WLF 419 - Waterfowl and Wetlands Ecology and Management
Lecture 12 – Survival Probability
Next Time – Philopatry

Survival probability is studied more extensively in waterfowl than any others group of birds. Data from recoveries of birds banded with legbands and recaptures and resightings of individuals marked with auxiliary markers provides the information needed to estimate survival probability. Analysis of data on marked waterfowl has led to the development of new methods for estimating survival probability and other demographic parameters. We will examine survival probability during three periods of the annual cycle; 1) nesting (mostly female survival), 2) brood rearing (duckling survival), and annual survival probability. We will examine sources of variation in survival probability and agents of of mortality

Survival Probability During Breeding

- Nesting Females
  - Despite cryptic plumage, nest concealment, and even defense by mate – risky time
- Study Approaches
  - Carcasses
  - Predator Food Habits
    - Scavengers/Secondary Predators
  - Radio Telemetry
    - Effects of transmitter
- Cygnini and Anserini
  - Poorly described
  - Assumed to be low
    - Natural Agents
    - Subsistence Harvest
      - Black Brant
    - Schmutz (1994) Emperor Geese
      - May-Sep, Monthly (0.98)

Table 4. Mean seasonal and monthly survival estimates[a] (SE[b]) for adult brant, 1991–93.

Time period[c]	Seasonal survival		Monthly survival	
	S	SE	S	SE
Nesting	0.984	0.019	0.988	0.040
Early fall	0.944	0.029	0.970	0.015
Late fall	0.987	0.036	0.998	0.010
Winter	1.000	0.0	1.000	0.0
Early spring	0.988	0.046	0.984	0.030
Late spring	0.860	0.035	0.908	0.024

[a] Taken from Model 7 of Table 1.
[b] Included a constant variance inflation factor of 1.63 for lack of model fit.
[c] Nesting survival interval = 1 Jun–15 Jul; early fall = 15 Jul–15 Sep; late fall = 15 Sep–1 Jan; winter = 1 Jan–1 Mar; early spring = 1 Mar–15 Apr; late spring = 15 Apr–1 Jun.

From Ward et al. (1997)

- Mergini and Aythini?
- Anatini
  - Primary cause of skewed sex-ratios

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Table 12-1. Some Breeding Season (April-September) Mortality Rates of Adult Female Ducks in North America and Principal Causes of Mortality[a]

Species	Habitat	Location	Method	Sample size[b]	Mortality rate[c]	Mortality causes[d]	Source
Mallard	Prairie	N.Dak.	Fox dens	494	0.28	P, u	Johnson and Sargeant (1977)
Mallard	Prairie	N.Dak.	Radiotracking	235	0.19 (0.09-0.31)[e]	P, m	Cowardin *et al.* (1985)
Mallard	Forest	Minn.	Radiotracking	109	0.25	U, p	Kirby and Cowardin (1986)
Mallard	Prairie-parkland	Alb., Man., Sask.	Reward bands	16,562	0.40	U	Blohm *et al.* (1987)
Black Duck	Forest	Maine	Radiotracking	19	0.26	P	Ringelman and Longcore (1983)

[a]Length of time represented in each study varies.
[b]Number of fox dens examined for Mallard remains or number of adult females banded or radiotracked.
[c]Values are averages presented in respective source, except for Kirby and Cowardin (1986) where we excluded data for the molt and premigration period and recalculated the value from data presented. Where data for more than 1 year were provided, we present the range in annual variation in parentheses.
[d]Mortality-cause codes are: p = predation, m = farm machinery, u = undetermined. Capital letters signify known or implied major mortality causes (>50% of mortality), and lowercase letters signify known or implied minor causes (< 50% of mortality).
[e]Authors indicated the rate was probably biased low.

From Sargeant and Raveling 1992

- Assessment Study
  - Parklands of MB, SK, and AB
  - 0.625 (SE = 0.0283) - 0.840 (SE = 0.0178) for 90 day period of summer
- ~50 – 60% of annual mortality
- Sources
  - Collisions

        - Weather
            - Particularly early nesting birds
        - Predation
            - Predator Removal
            - Islands
            - Avian and Mammalian
                - Trees in the Prairies
        - Contaminants
        - Diseases
        - Subsistence Hunting
    - Prairie Parklands
        - Foxes major predator
        - 800,000 ducks annually
            - 75% females
            - mostly dabbling ducks

Brood Survival

- Much recent work
- Methodology
    - Total brood loss
    - Brood Mixing
    - Independence of Fates

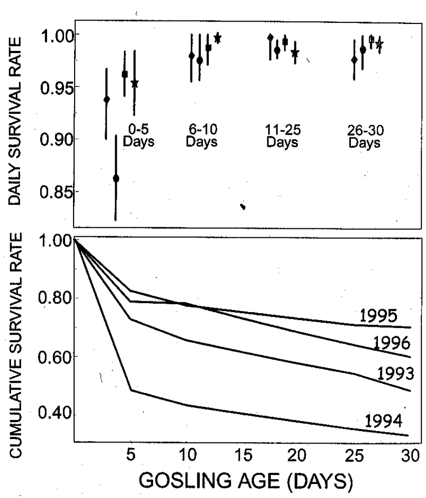

Fig. 2. Survival of emperor goose goslings on the Yukon-Kuskokwim Delta. We estimated survival rates with an iterative Mayfield method (Manly and Schmutz 2001), where daily survival rate was constant within each of 4 age classes but potentially different among age classes. We show daily survival rates of the most general model, i.e., where each age class differed in survival rate, and point estimates in 1993–96 are respectively represented by diamonds, ovals, squares, and stars. Vertical lines are 95% confidence intervals. We then show the pattern of cumulative survival to 30 days of age, using a parsimonious model where daily survival among some age classes >5 days of age were constrained equal.

- Often declining rate of mortality

From Schmutz et al. (2001)

- Anserini and Cygnini

Recent Estimates

Species	**Survival Probability (Gosling)**	**Principle Causes**	**Location**	**Source**
Emperor	0.534 (30 days, annual varitation)	Predation, Weather	YK Delta	Schmutz et al. (2001)
Black Brant	0.676 (25 days)	?	YK Delta	Flint et al. (1995)
Lesser Snow	~0.50	Habitat Degradation	LPB	Williams et al. (1993)
Cackling Canada Geese	0.45	?	YK Delta	Ely (Unpubl.)
Canada geese	~25-50%	Habitat Degradation, Molt Migrant?	Akimiski Island, Nunavut	Patton et al. (unpub.)

Table 12-4. Some Mortality Rates of Prefledged Swans and Geese in North America and Principal Causes of Mortality

Species/ subspecies	Habitat	Location[b]	Mortality rates[a]: 1st 2 weeks[c]	Mortality rates[a]: To fledging[d]	Mortality causes[e]	Source
Trumpeter Swan	Intermountain marsh/lake	Mont.		0.20	u	
				0.45[f]	u, *p*	Banko (1960)
	Intermountain marsh/lake	Mont.		0.73[f]	w, d	Page (1974) *in* Bellrose (1980)
	Intermountain marsh/lake	Oreg.		0.32	u	Cornely *et al.* (1985*a*)
	Forest deltas	Alaska		0.05		
				0.23(0.18-0.29)[f,g]	u, *h*, *p*	Hansen *et al.* (1971)
Tundra Swan	Tundra	Alaska (2)		0.31(0.24-0.39)[f,g]	u, *w*	Lensink (1973)
White-fronted Goose	Tundra	Alaska		0.12[h,i]	*p*	Mickelson (1975)
	Tundra	Alaska	0.13[h]		u	Ely and Raveling (1984)
Snow Goose	Tundra	N.W.T. (7)	0.15[g,h]	0.19[g,h]	*p*	Cooch (1958)
Emperor Goose	Tundra	Alaska		0.22[h,i]	*p*	Mickelson (1975)
	Tundra	Alaska		0.32[h]	*p*	Eisenhauer and Kirkpatrick (1977)
Canada Goose (subspecies)						
Western	Intermountain marsh/lake	Mont.		0.17,0.20[f]	u, *p*	Geis (1956)
Giant	Reservoir	Mo.	0.29[g]	0.32(0.20-0.36)[f]	u, *p*, *d*, *w*	Brakhage (1965)
	Forest bog lakes	Mich.		0.22,0.28[f]	u, *p*	Sherwood (1968)
	Forest bog lakes	Mich.		0.84[f]	d	Sherwood (1968)
	Prairie	Iowa		<0.10,0.27[f]	*w*, *p*	Nigus and Dinsmore (1980)
	Savanna	Wis.	0.25[g]	0.39(0.28-0.52)[f]	u	Zicus (1981)
Lesser/Hutchins	Tundra	N.W.T.		0.10,0.15[h]	*p*	MacInnes (1962)
	Tundra	N.W.T.(6)	0.23 (0.13-0.35)[f]	0.26(0.14-0.39)[f,g]	*p*	MacInnes *et al.* (1974)
Cackling	Tundra	Alaska		0.13[h,i]	*p*	Mickelson (1975)
Brant	Tundra	Alaska		0.15[h,i]	*p*	Mickelson (1975)
	Tundra	Alaska	0.10 (0.03-0.17)[g,h]	0.29(0.15-0.42)[g,h]	*p*	Eisenhauer (1977)

[a]Underlined rates pertain to losses of entire broods only; other rates pertain to losses of total young hatched or changes in average brood sizes. Most values are either from 1 year or are weighted averages presented in respective sources; where data exist for 2 years, both values are provided, but where data for 3 or more years were provided, we calculated unweighted means and present the range of annual variation.
[b]Number in parentheses refers to location shown on Figure 12-1.
[c]Approximate first 2 weeks after hatch, but length of period varies by about 1 week.
[d]Approximate period to fledging, but length of period varies from about 2 weeks before fledging to 3 weeks after fledging.
[e]Mortality-cause codes are: d = disease, h = human disturbance, p = predation, u = undetermined, and w = weather. If more than one cause was considered significant, the codes are listed in the order of importance implied. Italicized codes were suggested from conclusions in source, but no quantitative data were presented.
[f]Rate based on total counts of difference between numbers of young hatched and numbers fledged, so losses of entire broods are accounted for even if unspecified, except for Lensink's (1973) study in which mortality was estimated from comparisons to average clutch sizes and thus included unhatched eggs as well as missing cygnets.
[g]Calculation made from data presented in source; unweighted average for studies of Hansen *et al.* (1971), Lensink (1973), and MacInnes *et al.* (1974).
[h]Rate based on counts of average brood sizes and does not account for losses of entire broods.
[i]From Mickelson (1975, Table 3); we were unable to obtain these same values from data presented in that table or in appendices.

From Sargeant and Raveling (1992)

- Mortality Agents
  - Weather
    - Long Brooding Period
  - Predation
    - Avian
    - Can defend against some predators
- Ducks
  - Low initial survival probability

J. Wildl. Manage. 61(1):1997 SPECTACLED EIDER SURVIVAL • *Flint and Grand* 219

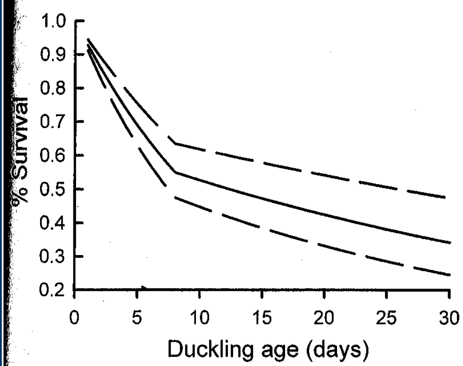

Fig. 1. Pooled survival function of juvenile spectacled eiders on the Yukon-Kuskokwim Delta, Alaska, 1993–95, calculated by estimating a separate daily survival rate for ages 1–8 and 9–30. Confidence limits assume no covariance among daily survival rates.

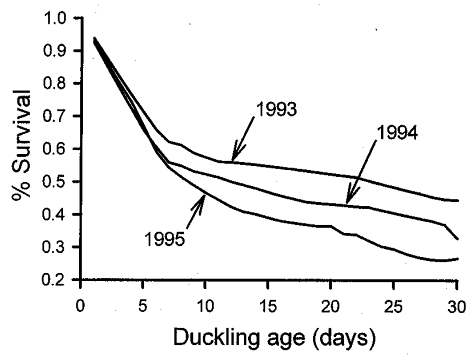

Fig. 2. Survival functions of juvenile spectacled eiders on the Yukon-Kuskokwim Delta, Alaska, 1993–95, calculated by estimating a separate daily survival rate for each age. Period survival to age *i* is estimated as the product of the individual daily survival probabilities up to age *i*.

From Flint and Grand (1997)

- Much recent work

Table 12-5. Some Mortality Rates of Prefledged Ducks in North America and Principal Causes of Mortality

Species	Habitat	Location	Mortality rates[a]		Mortality causes[d]	Source
			1st 2 weeks[b]	To fledging[c]		
North American Wood Duck	Riverine	Mass.		0.54 (0.47-0.58)	u, *p*	Grice and Rogers (1965)
	Woodland impoundments	Md.	0.44 (0.36-0.47)	0.47 (0.41-0.50)	u	McGilvrey (1969)
	Impoundment	Mich.	–[e]	0.44, 0.48	u	Baker (1970)
	River bottomland	Alaska		0.48, 0.33	u	Brown (1972)
	Forest impoundment	N.Y.		0.35, 0.35	u	Haramis and Thompson (1984)
	Forest lakes/ponds	Minn.	0.51	0.59	u	Ball *et al.* (1975)
Gadwall/Northern Pintail	Prairie impoundments	Alb.	0.53	0.73	u, *p*	Duncan (1986)
Mallard	Prairie ponds	Sask.	0.52 (0.35-0.65)[f]	0.72 (0.27-0.61)	u	Dzubin and Gollop (1972)
	Forest ponds	Minn.	0.39	0.56	u	Ball *et al.* (1975)
	Prairie ponds	N.Dak.	0.44	0.56, 0.44		
				0.65	p	Talent *et al.* (1983)
	Prairie ponds	N.Dak.	0.26 (0.13-0.33)[f]		u, *p*	Cowardin *et al.* (1985)
	Prairie lake	Mont.	0.33	0.37		
			0.52	0.61	u, *p*	Orthmeyer (1987)
Black Duck	Estuary	Que.	0.36	0.45		
				0.66 (0.60-0.75)	u, *p*, *w*	Reed (1975*a*)
	Forest ponds	Maine	0.39	0.19		
				0.58	u	Ringelman and Longcore (1982)
Canvasback	Prairie ponds	Man.	0.16 (0.03-0.29)[g]	0.21 (0.06-0.31)[g]	u	Stoudt (1982)
Redhead	Farmland lake	Que.		0.51 (0.48-0.52)[g]	u, *w*, *p*	Alliston (1979)
Ring-necked Duck	Forest ponds	Maine	0.46	0.23		
				0.63	u, *f*	McAuley and Longcore (1988)
Eider	Coastal island	N.S.		0.75	u, *p*, *w*	McAloney (1973)

[a]Underlined rates pertain to losses of entire broods only; other rates pertain to losses of ducklings. Most values are averages presented in respective source; where data for 2 years were provided we present both values, but where data for 3 or more years were provided we present the summary value provided in source for all years combined and the range of annual variation. If no summary value was provided in source, we calculated an unweighted average.
[b]Approximate first 2 weeks after hatch, but length of period varies from 2 to 24 days after hatch.
[c]For most species the duckling growth period represented is from hatch to about mid-Class III.
[d]Mortality-agent codes are: f = food shortage, p = predation, u = undetermined, and w = weather. When more than one cause was considered significant, the codes are listed in order of importance presented or implied in source. Codes that are italicized are suggested from conclusions in source, but no quantitative data were presented.
[e]Seventy-four percent of the mortality occurred during the first 2 weeks after hatching.
[f]Mortality period represented is from nest to arrival on water.
[g]Does not include losses of entire broods.

From Sargeant and Raveling (1992)

Annual Survival Probability

- Methodology
    - Band recovery studies
        - True Survival Probability
    - Mark-recapture/resight studies
        - Apparent Survival Probability

Table 14-1. Annual survival rate estimates of North American Anatidae

Species/ subspecies	Banding period	Banding years	Banding location	Sex[a]	Age[b]	Annual survival[c]	Source
Trumpeter Swan	Summer	1949-82	MT	M&F	A	0.88	Anderson et al. 1986
White-fronted Goose	Preseason	1967-69	AK	M	A&S	0.70	Timm & Dau 1979
				F	A&S	0.65	
Canada Goose (primarily *canadensis* & *interior*)	Preseason	1963-80	Eastern North America (N.A.)	M&F	A	0.70	Stotts 1983
				M&F	Y	0.60	
fulva	Preseason	1956-60	Glacier Bay, AK	M&F	A	0.84	Ratti et al. 1978
interior	In season	1976-82	WI	M&F	A	0.77	Samuel et al. 1986
				M&F	Y	0.64	
leucopareia	Spring	1976-79	AK	M&F	A	0.77	Yparraguirre 1982
maxima	Preseason	1966-74	MI	M&F	A&Y	0.75	Tacha et al. 1980
moffitti	Preseason	1953-73	Western N.A.	M&F	A	0.64	Krohn & Bizeau 1980
				M&F	Y	0.53	
Brant	Summer	1956-75	Keewatin, N.W.T.	M&F	A	0.79	Kirby et al. 1986
Wood Duck	Preseason	1960-68	Atlantic Flyway N.A.	M	A	0.54	F. A. Johnson et al. 1986
				M	Y	0.44	
				F	A	0.49	
				F	Y	0.42	
American Wigeon	Winter	1951-69	CA	M	A	0.64	Rienecker 1976
				F	A	0.61	
Green-winged Teal	Preseason	1955-61	Sask.	M	A	0.50	Martin et al. 1979
Mallard	Preseason	1969-81	FL	M&F	A&Y	0.37	Johnson et al. 1984
	Preseason	1950-71	N.A.	M	A	0.63	Anderson 1975b:22
				M	Y	0.50	
				F	A	0.56	
				F	Y	0.50	
Black Duck	Preseason	1950-83	Eastern N.A.	M	A	0.63	Krementz et al. 1987
				M	Y	0.48	
				F	A	0.47	
				F	Y	0.38	
Northern Pintail	Preseason	1948-79	CA	M	A	0.72	Rienecker 1987
				M	Y	0.56	
				F	A	0.60	
				F	Y	0.51	
Blue-winged Teal	Preseason	1948-76	N.A.	M	A	0.59	L. D. Schroeder, unpubl. data
				M	Y	0.44	
				F	A	0.52	
				F	Y	0.32	
Canvasback	Winter	1955-75	N.A.	M	A	0.76	Nichols & Haramis 1980
				F	A	0.61	
Ring-necked Duck	Preseason	1966-76	Eastern N.A.	M	A	0.70	Conroy & Eberhardt 1983
				M	Y	0.41	
				F	A	0.47	
				F	Y	0.33	

[a]M = male, F = female.
[b]A = adult, S = subadult, Y = young.
[c]All estimates except those for the *leucopareia* subspecies of the Canada Goose were obtained using band recovery data with the models of Brownie et al. (1985). The *leucopareia* estimates were obtained using resighting data in conjunction with the Jolly-Seber model (Seber 1982). All estimates represent arithmetic means over years and, in many cases, geographic areas.

From Johnson et al. (1992)

- Recent Work
- Sources of variation
    - Age

▪ Ducks and Geese?
▪ How long does difference persist?

- Sex
    - Ducks Only?
    - Adults and Young?
- Geography
- Phylogeny

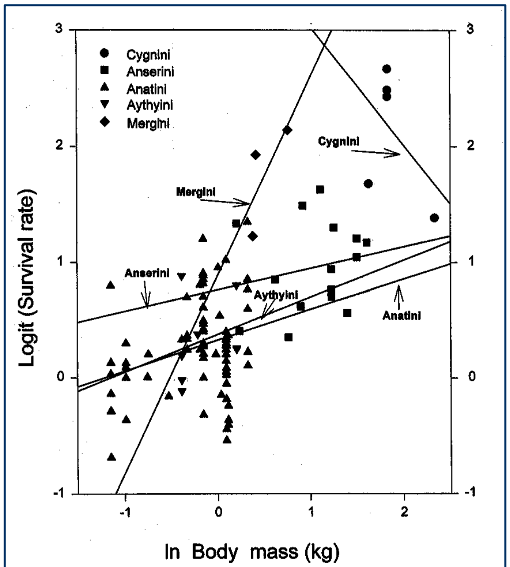

Fig. 1. Relationships between survival rate and body mass in waterfowl tribes. The Tadornini is not included.

From Krementz et al. (1997)

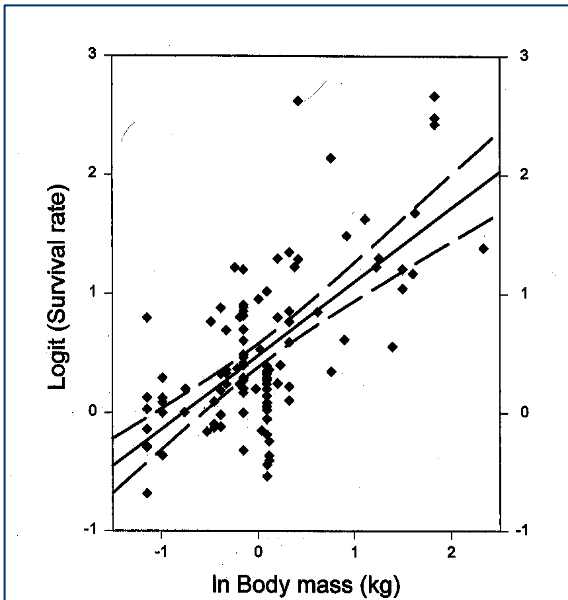

Fig. 2. Relationship between survival rate and body mass in waterfowl. Confidence limits are 95% intervals around the regression line.

- Body Mass
- Habitat?
- Population Density
    - Basis for harvest management
    - Evidence?

- Sources of Variation
    - Summer components
    - Fall/Winter
        - Harvest and Weather

TABLE 1. Average annual survival rate (×100), standard error (in parentheses), and body mass (kg) of adult female waterfowl from around the world.

Species	Survival	Estimator[a]	Reference[b]	Body mass	Reference
		Africa			
Anas undulata	72.2 (4.48)	B	1	1.008	Dunning 1993
		Australia			
Anas gibberifrons	55.0 (17.0)	B	2	0.474	Marchant & Higgins 1990
Anas superciliosa	63.0 (6.0)	B	2	1.025	Marchant & Higgins 1990
		Europe			
Bucephala clangula	77.2 (3.4)	C	3	0.787	Dunning 1993
Somateria mollissima	89.5 (1.46)	C	4	2.142	Dunning 1993
Anas clypeata	58.1 (2.96)	B	5	0.680	Dunning 1993
Aythya ferina	59.2 (2.22)	B	5	0.807	Dunning 1993
Aythya fuligula	70.7 (1.96)	B	5	0.680	Dunning 1993
		New Zealand			
Anas platyrhynchos	44.0 (5.0)	B	6	1.123	Marchant & Higgins 1990
	41.0 (4.0)				
	40.0 (5.0)				
	59.0 (6.0)				
Anas superciliosa	55.0 (12.0)	B	7	0.981	Marchant & Higgins 1990
Anas rhynchotis	68.2 (3.56)	B	8	0.614	Marchant & Higgins 1990
Anas gibberifrons	50.1 (11.29)	B	8	0.469	Dunning 1993
Cygnus atratus	84.3 (5.1)	B	8	5.100	Marchant & Higgins 1990
Branta c. maxima	74.0 (1.7)	B	5	4.489	Marchant & Higgins 1990
	77.0 (1.1)	B	5		
Tadorna variegata	79.4 (19.9)	B	8	1.387	Marchant & Higgins 1990
	55.5 (2.4)				
	52.6 (5.7)				
	70.1 (3.93)				
	64.4 (4.45)				
	68.2 (3.56)				
		North America			
Cygnus buccinator	80.0 (1.0)	B	9	10.300	Dunning 1993
Cygnus columbianus	92.3 (4.3)	S	6	6.255	Bellrose 1976
	91.9 (4.7)				
	93.5 (6.6)				
Anser albifrons	64.9 (6.9)	B	10	2.456	Dunning 1993
Chen caerulescens	81.6 (1.6)	B	11	2.517	Dunning 1993
Chen canagica	58.6 (4.5)	C	12	2.150	C. Dau & J. Schmutz unpubl.
Branta c. canadensis	66.8 (2.6)	B	13	3.420	Bellrose 1976
	71.9 (1.5)				
	68.2 (1.9)				
B. c. occidentalis	83.6 (4.3)	B	14	3.043	Bellrose 1976
B. c. leucoparia	70.0 (2.0)	C	15	1.940	Dunning 1993
B. c. interior	78.6 (3.1)	S	16	3.514	Bellrose 1976
B. c. maxima	76.4 (5.47)	B	17	4.995	Bellrose 1976
B. c. moffitti	63.6 (1.0)	B	18	4.044	Dunning 1993
B. c. minima	59.9 (1.5)	C	19	1.264	Dunning 1993
Branta bernicla	79.2 (3.64)	B	20	1.230	Bellrose 1976
	83.5 (4.11)	B	21	1.390	Bellrose 1976
Aix sponsa	47.6 (1.66)	B	22	0.635	Dunning 1993
	46.9 (1.85)				
	52.4 (2.15)				
Anas americana	58.2 (3.63)	C	23	0.719	Dunning 1993
	58.9 (6.35)				
	66.7 (6.01)				
	56.0 (6.0)	C	24		
Anas platyrhynchos	56.8 (4.3)	B	25	1.098	Bellrose 1976
	58.1 (12.4)				
	56.0 (4.1)				
	55.0 (2.5)				

TABLE 1. Continued.

Species	Survival	Estimator[a]	Reference[b]	Body mass	Reference
	58.6 (6.9)				
	59.7 (4.8)				
	73.5 (13.7)				
	51.3 (7.5)				
	53.6 (8.8)				
Anas rubripes	45.4 (3.9)	B	26	1.100	Dunning 1993
	48.7 (6.6)				
	57.3 (5.2)				
	39.1 (5.3)				
	36.8 (4.5)				
	52.1 (3.8)				
	50.6 (2.5)				
Anas acuta	69.3 (6.0)	B	27	0.860	Bellrose 1976
	62.0 (7.4)				
	61.4 (4.5)				
	57.3 (5.4)				
	60.3 (6.1)				
	71.2 (4.0)				
	64.7 (2.5)				
	56.7 (4.9)				
	54.2 (5.1)				
	55.1 (4.6)				
	76.9 (9.7)				
	70.8 (5.4)				
	50.0 (4.5)				
	42.1 (21.5)				
	66.8 (10.6)				
	70.1 (5.3)				
	57.1 (9.1)				
	59.8 (4.1)				
Anas discors	52.2 (1.8)	B	28	0.374	Bellrose 1976
	50.0 (2.7)				
	57.3 (3.1)				
	53.1 (9.2)				
	41.0 (6.0)	C	24		
Anas crecca	68.9 (15.1)	B	29	0.318	Dunning 1993
	50.7 (29.4)				
	33.4 (3.22)				
	53.1 (6.01)				
	46.5 (3.04)				
	42.8 (14.98)				
	42.9 (4.75)				
Anas strepera	69.0 (6.51)	B	30	0.828	Bellrose 1976
	56.0 (5.0)	C	24		
Anas fulvigula	46.3 (5.6)	B	31	0.952	P. Gray unpubl.
Anas clypeata	46.0 (5.0)	C	24	0.590	Dunning 1993
Aythya collaris	54.7 (7.7)	B	32	0.680	Dunning 1993
	49.5 (4.3)				
	47.1 (8.0)				
Aythya valisineria	56.2 (5.0)	B	33	1.230	Nichols & Haramis 1981
	56.1 (5.2)				
	69.0 (6.9)				
Melanitta fusca	77.3 (1.76)	B	34	1.467	G. Dobush unpubl.
Somateria mollissima	87.3 (1.56)	B	34	1.521	Bellrose 1976

[a] B = Brownie et al. (1985); C = Cormack-Jolly-Seber (Pollock et al. 1990); S = SURVIV (White 1983).

[b] 1 = Dean and Skead (1989); 2 = Halse et al. (1993); 3 = Dow and Fredga (1984); 4 = Coulson (1984); 5 = J. D. Nichols (unpubl. data); 6 = Nichols et al. (1992); 7 = Caithness et al. (1991); 8 = R. J. Barker (unpubl. data); 9 = Anderson et al. (1986); 10 = Timm and Dau (1979); 11 = Francis et al. (1992); 12 = Petersen (1992); 13 = Hestbeck (1994); 14 = Ratti et al. (1978); 15 = Yparraguirre (1982); 16 = Samuel et al. (1990); 17 = Tacha et al. (1980); 18 = Krohn and Bizeau (1980); 19 = Raveling et al. (1992); 20 = Conroy et al. (1989); 21 = Lensink (1988); 22 = Johnson et al. (1986); 23 = Rienecker (1976); 24 = T. S. Arnold and W. R. Clark (unpubl. data); 25 = Trost (1987); 26 = Krementz et al. (1987); 27 = Hestbeck (1993); 28 = USFWS (unpubl. data); 29 = Chu et al. (1995); 30 = Szymczak and Rexstad (1991); 31 = F. A. Johnson (unpubl. data); 32 = Conroy and Eberhardt (1983); 33 = Nichols and Haramis (1980); 34 = D. G. Krementz (unpubl. data).

From Krementz et al. (1997)

Which parameters are most important?

- Which parameters should we target with management actions?
- Which parameters had the most influence on population dynamics?
- Are the patterns the same across all taxa?
    - What factors would influence your answers?

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