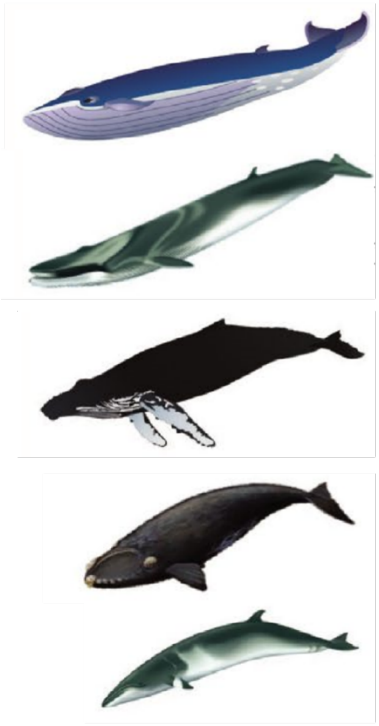
The collapse and recovery potential of carbon sequestration by baleen whales in the Southern Ocean

Supplementary Figures



Blue whale *(Balaenoptera muslculus intermedia).*
Adult weight : between 102 and 117 tons
IUCN status: Endangered

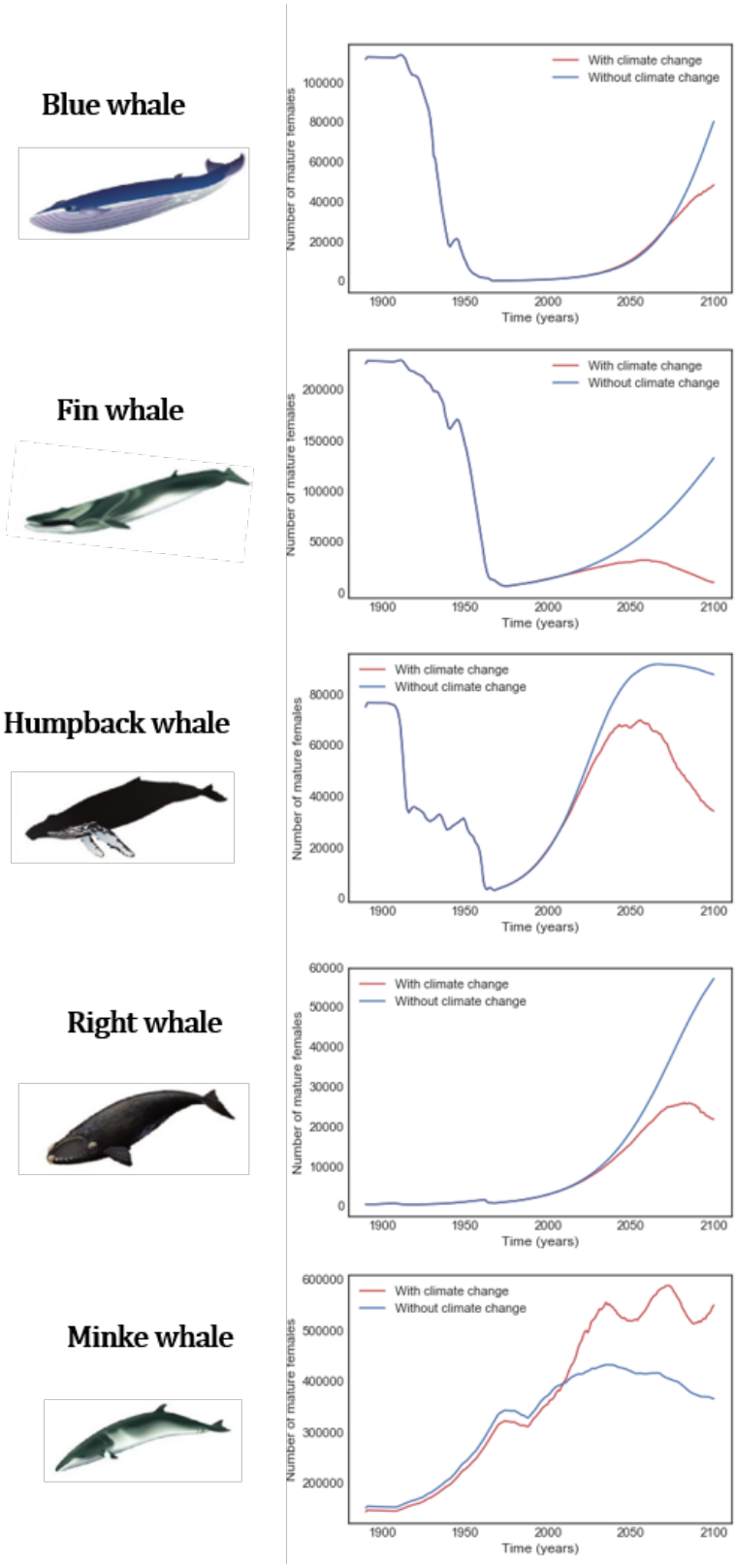
Fin whale *(Balaenoptera physalus).*
Adult weight : between 65 and 45 tons
IUCN status : Vulnerable

Humpback whale *(Megaptera novaeangliae).*
Adult weight : 30 tons
IUCN status : Least concern

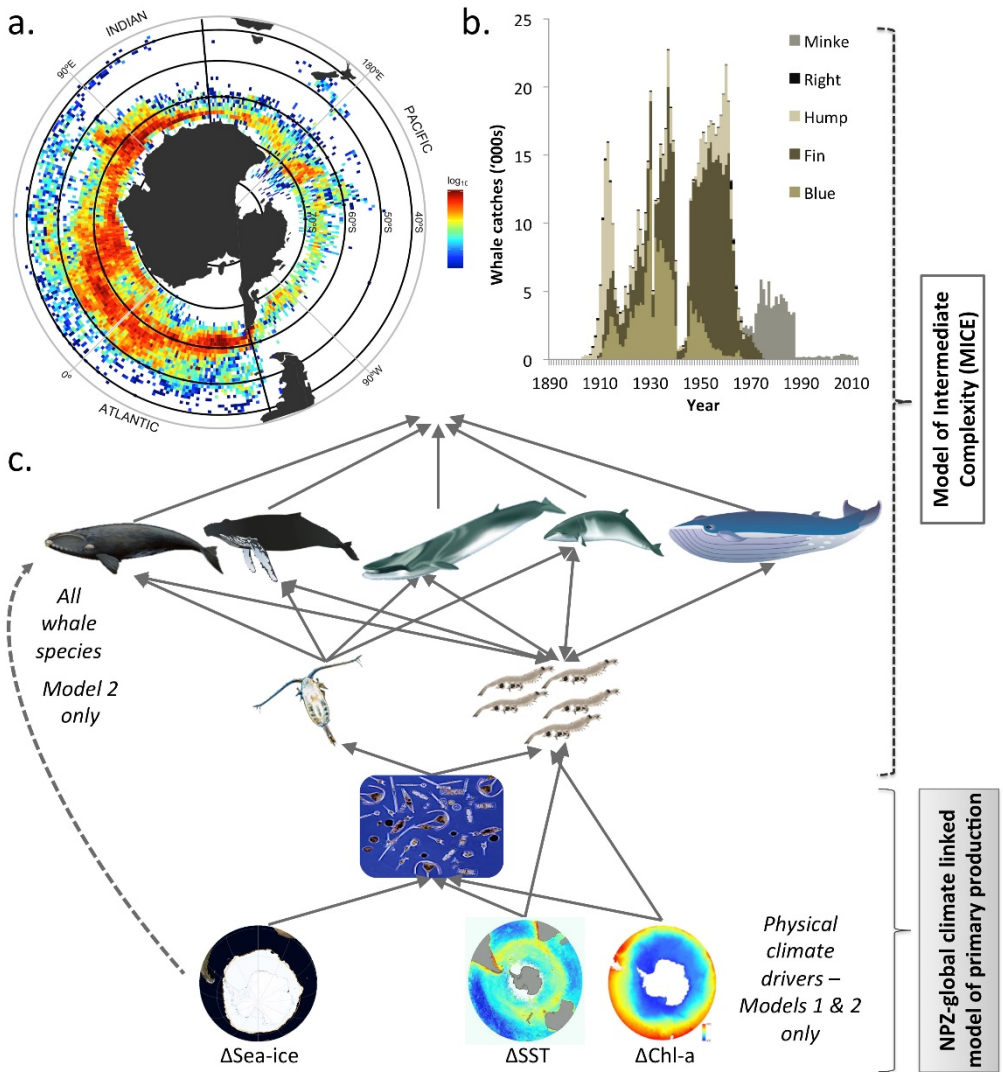
Right whale *(Eubalaena australis).*
Adult weight : 40 tons
IUCN status : Least concern

Minke whale *(Balaenoptera bonaerensis).*
Adult weight: 6 tons
IUCN status : Near threatened

Supplementary Figure 1. Characteristics of the five baleen whale species included in the study.



Supplementary Figure 2. Whale population dynamics (number of mature females) predicted by Tulloch et al. (2017, 2019) from 1890 to 2100.



Supplementary Figure 3. Historical whale harvests shown by a) heat map, where black circumpolar bands identify the four latitude bands used in the model, and thick black lines at 60°W and 130°E identify breaks between the two oceanic regions modeled, and b) stacked column graph of total harvest over time between 1890 and 2015; c) schematic of direct interactions between physical climate drivers (bottom from left – changes in sea-ice, chlorophyll, sea-surface temperature) and biological features of models (phytoplankton, copepods, krill, and whales) detailing the relationships in the best-fit model that had environmental forcing from temperature and phytoplankton (Model 1) and alternative scenarios where sea-ice was also linked to future whale distribution (Model 2), or all climate drivers are excluded (Model 3). Arrows identify the direction of the driver and/or interaction, whales depicted from left to right are southern right, humpback, fin, antarctic minke, and blue. [From Tulloch et al. 2019]. In this paper we used outputs from Model 2 and Model 3 as inputs for our carbon sequestration calculation.

Supplementary Tables

Supplementary Table 1. Annual carbon sequestration by the five species of southern whales and by three types of coastal ecosystems (mangroves, seagrass and salt marshes).

	Carbon flux (10^6 tons per year)	Reference
Southern whales	3.8 – 20.8	This paper
Mangroves	31.2 – 34.4	Howard et al. 2017
seagrass	41.4 – 82.8	Howard et al. 2017
Salt marshes	4.8 - 87.2	Howard et al. 2017

Supplementary Table 2. Whale population parameters for the five species from Tulloch et al. (2017) and Pershing et al. (2010) (for maximum age).

	Annual survival rate >1 year	Annual survival rate <1 year	Age at maturity (year)	Maximum age (year)	Sex ratio (female)
Blue whale	0.960	0.819	6	130	0.475
Fin whale	0.951	0.806	6	118	0.49
Humpback whale	0.922	0.760	5	74	0.54
Right whale	0.980	0.822	6	96	0.47
Minke whale	0.922	0.806	10	86	0.56

Supplementary Table 3. Female and male growth parameters for the five species from Tulloch et al. (2017) corresponding to the Von Bertalanffy equation for each species: $m(a) = m_{inf} \cdot (1 - e^{-k(a-a_0)})$ (Pershing et al. 2010).

	a_0 (year)		m_{inf} (ton)		k (year^{-1})
	Female	Male	Female	Male	
Blue whale	4.5	4.9	117	102	0.2
Fin whale	4.8	5.3	64.5	55	0.2
Humpback whale	9.4	9.4	30	30	0.1
Right whale	9.4	9.4	40	40	0.1
Minke whale	1	1	6	6	0.2

Supplementary Table 4. Iron concentrations in faeces (mg iron per Kg faeces dry weight) for the five whale species, mean value ± standard error (Nicol et al. 2006; Wing et al. 2014).

	[Fe] mg/kg dry weight	Number of samples
Blue whale	172.4 ± 57.05	15
Fin whale	237.4 ± 103.53	2
Humpback whale	118.6 ± 28.42	2
Right whale	400 ± 150	6 - 12
Minke whale	204.9 ± 80.29	17