

**Supplementary Information**

**Supplementary Table S1.** The top 20 tested POPAN models and their respective selection metrics. . The final model used for inference had the lowest AICc value. Candidate models considered different covariate relationships with apparent survival probability (Phi), detection probability (p), and entry probability (pent), and either equal superpopulation size (N) between males and females (~1) or sex specific superpopulation sizes.

Model Formula	AICc	$\Delta$ AICc	AICc Weight	Deviance
Phi(~Sex + SST)p(~Sex + time)pent(~Sex + time)N(~1)	1799.298	0	0.303235	-9545.73
Phi(~Sex + Chla)p(~Sex + time)pent(~Sex + time)N(~1)	1799.975	0.6767	0.21619	-9545.06
Phi(~Sex + SST)p(~time)pent(~Sex + time)N(~Sex)	1801.03	1.7321	0.127544	-9544
Phi(~Sex + SST)p(~Sex + time)pent(~Sex + time)N(~Sex)	1801.223	1.924613	0.115839	-9545.85
Phi(~Sex + Chla)p(~Sex + time)pent(~Sex + time)N(~Sex)	1801.566	2.268213	0.097554	-9545.51
Phi(~Sex + SST)p(~time)pent(~Sex + time)N(~1)	1802.491	3.192532	0.061451	-9540.5
Phi(~Sex + Chla)p(~time)pent(~Sex + time)N(~Sex)	1803.06	3.762	0.046224	-9541.97
Phi(~Sex + time)p(~Sex + time)pent(~Sex + time)N(~Sex)	1805.751	6.452406	0.012041	-9555.66
Phi(~Sex + time)p(~Sex + time)pent(~Sex + time)N(~1)	1805.956	6.658028	0.010864	-9553.4
Phi(~Sex + time)p(~time)pent(~Sex + time)N(~Sex)	1807.583	8.285128	0.004816	-9551.78
Phi(~Sex + SST)p(~Sex + time)pent(~Sex + Chla)N(~1)	1809.536	10.23824	0.001814	-9521.25
Phi(~Sex + SST)p(~Sex + time)pent(~Sex + Chla)N(~Sex)	1811.377	12.07868	0.000723	-9521.44
Phi(~Sex + SST)p(~time)pent(~Sex + Chla)N(~Sex)	1811.897	12.59884	0.000557	-9518.89
Phi(~Sex + SST)p(~Sex + time)pent(~Sex + SST)N(~1)	1812.807	13.50924	0.000353	-9517.97
Phi(~Sex)p(~Sex + time)pent(~Sex + time)N(~1)	1814.92	15.62173	0.000123	-9528.07
Phi(~Sex + time)p(~Sex + time)pent(~Sex + Chla)N(~1)	1815.137	15.8391	0.00011	-9529.89

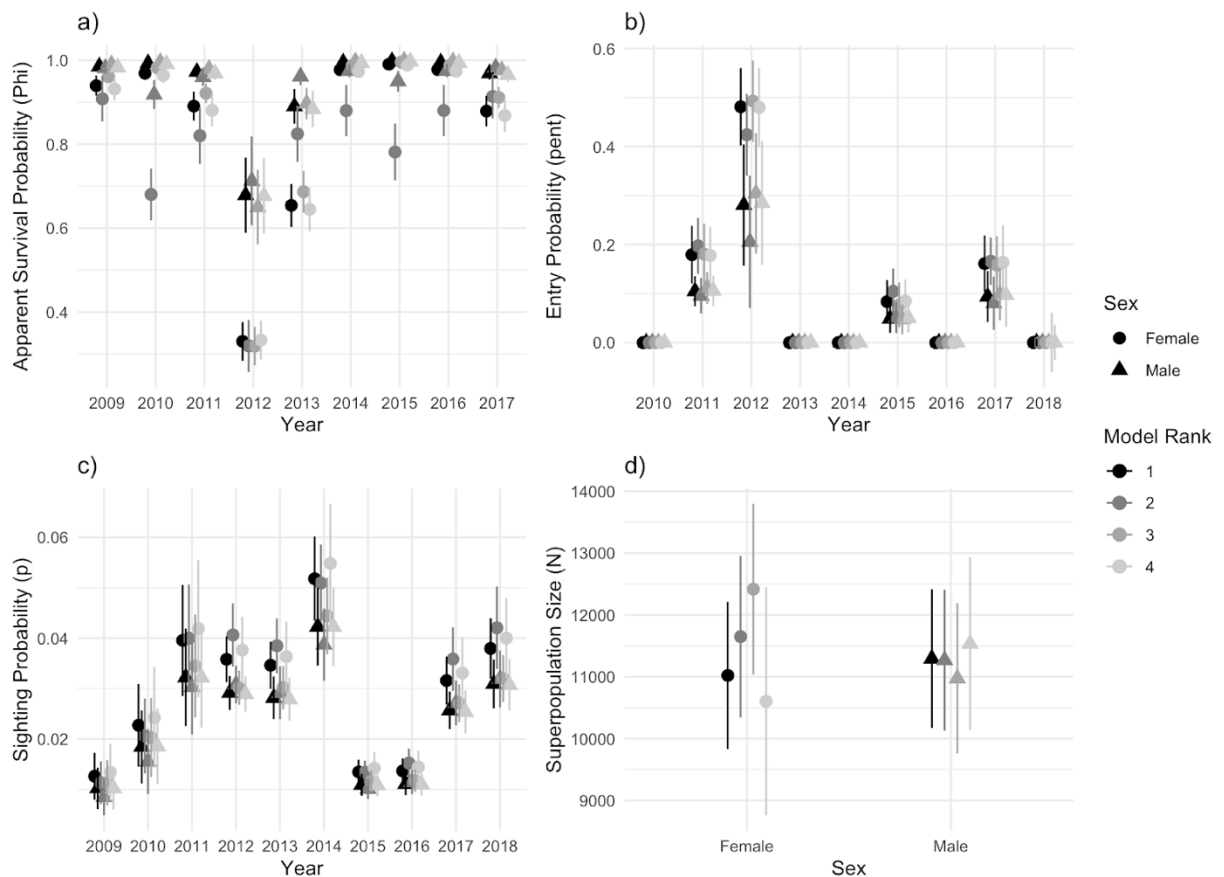
Phi(~Sex)p(~Sex + time)pent(~Sex + time)N(~Sex)	1815.5	16.2019	9.20E-05	-9529.53
Phi(~Sex + SST)p(~time)pent(~Sex + Chla)N(~1)	1815.518	16.21982	9.11E-05	-9513.24
Phi(~Sex + Chla)p(~Sex + time)pent(~Sex + Chla)N(~1)	1815.972	16.67394	7.26E-05	-9514.81
Phi(~Sex + SST)p(~time)pent(~Sex + SST)N(~Sex)	1816.856	17.55754	4.67E-05	-9513.93

**Supplementary Table S2.** Parameters of the top four POPAN models and their resulting superpopulation size. All four models accounted for 73.9% of the AICc weight. In parentheses, AICc weight is reported in bold in the top row, while remaining rows include the confidence intervals in parentheses.

Parameter & Year	Model 1	Model 2	Model 3	Model 4
Phi Female 2009	0.94 (0.87-0.97)	0.91 (0.73-0.97)	0.96 (0.92-0.98)	0.93 (0.85-0.97)
Phi Female 2010	0.97 (0.92-0.99)	0.68 (0.55-0.79)	0.98 (0.96-0.99)	0.96 (0.91-0.99)
Phi Female 2011	0.89 (0.8-0.94)	0.82 (0.65-0.92)	0.92 (0.86-0.96)	0.88 (0.78-0.94)
Phi Female 2012	0.33 (0.25-0.43)	0.32 (0.21-0.45)	0.32 (0.24-0.42)	0.33 (0.25-0.43)
Phi Female 2013	0.65 (0.55-0.75)	0.82 (0.66-0.92)	0.69 (0.58-0.77)	0.64 (0.54-0.74)
Phi Female 2014	0.98 (0.94-0.99)	0.88 (0.7-0.96)	0.99 (0.97-0.99)	0.97 (0.92-0.99)
Phi Female 2015	0.99 (0.97-1)	0.78 (0.62-0.89)	1 (0.99-1)	0.99 (0.96-1)
Phi Female 2016	0.98 (0.94-0.99)	0.88 (0.7-0.96)	0.99 (0.97-1)	0.97 (0.93-0.99)
Phi Female 2017	0.88 (0.79-0.93)	0.91 (0.74-0.98)	0.91 (0.85-0.95)	0.87 (0.77-0.93)
Phi Male 2009	0.99 (0.96-0.99)	0.98 (0.93-1)	0.99 (0.97-1)	0.98 (0.95-0.99)
Phi Male 2010	0.99 (0.98-1)	0.92 (0.82-0.97)	1 (0.99-1)	0.99 (0.97-1)
Phi Male 2011	0.97 (0.93-0.99)	0.96 (0.89-0.99)	0.98 (0.95-0.99)	0.97 (0.92-0.99)
Phi Male 2012	0.68 (0.48-0.83)	0.71 (0.47-0.87)	0.65 (0.46-0.8)	0.68 (0.48-0.82)
Phi Male 2013	0.89 (0.78-0.95)	0.96 (0.89-0.99)	0.9 (0.8-0.95)	0.88 (0.77-0.95)
Phi Male 2014	0.99 (0.98-1)	0.97 (0.92-0.99)	1 (0.99-1)	0.99 (0.98-1)
Phi Male 2015	1 (0.99-1)	0.95 (0.87-0.98)	1 (1-1)	1 (0.99-1)
Phi Male 2016	0.99 (0.98-1)	0.97 (0.92-0.99)	1 (0.99-1)	0.99 (0.98-1)
Phi Male 2017	0.97 (0.92-0.99)	0.98 (0.93-1)	0.98 (0.94-0.99)	0.97 (0.91-0.99)
p Female 2009	0.01 (0.01-0.03)	0.01 (0.01-0.02)	0.01 (0.01-0.02)	0.01 (0.01-0.03)
p Female 2010	0.02 (0.01-0.05)	0.02 (0.01-0.04)	0.02 (0.01-0.04)	0.02 (0.01-0.05)

p Female 2011	0.04 (0.02-0.07)	0.04 (0.02-0.07)	0.03 (0.02-0.06)	0.04 (0.02-0.08)
p Female 2012	0.04 (0.03-0.05)	0.04 (0.03-0.05)	0.03 (0.02-0.04)	0.04 (0.03-0.05)
p Female 2013	0.03 (0.03-0.05)	0.04 (0.03-0.05)	0.03 (0.02-0.04)	0.04 (0.02-0.05)
p Female 2014	0.05 (0.04-0.07)	0.05 (0.04-0.07)	0.04 (0.03-0.06)	0.05 (0.04-0.08)
p Female 2015	0.01 (0.01-0.02)	0.01 (0.01-0.02)	0.01 (0.01-0.02)	0.01 (0.01-0.02)
p Female 2016	0.01 (0.01-0.02)	0.02 (0.01-0.02)	0.01 (0.01-0.02)	0.01 (0.01-0.02)
p Female 2017	0.03 (0.02-0.04)	0.04 (0.03-0.05)	0.03 (0.02-0.04)	0.03 (0.02-0.05)
p Female 2018	0.04 (0.03-0.05)	0.04 (0.03-0.06)	0.03 (0.02-0.04)	0.04 (0.03-0.06)
p Male 2009	0.01 (0-0.02)	0.01 (0-0.02)	-	0.01 (0-0.02)
p Male 2010	0.02 (0.01-0.04)	0.02 (0.01-0.03)	-	0.02 (0.01-0.04)
p Male 2011	0.03 (0.02-0.06)	0.03 (0.02-0.06)	-	0.03 (0.02-0.06)
p Male 2012	0.03 (0.02-0.04)	0.03 (0.02-0.04)	-	0.03 (0.02-0.04)
p Male 2013	0.03 (0.02-0.04)	0.03 (0.02-0.04)	-	0.03 (0.02-0.04)
p Male 2014	0.04 (0.03-0.06)	0.04 (0.03-0.06)	-	0.04 (0.03-0.06)
p Male 2015	0.01 (0.01-0.02)	0.01 (0.01-0.01)	-	0.01 (0.01-0.02)
p Male 2016	0.01 (0.01-0.02)	0.01 (0.01-0.02)	-	0.01 (0.01-0.02)
p Male 2017	0.03 (0.02-0.03)	0.03 (0.02-0.04)	-	0.03 (0.02-0.04)
p Male 2018	0.03 (0.02-0.04)	0.03 (0.02-0.05)	-	0.03 (0.02-0.04)
N Female	10659.81 (8883.73-12830.17)	10575.65 (8811.48-12732.36)	12131.42 (10036.25-14706.18)	10217.68 (7684.39-13694.53)
N Male	-	-	10933.45 (9038.49-13302.48)	11472.12 (9342.79-14176.92)
pent Female 2010	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
pent Female 2011	0.18 (0.09-0.32)	0.2 (0.11-0.33)	0.18 (0.09-0.33)	0.18 (0.09-0.32)
pent Female 2012	0.48 (0.33-0.63)	0.42 (0.27-0.59)	0.49 (0.34-0.65)	0.48 (0.33-0.63)
pent Female 2013	0 (0-1)	0 (0-1)	0 (0-0)	0 (0-0)
pent Female 2014	0 (0-0)	0 (0-1)	0 (0-0)	0 (0-1)
pent Female 2015	0.08 (0.03-0.22)	0.1 (0.04-0.24)	0.08 (0.02-0.23)	0.08 (0.03-0.22)
pent Female 2016	0 (0-1)	0 (0-1)	0 (0-0)	0 (0-1)
pent Female 2017	0.16 (0.08-0.31)	0.17 (0.09-0.28)	0.16 (0.07-0.31)	0.16 (0.06-0.37)
pent Female 2018	0 (0-1)	0 (0-0)	0 (0-1)	0 (0-1)
pent Male 2010	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
pent Male 2011	0.1 (0.06-0.18)	0.1 (0.04-0.19)	0.11 (0.06-0.19)	0.11 (0.06-0.18)
pent Male 2012	0.28 (0.11-0.56)	0.21 (0.05-0.57)	0.3 (0.12-0.58)	0.28 (0.11-0.57)
pent Male 2013	0 (0-0)	0 (0-1)	0 (0-0)	0 (0-0)

pent Male				
2014	0 (0-0)	0 (0-1)	0 (0-0)	0 (0-1)
pent Male				
2015	0.05 (0.01-0.15)	0.05 (0.01-0.16)	0.05 (0.01-0.16)	0.05 (0.02-0.15)
pent Male				
2016	0 (0-1)	0 (0-1)	0 (0-0)	0 (0-1)
pent Male				
2017	0.09 (0.03-0.26)	0.08 (0.02-0.27)	0.1 (0.03-0.26)	0.1 (0.02-0.31)
pent Male				
2018	0 (0-1)	0 (0-0)	0 (0-1)	0 (0-1)



**Supplementary Figure S1.** Comparison of parameter estimates from the top four mark-resight models. a) Apparent survival estimates by year. b) Entry probability estimates by year. c) Sighting probability estimates by year. d) Superpopulation size estimates by sex. See results for model specifications. Vertical lines represent standard errors. We note that while standard errors were low for many entry probability estimates, the full confidence intervals spanned 0-1 in many cases (see Supplementary Table S2).