1983-34

ASSESSMENT OF SPACE AND USE CONFLICTS BETWEEN THE FISHING AND OIL INDUSTRIES

VOLUME IV

CATCH LOSS MODEL

PREPARED BY

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JANUARY, 1981

Centaur Associates, Inc.

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1.0 INTRODUCTION

This is Volume IV of a study assessing the potential interactions between the fishing industry and oil/gas development on the U.S. Outer Continental Shelf. This Volume presents results of a modeling effort to estimate the loss in catch to the commercial fishing industry due to OCS structures located on fishing grounds. Various OCS structures have buffer zones surrounding them within which fishing cannot be conducted. The distances involved have been assessed in Volume I. The model assumes that fish move randomly in an area around an OCS structure. A Markov type statistical process is used to model the statistical probabilities of fish moving into and out of the buffer zone and the probability of being caught while outside the buffer zone. The relative catch under various OCS development alternatives and with various assumed parameters is compared with the relative catch under no OCS development and analogous parameters. This produces a percentage catch loss which can be applied to the expected quantity and value of catch to estimate the expected loss.

The model was applied to one lease sale scenario in each of six OCS lease sale regions; the North Atlantic, Mid Atlantic, South Atlantic, Gulf of Mexico, Southern California, and Northern/Central California. Consideration was given to the major species for which catch is expected to be affected due to loss of offshore fishing space.

Section 2.0 of this Volume describes the model and its use and the method for estimating parameters. Sections 3.0 through 8.0 presents the results for the lease sale scenarios for the six regions respectively. Appendix 1 provides a literature rewiew of fish movement behavior.

2.0 METHODOLOGY

Structures associated with OCS oil/gas development will occupy physical space in the waters of the continental shelf. These have the potential for affecting catch in fisheries in the waters which the OCS structures may occupy. As has been described in Volume I, Section 3.0, there is the potential for a loss of fishing waters for fishing vessels. Such a spatial loss may be potentially associated with both surface and subsurface OCS structures. The spatial loss can be expressed in terms of a buffer zone around particular structures in which fishing is effectively foreclosed. Section 3.6 of Volume I presents estimates of the sizes of buffer zones for various OCS structures.

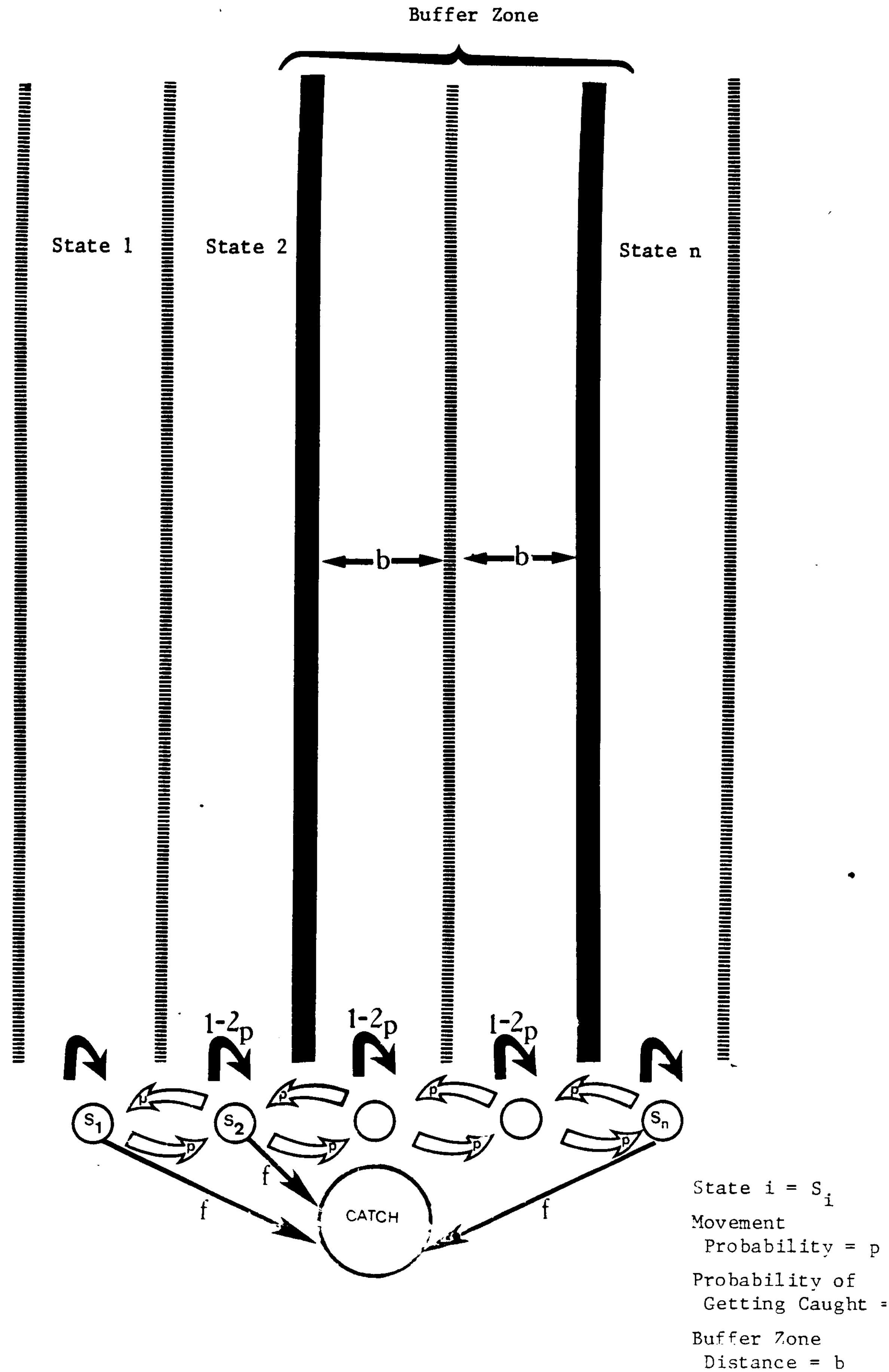
Given a buffer zone, the question remains as to the effect on total catch that such a foreclosure would have. To our knowledge the only previous attempts have included: 1) statistical analysis of historical catch-by-area data over a time period during which OCS structures were placed in an area; and 2) estimating the catch effect as being proportional to the area of a fishery foreclosed to fishing. In the attempts we are aware of the first method has not produced usable results. This has been no doubt due to the lack of an adequate historical data base giving fine enough resolution coupled with the great year-to-year variation (due to natural factors as well as changes in the exploitation rate) inherent in fisheries. The second method provides a reasonable first-order approximation to the catch loss. However, it does not allow consideration of the fact that certain fish may, during a season, move in and out of the buffer zone and that some of these fish may be caught when outside the buffer zone. Thus in many instances the catch loss will be less than proportional to the area foreclosed. Also, the second method does not directly consider the fact that foreclosure of a certain fishing area may increase the exploitation rate in other areas of the fishery such that catch may not decrease in direct proportion to the ratio of area foreclosed.

The objective of this methodology is to build upon the second method by taking into explicit account the effect of both fish movement and the exploitation rate. The model calculates the expected catch loss due to the placement of OCS structures as a function of the amount of various types of such structures and various parameters describing the fishery.

2.1 Approach

The overall approach consisted of using a Markov "random walk" type of probabilistic model of fish movement and catch. The basic structure of the model is illustrated in Exhibit 2-1. In this model a series of states were defined corresponding to spatial areas occupied by a stock of fish. The spacial areas are long, thin rectangles spaced within and to either side of the buffer zone. In any given period of time a fish in state i has a certain probability (defined by p) of moving to either state adjacent to it. In addition, for those states outside the buffer zone there is a probability (defined by f) that a fish will be caught and enter a state known as "catch". The width of the buffer zone is

Exhibit 2-1


Buffer Zone
State 1
State 2
State n
b
b
1-2p
1-2p
1-2p
p
p
p
p
p
p
p
p
S1
S2
Sn
f
f
f
CATCH
State i = Si
Movement
Probability = p
Probability of
Getting Caught =
Buffer Zone
Distance = b

defined by a parameter b measured from the center of the structure to the edge of the buffer zone.

The model reduces to one dimension what is essentially a two dimensional process. That is, fish can swim in random directions not just left and right along a line. However, when the buffer zone is long relative to its width (such as in the case of a pipeline) random movement between states along the axis perpendicular to the long axis of the buffer zone are probabilistically identical at the limit to a two dimensional modeling. For other cases such as buffer zones around platforms this is not as true. However, the effect of any error in this approximation is to overestimate the catch loss associated with OCS structures. This is because a more nearly circular or square buffer zone allows fish to move outside the buffer zone along the other axis.

The model begins with a set of initial conditions and is run through many iterations. Over a large number of iterations the transition probabilities (p) model a probabilistic process analogous to one in which for a given fish which starts at state i at time equals 0, the probability distribution of its location at a later time t can be described by a normal or Gaussian distribution function. The variance (square of the standard deviation) of this function is typically referred to as the dispersion coefficient and expressed as a^2 (See Jones, 1959). The parameter a^2 is normally expressed in units of $miles^2$ per day. The dispersion coefficient is related to the transition probabilities as follows:

$$1) \qquad p = a^2/(2 * d^2) * \underline{t}$$

where $\underline{t}$ is the time period for each model iteration and d is the physical width of each spatial state as represented in the model. Throughout this report the character "*" represents multiplication and "/" division using typical computer notation. If a^2 is expressed in $miles^2$ / day, d in miles, and t in days, the probability p is dimensionless.

The derivation of Expression 1 can be shown as follows. The generalized formula for the variance of a probability distribution function is

$$2) \qquad \sum_{i=1}^{I} p_i * (x_i - E(\underline{x}))^2$$

where x_i is a value of the random variable, p_i is the probability of the distribution function taking on that value, and $E(\underline{x})$ is the mean of the distribution function. Thus in the Markov model the probability distribution function for the location of a fish in state i after one model iteration can be described as

Location state	$x_i - E(x)$	Probability of being in this state	$p_i(x_i - E(x))^2$
i-1	-d	p	pd^2
i	0	1-2p	0
i+1	d	p	pd^2
Variance = Sum =			$2pd^2$

The variance for one model iteration equals $a^2 * \underline{t}$ since the variance of a sum of n random varibles equals n times the variance of one random variable and because one model iteration can be viewed as the sum of $\underline{t}$ daily iterations. From the central limit theorem it can be seen that the sum of a large number of the above probability distribution functions will approach a normal function.

When $(a^2 * \underline{t})$ is substituted for the variance in the above derivation expression 1 results.

The parameters $\underline{t}$ and d are selected for each model run depending upon the number of iterations and states to be used when running the model. The variables $\underline{t}$ and d must be large enough to obtain a reasonable representation of reality.

Expression 1 can be rearranged as follows:

3) $$p = (a / b)^2 / (2 * \underline{t}) * (b^2/d^2)$$

The right-most expression in parenthesis is simply one half the number of states in the buffer zone as represented in the model (i.e. as shown in Exhibit 2-1 b divided by d equals one half the number of states in the buffer zone). This is determined when setting up each model run. Expression 3 shows that the model input variables a and b can be collapsed into one parameter, $(a/b)^2$, for input into the model.

A series of variables $s_{i,t}$ defines the expected stock of fish in state i at time period t where t is measured from some starting time

$t = 0$. Using Markov theory the probability distribution of stock at time period t+1 can be defined as follows:

$$4) \sum_{i=1}^{N} s_{i,t+1} = s_{i-1,t} * p + s_{i+1,t} * p + s_{i,t} * (1-2p)$$

where N is the total number of states being modeled. In practice N is selected so that the states furthest from the buffer zone show no difference in the stock they contain from the baseline case of no buffer zone.

c_t is defined as accumulated catch (from some starting time $t= 0$) The addition to c in time period t can be calculated as:

$$5) \quad s_{i,t} * f \text{ for all states i outside the buffer zone}$$

Note that s_i need not be the actual distribution of stock in state i but can be thought of probabilistically as the expected value of the stock in state i at a given time period. Fish of course are not uniformly distributed at all times. Rather the model assumes that the probability distibution of fish over the area being modeled is uniform for the baseline case without the intrusion of the buffer zone. In other words, for the baseline case at any given time the probability of finding fish at any given point in the area being modeled is considered to be the same. This same assumption of uniform probability distribution is applied to the buffer zone case at some initial time period ($t=0$). This is conceived to correspond to the time of an annual recruitment of new stock to the fishery at which point a new period of annual fishing begins. When a buffer zone is added the probabilistic distribution of fish changes relative to the baseline case of no buffer zone and to the initial condition in the buffer zone case. This is because the expected stock within the buffer zone does not decrease due to fishing pressure. Inside the buffer zone the stock does not change due to fishing pressure in the buffer zone itself, however it does change as fish move randomly to states outside the buffer zone where they are subsequently caught.

The model assumes an initial biomass m_i in each state, the probability distribution of which is distributed uniformly among the states.

Conceptually the model is run twice. Once for the baseline catch where there is no buffer zone and fishing takes place in all states. The model is then run again with certain states designated as no-fishing states corresponding to areas within a buffer zone. This can be described as follows:

$$6)\qquad c_T = \sum_{\substack{\text{for } i \text{ outside} \\ \text{the buffer zone}}}^{N} \sum_{t=1}^{T} g_{i,t} * f * m_i$$

where c_T is total accumulated catch through some time period T and g is the relative stock size in each state relative to the initial expected value biomass m at time period 0.

If c_T is defined as catch with a buffer zone, c'_T as catch without the buffer zone (i.e. baseline case), and g' and f' as the analog to g and f respectively for the baseline case, the expected catch loss percentage L can be expressed as:

$$7)\qquad L = 1 - c/c'$$

or:

$$8)\qquad L = 1 - \left[\frac{\sum g_{i,t} * f * m_i}{\sum g'_{i,t} * f' * m_i}\right] = 1 - \left[\frac{\sum g_{i,t} * f}{\sum g'_{i,t} * f'}\right]$$

where the summation is taken as in expression 6 and where m_i cancels out. Thus it is not necessary to know the absolute value of m_i. Rather, m_i is a function of recruitment of fish to the fishery and is constant between the baseline and buffer zone cases.

When the model is run to calculate catch loss, T is chosen to represent one year or 365 days. This is based on the generalized assumption that fisheries typically have an annual recruitment of new additions to stocks.

The parameters f and f' are analogous to the fishing exploitation rate F as commonly seen in fishery population dynamics. F represents the instantaneous fishing mortality or exploitation rate and is a function of the fishing pressure in a given fishery. Using this concept catch in a given area through time period t with an initial biomass m can be defined as

$$9)\qquad m * (1-e^{-Ft})$$

See Beverton and Holt (1957) for a detailed explanation of the theory behind the concept of the parameter F.

Expression 6 as used in the catch loss model is really the descrete time period analogy to expression 9. The f and f' as used in the model represents the fishing exploitation rate over the time period of each discrete model iteration. Each model iteration represents the time between which the new state variables $g_{i,t}$ are calculated. The parameter f' as used in the model is related to F as follows:

$$10)\qquad f' = 1 - e^{-F*\underline{t}}$$

This is because m * f' must equal expression 9 where t = $\underline{t}$.

Note that the probabilities of fish being caught (f and f') in any model iteration can be different between the baseline and buffer zone cases. When a buffer zone is introduced the effective fishing area is decreased. However the number of vessels and total fishing effort is assumed to remain the same. This means that the effective fishing effort per area increases. Specifically, if A = the total area of the fishery, r = the percentage of the fishery occupied by buffer zones, F = the fishing pressure (or probability of fish being caught) with the buffer zone, and F_b = the fishing pressure with the buffer zone, then because the effective fishing area is reduced by a factor of (1-r) with the buffer zone:

$$11)\qquad \begin{aligned} F &= h * w/A \\ F_b &= h * w/(A * (1-r)) \end{aligned}$$

where w is the total amount of water "fished" (which is equal to the average vessel speed times the time fished times the effective sweep width of the gear with an allowance for losses), and h is a scaling parameter which relates the real world fishing exploitation rate to the total amount of water "fished". Note that the actual value of h need not be known because it is constant between the two cases and therefore cancels out.

Thus:

$$12)\qquad F_b = F / (1-r)$$

The value of f can be calculated in a manner analogous to equation 10 when the F_b from expression 12 is substituted for F in expression 9. This yields the following:

13) $$f = 1 - e^{-F * \underline{t} / (1-r)}$$

2.2 Model Computation

The model uses a two stage procedure for calculating the expected catch loss on a digital computer. Stage 1 calculates the catch loss for a fishery where r (the ratio of the areas of the buffer zones to the area of the fishery) is equal to one percent. The resultant catch loss for this one percent case is termed the catch loss parameter, or M, and is a function of the dispersion coefficient divided by the square of the buffer zone, a^2/b^2 and the instantaneous fishing mortality, F. Exhibit 2-2 presents the results of Stage I. Stage II uses as inputs the catch loss parameter M, the fishery exploitation rate F, the area of the fishery A and data on the number of OCS structures and the width of associated buffer zones. From this the total area of buffer zones is calculated for a particular lease sale scenario and a particular value of the ratio of the area of buffer zones to area of fishery is calculated. Through a procedure described later the parameter M is then used to calculate the catch loss for the actual value of this ratio.

It was necessary to use this two-stage procedure because of the large amount of computer time required for each run. This procedure allows a smooth curve to be fitted through points plotted from the results of a series of runs. The intermediate output shown in Exhibit 2-2 can then be used to estimate the catch loss parameter M without having to make further runs of Stage 1. An additional advantage of the two stage procedure is the fact that the intermediate results as presented in Exhibit 2-2 show clearly the effects of variations in F and a^2/b^2.

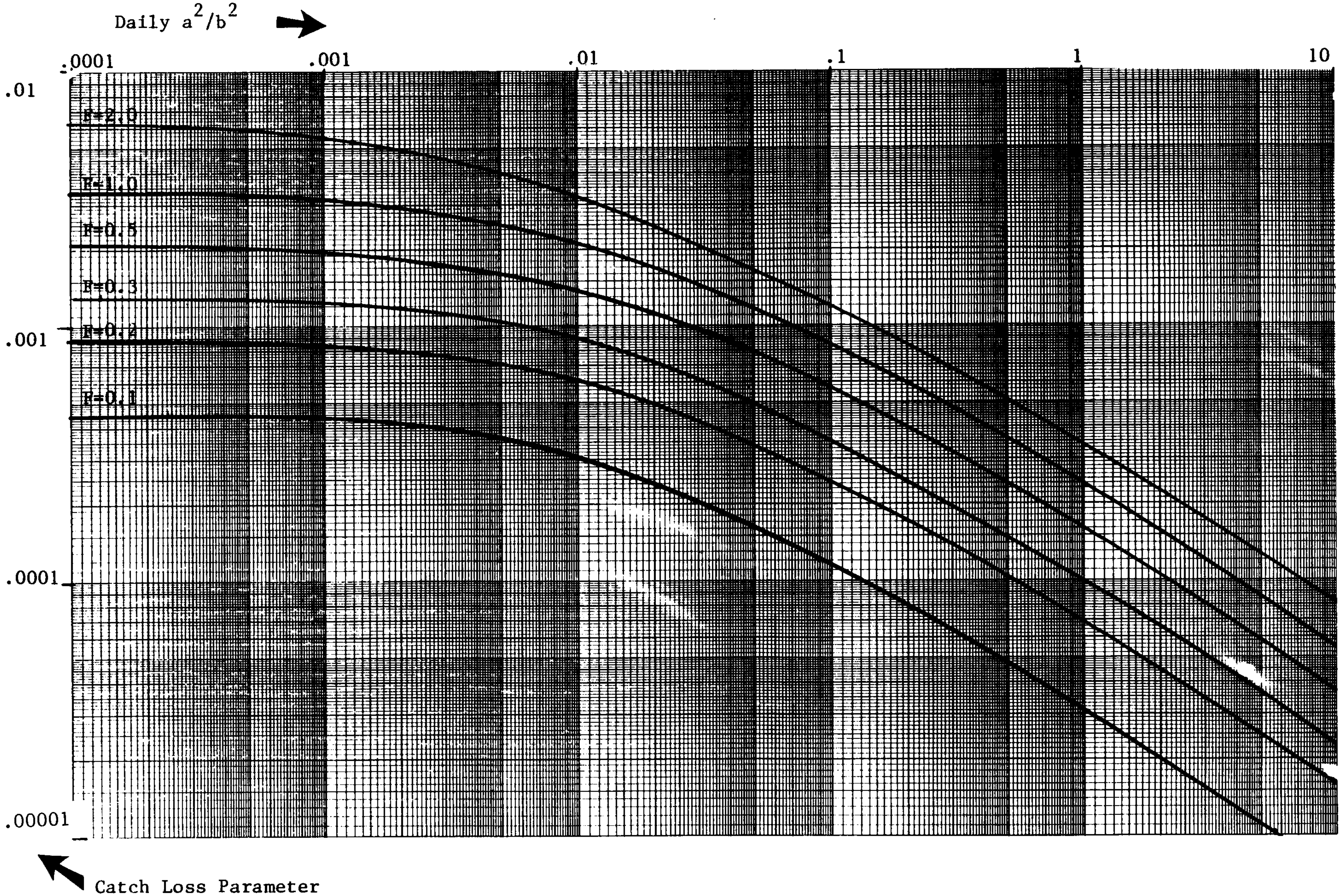
As the dispersion coefficient decreases relative to the buffer zone distance it levels off and converges toward the value associated with no movement of the fish. This reflects the fact that at zero or low values of the dispersion coefficient there is little movement of the fish into and out of the buffer zone. The catch loss is less than proportional to the percentage of fishing area foreclosed because increased fishing effort is applied to the remaining fishing area and stock. The catch loss increases with increasing F because at higher F there are diminishing returns associated with adding a marginal unit of fishing effort relative to the area and stock as the overall fishing effort increases.

As the dispersion coefficient approaches and exceeds the buffer zone distance the catch loss begins to decrease rapidly. This represents the fact that fish are moving more freely into and out of the buffer zone and have a relatively greater chance of being caught because of the higher proportion of time outside the buffer zone. There is no longer a certain percentage of the total stock that effectively remains in a sanctuary. At the extreme very mobile species such as tuna or mackerel would have a very insignificant catch loss. In fact a negligible catch loss would be associated with nearly all pelagic species.

The results of Stage I were produced by running a series of computations for various values of the two parameters and fitting the parametric

Exhibit 2-2

Catch Loss Parameter As a Function of F and Dispersion Coefficient



curves. Exhibit 2-3 presents a flowchart of Stage I.

In step 1 of Exhibit 2-3 the input parameters SIG, NB, and FI are read into the program. These are defined as follows:

$$SIG = (a / b)^2 * \underline{t}$$

$$NB = b^2/d^2$$

$$FI = F * \underline{t} / 365$$

where the variables on the right hand side of the equals sign are defined in Section 2.1 The method of selecting these parameters is described later.

SIG can be thought of as the daily dispersion coefficient adjusted to be the variance of the random movement over a period of one model iteration divided by b squared. NB is simply one half the number of states in the buffer zone. FI is simply the fishery exploitation rate F (given in annual units) adjusted to the period of each model iteration.

In step 2 the transition probability P is calculated. This is done according to a slight rearrangement of expression 3 in Section 2.1.

In step 3 FB is defined as the parameter f in Section 2.1 and FN as f'. They are adjusted according to expressions 10 and 13 in Section 2.1 by substituting the definition of FI.

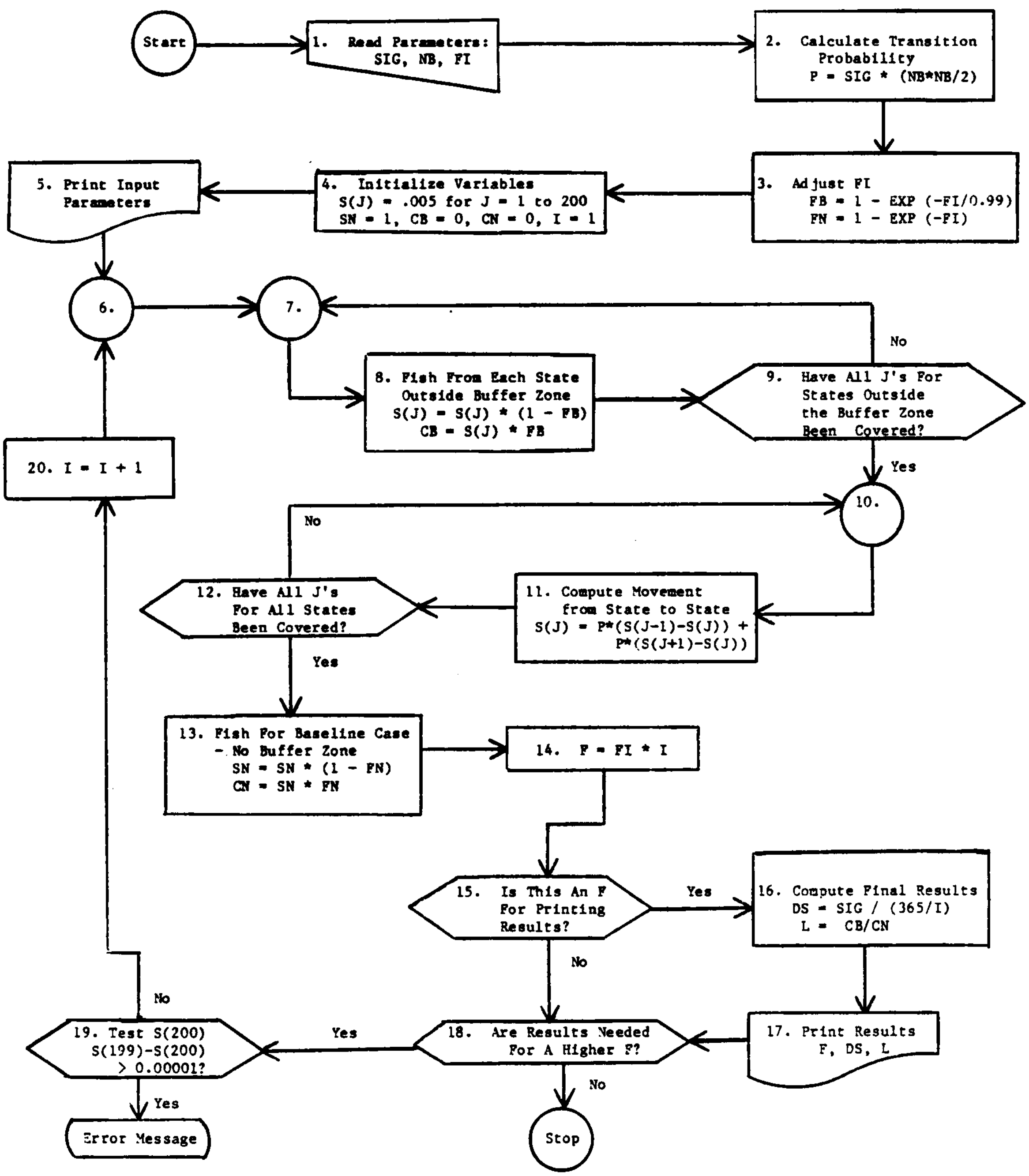
In step 4 S(J) is defined as $g_{i,t}$ in Section 2.1 (for the buffer zone case) where J is each state i and S(J) takes on new values in each model iteration corresponding to increases in the variable t. The total number of states J in the model is 200. Thus the initial value of each S(J) equals 0.005 so that the sum of the S(J)'s which is the total stock being modeled equals 1. SN is the total stock in each model iteration for the baseline case of no buffer zone. Since areas fished and fish distribution are assumed random in the baseline case, $s_{i,t}$ would be equal for each i because the model would fish from each state evenly (i.e. no states are no-fishing states). Thus only one variable SN is needed to correspond to the S(J)'s and it takes on an initial value of 1.0. CB is defined as accumulated catch with a buffer zone and CN as accumulated catch with no buffer zone. They take on initial values of 0. The index I described in step 6 is set to 1.

In step 5 the input parameters are echoed to the hard copy output for future reference.

Step 6 is the beginning of the outer loop which terminates in step 18 which calculates new results for each time period t. I is defined as the index register for the outer loop for each iteration corresponding to a new time period. It is incremented each iteration in step 20.

Exhibit 2-3

Flowchart of Stage I Model



Steps 7 and 9 define a loop to fish from each state outside the buffer zone. In step 8 each S(J) is decreased by the amount caught and this amount is added to CB on each iteration. This is related to expressions 5 and 6 in Section 2.1.

Steps 10 and 12 define a loop to compute the relative movement between the various S(J)'s. The calculation is performed in Step 11 and corresponds to expression 4 in Section 2.1.

Step 13 performs the calculation for fishing during each model iteration for the baseline case of no buffer zone. It is analogous to step 8.

In step 14, F, the fishery exploitation rate expressed in annual units is calculated. This is the same F described in expressions 9 and 10 of Section 2.1 and used to define FI. Step 14 is calculating the appropriate F that the results of the model up through iteration I would represent.

In step 15 certain loops corresponding to certain preselected values of F are selected for printing results. It would be impractical to print results for each iteration. Results are printed for values of F such as .1, .2, .3, ... 1.0, 1.5, 2.0.

In step 16 certain computations are made to obtain final results. DS is defined as $(a/b)^2$ as described in expression 3 of Section 2.1. This can be seen to be true because (365/I) is simply the number of days represented by each model iteration which equals $\underline{t}$. This is based on the assumption that a run of the model up through a value of F represents the fishery over a period of one year. This in turn is based on the generalized assumption (which is true for most fisheries) that the fishery has an annual recruitment of additional stocks to the fishery. L which is the calculated catch loss percentage is also calculated in step 16 corresponding to expression 7 in Section 2.1.

In step 17 the results for F (the fishery exploitation rate), DS (a^2/b^2 or the daily dispersion coefficient divided by the square of the width of the buffer zone-measured from the center to the edge), and L (the percentage catch loss due to the addition of a buffer zone where the buffer zone is equal to one percent of the area of a fishery) are printed.

In step 18 a decision is made to compute another time period iteration if I is less than some value corresponding to some upper value of F. The program currently sets this value to F equal to 2.0.

In step 19 a test is made to see if the results at this point have resulted in a significant difference in the values of S(200) and S(199). If this were to be true the results could be invalid. This is because the probabilistic characteristics of the random fish movement would affect areas beyond those being modeled. If such a condition were to occur, (this would happen if one wanted to model cases with even lower values of M) the coding could be changed so that the number of states S(J) could be increased with corresponding changes in the initial values. However, for the range of results presented in Exhibit 2-2, 200 states proved adequate.

It should be noted that the actual coding for Stage I only actually calculates results for a series of states S(J) extending from the center to one side of the buffer zone. This is because the values of S(J) in the corresponding "mirror image" locations to the other side would be identical. This can be seen through arguments of mathematical symetry by referring to Exhibit 2-1. Under the system used in this program S(1) is the first state to the right of the centerline of the buffer zone. S(100) is the state furthest to the right of the buffer zone.

Exhibit 2-4 presents sample output from the Stage I program for some of the values used to create Exhibit 2-2. It can be seen that the output from each individual run of the model "cuts across" the curves of constant F in Exhibit 2-2.

Stage I calculates catch loss percentage as a function of F and $(a/b)^2$ for a buffer zone which is one percent of the area of the fishery. The resultant catch loss percentage is termed the catch loss parameter, M. In Stage II M can be used to estimate the expected catch loss for other ratios of area of the buffer zones to area of fishery. Exhibit 2-5 presents a flowchart of the Stage II program.

In step 1 the parameters VL, F, A, PD, M, B1, B2, B3 and B4 are read in. These are defined as follows:

VL = the baseline value of landings for the fishery (This is a dollar value which can typically be expected in the future. It is used as a figure against which to judge the significance of the catch loss.)

F = the fishery exploitation rate in annual units

PD = the percentage of development activity (i.e. lease areas) expected to be in the fishery

PT = the percentage of trunk pipeline expected to be in the fishery

A = the area of the fishery

M = the catch loss parameter

B1, B2, B3, B4 = the width of the buffer zone (from the middle to the outside edge) for platforms, drilling rigs, trunkline, and connecting line respectively

In step 2 the above parameters are echoed back to hard copy output for future reference.

Exhibit 2-4

Examples of Stage I
Catch Loss Model Output

SIGMA↑2/B↑2 PER ITERATION = .9125000238   FISHING ENDS IN STATE NUMBER 1   F PER ITERATION = .0025000000
P (TRANSITION PROBABILITY) = .45625001   FB = .25220660846705E-02   FN = .24960776025397E-02

F (FOR FISHERY)	DAILY SIGMA↑2/B↑2	PERCENTAGE CATCH LOSS	CATCH WITH BUFFER	CATCH NO BUFFER	ITERATIONS
.10	.10000000	.00013470	.95149764027689E-01	.95162581964034E-01	40
.15	.15000001	.00016630	.13726885906770E+00	.13929202357493E+00	60
.20	.20000000	.00019085	.18123465159803E+00	.18126924692201E+00	80
.30	.30000001	.00022683	.25912298886713E+00	.25918177931827E+00	120
.40	.40000001	.00025141	.32959706801788E+00	.32967995396434E+00	160
.50	.50000000	.00026832	.39336376433823E+00	.39346934028735E+00	200
.60	.60000002	.00027961	.45106220564061E+00	.45118836390595E+00	240
.80	.80000001	.00029020	.55051122921792E+00	.55067103588276E+00	320
1.00	1.00000000	.00028977	.63193739021494E+00	.63212055882853E+00	400
1.20	1.20000005	.00028210	.69860865565452E+00	.69880578808778E+00	480
1.50	1.50000000	.00026221	.77666613351083E+00	.77686983985155E+00	600

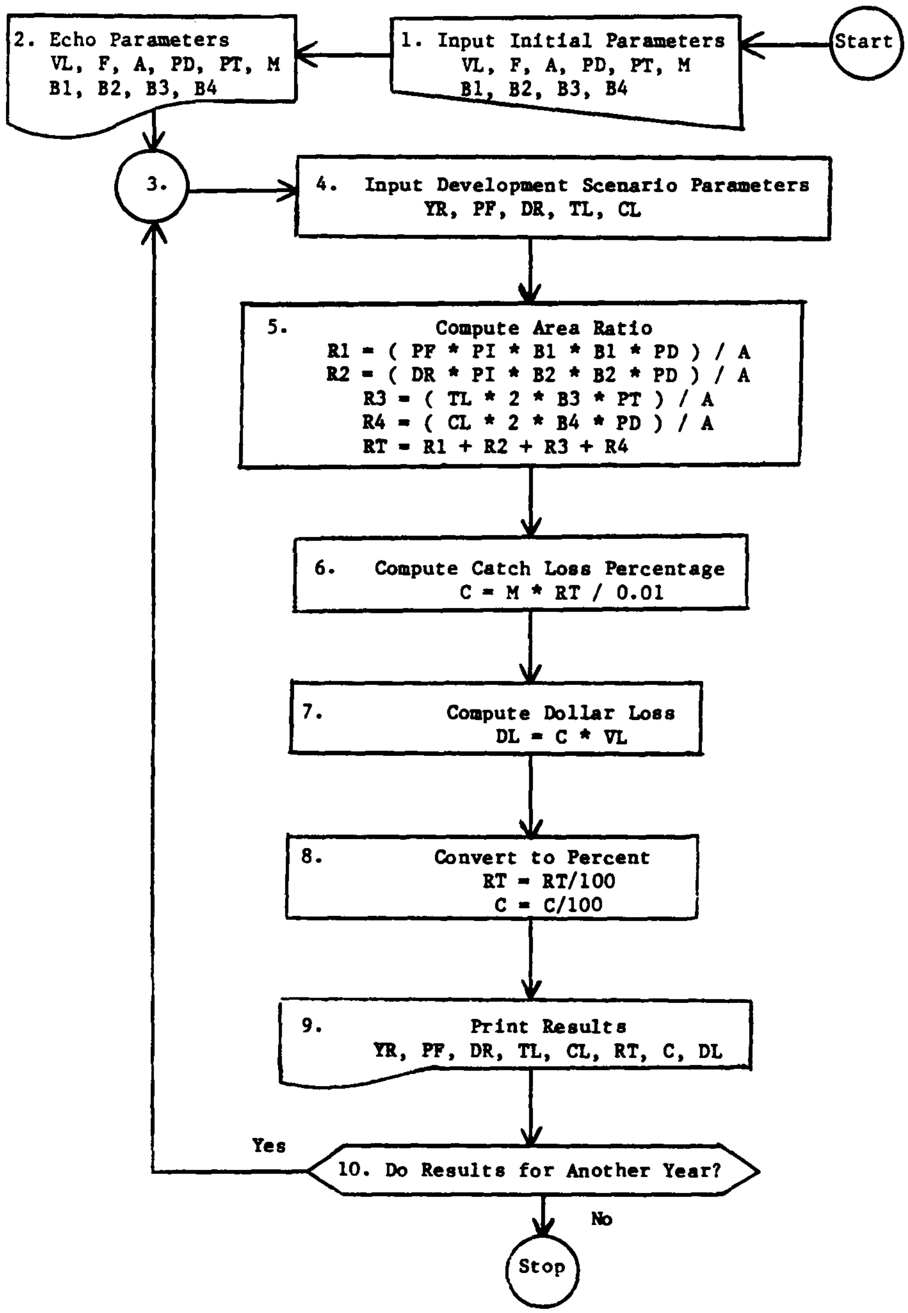
SIGMA↑2/B↑2 PER ITERATION = .1825000048   FISHING ENDS IN STATE NUMBER 1   F PER ITERATION = .0100000000
P (TRANSITION PROBABILITY) = .09125000   FB = .10050166739665E-01   FN = .99501662508318E-02

F (FOR FISHERY)	DAILY SIGMA↑2/B↑2	PERCENTAGE CATCH LOSS	CATCH WITH BUFFER	CATCH NO BUFFER	ITERATIONS
.10	.00500000	.00038488	.95125955922703E-01	.95162581964039E-01	10
.15	.00750000	.00052186	.13921933254406E+00	.13929202357494E+00	15
.20	.01000000	.00063777	.18115363972945E+00	.18126924692201E+00	20
.30	.01500000	.00082481	.25896800374285E+00	.25918177931828E+00	30
.40	.02000000	.00096878	.32936056565726E+00	.32967995396436E+00	40
.50	.02500000	.00108107	.39304397161843E+00	.39346934028736E+00	50
.60	.03000000	.00116854	.45066113200268E+00	.45118836390597E+00	60
.80	.04000000	.00128631	.54996270209241E+00	.55067103588277E+00	80
1.00	.05000000	.00134676	.63126924594368E+00	.63212055882855E+00	100
1.20	.06000000	.00136531	.69785169804970E+00	.69880578808779E+00	120
1.50	.07500000	.00133753	.77583075406114E+00	.77686983985156E+00	150
2.00	.10000000	.00120150	.86362582223771E+00	.86466471676338E+00	200

Results are shown for two separate runs. Note how each run yields various combinations of F and DS (Shown as DAILY SIGMA on printout). SIG shown as SIGMA!2/B!2 PER ITERATION, NB Shown as FISHING ENDS IN STATE NUMBER, FI shown as F PER ITERATION, CB as CATCH WITH BUFFER , CN as CATCH NO BUFFER, and I as ITERATIONS

Exhibit 2-5

Flowchart for Stage II of Model



Steps 3 and 10 define a loop, each iteration of which calculates results for subsequent years in the development scenario.

In step 4 the development scenario parameters relevant to a particular year are input. These are defined as follows:

YR = the year of the development scenario for which the current iteration is computing (this is for reference on output only)

PF = the number of platforms for the total development scenario

DR = the number of drilling rigs for the total development scenario

TL = the miles of trunk pipeline for the total development scenario

CL = the miles of gathering pipeline for the total development scenario

In step 5 calculations are made to determine the total area of buffer zones associated with each of the four types of OCS structures. These are then summed and divided by A to determine a value of RT which is the overall ratio of buffer zones to area of fishery for all four types of structures. R1 and R2 perform this calculation for platforms and drilling rigs respectively using area formulas for circles. PI = 3.14159. R3 and R4 perform this calculation for trunk and connecting (or gathering) pipelines respectively using area formulas for rectangles.

Step 6 computs the percentage catch loss, C, based on RT and M. The equation used in step 6 estimates C for ratios, RT other than 0.01 by pro-rating M by the ratio RT/0.01.

In step 7 the estimated dollar loss, DL, to the fishery based on the baseline value of landings is calculated.

Step 8 converts RT and C to percents instead of percentages.

Step 9 outputs the results of Stage II which include (in addition to the yearly input parameters YR, PF, DR, TL, and CL):

RT = the ratio of total areas of buffer zones to the area of the fishery expressed as a percent

C = the catch loss expressed as a percent of what landings would otherwise have been.

DL = the expected dollar loss based on the value of landings in the fishery

2.3 Estimation of Parameters

The parameter a^2, also called the dispersion coefficient, is a measure of the degree to which fish undertake random movement over a period of time. Unfortunately there is a paucity of data with which to estimate this parameter with precise accuracy. A thorough review of the literature was undertaken and for only two relevant species, haddock and winter flounder, was there specific research which undertook to measure this parameter. For many of the other species involved there has been general research which provides some information on movement patterns. One reason for this is the fact that most tagging studies are undertaken to determine overall seasonal movements, seasonal distribution, abundance, or growth rates of fish stocks. In this regard fish recaptured within a short time period following release have traditionally been of little interest to the investigators. Individual recoveries of tagged fish which would be necessary to calculate an a^2 have rarely been reported in the literature.

In order to obtain estimates of a^2 for the model the approach has been to review available information on movement behavior and draw appropriate analogies. Note from Exhibit 2-2 that the catch loss parameter M is not extremely sensitive to precise values of the dispersion coefficient. Feeding and general behavior patterns of most fish species will tend to determine the extent of daily movements. Within any buffer zone, species which tend to be relatively sedentary would be less readily available to fishing gear than would a species which actively seeks and pursues a mobile prey. In this context the gadid species, particularly cod and silver hake, would be more likely to move out of a buffer zone during daily feeding activities than would most of the flatfish (flounders and soles) which remain buried in the substrate except for sporadic feeding activities. Flatfish are relatively poor swimmers and are well-adapted to a semi-sedentary existence, whereas the gadids, although demersal, are relatively mobile fish. Appendix 1 summarizes the relevant findings on species movement from the literature review.

Certain of the species which have been analyzed exhibit periods of migratory behavior on a seasonal basis. To the extent possible these periods were disregarded in estimating the dispersion coefficient. This is because the periods of migration are typically of short duration and the situation of most interest to this analysis is the period of time when the fish are "on the fishing grounds".

Exhibit 2-6 presents the movement parameter values which have been estimated for the purpose of this analysis. The dispersion coefficient is expressed in miles squared per day and the buffer zone distance is expressed in miles. For the purposes of the model a buffer zone distance of 0.5 miles was used for b in the case of platforms and drilling rigs. This represents an allowance of 0.25 miles for anchoring systems and/or satelite subsea completions plus 0.25 miles for the high range of buffer zone distances as presented in Section 3.6 of Volume I. This may also

Exhibit 2-6

Species Parameters

	Daily a2	Daily a2/b2	F	Catch Loss Parameter M
North Atlantic				
Flatfish (flounder)	0.03	0.12	0.5	0.0005
Other Groundfish (non-flatfish)	2.2	8.8	0.25	0.00002
Ocean Quahog/Surf Clam	0.0	0.0	0.25	0.001
Sea Scallop	0.014	0.056	0.9	0.0012
Lobster	0.0004	0.0016	0.8	0.003
Mid-Atlantic				
Groundfish	2.2	8.8	0.4	0.00003
Ocean Quahog	0.0	0.0	0.15	0.0007
Surf Clam	0.0	0.0	0.25	0.001
Sea Scallop	0.014	0.056	0.7	0.001
Lobster	0.0004	0.0016	0.5	0.002
South Atlantic				
Groundfish	2.2	8.8	0.3	0.000025
Shrimp	2.0	8.0	1.0	0.00005

Exhibit 2-6 (cont.)

Species Parameters

	Daily a2	Daily a2/b2	F	Catch Loss Parameter M
Eastern Gulf of Mexico				
Shrimp	2.0	8.0	2.6	0.0001
Croaker (non-food-fish)	0.03	0.12	0.4	0.00035
Southern California				
Rockfish	6.8e-5	2.5e-4	0.4	0.0015
Sole	0.03	0.12	0.3	0.0003
Northern California				
Rockfish	6.8e-5	2.7e-4	0.4	0.0015
Sole	0.03	0.12	0.3	0.0003
Shrimp	2.0	8.0	1.4	0.00006

* e-5 means times 10^{-5}

Source: See Text.

be on the high side because not all platforms will have anchoring systems or satelite subsea completions. (This effect may cancel out however, because some satelite subsea completion systems may be somewhat larger than this.) Buffer zone distances for pipelines have been estimated at 0.25 miles as per Volume I. This is also the high range. Species have been segmented into fishery groups by region having relatively similar parameters. The values of F have been selected from data in the various applicable Fishery Management Plans. Where specific data was not available estimates were made based on general characteristics of the fishery. The following presents the rationale for the values selected for a^2 based on the best currently available data.

a) Flounder

As discussed in Appendix 1 a tagging study of winter flounder showed a calculated a^2 of 0.03 during a period when the directional component was at a low value of 0.0004 miles. This represents a situation where the fish were not undertaking migrations. Thus this is the best situation to estimate the truly random component of movement. In lieu of better data for any of the other species, this figure is applied to all flounder since the literature review suggests that their movement behavior is likely to be similar.

b) Other Groundfish

As discussed in Appendix 1 a study analyzing haddock movements showed a dispersion coefficient of 2.2 when the directional component was at a low value of 0.024 miles indicating no migration. In lieu of better data for the other species this figure is applied to all non-flounder groundfish since their movement behavior is likely to be similar.

c) Ocean Quahog

These are essentially sedentary and have been assigned a dispersion coefficient of 0.

d) Surf Clam

These are essentially sedentary and have been assigned a dispersion coefficient of 0.

e) Sea Scallop

From Appendix 1 a tagging study showed that within 6 months 20 percent of tagged scallops were taken beyond 2 miles of the release site and three percent were taken beyond 10 miles. Since scallops are essentially non-migratory it is assumed that these data represent a normal or Gaussian distribution function with the statistical variance representing the dispersion coefficient. Under this assumption the data imply that two miles equals 1.28 standard deviations (i.e. 1.28 standard deviations corresponds to the 80th percentile of a one-sided normal distribution) for the probability distribution at 180 days. The standard deviation (for 180 days) is thus equal to (2.0/1.28) or 1.56 miles. The variance (for 180 days) which is the square of the standard deviation equals 2.43. Since the standard deviation for 180 days equals 180 times the daily standard deviation or 180 times a^2, a^2 equals 2.43/180 which equals 0.014.

In summary:

$$2 \text{ miles} = 1.28 * a_{(180 \text{ days})}$$

$$\text{or } a^2_{(\text{daily})} = (2/1.28)^2/180 = 0.014$$

$$10 \text{ miles} = 2.96 * a_{(180 \text{ days})}$$

$$\text{or } a^2_{(\text{daily})} = (10/2.96)^2/180 = 0.063$$

Taking the lower value, 0.014 was assigned as the dispersion coefficient.

f) Northern Lobster

Precise data for the dispersion coefficient of lobster are not available. However, from Appendix 1 local directional movements appear to be in the range of 0.006 to 0.06 miles per day. If it is assumed that the upper figure of 0.06 miles per day represents three standard deviations of a normal probability distribution. (This corresponds approximately to the 99th percentile of a one-sided normal distribution), then the daily standard deviation would equal 0.06/3 or 0.02. The dispersion coefficient which is the square of the daily standard deviation would thus equal 0.0004.

g) Shrimp

Precise data for the dispersion coefficient for shrimp are not available. From Appendix 1 it appears that shrimp show a considerable degree of movement. In general shrimp undertake moderate degrees of migrations. White shrimp appear to be more highly migratory than either brown shrimp or white shrimp. During migrations white shrimp can move at 1 to 4 miles per day. Although their migrations are not as extensive as white shrimp, brown shrimp can travel at 2-3 miles per day. Once on the fishing grounds where they spend most of their adult life cycle pink shrimp have a lower speed of movement of approximately 0.3 miles per day.

In general once on the fishing grounds (where they spend most of their adult life cycle) most shrimp stocks will move about within a range of roughly 30-40 miles. Shrimp frequently move horizontal distances by moving up from the bottom in order to drift with currents. The general movement behavior of shrimp suggests that they exhibit a considerable degree of dispersion movement. With the exception of pink shrimp the above data on speeds of movement suggest that shrimp may undertake local daily movements at rates similar to those for haddock which would imply a dispersion coefficient with an order of magnitude around 2.0.

From Appendix 1 it was reported that for brown shrimp few tagged individuals travel more than 30 miles. The maximum distance reported was 70 miles, while the average distance traveled was 16 miles. If it is assumed that this represents random movement and not migration, the method described for calculating the dispersion coefficients under sea scallops above can be applied. The following assumptions are made. Seventy miles (the maximum distance traveled) represents three standard deviations. Sixteen miles represents the median (although it is really the mean) distance traveled which corresponds to 0.67 standard deviations. These took place within 180 days. Similarly, for pink shrimp while on the fishing grounds (where they apparently do not migrate extensively) the maximum distance traveled was 35 miles in 106 days. Based upon these assumptions the following values for the dispersion coefficient result:

For brown shrimp:

$$70 \text{ miles} = 3.0 * a_{(180)}$$

$$\text{or} \quad a^2_{(daily)} = (70/3)^2/180 = 3.02$$

$$16 \text{ miles} = 0.67 * a_{(180)}$$

$$\text{or} \quad a^2_{(daily)} = (16/0.67)^2/180 = 3.17$$

For pink shrimp:

$$35 \text{ miles} = 3.0 * a_{(106)}$$

$$\text{or} \quad a^2_{(daily)} = (35/3)^2/106 = 1.28$$

Based on the above considerations shrimp have been assigned a dispersion coefficient of 2.0.

h) Croaker

Data specific to the movement of croaker are not available. From Appendix 1, related species move at typical rates of 0.6 to 2 miles per day. In lieu of better available data the assumption has been made that the dispersion coefficient is similar to that of flounder or 0.03.

i) Rockfish

Rockfish appear to be resident in very localized areas. No specific movement data are available. However from Appendix 1, Atlantic redfish which are similarly resident in character showed a maximum movement of 2/3 mile in two years. Assuming that this represents three standard deviations of a normal probability distribution, the standard deviation over 730 days (two years) equals 0.223 miles. The variance over 730 days equals the square of the standard deviation or 0.0499. The dispersion coefficient equals the daily standard deviation which equals 0.0499/730 or 6.8 times 10^{-5}.

j) Sole

From the literature review described in Appendix 1 the various species of sole exhibit seasonal migration at rates ranging from roughly 0.8 to 4 miles per day. Typical values are probably closer to 1 mile per day. These rates are similar to those for flounders. This fact and the fact that general behavior of these species is similar to flounders suggests that the dispersion coefficient should be of the same order of magnitude. Sole has thus been assigned a dispersion coefficient of 0.03.

3.0 North Atlantic Region

Major domestic fisheries for which a discernible catch loss impact is expected include:

- Ocean Quahog
- Sea Scallop
- Lobster Otter Trawl
- Groundfish Otter Trawl (flounder)
- Groundfish Otter Trawl (other groundfish)

The groundfish were separated into two fisheries for this analysis because flounder as opposed to other groundfish appear to have significantly different local movement characteristics resulting in significantly different results from the catch loss model. The model was applied to the above fisheries and the results are presented in this section. Exhibit 3-1 presents the values for parameters which were used in the application of the model. The benchmark value of landings was a figure chosen to represent the typical future value of the landings in each fishery. It was based on the trend line in landings with a subjective adjustment for future growth potential. The price applied to these landings was based on recent price trends in the fishery. No attempt was made to project future price increases inasmuch as inflationary price trends can be incorporated by viewing the dollar loss as future losses expressed in 1980 dollars. Also, the real purpose of this figure is to provide a relative benchmark for comparing the impact of the projected loss in catch. The area of the fishery is an input into Stage II of the model although the model is not particularly sensitive to it. It was estimated by review of generally accepted boundaries of fisheries with emphasis on the particular area where the fishery is fished extensively. Where a fishery crossed into another region only the area in this region was included. The percentage of lease area and the percentage of trunkline in a fishery was estimated based on a comparison of potential lease sites and pipeline corridors with the generally accepted boundaries of the fishery.

Buffer zone distances used were 0.5 miles for drilling rigs and platforms (this includes 0.25 miles for the actual buffer zone and 0.25 miles for the extent of an anchoring system or satellite subsea completions) and 0.25 miles for pipelines. Referring to Section 3.0, Volume I it can be seen that these buffer zone distances are on the high end of the expected range and in fact many of the platforms will be vertical bottom-founded structures without the extended anchoring systems. Also, as discussed in Section 3.6 of Volume I a buffer zone around a pipeline may not exist in fact.

The OCS development scenario selected for analysis is that associated with OCS Lease Sale No. 52. The mean case input parameters describing this lease sale are presented in Exhibit 3-2 over an expected 30 year period.

Exhibit 3-1

Model Inputs
North Atlantic Region

Fishery	Benchmark Value of Landings (thousand dollars)	F	Area of Fishery (square miles)	Percent[6] of Lease Area in Fishery	Percent Trunkline[6] in Fishery	Catch Loss Parameter
Groundfish[1] Otter Trawl, Flounder.	24,000	0.5	10,000	0.8	1.0	5.0e-04
Other[2] Groundfish Otter Trawl	26,250	0.25	10,000	0.4	1.0	2.0e-05
Ocean Quahog/[3] Surf Clam	3,500	0.25	2,000	0.3	0.1	1.0e-03
Sea Scallop[4]	30,000	0.9	3,000	0.3	0.05	1.2e-03
Lobster[5] Otter Trawl	3,600	0.8	4,000	0.7	0.05	3.0e-03

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1 The value of flatfish landings by otter trawl gear for the New England Region was derived by applying the average 1979 price of 40 cents per pound to 60 million pounds. Major species included in this group were blackback flounder, fluke, gray sole, lemon sole, sand dab, and yellowtail flounder. The price per pound for flatfish species vary by up to 50 percent and a weighted average price was developed based on the average relative proportion of landings. Recent prices of various flatfish were obtained from fisheries of the U. S. (NMFS, 1979) five year average landings for the 1971 to 1975 period were calculated (NMFS, 1971 to 1975). Total flatfish landings have increased approximately 40 percent since that time. Total landings were not increased in the model's inputs because a large portion of total flatfish landed in this region is harvested in areas other than those associated with possible OCS development and pipeline routes. An F-value of 0.5 was projected for yellowtail founder in the Fishery Management Plan for Atlantic Groundfish. (New England Fishery Management Council, 1977). This F-value was only available for flounder and was used for all flatfish. This F-value may be slightly lower for other flounder species and this represents an estimate for projecting impacts.

The size of the fishing area was projected in overlay number 3 of Fishing and Petroleum Interactions on Georges Bank (New England Regional Commission, 1977). This area was increased slightly to account for flounder fishing areas located near shore between the 20 and 40 meter isobath. Unique calculations were used for flatfish, such as flounder and Groundfish, due to the different fishing exploitation rates and catch loss parameters for these two species.

2 The benchmark value of landings for other groundfish otter trawling for this region was derived by applying a weighted average price of 30 cents per pound to 88 million pounds. Species included in this group were: cod, Atlantic ocean perch, pollock, and whiting. Twenty other species combined account for about 10 percent of the value of landings. A weighted average price was developed by applying a relative weighting to 1979 prices for different species. Recent prices of the various species were obtained from Fisheries of the U.S (NMFS, 1979). Five year average landings were estimated at 88 million pounds for 1971 to 1975 (NMFS 1971 to 1975). Total groundfish landings have increased approximately 40 percent since the 1971 to 1975 period. Total landings were not increased as a large portion of total catch is harvested in areas other than those associated with possible OCS development. An F-value of 0.2 was projected for Cod and 0.5 for haddock in the Fishery Management Plan for Atlantic Groundfish and 0.1 for Pollock (New England Fishery Management Council 1977a, 1978a). An average F-value of 0.25 was assumed for all non-flat groundfish. The size of fishing area was projected from fishing productivity maps of Georges Bank and Nantucket shoals (New England Regional Commission, 1977). These are the two main fishing areas for groundfish. This area was slightly expanded to include fishing grounds in other areas near shore.

3 The benchmark value of ocean quahog and surf clams was derived by applying the average 1979 price of 40 cents per pound to 8.75 million pounds or 600,000 bushels. This projection is greatly in excess of current landings. Maximum sustainable is projected at 3.5 million bushels of ocean quahogs and 25,000 bushels of surf clams for this region. It is unlikely that production of ocean quahogs will approach this level but the potential production is expected to be greatly expanded from current levels. This projection is optimistic and represents a maximum benchmark at the time when oil development would take place. An average F-value of 0.25 was projected for the Mid-Atlantic Region in the Surf Clam and Ocean Quahog Fishery Management Plan (Mid-Atlantic Fishery Management Council 1979) and was used for this region. The size of the fishing grounds were projected from fishing productivity maps of Georges Bank and Nantucket Shoals (New England Regional Commission, 1977).

4 Sea scallop landings were projected at 9 million pounds and were valued at $30 million with a price of $3.33. This price was the average 1979 price from Fisheries of the United States (NMFS, 1979). The 9 million pounds of meat landed is greater than the 5 year average landings of 1971 to 1975 (NMFS 1971-75) and reflects increased effort due to higher prices.

An F-value was estimated at 0.66 for calico scallops (Allen, P. 1972). This value was increased to 0.9 to reflect extremely fishing pressure on scallop stocks. Fishing area was estimated at 3,000 square miles from charts in Fishing and Petroleum Interactions on Georges Bank (New England Regional Commission, 1977)

[5] The value of lobster landings associated with otter trawling gear is $3.6 million and was derived by applying a price of $2 to 1.8 million pounds. Price was determined from Fisheries of the United States, 1979. Average otter trawl landings between 1970 and 1975 was 1.2 million pounds. To reflect total incidental catch of American Lobster by other otter trawl vessels catch was increased. An F-value of 0.8 was obtained from the Lobster Fishery Management Plan (New England Fishery Management Council, 1978). Square miles of fishing area was estimated at 4,000 square miles from charts in Fishing and Petroleum Interactions on Georges Bank (New England Regional Commission, 1977). Lobster trawling primarily takes place along to 100 to 500 fathom drop off and this area was measured to determine fishing area.

[6] The portion of the lease area in the fishery was estimated using the relative location of fishing grounds and the lease blocks. Data on fisheries location were taken from visuals from New England Regional Commission (1977). Data on lease blocks and pipeline routes were taken from preliminary visuals for Lease Sale No. 52 supplied by BLM New York Outer Continental Shelf Office. Lease sale areas were charted relative to fishing grounds. The portion of trunk line in the fishery was estimated similarly using a subjective interpretation of potential pipeline routes.

Results of the catch loss analysis are presented over a thirty year mean case development scenario by species in Exhibits 3-3 through 3-7. Percent of area lost is the actual percent (as opposed to a fraction) of the fishery occupied by both the surface and sub-surface OCS structures including the associated buffer zones. Percent of catch lost is the expected decrease in catch (expressed in percent) as determined by applying the methodology described in Section 2.0. Dollar loss is simply the percentage of catch lost times the benchmark value of landings presented in Exhibit 3-1. Note that this figure is expressed in thousands of dollars with a decimal point (not a comma).

Exhibit 3-8 shows the range of area loss, catch loss and associated dollar loss from the catch model over various levels of OCS development. The maximum figure represents the catch model using the high case scenario for the amount of OCS development. This is for one of the steady state years such as 2009 after the development phase. The mean figure represents the mean case development scenario for that year such as presented in the previous Exhibits. The minimum figure represents the low case development scenario.

Exhibit 3-2

PROJECTED DEVELOPMENT SCENARIO
FOR OCS ACTIVITY (MEAN CASE)
NORTH ATLANTIC LEASE SALE NO. 52.

YEAR	NUMBER OF PLATFORMS	NUMBER OF DRILLING RIGS	MILES OF TRUNKLINE	MILES OF CONNECTING LINE
1980	0	0	0	0
1981	0	0	0	0
1982	0	0	0	0
1983	0	0	0	0
1984	0	1	0	0
1985	0	2	0	0
1986	0	1	0	0
1987	0	1	0	0
1988	0	0	0	0
1989	0	0	0	0
1990	0	0	0	0
1991	12	0	0	0
1992	17	0	0	0
1993	20	0	0	0
1994	20	0	100	20
1995	20	0	200	50
1996	20	0	250	80
1997	20	0	300	103
1998	20	0	300	103
1999	20	0	300	103
2000	20	0	300	103
2001	20	0	300	103
2002	20	0	300	103
2003	20	0	300	103
2004	20	0	300	103
2005	20	0	300	103
2006	20	0	300	103
2007	20	0	300	103
2008	20	0	300	103
2009	20	0	300	103

Source: Platforms, rigs, trunkline, and connecting line by year (all for the low, mean and high cases) given by personnal communication from Mr. Neville Chow, Bureau of Land Management, New York Outer Continental Shelf Office.

Exhibit 3-3

Catch Loss

North Atlantic Region-Lease Sale No. 52

Ocean Quahog Fishery

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.000000	0.00000000	0.000
1982	0.000000	0.00000000	0.000
1983	0.000000	0.00000000	0.000
1984	0.011781	0.00117810	0.041
1985	0.023562	0.00235620	0.082
1986	0.011781	0.00117810	0.041
1987	0.011781	0.00117810	0.041
1988	0.000000	0.00000000	0.000
1989	0.000000	0.00000000	0.000
1990	0.000000	0.00000000	0.000
1991	0.141372	0.01413720	0.495
1992	0.200277	0.02002770	0.701
1993	0.235620	0.02356200	0.825
1994	0.635620	0.06356200	2.225
1995	1.110620	0.11106200	3.887
1996	1.460620	0.14606200	5.112
1997	1.758120	0.17581200	6.153
1998	1.758120	0.17581200	6.153
1999	1.758120	0.17581200	6.153
2000	1.758120	0.17581200	6.153
2001	1.758120	0.17581200	6.153
2002	1.758120	0.17581200	6.153
2003	1.758120	0.17581200	6.153
2004	1.758120	0.17581200	6.153
2005	1.758120	0.17581200	6.153
2006	1.758120	0.17581200	6.153
2007	1.758120	0.17581200	6.153
2008	1.758120	0.17581200	6.153
2009	1.758120	0.17581200	6.153

Exhibit 3-4

Catch Loss

North Atlantic Region-Lease Sale No. 52

Sea Scallop Fishery

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.000000	0.00000000	0.000
1982	0.000000	0.00000000	0.000
1983	0.000000	0.00000000	0.000
1984	0.007854	0.00094248	0.283
1985	0.015708	0.00188496	0.565
1986	0.007854	0.00094248	0.283
1987	0.007854	0.00094248	0.283
1988	0.000000	0.00000000	0.000
1989	0.000000	0.00000000	0.000
1990	0.000000	0.00000000	0.000
1991	0.094248	0.01130980	3.393
1992	0.133518	0.01602220	4.807
1993	0.157080	0.01884960	5.655
1994	0.340413	0.04084960	12.255
1995	0.573747	0.06884960	20.655
1996	0.765414	0.09184960	27.555
1997	0.922080	0.11065000	33.195
1998	0.922080	0.11065000	33.195
1999	0.922080	0.11065000	33.195
2000	0.922080	0.11065000	33.195
2001	0.922080	0.11065000	33.195
2002	0.922080	0.11065000	33.195
2003	0.922080	0.11065000	33.195
2004	0.922080	0.11065000	33.195
2005	0.922080	0.11065000	33.195
2006	0.922080	0.11065000	33.195
2007	0.922080	0.11065000	33.195
2008	0.922080	0.11065000	33.195
2009	0.922080	0.11065000	33.195

Exhibit 3-5

Catch Loss

North Atlantic Region-Lease Sale No. 52

Lobster Otter Trawl Fishery

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.000000	0.00000000	0.000
1982	0.000000	0.00000000	0.000
1983	0.000000	0.00000000	0.000
1984	0.013745	0.00412335	0.148
1985	0.027489	0.00824670	0.297
1986	0.013745	0.00412335	0.148
1987	0.013745	0.00412335	0.148
1988	0.000000	0.00000000	0.000
1989	0.000000	0.00000000	0.000
1990	0.000000	0.00000000	0.000
1991	0.164934	0.04948020	1.781
1992	0.233657	0.07009690	2.523
1993	0.274890	0.08246700	2.969
1994	0.512390	0.15371700	5.534
1995	0.837390	0.25121700	9.044
1996	1.131140	0.33934200	12.216
1997	1.363640	0.40909200	14.727
1998	1.363640	0.40909200	14.727
1999	1.363640	0.40909200	14.727
2000	1.363640	0.40909200	14.727
2001	1.363640	0.40909200	14.727
2002	1.363640	0.40909200	14.727
2003	1.363640	0.40909200	14.727
2004	1.363640	0.40909200	14.727
2005	1.363640	0.40909200	14.727
2006	1.363640	0.40909200	14.727
2007	1.363640	0.40909200	14.727
2008	1.363640	0.40909200	14.727
2009	1.363640	0.40909200	14.727

Exhibit 3-6

Catch Loss

North Atlantic Region-Lease Sale No. 52

Groundfish Otter Trawl Fishery
Other Groundfish (non-flounder)

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.000000	0.00000000	0.000
1982	0.000000	0.00000000	0.000
1983	0.000000	0.00000000	0.000
1984	0.003142	0.00000628	0.002
1985	0.006283	0.00001257	0.003
1986	0.003142	0.00000628	0.002
1987	0.003142	0.00000628	0.002
1988	0.000000	0.00000000	0.000
1989	0.000000	0.00000000	0.000
1990	0.000000	0.00000000	0.000
1991	0.037699	0.00007540	0.020
1992	0.053407	0.00010681	0.028
1993	0.062832	0.00012566	0.033
1994	0.602832	0.00120566	0.316
1995	1.162830	0.00232566	0.610
1996	1.472830	0.00294566	0.773
1997	1.768830	0.00353766	0.929
1998	1.768830	0.00353766	0.929
1999	1.768830	0.00353766	0.929
2000	1.768830	0.00353766	0.929
2001	1.768830	0.00353766	0.929
2002	1.768830	0.00353766	0.929
2003	1.768830	0.00353766	0.929
2004	1.768830	0.00353766	0.929
2005	1.768830	0.00353766	0.929
2006	1.768830	0.00353766	0.929
2007	1.768830	0.00353766	0.929
2008	1.768830	0.00353766	0.929
2009	1.768830	0.00353766	0.929

Exhibit 3-7

Catch Loss

North Atlantic Region-Lease Sale No. 52

Groundfish Otter Trawl Fishery
Flounder

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.000000	0.00000000	0.000
1982	0.000000	0.00000000	0.000
1983	0.000000	0.00000000	0.000
1984	0.006283	0.00031416	0.075
1985	0.012566	0.00062832	0.151
1986	0.006283	0.00031416	0.075
1987	0.006283	0.00031416	0.075
1988	0.000000	0.00000000	0.000
1989	0.000000	0.00000000	0.000
1990	0.000000	0.00000000	0.000
1991	0.075398	0.00376992	0.905
1992	0.106814	0.00534072	1.282
1993	0.125664	0.00628320	1.508
1994	0.705664	0.03528320	8.468
1995	1.325660	0.06628320	15.908
1996	1.695660	0.08478320	20.348
1997	2.037660	0.10188300	24.452
1998	2.037660	0.10188300	24.452
1999	2.037660	0.10188300	24.452
2000	2.037660	0.10188300	24.452
2001	2.037660	0.10188300	24.452
2002	2.037660	0.10188300	24.452
2003	2.037660	0.10188300	24.452
2004	2.037660	0.10188300	24.452
2005	2.037660	0.10188300	24.452
2006	2.037660	0.10188300	24.452
2007	2.037660	0.10188300	24.452
2008	2.037660	0.10188300	24.452
2009	2.037660	0.10188300	24.452

Exhibit 3-8

Minimum and Maximum Losses
Expected With Different Levels of OCS
Activity in the North Atlantic
Lease Sale No. 52

Fishery		Percent of Area Lost	Percent of Catch Lost	Dollar Loss (thousands)
Groundfish Otter Trawl (Flounder)				
	Maximum	2.6405	0.1320	31.686
	Mean	2.0377	0.1019	24.452
	Minimum	0.0063	0.0003	0.075
Other Groundfish Otter Trawl				
	Maximum	2.3203	0.0046	1.218
	Mean	1.7688	0.0035	0.929
	Minimum	0.0031	0.000006	0.002
Ocean Quahog/Surf Clam				
	Maximum	2.2009	0.2201	7.703
	Mean	1.7581	0.1758	6.153
	Minimum	0.0118	0.0012	0.041
Sea Scallop				
	Maximum	1.1340	0.1361	40.822
	Mean	0.9221	0.1107	33.195
	Minimum	0.0079	0.0009	0.283

Exhibit 3-8 (cont.)

Minimum and Maximum Losses
Expected With Different Levels of OCS
Activity in the North Atlantic Region
Lease Sale No. 52

Fishery	Percent of Area Lost	Percent of Catch Lost	Dollar Loss (Thousands)
Lobster Otter Trawl			
Maximum	1.6511	0.4953	17.832
Mean	1.3636	0.4091	14.727
Minimum	0.0137	0.0041	0.148

OCS Activities

	Platforms	Drilling Rigs	Miles of Trunkline	Miles of Connecting Line
Maximum[1]	30	0	400	113
Mean	20	0	300	103
Minimum[1]	1	0	0	0

[1] Figures for minimum and maximum obtained as in Exhibit 3-2 with respect to the low and high case data.

4.0 Mid-Atlantic Region

Major domestic fisheries for which a discernible catch loss impact is expected include:

- Surf Clam
- Ocean Quahog
- Groundfish Otter Trawl
- Lobster Otter Trawl
- Sea Scallop

The model was applied to these fisheries and the results are presented in this section. Exhibit 4-1 presents the values for parameters which were used in the application of the model. The benchmark value of landings was a figure chosen to represent the typical future value of the landings in each fishery. It was based on the trend line in landings with a subjective adjustment for future growth potential. The price applied to these landings was based on recent price trends in the fishery. No attempt was made to project future price increases inasmuch as inflationary price trends can be incorporated by viewing the dollar loss as future losses expressed in 1980 dollars. Also, the real purpose of this figure is to provide a relative benchmark for comparing the impact of the projected loss in catch. The area of the fishery is an input into Stage II of the model although the model is not particularly sensitive to it. It was estimated by review of generally accepted boundaries of fisheries with emphasis on the particular area where the fishery is fished extensively. Where a fishery crossed into another region only the area in this region was shown. The percentage of lease area and percentage of trunkline in a fishery was estimated based on a comparison of potential lease sites and pipeline corridors with the generally accepted boundaries of the fishery.

Buffer zone distances used were 0.5 miles for drilling rigs and platforms (this includes 0.25 miles for the actual buffer zone and 0.25 miles for the extent of an anchoring system or satellite subsea completions) and 0.25 miles for pipelines. Referring to Section 3.0, Volume I it can be seen that these buffer zone distances are on the high end of the expected range and in fact many of the platforms will be vertical bottom-founded structures without the extended anchoring systems. Also, as discussed in Section 3.6 of Volume I a buffer zone around a pipeline may not exist in fact.

The OCS development scenario selected for analysis is that associated with OCS Lease Sale No. 59. The mean case input parameters describing this lease sale are presented in Exhibit 4-2 over an expected 30 year period.

Results of the catch loss analysis are presented over a thirty year mean case development scenario by species in Exhibits 4-3 through 4-7.

Exhibit 4-1

Model Inputs

Mid-Atlantic Region

Fishery	Benchmark Value of Landings (thousand dollars)	F	Area of Fishery (square miles)	Percent[6] of Lease Area in Fishery	Percent of[6] Trunkline in Fishery	Catch Loss Parameter
Surf Clam[1]	25,000	0.25	10,000	0.0	0.5	1.0e-03
Ocean Quahog[2]	14,700	0.15	10,000	0.4	0.65	7.0e-04
Groundfish[3] Otter Trawl	15,000	0.4	6,000	0.3	1.0	3.0e-05
Lobster[4] Otter Trawl	2,250	0.5	10,000	0.9	1.0	2.0e-03
Sea Scallop[5]	12,000	0.7	6,000	0.3	1.0	1.0e-03

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1 The value of surf clams was derived by applying the average 1979 price of 55 cents to 45 million pounds. Recent prices of surf clams are available in Fisheries of the U.S. (NMFS, 1979). Five year average landings of 65 million pounds were available from the same source. The 1974 to 1978 average was reduced to 45 million pounds to reflect declining productivity in this region and the biological limits noted in the Surf Clam and Ocean Quahog Fishery Management Plan (Mid-Atlantic Fishery Council, 1977). The F-value, or harvesting mortality rate, was also available from the management plan and was .25. This low F-value is consistent with a fishery with a high utilization rate and a slow growth rate such as surf clams. Area in the fishery was estimated by charting the 0 to 40 meter isobaths. This is the area in which the majority of surf clam dredging takes place. The North-South limits range from Southern Virginia to New York. Commercial grounds are primarily concentrated off the Virginia, Maryland and New Jersey coasts.

2 Ocean quahog landings were projected at a baseline of $14.7 million. This represents a 50 percent increase over 1979 landings which were valued at $10 million. This projection takes into consideration the extreme recent growth of this fishery and plans to increase utilization of this resource. Informal contact with NMFS officials late in 1980 indicate that catch will again be up in 1980. A F-value of .15 is projected in the Surf Clam and Ocean Quahog Management Plan. This low F-value reflects a slower growth rate and increased utilization (Mid Atlantic Fishery Management Council, 1979). Area in the fishery was derived by charting the 30 to 75 meter isobath.

3 The value of groundfish was derived by applying the average 1979 price of 33 cents per pound to average landings of 45 million pounds (NMFS, 1979). Species included in this group primarily were butterfish, flounder, scup, gray sea trout, striped bass, whiting, hake, black drum and black sea bass. Benchmark landings were derived by calculating average landings between 1971 and 1975 as reported in Fishery Statistics of the United States (NMFS, 1979). The average ex-vessel price per pound used was weighted for species composition. Landings were specifically for otter trawl gear and did not include the listed species caught with other gear types. The F-value for this fishery was derived in the Fishery Management Plan for Atlantic Groundfish (The New England Regional Fisheries Management Council, 1977). However, this F-value applies to the New England region where fishing pressure is greater. Fishing mortality in this region was estimated at 0.4. The square miles of fishing area was estimated by charting the 0 to 40 meter isobath. Total area was reduced to account for the fact that activity is primarily concentrated in areas off the New Jersey, New York, and Virginia coasts.

4 The baseline value of lobster trawling was derived by applying the 1979 average price of $2.00 per pound to 1,125 million pounds. Average landings (NMFS, 1971-75) between 1971 and 1975 were 750,000 pounds. This figure was increased by 100,000 pounds to reflect the incidental catch of lobster in other trawl fisheries and by 275,000 pounds to reflect increased participation. The F-value was developed for the Draft Lobster Fishery Management Plan and was estimated at 0.8 North Atlantic Fishery Management Plan, 1978. An F-value of 0.5 was utilized for the Mid-Atlantic region to reflect a lower level of pressure on the fish stocks in this region. An area of 10,000 square miles was estimated by charting the 30 to 200 meter isobath. Effort in the lobster trawl is essentially limited to the area off the New York Coast with very little effort in the southern areas of the region.

5 Sea scallop landings for the Mid Atlantic region had a baseline value of $12 million. This is derived by applying an average 1979 price of $3.00 per pound (NMFS, 1979) to 4 million pounds (NMFS, 1971-75). The 1974 to 1978 average landings were 1.8 million pounds in this region. Interest in this fishery has greatly expanded and current landings are believed to be approximately 4 million pounds. F-values for scallops were unavailable from a management plan. Mortality was estimated at 0.66 for the Calico Scallop (Allen, 1972). This appears to be an appropriate value due to extremely high harvesting pressure on Scallop stocks. Square miles of fishing area was estimated at 6,000 square miles by charting the 30 to 75 meter isobath (Department of Interior, Lease Sale No. 49., 1979). The total area was reduced to reflect the fact that sea scallops are highly concentrated in beds.

6 The portion of the lease area in the fishery was estimated using the relative location of the fishing grounds and the lease blocks in BLM EIS Lease Sale 49, Visual No. 6. The portion of trunk line in the fishery was estimated similarly using a subjective interpretation of potential pipeline routes.

Percent of area lost is the actual percent (as opposed to a percentage) of the fishery occupied by both the surface and sub-surface OCS structures including the associated buffer zones. Percent of catch lost is the expected decrease in catch (expressed as a percent) as determined by applying the methodology described in Section 2.0. Dollar loss is simply the percentage of catch lost times the benchmark value of landings presented in Exhibit 4-1. Note that this figure is expressed in thousands of dollars with a decimal point (not a comma).

Exhibit 4-8 shows the range of area loss, catch loss and associated dollar loss from the catch model over various levels of OCS development. The maximum figure represents the catch model using the high case scenario for the amount of OCS development. This is for one of the steady state years such as 2009 after the development phase. The mean figure represents the mean case development scenario for that year such as presented in the previous Exhibits. The minimum figure represents the low case development scenario.

Exhibit 4-2

PROJECTED DEVELOPMENT SCENARIO
FOR OCS ACTIVITY (MEAN CASE)
MID-ATLANTIC LEASE SALE NO. 59

YEAR	NUMBER OF PLATFORMS	NUMBER OF DRILLING RIGS	MILES OF TRUNKLINE	MILES OF CONNECTING LINE
1980	0	0	0	0
1981	0	1	0	0
1982	0	1	0	0
1983	0	1	0	0
1984	0	1	0	0
1985	0	2	0	0
1986	0	2	0	20
1987	9	0	50	40
1988	18	13	100	60
1989	24	25	150	80
1990	26	20	200	90
1991	26	20	270	100
1992	26	20	270	100
1993	26	20	270	100
1994	26	15	270	100
1995	26	10	270	100
1996	26	3	270	100
1997	26	0	270	100
1998	26	0	270	100
1999	26	0	270	100
2000	26	0	270	100
2001	26	0	270	100
2002	26	0	270	100
2003	26	0	270	100
2004	26	0	270	100
2005	26	0	270	100
2006	26	0	270	100
2007	26	0	270	100
2008	26	0	270	100
2009	26	0	270	100

Source: Platforms and rigs by year and total pipelines (all for low, mean and high cases) given by personnal communication from Mr. Neville Chow, Bureau of Land Management, New York Outer Continental Shelf Office. Breakdown between trunkline and connecting line estimated by Centaur Associates.

Exhibit 4-3

Catch Loss

Mid Atlantic Region-Lease Sale No. 59

Lobster Otter Trawl Fishery

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.007069	0.00141372	0.032
1982	0.007069	0.00141372	0.032
1983	0.007069	0.00141372	0.032
1984	0.007069	0.00141372	0.032
1985	0.014137	0.00282744	0.064
1986	0.104137	0.02082740	0.469
1987	0.493617	0.09872350	2.221
1988	0.989127	0.19782500	4.451
1989	1.456360	0.29127200	6.554
1990	1.730160	0.34603100	7.786
1991	2.125160	0.42503100	9.563
1992	2.125160	0.42503100	9.563
1993	2.125160	0.42503100	9.563
1994	2.089810	0.41796300	9.404
1995	2.054470	0.41089400	9.245
1996	2.004990	0.40099800	9.022
1997	1.983780	0.39675700	8.927
1998	1.983780	0.39675700	8.927
1999	1.983780	0.39675700	8.927
2000	1.983780	0.39675700	8.927
2001	1.983780	0.39675700	8.927
2002	1.983780	0.39675700	8.927
2003	1.983780	0.39675700	8.927
2004	1.983780	0.39675700	8.927
2005	1.983780	0.39675700	8.927
2006	1.983780	0.39675700	8.927
2007	1.983780	0.39675700	8.927
2008	1.983780	0.39675700	8.927
2009	1.983780	0.39675700	8.927

Exhibit 4-4

Catch Loss

Mid Atlantic Region-Lease Sale No. 59

Sea Scallop Fishery

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.003927	0.00039270	0.047
1982	0.003927	0.00039270	0.047
1983	0.003927	0.00039270	0.047
1984	0.003927	0.00039270	0.047
1985	0.007854	0.00078540	0.094
1986	0.057854	0.00578540	0.694
1987	0.552010	0.05520100	6.624
1988	1.105070	0.11050700	13.261
1989	1.642420	0.16424200	19.709
1990	2.072310	0.20723100	24.868
1991	2.680640	0.26806400	32.168
1992	2.680640	0.26806400	32.168
1993	2.680640	0.26806400	32.168
1994	2.661010	0.26610100	31.932
1995	2.641370	0.26413700	31.696
1996	2.613880	0.26138800	31.367
1997	2.602100	0.26021000	31.225
1998	2.602100	0.26021000	31.225
1999	2.602100	0.26021000	31.225
2000	2.602100	0.26021000	31.225
2001	2.602100	0.26021000	31.225
2002	2.602100	0.26021000	31.225
2003	2.602100	0.26021000	31.225
2004	2.602100	0.26021000	31.225
2005	2.602100	0.26021000	31.225
2006	2.602100	0.26021000	31.225
2007	2.602100	0.26021000	31.225
2008	2.602100	0.26021000	31.225
2009	2.602100	0.26021000	31.225

Exhibit 4-5

Catch Loss

Mid Atlantic Region-Lease Sale No. 59

Groundfish Otter Trawl Fishery

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.003927	0.00001178	0.002
1982	0.003927	0.00001178	0.002
1983	0.003927	0.00001178	0.002
1984	0.003927	0.00001178	0.002
1985	0.007854	0.00002356	0.004
1986	0.057854	0.00017356	0.026
1987	0.552010	0.00165603	0.248
1988	1.105070	0.00331521	0.497
1989	1.642420	0.00492727	0.739
1990	2.072310	0.00621693	0.933
1991	2.680640	0.00804193	1.206
1992	2.680640	0.00804193	1.206
1993	2.680640	0.00804193	1.206
1994	2.661010	0.00798302	1.197
1995	2.641370	0.00792412	1.189
1996	2.613880	0.00784165	1.176
1997	2.602100	0.00780631	1.171
1998	2.602100	0.00780631	1.171
1999	2.602100	0.00780631	1.171
2000	2.602100	0.00780631	1.171
2001	2.602100	0.00780631	1.171
2002	2.602100	0.00780631	1.171
2003	2.602100	0.00780631	1.171
2004	2.602100	0.00780631	1.171
2005	2.602100	0.00780631	1.171
2006	2.602100	0.00780631	1.171
2007	2.602100	0.00780631	1.171
2008	2.602100	0.00780631	1.171
2009	2.602100	0.00780631	1.171

Exhibit 4-6

Catch Loss

Mid Atlantic Region-Lease Sale No. 59

Ocean Quahog Fishery

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.003142	0.00021991	0.032
1982	0.003142	0.00021991	0.032
1983	0.003142	0.00021991	0.032
1984	0.003142	0.00021991	0.032
1985	0.006283	0.00043982	0.065
1986	0.046283	0.00323982	0.476
1987	0.270774	0.01895420	2.786
1988	0.542390	0.03796730	5.581
1989	0.801439	0.05610070	8.247
1990	0.974514	0.06821600	10.028
1991	1.222010	0.08554100	12.575
1992	1.222010	0.08554100	12.575
1993	1.222010	0.08554100	12.575
1994	1.206310	0.08444140	12.413
1995	1.190600	0.08334180	12.251
1996	1.168610	0.08180250	12.025
1997	1.159180	0.08114270	11.928
1998	1.159180	0.08114270	11.928
1999	1.159180	0.08114270	11.928
2000	1.159180	0.08114270	11.928
2001	1.159180	0.08114270	11.928
2002	1.159180	0.08114270	11.928
2003	1.159180	0.08114270	11.928
2004	1.159180	0.08114270	11.928
2005	1.159180	0.08114270	11.928
2006	1.159180	0.08114270	11.928
2007	1.159180	0.08114270	11.928
2008	1.159180	0.08114270	11.928
2009	1.159180	0.08114270	11.928

Exhibit 4-7

Catch Loss

Mid Atlantic Region-Lease Sale No. 59

Surf Clam Fishery

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.000000	0.00000000	0.000
1982	0.000000	0.00000000	0.000
1983	0.000000	0.00000000	0.000
1984	0.000000	0.00000000	0.000
1985	0.000000	0.00000000	0.000
1986	0.000000	0.00000000	0.000
1987	0.125000	0.01250000	3.125
1988	0.250000	0.02500000	6.250
1989	0.375000	0.03750000	9.375
1990	0.500000	0.05000000	12.500
1991	0.675000	0.06750000	16.875
1992	0.675000	0.06750000	16.875
1993	0.675000	0.06750000	16.875
1994	0.675000	0.06750000	16.875
1995	0.675000	0.06750000	16.875
1996	0.675000	0.06750000	16.875
1997	0.675000	0.06750000	16.875
1998	0.675000	0.06750000	16.875
1999	0.675000	0.06750000	16.875
2000	0.675000	0.06750000	16.875
2001	0.675000	0.06750000	16.875
2002	0.675000	0.06750000	16.875
2003	0.675000	0.06750000	16.875
2004	0.675000	0.06750000	16.875
2005	0.675000	0.06750000	16.875
2006	0.675000	0.06750000	16.875
2007	0.675000	0.06750000	16.875
2008	0.675000	0.06750000	16.875
2009	0.675000	0.06750000	16.875

Exhibit 4-8

Minimum and Maximum Losses
Expected With Different Levels of OCS
Activity in the Mid-Atlantic Region
Lease Sale No. 59

Fishery	Percent of Area Lost	Percent of Catch Lost	Dollar Loss (Thousands)
Surf Clam			
Maximum	1.1200	0.1120	28.000
Mean	0.6750	0.0675	16.875
Minimum	0.4825	0.0483	12.062
Ocean Quahog			
Maximum	2.0414	0.1429	21.006
Mean	1.1592	0.0811	11.928
Minimum	0.6767	0.0474	6.963
Groundfish Otter Trawl			
Maximum	4.4650	0.0134	2.009
Mean	2.6021	0.0078	1.171
Minimum	1.6701	0.0050	0.752
Lobster Otter Trawl			
Maximum	3.5571	0.7114	16.007
Mean	1.9838	0.3968	8.927
Minimum	1.0762	0.2152	4.843

Exhibit 4-8 (cont.)

Minimum and Maximum Losses
Expected With Different Levels of OCS
Activity in the Mid-Atlantic Region
Lease Sale No. 59

Fishery	Percent of Area Lost	Percent of Catch Lost	Dollar Loss (thousands)
Sea Scallop			
Maximum	4.4650	0.4465	53.580
Mean	2.6021	0.2602	31.225
Minimum	1.6701	0.1670	20.041

OCS Activities

	Platforms	Miles of Drilling Rigs	Miles of Trunk Line	Miles of Connecting Lines
Maximum[1]	59	0	448	200
Mean	26	0	270	100
Minimum[1]	3	0	193	20

[1] Figures for minimum and maximum obtained as in Exhibit 4-2 with respect to the low and high case data.

5.0 South Atlantic Region

Major domestic fisheries for which a discernible catch loss impact is expected include:

- Groundfish Otter Trawl

- Shrimp Otter Trawl

The model was applied to these fisheries and the results are presented in this section. Exhibit 5-1 presents the values for parameters which were used in the application of the model. The benchmark value of landings was a figure chosen to represent the typical future value of the landings in each fishery. It was based on the trend line in landings with a subjective adjustment for future growth potential. The price applied to these landings was based on recent price trends in the fishery. No attempt was made to project future price increases inasmuch as inflationary price trends can be incorporated by viewing the dollar loss as future losses expressed in 1980 dollars. Also, the real purpose of this figure is to provide a relative benchmark for comparing the impact of the projected loss in catch. The area of the fishery is an input into Stage II of the model although the model is not particularly sensitive to it. It was estimated by review of generally accepted boundaries of fisheries with emphasis on the particular area where the fishery is fished extensively. Where a fishery crossed into another region only the area in this region was shown. The percentage of lease area and percentage of trunkline in a fishery was estimated based on a comparison of potential lease sites and pipeline corridors with the generally accepted boundaries of the fishery.

Buffer zone distances used were 0.5 miles for drilling rigs and platforms (this includes 0.25 miles for the actual buffer zone and 0.25 miles for the extent of an anchoring system) and 0.25 miles for pipelines. Referring to Section 3.0, Volume I it can be seen that these buffer zone distances are on the high end of the expected range and in fact most of the platforms will be vertical bottom-founded structures without the extended anchoring systems. Also, as discussed in Section 3.6 of Volume I a buffer zone around a pipeline may not exist in fact.

The OCS development scenario selected for analysis is that associated with OCS Lease Sale No. 43. The mean case input parameters describing this lease sale are presented in Exhibit 5-2 over an expected 30 year period.

Results of the catch loss analysis are presented over a thirty year mean case development scenario by species in Exhibits 5-3 through 5-4. Percent of area lost is the actual percent (as opposed to a percentage) of the fishery occupied by both the surface and sub-surface OCS structures including the associated buffer zones. Percent of catch lost is the expected decrease in catch (expressed as a percent and not a fraction) as determined by applying the methodology described in Section 2.0. Dollar loss is simply the percentage of catch lost times the benchmark value of landings presented in Exhibit 5-1. Note that this

Exhibit 5-1

Model Inputs

South Atlantic Region

Fishery	Benchmark Value of Landings (thousand dollars)	F	Area of Fishery (square miles)	Percent[3] of Lease Area in Fishery	Percent of[3] Trunkline in Fishery	Catch Loss Parameter
Ground fish[1] Otter Trawl	9,000	0.3	5,000	0.6	0.6	2.5e-05
Shrimp[2] Otter Trawl	56,000	1.0	10,000	0.0	0.5	5.0e-05

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1 The value of landings is based on data available from Fisheries of the United States and Fishery Statistics of the United States (NMFS, 1979). Species included under groundfish were: bluefish, croaker, drum, flounder, Atlantic mackerel, black sea bass, and gray sea trout. Benchmark revenue equals landings of 30 million pounds (NMFS, 1971-75) and a weighted average price of 30 cents per pound (NMFS, 1979). Landings were estimated to be 40 percent greater than the five year average landings for 1970 to 1975, the most recent years landing data was available. This 40 percent factor was included to account for extensive expansion which has taken place in the fishery during the past five years. The average ex-vessel price per pound used was the species composition applied to average 1979 prices (NMFS, 1979). An F-value of 1.0 for these fisheries derived from the Fishery Management Plan for Atlantic Groundfish (The New England Regional Fisheries Management Council, 1977). However, this F-value of applies to New England fisheries where fishing pressure is much greater for the above species than in the South Atlantic. Therefore, the F-value for groundfish the South Atlantic Region and was reduced to 0.3. The square miles of fishing area was estimated to be inside the 40 meter isobath. Groundfish otter trawling typically takes place in these waters. Total area was reduced to reflect the fact that activity is concentrated around North Carolina.

2 The value of landings is projected at $56 million. This was derived by applying the average 1979 price of $2.25 (NMFS, 1979) to average landings of 25 million pounds. Twenty-five million pounds was the five year average landings between 1973 and 1977 (NMFS, 1979). An F-value of 1.0 was projected as no management plan had been developed. A F-value of 2.4 was available for the Gulf of Mexico, however, this figure was greatly reduced as harvesting pressure is believed to be much less in the South Atlantic region. The landings for this region include those from the East

Coast landings of Florida to North Carolina. The area of the fishery was derived by charting the 20 meter isobath for this coast. Harvesting is primarily concentrated between Northern Florida and Cape Hatteras and was estimated at 10,000 square miles.

3 The portion of lease area in the fishery was estimated using the relative location of the fishing grounds and the lease blocks in BLM Environmental Impact Statement Lease No. 43. The proportion trunkline in the fishery was estimated similarly using a subjective interpretation of potential pipeline routes.

figure is expressed in thousands of dollars with a decimal point (not a comma).

Exhibit 5-5 shows the range of area loss, catch loss and associated dollar loss from the catch model over various levels of OCS development. The maximum figure represents the catch model using the high case scenario for the amount of OCS development. This is for one of the steady state years such as 2009 after the development phase. The mean figure represents the mean case development scenario for that year such as presented in the previous Exhibits. The minimum figure represents the low case development scenario.

Exhibit 5-2

PROJECTED DEVELOPMENT SCENARIO
FOR OCS ACTIVITY (MEAN CASE)
SOUTH ATLANTIC LEASE SALE NO. 43

YEAR	NUMBER OF PLATFORMS	NUMBER OF DRILLING RIGS	MILES OF TRUNKLINE	MILES OF CONNECTING LINE
1980	0	0	0	0
1981	0	6	0	0
1982	0	15	0	0
1983	4	18	0	0
1984	8	20	20	5
1985	10	20	50	10
1986	12	20	80	20
1987	14	20	100	30
1988	16	10	120	40
1989	17	5	150	50
1990	18	2	180	60
1991	18	0	180	60
1992	18	0	180	60
1993	18	0	180	60
1994	18	0	180	60
1995	18	0	180	60
1996	18	0	180	60
1997	18	0	180	60
1998	18	0	180	60
1999	18	0	180	60
2000	18	0	180	60
2001	18	0	180	60
2002	18	0	180	60
2003	18	0	180	60
2004	18	0	180	60
2005	18	0	180	60
2006	18	0	180	60
2007	18	0	180	60
2008	18	0	180	60
2009	18	0	180	60

Source: Total pipelines and platforms for low and high case given in Final Environmental Impact Statement, OCS Lease Sale No. 43, Vol. I, Bureau of Land Management, p. I-4. Mean case, allocation by year, breakdown between trunkline and connecting line and number of drilling rigs estimated by Centaur Associates.

Exhibit 5-3

Catch Loss

South Atlantic Region-Lease Sale No. 43

Groundfish Otter Trawl Fishery

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.056549	0.00014137	0.013
1982	0.141372	0.00035343	0.032
1983	0.207346	0.00051836	0.047
1984	0.413895	0.00103474	0.093
1985	0.642744	0.00160686	0.145
1986	0.901594	0.00225398	0.203
1987	1.100440	0.00275111	0.248
1988	1.205040	0.00301261	0.271
1989	1.407350	0.00351836	0.317
1990	1.628500	0.00407124	0.366
1991	1.609650	0.00402412	0.362
1992	1.609650	0.00402412	0.362
1993	1.609650	0.00402412	0.362
1994	1.609650	0.00402412	0.362
1995	1.609650	0.00402412	0.362
1996	1.609650	0.00402412	0.362
1997	1.609650	0.00402412	0.362
1998	1.609650	0.00402412	0.362
1999	1.609650	0.00402412	0.362
2000	1.609650	0.00402412	0.362
2001	1.609650	0.00402412	0.362
2002	1.609650	0.00402412	0.362
2003	1.609650	0.00402412	0.362
2004	1.609650	0.00402412	0.362
2005	1.609650	0.00402412	0.362
2006	1.609650	0.00402412	0.362
2007	1.609650	0.00402412	0.362
2008	1.609650	0.00402412	0.362
2009	1.609650	0.00402412	0.362

Exhibit 5-4

Catch Loss

South Atlantic Region-Lease Sale No. 43

Shrimp Otter Trawl Fishery

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.000000	0.00000000	0.000
1982	0.000000	0.00000000	0.000
1983	0.000000	0.00000000	0.000
1984	0.050000	0.00025000	0.140
1985	0.125000	0.00062500	0.350
1986	0.200000	0.00100000	0.560
1987	0.250000	0.00125000	0.700
1988	0.300000	0.00150000	0.840
1989	0.375000	0.00187500	1.050
1990	0.450000	0.00225000	1.260
1991	0.450000	0.00225000	1.260
1992	0.450000	0.00225000	1.260
1993	0.450000	0.00225000	1.260
1994	0.450000	0.00225000	1.260
1995	0.450000	0.00225000	1.260
1996	0.450000	0.00225000	1.260
1997	0.450000	0.00225000	1.260
1998	0.450000	0.00225000	1.260
1999	0.450000	0.00225000	1.260
2000	0.450000	0.00225000	1.260
2001	0.450000	0.00225000	1.260
2002	0.450000	0.00225000	1.260
2003	0.450000	0.00225000	1.260
2004	0.450000	0.00225000	1.260
2005	0.450000	0.00225000	1.260
2006	0.450000	0.00225000	1.260
2007	0.450000	0.00225000	1.260
2008	0.450000	0.00225000	1.260
2009	0.450000	0.00225000	1.260

Exhibit 5-5

Minimum and Maximum Losses
Expected With Different Levels of OCS
Activity in the South Atlantic Region
Lease Sale No. 43

Fishery	Percent of Area Lost	Percent of Catch Lost	Dollar Loss (Thousands)
Groundfish Otter Trawl			
Maximum	2.1556	0.0054	0.485
Mean	1.6097	0.0040	0.362
Minimum	1.0543	0.0026	0.237
Shrimp Otter Trawl			
Maximum	0.6000	0.0030	1.680
Mean	0.4500	0.0023	1.260
Minimum	0.3000	0.0015	0.840

OCS Activities

	Platforms	Drilling Rigs	Miles of Trunkline	Miles of Connecting Line
Maximum[1]	25	0	240	80
Mean	18	0	180	60
Minimum[1]	10	0	120	40

[1] Minimum and maximum figures based on total pipelines and platforms for low and high case given in Final Environmental Impact Statement, OCS Lease Sale No. 43, Vol. I, Bureau of Land Management, p. I-4. Breakdown between trunkline and connecting line estimated by Centaur Associates.

6.0 Eastern Gulf of Mexico Region

Major domestic fisheries for which a discernible catch loss impact is expected include:

- Shrimp Otter Trawl

- Non-Food Fish Otter Trawl

The model was applied to these fisheries and the results are presented in this section. Exhibit 6-1 presents the values for parameters which were used in the application of the model. The benchmark value of landings was a figure chosen to represent the typical future value of the landings in each fishery. It was based on the trend line in landings with a subjective adjustment for future growth potential. The price applied to these landings was based on recent price trends in the fishery. No attempt was made to project future price increases inasmuch as inflationary price trends can be incorporated by viewing the dollar loss as future losses expressed in 1980 dollars. Also, the real purpose of this figure is to provide a relative benchmark for comparing the impact of the projected loss in catch. The area of the fishery is an input into Stage II of the model although the model is not particularly sensitive to it. It was estimated by review of generally accepted boundaries of fisheries with emphasis on the particular area where the fishery is fished extensively. Where a fishery crossed into another region only the area in this region was shown. The percentage of lease area and percentage of trunkline in a fishery was estimated based on a comparison of potential lease sites and pipeline corridors with the generally accepted boundaries of the fishery.

Buffer zone distances used were 0.5 miles for drilling rigs and platforms (this includes 0.25 miles for the actual buffer zone and 0.25 miles for the extent of an anchoring system) and 0.25 miles for pipelines. Referring to Section 3.0, Volume I it can be seen that these buffer zone distances are on the high end of the expected range and in fact most of the platforms will be vertical bottom-founded structures without the extended anchoring systems. Also, as discussed in Section 3.6 of Volume I a buffer zone around a pipeline may not exist in fact.

The OCS development scenario selected for analysis is that associated with OCS Lease Sale No. 65. The mean case input parameters describing this lease sale are presented in Exhibit 6-2 over an expected 30 year period.

Results of the catch loss analysis are presented over a thirty year mean case development scenario by species in Exhibits 6-3 through 6-4. Percent of area lost is the actual percent (as opposed to a percentage) of the fishery occupied by both the surface and sub-surface OCS structures including the associated buffer zones. Percent of catch lost is the expected decrease in catch (expressed as a percent and not a fraction as determined by applying the methodology described in Section 2.0. Dollar loss is simply the percentage of catch lost times the

Exhibit 6-1

Model Inputs

Eastern Gulf of Mexico Region

Fishery	Benchmark Value of Landings (thousand dollars)	F	Area of Fishery (square miles)	Percent[3] of Lease Area in Fishery	Percent of[3] Trunkline in Fishery	Catch Loss Parameter
Shrimp[1] Otter Trawl	446,000	2.6	10,000	0.7	1.0	1.0e-04
Non-foodfish[2] Otter Trawl	4,000	0.4	10,000	0.2	0.2	3.5e-04

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1 Value of landings is based on National Marine Fisheries Service data (NMFS 1971-1975, NMFS, 1979). Species used were brown, white, pink and royal red shrimp. Landings of specific species are extremely volatile from one season to the next and five year average landings was used. Data was available for the Gulf of Mexico from Key West to the Mexican border. The F-value or fishing mortality rate, was based on the Shrimp Management Plan (Gulf of Mexico Fishery Management Council, 1980). Different F-values exist for different species and an average F-value was used for the species which are of primary economic importance. Square miles of fishing area were derived by charting depth contours where shrimp are caught. Landings by water depth are included in the Shrimp Management Plan (Gulf of Mexico Fishery Management Council, 1980). Although water depth of landings varies during the year and from region to region most shrimp in the relevant region are caught in water less than 15 fathoms in depth. Inland waters were excluded from this estimate because the large scale fleet does not fish these inland shallow waters.

2 Value of landings is based on the Groundfish Management Plan (Gulf of Mexico Fishery Management Council, 1978). Species used were Atlantic Croaker, spot, sand seatrout, sea catfish and Atlantic cutlass fish. Benchmark revenues equals landings of 5 cents per pound (NMFS, 1979). Since croker compose 70 percent of landings and virtually all is sold to industrial users the industrial non-food fish price was used. Area of the fishery was calculated from maps in the Groundfish Management Plan. Primary fishing areas are between point Point Au Fer, Louisiana (91° 30' W) and Perdido Bay (Florida 87° 30' W) and at water depths less than 35 fathoms. One F-value of .4 was obtained from the Draft Fishery Management Plan. The majority of this mortality rate is due to incidental catch in shrimp nets which is discarded at sea.

[3] The portion of lease area in the fishery was estimated using the relative locations of the fishing grounds and lease blocks in BLM EIS Lease Sale No. 65 (Department of Interior Lease Sale No. 65, 1978a). The location of the lease area was charted relative to the fishing areas. The portion of the trunk line in the fishery was estimated similarly a subjective interpretation of potential pipeline routes.

benchmark value of landings presented in Exhibit 6-1. Note that this figure is expressed in thousands of dollars with a decimal point (not a comma).

Exhibit 6-5 shows the range of area loss, catch loss and associated dollar loss from the catch model over various levels of OCS development. The maximum figure represents the catch model using the high case scenario for the amount of OCS development. This is for one of the steady state years such as 2009 after the development phase. The mean figure represents the mean case development scenario for that year such as presented in the previous Exhibits. The minimum figure represents the low case development scenario.

Exhibit 6-2

PROJECTED DEVELOPMENT SCENARIO
FOR OCS ACTIVITY (MEAN CASE)
EASTERN GULF OF MEXICO LEASE SALE NO. 65

YEAR	NUMBER OF PLATFORMS	NUMBER OF DRILLING RIGS	MILES OF TRUNKLINE	MILES OF CONNECTING LINE
1980	0	0	0	0
1981	0	1	0	0
1982	0	3	20	20
1983	1	6	30	30
1984	3	8	40	40
1985	5	13	70	70
1986	7	14	90	90
1987	9	14	130	130
1988	11	14	160	160
1989	13	14	200	200
1990	15	10	230	230
1991	16	8	275	275
1992	16	4	275	275
1993	16	0	275	275
1994	16	0	275	275
1995	16	0	275	275
1996	16	0	275	275
1997	16	0	275	275
1998	16	0	275	275
1999	16	0	275	275
2000	16	0	275	275
2001	16	0	275	275
2002	16	0	275	275
2003	16	0	275	275
2004	16	0	275	275
2005	16	0	275	275
2006	16	0	275	275
2007	16	0	275	275
2008	16	0	275	275
2009	16	0	275	275

Source: Total pipelines and platforms for low and high case given in Final Environmental Impact Statement, OCS Lease Sale No. 65, Vol. I, Bureau of Land Management, p. I-8. Mean case, allocation by year, breakdown between trunkline and connecting line, and number of drilling rigs estimated by Centaur Associates.

Exhibit 6-3

Catch Loss

Eastern Gulf of Mexico Region-Lease Sale No. 65

Shrimp Otter Trawl Fishery

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.005498	0.00005498	0.245
1982	0.186493	0.00186493	8.318
1983	0.293485	0.00293485	13.089
1984	0.400476	0.00400476	17.861
1985	0.693961	0.00693961	30.951
1986	0.880454	0.00880454	39.268
1987	1.231450	0.01231450	54.923
1988	1.497450	0.01497450	66.786
1989	1.848440	0.01848440	82.440
1990	2.092450	0.02092440	93.323
1991	2.469450	0.02469450	110.137
1992	2.447460	0.02447460	109.157
1993	2.425460	0.02425460	108.176
1994	2.425460	0.02425460	108.176
1995	2.425460	0.02425460	108.176
1996	2.425460	0.02425460	108.176
1997	2.425460	0.02425460	108.176
1998	2.425460	0.02425460	108.176
1999	2.425460	0.02425460	108.176
2000	2.425460	0.02425460	108.176
2001	2.425460	0.02425460	108.176
2002	2.425460	0.02425460	108.176
2003	2.425460	0.02425460	108.176
2004	2.425460	0.02425460	108.176
2005	2.425460	0.02425460	108.176
2006	2.425460	0.02425460	108.176
2007	2.425460	0.02425460	108.176
2008	2.425460	0.02425460	108.176
2009	2.425460	0.02425460	108.176

Exhibit 6-4

Catch Loss

Eastern Gulf of Mexico Region-Lease Sale No. 65

Fish Otter Trawl Fishery
(Non-Food Fish)

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.001571	0.00005498	0.002
1982	0.044712	0.00156493	0.063
1983	0.070996	0.00248485	0.099
1984	0.097279	0.00340476	0.136
1985	0.168274	0.00588961	0.236
1986	0.212987	0.00745454	0.298
1987	0.296128	0.01036450	0.415
1988	0.359270	0.01257450	0.503
1989	0.442412	0.01548440	0.619
1990	0.499270	0.01747450	0.699
1991	0.587699	0.02056950	0.823
1992	0.581416	0.02034960	0.814
1993	0.575133	0.02012970	0.805
1994	0.575133	0.02012970	0.805
1995	0.575133	0.02012970	0.805
1996	0.575133	0.02012970	0.805
1997	0.575133	0.02012970	0.805
1998	0.575133	0.02012970	0.805
1999	0.575133	0.02012970	0.805
2000	0.575133	0.02012970	0.805
2001	0.575133	0.02012970	0.805
2002	0.575133	0.02012970	0.805
2003	0.575133	0.02012970	0.805
2004	0.575133	0.02012970	0.805
2005	0.575133	0.02012970	0.805
2006	0.575133	0.02012970	0.805
2007	0.575133	0.02012970	0.805
2008	0.575133	0.02012970	0.805
2009	0.575133	0.02012970	0.805

Exhibit 6-5

Minimum and Maximum Losses
Expected With Different Levels of OCS
Activity in the Eastern Gulf of Mexico
Lease Sale No. 65

Fishery	Percent of Area Lost	Percent of Catch Lost	Dollar Loss (Thousands)
Shrimp Otter Trawl			
Maximum	3.1179	0.0312	139.060
Mean	2.4255	0.0243	108.176
Minimum	1.7275	0.0173	77.046
Non-Foodfish Otter Trawl			
Maximum	0.7408	0.0259	1.037
Mean	0.5751	0.0201	0.805
Minimum	0.4079	0.0143	0.571

OCS Activities

	Platforms	Drilling Rigs	Miles of TrunkLine	Miles of Connecting Line
Maximum[1]	26	0	350	350
Mean	16	0	275	275
Minimum[1]	5	0	200	200

[1] Minimum and maximum figures based on total pipelines and platforms for low and high case given in Final Environmental Impact Statement, OCS Lease Sale No. 65, Vol. I, Bureau of Land Management, p. I-8. Breakdown between trunkline and connecting line estimated by Centaur Associates.

7.0 Southern California Region

Major domestic fisheries for which a discernible catch loss impact is expected include:

- Otter Trawl (sole and other flatfish)
- Otter Trawl (rockfish)

Rockfish and sole (along with other flatfish) have been treated separately in this analysis because of their relatively different movement characteristics

The model was applied to these fisheries and the results are presented in this section. Exhibit 7-1 presents the values for parameters which were used in the application of the model. The benchmark value of landings was a figure chosen to represent the typical future value of the landings in each fishery. It was based on the trend line in landings with a subjective adjustment for future growth potential. The price applied to these landings was based on recent price trends in the fishery. No attempt was made to project future price increases inasmuch as inflationary price trends can be incorporated by viewing the dollar loss as future losses expressed in 1980 dollars. Also, the real purpose of this figure is to provide a relative benchmark for comparing the impact of the projected loss in catch. The area of the fishery is an input into Stage II of the model although the model is not particularly sensitive to it. It was estimated by review of generally accepted boundaries of fisheries with emphasis on the particular area where the fishery is fished extensively. The percentage of lease area and percentage of trunkline in a fishery was estimated based on a comparison of potential lease sites and pipeline corridors with the generally accepted boundaries of the fishery.

Buffer zone distances used were 0.5 miles for drilling rigs and platforms (this includes 0.25 miles for the actual buffer zone and 0.25 miles for the extent of an anchoring system) and 0.25 miles for pipelines. Referring to Section 3.0, Volume I it can be seen that these buffer zone distances are on the high end of the expected range and in fact most of the platforms will be vertical bottom-founded structures without the extended anchoring systems. Also, as discussed in Section 3.6 of Volume I a buffer zone around a pipeline may not exist in fact.

The OCS development scenario selected for analysis is that associated with OCS Lease Sale No. 48. The mean case input parameters describing this lease sale are presented in Exhibit 7-2 over an expected 30 year period.

Results of the catch loss analysis are presented over a thirty year mean case development scenario by species in Exhibits 7-3 through 7-4. Percent of area lost is the actual percent (not a fraction) of the

Exhibit 7-1

Model Inputs
Southern California Region

Fishery	Benchmark Value of Landings (thousand dollars)	F	Area of Fishery (square miles)	Percent[3] of Lease Area in Fishery	Percent of[3] Trunkline in Fishery	Catch Loss Parameter
Groundfish[1] Otter Trawl (Sole and Flatfish)	200	0.3	2,000	0.4	0.4	3.0e-04
Rockfish[2] Otter Trawl	800	0.4	2,000	0.3	0.4	1.5-03

1 Based on data from the Pacific Coast Groundfish Plan (Pacific Fishery Management Council, 1980). Species categories used were dover sole, English sole, petrale sole, sand sole and starry flounder. Catch data was for landings south of Point Conception. Very small amounts of flatfish are caught in this region with 1973 to 1978 landings averaging 900,000 pounds. Benchmark revenues equals landings of 900,000 times 22 cents per pound (average 1978 price). The F-value of .3 was obtained from the Pacific Coast Groundfish Plan. The corresponding area of the fishery was estimated using maps of fishing grounds developed by Orcutt (1969) and Bell and Ally (1972).

2 Baseline landings were calculated from the Pacific Coast Groundfish Plan (Pacific Fishery Management Council, 1980). The main species were ling cod, pacific cod, sablefish, Pacific ocean perch, and rockfish. Average landings in this region between 1973 and 1978 were 4 million pounds. Benchmark revenues equal $800,000 and were derived by applying 20 cents per pound to the 4 million pounds. The F-value of .4 was obtained from the Pacific Coast Groundfish Plan. The corresponding area of the fishery was estimated using maps of fishing grounds developed by Orcutt (1969) and Bell and Ally (1972).

3 The portion of the lease area in the fishery was estimated using the relative location of the fishing grounds and the lease blocks in BLM EIS Lease Sale No. 48. The portion of trunkline in the fishery was estimated similarly using a subjective interpretation of potential pipeline routes.

fishery occupied by both the surface and sub-surface OCS structures including the associated buffer zones. Percent of catch lost is the expected decrease in catch (expressed as a percent) by applying the methodology described in Section 2.0. Dollar loss is simply the percentage of catch lost times the benchmark value of landings presented in Exhibit 7-1. Note that this figure is expressed in thousands of dollars with a decimal point (not a comma).

Exhibit 7-5 shows the range of area loss, catch loss and associated dollar loss from the catch model over various levels of OCS development. The maximum represents the catch model using the high case scenario for the amount of OCS development. This is for one of the steady state years such as 2009 after the development phase. The mean represents the mean case development scenario for that year such as presented in the previous Exhibits. The minimum figure represents the low case development scenario.

Exhibit 7-2

PROJECTED DEVELOPMENT SCENARIO
FOR OCS ACTIVITY (MEAN CASE)
SOUTHERN CALIFORNIA LEASE SALE NO. 48

YEAR	NUMBER OF PLATFORMS	NUMBER OF DRILLING RIGS	MILES OF TRUNKLINE	MILES OF CONNECTING LINE
1980	0	0	0	0
1981	0	6	50	50
1982	6	8	100	100
1983	15	10	150	150
1984	22	5	200	200
1985	27	15	250	250
1986	30	12	300	300
1987	31	9	310	310
1988	31	5	315	315
1989	31	2	320	320
1990	31	1	320	320
1991	31	0	320	320
1992	31	0	320	320
1993	31	0	320	320
1994	31	0	320	320
1995	31	0	320	320
1996	31	0	320	320
1997	31	0	320	320
1998	31	0	320	320
1999	31	0	320	320
2000	31	0	320	320
2001	31	0	320	320
2002	31	0	320	320
2003	31	0	320	320
2004	31	0	320	320
2005	31	0	320	320
2006	31	0	320	320
2007	31	0	320	320
2008	31	0	320	320
2009	31	0	320	320

Source: Total pipelines and platforms for mean case given in Draft Environmental Impact Statement, OCS Lease Sale No. 48, Vol. I, Bureau of Land Management, p. 9. Allocation by year, breakdown between trunkline and connecting line and number of drilling rigs estimated by Centaur Associates.

Exhibit 7-3

Catch Loss

Southern California Region-Lease Sale No. 48

Otter Trawl Fishery
(Sole and Flatfish)

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	1.094250	0.03282740	0.066
1982	2.219910	0.06659740	0.133
1983	3.392700	0.10178100	0.204
1984	4.424120	0.13272400	0.265
1985	5.659740	0.16979200	0.340
1986	6.659740	0.19979200	0.400
1987	6.828320	0.20485000	0.410
1988	6.865490	0.20596500	0.412
1989	6.918370	0.20755100	0.415
1990	6.902660	0.20708000	0.414
1991	6.886950	0.20660800	0.413
1992	6.886950	0.20660800	0.413
1993	6.886950	0.20660800	0.413
1994	6.886950	0.20660800	0.413
1995	6.886950	0.20660800	0.413
1996	6.886950	0.20660800	0.413
1997	6.886950	0.20660800	0.413
1998	6.886950	0.20660800	0.413
1999	6.886950	0.20660800	0.413
2000	6.886950	0.20660800	0.413
2001	6.886950	0.20660800	0.413
2002	6.886950	0.20660800	0.413
2003	6.886950	0.20660800	0.413
2004	6.886950	0.20660800	0.413
2005	6.886950	0.20660800	0.413
2006	6.886950	0.20660800	0.413
2007	6.886950	0.20660800	0.413
2008	6.886950	0.20660800	0.413
2009	6.886950	0.20660800	0.413

Exhibit 7-4

Catch Loss

Southern California Region-Lease Sale No. 48

Otter Trawl Fishery
(Rockfish)

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.945686	0.14185300	1.135
1982	1.914930	0.28724000	2.298
1983	2.919530	0.43792900	3.503
1984	3.818090	0.57271300	4.582
1985	4.869800	0.73047000	5.844
1986	5.744800	0.86172000	6.894
1987	5.896240	0.88443600	7.075
1988	5.936620	0.89049300	7.124
1989	5.988770	0.89831600	7.187
1990	5.976990	0.89654900	7.172
1991	5.965210	0.89478200	7.158
1992	5.965210	0.89478200	7.158
1993	5.965210	0.89478200	7.158
1994	5.965210	0.89478200	7.158
1995	5.965210	0.89478200	7.158
1996	5.965210	0.89478200	7.158
1997	5.965210	0.89478200	7.158
1998	5.965210	0.89478200	7.158
1999	5.965210	0.89478200	7.158
2000	5.965210	0.89478200	7.158
2001	5.965210	0.89478200	7.158
2002	5.965210	0.89478200	7.158
2003	5.965210	0.89478200	7.158
2004	5.965210	0.89478200	7.158
2005	5.965210	0.89478200	7.158
2006	5.965210	0.89478200	7.158
2007	5.965210	0.89478200	7.158
2008	5.965210	0.89478200	7.158
2009	5.965210	0.89478200	7.158

Exhibit 7-5

Minimum and Maximum Losses
Expected With Different Levels of OCS
Activity in Southern California
Lease Sale No. 48

Fishery	Percent of Area Lost	Percent of Catch Lost	Dollar Loss (Thousands)
Groundfish Otter Trawl (Sole)			
Maximum	10.9425	0.3283	0.657
Mean	6.8870	0.2066	0.413
Minimum	4.1571	0.1247	0.249
Groundfish Otter Trawl (Rockfish)			
Maximum	9.4569	1.4185	11.348
Mean	5.9652	0.8948	7.158
Minimum	3.6178	0.5427	4.341

OCS Activities

	Platforms	Drilling Rigs	Miles of Pipeline	Miles of Trunkline
Maximum[1]	60	0	500	500
Mean	31	0	320	320
Minimum[1]	10	0	200	200

[1] Minimum and maximum figures estimated by Centaur Associates using as a basis the mean steady-state figures presented in Exhibit 7-2.

8.0 Central and Northern California Region

Major domestic fisheries for which a discernible catch loss impact is expected include:

- Otter Trawl (sole and other flatfish)
- Otter Trawl (rockfish)
- Shrimp Otter Trawl

Rockfish and sole (along with other flatfish) have been treated separately in this analysis because of their relatively different movement characteristics. The model was applied to these fisheries and the results are presented in this section. Exhibit 8-1 presents the values for parameters which were used in the application of the model. The benchmark value of landings was a figure chosen to represent the typical future value of the landings in each fishery. It was based on the trend line in landings with a subjective adjustment for future growth potential. The price applied to these landings was based on recent price trends in the fishery. No attempt was made to project future price increases inasmuch as inflationary price trends can be incorporated by viewing the dollar loss as future losses expressed in 1980 dollars. Also, the real purpose of this figure is to provide a relative benchmark for comparing the impact of the projected loss in catch. The area of the fishery is an input into Stage II of the model although the model is not particularly sensitive to it. It was estimated by review of generally accepted boundaries of fisheries with emphasis on the particular area where the fishery is fished extensively. The percentage of lease area and percentage of trunkline in a fishery was estimated based on a comparison of potential lease sites and pipeline corridors with the generally accepted boundaries of the fishery.

Buffer zone distances used were 0.5 miles for drilling rigs and platforms (this includes 0.25 miles for the actual buffer zone and 0.25 miles for the extent of an anchoring system or satellite subsea completions) and 0.25 miles for pipelines. Referring to Section 3.0, Volume I it can be seen that these buffer zone distances are on the high end of the expected range and in fact many of the platforms will be vertical bottom-founded structures without the extended anchoring systems. Also, as discussed in Section 3.6 of Volume I a buffer zone around a pipeline may not exist in fact.

The OCS development scenario selected for analysis is that associated with OCS Lease Sale No. 53. The mean case input parameters describing this lease sale are presented in Exhibit 8-2 over an expected 30 year period.

Results of the catch loss analysis are presented over a thirty year mean case development scenario by species in Exhibits 8-3 through 8-5. Percent of area lost is the actual percent (as opposed to a fraction) of

Exhibit 8-1

Model Inputs

Northern California Region

Fishery	Benchmark Value of Landings (thousand dollars)	F	Area of Fishery (square miles)	Portion[4] of Lease Area in Fishery	Portion of[4] Trunkline in Fishery	Catch Loss Parameter
Groundfish[1] Otter Trawl (Sole and Flatfish)	9,400	0.3	5,000	0.5	0.5	3.0e-04
Groundfish[2] Otter Trawl (Rockfish and Non-Flatfish)	5,000	0.4	2,500	0.1	0.7	1.5e-03
Shrimp[3] Otter Trawl	3,600	1.4	1,000	0.1	0.1	6.0e-05

1 Based on data from the Pacific Coast Groundfish Plan (Pacific Fishery Management Council, Portland OR, August, 1980). Species categories used were Dover sole, English sole, Petrale sole, and other flatfish (i.e. butter sole, flathead sole, Pacific sand dab, rex sole, sand sole and starry flounder). Catch data were totaled for the Conception, Monterry, and Eureka statistical reporting areas. As defined these areas extend from the Mexican border (although negligible amounts are caught south of the Santa Barbara channel) to Cape Blanco, OR. The corresponding area of the fishery was estimated using BLM EIS Lease Sale No. 53, Visual No. 3 with a small adjustment for the fishery area off Oregon and in the Santa Barbara Channel. Benchmark revenue equals landings of 42.7 million pounds (19,400 metric tons) times 22 cents per pound (typical 1978 price). Benchmark landings were estimated as the 1979 trawl catch divided by the 1979 total catch (recreational and commercial) times the allowable biological catch (ABC) or (16,112 / 28,428) * 34,400 (figures in metric tons). Since the fishery is close to the ABC this essentially prorates the ABC to the trawl fishery based on the 1979 proportion of landings.

(footnotes cont.)

Exhibit 8-1 (cont.)

2 Calculated as above using data from the Pacific Coast Groundfish Plan (August, 1980). Species categories used were rockfish and lingcod. Benchmark revenue equals benchmark landings of 25 million pounds (11,500 metric tons) times 20 cents per pound (typical 1978 price). Benchmark landings calculated as in above footnote or (10,373 / 36,385) * 40,300, (figures in metric tons).

3 Based on data from the Pink Shrimp Fishery Management Plan (Pacific Fishery Management Council , Portland, OR, July, 1980). Pink shrimp is the only species covered. Catch data used were those reported for Pacific Marine Fisheries Commission statistical subunits (for pink shrimp data) No 98, 96, 94, and 92/Oregon statistical area 19. As defined these areas extend from the Mexico border to a line off Rogue River, OR. Data for area 92 are aggregated with Oregon area 19 because a single fishery extends across the common boundary. In actual fact there is only a neglibible catch south of Pt. Conception. The corresponding area of the fishery was estimated from BLM EIS Lease Sale No. 53, Visual No. 3 with a small adjustment for the portion of the fishery in Oregon. Benchmark revenue equals benchmark landings of 15.7 million pounds times 23 cents per pound (1977 California price). Benchmark landings were taken as the estimated maximum sustainable yield corresponding to the area defined above. The fishery has expanded rapidly since 1977 and MSY appears to be a reasonable estimate of future catch.

4 The portion of the lease area in the fishery was estimated using the relative location of the fishing grounds and the lease blocks in BLM EIS Lease Sale No. 53, Visual No. 3. The portion of trunk line in the fishery was estimated similarly using a subjective interpretation of potential pipeline routes.

the fishery occupied by both the surface and sub-surface OCS structures including the associated buffer zones. Percent of catch lost is the expected decrease in catch (expressed as a percent as opposed to a fraction) by applying the methodology described in Section 2.0. Dollar loss is simply the percentage of catch lost times the benchmark value of landings presented in Exhibit 8-1. Note that this figure is expressed in thousands of dollars with a decimal point (not a comma).

Exhibit 8-6 shows the range of area loss, catch loss and associated dollar loss from the catch model over various levels of OCS development. The maximum represents the catch model using the high case scenario for the amount of OCS development. This is for one of the steady state years such as 2009 after the development phase. The mean represents the mean case development scenario for that year such as presented in the previous Exhibits. The minimum figure represents the low case development scenario.

Exhibit 8-2

PROJECTED DEVELOPMENT SCENARIO
FOR OCS ACTIVITY (MEAN CASE)
NORTHERN CALIFORNIA LEASE SALE NO. 53

YEAR	NUMBER OF PLATFORMS	NUMBER OF DRILLING RIGS	MILES OF TRUNKLINE	MILES OF CONNECTING LINE
1980	0	0	0	0
1981	0	2	0	0
1982	0	6	0	0
1983	0	7	0	0
1984	0	4	0	0
1985	0	2	0	0
1986	11	1	20	4
1987	17	0	40	8
1988	22	0	60	12
1989	26	0	80	16
1990	29	0	92	20
1991	29	0	92	20
1992	29	0	92	20
1993	29	0	92	20
1994	29	0	92	20
1995	29	0	92	20
1996	29	0	92	20
1997	29	0	92	20
1998	29	0	92	20
1999	29	0	92	20
2000	29	0	92	20
2001	29	0	92	20
2002	29	0	92	20
2003	29	0	92	20
2004	29	0	92	20
2005	29	0	92	20
2006	29	0	92	20
2007	29	0	92	20
2008	29	0	92	20
2009	29	0	92	20

Source: Wells, platforms, and subsea or floating production systems by year given in Final Environmental Impact Statement, OCS Lease Sale No. 53, Vol. I, Bureau of Land Management, September, 1980, p. 1-16 thru 1-18. Platforms in Exhibit 8-2 includes total of platforms and subsea or floating production systems in the EIS. Subsea completions are assumed on average to lie within a 1/4 mile radius as discussed in Section 2.3. Drilling rigs in Exhibit 8-2 equals total exploratory and delineation wells each year in the EIS divided by 6 based on the assumption that each well requires a drilling rig for 2 months. A figure of 92 miles of pipeline was given in the EIS, p. 4-30. This was assumed to be trunkline since p. 1-20 shows a figure of 112 miles which includes delivery and gathering lines . Breakdown of pipeline by year was estimated by Centaur Associates.

Exhibit 8-3

Catch Loss

Northern California Region-Lease Sale No. 53

Otter Trawl Fishery
(Sole and Flatfish)

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.015708	0.00047124	0.044
1982	0.047124	0.00141372	0.133
1983	0.054978	0.00164934	0.155
1984	0.031416	0.00094248	0.089
1985	0.015708	0.00047124	0.044
1986	0.214248	0.00642744	0.604
1987	0.373518	0.01120550	1.053
1988	0.532788	0.01598360	1.502
1989	0.684204	0.02052610	1.929
1990	0.787766	0.02363300	2.222
1991	0.787766	0.02363300	2.222
1992	0.787766	0.02363300	2.222
1993	0.787766	0.02363300	2.222
1994	0.787766	0.02363300	2.222
1995	0.787766	0.02363300	2.222
1996	0.787766	0.02363300	2.222
1997	0.787766	0.02363300	2.222
1998	0.787766	0.02363300	2.222
1999	0.787766	0.02363300	2.222
2000	0.787766	0.02363300	2.222
2001	0.787766	0.02363300	2.222
2002	0.787766	0.02363300	2.222
2003	0.787766	0.02363300	2.222
2004	0.787766	0.02363300	2.222
2005	0.787766	0.02363300	2.222
2006	0.787766	0.02363300	2.222
2007	0.787766	0.02363300	2.222
2008	0.787766	0.02363300	2.222
2009	0.787766	0.02363300	2.222

Exhibit 8-4

Catch Loss

Northern California Region-Lease Sale No. 53

Otter Trawl Fishery
(Rockfish)

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.006283	0.00094248	0.047
1982	0.018850	0.00282744	0.141
1983	0.021991	0.00329868	0.165
1984	0.012566	0.00188496	0.094
1985	0.006283	0.00094248	0.047
1986	0.325699	0.04885490	2.443
1987	0.629407	0.09441110	4.721
1988	0.933115	0.13996700	6.998
1989	1.233680	0.18505200	9.253
1990	1.419110	0.21286600	10.643
1991	1.419110	0.21286600	10.643
1992	1.419110	0.21286600	10.643
1993	1.419110	0.21286600	10.643
1994	1.419110	0.21286600	10.643
1995	1.419110	0.21286600	10.643
1996	1.419110	0.21286600	10.643
1997	1.419110	0.21286600	10.643
1998	1.419110	0.21286600	10.643
1999	1.419110	0.21286600	10.643
2000	1.419110	0.21286600	10.643
2001	1.419110	0.21286600	10.643
2002	1.419110	0.21286600	10.643
2003	1.419110	0.21286600	10.643
2004	1.419110	0.21286600	10.643
2005	1.419110	0.21286600	10.643
2006	1.419110	0.21286600	10.643
2007	1.419110	0.21286600	10.643
2008	1.419110	0.21286600	10.643
2009	1.419110	0.21286600	10.643

Exhibit 8-5

Catch Loss

Northern California Region-Lease Sale No. 53

Shrimp Trawl Fishery

YEAR	PERCENT OF AREA LOST	PERCENT OF CATCH LOST	DOLLAR LOSS (THOUSANDS)
1980	0.000000	0.00000000	0.000
1981	0.015708	0.00009425	0.003
1982	0.047124	0.00028274	0.010
1983	0.054978	0.00032987	0.012
1984	0.031416	0.00018850	0.007
1985	0.015708	0.00009425	0.003
1986	0.214248	0.00128549	0.046
1987	0.373518	0.00224111	0.081
1988	0.532788	0.00319673	0.115
1989	0.684204	0.00410522	0.148
1990	0.787766	0.00472660	0.170
1991	0.787766	0.00472660	0.170
1992	0.787766	0.00472660	0.170
1993	0.787766	0.00472660	0.170
1994	0.787766	0.00472660	0.170
1995	0.787766	0.00472660	0.170
1996	0.787766	0.00472660	0.170
1997	0.787766	0.00472660	0.170
1998	0.787766	0.00472660	0.170
1999	0.787766	0.00472660	0.170
2000	0.787766	0.00472660	0.170
2001	0.787766	0.00472660	0.170
2002	0.787766	0.00472660	0.170
2003	0.787766	0.00472660	0.170
2004	0.787766	0.00472660	0.170
2005	0.787766	0.00472660	0.170
2006	0.787766	0.00472660	0.170
2007	0.787766	0.00472660	0.170
2008	0.787766	0.00472660	0.170
2009	0.787766	0.00472660	0.170

Exhibit 8-6

Minimum and Maximum Losses
Expected With Different Levels of OCS
Activity in Northern California
Lease Sale No. 53

Fishery	Percent of Area Lost	Percent of Catch Lost	Dollar Loss (Thousands)
Groundfish Otter Trawl (Sole)			
Maximum	1.0706	0.0321	3.019
Mean	0.7878	0.0236	2.222
Minimum	0.2735	0.0082	0.771
Groundfish Otter Trawl (Rockfish)			
Maximum	1.8082	0.2712	13.562
Mean	1.4191	0.2129	10.643
Minimum	0.3014	0.0452	2.261
Shrimp Otter Trawl			
Maximum	1.0706	0.0064	0.231
Mean	0.7878	0.0047	0.170
Minimum	0.2735	0.0016	0.059

OCS Activities

	Platforms	Drilling Rigs	Miles of Trunkline	Miles of Connecting Lines
Maximum[1]	44	0	115	30
Mean	29	0	92	20
Minimum[1]	17	0	16	12

[1] Figures for minimum and maximum obtained as in Exhibit 8-2 with respect to the low and high case data except that miles of pipeline was estimated by Centaur Associates.

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APPENDIX I

Literature Review of Movement Behavior

Introduction

The information presented here was extracted largely from published literature on tagging studies of the species concerned. Available information proved fragmentary and rarely directly applicable to the specific problem addressed here.

Most tagging studies are undertaken to determine overall seasonal movements, seasonal distribution, abundance, or growth rates of fish stocks. As a result, fish recaptured within short time periods following release are of little interest to the investigator, and individual recoveries of tagged fish are rarely reported in the literature. The reader should thus be aware that the rates of movement presented here are merely indications of the capabilities of individual fish and may not necessarily represent movements of entire stocks of any given species.

Cod (*Gadus morhua*)

Tagging studies indicate average daily migration rates of 1-16 miles per day (mpd) during seasonal migrations.

Templeman (1979) reports movements of Newfoundland stocks over distances of 650 miles in 567 days and 1230 miles in 600 days, i.e. 1-2 mpd. On the other hand Wise (1961) reports average rates of 3 mpd with a maximum rate of 16 mpd sustained over a one month period.

Jean (1963) states that northwest Atlantic cod move at least 3-5 mpd during winter migrations, Taning (1937) reports average rates of 4-4½ mpd, and Harden Jones (1968) reports an average migration speed of 7 mpd for Barents Sea stocks.

Blaxter and Dickson (1959), in laboratory experiments, recorded maximum swimming speeds between 1.7 and 4.8 mph, depending upon the size of fish, but point out that such speeds could not be maintained for extended periods.

Thus, the most commonly cited average speed of migrating stocks appears to be 3-4 mpd, with occasional reports of more rapid rates.

Haddock (*Melanogrammus aeglefinus*)

Detailed analyses of haddock movements based on tagging studies in the northern North Sea are presented by Jones (1959, 1963). Returns indicated a rate of movement between 0.68 and 0.82 mpd. Jones subjected tag returns to further analysis and derived a directional component of movement and a random dispersion coefficient, shown below.

Estimated Values of V and a^2 for Different Haddock Tagging Experiments

Date	Year-Class	Directional Component of Movement (V) miles/day	Dispersion Coefficient (a^2) miles^2/day
June 1956	1954	-0.076	20.5
May 1957 to 18 November	1955	0.024	2.2
After 18 November	1955	0.17	35.6
Nov./Dec. 1957	1955	0.82	118.0

McCracken (1963) reported apparent rates of movement from 1-3 mpd for fish migrating between summer onshore areas and the winter offshore grounds of the Nova Scotia banks. Maximum swimming speeds under laboratory conditions range from 1.7-4.1 mph, depending upon size of fish (Blaxter and Dickson, 1959).

Hakes (Urophycis tenuis and U. chuss)

The only pertinent data encountered concerns the white hake (U. tenuis). Kohler (1971) reported that most fish tagged in the southern Gulf of St. Laurence moved 30 miles in one month, i.e. 1 mpd, with a few individuals travelling at 2 mpd.

No appropriate information was encountered concerning the red hake (U. chuss).

Whiting or Silver Hake (Merluccius bilinearis)

We were unable to locate any data concerning the speed of movement of whiting. Migratory rates may be similar to those reported for cod.

Sea herring (Clupea harengus)

Winters and Beckett (1978) report migration speeds varying from 2-8 mpd in stocks of herring off southwest Newfoundland. Zinkevitch (1967) indicates that movements on the southern Georges Bank may reach 4 mpd, but suggests that most fish probably average approximately 1 mpd. In a series of tag returns from the southern North Sea, Bolster (1955) reported average rates of movement ranging from 2-14½ mpd and distances travelled from 3-200 miles.

Maximum swimming speeds of 4 mph are recorded by Blaxter and Dickson (1959) for North Sea herring under laboratory conditions.

Flounders

Yellowtail flounder (Limanda ferruginea)

Royce et al. (1959) report that yellowtail flounder migrate seasonally over distances up to 170 miles, but that most fish appear to travel less than 50 miles. Recoveries of tagged fish indicate an average rate of movement approximately 1 mpd.

Summer flounder (<u>Paralichthys dentatus</u>)

A slow offshore spawning movement is reported from many sources. Most fish travel less than 25 miles and very few move more than 70-80 miles offshore. Speed of travel is not reported, but is unlikely to be rapid.

Winter flounder (<u>Pseudopleuronectes americanus</u>)

Major movements of winter flounder consist of offshore movements during the summer and a return to shallow inshore areas during winter and early spring. Migrations are not extensive, and rarely exceed 50-60 miles in straight line distance (Saila, 1961; Perlmutter, 1947). Saila (1961) subjected tag returns to analysis based on the diffusion and dispersion concepts discussed by Beverton and Holt (1957) and applied by Jones (1959) to haddock movements. The directional components and dispersion coefficients derived by Saila are presented below.

Estimates of V and a^2 from Available Tag-return Data

	Period	Number of fish	Directional component miles/day	Dispersion coeff. $miles^2/day$
1.	June-Nov (365 days at large)	78	.029	.670
2.	June-Nov (365 days at large*)	32	.033	1.10
3.	Nov.-June (365 days at large)	60	.0004	.030
4.	Nov.-June (365 days at large*)	72	.0024	.016

*Period 2 and 4 coefficients of directional movement and dispersion have been obtained by subtracting 365 or 730 from each recovery period under the assumption of an annual return to the breeding area by individual fish.

McCracken recorded small scale seasonal movements of Nova Scotia stocks, reporting rates of movement in the order of 20 miles per month, i.e. 0.6 mpd.

Dover sole (Microstomus pacificus)

Stocks move from inshore summer grounds to deeper offshore areas in winter. The majority do not appear to travel more than 30-40 miles in seasonal movements. The onshore-offshore migration of approximately 30 miles is accomplished in approximately one month, thus requiring an average speed of movement of roughly 1 mpd (Hagerman, 1952; Westrheim and Morgan, 1963).

Petrale sole (Eopsetta jordani)

Migrations are generally parallel to the coast rather than onshore-offshore. Tagging studies reported by Best (1963) from California indicate an average rate of 2 mpd in terms of straight line movements, with individual rates varying from 1-4 mpd.

English sole (Parophrys vetulus)

Pattie (1969) reported the maximum distance travelled by fish tagged off the coast of Washington was 370 nautical miles in a maximum time of 18 months. This would indicate a daily rate of movement of 0.8 mpd.

From tagging studies off California, Jow (1969) reports that few fish move more than 25-50 miles either in a coastwise or onshore-offshore direction. He cites one recovery which would indicate a speed of movement of approximately 3 mpd.

Rockfish (*Sebastes paucispinnis*, *S. goodei*, *S. flavidus*, and others)

Migratory movements along the California coast are apparently not extensive. We were unable to locate any references to speed of movement of any species of *Sebastes*.

Movements of the redfish or ocean perch (*S. marinus*) of the Atlantic have been studied by means of tagging programs, and indicate very little migratory activity. Redfish tagged in shallow waters at Eastport, Maine moved a maximum straight line distance of 2/3 mile in 2 years (Kelly and Barker, 1961).

Gray seatrout (*Cynoscion regalis*)

Available literature does not provide specific information on the rate of movement of gray seatrout during either their offshore spawning movements or their seasonal north-south migrations. A related species *Cynoscion nebulosus* undertakes migrations of much shorter distances, and tagging studies in Florida indicate average rates of 1.2 mpd (Ingle et al., 1962) and a maximum reported rate of approximately 2 mpd (Moffet, 1961).

Croaker (*Micropogon undulatus*)

We were unable to locate data on rates of movement. Related sciaenids appear to travel at rates between 0.6 mpd (*Sciaenops ocellata*; Ingle et al., 1962) and 2 mpd (*Cynoscion regalis*; Moffet, 1961).

White shrimp (Penaeus setiferus)

Movements of juveniles and adults in the Atlantic and Gulf of Mexico consist primarily of onshore-offshore displacements on a seasonal basis. Superimposed upon these movements in the Atlantic is a general southward movement in late fall-early winter and a reversed trend in early spring.

Lindner and Anderson (1961) and Lindner and Cook (1970) report the longest north-south movement of 360 miles in 95 days. They consider the speed of movement to vary from 1.6 to 4 mpd during these longshore migrations. Onshore-offshore movements are considerably slower. Klima (1964) reports migratory distances of 70-120 miles at rates approximating 1 mpd.

Brown shrimp (Peneaus aztecus)

Brown shrimp tend to be less migratory than whites. Reports by Klima (1964) from the coasts of Louisiana and Texas indicate that few tagged individuals travel more than 30 miles from point of release. A straight line distance of 70 miles was the longest recorded, and the average distance travelled for all recaptures within 180 days of release was 16 miles. Klima's data indicate a maximum rate of travel of 2-3 mpd for Gulf of Mexico stocks.

Data cited by Cook and Lindner (1967) from North Carolina indicate maximum distances travelled to be approximately 150 miles, and speed of travel to be approximately 4 mpd.

Pink shrimp (Penaeus duorarum)

Although juveniles undergo migrations of up to 100 miles from estuarine nursery areas to spawning areas exploited by the commercial fisheries, movements on the grounds appear to be extremely limited. The maximum distance travelled on the fishing grounds of Dry Tortugas, Florida was reported to be 35 miles in 106 days, and an indicated speed of movement of approximately 0.3 mpd (Costello and Allen, 1966).

Migrations of juveniles to the fishing grounds appear to be accomplished at rates between 1 and 3 mpd (Costello and Allen, op. cit.; Yokel et al., 1970).

Northern lobster (Homarus americanus)

Lobster stocks tend to be local in distribution and do not undertake long migrations. Wilder (1963) reported displacement movements up to 60 miles in 6 months, and only 65 miles during 18 months. Speed of travel during migratory movements are relatively slow. Saila and Flowers (1968) released lobsters, caught in deep offshore waters, in inshore areas of Rhode Island. They reported a maximum distance of 137 miles travelled back to deep water over a period of 264 days. Their observations indicate a daily rate of movement of 0.3-0.5 mpd. Saila and Flowers (op. cit.) also calculated that lobsters which were not migrating showed local directional movements of 0.006 mpd to 0.06 mpd.

Sea Scallop (Placopecten Magellanicus)

Sea scallops are essentially non-migratory and movements are restricted and local. Posgay (1963) reports that approximately 80% of all tagged scallops recovered within 6 months of release were taken within 2 miles of the release site; 16% were returned from distances of 2-10 miles, and only 3% had travelled more than 10 miles.