Canadian Atlantic Fisheries
Scientific Advisory Committee

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CAFSAC Research Document 90/39

CSCPCA Document de recherche 90/39

EFFECT OF FISHERY COMPETITION ON MANAGEMENT CHOICES

by

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ABSTRACT

The purpose of this work was to develop a simulation model to examine the management choices of a fishery when another fishery is in competition for the resource and the managers have no control over the catch of the competing fishery. The simulation model is an age-structured model of a fish stock with a one year time step. Recruitment is constant and natural and fishing mortality are modelled using Pope's approximation to the Gulland catch equation. The region is divided into two areas and the amount of mixing of fish between the two areas can be varied. The stock is fished by two fisheries. Fishery "A" is the fishery for which we are considering management strategies (the Canadian fishery) and Fishery "B" is the competing fishery; it is only permitted to fish in area 2. Fishery "B" can be of type "allowance" in which it has a preset allowance of fish for area 2, or "unlimited" in which case there is no limit on its fishing effort in area 2. A set of simulations was conducted to examine the consequences of various possible fishing strategies for fishery A, for the two types of fishery B and different amounts of fish mixing between the two areas. The results show that the best management choice for fishery A depends on (i) the current management strategy, (ii) the goal of any change in management, (iii) whether the competing fishery is an allowance or an unlimited fishery, and (iv) the degree to which the fish mix between areas. In general, the unlimited fishery B results in lower stock biomass and catch for fishery A, than the allowance fishery B. Also in general, the more the fish can be assumed to mix between the two areas, the lower will be the total stock biomass and the catch for fishery A. Discussion focusses on possible implications of the results for the cod fisheries in 3Ps and 2J3KL.

RESUME

Les travaux décrits ici avaient pour objet d'établir un modèle de simulation afin d'examiner les orientations possibles dans la gestion d'une pêcherie donnée lorsqu'une autre pêcherie lui dispute la ressource et que les gestionnaires n'ont aucun droit de regard sur les prises de la pêcherie concurrente. Le modèle de simultation est un modèle d'un stock de poisson structuré selon l'âge et utilisant l'année comme unité de temps . Le recrutement est constant et les mortalités naturelle et due à la pêche sont modélisées d'après l'approximation de Pope à l'équaton des prises de Gulland. La région est divisée en deux zones et l'ampleur des échanges de poisson entre les deux zones peut varier. Le stock est exploité par deux pêcheries. Les stratégies de gestion envisagées visent la pêcheries "A" (canadienne). La pêcherie "B" est la pêcherie concurrente, qui est limitée à la zone 2 et peut soit faire l'objet d'une allocation établie d'avance, soit être libre de toute restriction de l'effort dans la zone en question. On a procédé à des simultations afin d'examiner les conséquences de diverses stratégies de gestion pour la pêcherie A, pour les deux sortes possibles de pêcherie B ainsi que pour différents degrés d'échange de poisson entre les deux zones. Les résultats révèlent que le choix de la meilleure formule de gestion pour la pêcherie A dépend (i) de la stratégie de gestion déjà en place; (ii) du but visé par toute changement de stratégie; (iii) du genre de pêcherie concurrente (allocation ou effort non restreint) et (iv) du degré d'échange de poisson entre les zones. En général, si l'on compare les effets d'une pêcherie B non restreinte à ceux d'une pêcherie B à allocation, la première aboutit à une biomasse et à des prises plus basses pour la pêcherie A. En outre, plus il semble y avoir d'échanges de poisson entre les deux zones, plus la biomasse totale du stock et les prises dans la pêcherie A sont basses. On discute ici des conséquences possibles de ces résultats sur la pêche de la morue dans les divisions 3Ps et 2J3KL.

INTRODUCTION

The purpose of this work is to examine the management choices of a fishery when another fishery is in competition for the resource and the managers have no control over the catch of the competing fishery. This is a common situation; in the case of Newfoundland groundfish management, the two most obvious examples are the 3Ps cod stock in which the Canadian fishery is in competition with the French, and the 2J3KL cod stock in which the Canadian fishery is in competition with the foreign fishery. In both cases the competing fishery is restricted to a portion of the management region.

Models of multi-fleet fisheries have been developed by Clark and Kirkwood (1979), McKelvey (1983), Murawski (1984) and Charles and Reed (1985). The purpose of these models is to determine the optimal combination of several fleet types under various conditions. The implicit assumption is that there is one management body (e.g., country) that has control over fishing of the whole stock, or that several management bodies co-operate to establish combined fishing levels. The present study is different in that the management body is assumed to have control over only one of the fisheries. The question is: what are the consequences of various management decisions, given the fishing level of the competing fishery? In other words, the competing fishery acts as a constraint on the management options. My approach was to develop a simple, generic model of a single stock harvested by two fisheries, and to conduct simulation studies to examine the consequences of various management choices.

THE MODEL

The simulation model (Figure 1) is an age-structured model of a fish stock with a one year time step. Recruitment is constant and natural and fishing mortality are modelled using Pope's approximation to the Gulland catch equation. The region is divided into two areas (areas 1 and 2) and the amount of mixing of fish between the two areas can be varied. The stock is fished by two fisheries. Fishery "A" is the fishery for which we are considering management strategies (i.e., the Canadian fishery). Fishery "B" is the competing fishery; it is only permitted to fish in area 2 (i.e., the disputed zone for the French fishery in 3Ps, or the area outside the 200 mile limit for the foreign fishery in 2J3KL).

Fishery "B" can be of type "allowance" or "unlimited". An allowance fishery is a competing fishery in which an allowance of fish has been preset for area 2. The French fishery in 3Ps is an example of an allowance fishery, since it has an allowance per year within the disputed zone of 3Ps. An unlimited fishery is a competing fishery for which there is no limit imposed on its fishing effort in area 2. The foreign fishery outside the 200 mile limit in 2J3KL is (more or less) an example of an unlimited fishery, since there are virtually no limits placed on the total amount of fish taken.

SIMULATIONS

The purpose of the simulations is not to represent any particular fish stock or fishery but rather to conduct generic simulations to look at the qualitative consequences of possible management choices. This type of simulation experiment can be termed "exploratory". I used a fish population with five age classes having mean weights at age of 0.6, 1.8, 4.1, 7.6 and 12.1 kg respectively. The starting population numbers in each simulation run were 100, 33, 11, 4, and 1 (1000's or 10000's of individuals) for the five ages respectively. These were divided evenly between the two areas. Each year a constant recruitment of 100 was added to the youngest age, divided evenly between the areas. The instantaneous natural mortality rate was 0.2. The fishing mortality was applied as a percentage of individuals (i.e., "exploitation rate", not "instantaneous mortality rate"); the partial recruitments applied to the fishing mortality were 0.05, 0.9, 1.0, 0.4 and 0.2 respectively for the ages.

The goal of the simulations was to examine the implications of various shifts in management strategy of fishery A (Canadian fishery) under four conditions (Figure 2). The four conditions are: (i) fishery B is an allowance fishery and there is no mixing of fish between areas 1 and 2, (ii) fishery B is an allowance fishery and there is mixing of fish between the areas, (iii) fishery B is an unlimited fishery and there is no mixing of fish between the areas and (iv) fishery B is an unlimited fishery and there is mixing of fish between the areas.

Fishery A used one of seven possible management strategies: (i) "light combined", where fishery A limits its catch such that the total exploitation rate on the fully recruited ages imposed by both fisheries combined is 20% for the whole region (areas 1 and 2 combined), (ii) "heavy combined", where fishery A limits its catch such that the total exploitation rate on the fully recruited ages imposed by both fisheries combined is 60% for the whole region, (iii) "light separate", where fishery A limits its catch in each area separately such that the total catch (both fisheries) in each separate area is limited to 20% (for fully recruited ages), (iv) "heavy separate", where fishery A limits its catch in each area separately such that the total catch (both fisheries) in each separate area is limited to 60% (for fully recruited ages), (v) "heavy/light separate", fishery A limits its catch in area 1 to 60% (for fully recruited ages), and in area 2 so that both fisheries combined take 20% (for fully recruited ages), (vi) "light/unlimited separate", where fishery A limits its catch in area 1 to 20% for fully recruited ages, but is allowed unlimited fishing in area 2 and (vii) "heavy/unlimited separate", where fishery A limits its catch in area 1 to 60% for fully recruited ages, but is allowed unlimited fishing in area 2.

The following assumptions are made: (i) if fishery B is an allowance fishery, it gets the allowed amount of fish, unless the biomass in area 2 is less than the allowance, in which case it takes the whole biomass; (ii) if fishery B has an allowance and fishery A is unlimited in area 2 then fishery A takes whatever is left over after fishery B has taken its allowance; (iii) if both fisheries are unlimited in area 2 then each takes half of the biomass. A total of 28 simulations were conducted: 4 conditions times 7 fishery A management strategies (Figure 2). Each simulation was run for 20 years, enough time to reach equilibrium conditions.

RESULTS

The output from each of the 28 runs consists of a time trace for each of 6 variables: biomass in area 1, biomass in area 2, total biomass of the stock (area 1 plus area 2), catch by fishery A, catch by fishery B, and total catch of both fisheries. The equilibrium values for these outputs are shown in Appendix 1. The results of interest are the differences between pairs of simulations of (i) the catch of fishery A (the Canadian fishery) and (ii) the total stock biomass. In general there will be a trade-off between these two. The results are therefore best discussed relative to the management objectives of the managers of fishery A. Five objectives were considered:
(i) Obtain the largest catch for fishery A; this will generally be obtained at the expense of the stock size.
(ii) Obtain the largest total stock biomass; this will generally be obtained at the expense of the catch of fishery A.
(iii) Find the largest increase in catch for fishery A possible **relative** to the decrease in stock biomass that this will entail; this objective assumes that the managers want to increase the catch of fishery A, but that they want to do this with the smallest possible cost to the stock biomass.
(iv) Find the largest increase in total biomass possible **relative** to the decrease in catch of fishery A that this will entail; this objective assumes that the managers want to increase the stock biomass, but that they want to do this with the smallest possible cost to fishery A.
(v) Finally, the most pallatable objective would be to increase both the catch of fishery A and the total stock biomass; however this is only possible under very limited circumstances.

A simple method for comparing the results of two management strategies is to look at the percent change in stock biomass relative to the percent change in catch of fishery A. However, the normal situation is that when one of these increases the other decrease. An increase from 100 to 200 is an increase of 100%, while a decrease from 100 to 50 is a decrease of 50%. However, one might argue that doubling a quantity should be viewed as an equivalent magnitude of change as halving that quantity. Therefore, the changes in total stock biomass and catch of fishery A were log-transformed to make comparisons of increases and decreases equivalent. Appendix 2 gives the log- transformed values of the total stock biomass and the catch of fishery A for all comparisons of fishery A management strategies, for each of the four sets of conditions. Table 1 gives the results of the simulations in terms of the the five goals described above.

The results show that the best management choice for fishery A depends on (i) the current management strategy, (ii) the goal of any change in management, (iii) whether the competing fishery is an allowance or an unlimited fishery, and (iv) the degree to which the fish mix between areas. In general, the unlimited fishery B results in lower stock biomass and catch for fishery A, than the allowance fishery B. Also in general, the more the fish can be assumed to mix between the two areas, the lower will be the total stock biomass and the catch for fishery A.

Points Relevant to Newfoundland Cod Stocks

The simulations reported here are not meant to mimic in detail any particular real situation; they do not represent a specific fish species or stock, or a particular geographic region or fishery. The purpose is rather to develop qualitative results to serve as a starting point for discussions of particular stocks. As examples of this type of discussion I refer here to the 3Ps and 2J3KL cod stocks. Specific advice developed from the model for these stocks would require the model to be tailored more exactly to detailed information on these stocks. Relevant simulation runs are shown in Figures 3-6.

Two of the goals of Canadian cod management are conservation of stocks and benefits to Canadians. The combination of these goals is problematic for at least two reasons. First, on the short-term there is likely to be a trade-off between conservation and benefit to Canadians. If Canadian catches are high on the short term, the stock size will most likely decrease. There is a well-established negative relationship in ecology between population size and probability of population extinction (e.g., MacArthur and Wilson 1967, Christianson and Fenchel 1977). Therefore, on the short-term, high Canadian catches (large benefit to Canadians) are likely to compromise the goal of conservation of the stock. The second problem relates to the time scale over which the "benefit to Canadians" is calculated. By reducing Canadian catches now, the present benefit to Canadians might be reduced, but depending on the time span over which the benefit is calculated, this may be more than compensated by the future benefit to Canadians if the current catch is reduced, allowing larger stock sizes and Canadian catches in future.

To examine the possible implications of the present simulations, I focus attention on the two cod stocks mentioned in the introduction, 3Ps and 2J3KL. In each case I will examine the following four questions: (i) is there any Canadian management choice that would result in both an increase in Canadian catches and an increase in the stock biomass? (ii) what would be the effect if Canadian managers allowed Canadian vessels unlimited fishing in area 2 (i.e., the disputed zone in 3Ps or the area outside the 200 mile limit in 2J3KL)? (iii) assuming that Canadian managers have already decided that they want to increase catches, how could they do this while causing the least damage to the stock biomass? and (iv) assuming that Canadian managers have already decided that they want to increase the stock biomass, how could they do this while causing the least damage to Canadian catches?

<u>3Ps</u>

The French fishery in 3Ps is an allowance fishery. Therefore, depending on the degree of movement of the cod between the disputed zone and the rest of 3Ps, the 3Ps cod stock is an example of condition 1 or 2. The current management strategy for the

Canadian fishery in 3Ps is to set a TAC to target a certain fishing mortality for the whole stock (including both fisheries and all areas). The most recent assessment of 3Ps cod shows a fully recruited fishing mortality of 0.43, which translates into 35% on fully recruited ages. Therefore, the current 3Ps situation is between the strategies I have called "light combined" and "heavy combined", but closer to the strategy "heavy combined".

From Table 1 (condition 1 or 2, goal 5, current strategy 1 or 2) and Figures 3 and 4, it appears that it would not be possible for the Canadian fishery to increase its catch without having a negative impact on the stock biomass. The likely effect of allowing the Canadian fleet to have unlimited access to the fish in the disputed zone depends on the degree of mixing of the fish between the disputed zone and the remainder of 3Ps (Appendix 1). If there is complete mixing (condition 2), allowing the Canadian fleet unlimited access in the disputed zone would result, in the longrun, in decreases in both Canadian catches and the 3Ps stock biomass; this is clearly a management choice to be avoided. However, if one could assume that the fish in the disputed zone do not mix with the other fish in 3Ps (they are effectively a separate population), then it appears that the longterm catch of the Canadian fleet could then be increased if it were to allow Canadians unlimited access in the restricted zone. Although this would result in an increase in Canadian catch, it would also cause a decrease in the total stock biomass. The real situation in 3Ps is obviously somewhere between the mixing and no mixing cases; specific advice would require some information about the amount of mixing.

If the managers have already decided that they want to increase the Canadian catch, the most conservative (i.e., highest ratio of catch increase to stock decrease) way to do this would appear to be to increase the fishing mortality in the nondisputed zone, but leave the fishing mortality in the disputed zone as before (i.e., shift to strategy 5). This is true no matter what the degree of mixing of the fish between the areas. If the managers have already decided that they want to increase the 3Ps stock biomass, the most conservative (i.e., highest ratio of stock increase to Canadian catch decrease) way to do this depends again on the degree to which the fish mix between the disputed zone and the rest of 3Ps. If the fish do not mix, the best way to accomplish this would be to reduce the catch outside the disputed zone while allowing unlimited fishing by the Canadian fleet within the disputed zone. However, if the fish do mix well throughout 3Ps then the best way to increase the stock biomass would be to keep the Canadian catch outside the disputed zone as before, but reduce the Canadian catch in the disputed zone. In this case information on the amount of movement of the fish within 3Ps is again a critical factor for determining the best management choice.

2J3KL

The foreign fishery in 2J3KL is (more or less) an unlimited fishery outside the 200 mile limit. Therefore, depending on the degree of movement of the cod between the areas inside and outside the 200 mile limit, the 2J3KL cod stock is an example of condition 3 or 4. The current management strategy for the Canadian fishery in 2J3KL is again to set a TAC to target a certain fishing mortality for the whole stock (including both fisheries and both areas). The most recent CAFSAC assessment shows a fully recruited fishing mortality of 0.65, which translates into 48% of fully recruited ages. Therefore, the current 2J3KL situation is again between the strategies "light combined" and "heavy combined", but closest to "heavy combined".

From Table 1 (condition 3 or 4, goal 5, current strategy 1 or 2) and Figures 5 and 6, it appears that, unlike the 3Ps case, it would be possible to change the management strategy for this fishery in such a way as to increase both the Canadian catch and the stock biomass. The results indicate that this could be done by reducing the Canadian catch within the 200 mile limit, but allowing the Canadian fleet unlimited access to any fish outside the 200 mile limit. Furthermore, the results indicate that even if the Canadian catch inside the 200 mile limit is not reduced, there would be virtually no reduction in the stock. This is because the model assumes that the fish caught by the Canadian fleet outside the 200 mile limit would be caught by the foreign fleet if the Canadians were not there; the effect on the population dynamics of the stock is equivalent. This is true for both the unmixed and well mixed stocks. **However** it should be noted that the decision to allow unlimited Canadian fishing outside the 200 mile limit is only justifiable if the take of the foreign fleet is unlimited. As mentioned above, the unlimited fishery B has a very detrimental impact on the stock when compared with the allowance fishery B. If limits were to be placed on the foreign catches, then there would be a very good opportunity to increase the total stock, especially if it is well mixed, by placing limits on the Canadian fishery in the area outside the 200 mile limit. This situation would then more closely approximate the 3Ps French/Canada situation.

If the managers have already decided that they want to increase the Canadian catch, the most conservative (i.e., highest ratio of catch increase to stock decrease) way to do this in the unlimited fishery B situation would be to to allow unlimited fishing by the Canadian fleet outside the 200 mile limit. This is true no matter what the degree of mixing of the fish between the areas is. If the managers have already decided that they want to increase the 2J3KL stock biomass, the most conservative (i.e., highest ratio of stock increase to Canadian catch decrease) way to do this is to reduce the Canadian TAC such that the total fishing mortality is reduced.

ACKNOWLEDGEMENTS

I would like to thank Jake Rice for his comments on the manuscript and Nick Payton for computing assistance.

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Table 1. Simulation results for 5 management objectives current management strategies and 4 conditions (see text).

Condition 1: Allowance fishery B, no mixing of fish

Current Strategy	Result for Objective 1	2	3	4	5
1. light combined	7	N/A	5	N/A	N/A
2. heavy combined	7	1,3	7	6	N/A
3. light separate	7	N/A	5	N/A	N/A
4. heavy separate	7	1,3	7	6	N/A
5. heavy/light separate	7	1,3	6	1,3	N/A
6. light/unlimited separate	7	1,3	7	1,3,5	N/A
7. heavy/unlimited separate	N/A	1,3	N/A	6	N/A

Condition 2: Allowance fishery B, complete mixing of fish

Current Strategy	Result for Objective 1	2	3	4	5
1. light combined	2,4	N/A	5	N/A	N/A
2. heavy combined	N/A	1,3	N/A	5	N/A
3. light separate	2,4	N/A	5	N/A	N/A
4. heavy separate	N/A	1,3	N/A	5	N/A
5. heavy/light separate	2,4	1,3	2,4	1,3	N/A
6. light/unlimited separate	2,4	1,3	N/A	1,3	2,4
7. heavy/unlimited separate	2,4	1,3	N/A	1,3	2,4,5,6

Condition 3: Unlimited fishery B, no mixing of fish

Current Strategy	Result for Objective 1	2	3	4	5
1. light combined	7	3,6	2,4,5	3	6
2. heavy combined	7	3,6	7	1,3	6
3. light separate	7	N/A	1	N/A	N/A
4. heavy separate	7	3,6	N/A	1	6
5. heavy/light separate	7	3,6	N/A	1	6
6. light/unlimited separate	7	N/A	7	N/A	N/A
7. heavy/unlimited separate	N/A	3,6	N/A	6	N/A

Condition 4: Unlimited fishery B, complete mixing of fish

Current Strategy	Result for Objective 1	2	3	4	5
1. light combined	7	N/A	7	N/A	N/A
2. heavy combined	7	1,3,6	7	1,3	6
3. light separate	7	N/A	7	N/A	N/A
4. heavy separate	7	1,3,6	N/A	1,3	6
5. heavy/light separate	7	1,3,6	N/A	1,3	6
6. light/unlimited separate	7	N/A	7	N/A	N/A
7. heavy/unlimited separate	N/A	1,3,6	N/A	6	N/A

Figure 1. Flow diagram of simulation model of 2 fisheries on one stock. $N_{t,i,1}$=number of individuals in year t, age i, in area 1, C=number of individuals caught, m=natural mortality rate, $Z_{t,i,1,2}$=number of individuals in year t, age i, moving from area 1 to area 2.

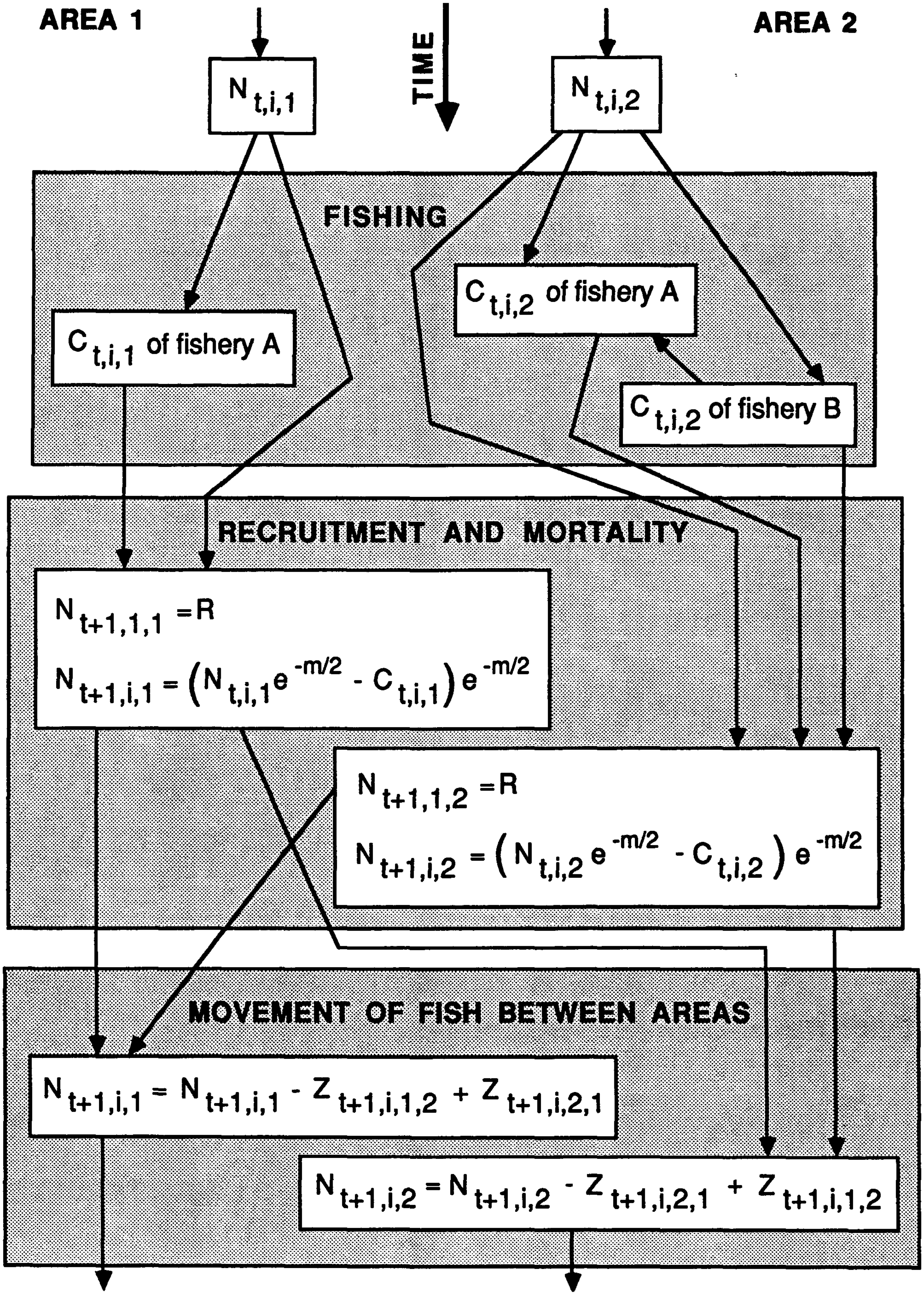


Figure 2. Illustration of 7 fishing strategies and 4 conditions considered in the simulation experiment. All combinations of strategies and conditions were simulated.

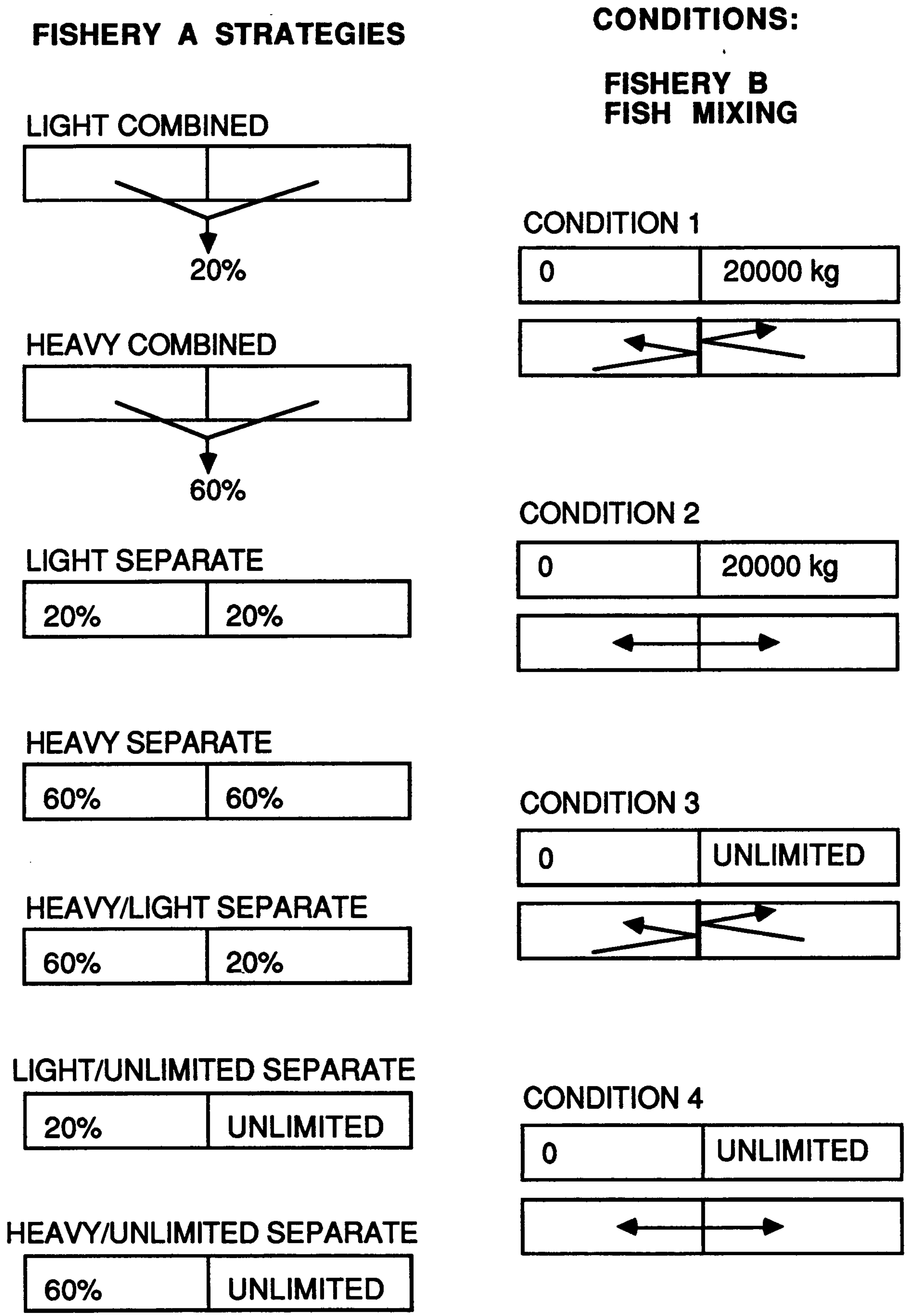


Figure 3. Simulation results for condition 1, in which fishery B is an allowance fishery and fish do not mix between the two areas. Results are shown for strategies referred to in the discussion.

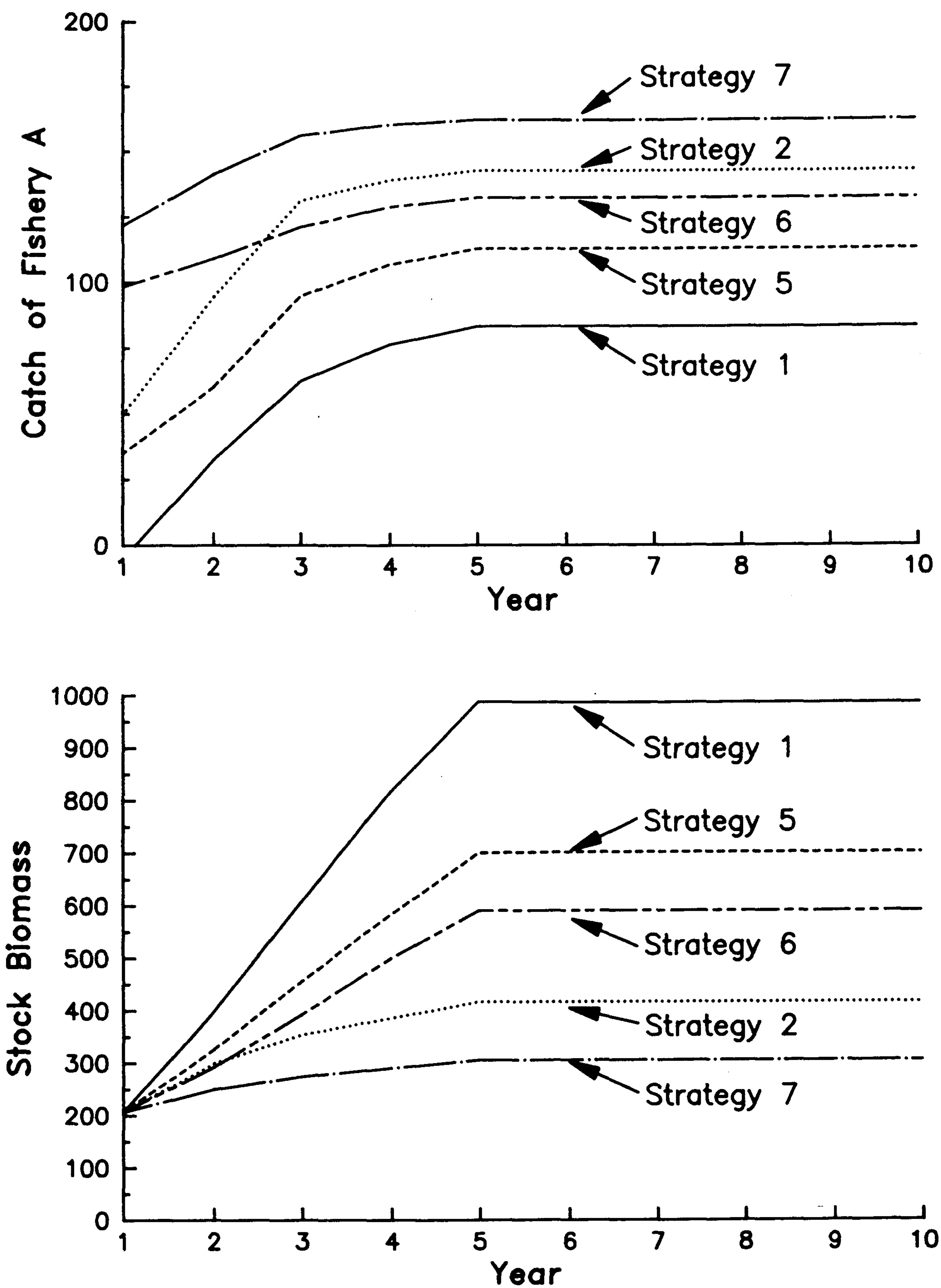


Figure 4. Simulation results for condition 2, in which fishery B is an allowance fishery and fish mix between the two areas. Results are shown for strategies referred to in the discussion.

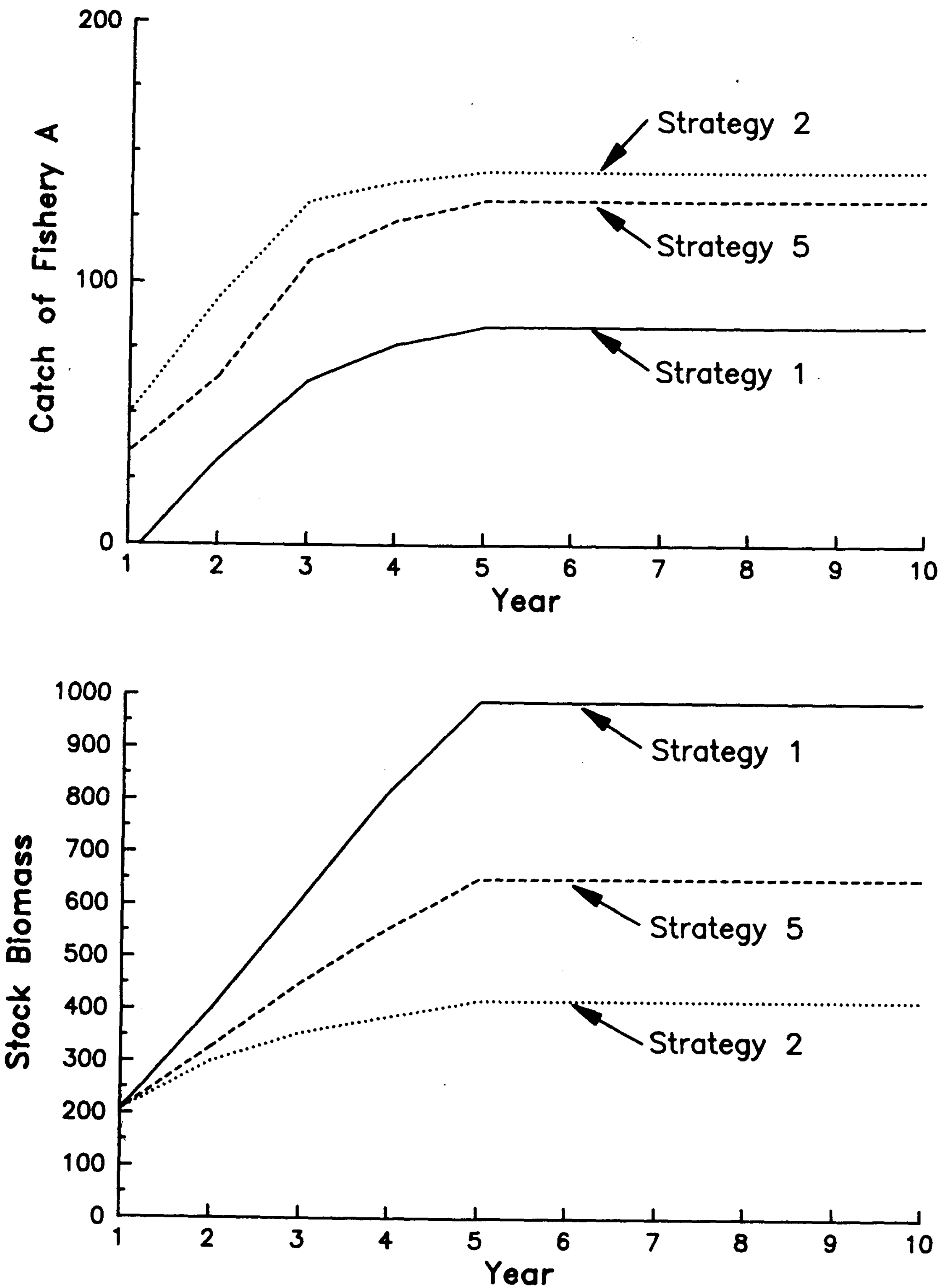


Figure 5. Simulation results for condition 3, in which fishery B is an unlimited fishery and fish do not mix between the two areas. Results are shown for strategies referred to in the discussion.

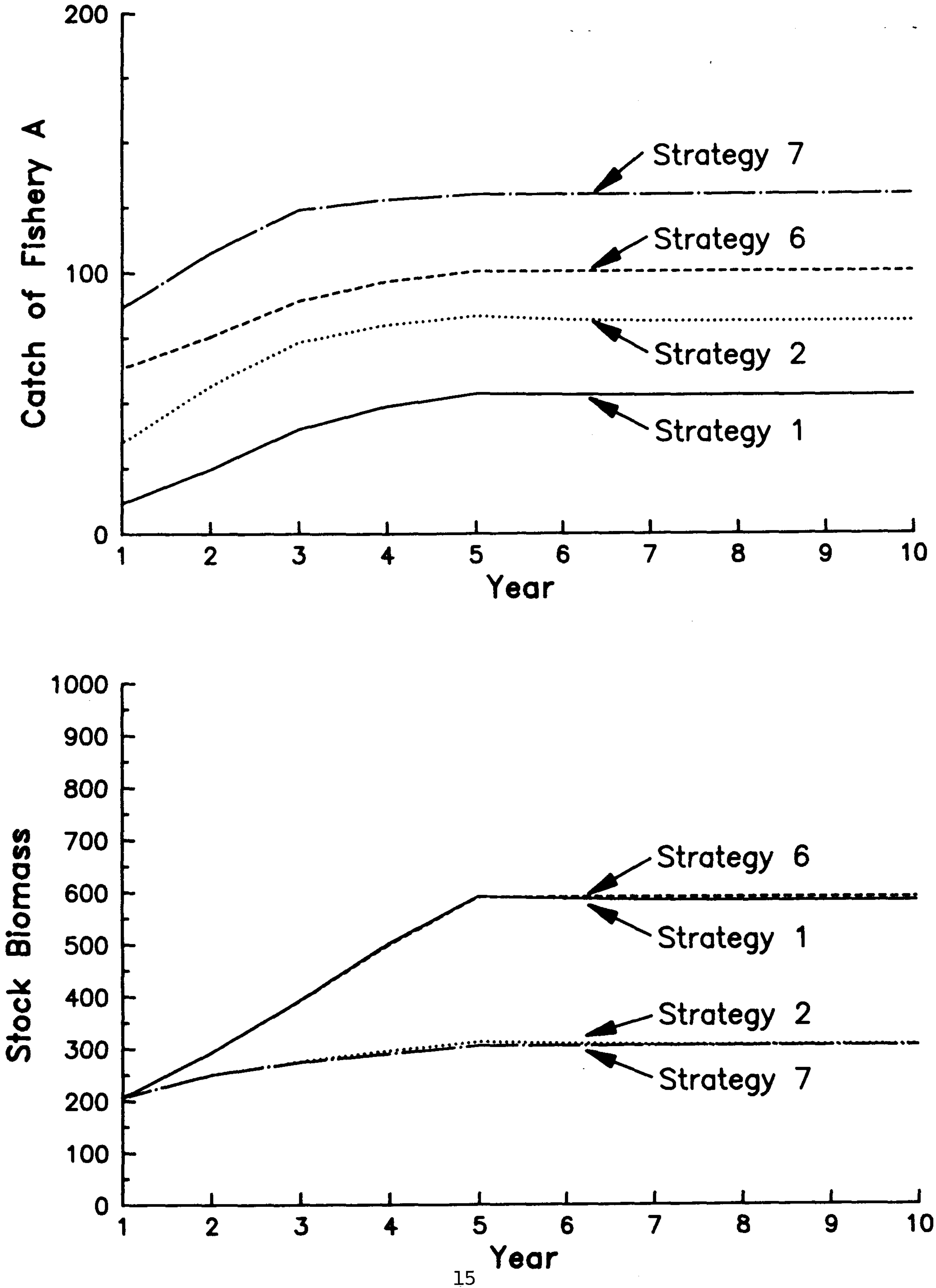
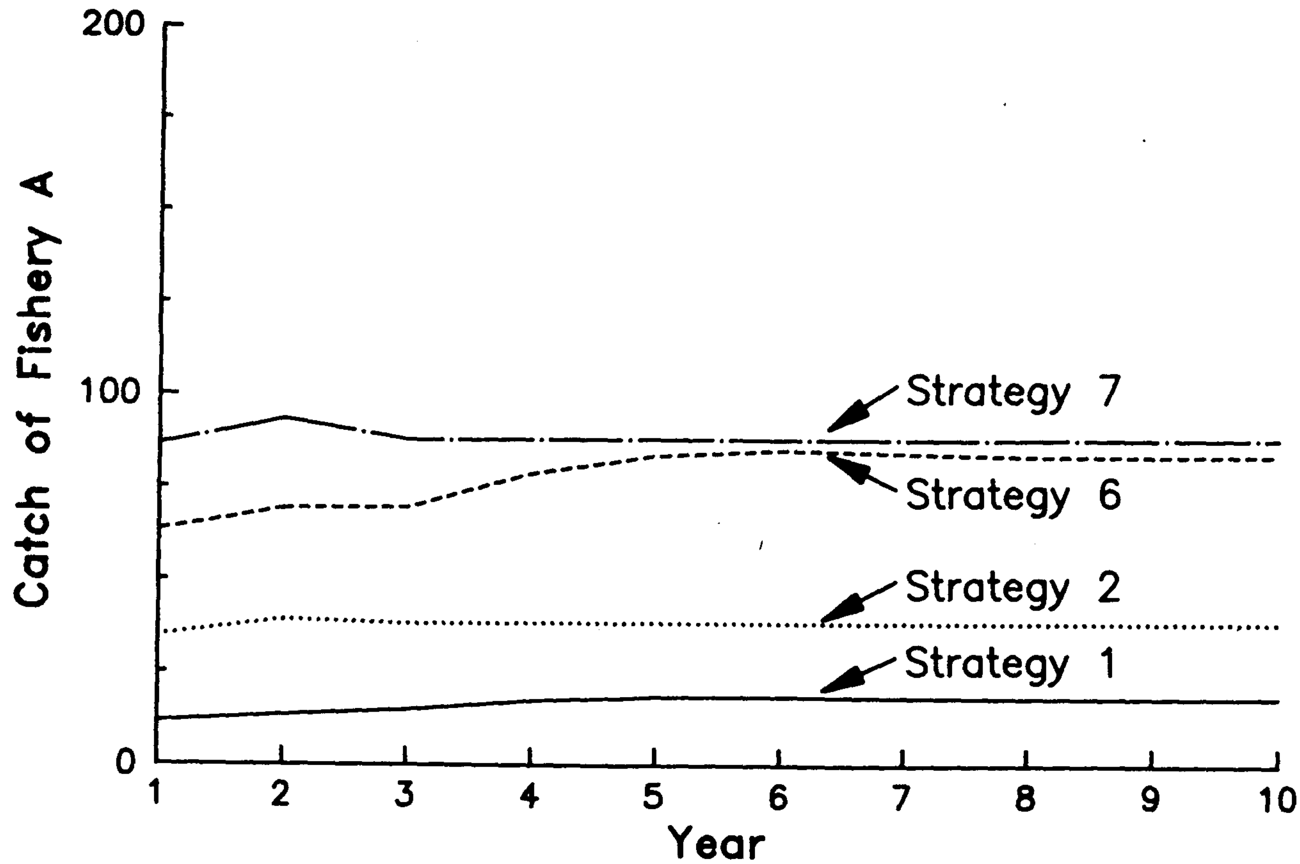
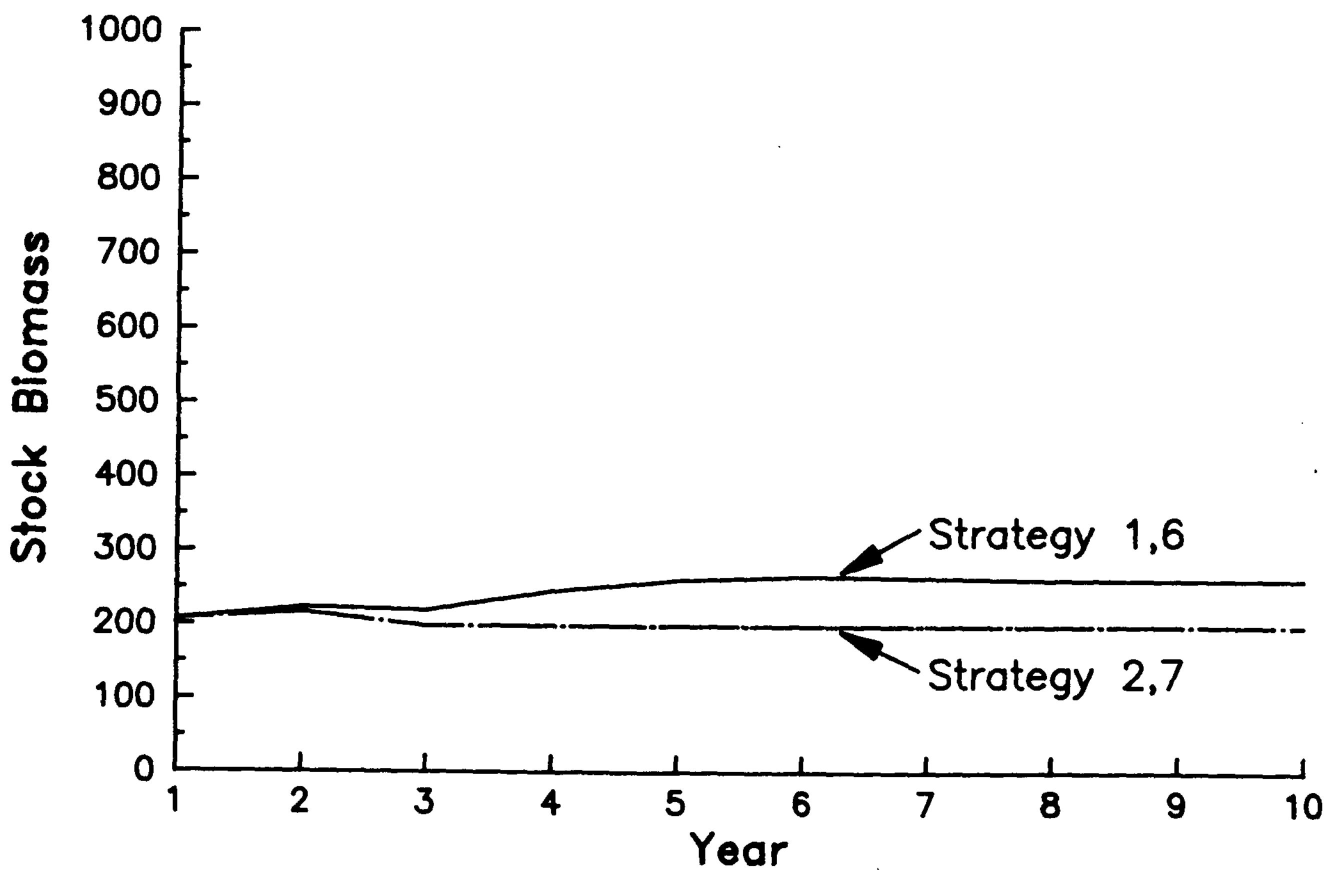


Figure 6. Simulation results for condition 4, in which fishery B is an unlimited fishery and fish mix between the two areas. Results are shown for strategies referred to in the discussion.





Appendix 1. Equilibrium values of catches and biomass for 7 strategies and 4 conditions (see text).

Strategy Fish. A	Cond.	Catch A	Catch B	Total Catch	Biomass Area 1	Biomass Area 2	Total Biomass
1	1	83.20	20.00	103.20	493.40	493.40	986.70
1	2	83.20	20.00	103.20	493.40	493.40	986.70
2	1	142.50	20.00	162.50	208.40	208.40	416.90
2	2	142.50	20.00	162.50	208.40	208.40	416.90
1	3	52.89	97.30	150.20	486.30	97.30	583.60
1	4	18.21	131.00	149.20	131.00	131.00	262.00
2	3	81.25	97.30	178.60	209.90	97.30	307.20
2	4	38.32	99.30	137.60	99.30	99.30	198.60
3	1	83.20	20.00	103.20	493.40	493.40	986.70
3	2	83.20	20.00	103.20	493.40	493.40	986.70
4	1	142.50	20.00	162.50	208.40	208.40	416.90
4	2	142.50	20.00	162.50	208.40	208.40	416.90
3	3	51.60	97.30	148.90	493.40	97.30	590.70
3	4	18.21	131.00	149.20	131.00	131.00	262.00
4	3	81.23	97.30	178.50	208.40	97.30	305.70
4	4	38.32	99.30	137.60	99.30	99.30	198.60
5	1	112.80	20.00	132.80	208.40	493.40	701.80
5	2	131.50	20.00	151.50	325.00	325.00	650.00
5	3	81.23	97.30	178.50	208.40	97.30	305.70
5	4	38.32	99.30	137.60	99.30	99.30	198.60
6	1	132.30	16.59	148.90	493.40	97.30	590.70
6	2	131.90	17.35	149.20	131.00	131.00	262.00
7	1	161.90	16.59	178.50	208.40	97.30	305.70
7	2	121.00	16.65	137.60	99.30	99.30	198.60
6	3	100.30	48.65	148.90	493.40	97.30	590.70
6	4	83.72	65.51	149.20	131.00	131.00	262.00
7	3	129.90	48.65	178.50	208.40	97.30	305.70
7	4	87.97	49.65	137.60	99.30	99.30	198.60

Appendix 2. Comparisons of equilibrium stock biomass and catch of fishery A for 7 strategies and 4 conditions (see text). All biomass and catch values were log-transformed before ratios were calculated.

From Strategy	To Strategy	Biomass Ratio	Catch Ratio	Biomass Ratio per Catch Ratio	Catch Ratio per Biomass Ratio
Condition 1: Allowance Fishery B, No Fish Mixing					
1	1	0.00	0.00	N/A	N/A
1	2	-0.86	0.54	-1.58	-0.63
1	3	0.00	0.00	N/A	N/A
1	4	-0.86	0.54	-1.58	-0.63
1	5	-0.34	0.31	-1.10	-0.91
1	6	-0.51	0.46	-1.11	-0.90
1	7	-1.17	0.66	-1.77	-0.57
2	1	0.86	-0.54	-1.58	-0.63
2	2	0.00	0.00	N/A	N/A
2	3	0.86	-0.54	-1.58	-0.63
2	4	0.00	0.00	N/A	N/A
2	5	0.52	-0.24	-2.21	-0.45
2	6	0.35	-0.08	-4.36	-0.23
2	7	-0.31	0.12	-2.61	-0.38
3	1	0.00	0.00	N/A	N/A
3	2	-0.86	0.54	-1.58	-0.63
3	3	0.00	0.00	N/A	N/A
3	4	-0.86	0.54	-1.58	-0.63
3	5	-0.34	0.31	-1.10	-0.91
3	6	-0.51	0.46	-1.11	-0.90
3	7	-1.17	0.66	-1.77	-0.57
4	1	0.86	-0.54	-1.58	-0.63
4	2	0.00	0.00	N/A	N/A
4	3	0.86	-0.54	-1.58	-0.63
4	4	0.00	0.00	N/A	N/A
4	5	0.52	-0.24	-2.21	-0.45
4	6	0.35	-0.08	-4.36	-0.23
4	7	-0.31	0.12	-2.61	-0.38
5	1	0.34	-0.31	-1.10	-0.91
5	2	-0.52	0.24	-2.21	-0.45
5	3	0.34	-0.31	-1.10	-0.91
5	4	-0.52	0.24	-2.21	-0.45
5	5	0.00	0.00	N/A	N/A
5	6	-0.17	0.16	-1.11	-0.90
5	7	-0.83	0.35	-2.35	-0.43
6	1	0.51	-0.46	-1.11	-0.90
6	2	-0.35	0.08	-4.36	-0.23
6	3	0.51	-0.46	-1.11	-0.90
6	4	-0.35	0.08	-4.36	-0.23
6	5	0.17	-0.16	-1.11	-0.90
6	6	0.00	0.00	N/A	N/A
6	7	-0.66	0.20	-3.31	-0.30
7	1	1.17	-0.66	-1.77	-0.57
7	2	0.31	-0.12	-2.61	-0.38
7	3	1.17	-0.66	-1.77	-0.57

7	4	0.31	-0.12	-2.61	-0.38
7	5	0.83	-0.35	-2.35	-0.43
7	6	0.66	-0.20	-3.31	-0.30
7	7	0.00	0.00	N/A	N/A

Condition 2: Allowance Fishery B, Fish Mixing

1	1	0.00	0.00	N/A	N/A
1	2	-0.86	0.54	-1.58	-0.63
1	3	0.00	0.00	N/A	N/A
1	4	-0.86	0.54	-1.58	-0.63
1	5	-0.42	0.46	-0.90	-1.11
1	6	-1.33	0.46	-2.86	-0.35
1	7	-1.60	0.38	-4.25	-0.24
2	1	0.86	-0.54	-1.58	-0.63
2	2	0.00	0.00	N/A	N/A
2	3	0.86	-0.54	-1.58	-0.63
2	4	0.00	0.00	N/A	N/A
2	5	0.44	-0.08	-5.55	-0.18
2	6	-0.46	-0.08	5.81	0.17
2	7	-0.74	-0.17	4.43	0.23
3	1	0.00	0.00	N/A	N/A
3	2	-0.86	0.54	-1.58	-0.63
3	3	0.00	0.00	N/A	N/A
3	4	-0.86	0.54	-1.58	-0.63
3	5	-0.42	0.46	-0.90	-1.11
3	6	-1.33	0.46	-2.86	-0.35
3	7	-1.60	0.38	-4.25	-0.24
4	1	0.86	-0.54	-1.58	-0.63
4	2	0.00	0.00	N/A	N/A
4	3	0.86	-0.54	-1.58	-0.63
4	4	0.00	0.00	N/A	N/A
4	5	0.44	-0.08	-5.55	-0.18
4	6	-0.46	-0.08	5.81	0.17
4	7	-0.74	-0.17	4.43	0.23
5	1	0.42	-0.46	-0.90	-1.11
5	2	-0.44	0.08	-5.55	-0.18
5	3	0.42	-0.46	-0.90	-1.11
5	4	-0.44	0.08	-5.55	-0.18
5	5	0.00	0.00	N/A	N/A
5	6	-0.91	0.00	N/A	0.00
5	7	-1.18	-0.09	13.60	0.07
6	1	1.33	-0.46	-2.86	-0.35
6	2	0.46	0.08	5.81	0.17
6	3	1.33	-0.46	-2.86	-0.35
6	4	0.46	0.08	5.81	0.17
6	5	0.91	0.00	N/A	0.00
6	6	0.00	0.00	N/A	N/A
6	7	-0.28	-0.09	3.16	0.32
7	1	1.60	-0.38	-4.25	-0.24
7	2	0.74	0.17	4.43	0.23
7	3	1.60	-0.38	-4.25	-0.24
7	4	0.74	0.17	4.43	0.23
7	5	1.18	0.09	13.60	0.07
7	6	0.28	0.09	3.16	0.32

7	7	0.00	0.00	N/A	N/A

Condition 3: Unlimited Fishery B, No Fish Mixing

1	1	0.00	0.00	N/A	N/A
1	2	-0.64	0.42	-1.52	-0.66
1	3	0.01	-0.02	-0.63	-1.60
1	4	-0.65	0.42	-1.52	-0.66
1	5	-0.65	0.42	-1.52	-0.66
1	6	0.01	0.63	0.02	53.28
1	7	-0.65	0.90	-0.72	-1.39
2	1	0.64	-0.42	-1.52	-0.66
2	2	0.00	0.00	N/A	N/A
2	3	0.65	-0.44	-1.48	-0.68
2	4	-0.00	0.00	N/A	0.00
2	5	-0.00	0.00	N/A	0.00
2	6	0.65	0.21	3.11	0.32
2	7	-0.00	0.47	-0.01	-145.00
3	1	-0.01	0.02	-0.63	-1.60
3	2	-0.65	0.44	-1.48	-0.68
3	3	0.00	0.00	N/A	N/A
3	4	-0.66	0.44	-1.49	-0.67
3	5	-0.66	0.44	-1.49	-0.67
3	6	0.00	0.65	0.00	N/A
3	7	-0.66	0.92	-0.72	-1.39
4	1	0.65	-0.42	-1.52	-0.66
4	2	0.00	0.00	N/A	0.00
4	3	0.66	-0.44	-1.49	-0.67
4	4	0.00	0.00	N/A	N/A
4	5	0.00	0.00	N/A	N/A
4	6	0.66	0.21	3.12	0.32
4	7	0.00	0.47	0.00	N/A
5	1	0.65	-0.42	-1.52	-0.66
5	2	0.00	0.00	N/A	0.00
5	3	0.66	-0.44	-1.49	-0.67
5	4	0.00	0.00	N/A	N/A
5	5	0.00	0.00	N/A	N/A
5	6	0.66	0.21	3.12	0.32
5	7	0.00	0.47	0.00	N/A
6	1	-0.01	-0.63	0.02	53.28
6	2	-0.65	-0.21	3.11	0.32
6	3	0.00	-0.65	0.00	N/A
6	4	-0.66	-0.21	3.12	0.32
6	5	-0.66	-0.21	3.12	0.32
6	6	0.00	0.00	N/A	N/A
6	7	-0.66	0.26	-2.51	-0.40
7	1	0.65	-0.90	-0.72	-1.39
7	2	0.00	-0.47	-0.01	-145.00
7	3	0.66	-0.92	-0.72	-1.39
7	4	0.00	-0.47	0.00	N/A
7	5	0.00	-0.47	0.00	N/A
7	6	0.66	-0.26	-2.51	-0.40
7	7	0.00	0.00	N/A	N/A

Condition 4: Unlimited Fishery B, Fish Mixing

1	1	0.00	0.00	N/A	N/A
1	2	-0.28	0.75	-0.37	-2.72
1	3	0.00	0.00	N/A	N/A
1	4	-0.28	0.75	-0.37	-2.72
1	5	-0.28	0.75	-0.37	-2.72
1	6	0.00	1.54	0.00	N/A
1	7	-0.28	1.59	-0.17	-5.77
2	1	0.28	-0.75	-0.37	-2.72
2	2	0.00	0.00	N/A	N/A
2	3	0.28	-0.75	-0.37	-2.72
2	4	0.00	0.00	N/A	N/A
2	5	0.00	0.00	N/A	N/A
2	6	0.28	0.79	0.35	2.88
2	7	0.00	0.84	0.00	N/A
3	1	0.00	0.00	N/A	N/A
3	2	-0.28	0.75	-0.37	-2.72
3	3	0.00	0.00	N/A	N/A
3	4	-0.28	0.75	-0.37	-2.72
3	5	-0.28	0.75	-0.37	-2.72
3	6	0.00	1.54	0.00	N/A
3	7	-0.28	1.59	-0.17	-5.77
4	1	0.28	-0.75	-0.37	-2.72
4	2	0.00	0.00	N/A	N/A
4	3	0.28	-0.75	-0.37	-2.72
4	4	0.00	0.00	N/A	N/A
4	5	0.00	0.00	N/A	N/A
4	6	0.28	0.79	0.35	2.88
4	7	0.00	0.84	0.00	N/A
5	1	0.28	-0.75	-0.37	-2.72
5	2	0.00	0.00	N/A	N/A
5	3	0.28	-0.75	-0.37	-2.72
5	4	0.00	0.00	N/A	N/A
5	5	0.00	0.00	N/A	N/A
5	6	0.28	0.79	0.35	2.88
5	7	0.00	0.84	0.00	N/A
6	1	0.00	-1.54	0.00	N/A
6	2	-0.28	-0.79	0.35	2.88
6	3	0.00	-1.54	0.00	N/A
6	4	-0.28	-0.79	0.35	2.88
6	5	-0.28	-0.79	0.35	2.88
6	6	0.00	0.00	N/A	N/A
6	7	-0.28	0.05	-5.91	-0.17
7	1	0.28	-1.59	-0.17	-5.77
7	2	0.00	-0.84	0.00	N/A
7	3	0.28	-1.59	-0.17	-5.77
7	4	0.00	-0.84	0.00	N/A
7	5	0.00	-0.84	0.00	N/A
7	6	0.28	-0.05	-5.91	-0.17
7	7	0.00	0.00	N/A	N/A