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Population and Mortality Predictions of the Florida Manatee – Ten Year Watercraft Mortality

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Abstract

The West Indian Manatee is currently listed as a threatened species by the U.S Fish and Wildlife service. A threatened designation means population levels still are at risk of becoming endangered again in the foreseeable future. This project seeks to forecast how many manatees would perish from watercraft strikes (the greatest threat to their survival) based upon the most current method utilized for projecting manatee population growth.

The latest version, known as the Core Biological Model (version 6) or CBMv6, was employed along with the most current manatee population data, which was provided by Dr. Jeffrey A. Hostetler. Dr. Hostetler is the predominate research scientist for the Florida Manatee population. The most current Florida Manatee total population stands at: 6,352.

The results sought are the total number of watercraft deaths, expected for the next 10 consecutive years. The calculation will require, from the current population, predicting the population growth factors for each of the four regions (ATL, USJ, NW, and SW), with segregation by sex, age, and reproductive status.

Keywords

Florida manatee population, mortality prediction, watercraft strike, Core Biological Model, modeling matrix, survival rate, reproductive rate

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PROBLEM STATEMENT

The goal of this project is to predict the total amount of West Indian manatees killed by watercraft strikes over the course of the next 10 years.

MOTIVATION

The West Indian Manatee, also known as the Florida Manatee (*Trichechus manatus latirostris*), is found throughout the coastal waters of Florida, and its rivers. On March 30th, 2017 the U.S Fish and Wildlife Service reclassified the once Endangered animal to Threatened (www.fws.gov). Under these terms Threatened means that the population is likely to become Endangered again in the foreseeable future without safeguards. Given their Threatened status the species still has certain protections afforded by the Endangered Species Act (under the Marine Mammal Protection Act). They include Manatee protection areas, and population monitoring.

The four regions are Atlantic, Upper St. John's River, Northwest, and Southwest. Based upon the most current population numbers provided by Dr. Hostetler (2017) the population of manatees consists of:

starting population (survey) ALT:	3221
starting population (survey) USJ:	340
starting population (survey) NW:	610
starting population (survey) SW:	2181
Total population:	6352

That being said, Watercraft strikes are the most prevalent cause of death for manatees. In order to illustrate the future impact of watercraft strikes on the manatee population the most current version of the Common Biological Model (CBMv6) is applied. The purpose of this paper is to calculate the expected total watercraft deaths of Florida manatees for the next 10 years. Due to differing survival rates within the four regions, a separate calculation will be required for each region (ATL, USJ, NW, SW), which will include predicting future population growth.

MATHEMATICAL DESCRIPTION AND SOLUTION APPROACH

The latest Common Biological Model (CBMv6) seeking to forecast the amount of manatees that died per year by watercraft strikes for the next 10 years is applied.

The CBMv6 is a predictive modeling matrix used to calculate the future population by stages. These states are assigned from “Status and Threats Analysis for the Florida Manatee”, 2016 (Runge, Sanders-Reed and Langtimm), below Figure one from Runge.

Figure 1. Life-history stages and transitions for the manatee population model. Sex- and stage-specific survival (s) and reproductive (γ) rates govern the transition between stages. Females (♀) and males (♂) are separately accounted for in the model. Calves enter the population model as separate entities at 1.5 years; until that time, they are counted as part of the female-with-calf pair. (The 0.5-year stage is shown for completeness but is not tracked separately in the model)¹

The matrix applied for predicting population mortality, growth, and reproduction (Figure 2):

Matrix Population Model										
	f2	f3	f4	fP	fC	fB	m2	m3	m4	ma
Starting population vector:	0	0	0	0	0	0	0	0	0	0
					(0.5 * s[1])(fc)					f2
	f2 * s[2]									f3
		f3 * s[3]								f4
			(s[4](1-g[4])) * f4	(s[p] * (1-g[p])) * fp		(s[a] * g[b]) * fb				fP
			(s[4] * g[4]) * f4	(s[p] * g[p]) * fp		(s[a] * (1-g[b])) * fb				fC
					s[a]*fc					fB
					(0.5 * s[1]) * fc					m2
							s[2] * m2			m3
								s[3] * m3		m4
									s[4] * m4	ma
watercraft death	f2 * w[2]	f3 * w[3]	w[4] * f4	w[p] * fp	(w[1]+w[a]) * fc	w[a] * fb	w[2] * m2	w[3] * m3	w[4] * m4	w[a] * ma
cold death	f2 * c[2]	f3 * c[3]	c[4] * f4	c[p] * fp	(c[1]+c[a]) * fc	c[a] * fb	c[2] * m2	c[3] * m3	c[4] * m4	c[a] * ma
other death	f2 * o[2]	f3 * o[3]	o[4] * f4	o[p] * fp	(o[1]+o[a]) * fc	o[a] * fb	o[2] * m2	o[3] * m3	o[4] * m4	o[a] * ma

Figure 2 – CBMv6 (Common Biological Model)

The model utilizes stages assigned (see figure 3¹ below) by sex, age, and reproductive status (i.e. **f1**= female calf 0.5-1.5 years of age, **f2**= female calf 1.5-2.5 years of age, and so on (see figure 3)). Each region must be independently calculated by each stage (f2, f3, fA, excreta) due to differing survival (see figure 3) and reproductive rates within the four regions, which results in the watercraft mortality projection (figure 4).

f2	s[2] female (1.5-2.5 years)
f3	s[3] female (2.5-3.5 years)
f4	s[4] female (3.5-4.5 years)
fP	s[P] Pre-breeder female (+4.5 years)
fC	s[A] female Adult with calf (+4.5 years)
fB	s[A] female Adult (+4.5 years)
m2	s[2] male (1.5-2.5 years)
m3	s[3] male (2.5-3.5 years)
m4	s[4] male (3.5-4.5 years)
ma	s[A] male adult

Figure 3 - Stages

Survival rate	ATL	USJ	NW	SW
S[1]	0.8356	0.8665	0.9261	0.94
S[2]	0.8726	0.8538	0.9428	0.9343
S[3]	0.9729	0.979	0.978	0.9759
S[4]	0.9729	0.979	0.978	0.9759
S[P]	0.9729	0.979	0.978	0.9759
S[A]	0.9729	0.979	0.978	0.9759

Figure 4 Survival rates by region

The model predicts the total population for a region, broken down into ten stages (Figure 3 and Figure 1) of the manatee life cycle based on age, sex, and reproductive status. This is done by multiplying the matrix by a starting population or population vector.

This S[x] represents the Survival rates of the manatees in a specific region, and g[x] represents the reproductive rates. Each row of the matrix calculates the predicted population and mortalities.

	Mortality fraction equations
Watercraft	$w[x] = (1 - s[x]) * \pi [x,w]$
Cold	$c[x] = (1 - s[x]) * \pi [x,c]$
Other	$o[x] = (1 - s[x]) * (\pi [x,w] - \pi [x,c])$

Figure 5 w-Watercraft, c-Cold, o-Other

	$\pi [x,w]$	$\pi [x,c]$
[1]	0.6008	0.1661
[2]	0.6008	0.1661
[3]	0.7927	0.0454
[4]	0.7927	0.0454
[p]	0.7927	0.0454
[a]	0.7927	0.0454

Figure 6 Mortality fractions for watercraft mortalities and cold snap mortalities

Reproductive rates	
g[4]	0
g[B]	0.307
g[P]	0.304

Figure 7 Reproductive rates

¹ Stages are assigned by (Runge, Sanders-Reed and Langtimm)

DISCUSSION

As anticipated, the model predicts a rising population, which naturally increases mortality numbers as the population grows. In ten years' time the total number of manatee mortalities as a result of watercraft is predicted to reach 2,395 in total across the four regions of Florida.

For perspective, 2,395 manatee deaths as a result of watercraft in ten years is more than one-third of the entire present population (6,352 total manatees). However, the model also predicts a manatee population increasing in the next 10 years to 9,529.

By comparison, the model predicts approximately 356 deaths from cold weather conditions and 672 deaths related to other causes in the next 10 years, which combined is less than half than the predicted watercraft deaths. Thus, at present the greatest single mortality risk for manatees are watercraft deaths.

CONCLUSIONS AND RECOMMENDATIONS

By comparison the single greatest threat to the Florida manatee is watercraft, which is more than double all other mortality causes. Thus the majority of deaths are a consequence of human behavior. While most Floridians are aware of the threat to manatees, the magnitude can be put into better perspective when projecting over a ten-year period. Perhaps human behavior would be impacted, to the benefit of manatees, if it were common knowledge that the leading cause of manatee deaths is associated with watercraft.

Based upon the aforementioned calculation results, perhaps greater care and caution would be taken in the manatee habitat if there were awareness that over the next ten years more than one third of the present day population is predicted to die as a result of watercraft. Perhaps a campaign utilizing a ten-year projection would help public perception of these grim realities.

NOMENCLATURE

ATL	-	Atlantic Management Unit
s	-	Survival rate
π	-	[also pi] fraction of mortality
g	-	Reproductive rates
x	-	= stage x (i.e. s[1], s[P], s[A]...)
ESA	-	Endangered Species Act
F2	-	Female Calf Age 1.5-2.5
F3	-	Female sub Adult Age 2.5-3.5
F4	-	Female Sub Adult Age 3.5-4.5
FP	-	Female Prebreeder Age 4.5 – 5.5
FB	-	Female with Calf Age 4.5 – 5.5
M2	-	Male Calf Age 1.5-2.5
M3	-	Male Sub Adult Age 2.5-3.5
M4	-	Male Sub Adult Age 3.5-4.5
MA	-	Male Adult Age 4.5-5.5
Other	-	Death by any other means than water craft and cold snap

BIBLIOGRAPHY

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Appendix

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[USJ](#).....

[NW](#).....

[SW](#).....

In consideration for how small the print would be I have limited the prediction model to one per page for ease of view.

ATL

Starting Total

3221

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	107	90	84	224	266	706	107	90	84	1197	3353
											First year
					111.1348						111
	93.3682										93
		87.561									88
			81.7236	151.679							233
				66.2506		210.8683					277
					258.7914	475.9991					735
					111.1348						111
							93.3682				93
								87.561			88
									81.7236	1164.561	1246
Watercraft	8.189985	1.933395	1.804502	4.812006	31.98748	15.16641	8.189985	1.933395	1.804502	25.71416	102
Cold	2.264242	0.110731	0.103349	0.275596	7.59089	0.86862	2.264242	0.110731	0.103349	1.472717	15
Other	3.177573	0.394874	0.368549	0.982798	11.36063	3.097568	3.177573	0.394874	0.368549	5.251826	29

Appendices 2

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	111	93	88	233	277	735	111	93	88	1246	3490
											second year
					115.7803						116
	96.97623										97
		90.83792									91
			85.1881	158.0459							243
				69.03153		219.4674					288
					269.609	495.4102					765
					115.7803						116
							96.97623				97
								90.83792			91
									85.1881	1212.511	1298
Watercraft	8.506471	2.005752	1.881	5.013994	33.32457	15.78489	8.506471	2.005752	1.881	26.7729	106
Cold	2.351739	0.114875	0.10773	0.287165	7.908192	0.904042	2.351739	0.114875	0.10773	1.533354	16
Other	3.300363	0.409652	0.384173	1.024052	11.83551	3.223886	3.300363	0.409652	0.384173	5.468063	30

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	116	97	91	243	288	765	116	97	91	1298	3633
											Third year
					120.5349						121
	101.0299										101
		94.34817									94
			88.37621	164.7031							253
				71.93927		228.4962					300
					280.6807	515.791					796
					120.5349						121
							101.0299				101
								94.34817			94
									88.37621	1262.531	1351
Watercraft	8.862044	2.08326	1.951396	5.225193	34.69307	16.43427	8.862044	2.08326	1.951396	27.87738	110
Cold	2.450043	0.119314	0.111762	0.29926	8.232947	0.941234	2.450043	0.119314	0.111762	1.596611	16
Other	3.43832	0.425482	0.39855	1.067187	12.32154	3.356514	3.43832	0.425482	0.39855	5.69364	31

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	121	101	94	253	300	796	121	101	94	1351	3782
											Forth year
					125.5219						126
	105.1787										105
		98.29196									98
			91.79134	171.3697							263
				74.85113		237.8904					313
					292.2936	536.9969					829
					125.5219						126
							105.1787				105
								98.29196			98
									91.79134	1314.298	1406
Watercraft	9.225971	2.170341	2.026803	5.436692	36.12847	17.10994	9.225971	2.170341	2.026803	29.02042	115
Cold	2.550655	0.124301	0.11608	0.311374	8.57358	0.979931	2.550655	0.124301	0.11608	1.662075	17
Other	3.579517	0.443268	0.413952	1.110383	12.83134	3.494511	3.579517	0.443268	0.413952	5.927092	32

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	126	105	98	263	313	829	126	105	98	1406	3937
											Fifth Year
					130.6634						131
	109.5304										110
		102.3284									102
			95.62824	178.1964							274
				77.83293		247.6927					326
					304.2662	559.124					863
					130.6634						131
							109.5304				110
								102.3284			102
									95.62824	1367.984	1464
Watercraft	9.607689	2.259467	2.111525	5.65327	37.60832	17.81496	9.607689	2.259467	2.111525	30.20584	119
Cold	2.656187	0.129406	0.120933	0.323778	8.924761	1.020309	2.656187	0.129406	0.120933	1.729968	18
Other	3.727617	0.461471	0.431255	1.154616	13.35692	3.638504	3.727617	0.461471	0.431255	6.169201	34

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	131	110	102	274	326	863	131	110	102	1464	4098
											Sixth Year
					136.0046						136
	114.0169										114
		106.5622									107
			99.55529	185.4172							285
				80.98683		257.8777					339
					316.7039	582.1147					899
					136.0046						136
							114.0169				114
								106.5622			107
									99.55529	1423.948	1524
Watercraft	10.00123	2.352951	2.198236	5.882348	39.14566	18.5475	10.00123	2.352951	2.198236	31.44157	124
Cold	2.764987	0.13476	0.125899	0.336897	9.289585	1.062264	2.764987	0.13476	0.125899	1.800741	19
Other	3.880303	0.480564	0.448965	1.201403	13.90292	3.788116	3.880303	0.480564	0.448965	6.421584	35

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	136	114	107	285	339	899	136	114	107	1524	4266
											Seventh year
					141.5776						142
	118.6776										119
		110.927									111
			103.6743	192.9658							297
				84.28392		268.4594					353
					329.6813	606.0012					936
					141.5776						142
							118.6776				119
								110.927			111
									103.6743	1482.217	1586
Watercraft	10.41006	2.44933	2.289186	6.121828	40.7497	19.30857	10.41006	2.44933	2.289186	32.72816	129
Cold	2.878013	0.14028	0.131108	0.350613	9.670237	1.105853	2.878013	0.14028	0.131108	1.874427	19
Other	4.038921	0.500248	0.46754	1.250314	14.47261	3.943558	4.038921	0.500248	0.46754	6.684357	36

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	142	119	111	297	353	936	142	119	111	1586	4441
											Eight Year
					147.3762						147
	123.5406										124
		115.4615									115
			107.9209	200.8664							309
				87.73476		279.4699					367
					343.184	630.8556					974
					147.3762						147
							123.5406				124
								115.4615			115
									107.9209	1542.913	1651
Watercraft	10.83662	2.549453	2.382953	6.372474	42.41869	20.10049	10.83662	2.549453	2.382953	34.06838	134
Cold	2.995943	0.146014	0.136478	0.364968	10.0663	1.151208	2.995943	0.146014	0.136478	1.951185	20
Other	4.204421	0.520697	0.486691	1.301506	15.06536	4.105298	4.204421	0.520697	0.486691	6.958081	38

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	147	124	115	309	367	974	147	124	115	1651	4623
											Ninth Year
					153.4181						153
	128.6004										129
		120.1926									120
			112.3325	209.0918							321
				91.32744		290.9264					382
					357.2534	656.7167					1014
					153.4181						153
							128.6004				129
								120.1926			120
									112.3325	1606.097	1718
Watercraft	11.28045	2.65392	2.480363	6.633422	44.15772	20.92448	11.28045	2.65392	2.480363	35.4635	140
Cold	3.118648	0.151997	0.142057	0.379913	10.47899	1.1984	3.118648	0.151997	0.142057	2.031087	21
Other	4.376621	0.542033	0.506586	1.354801	15.68299	4.273589	4.376621	0.542033	0.506586	7.243019	39

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	153	129	120	321	382	1014	153	129	120	1718	4812
											Tenth Year
					159.7057						160
	133.8726										134
		125.1154									125
			116.9354	217.6487							335
				95.06494		302.8529					398
					371.8948	683.6386					1056
					159.7057						160
							133.8726				134
								125.1154			125
									116.9354	1671.86	1789
Watercraft	11.74292	2.762617	2.581999	6.90489	45.96744	21.78228	11.74292	2.762617	2.581999	36.91559	146
Cold	3.246502	0.158222	0.147878	0.395461	10.90845	1.247528	3.246502	0.158222	0.147878	2.114252	22
Other	4.556049	0.564233	0.527344	1.410246	16.32573	4.448784	4.556049	0.564233	0.527344	7.539591	41

USJ

Starting Total

340

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	14	11	10	12	34	72	14	11	10	118	351
											second year
					14.7305						15
	12.0932										12
		10.769									11
			9.79	8.176608							18
				3.571392		21.63982					25
					33.286	48.84818					82
					14.7305						15
							12.0932				12
								10.769			11
									9.79	115.522	125
Watercraft	1.145605	0.183114	0.166467	0.19976	3.293019	1.198562	1.145605	0.183114	0.166467	1.964311	10
Cold	0.316719	0.010487	0.009534	0.011441	0.786344	0.068645	0.316719	0.010487	0.009534	0.112501	2
Other	0.444475	0.037399	0.033999	0.040799	1.173638	0.244793	0.444475	0.037399	0.033999	0.401188	3

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	15	12	11	18	25	82	15	12	11	125	365
											second year
					10.53324						11
	12.85383										13
		11.76547									12
			10.47716	12.16588							23
				5.313833		24.53186					30
					24.52798	55.37648					80
					10.53324						11
							12.85383				13
								11.76547			12
									10.47716	121.916	132
Watercraft	1.127501	0.259788	0.231341	0.385962	3.031741	1.764421	1.127501	0.259788	0.231341	2.691974	11
Cold	0.311714	0.014879	0.01325	0.022105	0.719457	0.101053	0.311714	0.014879	0.01325	0.154176	2
Other	0.437451	0.053059	0.047249	0.078828	1.076749	0.360363	0.437451	0.053059	0.047249	0.549805	3

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	11	13	12	23	30	80	11	13	12	132	379
											Third year
					12.46953						12
	9.191308										9
		12.5055									13
			11.44663	15.33247							27
				6.696942		23.86589					31
					29.03688	53.87317					83
					12.46953						12
							9.191308				9
								12.5055			13
									11.44663	128.8053	140
Watercraft	0.806235	0.276128	0.252748	0.486422	3.589055	1.716521	0.806235	0.276128	0.252748	2.844093	11
Cold	0.222895	0.015815	0.014476	0.027859	0.851712	0.09831	0.222895	0.015815	0.014476	0.162889	2
Other	0.312805	0.056396	0.051621	0.099346	1.274684	0.35058	0.312805	0.056396	0.051621	0.580874	3

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	12	9	13	27	31	83	12	9	13	140	395
											Forth year
					12.76915						13
	10.88091										11
		8.942223									9
			12.1666	18.13316							30
				7.92023		24.7636					33
					29.73458	55.89959					86
					12.76915						13
							10.88091				11
								8.942223			9
									12.1666	136.4512	149
Watercraft	0.954442	0.197449	0.268645	0.575273	3.675293	1.781088	0.954442	0.197449	0.268645	3.012917	12
Cold	0.26387	0.011308	0.015386	0.032947	0.872177	0.102008	0.26387	0.011308	0.015386	0.172558	2
Other	0.370307	0.040327	0.054868	0.117493	1.305312	0.363767	0.370307	0.040327	0.054868	0.615354	3

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	13	11	9	30	33	86	13	11	9	149	412
											Fifth Year
					13.6553						14
	11.14236										11
		10.58604									11
			8.699889	20.51713							29
				8.961504		25.57724					35
					31.7981	57.73624					90
					13.6553						14
							11.14236				11
								10.58604			11
									8.699889	144.5902	153
Watercraft	0.977375	0.233746	0.192098	0.650904	3.930351	1.839608	0.977375	0.233746	0.192098	3.192632	12
Cold	0.27021	0.013387	0.011002	0.037279	0.932704	0.105359	0.27021	0.013387	0.011002	0.18285	2
Other	0.379205	0.04774	0.039234	0.13294	1.395898	0.375719	0.379205	0.04774	0.039234	0.652059	3

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	14	11	11	29	35	90	14	11	11	153	429
											Sixth Year
					14.43029						14
	11.91562										12
		10.8404									11
			10.29916	19.78396							30
				8.641272		26.74214					35
					33.60274	60.36581					94
					14.43029						14
							11.91562				12
								10.8404			11
									10.29916	149.1359	159
Watercraft	1.045203	0.239362	0.227411	0.627645	4.153411	1.923392	1.045203	0.239362	0.227411	3.293004	13
Cold	0.288962	0.013709	0.013024	0.035947	0.985638	0.110158	0.288962	0.013709	0.013024	0.188599	2
Other	0.405521	0.048887	0.046446	0.128189	1.47512	0.392831	0.405521	0.048887	0.046446	0.672559	4

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	14	12	11	30	35	94	14	12	11	159	446
											Seventh year
					14.78319						15
	12.59187										13
		11.5927									12
			10.54663	20.37044							31
				8.897432		28.06656					37
					34.42452	63.35545					98
					14.78319						15
							12.59187				13
								11.5927			12
									10.54663	155.1144	166
Watercraft	1.104522	0.255973	0.232875	0.646251	4.254986	2.018648	1.104522	0.255973	0.232875	3.425012	14
Cold	0.305361	0.01466	0.013337	0.037012	1.009743	0.115613	0.305361	0.01466	0.013337	0.196159	2
Other	0.428535	0.05228	0.047562	0.131989	1.511195	0.412286	0.428535	0.05228	0.047562	0.69952	4

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	15	13	12	31	37	98	15	13	12	166	464
											Eight Year
					15.44355						15
	12.89981										13
		12.25063									12
			11.27854	20.93513							32
				9.144081		29.20495					38
					35.96226	65.92519					102
					15.44355						15
							12.89981				13
								12.25063			12
									11.27854	161.1716	172
Watercraft	1.131534	0.270501	0.249036	0.664166	4.445056	2.100526	1.131534	0.270501	0.249036	3.558758	14
Cold	0.312829	0.015492	0.014263	0.038039	1.054848	0.120303	0.312829	0.015492	0.014263	0.203819	2
Other	0.439016	0.055247	0.050863	0.135648	1.5787	0.429009	0.439016	0.055247	0.050863	0.726836	4

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	15	13	12	32	38	102	15	13	12	172	483
											Ninth Year
					16.02223						16
	13.47605										13
		12.55023									13
			11.91864	21.81312							34
				9.527568		30.43177					40
					37.30977	68.69453					106
					16.02223						16
							13.47605				13
								12.55023			13
									11.91864	167.7768	180
Watercraft	1.182079	0.277116	0.26317	0.69202	4.611613	2.188764	1.182079	0.277116	0.26317	3.704604	15
Cold	0.326803	0.015871	0.015072	0.039634	1.094373	0.125356	0.326803	0.015871	0.015072	0.212172	2
Other	0.458626	0.056598	0.05375	0.141337	1.637854	0.44703	0.458626	0.056598	0.05375	0.756623	4

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	16	13	13	34	40	106	16	13	13	180	503
											Tenth Year
					16.69501						17
	13.98099										14
		13.11084									13
			12.21012	22.84106							35
				9.976557		31.6614					42
					38.87644	71.47019					110
					16.69501						17
							13.98099				14
								13.11084			13
									12.21012	174.8256	187
Watercraft	1.226372	0.289495	0.269606	0.724631	4.805258	2.277202	1.226372	0.289495	0.269606	3.860247	15
Cold	0.339049	0.01658	0.015441	0.041502	1.140327	0.130421	0.339049	0.01658	0.015441	0.221086	2
Other	0.475811	0.059126	0.055064	0.147998	1.706629	0.465093	0.475811	0.059126	0.055064	0.788412	4

NW

Starting Total

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	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	24	21	19	41	54	119	24	21	19	214	640
											First year
					25.0047						25
	22.6272										23
		20.538									21
			18.582	27.90821							46
				12.18979		35.72927					48
					52.812	80.65273					133
					25.0047						25
							22.6272				23
								20.538			21
									18.582	209.292	228
Watercraft	0.824778	0.366227	0.331349	0.715015	3.33928	2.075289	0.824778	0.366227	0.331349	3.732032	13
Cold	0.228022	0.020975	0.018977	0.040951	0.716774	0.118857	0.228022	0.020975	0.018977	0.213743	2
Other	0.32	0.074798	0.067674	0.146034	1.122546	0.423854	0.32	0.074798	0.067674	0.762225	3

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	25	23	21	46	48	133	25	23	21	228	665
											second year
					20.02059						20
	21.8191										22
		22.014									22
			19.98142	31.48031							51
				13.75002		39.86328					54
					46.62046	89.98455					137
					20.02059						20
							21.8191				22
								22.014			22
									19.98142	221.6986	242
Watercraft	1.913908	0.486081	0.441201	0.998711	5.762445	2.867112	1.913908	0.486081	0.441201	4.895228	20
Cold	0.529128	0.027839	0.025269	0.057199	1.367475	0.164207	0.529128	0.027839	0.025269	0.280362	3
Other	0.742563	0.099277	0.09011	0.203975	2.046582	0.585575	0.742563	0.099277	0.09011	0.999795	6

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	20	22	22	51	54	137	20	22	22	242	691
											Third year
					22.39964						22
	17.46996										17
		21.2278									21
			21.41742	34.84671							56
				15.2204		40.80122					56
					52.16038	92.10179					144
					22.39964						22
							17.46996				17
								21.2278			21
									21.41742	235.1305	257
Watercraft	1.532414	0.468722	0.472909	1.10551	6.447197	2.934572	1.532414	0.468722	0.472909	5.191812	21
Cold	0.423658	0.026845	0.027085	0.063315	1.529972	0.168071	0.423658	0.026845	0.027085	0.297349	3
Other	0.59455	0.095731	0.096586	0.225788	2.289778	0.599353	0.59455	0.095731	0.096586	1.060369	6

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	22	17	21	56	56	144	22	17	21	257	720
											Forth year
					23.40584						23
	19.54592										20
		16.99653									17
			20.65253	38.09861							59
				16.64077		43.08827					60
					54.50344	97.2644					152
					23.40584						23
							19.54592				20
								16.99653			17
									20.65253	249.5955	270
Watercraft	1.714511	0.375293	0.456019	1.208676	6.736807	3.099064	1.714511	0.375293	0.456019	5.511206	22
Cold	0.474002	0.021494	0.026117	0.069224	1.598699	0.177492	0.474002	0.021494	0.026117	0.315641	3
Other	0.665201	0.076649	0.093137	0.246858	2.392635	0.632949	0.665201	0.076649	0.093137	1.125601	6

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	23	20	17	59	60	152	23	20	17	270	750
											Fifth Year
					24.95479						25
	20.42393										20
		19.01623									19
			16.53592	39.78265							56
				17.37633		45.33006					63
					58.11038	102.3249					160
					24.95479						25
							20.42393				20
								19.01623			19
									16.53592	262.9243	279
Watercraft	1.791528	0.419889	0.365122	1.262102	7.182637	3.260302	1.791528	0.419889	0.365122	5.805514	23
Cold	0.495294	0.024048	0.020912	0.072284	1.704498	0.186726	0.495294	0.024048	0.020912	0.332497	3
Other	0.695082	0.085758	0.074572	0.25777	2.550975	0.66588	0.695082	0.085758	0.074572	1.18571	6

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	25	20	19	56	63	160	25	20	19	279	781
											Sixth Year
					26.19873						26
	21.77555										22
		19.87044									20
			18.50089	38.13547							57
				16.65687		47.91885					65
					61.00705	108.1686					169
					26.19873						26
							21.77555				22
								19.87044			20
									18.50089	271.8868	290
Watercraft	1.910088	0.43875	0.40851	1.209845	7.540675	3.446497	1.910088	0.43875	0.40851	6.003412	24
Cold	0.528072	0.025128	0.023396	0.069291	1.789464	0.19739	0.528072	0.025128	0.023396	0.343831	4
Other	0.741081	0.08961	0.083434	0.247097	2.678135	0.703908	0.741081	0.08961	0.083434	1.226129	7

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	26	22	20	57	65	169	26	22	20	290	813
											Seventh year
					26.97974						27
	22.86101										23
		21.18543									21
			19.33195	38.35065							58
				16.75086		50.52943					67
					62.82572	114.0616					177
					26.97974						27
							22.86101				23
								21.18543			21
									19.33195	282.5182	302
Watercraft	2.005301	0.467786	0.42686	1.216672	7.765468	3.63426	2.005301	0.467786	0.42686	6.238159	25
Cold	0.554395	0.026791	0.024447	0.069682	1.842809	0.208144	0.554395	0.026791	0.024447	0.357276	4
Other	0.778022	0.09554	0.087181	0.248491	2.757973	0.742256	0.778022	0.09554	0.087181	1.274073	7

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	27	23	21	58	67	177	27	23	21	302	846
											Eight Year
					28.10971						28
	23.54252										24
		22.24148									22
			20.61131	39.05911							60
				17.0603		52.83274					70
					65.457	119.2609					185
					28.10971						28
							23.54252				24
								22.24148			22
									20.61131	293.67	314
Watercraft	2.065081	0.491104	0.455109	1.239148	8.090704	3.799923	2.065081	0.491104	0.455109	6.484397	26
Cold	0.570922	0.028127	0.026065	0.070969	1.91999	0.217631	0.570922	0.028127	0.026065	0.371378	4
Other	0.801216	0.100302	0.092951	0.253082	2.873483	0.776091	0.801216	0.100302	0.092951	1.324365	7

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	28	24	22	60	70	185	28	24	22	314	881
											Ninth Year
					29.20131						29
	24.52853										25
		22.90451									23
			21.63874	40.40513							62
				17.64822		55.17159					73
					67.99894	124.5404					193
					29.20131						29
							24.52853				25
								22.90451			23
									21.63874	305.7643	327
Watercraft	2.151571	0.505744	0.477795	1.28185	8.404896	3.968141	2.151571	0.505744	0.477795	6.751445	27
Cold	0.594833	0.028965	0.027365	0.073415	1.99455	0.227266	0.594833	0.028965	0.027365	0.386673	4
Other	0.834772	0.103293	0.097584	0.261803	2.985071	0.810448	0.834772	0.103293	0.097584	1.378906	8

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	29	25	23	62	73	193	29	25	23	327	917
											Tenth Year
					30.42412						30
	25.48107										25
		23.86381									24
			22.2838	42.01228							64
				18.35019		57.50772					76
					70.84639	129.8138					201
					30.42412						30
							25.48107				25
								23.86381			24
									22.2838	318.5304	341
Watercraft	2.235125	0.526926	0.492039	1.332837	8.756851	4.136164	2.235125	0.526926	0.492039	7.033328	28
Cold	0.617933	0.030178	0.02818	0.076335	2.078072	0.236889	0.617933	0.030178	0.02818	0.402817	4
Other	0.86719	0.107619	0.100493	0.272217	3.110071	0.844765	0.86719	0.107619	0.100493	1.436478	8

SW

Starting Total

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	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	78	69	64	166	175	451	78	69	64	792	2300
											First year
					82.25						82
	72.8754										73
		67.3371									67
			62.4576	112.7516							175
				49.24782		135.1202					184
					170.7825	305.0107					476
					82.25						82
							72.8754				73
								67.3371			67
									62.4576	772.9128	835
Watercraft	3.07886	1.318181	1.22266	3.171276	9.651612	8.615936	3.07886	1.318181	1.22266	15.13042	48
Cold	0.851196	0.075496	0.070025	0.181627	1.935525	0.493457	0.851196	0.075496	0.070025	0.866559	5
Other	1.194544	0.269224	0.249715	0.647697	3.130363	1.759707	1.194544	0.269224	0.249715	3.090218	12

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	82	73	67	175	184	476	82	73	67	835	2390
											second year
					77.02895						77
	71.77135										72
		70.90048									71
			65.51226	118.6409							184
				51.82015		142.1101					194
					179.3716	320.7892					500
					77.02895						77
							71.77135				72
								70.90048			71
									65.51226	812.7319	878
Watercraft	6.295573	1.565522	1.446547	3.763873	22.17093	10.22107	6.295573	1.565522	1.446547	17.94557	73
Cold	1.740504	0.089662	0.082848	0.215567	5.261343	0.585387	1.740504	0.089662	0.082848	1.02779	11
Other	2.442573	0.31974	0.295441	0.768729	7.874197	2.087538	2.442573	0.31974	0.295441	3.665179	21

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	77	72	71	184	194	500	77	72	71	878	2487
											Third year
					81.02404						81
	67.21546										67
		69.82635									70
			68.97907	124.6972							194
				54.46542		149.3882					204
					188.6747	337.2183					526
					81.02404						81
							67.21546				67
								69.82635			70
									68.97907	854.4437	923
Watercraft	5.895944	1.541804	1.523096	3.956009	23.32082	10.74454	5.895944	1.541804	1.523096	18.86659	75
Cold	1.63002	0.088303	0.087232	0.226571	5.534221	0.615368	1.63002	0.088303	0.087232	1.080539	11
Other	2.287524	0.314896	0.311075	0.80797	8.28259	2.19445	2.287524	0.314896	0.311075	3.853287	21

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	81	67	70	194	204	526	81	67	70	923	2590
											Forth year
					85.17003						85
	70.70158										71
		65.39392									65
			67.93405	131.1456							199
				57.28199		157.0739					214
					198.3292	354.5674					553
					85.17003						85
							70.70158				71
								65.39392			65
									67.93405	898.398	966
Watercraft	6.201736	1.443934	1.500021	4.160586	24.51415	11.29732	6.201736	1.443934	1.500021	19.83713	78
Cold	1.714561	0.082698	0.08591	0.238288	5.817407	0.647027	1.714561	0.082698	0.08591	1.136124	12
Other	2.406166	0.294907	0.306362	0.849753	8.70641	2.30735	2.406166	0.294907	0.306362	4.051508	22

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	85	71	65	199	214	553	85	71	65	966	2697
											Fifth Year
					89.55788						90
	74.31937										74
		68.78557									69
			63.62175	134.8045							198
				58.88012		165.1393					224
					208.5468	372.7738					581
					89.55788						90
							74.31937				74
								68.78557			69
									63.62175	940.1445	1004
Watercraft	6.519078	1.518823	1.404803	4.276663	25.77708	11.87742	6.519078	1.518823	1.404803	20.75891	82
Cold	1.802295	0.086987	0.080457	0.244936	6.117112	0.680251	1.802295	0.086987	0.080457	1.188917	12
Other	2.529289	0.310202	0.286915	0.87346	9.154952	2.425828	2.529289	0.310202	0.286915	4.239772	23

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	90	74	69	198	224	581	90	74	69	1004	2807
											Sixth Year
					93.59532						94
	78.1482										78
		72.30532									72
			66.92148	134.362							201
				58.68686		173.629					232
					217.9485	391.9378					610
					93.59532						94
							78.1482				78
								72.30532			72
									66.92148	976.5642	1043
Watercraft	6.854932	1.596541	1.477663	4.262626	26.93916	12.48803	6.854932	1.596541	1.477663	21.56308	85
Cold	1.895147	0.091438	0.08463	0.244132	6.392883	0.715222	1.895147	0.091438	0.08463	1.234974	13
Other	2.659595	0.326075	0.301796	0.870593	9.567675	2.550538	2.659595	0.326075	0.301796	4.404014	24

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	94	78	72	201	232	610	94	78	72	1043	2922
											Seventh year
					97.06157						97
	81.67127										82
		76.03039									76
			70.34584	136.2968							207
				59.53193		182.161					242
					226.0201	411.1973					637
					97.06157						97
							81.67127				82
								76.03039			76
									70.34584	1015.207	1086
Watercraft	7.163965	1.678793	1.553275	4.324006	27.93684	13.10168	7.163965	1.678793	1.553275	22.41634	89
Cold	1.980584	0.096149	0.08896	0.247647	6.62964	0.750367	1.980584	0.096149	0.08896	1.283842	13
Other	2.779495	0.342874	0.317239	0.883129	9.922008	2.67587	2.779495	0.342874	0.317239	4.578283	25

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	97	82	76	207	242	637	97	82	76	1086	3042
											Eight Year
					100.9793						101
	84.69592										85
		79.45798									79
			73.96996	139.9257							214
				61.11695		190.3243					251
					235.1431	429.6246					665
					100.9793						101
							84.69592				85
								79.45798			79
									73.96996	1056.135	1130
Watercraft	7.429279	1.754476	1.633298	4.439132	29.06447	13.68881	7.429279	1.754476	1.633298	23.32003	92
Cold	2.053933	0.100483	0.093543	0.254241	6.897235	0.783994	2.053933	0.100483	0.093543	1.335599	14
Other	2.882432	0.358332	0.333583	0.906642	10.3225	2.795785	2.882432	0.358332	0.333583	4.762853	26

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	101	85	79	214	251	665	101	85	79	1130	3167
											Ninth Year
					105.0522						105
	88.11455										88
		82.40066									82
			77.30467	144.8369							222
				63.26211		198.553					262
					244.6272	448.1994					693
					105.0522						105
							88.11455				88
								82.40066			82
									77.30467	1099.479	1177
Watercraft	7.729151	1.819452	1.70693	4.594942	30.23674	14.28065	7.729151	1.819452	1.70693	24.2771	96
Cold	2.136837	0.104205	0.09776	0.263164	7.175424	0.81789	2.136837	0.104205	0.09776	1.390413	14
Other	2.998777	0.371603	0.348621	0.938465	10.73884	2.916661	2.998777	0.371603	0.348621	4.958322	27

	f2	f3	f4	fP	fC (female w/calf)	fB	m2	m3	m4	ma	
Starting population vector:	105	88	82	222	262	693	105	88	82	1177	3296
											Tenth Year
					109.3864						109
	91.66851										92
		85.72664									86
			80.16761	150.4206							231
				65.70096		206.9337					273
					254.7199	467.1174					722
					109.3864						109
							91.66851				92
								85.72664			86
									80.16761	1144.893	1225
Watercraft	8.040894	1.892892	1.770145	4.772084	31.48423	14.88342	8.040894	1.892892	1.770145	25.27986	100
Cold	2.223023	0.108411	0.101381	0.27331	7.471465	0.852412	2.223023	0.108411	0.101381	1.447844	15
Other	3.119728	0.386602	0.361532	0.974644	11.1819	3.03977	3.119728	0.386602	0.361532	5.163125	28