Chapter 7
BAG LIMIT ANALYSIS

A bag limit analysis is used to determine the effect a simulated bag limit would have on a particular fishery either by estimating the percent of positive catch trips for a given species that exceed the bag limit or by evaluating the reduction in overall harvest resulting from a simulated bag limit regulation. The four basic steps involved in the analysis of a simulated bag limit are as follows:

1. Definition of directed effort

   Directed effort can be defined as those trips where the species of interest was actually caught, or those trips that targeted the species of interest, or either the species of interest was caught or targeted on a given trip. Another option for defining directed effort is to include species associations. For instance, trips targeting one species would be redefined as targeting a group of associated species. The decision of how to define directed effort should be based on the specific management questions to be addressed (see Chapter 10 for further discussion of directed effort). For this bag limit analysis directed effort is defined as those trips where the angler harvested at least one fish of the species of interest.

2. Weighting of strata

   When performing catch-per-trip analyses among state/mode/wave strata, data must be reweighted prior to pooling among strata. Reweighting of data is necessary due to the non-random distribution of intercepts among strata (see Chapter 4 for details on proper weighting of strata for catch-per-trip analyses).

3. Calculations involving group catches

   Group catches are those catches that cannot be separated into catch for each individual angler in the fishing party. Group catches are coded in Record Type 4 of the intercept interview files. Group catches can either be removed from the data prior to performing a bag limit analysis or used in the analysis by dividing the total group catch by the total anglers in the party. In either case, it is important to identify the biases introduced into the analysis with either the removal or averaging of group catch data.

4. Quasi post-stratification

   The post-stratification variable in this analysis is catch (-per-trip), therefore, the strata are the number of fish caught. This is termed quasi post-stratification since an analysis variable ("catch") is used as the strata variable. This method is valid for the bag limit analysis since the mortality reduction associated with a specific bag limit is being calculated. As a check, the harvest estimate from the bag limit should be nearly identical to the MRFSS estimate for that species. The estimate calculated from the bag limit analysis should not, however, replace the MRFSS estimate because the variances associated with quasi post-stratification are artificially reduced (see Chapter 6 for details on post-stratification).

Computational Steps (see Chapter 4 for details on catch-per-trip analysis shown in steps 1-10):

1. Calculate the total number of fish of a given species available for inspection (Type A Catch) and the number of fish not brought back in whole form (Type B1 Catch) for each separate interview (ID_CODE) for a given state/mode/wave stratum.

    a. From the Type 2 and Type 3 records, select the records with the given species code (SP_CODE).
    b. Keep only the first record for each ID_CODE.
    c. Keep the variable NUM_FISH (Type 2 records: # of Type B1 fish) and FSHINSP (Type 3 records: # of Type A fish inspected).

2. Merge the subsetted Type 2 and Type 3 records with the Type 1 records by ID_CODE. Sum NUM_FISH and FSHINSP.

3. Deal with group catches by either ignoring them (go to step 4) or by dividing the group catches evenly among anglers.

    a. Calculate the total number of fish caught by ID_CODE from the Type 2 and Type 3 records (NUM_FISH + FSHINSP).
    b. If CNTRBTRS = 0 then delete. Calculate catch-per-trip as FSHINSP/CNTRBTRS.

4. Calculate catch frequencies by state/mode/wave stratum.

5. Calculate total intercepts by state/mode/wave stratum.

6. Merge the catch frequency data with the total intercept data by state/mode/wave stratum.

7. Calculate relative frequency by state/mode/wave stratum.

8. From the SAS trip estimation files, select the records with the given state/mode/wave stratum and keep the variable NUMRTRIP (total estimated number of trips for that stratum).

9. Merge the trip data (NUMRTRIP) with the relative catch frequency data by state/mode/wave stratum.

10. Calculate the estimated number of directed trips by catch frequency for each state/mode/wave stratum by multiplying each relative catch frequency times NUMRTRIP.

11. Sum the estimated number of directed trips for each catch frequency across strata.

12. Calculate the fish harvested for each catch frequency by multiplying the estimated catch by the total number of directed trips.

13. Calculate total harvest by summing all catches.

14. To simulate a bag limit, add all directed trips for catch frequencies greater than the simulated bag limit to the catch frequency equal to that bag limit.

15. For all catch frequencies greater than the bag limit, set the number of directed trips equal to zero.

16. Recalculate the total harvest following steps 12 & 13.

Data on the number of intercepted directed fishing trips and the total number of intercepted trips for a given year/state/wave/mode stratum for each catch class from the intercept survey, and the estimated number of fishing trips for a given year/state/wave/mode stratum are used to estimate the number of directed fishing trips by year/state/wave/mode stratum for each catch class (Table 8) following the equation:

$$t_{C=X} = \frac{t_{C=X\ (ijk)}}{A_{ijk}} x t_{ijk}$$

where:
- i = state
- j = mode
- k = wave
- C = catch class
- X = number of fish in catch
- $\tau_{C=X}$ = total number of directed trips with C=X in a given state/mode/wave stratum
- τ_{ijk} = estimated number of trips in a given state/mode/wave stratum
- $t_{C=X\ ijk}$ = number of intercepted directed trips with C=X in a given state/mode/wave stratum
- A_{ijk} = total number of intercepted trips in a given state/mode/wave stratum

Table 8. 1990 MRFSS trip and angler data for estimating total number of directed trips by wave/mode strata and catch class in a bag limit analysis.

Wave/Mode Strata	Catch	# Intercepted Directed Trips	Total Intercepted Trips	Total Estimated Trips	Total Directed Trips
Wave 3 Shore	1	3	357	285,769	2,401
	6	1	357	285,769	801
Wave 3 Party/charter Boat	1	1	243	103,809	431
Wave 3 Private/Rental Boat	1	71	1417	776,287	39,824
	2	46	1417	776,287	25,802
	3	26	1417	776,287	14,583
	4	11	1417	776,287	6170
	:	:	:	:	:

For example, the total number of directed trips for Wave 3 shore mode for a catch of one fish is:

(3/357) *x* (285,769) = 2401 trips

The estimated number of directed fishing trips for each catch class is obtained by summing the directed trips across wave/mode strata. The total estimated bluefish harvest is then obtained by multiplying the number of bluefish caught per trip times the estimated number of directed fishing trips within each catch class (Table 9). For example, for the catch class of two fish per trip, the total estimated number of directed trips is 94,815 leading to an estimated bluefish harvest in the catch class of:

2 bluefish/trip *x* 94,815 trips = 189,630 bluefish harvested

Table 9. Estimated bluefish harvest for catch classes of bluefish from the 1990 MRFSS catch and trip estimates for New York.

# Bluefish Caught	Frequency %	Cumulative Frequency %	Estimated Directed Trips	Estimated Bluefish Harvested
1	31	31	174,419	174,419
2	17	48	94,815	189,630
3	12	60	68,986	206,959
4	7	67	38,608	154,432
5	6	73	33,750	168,750
6	5	78	28,347	170,082
7	3	81	16,457	115,201
8	4	85	23,722	189,773
9	1	86	7,548	67,934
10	3	89	16,570	165,699
11	1	90	4,842	53,265
12	3	93	15,347	184,164
13	1	94	3,769	48,997
14	1	95	3,486	48,806
15	1	96	6,592	98,882
>15	4	100	26,160	766,226
		Totals	563,418	2,803,219

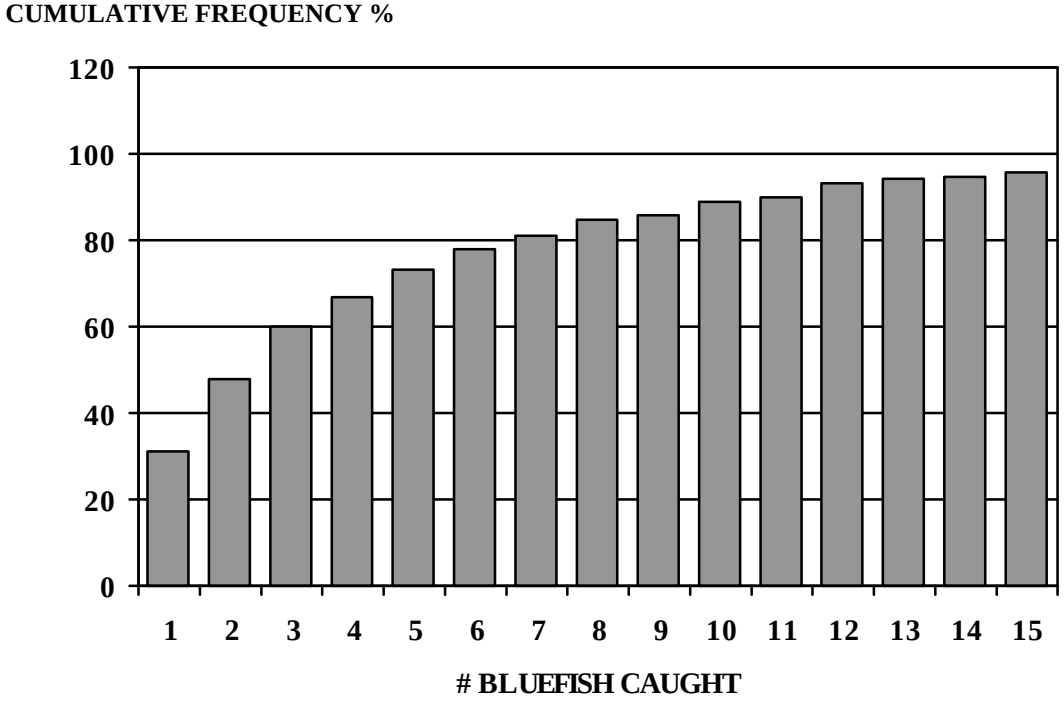

Figure 20. Bluefish catch frequency data from the 1990 MRFSS for New York.

The effects of a simulated bag limit on bluefish harvest are demonstrated using 1990 MRFSS data for New York. The catch frequency of bluefish caught in New York in 1990 is calculated and cumulative frequency is obtained (Figure 20). To simulate a bag limit of 10 bluefish, it is assumed that a cumulative catch frequency of 100% is reached at the 10 fish bag limit instead of the greater than 15 fish catch frequency (Table 9). Estimation of the number of directed trips for the bag limit analysis is performed by summing the estimated number of directed trips for catch classes 11 through >15 (60,196 directed trips) and adding them to the estimated number of directed trips for a catch class of 10 fish (16,570 directed trips), giving an estimate of 76,766 directed trips (Table 10). The estimated number of directed trips for catch classes greater than 10 fish are set to zero. The estimated bluefish harvest for each catch class is recalculated by multiplying the number of bluefish caught times the estimated number of trips. The estimates of harvest will remain the same for all catch classes below the bag limit and will only differ for the catch class corresponding to the bag limit; in this example, 10 fish. For example, the estimated bluefish harvest for New York in 1990 for 10 fish was 165,699, while the estimated harvest based on the simulated bag limit of 10 fish is 767,656 (Table 10, Figure 21).

Table 10. Simulation of the effects of a 10 fish bag limit on estimated bluefish harvest for the state of New York. Data is based on the 1990 MRFSS.

# of Bluefish	Frequency %	Cumulative Frequency %	Estimated Directed Trips	Estimated Bluefish Harvest
1	31	31	174,419	174,419
2	17	48	94,815	189,630
3	12	60	68,986	206,959
4	7	67	38,608	154,432
5	6	73	33,750	168,750
6	5	78	28,347	170,082
7	3	81	16,457	115,201
8	4	85	23,722	189,773
9	1	86	7,548	67,934
10	14	100	76,766	767,656
11	0	100	0	0
12	0	100	0	0
13	0	100	0	0
14	0	100	0	0
15	0	100	0	0
>15	0	100	0	0
		Totals	563,418	2,204,835

*** *Result would be a 21% harvest reduction.*

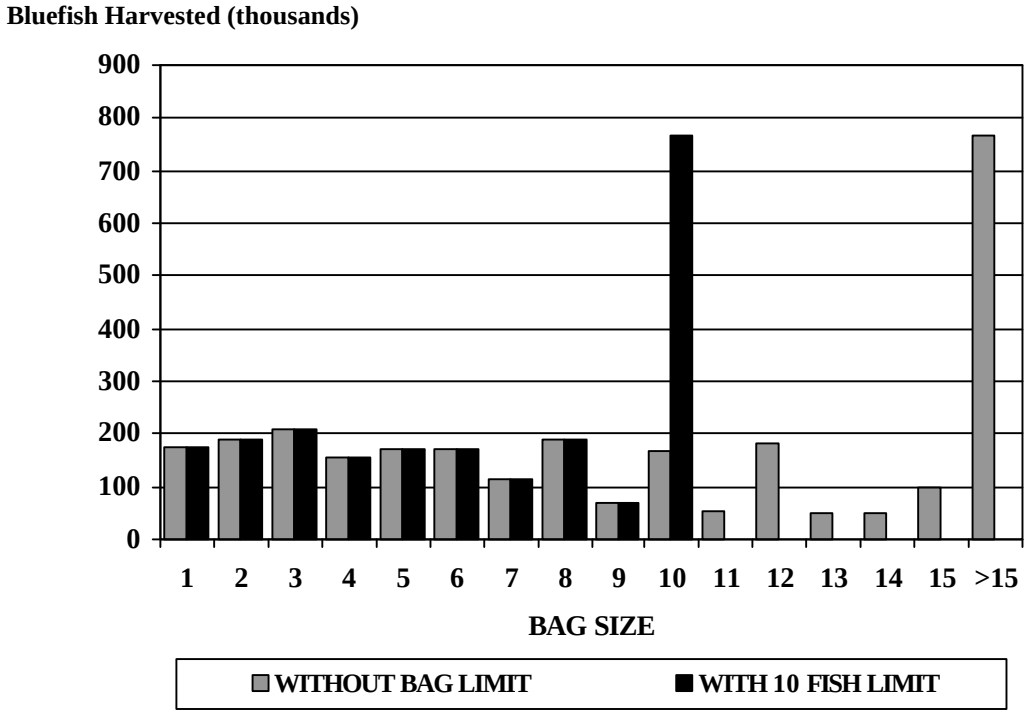

Figure 21. Comparison of New York bluefish harvest without a bag limit and with a 10 fish bag limit. Data are from the 1990 MRFSS.

The total estimated number of trips in the bag limit analysis will remain the same at 563,418 fishing trips for bluefish in New York in 1990. However, the total estimated bluefish harvest is reduced from a total harvest of 2,803,219 bluefish with no bag limit to 2,204,835 bluefish with a bag limit of 10 fish, corresponding to a harvest reduction of 21% (Table 10).

The bag limit analysis can be performed for various bag limits to monitor the effect on total harvest reduction. For example, a similar bag limit analysis using the MRFSS data in Table 9 for a bag limit of 5 bluefish would reduce the total estimated bluefish harvest by 41%, from a total harvest of 2,803,219 bluefish harvested with no bag limit to 1,658,390 bluefish harvested under a 5 fish bag limit (Table 11).

Table 11. Simulation of the effects of a five fish bag limit on estimated bluefish harvest for the state of New York. Data is based on the 1990 MRFSS.

# of Bluefish	Frequency %	Cumulative Frequency %	Estimated Directed Trips	Estimated Bluefish Harvest
1	31	31	174,419	174,419
2	17	48	94,815	189,630
3	12	60	68,986	206,959
4	7	67	38,608	154,432
5	33	100	186,590	932,950
6	0	100	0	0
7	0	100	0	0
8	0	100	0	0
9	0	100	0	0
10	0	100	0	0
11	0	100	0	0
12	0	100	0	0
13	0	100	0	0
14	0	100	0	0
15	0	100	0	0
>15	0	100	0	0
		Totals	563,418	1,658,390

*** *Result would be a 41% harvest reduction.*

Several other associated management issues may need to be considered when evaluating the bag limit analysis:

1) Possible changes in directed fishing effort on the species may occur due to the imposition of a bag limit. For example, if the species is of great importance to the angler, anglers may use the bag limit as a goal and therefore increase fishing effort in an attempt to catch the maximum allowable catch for that species. On the other hand, fishing effort may decline if anglers consider the limit too restrictive and therefore not worth targeting the species.

2) Compliance issues will need to be considered before implementation of bag limit regulations. Specific considerations may need to be given to whether anglers will comply with the regulation, and what type of enforcement would be required to monitor compliance.

3) Consideration must be given on how to express the bag limit regulation; as fish per individual angler, or fish per boat, or fish per fishing party? This may be influenced by the specific fishery under consideration, with some fisheries lending themselves better to management on an individual angler basis and others better managed on a boat or fishing party basis. The expression of the bag limit regulation may also influence the manner in which group catches will be analyzed. For example, if the bag limit regulation is expressed on the basis of boat or fishing party catches then group catches would be an important component of the bag limit analysis.

4) The imposition of a bag limit regulation may cause additional hooking mortality due to increased catch and release in the fishery. This hooking mortality needs to be factored into any model designed to reduce overall mortality through a bag limit.

5) Consideration must also be given to the effect the bag limit will have on the directed effort of other managed species. The use of bag limit regulations to decrease fishing effort on one species may cause an associated increase in directed fishing effort for another species of interest to the angler.