Supplementary materials for Kurota et al. (2008)

(a) Calculation conditions and diagnostics for MCMC simulations

This Bayesian analysis was implemented using WINBUGS software (version 1.4.3). Calculation conditions for MCMC simulations are listed as follows:

Base case scenario

(1) Pop-up satellite tag: This implementation used four chains, 110 000 iterations per chain, a burn-in of 10 000. The net number of iterations used was 100 000×4. (2) Archival tag: This implementation used six chains, 11 000 iterations per chain, a burn-in of 1000. The net number of iterations used was 10 000×6. (3) Conventional tag: This implementation used six chains, 11 000 iterations per chain, a burn-in of 1000. The net number of iterations used was 10 000×6.

Sensitivity tests

(1) Pop-up satellite tag: This implementation used four chains, 110 000 iterations per chain, a burn-in of 10 000. The net number of iterations used was 100 000×4. (2) Archival tag: This implementation used four chains, 11 000 iterations per chain, a burn-in of 1000. The net number of iterations used was 10 000×4. (3) Conventional tag: This implementation used two chains, 11 000 iterations per chain, a burn-in of 1000. The net number of iterations used was 10 000×2.

We compared the base case result for the conventional tag model with those from chains that were five times longer (50 000). Those two results were identical (Table S1). Convergence diagnostics also showed that the base case run had converged quickly and satisfactorily (Table S2, Figure S1). Therefore, the number of sampling iterations and the length of burn-in were regarded to be reasonable. It was assumed that the reported posteriors were representative of the underlying stationary distributions.

(b) Results for all scenarios of archival and conventional tag models

Tables S3 and S4 show detailed results for all sensitivity tests of archival and conventional tag models, respectively.

Table S1. Comparison of the posterior distribution of some key parameters for the conventional tag model between the first 10% of each chain and the last 10%.

		10 000 replicates						50 000 replicates					
		First 10%			Last 10%			First 10%			Last 10%		
		$F_{2,1,2000}$	$R_{3,1,1999\text{-}2005}$	$T_{2,1,2}$	$F_{2,1,2000}$	$R_{3,1,1999\text{-}2005}$	$T_{2,1,2}$	$F_{2,1,2000}$	$R_{3,1,1999\text{-}2005}$	$T_{2,1,2}$	$F_{2,1,2000}$	$R_{3,1,1999\text{-}2005}$	$T_{2,1,2}$
Chain1	Min.	0.016	0.071	0.030	0.017	0.067	0.038	0.013	0.062	0.027	0.011	0.053	0.026
	1st Qu.	0.048	0.099	0.090	0.048	0.095	0.087	0.047	0.098	0.093	0.047	0.099	0.093
	Median	0.062	0.109	0.116	0.062	0.108	0.110	0.061	0.110	0.116	0.061	0.111	0.116
	3rd Qu.	0.081	0.123	0.144	0.082	0.122	0.135	0.079	0.124	0.141	0.079	0.124	0.142
	Max.	0.187	0.178	0.264	0.182	0.210	0.260	0.203	0.210	0.257	0.237	0.238	0.304
Chain2	Min.	0.014	0.063	0.032	0.015	0.070	0.041	0.014	0.064	0.033	0.011	0.054	0.028
	1st Qu.	0.048	0.097	0.093	0.045	0.102	0.091	0.048	0.098	0.095	0.047	0.098	0.093
	Median	0.062	0.109	0.119	0.058	0.113	0.115	0.062	0.109	0.117	0.061	0.110	0.115
	3rd Qu.	0.080	0.123	0.143	0.077	0.125	0.140	0.078	0.123	0.142	0.079	0.124	0.141
	Max.	0.324	0.191	0.260	0.203	0.187	0.255	0.182	0.214	0.292	0.289	0.213	0.291
Chain3	Min.	0.018	0.065	0.031	0.013	0.067	0.031						
	1st Qu.	0.047	0.098	0.091	0.047	0.097	0.097						
	Median	0.062	0.109	0.115	0.061	0.109	0.116						
	3rd Qu.	0.080	0.122	0.139	0.080	0.122	0.138						
	Max.	0.269	0.172	0.250	0.249	0.177	0.266						
Chain4	Min.	0.013	0.065	0.035	0.020	0.059	0.029						
	1st Qu.	0.048	0.097	0.090	0.049	0.095	0.090						
	Median	0.061	0.108	0.113	0.063	0.106	0.113						
	3rd Qu.	0.077	0.122	0.139	0.079	0.121	0.135						
	Max.	0.209	0.191	0.236	0.186	0.176	0.219						
Chain5	Min.	0.020	0.063	0.035	0.015	0.067	0.041						
	1st Qu.	0.049	0.097	0.090	0.047	0.100	0.091						
	Median	0.063	0.108	0.111	0.059	0.112	0.116						
	3rd Qu.	0.079	0.120	0.136	0.075	0.125	0.141						
	Max.	0.216	0.178	0.245	0.185	0.177	0.263						
Chain6	Min.	0.015	0.071	0.035	0.016	0.058	0.035						
	1st Qu.	0.047	0.100	0.099	0.047	0.096	0.090						
	Median	0.062	0.110	0.119	0.061	0.108	0.113						
	3rd Qu.	0.080	0.124	0.143	0.079	0.122	0.137						
	Max.	0.202	0.189	0.259	0.178	0.180	0.278						

Table S2. The proportion of MC errors to estimated posterior SDs.

Parameter	Age	Area	mean	sd	MC error	MC error/sd
Average fishing mortality (t: 1990-2006)						
$F_{1,1,t}$	0-3	west	0.082	(0.012)	1.39E-04	0.011
$F_{2,1,t}$	4-8	west	0.111	(0.014)	1.52E-04	0.011
$F_{3,1,t}$	9+	west	0.167	(0.029)	2.33E-04	0.008
$F_{1,2,t}$	0-3	east	0.364	(0.092)	7.51E-04	0.008
$F_{2,2,t}$	4-8	east	0.180	(0.036)	2.80E-04	0.008
$F_{3,2,t}$	9+	east	0.330	(0.055)	3.69E-04	0.007
Reporting rate						
$R_{3,1,1990\text{-}1998}$		west	0.232	(0.037)	6.08E-04	0.016
$R_{3,1,1999\text{-}2005}$		west	0.112	(0.019)	2.09E-04	0.011
$R_{3,1,2006}$		west	0.057	(0.010)	1.07E-04	0.011
$R_{3,2,1990\text{-}1998}$		east	0.136	(0.042)	5.04E-04	0.012
$R_{3,2,1999\text{-}2005}$		east	0.064	(0.019)	2.25E-04	0.012
$R_{3,2,2006}$		east	0.023	(0.007)	7.97E-05	0.012
Movement rate						
$T_{1,1,2}$	0-3	west to east	0.062	(0.020)	2.02E-04	0.010
$T_{2,1,2}$	4-8	west to east	0.118	(0.035)	3.72E-04	0.011
$T_{3,1,2}$	9+	west to east	0.159	(0.036)	2.54E-04	0.007
$T_{1,2,1}$	0-3	east to west	0.185	(0.158)	1.06E-03	0.007
$T_{2,2,1}$	4-8	east to west	0.184	(0.140)	1.33E-03	0.009
$T_{3,2,1}$	9+	east to west	0.258	(0.149)	1.40E-03	0.009
Degree of mixing						
Ffy_1		west	0.661	(0.071)	4.91E-04	0.007
Ffy_2		east	0.079	(0.060)	3.71E-04	0.006
Natural mortality						
M			0.136	(0.012)	8.50E-05	0.007

Table S3. Summary results for the archival tag model.

Scenario name			1 (base)		2		3		4		5		6		7	
DIC			365.2		387.2		365.0		372.3		375.8		363.9		366.4	
No. parameter			45		45		45		45		45		44		47	
Parameter	Age	Area	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
Average fishing mortality (t: 1997-2006)																
$F_{2,1,t}$	4-8	west	0.117	(0.029)	0.143	(0.035)	0.108	(0.027)	0.118	(0.029)	0.146	(0.036)	0.117	(0.029)	0.115	(0.029)
$F_{3,1,t}$	9+	west	0.151	(0.030)	0.227	(0.042)	0.131	(0.027)	0.157	(0.031)	0.224	(0.041)	0.152	(0.030)	0.149	(0.033)
$F_{2,2,t}$	4-8	east	0.239	(0.079)	0.259	(0.087)	0.233	(0.077)	0.253	(0.084)	0.244	(0.081)	0.238	(0.078)	0.242	(0.081)
$F_{3,2,t}$	9+	east	0.403	(0.110)	0.567	(0.171)	0.366	(0.101)	0.522	(0.148)	0.440	(0.127)	0.399	(0.109)	0.418	(0.119)
Reporting rate																
$R_{2,1,1997\text{-}2005}$		west	0.70		0.30		0.90		0.70		0.30		0.70		0.74	(0.112)
$R_{2,1,2006}$		west	0.36	(0.165)	0.24	(0.117)	0.41	(0.182)	0.30	(0.150)	0.27	(0.132)	0.30	(0.136)	0.35	(0.167)
$R_{2,2,1997\text{-}2005}$		east	0.70		0.30		0.90		0.30		0.70		0.70		0.62	(0.111)
$R_{2,2,,2006}$		east	0.25	(0.120)	0.17	(0.083)	0.29	(0.137)	0.19	(0.091)	0.20	(0.100)	0.30	(0.136)	0.24	(0.118)
Movement rate																
$T_{2,1,2}$	4-8	west to east	0.090	(0.031)	0.098	(0.032)	0.085	(0.030)	0.115	(0.036)	0.080	(0.028)	0.090	(0.031)	0.095	(0.033)
$T_{3,1,2}$	9+	west to east	0.162	(0.038)	0.187	(0.040)	0.152	(0.037)	0.205	(0.042)	0.149	(0.035)	0.160	(0.038)	0.170	(0.040)
$T_{2,2,1}$	4-8	east to west	0.204	(0.166)	0.197	(0.161)	0.211	(0.169)	0.177	(0.151)	0.218	(0.172)	0.204	(0.165)	0.200	(0.164)
$T_{3,2,1}$	9+	east to west	0.373	(0.201)	0.320	(0.183)	0.404	(0.208)	0.259	(0.159)	0.424	(0.215)	0.374	(0.200)	0.350	(0.196)
Degree of mixing																
Ffy_1		west	0.392	(0.151)	0.562	(0.187)	0.339	(0.133)	0.384	(0.148)	0.576	(0.188)	0.389	(0.152)	0.382	(0.153)
Ffy_2		east	0.247	(0.189)	0.344	(0.232)	0.220	(0.172)	0.338	(0.231)	0.251	(0.192)	0.246	(0.187)	0.260	(0.195)
Natural mortality																
M			0.136	(0.013)	0.121	(0.011)	0.140	(0.013)	0.129	(0.012)	0.126	(0.012)	0.135	(0.013)	0.135	(0.013)

Table S3 (continued).

Scenario name			8		9			11		12		13		14	
DIC			366.4		376.9			364.1		363.8		334.3		367.8	
No. parameter			47		45			46		45		43		46	
Parameter	Age	Area	mean	sd	mean	sd		mean	sd	mean	sd	mean	sd	mean	sd
Average fishing mortality (t: 1997-2006)															
$F_{2,1,t}$	4-8	west	0.120	(0.028)	0.272	(0.109)		0.120	(0.030)	0.115	(0.028)	0.122	(0.030)	0.122	(0.031)
$F_{3,1,t}$	9+	west	0.150	(0.029)	0.222	(0.082)		0.156	(0.031)	0.143	(0.030)	0.156	(0.032)	0.158	(0.032)
$F_{2,2,t}$	4-8	east	0.232	(0.068)	0.816	(0.278)		0.241	(0.081)	0.238	(0.080)	0.231	(0.070)	0.237	(0.079)
$F_{3,2,t}$	9+	east	0.388	(0.100)	0.925	(0.291)		0.407	(0.110)	0.387	(0.109)	0.389	(0.106)	0.410	(0.118)
Reporting rate															
$R_{2,1,1997\text{-}2005}$		west	0.70		0.70			0.70		0.70		0.70		0.70	
$R_{2,1,2006}$		west	0.70		0.33	(0.161)		0.36	(0.167)	0.34	(0.161)			0.36	(0.172)
$R_{2,2,1997\text{-}2005}$		east	0.70		0.70			0.70		0.70		0.70		0.70	
$R_{2,2,,2006}$		east	0.70		0.23	(0.115)		0.25	(0.120)	0.23	(0.114)			0.24	(0.121)
Movement rate															
$T_{2,1,2}$	4-8	west to east	0.089	(0.031)	0.068	(0.027)		0.092	(0.031)	0.090	(0.031)	0.092	(0.031)	0.098	(0.036)
$T_{3,1,2}$	9+	west to east	0.158	(0.038)	0.135	(0.031)		0.162	(0.038)	0.158	(0.038)	0.157	(0.038)	0.166	(0.041)
$T_{2,2,1}$	4-8	east to west	0.206	(0.167)	0.234	(0.180)		0.201	(0.164)	0.206	(0.166)	0.205	(0.166)	0.219	(0.182)
$T_{3,2,1}$	9+	east to west	0.385	(0.204)	0.563	(0.247)		0.367	(0.199)	0.399	(0.204)	0.408	(0.209)	0.373	(0.205)
Degree of mixing															
Ffy_1		west	0.380	(0.149)	0.230	(0.114)		0.388	(0.152)	0.402	(0.154)	0.378	(0.147)	0.386	(0.156)
Ffy_2		east	0.253	(0.192)	0.141	(0.130)		0.243	(0.188)	0.252	(0.191)	0.242	(0.186)	0.243	(0.188)
Natural mortality															
M			0.137	(0.013)	0.137	(0.013)	M_2	0.201	(0.020)	0.088	(0.034)	0.135	(0.013)	0.136	(0.013)
							M_3	0.110	(0.011)						
Overdispersion															
k														6.472	(2.195)

Table S4. Summary results for the conventional tag model.

Scenario name			1b		1c		2		3		4		5		6		7	
DIC (base case: 1614.8)			1615.6		1624.1		1616.1		1614.9		1614.0		1617.0		1614.5		1614.8	
No. parameter (base case: 109)			111		107		109		109		109		109		107		109	
Parameter	Age	Area	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
Average fishing mortality (t: 1990-2006)																		
$F_{1,1,t}$	0-3	west	0.081	(0.012)	0.092	(0.014)	0.085	(0.013)	0.080	(0.012)	0.079	(0.012)	0.086	(0.013)	0.089	(0.013)	0.080	(0.012)
$F_{2,1,t}$	4-8	west	0.111	(0.014)	0.119	(0.015)	0.127	(0.016)	0.105	(0.013)	0.111	(0.014)	0.128	(0.016)	0.119	(0.014)	0.110	(0.014)
$F_{3,1,t}$	9+	west	0.166	(0.028)	0.180	(0.031)	0.206	(0.032)	0.156	(0.028)	0.170	(0.028)	0.204	(0.031)	0.174	(0.030)	0.166	(0.029)
$F_{1,2,t}$	0-3	east	0.364	(0.092)	0.358	(0.085)	0.365	(0.090)	0.364	(0.092)	0.362	(0.089)	0.370	(0.094)	0.358	(0.093)	0.363	(0.092)
$F_{2,2,t}$	4-8	east	0.178	(0.035)	0.178	(0.033)	0.195	(0.039)	0.175	(0.034)	0.189	(0.038)	0.184	(0.037)	0.175	(0.035)	0.181	(0.036)
$F_{3,2,t}$	9+	east	0.327	(0.055)	0.342	(0.058)	0.427	(0.084)	0.308	(0.051)	0.400	(0.072)	0.351	(0.061)	0.313	(0.052)	0.341	(0.059)
Reporting rate																		
$R_{3,1,1990\text{-}1998}$		west	0.234	(0.037)	0.169	(0.020)	0.215	(0.031)	0.240	(0.038)	0.251	(0.040)	0.203	(0.030)	0.199	(0.025)	0.239	(0.039)
$R_{3,1,1999\text{-}2005}$		west	0.111	(0.020)	0.169	(0.020)	0.091	(0.015)	0.121	(0.021)	0.122	(0.021)	0.084	(0.014)	0.093	(0.012)	0.116	(0.020)
$R_{3,1,2006}$		west	0.101	(0.060)	0.086	(0.010)	0.074	(0.012)	0.055	(0.010)	0.053	(0.009)	0.077	(0.013)	0.040	(0.005)	0.055	(0.010)
$R_{3,2,1990\text{-}1998}$		east	0.139	(0.044)	0.081	(0.021)	0.115	(0.034)	0.148	(0.049)	0.099	(0.029)	0.154	(0.051)	0.199	(0.025)	0.126	(0.040)
$R_{3,2,1999\text{-}2005}$		east	0.065	(0.019)	0.081	(0.021)	0.052	(0.014)	0.071	(0.022)	0.044	(0.011)	0.075	(0.024)	0.093	(0.012)	0.059	(0.017)
$R_{3,2,2006}$		east	0.069	(0.047)	0.029	(0.007)	0.029	(0.008)	0.023	(0.007)	0.028	(0.007)	0.022	(0.007)	0.040	(0.005)	0.023	(0.006)
Movement rate																		
$T_{1,1,2}$	0-3	west to east	0.061	(0.020)	0.072	(0.022)	0.070	(0.021)	0.058	(0.020)	0.083	(0.024)	0.053	(0.018)	0.045	(0.014)	0.066	(0.021)
$T_{2,1,2}$	4-8	west to east	0.118	(0.036)	0.124	(0.037)	0.127	(0.036)	0.112	(0.034)	0.152	(0.041)	0.104	(0.033)	0.091	(0.027)	0.127	(0.038)
$T_{3,1,2}$	9+	west to east	0.156	(0.036)	0.164	(0.036)	0.183	(0.038)	0.149	(0.036)	0.196	(0.038)	0.149	(0.034)	0.142	(0.033)	0.165	(0.037)
$T_{1,2,1}$	0-3	east to west	0.190	(0.162)	0.166	(0.147)	0.181	(0.154)	0.187	(0.159)	0.164	(0.148)	0.201	(0.167)	0.220	(0.176)	0.181	(0.156)
$T_{2,2,1}$	4-8	east to west	0.194	(0.148)	0.167	(0.129)	0.180	(0.135)	0.192	(0.148)	0.149	(0.112)	0.225	(0.164)	0.286	(0.175)	0.181	(0.137)
$T_{3,2,1}$	9+	east to west	0.265	(0.152)	0.233	(0.138)	0.243	(0.135)	0.275	(0.158)	0.195	(0.113)	0.303	(0.169)	0.401	(0.159)	0.241	(0.141)
Degree of mixing																		
Ffy_1		west	0.661	(0.072)	0.667	(0.071)	0.730	(0.082)	0.636	(0.068)	0.641	(0.070)	0.748	(0.082)	0.688	(0.071)	0.658	(0.072)
Ffy_2		east	0.078	(0.059)	0.087	(0.065)	0.088	(0.066)	0.075	(0.056)	0.086	(0.065)	0.078	(0.058)	0.070	(0.052)	0.081	(0.061)
Natural mortality																		
M			0.137	(0.012)	0.138	(0.012)	0.121	(0.010)	0.141	(0.013)	0.129	(0.011)	0.127	(0.011)	0.137	(0.012)	0.136	(0.012)

Table S4 (continued).

Scenario name			8		9		10			11		12		13		14	
DIC (base case: 1614.8)			1617.1		1629.5		1622.8			1629.9		1614.7		1564.6		1617.5	
No. parameter (base case: 109)			115		109		109			111		109		109		110	
Parameter	Age	Area	mean	sd	mean	sd	mean	sd		mean	sd	mean	sd	mean	sd	mean	sd
Average fishing mortality (t: 1990-2006)																	
$F_{1,1,t}$	0-3	west	0.083	(0.012)	0.222	(0.039)	0.073	(0.011)		0.080	(0.012)	0.083	(0.013)	0.086	(0.013)	0.086	(0.014)
$F_{2,1,t}$	4-8	west	0.114	(0.014)	0.211	(0.031)	0.105	(0.013)		0.115	(0.014)	0.111	(0.014)	0.117	(0.015)	0.109	(0.014)
$F_{3,1,t}$	9+	west	0.168	(0.028)	0.394	(0.103)	0.163	(0.028)		0.162	(0.028)	0.164	(0.029)	0.172	(0.030)	0.170	(0.029)
$F_{1,2,t}$	0-3	east	0.385	(0.098)	0.656	(0.186)	0.361	(0.093)		0.370	(0.095)	0.366	(0.093)	0.368	(0.091)	0.379	(0.095)
$F_{2,2,t}$	4-8	east	0.180	(0.034)	0.790	(0.269)	0.180	(0.037)		0.188	(0.038)	0.178	(0.035)	0.181	(0.035)	0.179	(0.036)
$F_{3,2,t}$	9+	east	0.316	(0.049)	0.919	(0.195)	0.325	(0.055)		0.324	(0.055)	0.323	(0.054)	0.310	(0.051)	0.339	(0.061)
Reporting rate																	
$R_{3,1,1990\text{-}1998}$		west	0.234	(0.037)	0.117	(0.014)	0.308	(0.048)		0.273	(0.043)	0.221	(0.038)	0.233	(0.037)	0.238	(0.040)
$R_{3,1,1999\text{-}2005}$		west	0.104	(0.017)	0.073	(0.012)	0.161	(0.027)		0.133	(0.022)	0.109	(0.021)	0.110	(0.019)	0.109	(0.020)
$R_{3,1,2006}$		west	0.104	(0.017)	0.035	(0.006)	0.082	(0.014)		0.068	(0.011)	0.053	(0.010)	0.056	(0.010)	0.056	(0.010)
$R_{3,2,1990\text{-}1998}$		east	0.141	(0.045)	0.156	(0.052)	0.210	(0.067)		0.161	(0.050)	0.130	(0.044)	0.136	(0.044)	0.125	(0.041)
$R_{3,2,1999\text{-}2005}$		east	0.062	(0.018)	0.095	(0.027)	0.112	(0.032)		0.078	(0.022)	0.062	(0.021)	0.063	(0.019)	0.063	(0.019)
$R_{3,2,2006}$		east	0.062	(0.018)	0.032	(0.009)	0.040	(0.011)		0.028	(0.008)	0.021	(0.007)	0.022	(0.007)	0.022	(0.007)
Movement rate																	
$T_{1,1,2}$	0-3	west to east	0.058	(0.019)	0.042	(0.016)	0.051	(0.018)		0.060	(0.019)	0.063	(0.022)	0.064	(0.021)	0.064	(0.023)
$T_{2,1,2}$	4-8	west to east	0.119	(0.035)	0.055	(0.021)	0.109	(0.034)		0.121	(0.035)	0.119	(0.035)	0.120	(0.035)	0.129	(0.041)
$T_{3,1,2}$	9+	west to east	0.154	(0.036)	0.132	(0.027)	0.154	(0.036)		0.157	(0.037)	0.156	(0.036)	0.156	(0.037)	0.164	(0.038)
$T_{1,2,1}$	0-3	east to west	0.195	(0.164)	0.202	(0.169)	0.212	(0.173)		0.190	(0.161)	0.184	(0.157)	0.187	(0.158)	0.205	(0.180)
$T_{2,2,1}$	4-8	east to west	0.195	(0.149)	0.445	(0.239)	0.242	(0.166)		0.207	(0.144)	0.181	(0.142)	0.190	(0.143)	0.220	(0.163)
$T_{3,2,1}$	9+	east to west	0.261	(0.150)	0.672	(0.199)	0.308	(0.163)		0.262	(0.150)	0.266	(0.154)	0.275	(0.158)	0.259	(0.155)
Degree of mixing																	
Ffy_1		west	0.659	(0.071)	0.530	(0.061)	0.602	(0.070)		0.609	(0.070)	0.677	(0.074)	0.645	(0.070)	0.646	(0.079)
Ffy_2		east	0.080	(0.061)	0.042	(0.034)	0.065	(0.049)		0.070	(0.055)	0.081	(0.060)	0.077	(0.058)	0.079	(0.062)
Natural mortality																	
M			0.138	(0.012)	0.126	(0.011)	0.128	(0.011)	M_1	0.268	(0.023)	0.118	(0.031)	0.136	(0.012)	0.136	(0.012)
									M_2	0.195	(0.018)						
									M_3	0.116	(0.011)						
Overdispersion																	
k																4.868	(1.889)

Figure S1. Gelman-Rubin-Brooks (BGR) plot for key parameters for the conventional tag model to examine MCMC convergence.