# AN ALTERNATIVE APPROACH TO DETERMINING SUBSISTENCE HARVEST LEVELS

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Table 1 of the Subsistence Harvest Management Plan (SHMP) lists the strike/harvest levels for 12 ranges of population abundance (referred to as blocks) for each of three possible trends in abundance (increasing, zero, and declining). Table 1 of the SHMP therefore constitutes the *harvest rule*. These strike/harvest levels are a function of the average abundance over the five years prior to the start of the five-year period for which strike/harvest levels are needed and the trend in abundance for the ten years prior to the start of this five-year period. The alternative values listed in Table 1 below are based on the same basic structure for selecting strike/harvest levels as that used to construct Table 1 of the SHMP, except that different levels of precaution (e.g. different rates of recovery) apply to different population sizes.

Table 1. Strike/harvest levels (number per 5-year period). This table is preliminary and intended as an example of an alternative approach to determining harvest levels. I have been asked to examine in more detail if harvests can reasonably be increased for population sizes in the range 500-600. This table may be modified accordingly and will be updated based on an increased number of simulations before the 2 August hearing.

| **Population (Five year averages)** | **Harvest** | | |
|---|---|---|---|
| | **Increasing Trend** | **Zero Trend** | **Decreasing Trend** |
| <260 | 0 | 0 | 0 |
| 260-299 | 4 | 4 | 2 |
| 300-349 | 10 | 5 | 2 |
| 350-399 | 12 | 8 | 8 |
| 400-449 | 13 | 9 | 9 |
| 450-499 | 13 | 12 | 12 |
| 500-549 | 14 | 12 | 12 |
| 550-599 | 14 | 14 | 14 |
| 600-649 | 14 | 14 | 14 |
| 650-699 | 26 | 20 | 20 |
| 700-779 | 26 | 23 | 23 |

The values in Table 1 of the SHMP are based on a computer model which seeks out the largest harvest in each block that meets the 25/95 criterion[1]. The 25/95 criterion therefore applies to all blocks (a total of 30 blocks are included in the computer model used by the NMFS) and it relates to recovery to the assumed OSP level of 780 animals. Table 1 above is based on different ways to formulate the policy goal. A key difference between the policy goal underlying Table 1 above and Table 1 of the SHMP is that rather than a

[1] The 25/95 criterion implies that there will be no more than a 5% probability that difference between the time to recover to the target population size under a harvest rule and the time to recover under no harvesting does not exceed 25% of the time to recover under no harvest.

single goal of recovery to 780, there are a set of intermediate goals for each of three ranges of population size (below 500, between 500 and 600, and above 600).

The approach used to select the strike/harvest levels in Table 1 differs from that used by the NMFS in three ways:

1. The definition of recovery in the SHMP relates to the percentage delay in recovery. This statistic can, however, be misleading. For example, if the time to recovery is only 2 years, a 25% delay in recovery is only six months, a negligible amount of time given our knowledge of the dynamics of the population. Table 1 above is based therefore on the percentage delay in recovery and the actual delay in recovery (i.e. the delay in recovery expressed in numbers of years rather than as a percentage of the time to recovery in the absence of strikes/harvest). The criterion for recovery is that *either* the percentage delay in recovery is less than 25% for a pre-specified level of probability *or* the actual delay in recovery is less than 5 years for a pre-specified level of probability.
2. "Recovery" as defined in SHMP relates to recovery to the assumed OSP level of 780 animals. Table 1 above is based on intermediate goals for recovery:
   A) for population sizes below 500 animals, the intermediate goal is recovery to 500 animals;
   B) for population sizes between 500 and 600 animals, the intermediate goal is recovery to 600 animals; and
   C) for population sizes above 600 animals, the intermediate goal is recovery to 780 animals.

   Although Table 1 above involves three intermediate goals, the ultimate objective is still recovery to the assumed OSP level of 780 animals, and applying the harvest rule defined by Table 1 which still achieve this objective. Intermediate goals are included when calculating the table of strike/harvest levels so that different levels of precaution can be applied for different ranges of population sizes.
3. The 25/95 criterion is applied for all blocks when computing the strike/harvest limits in the SHMP. Table 1 above has recovery criteria that are specific to the size of the population.
   A) for population sizes below 500 animals, the criterion is 25/95, i.e. the strikes/harvests are selected so that the delay in recovery is equivalent to that in SHMP for these population sizes;
   B) for population sizes between 500 and 600 animals, the criterion is 25/80; and
   C) for population sizes above 600 animals, the criterion is 25/65.

The above specifications (see Table 2 for a summary) imply that the greatest precaution occurs for population sizes less than 500 animals and least precaution for population sizes above 600 animals.

Table 2. Overview of criteria used to define the strike/harvest levels in Table 1.

| **Abundance Range** | **Intermediate Recovery goal** | **Probability Percentage Delay Exceeds 25%** | **Probability Actual Delay Exceeds 5 years** |
|---|---|---|---|
| <260 | | Zero harvest | |
| 260-500 | 500 | <5% | <5% |
| 500-600 | 600 | <20% | <5% |
| 600-780 | 780 | <35% | <10% |

## Technical Aspects

The value of each entry in the table of strike/harvest limits is calculated using simulation methods. The basic calculation process is identical that used in the SHMP except that the performance criterion differs depending on the population size when the harvest rule is first used. The calculation process involves projecting the following population dynamics model forward in time.

$$N_{t+1} = (N_t - H_t)[1 + R_{\max}(1 - \{(N_t - H_t)/K\}^z)] \quad (1)$$

where $N_t$ is the abundance at the start of year *t*;

$H_t$ is the harvest during year *t* (determined using the harvest rule);

$R_{\max}$ is the growth rate (selected from a uniform distribution between 2 and 6%);

$K$ is the carrying capacity; and

$z$ is a parameter that determines the ratio of OSP to *K*.

The model is projected forward for 30 scenarios: 10 scenarios regarding the population size when the harvest rule is first applied and three scenarios regarding the trend in the population size prior to this. The 10 abundance-related scenarios are 250-299, 300-349, 350-399, 400-449, 450-499, 500-549, 550-599, 600-649, 650-699, and 700-779, and the three trend scenarios are: a) increasing ($R_{\max}$ between 2 to 6%) over the 10 years prior to the first application of harvest plan, b) stable ($R_{\max}$ between -2 to 2%) over the 10 years prior to the first application of harvest plan, and c) declining ($R_{\max}$ between -2 to -10%) over the 10 years prior to the first application of harvest plan.

The values in the strike/harvest table are set to the maximum values such that:

$$\max_{a,t} Q_{a,t} < 1 \quad (2)$$

where $Q_{a,t}$ is the value of the performance criterion for abundance scenario *a* and trend scenario *t*:

$$Q_{a,t} = \min(p_{a,t}/\Omega_{a,t}, q_{a,t}/\Gamma_{a,t}) \quad (3)$$

$p_{a,t}$ is the probability that the percentage delay in recovery to the intermediate recovery goal (500 for population sizes less than 500, 600 for population sizes between 500 and 600, and 780 for population sizes above 600) for abundance scenario *a* and trend scenario *t* exceeds 25%;

$q_{a,t}$ is the probability that the actual delay (in years) exceeds five years; and

$\Omega_{a,t}$ is the pre-specified threshold probability that the percentage delay in recovery to the intermediate recovery goal exceeds 25% (0.05 for population sizes less than 500, 0.20 for population sizes between 500 and 600, and 0.35 for population sizes above 600).

$\Gamma_{a,t}$ is the pre-specified threshold probability that the actual delay in recovery (i.e. the delay expressed in numbers of years) to the recovery goal exceeds 25% (0.05 for population sizes less than 600, and 0.10 for population sizes above 600).