



## Sei Whale (*Balaenoptera borealis*)

### Population assessment.

Because the available published assessments for this species are not up to date, an updated population assessment is conducted here to enable assessment of the population reduction over the period 1937-2007 relative to Red List Criterion A. While the available data do not permit a scientifically rigorous estimation of the extent of population reduction, it is reasonable to use conventional population assessment methods to provide a crude indication of the extent of possible reduction relative to the criteria. A conventional deterministic age-structured model with an age at first capture (“recruitment”) ( $a_r$ ) and an age at first reproduction ( $a_m$ ), and linear density-dependence was applied to the North Pacific, North Atlantic and Southern Hemisphere regions separately. The parameter values are listed in Table 1a. The starting year was 1885 in the North Atlantic and 1900 in the North Pacific and Southern Hemisphere. The sex ratio of the population and catches is assumed to be 50:50.

Denoting the population of animals aged  $a$  in year  $t$  as  $P_{a,t}$ , the equations for the pre-recruit (unexploited) age classes are:

$$P_{a+1,t+1} = S P_{a,t} \quad (a < a_r)$$

where  $S = \exp(-M)$  is the annual survival rate. The exploitation rate (the annual fraction of the population that is taken) in year  $t$  is given by:

$$E_t = C_t / \sum_{a=a_r}^{a_m} P_{a,t}$$

where  $C_t$  is the historical catch in year  $t$ . Age classes from the age at first reproduction onwards are grouped together. The equations for the recruited age classes are:

$$P_{a+1,t+1} = S P_{a,t} (1 - E_t) \quad (a_r \leq a < a_m - 1)$$

$$P_{a_m,t+1} = S (P_{a_m-1,t} + P_{a_m,t}) (1 - E_t)$$

The mature population size in the starting year ( $t = 0$ ) is set to  $K$ , the nominal carrying capacity:

$$P_{a_m,0} = K$$

The values of  $K$  in each region were chosen so as to hit the population targets listed in Table 1b. The births in year  $t$  are given by:

$$P_{0,t} = R_t P_{a_m,t}$$

where  $R_t$  is the reproductive rate in year  $t$ . The density-dependent assumption is that  $R_t$  is linearly related to the mature population level:

$$R_t = R_K \left( P_{a_m,t} / K \right) + R_0 \left( 1 - P_{a_m,t} / K \right)$$

The minimum ( $R_K$ ) and maximum ( $R_0$ ) values of the reproductive rate are given by:

$$R_K = (1 - S) S^{-a_m}$$

$$R_0 = \left( 1 - \frac{S}{1+r} \right) \left( \frac{1+r}{S} \right)^{a_m}$$

The formula for  $R_K$  ensures that the net population growth rate is zero when the population is at carrying capacity, while the formula for  $R_0$  ensures that the annual population growth rate is  $r$  when the population size is low.

The above model is extremely crude, and does not take account of many possible factors that may have influenced Sei Whale population trends over the last 70 years. However, it provides a plausible, albeit very approximate quantification, of the possible extent of catch-related population reduction over this period.

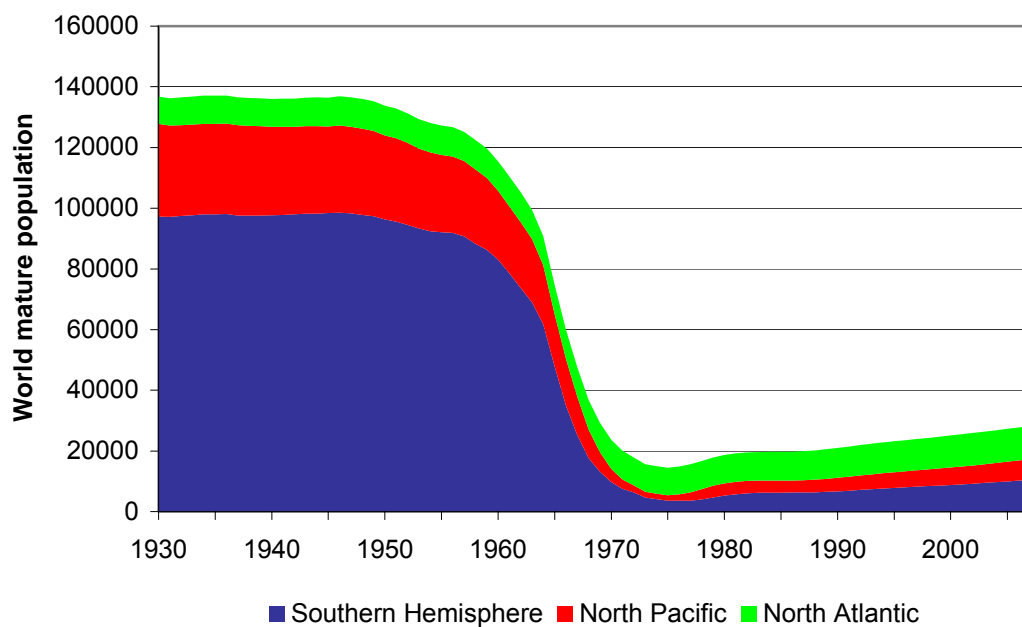
The results are shown in Figure 1. The current world mature population is only about 20% of the 1937 level. The extent of decline is not very sensitive to the choice of starting year, because the world population is estimated to have been roughly constant during 1930–50. However, the results are sensitive to the assumed maximum rate of increase; the value used here, while lower than those selected for some other baleen whales, is clearly plausible for Sei Whales.

**Table 1a:** Parameters of the logistic model for Sei Whales.

Age at 1 <sup>st</sup> reproduction	10
Age at recruitment	5
Natural mortality rate $M$	0.06
Max. rate of increase $r$	0.0266

**Table 1b:** Population targets.

Region	Component	Year	Estimate
Southern Hemisphere	expl.	1979	11,000
North Pacific	expl.	1974	8,600
North Atlantic	total	1989	12,000



**Figure 1:** Estimated population trajectory 1930-2007