Appendix 1. Review of literature on causes of nest failure for Marbled and Kittlitz's Murrelet in North America used in this publication.\*

Appendix 1. Review of includie on educes of next fandle for Marbled and Rithing			ii / iiici ica	used in this put	Jileation.													
Cause of Nest Failure	Kittlitz's Murrelet (Brachyramphus brevirostris; n = 177)				Marbled Murrelet (Brachyramphus marmoratus; $n = 41$ )													
	Icy Bay AK <sup>1</sup>	Kodiak Island AK <sup>2</sup>	Agattu Island AK <sup>3</sup>	Northwest mainland AK <sup>4</sup>	Santa Cruz Mountains CA <sup>5</sup>	San Mateo County CA <sup>6</sup>	Redwoods CA <sup>6,7</sup> **	Humboldt County CA <sup>8</sup>	Coos River OR <sup>9</sup>	Coastal OR <sup>10</sup>	Olympic Peninsula WA <sup>6,11</sup>	Olympic Peninsula WA and Vancouver Island BC <sup>12</sup>	Desolation and Clayoquot Sound BC <sup>13</sup>	Franklin River and Gilltoyees Inlet BC <sup>6</sup>	Southeast mainland AK <sup>14</sup>	Icy Bay AK <sup>1</sup>	Naked Island AK <sup>15</sup>	Total (Marbled Murrelet only)
1. Non-predatory failures during incubation <sup>+</sup>						<b>y</b>		<b>y</b> _	-									13
1.1 Egg abandoned for unknown reasons (in some cases, cameras documented that the egg was																		
scavenged after abandonment)		10	5		1							1	2				1	5
<b>1.2 Problem with egg viability</b> - Adult abandoned unviable or unfertile egg, or egg that failed to hatch	1	4	5		1							2	1					4
1.3 Parent depredated - Radio-tagged parent was depredated during incubation	3														3	1		4
<b>1.4 Disturbance</b> Researcher disturbance - adults returned to nest 0.1 times after being flushed during researcher nest																		0
searching efforts, and adult never returned again		2																0
Bear disturbance - "The incubating adult fled from the nest during mid-day when a brown bear (Ursus																		
arctos) approached. Although the bear did not find and eat the egg, neither adult murrelet returned to																		
the nest, and the egg eventually was discovered and eaten by a red fox." (Vulpes vulpes)				1														0
Unstable terrain - "Rocks rolling downhill repeatedly flushed incubating adult until egg was abandoned"	1																	0
Researcher disturbance - Adult was trapped on nest by researchers and egg broke during capture, or egg		2																0
was abandoned because trapped and satellite-tagged adult never returned to nest after trapping		Z																0
"Adult moved egg out of nest"		1																0
Egg abandoned - "after sporadic incubation by adults"		3																0
2. Predator-caused failures during incubation																		6
Egg depredated by red fox		28		1														0
Egg depredated by Black-billed Magpie (Pica hudsonia)		2																0
Egg depredated by Steller's Jay (Cyanocitta stelleri)					2		2											2
Adult depredated at pact by Pad shouldered Hawk (Ruteo lineatus)					1		1											1
Egg depredated at less by Red-should red mark (Butco Inteation)																		
Common Raven (predatory mammals do not occur at site)			10															0
Egg depredated by unknown predator		18	5															0
3. Non-predatory failures during nestling phase																		18
3.1 Poor nest placement												1						0
Unctable terrain "unstable terrain under the past rock and behind the past cup eroded forming a small												1						1
pit: the 2-day old nestling fell into the pit and could not climb out of it. although both parents continued																		
to make food deliveries for several days"	1																	0
3.2 Health problems																		0
Chick died from renal failure or dehydration; determined with necropsy (it is believed only 1 adult was																		
tending this chick, perhaps resulting in chick not getting enough food)										1								1
Saxitoxin poisoning determined with necropsy		10																0
Nestling died of "heart aneurysm caused by pulmonary edema. The cause of the edema was								1										1
3.3 Human disturbance								1										0
Researcher disturbance - trapped and satellite-tagged adult never returned to nest after trapping;																		
untagged adult incubated sporadically for 13 days; egg hatched and untagged adult made 3 fish																		
deliveries and then chick died		1																0
Chick backed off nest limb and fell to ground when human attempted to pick it up					1													1
3.4 Other																		0
Unick reli from nest platform (includes downy young found on forest floor), and additional details not provided on why chick fell; chick could have been seared from limb by predator, or this could be due to																		
poor nest placement (in one case nestling was collected by humans from the ground and successfully																		
raised in captivity, then chick was released at sea at fledging age; Hamer and Cummins 1991)						1	1		1	1	3			3				10
Nestling dead in nest from unknown cause (saxitoxin was not tested for, was not suspected by																		
researchers, or could not be tested for (e.g., chick had partially decomposed))		11											1					1
Nestling found dead in nest (saxitoxin was positively not to a factor)		2																0
"Exposure to inclement weather and/or starvation" (but details on how this was determined are not			27															0
provincu) Dead nextling was found in next with posigns of trauma or external injury (datarmined from reasonary)			21									2						0
Suspected chick died grounded while fledging (dead chick in invenile plumage was found below cliff												2						2
nest, with no signs of trauma or external injury (determined from necropsy))												1						1
4. Predator-caused failures during nestling phase																		4
Nestling depredated by red fox		13																0
Nesting depredated by Gray Jay (Perisoreus canadensis)					1		1											1
Nestling depredated by Steller's Jay					1													1
Nestling depredated by unknown raptor					1													1
Nestling depredated by unknown predator		6	4															0

\*Only instances in which nest failure is known with certainty or with reasonably descriptive evidence are reported here. We excluded some studies if the methods did not describe that nest failure was determined by cameras, video, necropsy, or direct human observation. Some examples of excluded studies for marbled murrelet: Marks and Naslund (1994) is sometimes cited as an example of nest failure caused by a sharp-shinned hawk (Accipiter striatus), but is not included here because a nest site was not found and thus the depredated adult was not positively nesting (adult could have been a prospecting nonbreeder). Another example: Silvergieter (2009) stated "four nests contained the predated remains of chicks" but it seems possible that chicks died in the nest and later were scavenged, and methods do not provide sufficient details to differentiate between these different outcomes. Not enough information is provided in the text to feel confident in the cause of failure in such causes. Similarly, in Nelson and Hammer (1995), predators with ? symbol are excluded here. Also, successful nests and nests that failed from unknown causes are excluded from this table, as are artificial nest studies. Importantly, there are many potential sources of bias in these studies and it should not be assumed that observations in this table are representative of population-wide causes of nest failure. A few obvious sources of bias in clude: (1) predation is difficult to document without remote cameras, and not all studies used cameras, (2) nest failure due to death of parent is typically only known when adults were radio tagged, and few studies have radio tagged both parents, (3) many nests are inaccessible to humans, biasing observations to human-accessible nests, (4) radio transmitters and cameras may influence parent or predator behavior and thus nest fuel exit or for chicks falling from limbs in forested environments are likely overreported relative to other causes of failure because fallen chicks are easier for humans to find (bein

Sources

<sup>1</sup>Kissling unpublished data, Day et al. (2017), USFWS (2013)

<sup>2</sup>Burkett et al. (2009), Lawonn 2012, Lawonn et al. (2009, 2011, 2012), Corcoran et al. 2014, Knudson et al. (2014, 2015, 2016, 2017), Shearn-Boschsler et al. (2014)
<sup>3</sup>Kaler et al. (2008, 2009, 2010, 2011)
<sup>4</sup>Kissling and Lewis (2016)
<sup>5</sup>Binford et al. (1975), Singer et al. (1991), Peery et al. (2004)
<sup>6</sup>Carter and Sealy (1987)
<sup>7</sup>Golightly and Schneider (2011), Hebert and Golightly (2007)
<sup>8</sup>Kerns and Miller (1995)
<sup>9</sup>Barber (1941)
<sup>10</sup>Nelson and Hamer (1995), Nelson and Peck (1995), Nelson and Wilson (2002)
<sup>11</sup>Hamer and Cummins (1991)
<sup>12</sup>Current study
<sup>13</sup>Silvergieter (2009)
<sup>14</sup>Barbaree et al. (2014)
<sup>15</sup>Naslund et al. (1995)

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