative values of P_i within each block and of the array of the cumulative block totals are each divided into two equal halves. The halves of the array of block totals and then of the block in which T lies are determined. These halves are again divided into two and the quarters in which T lies are determined. The process of dividing by two is continued until the trap to be selected is found. Once selected, each trap is removed from the array and the cumulative values in the relevant block, and the array of cumulative block totals are re-adjusted.

During the ordering process, the existence risk (E_r) is changed to one if a play is successfully risked, thus automatically changing the order of drilling for all subsequent traps. The year in which each trap may be drilled is then estimated, by matching up the traps in their drilling order with the number of new-field wildcat wells drilled for each year. The program then simulates drilling the traps and when discoveries are simulated it estimates their sizes and the years of discovey.

Determination of the alpha exponent:

An expert committee should examine the historic trends visible in a plot of log field size versus discovery sequence number for the oil accumulations that have already been discovered onshore and offshore Australia to decide on a range of trends that could apply in the future. The values of lambda can then be calculated for these trends in the field size. The SEAPUP program must be run a number of times, each time using a different value of alpha, so that the value of lambda for the simulated oil discoveries can be calculated and the relationship between lambda and alpha can be established. Once this has been done, a distribution of values for alpha may be selected such that SEAPUP will simulate discovery of oil accumulations according to the selected range of values for lambda.

The computer program carries out the following steps:

- the partially risked average accumulation sizes for onshore and offshore Australia are read from another input data file derived from program VALAL (version 5.1);
- distributions for the alpha factor, onshore and offshore, are read in from the input data file.

Economic accumulation size model

The likelihood of bringing an accumulation into economic production is determined by comparing the estimated size of the accumulation with an accumulation size selected at random from a distribution of accumulation sizes showing the range in the smallest size of accumulation that is thought could be brought into economic production during 1987 to 2000. A number of distributions, collectively called the economic accumulation size model, have been included in an input data file for the sub-basins throughout Australia.

The computer program reads in a distribution of the smallest size of accumulation that can be brought into economic production in each sub-basin from the input data file.

Lead time model

The lead time between simulated discovery and production of each oil accumulation is determined by random selection from a distribution of likely lead times, either onshore or offshore, which has been prepared using a combination of historic data and expert opinion within BMR.

The computer program reads in distributions for lead times, onshore and offshore, from the input data file.

Accumulation production rate model

Consideration of the production profiles for Australia's producing onshore fields and offshore platforms by an expert committee suggests that oil production (P_i) in each year, i, can be determined using the equations

$$
\begin{cases} ib/a, & 0 < i \leqslant a \\ b, & a < i \leqslant a+c \\ b(1-d)^{i-(a+c)}, & a+c < i \end{cases} \qquad (8)
$$

where a is the number of years taken to reach maximum production, b is the rate of maximum production (expressed as a fraction of the total resources), c is the number of years for which maximum production is maintained, and d is the proportion of the previous year's production by which production declines.

Similarly, a production profile for floating production systems (subroutine PRODFP) can be determined using the equations

$$
\begin{cases} e/c, & 0 < i \leqslant c \\ e/c(1-d)^{i-c} & c+1 \leqslant i \end{cases} \qquad (9)
$$

where e is the proportion produced in the first c years of plateau production, and d is the proportion of the previous year's production by which production declines and can be written

$$d = -\ln[(1-a)/(1-a+b)] \qquad (10)$$

Floating production systems are simulated only for accumulations in the Arafura, Bonaparte, Browse, and Money Shoal Basins smaller than fifty million barrels. The program estimates a production profile for each onshore and offshore accumulation using distributions for a,b,c,d, and e which have been prepared using a combination of historic production data and expert opinion within BMR. These distributions are as follows:-

(1) Onshore production systems (subroutine PRODON)

- a uniform distribution (between 0 and 2 inclusive) for the length of the production build-up in years (a);
- a uniform distribution (between 5 and 20 inclusive) for the percent of the resources produced during each year of plateau production (b);
- a uniform distribution (between 1 and 4 inclusive) for the length of plateau production in years (c); - a uniform distribution (between 5 and 20 inclusive) for the percent fall in annual production during each year of the production decline (d); (2) Floating production systems (Subroutine PRODFP)
- a uniform distribution (between 0.6 and 0.8) for the proportion of the resources produced during the period of initial production (e)
- a uniform distribution (either two or three years) showing the period of initial production in years (c); (3) Offshore platforms (subroutine PRODOP)
- a uniform distribution (between 0 and 2 inclusive) for the length of the production build-up in years (a);

- a uniform distribution (between 7 and 15 inclusive) for the percent of the resources produced during each year of plateau production (b);
- a uniform distribution (between 3 and 9 inclusive) for the length of plateau production in years (c);
- a uniform distribution (between 5 and 20 inclusive) for the percent fall in production in each year of the production decline (d).

PRODN calls one of the three subroutines to calculate separate production profiles, giving the percent of the undiscovered resource produced each year, for each economic accumulation. It then uses the estimated accumulation sizes, the selected lead times, and appropriate production profiles to estimate the amount of oil produced in each year from 1987 to 2000.

CHECKING THE DATA

The program checks the input data for each super-play (each trap type in each independent petroleum system). If an error or inconsistency is detected, it prints out a message, ignores the set of data, and reads the next set. If no errors are detected, the program reads the next set of data. Any error messages are printed out to a special file called ERRORS.

Subroutine GBMAX checks the value of lambda that was input to make sure that it is consistent with the (minimum) average value allowed by the model and, if not, it calculates and substitutes the (minimum) average value.

DESCRIPTION OF PROGRAM SEAPUP

Each iteration of program SEAPUP simulates drilling, discovery, and production of crude oil from each super-play (independent petroleum system) during the period 1987 to 2000. This work is carried out by the program in the following steps:

(1) The program uses the drilling model (subroutine FDRILL) to calculate the number of wells that may be drilled each year in offshore and onshore Australia;

(2) The value of lambda and corresponding values for slope, intercept, standard deviation of the residuals of the linear projection of the ln A versus drilling sequence number model are determined.

(a) if lambda = 0,

A value of the intercept is selected at random from a normal distribution with a mean equal to the value of the intercept in the input data and a standard deviation equal to the value of the standard deviation of residuals in the input data divided by the square root of the number of new-field wildcat wells. A value of the standard deviation of the residuals is selected at random from a normal distribution with a mean equal to the value of the standard deviation of the residuals in the input data and a standard deviation equal to the standard deviation of residuals in the input data divided by the square root of twice the number of new-field wildcat wells.

(b) if slope is < 0,

A value of lambda is selected at random from the normal distribution of lambda that is included in the input data. This value of lambda is used to calculate the corresponding values of slope, intercept, and standard deviation of residuals as described by Forman & Hinde (1985, 1986) and Forman & others (1988);

(3) The parameters of the linear model for ln V/A versus discovery sequence number are determined in a similar way;

(4) The maximum (most negative) slope (B_{max}), the standard deviation of the y-values (σ_y), and the sum of the y-values (S_y) of the linear models of ln A versus drilling sequence number and ln V/A versus discovery sequence number are calculated by subroutine GBMAX (Hinde, 1986) using the following equations.

$$S_y = n(a + B(n + 1)/2 \quad (11)$$

$$\sigma^2_y = \sigma^2_{res}(n - 2)/n + b^2(n^2-1)/12 \quad (12)$$

$$B_{max} = b/(1 - \exp(-\sigma_y\lambda)) \quad (13)$$

where b the slope, a the intercept, σ_{res} the standard deviation of residuals, n the number of data points, and lambda (λ) are the parameters of the linear models.

(5) A value for the success rate is selected at random from the triangular distribution of success rate;

(6) For each undrilled trap in the model:-

(a) A random value of ln A is selected by random sampling of the extrapolation of the ln A versus drilling sequence number model. A maximum cut-off value for each estimate of ln A is calculated using the input value for the intercept of the cut-off line, and the slope of the linear model of ln A versus drilling sequence number. The program will not accept values of ln A that are greater than the cut-off and requires that ln A be chosen again until a value is selected below the cut-off.

(b) A random value of ln V_A is selected by extrapolation and random sampling of the linear model of ln V_A versus discovery sequence number. A cut-off for ln V_A is calculated using either the input value for the intercept of the cut-off line or the triangular distribution for this value (if it was supplied) and the slope of the linear model of ln V_A versus discovery sequence number. If the value of ln V_A that is selected is greater than the cut-off, the program uses the cut-off value in its place.

(c) The log accumulation size is calculated using the values of ln A and ln V_A selected above in the formula, $\ln V = \ln V_A + \ln A$. If the value of ln V that results is greater than a limit of SDMAX standard deviations above the average value, the program will repeat the process of selecting values for ln A and ln V_A (The value of SDMAX is normally set at four standard deviations; the instruction that does this is a data statement at the top of the program).

(d) The accumulation size is calculated using: $V = \exp(\ln V)$. If the accumulation size exceeds a maximum value that may be specified in the input the program will repeat the process of selecting values of ln A and ln V_A and of calculating the accumulation size. If the accumulation size is less than the smallest size of accumulation to be included as a resource, the accumulation is excluded both from the assessment of undiscovered resources and from the estimate of future discovery and production.

(e) The amount of oil in the accumulation is calculated using the accumulation size in MOE and the proportion of oil to oil and gas;

(7) For each accumulation simulated in the projection:-

(a) A random value is selected from the input distribution for the lead time from discovery to start of production (for discoveries in the Timor Gap area, an additional random number, selected from a uniform distribution between two and 15 inclusive, is added to the lead time, and the accumulation size is divided by two);

(b) A minimum economic accumulation size cut-off is selected at random from the input distribution to determine whether or not the accumulation will be produced.

(8) The total amount of simulated oil discovered in each trap type of each super-play (IPS) is summed for later printout of the total risked average amount;

(9) Values of alpha are selected at random from the input distributions for onshore and offshore Australia;

(10) The program uses the efficiency of exploration model (subroutine FDISC) to order the onshore and offshore traps and their associated petroleum accumulations;

(11) The program determines the presence or absence of hydrocarbons within each IPS by comparing random numbers with the input probabilities that hydrocarbons have migrated within the play and that trap and seal are adequate to hold them;

(12) The resources of undiscovered crude oil contained within the simulated accumulations are added up and the total is stored in a histogram;

(13) The program uses subroutine PRODN to calculate the annual production from the economic oil accumulations. The totals for each year are stored in histograms.

(14) The program calculates totals for the number of wells drilled, the number of discoveries made, the amount of oil discovered, the success and discovery rates, and the number of accumulations brought into production both for each year and for the whole period from 1987 to 2000. In addition the program calculates how much of the oil will be economic and how much will occur in accumulations that may be brought into production during 1987 to 2000. These totals are stored in histograms.

(15) The size of each simulated discovery is recorded in a histogram according to its discovery sequence number.

Upon completion of all iterations:

(1) Each histogram of annual crude oil production is written onto a disc file;

(2) The risked average undiscovered crude oil resources of each super-play (IPS) and cumulative percentiles of the total risked undiscovered crude oil resources are written onto a print file;

(3) The input data for each super-play is written onto a second print file.

STRUCTURE OF INPUT DATA

The input data for program SEAPUP (version 5.1) are typed into a file in the following format. Items enclosed in square brackets [] are not required for SEAPUP. They are included so that the file may also be used to run program VALAL (Hinde, 1986).

Line	Cols	Variable	Description	Format
1	1-60	ITITLE	Title of project.	(A60)
2	1-3	OG	'OIL', 'GAS', or 'CON' (default 'OIL').	(A3,2X, 2I5,A3 2X,A11)
	6-10	NRUNS	Number of iterations to be used in the simulation.	
	11-15	NSTART	Start year of production estimate.	
	[16-18	ON_OFF	Whether onshore ('ON'), offshore ('OFF'), or all ('ALL'). (Only required by program VALAL).]	
	21-31	XBASIN	Optional basin to which the estimate is to be restricted. If specified, all accumulation sizes outside of this basin are set to zero and hence the results pertain only to this basin.	

			Only the first few letters of the basin need be specified. An underscore ('_') must be used to specify blanks. (XBASIN must not be specified if the data base contains data for both the onshore and offshore basin.)	
3	1	TYPE (5)	Type of distribution for value of alpha (offshore). (K-constant, E-truncated exponential, U-uniform, blank-frequency histogram, C-cumulative, T-triangular, B-binomial).	(A1,I5, (6F10.3))
	2-6	NUM (5)	Number of values specifying the distribution for alpha (offshore).	
	7-16	VAL (5,1)	The first X-value in the distribution for alpha (offshore).	
	17-26	FREQ (5,1)	Corresponding probability or relative frequency of the first X-value in the distribution for alpha.	
	27-36	VAL (5,2)	The second X-value for alpha.	
	37-46	FREQ (5,2)	Corresponding probability or relative frequency of the second X-value.	
	47-56	VAL (5,3)	The third X-value for alpha.	
	57-66	FREQ (5,3)	Corresponding probability or relative frequency of the third X-value.	
4		TYPE (6) etc	Type of distribution for value of alpha (onshore).	(A1,I5, (6F10.3))
5		TYPE (3) etc	Type of distribution for lead time (offshore).	(A1,I5, (6F10.3))
6		TYPE (4) etc	Type of distribution for lead time (onshore).	(A1,I5, (6F10.3))

Up to four continuation lines may be added if more than three values are required to specify these distributions. Up to three values can be entered per continuation line, 20 columns per value, starting in column 1 (each number has F10.3 format).

7	1-10	OFFMIN	Minimum value of the number of offshore wells drilled per year	(6F10.0)

			(triangular distribution).	
	11-20	OFFML	Most likely value of the number of offshore wells drilled per year.	
	21-30	OFFMAX	Maximum value of the number of offshore wells drilled per year.	
	31-40	ONMIN	Minimum value of the number of onshore wells drilled per year.	
	41-50	ONML	Most likely value of the number of onshore wells drilled per year.	
	51-60	ONMAX	Maximum value of the number of onshore wells drilled per year.	

If line 7 is left blank, the inbuilt drilling model is used. Lines 8 to 12 are repeated for each basin/sub-basin/trap/sequence level combination as required.

8	1-20	BASIN	Name of basin and sub-basin.	(A20,A1,A4,
	21	ONOFF	location (F = offshore; N-onshore).	I5,5F10.0)
	22-25	TRAPH	Trap type and sedimentary sequence. (T = upper part of sequence I = lower part of sequence)	
	26-30	MDRILL	Number of future wells to be drilled.	
	31-40	XTH1	Minimum value of the success rate (triangular distribution).	
	41-50	XTH2	Most likely value of the success rate.	
	51-60	XTH3	Maximum value of the success rate.	
	61-70	FLDMIN	A cut-off specifying the smallest size of accumulation to be included in the estimate. If not required, leave blank (Units are MOE).	
	71-80	FLDMAX	A cut-off specifying the maximum size for future generated accumulations. If not required, leave blank.	
9	1-10	POIL	Proportion of accumulations containing only oil.	(8F10.0)
	11-20	PGAS	Proportion of accumulations containing only gas.	
	21-30	OOGMIN	Minimum value (triangular distribution) for the proportion of oil to oil plus gas in the oil and gas	

			accumulations.	
	31-40	OOGML	Most likely value for this distribution.	
	41-50	OOGMAX	Maximum value for this distribution.	
	[51-60	HMAX	Used by program VALAL for an optional upper limit for the histogram of the individual assessment.]	
	61-70	AAMAX	Specifies a cut-off line for generated values of A. Ln(AAMAX) is the intercept of the line (at the next well) with a slope equal to the generated value of slope for ln A vs NFW number. If a value is generated higher than the cut-off, another value is generated. If not specified, no cut-off is used (units are sq. km.)	
	71-80	VAMAX	Specifies a cut-off line for maximum values of future generated values of V_A. Ln (VAMAX) is the the intercept of the line, (at the next accumulation), and the slope is the generated value of slope for ln V_A vs discovery number. If a value is generated higher than the cut-off, it is replaced with the cut-off (default value is 6; units are metres).	
10	1-5	RHORIZ	Probability that hydrocarbons have been generated and have migrated in this stratigraphic sequence.	(5F10.0, 5X,3F5.0, 5X,3F5.0)
	6-10	RTRAP	Probability that trap is adequate.	
	11-15	GMOE_MIN	A triangular distribution for the constant that converts gas in BCM's	
	16-20	GMOE_ML	to an equivalent volume of oil in MCM's. If not specified, a default value is used.	
	21-25	GMOE_MAX		
	31-35	CONDMN	Minimum value (triangular distribution) for the ratio of condensate (in MCM) to gas (BCM).	
	36-40	CONDML	Most likely value for this distribution.	
	41-45	CONDMX	Maximum value for this distribution.	

	51-55	CUTMIN	Minimum value (triangular distribution) for minimum economic accumulation size. (Oil-MCM, Gas-BCM, Con-MCM).	
	56-60	CUTML	Most likely value for this distribution.	
	61-65	CUTMAX	Maximum value for this distribution.	
11	1-10	SLOPE (1)	Slope of the line fitted to ln A vs drilling sequence number model.	(4F10.0, F5.0, 2I5)
	11-20	AINTA1	Intercept of the line fitted to ln A vs drilling sequence number model (in sq. km)	
	21-30	SDRES (1)	Standard deviation of the residuals to the line fitted to the ln A vs drilling sequence number model.	
	31-40	ALAM (1)	Lambda value for the ln A vs drilling sequence number model. If this value is less than the theoretical minimum value allowed by the model, the theoretical value is used.	
	41-45	SDLAM (1)	Standard deviation of lambda for the ln A vs drilling sequence number model.	
	46-50	NAREA	Number of data points.	
	51-55	NEXTA	Well number at which simulation is to start. (Default is NAREA+1.)	
12	1-10	SLOPE (2)	Slope of the line fitted to the ln V_A vs discovery sequence number model.	(4F10.0, F5.0,2I5, 3F5.0)
	11-20	AINTV1	Intercept of the line fitted to the ln V_A vs discovery sequence number model (metres).	
	21-30	SDRES (2)	Standard deviation of the residuals to the fitted line to the ln V_A vs discovery sequence number model.	
	31-40	ALAM (2)	Lambda value for the ln V_A vs discovery number model. If this value is less than the theoretical minimum value allowed by the model, the theoretical value is used.	
	41-45	SDLAM (2)	Standard deviation of lambda for the ln V_A vs discovery sequence number model.	
	46-50	NDISC	Number of data points.	
	51-55	NEXTV	Discovery number at which the	

		simulation is to start. (Default is NDISC+1.)
56-60	VAXMIN	Minimum value for the intercept, VAMAX, of the cut-off line for V_A (triangular distribution).
61-65	VAXML	Most likely value for this distribution.
66-70	VAXMAX	Maximum value for this distribution (This distribution, if present, overrides the value of VAMAX input above.)

RUNNING PROGRAM SEAPUP

Version 5.1 of SEAPUP is stored in directory SEAPUP5 of ALAN.RESAS on the BMR's DG computer. SEAPUP may be run either at the terminal or in batch mode. It requires two data files, one containing the input data and one, produced by program VALAL, containing the partially risked average accumulation sizes. Assuming the first file is called DATA, then the file of partially risked average trap sizes must be called DATA_FIELDS.

To run SEAPUP at the terminal type the command,

```
SEAPUP data p0 p1 basin
```

where 'data' is the name of the input data file. Type a '0' instead of 'p0' or 'p1' if the printout file, containing the risked undiscovered resources of each trap type of each basin and the total risked undiscovered resources (file DATA_LS0, see below), is to be printed. Type a '1' instead of 'p0' or 'p1' if the file listing the input data (file DATA_LS1, see below), is to be printed. Both files may be printed with the command,

```
SEAPUP data 0 1
```

Type the first few letters of a basin (enough to identify it uniquely) if the estimate is to refer to this basin. The results pertaining to the production are obtained by running program PROFILE as explained below.

To run SEAPUP in batch mode type,

```
SEAPUP/AFTER=+n BATCH data p0 p1 basin
```

where 'n' is the number of hours delay before SEAPUP is to run and 'data', 'p0', 'p1', basin are as described above.

The command, SEAPUP, may be typed at the terminal to get a list of the above instructions.

OUTPUT FROM THE PROGRAM

Assuming that the input data file for a SEAPUP run is called DATA, the following files are produced by the program.

File DATA_LS0

This print file lists the risked average undiscovered crude oil

File DATA_LS0

This print file lists the risked average undiscovered crude oil resources for each set of input data, and the average, standard deviation, and percentiles of the total undiscovered resources for each set of data. It also provides cumulative probability values for the distribution of the total undiscovered crude oil resources and the average value and standard deviation of the this total.

FIle DATA_LS1

This print file contains a list of the data values for each of the sets of input data as well as the input distributions for alpha, the lead times, and the production profiles.

File ERRORS

This print file contains a list of any errors or anomalies detected in the input data.

FIle DATA_Q

This disc file contains the histograms of the annual crude oil production estimate, the total amount discovered per year, the total number of wells drilled per year, the total number of discoveries per year, the number of economic discoveries brought into production per year, the success and discovery rates, and the sizes of the discoveries. It is used by program PROFILE to obtain printouts of the annual crude oil production profile at the required levels of probability.

OBTAINING THE PRODUCTION PROFILE

Program PROFILE reads file DATA_Q and creates a print file, called DATA_LSQ, containing the average production profile and production profiles at the 10, 20, 50, 80, and 90 percent probability levels. It also contains yearly values for: the number of wells drilled per year; the number of discoveries per year; the sizes of the simulated discoveries; the amount discovered per year (uneconomic + economic); the success rate (number of discoveries per well drilled); the discovery rate (MMB per well drilled); and the number of economic discoveries brought into production per year. Average annual values are also given for: the amount of crude oil discovered; the amount of uneconomic oil discovered; the amount of economic oil discovered; and the amount of economic oil in accumulations that are discovered and brought into production within the period of the estimate.

The program runs automatically when the above 'SEAPUP' commands are used. PROFILE can be run independently with the command,

PROFILE DATA p

where DATA is the name of the original SEAPUP data file. A '1' (number one, not lower case L) is typed instead of 'p' if the print file DATA_LSQ is to be printed.

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