The following supplements accompany the article

Running fast in the slow lane: rapid population growth of humpback whales after exploitation

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Supplement 1. Stratification by geographic regions

The study area of the aerial surveys was stratified into geographic regions to reduce variance and to improve the precision of the estimates (see Buckland *et al.*, 2001). The area was divided into five regions (or strata) that were sampled each year (**Figure S1**).

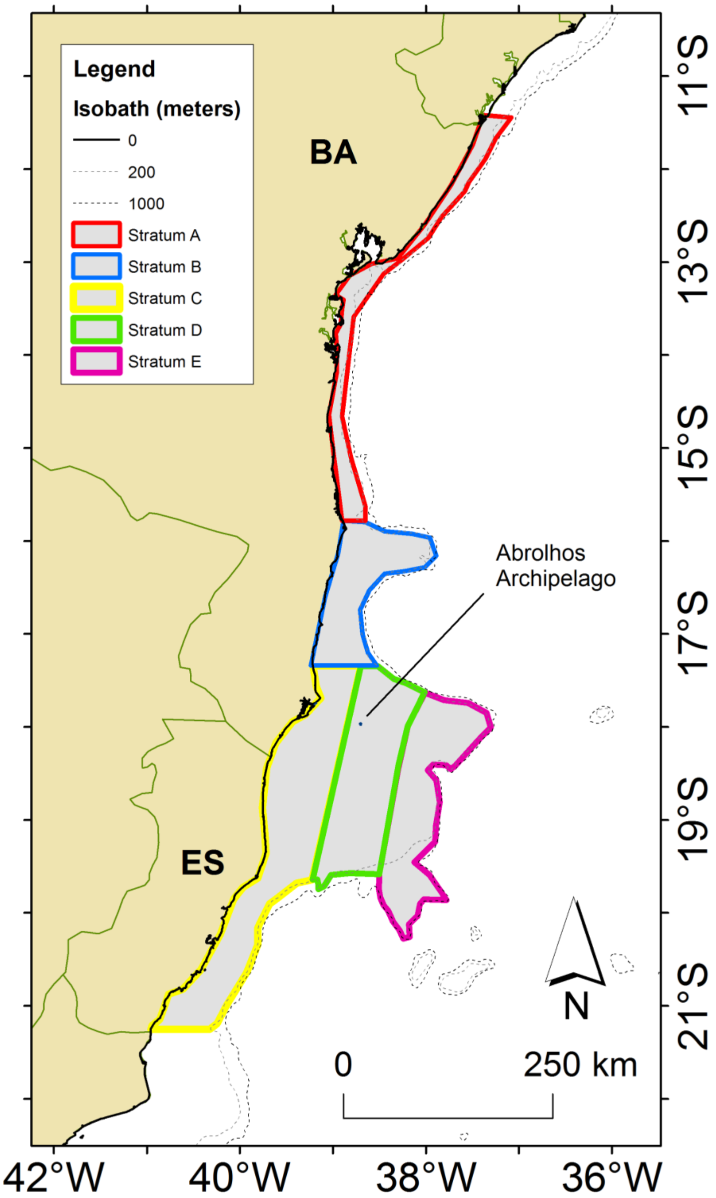

Figure S1: Study area and the stratification by geographic regions for the aerial surveys from 2001 to 2011 on the Brazilian coast. ES = State of Espírito Santo; BA = State of Bahia.

Supplement 2. Detection curves for each year

Half-normal detection curves without covariates for each year of study in the Brazilian coast overlaid on the data are shown in **Figures S2** and **S3**.

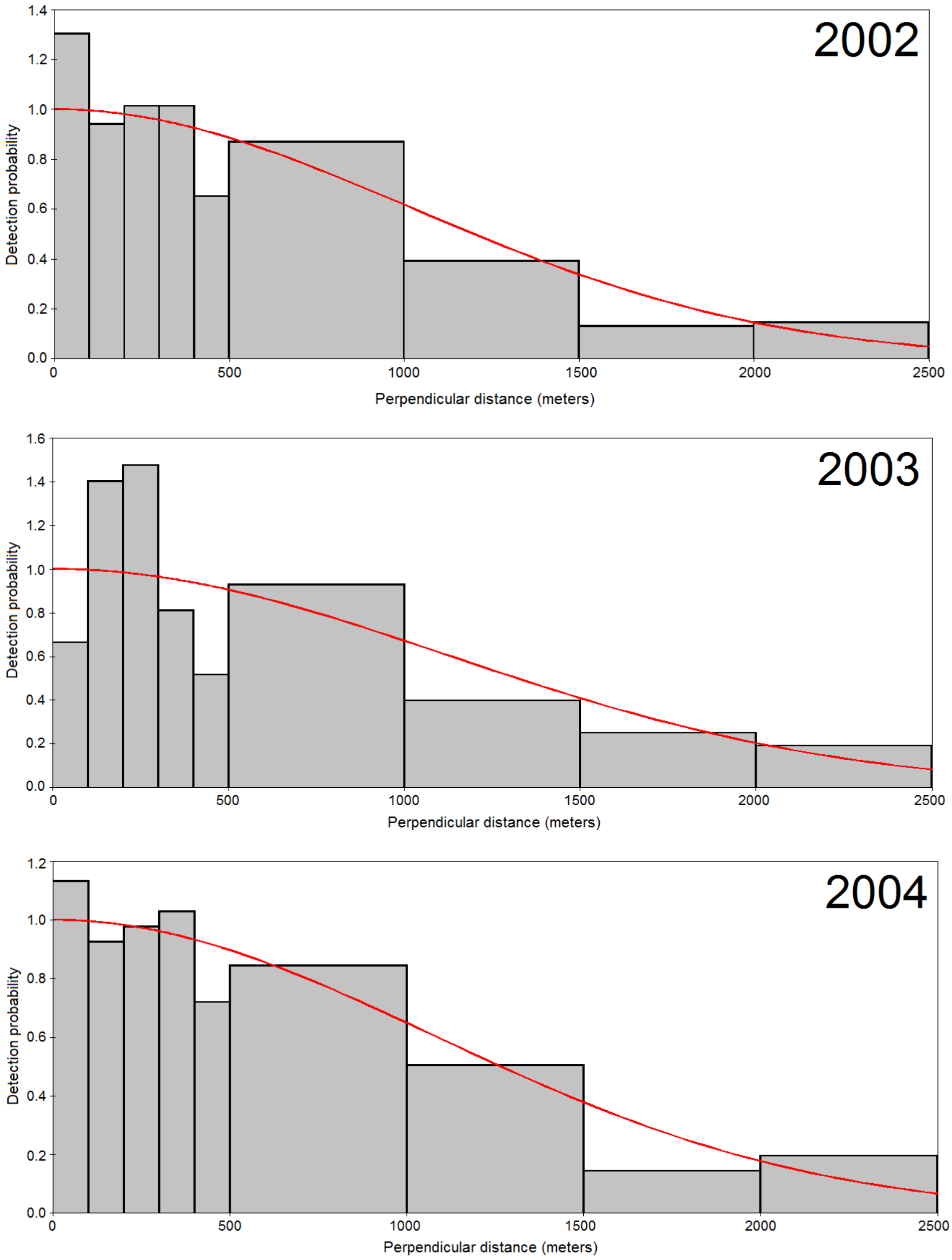

Figure S2: Detection curves of humpback whales detected through aerial surveys in their main breeding habitats off Brazil from 2002 to 2004.

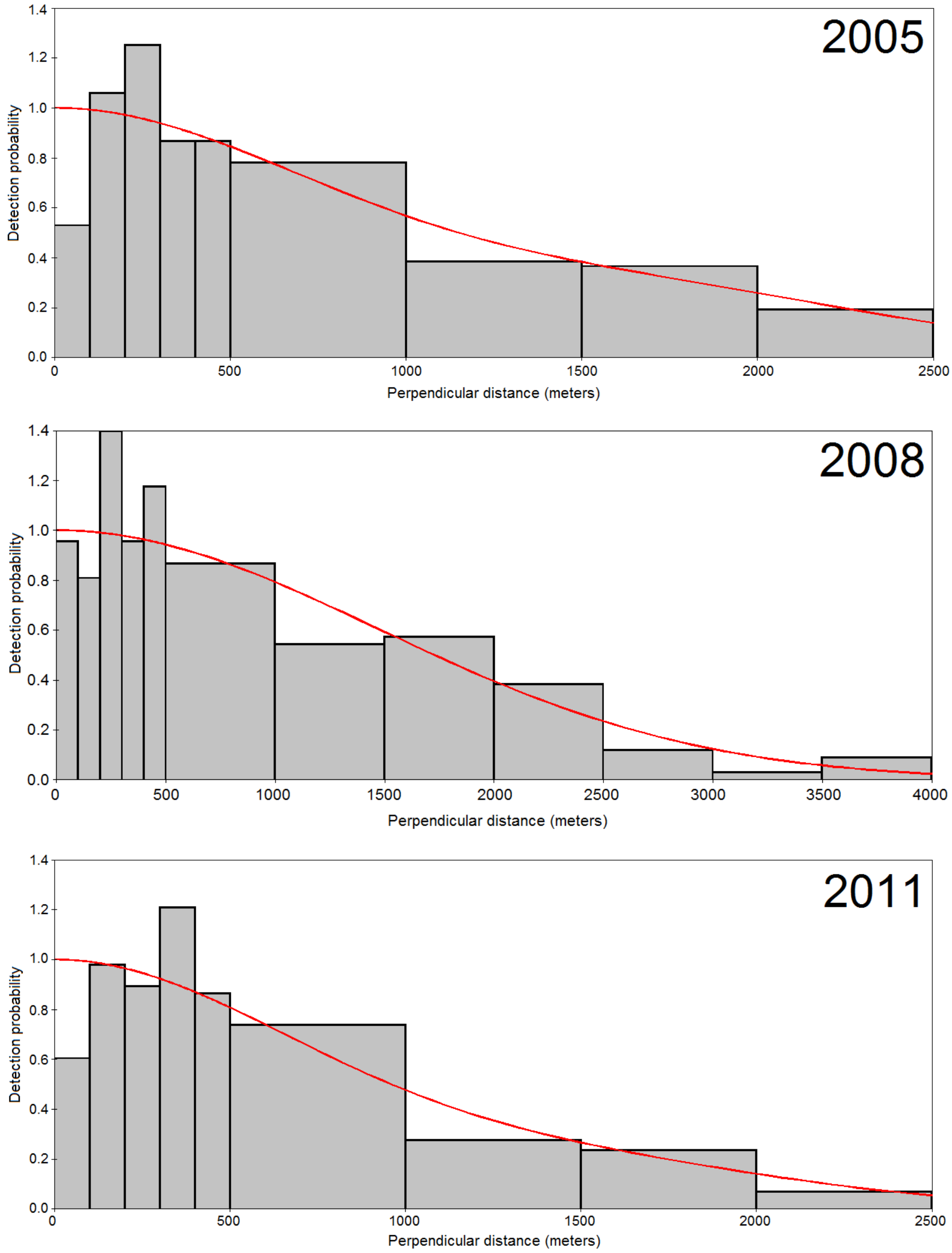

Figure S3: Detection curves of humpback whales detected through aerial surveys in their main breeding habitats off Brazil for 2005, 2008 and 2011.

Supplement 3. Model building and selection procedure

The first step was to fit a detection function without covariates using conventional distance sampling methods (Buckland et al. 2001). Each covariate was then included separately in the model. If a model containing a covariate was selected (based on a lower Akaike's information criterion (AIC) value, see Burnham & Anderson 2002), the remaining covariates were again separately added to the model with the covariate that was initially chosen. This procedure was repeated until the addition of new covariates did not improve the model fit. Frequently, however, the models did not converge when more than two covariates were included.

Supplement 4. Growth rate by geographic strata

Two generalized linear models (GLM) with Poisson error distributions were fitted to the data to explore the trends in abundance among regions (sampling strata). The model with an interaction between year and region, which allows for different rates of increase among regions, had considerably more support (AIC = 1,693.2; Akaike weght = 1) than the model including only the additive effects of these two variables (AIC = 2,703.1; Akaike weight = 0; Δ AIC = 1,009.9). Regions A and B presented a lower growth rates than the other areas (**Table S1**; **Figure S4**). Regions D and E, which cover the offshore waters of the Abrolhos Bank, had the highest growth rate.

Table S1: Uncorrected abundance trends for humpback whales among the geographical regions covered by the aerial surveys from 2001 to 2011.

Year / Regions	A	B	C	D	E
2001	47	55	965	944	204
2002	108	108	802	1634	373
2003	196	98	1178	1146	382
2004	51	99	672	2136	954
2005	151	106	1480	1739	668
2008	138	154	2004	1881	1223
2011	366	168	1908	3561	2828
Annual Rate of Growth (λ)	**1.158**	**1.093**	**1.098**	**1.110**	**1.267**
CI 95%	**0.985-1.363**	**1.031-1.159**	**1.008-1.196**	**1.031-1.194**	**1.161-1.383**

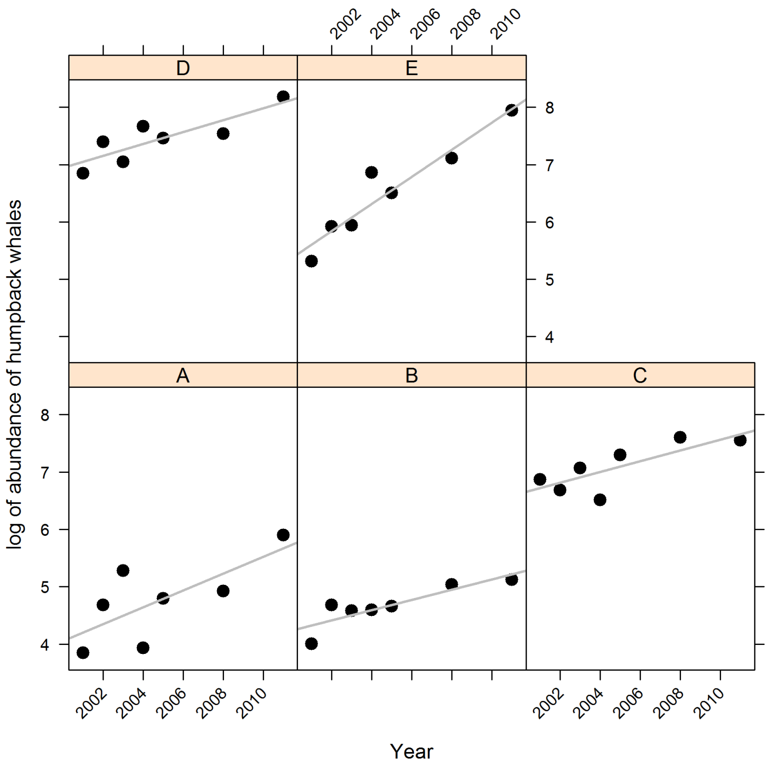

Figure S4: Abundance trends for humpback whales among the geographical regions covered by the aerial surveys from 2002 to 2011. Gray lines correspond to the linear model fitted to the natural log of the uncorrected abundance estimates, corresponding to an exponential growth model.

Supplement 5. Review of the population growth rates for humpback whales worldwide

A total of 28 growth rate estimates for humpback whales were found in the literature. Three studies did not report any error measure (Calambokidis, 2009; Calambokidis *et al*., 2008; Clapham *et al.*, 2003), such as the standard error or the confidence interval of the growth rates, and thus were excluded from the meta-analysis. The remaining growth rates are summarized in the forest plot below (**Figure S5**).

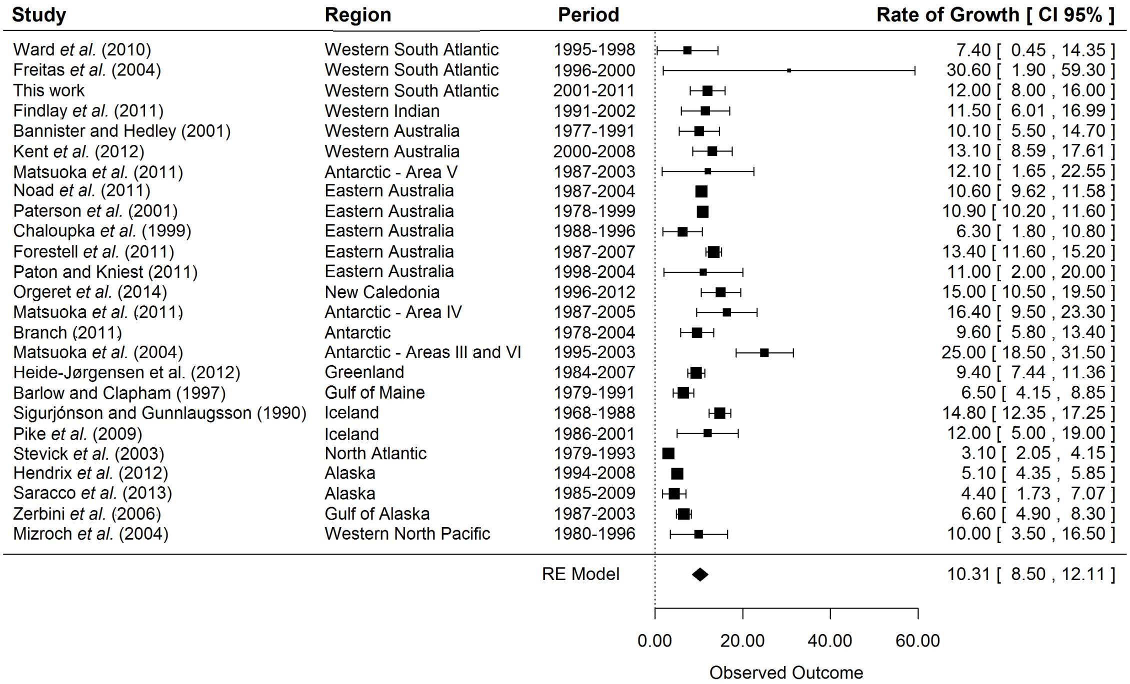

Figure S5: Forest plot with the population growth rate estimates for humpback whales reported by different studies worldwide (n = 25). Black boxes showing the point estimates are inversely proportional to the error of the estimates. The average growth rate according to a random effects (RE) meta-regression model with no moderator variables is shown at the bottom of the figure.

A total of 10 of these 28 studies presented errors that were too high to pass our precision criterion of a 30% coefficient of variation and were excluded from the analysis. Since our goal was to understand the regional differences in growth rates, studies that pooled two or more breeding/feeding sites were also excluded (Matsuoka *et al.*, 2004; Branch, 2011). The studies by Paterson *et al.* (2001) and Noad *et al.* (2011) partially used the same data to estimate growth rates, and thus we retained the more recent study and excluded the oldest. Finally, after a sensibility analysis (to check for funnel plots and residual errors), we excluded the study of Matsuoka *et al.* (2011) to avoid potential publication bias. Moreover, this study reported one of the highest growth rates among all of the studies reviewed here.

Supplement 6. Explanatory variables used in the meta-analysis

The explanatory variables (moderators) used in the meta-regression models and the rationale for their inclusion in the meta-analysis are described below. The variables that were correlated were eliminated before the analysis. The 10 variables that were considered in the meta-analysis were the following:

(a) *Length of the study in years*: the last year of sampling subtracted by the first year of sampling in each study. We expect that lower growth rates occur over longer time series of abundance estimates because a species cannot maintain its maximum growth rate indefinitely. Whenever the density of a population increases, density-dependent mechanisms tend to stop or slow down population growth.

(b) *Study method*: the studies were classified into three methods: (1) capture-recapture, (2) naïve count-based or (3) count-based with distance sampling. This variable focuses on possible biases associated with methodology.

(c) *Study platform*: the following platforms were used to estimate growth rates for this species: (1) airplane, (2) vessel or (3) shore-based stations. This variable focuses on possible biases associated with different research platforms.

(d) *Hemisphere*: the studies were classified into Southern or Northern Hemisphere populations. This is a spatial (geographical) variable considering that the hemispheres may have biological differences that affect the growth rates of populations (see Discussion of the main text).

(e) *Ocean*: the studies were assigned to one of the five oceans: (1) North Pacific, (2) North Atlantic, (3) South Pacific, (4) South Atlantic and (5) Indian Ocean. This is a spatial variable considering the biological differences among oceans and populations.

(f) *Breeding stock*: the Southern Hemisphere populations were assigned to one of the seven breeding stocks recognized by the IWC – A to G (IWC, 1998). The Northern Hemisphere populations were assigned to North Pacific or North Atlantic stocks. Breeding stocks are considered different demographic units (Baker *et al.*, 1993) and may present differences in growth rates due to their geographical segregation and the particular characteristics of their sites or exploitation history.

(g) *Time lag from the year when 90% of the whales were captured*: the middle year of the study period subtracted by the year that 90% of the catches occurred. This variable is intended to describe the time lapse since the lowest level of depletion for each population. We expect that the growth rate of populations that are far from their lowest level of depletion will start to slow down due to density-dependent mechanisms. The period immediately after the catches occurred will also present lower growth rates due to Allee effects and/or a higher proportion of immature individuals in the population.

(h) *Time length in years that the population was hunted*: the difference in the last year of capture from the first year, considering the period between 1881 and 2012. We expect that populations that were exploited for longer periods will have a lower growth rate due to increased mortality

(i) *Total whales captured by whaling activities*: whaling catch data was provided by the International Whaling Commission (IWC). A summary of the catches by year for each breeding stock are shown in **Figure S6**. We expect that stocks with higher catches will be farther from the carrying capacity and will show higher growth rates over a longer period.

(j) *Haplotype diversity*: diversity of haplotypes from the mitochondrial DNA control region of breeding stocks (Baker *et al.*, 1993; Baker and Medrano-González, 2002; Olavarria *et al.*, 2007; Engel *et al.*, 2008). We expect that populations with higher genetic diversity will have higher fitness and growth rates.

Type of habitat (either feeding or breeding ground) was not included in the meta-regression as a moderator because most studies in the Southern Hemisphere were conducted in breeding grounds, while most studies in the Northern Hemisphere were conducted in feeding grounds. Therefore, the effects of hemisphere and type of habitat could be confounded. Judging by few studies having been conducted in feeding grounds in the Southern Hemisphere and some studies having been conducted in both feeding and breeding grounds in the Northern Hemisphere, there is a negligible bias in the types of habitats, and if there is some bias, it would reinforce the predictions of our models.

The lack of carrying capacity (or pre-exploitation population levels) estimates for all of the humpback whale stocks preclude the inclusion of other more informative demographic explanatory variables in our meta-analysis.

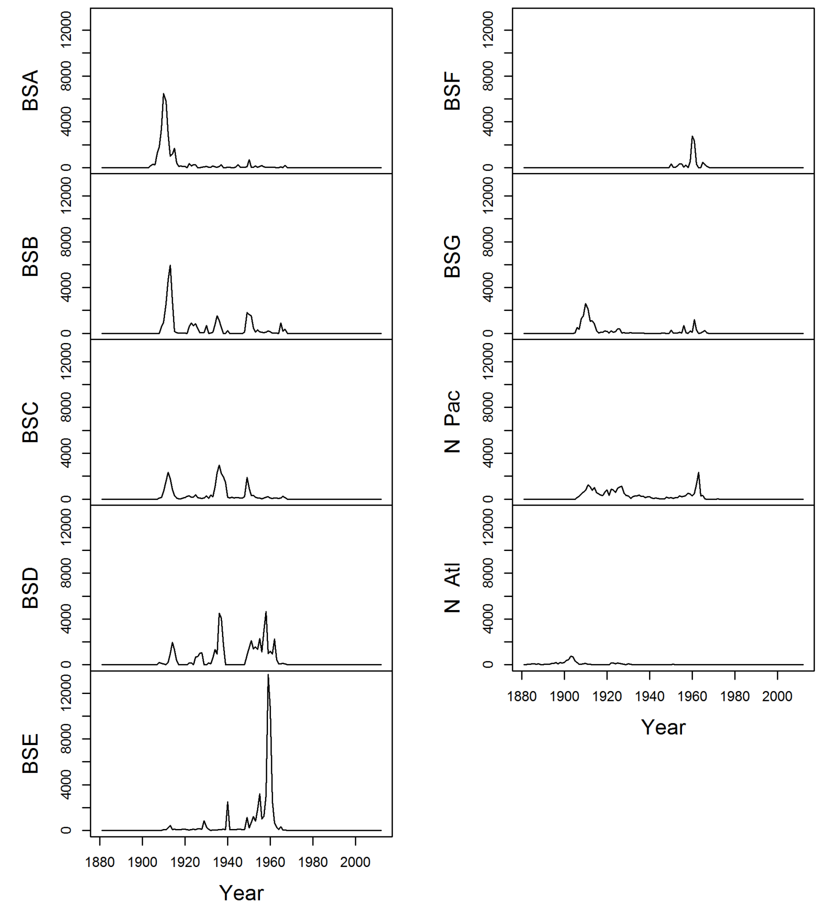

Figure S6: Catches of humpback whales by breeding stock (source: IWC catch series data).

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