Supplement 1: PSA attributes and thresholds and information used for scoring

Table S1 MSC (2018) PSA Productivity attributes and thresholds and scenario inputs for Wandering albatross and Black-browed albatross South Georgia populations * Max age is an estimated parameter given that even long-term studies have not been going long enough to determine with accuracy.

Productivity attributes and thresholds	**Species**	**Best available Data**	**Inaccurate (reduce by 1 SD)**	**Imprecise (lower 95% CI)**	**Inaccurate & imprecise**
Average age at maturity: High risk >15 years (3), Medium 5-15 years (2), Low: <5 years (1)	Wandering albatross	9.6 (BAS unpublished data)	7.9	9.5	7.8
	Black-browed albatross	10 (BAS unpublished data)	8	9.6	7.7
Average maximum age: High risk >25 years, Medium 10-25 years, Low <10 years	Wandering albatross	50 years*(Froy et al. 2013)	41.3	49.6	41
	Black-browed albatross	44 years* (Dupont et al. 2018)	35.3	42.3	33.9
Fecundity: High risk <100 eggs per year, Medium 100-20,000 eggs per year, Low >20,000 eggs per year	Wandering albatross	1 egg, biennial breeder (BAS unpublished data)	N/A	N/A	N/A
	Black-browed albatross	1 egg, annual breeder (BAS unpublished data)	N/A	N/A	N/A
Average maximum size: High risk >300cm, Medium 100-300cm, Low <100 cm	Wandering albatross	Body length: 127.5 cm (mean value from Onley & Scofield 2007)	105.5	119.6	99
	Black-browed albatross	Body length: 88cm (mean value from Onley & Scofield 2007)	86	87	85
Average size at maturity: High risk >200cm, Medium 40-200cm, Low <40cm	Wandering albatross	Body length: 127.5 cm (mean value from Onley & Scofield 2007)	105.5	119.6	99
	Black-browed albatross	Body length: 88cm (mean value from Onley & Scofield 2007)	86	87	85
Reproductive strategy: High risk live bearer, Medium Demersal egg layer, Low Broadcast spawner	Wandering albatross	Bird	Demersal egg layer	Live bearer	Demersal egg layer
	Black-browed albatross	Bird	Demersal egg layer	Live bearer	Demersal egg layer
Trophic level: high risk >3.25, Medium 2.75-3.25, Low <2.75	Wandering albatross	Tertiary consumers = high risk	N/A	N/A	N/A
	Black-browed albatross	Tertiary consumers = high risk	N/A	N/A	N/A

Table S2 MSC (2018) PSA Susceptibility attributes and scenario inputs/results for South Georgia Wandering albatross in southwest Atlantic tuna longline fisheries in period 2005-2010

Susceptibility attribute used	**Biological interpretation**	**Literal interpretation**
Areal overlap	% longline effort within species range highest in Q2=17.2% (95% UD) % of seabird distribution in ICCAT area highest in Q2 =19.9% (Carneiro et al. 2017) Areal overlap is 10-30%: Score is 2 (medium risk)	Use Species range map from BirdLife International (2022a) and fishing distribution from Tuck et al. (2011) Areal overlap is <10%: Score is 1 (low risk)
Encounterability	Bait is attractant. Every hook is at the surface at some point. High overlap with fishing gear. Score is 3 (high risk)	Depth overlap: Wandering albatross generall surface feeders, can dive up to 1m (Prince et al. 1994) Longline gear varies but surface longlines up to 300m deep (Domingo et al. 2014) Low overlap with fishing gear: Score is 1 (low risk)
Selectivity	Intent is to evaluate whether juveniles are captured rather than the size of individual. Two studies: 83% adults captured in pelagic longlines in SW Atlantic 1984-86 (Croxall & Prince 1990); 53% adults captured in pelagic longlines in Uruguayan waters (Jiménez et al. 2016) Juveniles caught in 5-50% of deployments, there for regularly caught: Score is 2 (medium risk)	Individuals are only less than size at maturity when chicks and are therefore never caught. Score is 1 (low risk)
Post-capture mortality:	Two studies: Birds captured in hooks or tangled in line during setting found during hauling with a probability of mortality of close to 1 (Jiménez et al. 2012) Some estimated survival of birds caught when hauling (Phillips & Wood 2020) Given high number of mortalities when setting, considered majority dead when released. Score is 3 (high risk)	If only catches considered, i.e. those captured in hauling, the survival is around 40% (Phillips & Ward 2020). Considered as “some released and survival”: Score is 2 (medium risk)

Table S3 MSC (2018) PSA Susceptibility attributes and scenario inputs/results for South Georgia Black-browed albatrosses in South African hake trawl fishery in 2004

Susceptibility attribute used	**Biological**	**Literal**
Areal overlap	May-Aug period with greatest concentration of birds from this population in SA waters (Clay et al. 2019) Four BBA tracked, spent approx. 39% of time on shelf where they'd overlap with trawlers (Petersen et al. 2009). Considering the concentration of the species relative to the fishing gear, overlap is >30%. Score is 3 (high risk)	Species range distribution from BirdLife International (2022b). Fishery distribution from Watkins et al. (2008) is small relative to overall distribution of BBA, <10% overlap. Score is 1 (low risk)
Encounterability	Birds are struck by warp cables at surface. Birds may aggregate near vessel due to offal discharge or hauling nets. Warp and birds are always at surface. High overlap with fishing gear. Score is 3 (high risk)	Gear deployment depth is >300m (Watkins et al. 2008) BBA diving depth average approx. 1.5m, deepest recorded 6m (Bentley et al. 2021) Low overlap with fishing gear. Score is 1 (low risk)
Selectivity	Intent is to evaluate whether juveniles are captured rather than the size of individual. 20% of warp strikes classed as heavy (but no info on adult/juveniles) (Watkins et al. 2008) Fishery using different gear but in same location shows greater bycatch risk for juveniles Considered juveniles 'regularly' caught (5-50% of gear deployments). Score is 2 (medium risk)	Individuals are only less than size at maturity when chicks and are therefore never caught. Score is 1 (low risk)
Post-capture mortality	20% of warp strikes classed as heavy (Watkins et al. 2008). Actual mortalities recorded where possible, which also includes injured birds unlikely to survive. For BBA this was 11 birds recorded. There is no information on whether heavy collisions resulted in injuries that could lead to death. This could be interpreted as either 'majority released' or 'some' released alive. To be precautionary, 'some' released alive is interpretation used. Score is 2 (medium risk)	Interpreted as majority released. Score is 1 (low risk)

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Supplement 2: Information inputs for Population Viability Analyses

Table S4 Values used for PVA for South Georgia Wandering albatross

Parameter	**Value selected**	**Reason/description**
Inbreeding depression	not evaluated	For simplicity have not included this
Reproductive system	Long-term monogamy	Must be a male for every breeding female
Age of first offspring females	10	BAS unpublished ringing data - rounded as value must be whole number
Age of first offspring males	10	BAS unpublished ringing data - rounded as value must be whole number
Maximum age female reproduction	45	Estimate - Not yet enough data to conclude - Pardo et al. (2013) showed probability of hatching and fledging check reduced in birds aged 42 and over. Other models have not included senescence at all
Maximum age male reproduction	45	Estimate - Not yet enough data to conclude - Pardo et al. (2013) showed probability of hatching and fledging check reduced in birds aged 42 and over. Other models have not included senescence at all
Maximum lifespan	50	Froy et al. (2013)
Maximum number of broods per year	1	Only one brood per year
Maximum number of progeny per brood	1	Only single check produced
Sex ratio at birth in % males	57%	Used value from Weimerskirch et al. (2005) for Crozet population of Wandering albatross
Density dependent reproduction	not evaluated	Pardo et al. (2017) models indicated some positive density dependent effect on reproduction but also showed a negative density dependent effect on juvenile survival. Since the latter cannot be captured in Vortex, and for simplicity, density dependent reproduction has not been included.
% adult females breeding (defined in Vortex manual as mean percentage of adult females that breed in a given year - or the probability that a given adult female will successfully produce offspring in a given year)	46%	Calculated probability of return * probability of breeding from Pardo et al. (2017) based on mean for period between 1981-1990.
SD in % breeding due to EV	10%	This value was selected based on Pardo et al. (2017) and because sensitivity tests run using a range of 5-15% for environmental variability did not lead to widely different outcomes
Mortality of females/males (used same values) from age 0-1	31%	69% breeding success (Mean calculated from period 1981-1990 in Pardo et al. (2017). Mortality is 1-0.69=0.31
Mortality from age 1-2	5%	95% juvenile survival (Mean calculated from period 1981-1990 in Pardo et al. (2017). Mortality is 1-0.95=0.05

Mortality from age 2-3	5%	
Mortality from age 3-4	5%	
Mortality from age 4-5	5%	
Mortality from age 5-6	4%	Survival =0.96 from Dillingham & Fletcher (2011), idealised scenario. Mortality is 1-0.96=0.04
Mortality from age 6-7	4%	
Mortality from age 7-8	4%	
Mortality from age 8-9	4%	
Mortality from age 9-10	4%	
SD in mortality at each age class due to EV	10%	This value was selected based on Pardo et al. (2017) and because sensitivity tests run using a range of 5-15% for environmental variability did not lead to widely different outcomes
Catastrophes	not evaluated	
Mate monopolization: % males in breeding pool	100	
Initial population size	6176	772 breeding pairs in 2014-15 (Poncet et al. 2017) Used 8x the number of breeding pairs. Pardo et al. (2017) produced stable age distributions from matrix models which indicated that about a quarter of all birds alive had bred that year.
Carrying capacity	19220	Highest number of breeding pairs estimated in Croxall et al. 1990 is 1922 breeding pairs in year 1962. Used 10x number of breeding pairs for overall size (higher value used as multiplier since population may not have been at carrying capacity at that point)
Extinction definition	Only one sex remains	
Immigration/emigration	not evaluated	
Number of years modelled	65	3 x modelled generation time (21.7 years)
Number of model iterations	1000	
Extinction definition	Only one sex remains	

Table S5 Values used for PVA for South Georgia Black-browed albatross

Parameter	**Value selected**	**Reason/description**
Inbreeding depression	not evaluated	For simplicity have not included this
Reproductive system	Long-term monogamy	Must be a male for every breeding female
Age of first offspring females	10	BAS unpublished ringing data
Age of first offspring males	10	BAS unpublished ringing data
Maximum age female reproduction	44	Assumed same as lifespan, no evidence of senescence
Maximum age male reproduction	44	Assumed same as lifespan, no evidence of senescence
Maximum lifespan	44	Max lifespan observed for BBA in Kerguelen, Dupont et al. (2018)
Maximum number of broods per year	1	Only one brood per year
Maximum number of progeny per brood	1	Only single check produced
Sex ratio at birth in % males	50%	Assumed 50%
Density dependent reproduction	not evaluated	Pardo et al. (2017) models indicated some positive density dependent effect on reproduction. But it also showed a negative density dependent effect on juvenile survival. Since the latter cannot be captured in Vortex, and for simplicity, density dependent reproduction has not been included.
% adult females breeding	65%	Calculated probability of return * probability of breeding. Value is mean from Pardo et al. (2017) data period between 1981-1989.
SD in % breeding due to EV	10%	This value was selected based on Pardo et al. (2017) and because sensitivity tests run using a range of 5-15% for environmental variability did not lead to widely different outcomes
Mortality of females/males (used same values) from age 0-1	44%	Breeding success highly variable. Croxall et al. (1998) indicates average breeding success was 36% in 1970s before significant population decline detected. Mortality =1-.36=.44. Since highly variable due to climate, used value from Pardo et al. (2017) of 15% SD due to EV.
Mortality from age 1-2	10%	0.9 highest juvenile survival value calculated from Pardo et al. (2017) period 1981-1989 (prior to main decline). Mortality is 1-.9=0.1
Mortality from age 2-3	10%	
Mortality from age 3-4	10%	
Mortality from age 4-5	10%	
Mortality from age 5-6	5%	Adult survival=0.95 from Dillingham & Fletcher (2011) idealised scenario for annually breeding albatross, e.g. closely related Campbell black-browed albatross.
Mortality from age 6-7	5%	
Mortality from age 7-8	5%	
Mortality from age 8-9	5%	

Mortality from age 9-10	5%	Croxall et al. (1998) indicate adult survival prior to significant declines was 93%, but even in 1976 fisheries could have impacted adult survival. So have used 0.95 as recommended in Dillingham & Fletcher (2011). Mortality is 1-0.95=0.05
SD in mortality at each age class due to EV	10%	This value was selected based on Pardo et al. (2017) and because sensitivity tests run using a range of 5-15% for environmental variability did not lead to widely different outcomes
Catastrophes	not evaluated	
Mate monopolization: % males in breeding pool	100	
Initial population size	594368	74296 bp counted in 2004 (Poncet et al. 2017). Not all colonies re-counted in 2014, so no overall updated total. Used 8x the number of breeding pairs as Pardo et al. (2017) produced stable age distributions from matrix models which indicated that about a quarter of all birds alive had bred that year.
Carrying capacity	2,000,000	Highest number of breeding pairs estimated in Prince et al. (1994) is 101,488 bp. Not all colonies had been sampled since 1976 but those that were varied with overall colonies counted showing stability or slight increase until 1998 and then sharp decrease after that point. However, some colonies already had declines before that point and likely were interacting with fisheries in Benguela in 1970s. 10x number of bp from 1994 = 1014880, used 2,000,000 as overall carrying capacity size (higher value used than multiplier since population may not have been at carrying capacity at that point) and don't want to limit population unnecessarily
Extinction definition	Only one sex remains	
Immigration/emigration	not evaluated	
Number of years modelled	70	3x modelled GT (23.6)
Number of model iterations	1000	
Extinction definition	Only one sex remains	

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Supplement 3: Scenario-specific results for PSA, PBR and PVA

Table S6 Results of MSC PSA for bycatch of South Georgia wandering albatross in southwest Atlantic longline fisheries circa 2005-2010 in eight scenarios

Scenario	**Total P**	**Total S**	**PSA score**	**Risk category**
PSA1: Best available P, Literal S (Default)	2.57	1.88	3.18	Medium
PSA2: Inaccurate P, Biological S	2.43	1.88	3.07	Medium
PSA3: Imprecise P, Biological S	2.57	1.88	3.18	Medium
PSA4: Inaccurate & Imprecise P, Biological S	2.29	1.88	2.96	Medium
PSA5: Best available P, Literal S	2.57	1.03	2.77	Medium
PSA6: Inaccurate P, Literal S	2.43	1.03	2.64	Low
PSA7: Imprecise P, Literal S	2.57	1.03	2.77	Medium
PSA8: Inaccurate & Imprecise P, Literal S	2.29	1.03	2.51	Low

Table S7 Results of PBR for bycatch of South Georgia wandering albatross in SW Atlantic longline fisheries circa 2005-2010 in six scenarios. Grey shading indicates high risk, i.e. estimated bycatch exceeds PBR level

Scenario	**f**	**τ**	**B**	**PBR**	**Risk**
PBR1:Bycatch 150	0.1	0.15	1553	23.3	High
PBR2:Bycatch 256	0.1	0.15	1553	23.3	High
PBR3:Bycatch 88	0.1	0.15	1553	23.3	High
PBR4:Bycatch 150	0.5	0.15	1553	116.8	High
PBR5:Bycatch 256	0.5	0.15	1553	116.8	High
PBR6:Bycatch 88	0.5	0.15	1553	116.8	Low

Table S8 Results of PVA for bycatch of South Georgia wandering albatross in SW Atlantic longline fisheries circa 2005-2010 in nine scenarios. Grey shading indicates high risk, i.e. annual population growth goes from positive (Default scenario) to negative

Scenario	**Annual % population change**	**Risk**
Default (no bycatch)	1.97%	N/A
PVA1: 150 annual mortalities: 80% adults, 50% females	-3.28%	High
PVA2:150 annual mortalities: 80% adults, 77% females	-3.45%	High
PVA3:150 annual mortalities: 53% adults; 77% females	-2.28%	High
PVA4:256 annual mortalities: 80% adults, 50% females	-9.85%	High
PVA5:256 annual mortalities: 80% adults, 77% females	-5.29%	High
PVA6:256 annual mortalities: 53% adults; 77% females	-4.46%	High
PVA7:88 annual mortalities: 80% adults, 50% females	0.36%	Low
PVA8:88 annual mortalities: 80% adults, 77% females	-0.83%	High
PVA9:88 annual mortalities: 53% adults; 77% females	-0.38%	High

Table S9 Results of MSC PSA for bycatch of South Georgia black-browed albatross in South Africa hake trawl fisheries circa 2004 in four scenarios

Scenario	**Total P**	**Total S**	**PSA score**	**Risk category**
PSA1: Best available P, Literal S (Default)	2.43	1.88	3.07	Medium
PSA2: Inaccurate P, Biological S	2.29	1.88	2.96	Medium
PSA3: Imprecise P, Biological S	2.43	1.88	3.07	Medium
PSA4: Inaccurate & Imprecise P, Biological S	2.29	1.88	2.96	Medium
PSA5: Best available P, Literal S	2.43	1.00	2.63	Low
PSA6: Inaccurate P, Literal S	2.29	1.00	2.49	Low
PSA7: Imprecise P, Literal S	2.43	1.00	2.63	Low
PSA8: Inaccurate & Imprecise P, Literal S	2.29	1.00	2.49	Low

Table S10 Results of PBR for bycatch of South Georgia black-browed albatross in South Africa hake trawl fisheries circa 2004 in six scenarios. Grey shading indicates high risk, i.e. estimated bycatch exceeds PBR level

Scenario	**f**	**τ**	**B**	**PBR**	**Risk**
PBR1: Bycatch 5000; f=0.1	0.1	0.1	74296	743	High
PBR2:Bycatch 2500; f=0.1	0.1	0.1	74296	743	High
PBR3:Bycatch 8500; f=0.1	0.1	0.1	74296	743	High
PBR4:Bycatch 5000; f=0.5	0.5	0.1	74296	3715	High
PBR5:Bycatch 2500; f=0.5	0.5	0.1	74296	3715	Low
PBR6:Bycatch 8500; f=0.5	0.5	0.1	74296	3715	High

Table S11 Results of PVA for bycatch of South Georgia black-browed albatross in South Africa hake trawl fisheries circa 2004 in six scenarios. Grey shading indicates high risk, i.e. annual population growth goes from positive (Default scenario) to negative

Scenario	**Annual % change in population size**	**Risk**
Default (no bycatch)	1.47%	N/A
PVA1: Bycatch 5000; 80% adults, 50% females	-0.33%	High
PVA2: Bycatch 2500; 80% adults, 50% females	0.94%	Low
PVA3: Bycatch 8500; 80% adults, 50% females	-2.29%	High
PVA4: Bycatch 5000; 39% adults, 59% females	0.22%	Low
PVA5: Bycatch 2500; 39% adults, 59% females	0.99%	Low
PVA6: Bycatch 8500; 39% adults, 59% females	-0.79%	High

Supplement 4: results of sensitivity tests in VORTEX

Table S12 Results of sensitivity tests in VORTEX varying four demographic parameters by 10% for South Georgia wandering albatross

Demographic parameter	**Baseline (low-high)**	**Mean λ (range)**	**CV λ**
Percent females breeding	46% (41.4-50.6)	1.0105 (1.007 – 1.014)	0.18%
Mortality to age 1 (inverse of breeding success)	28% (25-31)	1.0105 (1.008 – 1.012)	0.09%
Juvenile mortality (age 2-6)	15% (13.5-16.5)	1.0104 (1.008 – 1.013)	0.13%
Adult mortality (age >6)	4% (3.6-4.4)	1.0104 (1.007 – 1.014)	0.17%