APPENDIX A

TABLE A1

Information About At-Sea Surveys that were Foundational to Predictions Made by the 3D Seabird Collision Vulnerability Framework[a]

Survey Name	Type	Transect Width (meters)	References
[CNCA] Marine Mammal and Seabird Surveys of Central and Northern California Aerial survey, MMS OCSEAP	Aerial	50	Briggs et al., 1987; Ford et al., 2021
[OSPR] Office of Spill Prevention and Response, California Department of Fish and Wildlife	Aerial	50 or 75	Ford et al., 2021
[PSEA] Pacific Continental Shelf Environmental Assessment, U.S. Geological Survey	Aerial	75	Adams et al., 2014, 2016
[DODS] San Francisco Deep Ocean Disposal Site, U.S. Army Corps of Engineers	Vessel	300	Ford et al., 2021
[EPOC] Equatorial Pacific Ocean Climate Studies, NOAA PMEL	Vessel	300	Spear et al., 1995
[GOEO] Global Ocean Ecosystem Dynamics, NSF Ocean Sciences	Vessel	300	Ainley et al., 2005, 2009
[JVRK] Juvenile Rockfish Assessment Cruises, National Marine Fisheries Service	Vessel	300	Sakuma et al., 2006; Santora et al., 2011, 2012; Wells et al., 2017
[OCWA] Oregon, California, Washington Line-Transect Expeditions, NMFS SWFSC	Vessel	300	Philbrick et al., 2003; Appler et al., 2004
[RVWE] *Wecoma* Navy Acoustic Work	Vessel	300	D. Ainley, pers. obs. during cruise, July 2005

[a] Seabird observations derived from nine continuous strip-transect surveys used to derive density estimates. For each survey, 4-letter codes and names have been provided along with an indication of whether seabirds were counted from aircraft (aerial) or ship (vessel) and the width of the transect in which seabirds were counted. The references point to sources with additional information on each survey.

TABLE A2

Detection and Count Details for Each Seabird Included in the Analysis[a]

Flight Group, Common and Latin Name	Species Code	Effort with Presence (km^2)	Total Flux Corrected Counts[b]			
			Annual	Upwelling	Oceanic	Davidson
Small Albatross						
Black-footed Albatross *Phoebastria nigripes*	ALBF	2,489	5,882	4,644 (79.0%)	1,068 (18.2%)	170 (2.9%)
Laysan Albatross *Phoebastria immutabilis*	ALLA	183	276	60 (21.7%)	93 (33.7%)	123 (44.6%)
Fulmars						
Northern Fulmar *Fulmarus glacialis*	FUNO	3,674	11,208	3,183 (28.4%)	4,152 (37.0%)	3,873 (34.6%)
Surface-Feeding Shearwaters						
Buller's Shearwater *Ardenna bulleri*	SHBU	951	4,657	138 (3.0%)	4,495 (96.5%)	24 (0.5%)
Pink-footed Shearwater *Ardenna creatopus*	SHPF	2,074	8,249	4,297 (52.1%)	3,907 (47.4%)	45 (0.6%)
Larger Diving Shearwaters						
Sooty Shearwater *Ardenna grisea*	SHSO	8,001	347,262	220,998 (63.6%)	125,979 (36.3%)	285 (0.1%)
Short-tailed Shearwate *Ardenna tenuirostris*	SHST	108	246	45 (18.3%)	118 (48.0%)	83 (33.7%)
Smaller Diving Shearwaters						
Black-vented Shearwater *Puffinus opisthomelas*	SHBV	199	2,040	11 (0.5%)	693 (34.0%)	1,336 (65.5%)
Storm-Petrels						
Fork-tailed Storm-Petrel** *Hydrobates furcatus*	STFT	789	10,022	8,548 (85.3%)	1,327 (13.2%)	147 (1.5%)
Leach's Storm-Petrel *Hydrobates leucorhous*	STLA	2,289	8,367	4,310 (51.5%)	3,778 (45.2%)	279 (3.3%)
Ashy Storm-Petrel *Hydrobates homochroa*	STAS	695	2,253	678 (30.1%)	1,419 (63.0%)	156 (6.9%)
Pelicans						
Brown Pelican *	PELB	1,580	5,501	1,198	2,808	1,495

Flight Group, Common and Latin Name	Species Code	Effort with Presence (km^2)	Total Flux Corrected Counts[b]			
			Annual	Upwelling	Oceanic	Davidson
Pelecanus occidentalis				(21.8%)	(51.1%)	(27.2%)
Phalaropes						
Phalaropes *Phalaropus* spp.	PHAL	4,185	79,180	30,853 (39.0%)	45,476 (57.4%)	2,851 (3.6%)
Skuas						
Long-tailed Jaeger *Stercorarius longicaudus*	JALT	368	796	155 (19.5%)	638 (80.2%)	3 (0.4%)
Parasitic Jaeger *Stercorarius parasiticus*	JAPA	363	495	124 (25.1%)	360 (72.7%)	11 (2.2%)
Pomarine Jaeger *Stercorarius pomarinus*	JAPO	727	912	175 (19.2%)	600 (65.8%)	137 (15.0%)
South Polar Skua *Stercorarius maccormicki*	SKMA	145	159	35 (22.0%)	123 (77.4%)	1 (0.6%)
Large Gulls						
California Gull *Larus californicus*	GUCA	4,601	56,432	7,899 (14.0%)	26,092 (46.2%)	22,441 (39.8%)
Herring Gull *Larus argentatus*	GUHR	1,789	7,866	1,323 (16.8%)	1,701 (21.6%)	4,842 (61.6%)
Western Gull *Larus occidentalis*	GUWE	8,400	38,189	17,509 (45.9%)	13,346 (35.0%)	7,334 (19.2%)
Glaucous-winged Gull *Larus glaucescens*	GUGW	1,200	2,844	438 (15.4%)	530 (18.6%)	1,867 (66.0%)
Heermann's Gull *Larus heermanni*	GUHE	1,008	3,412	610 (17.9%)	1,928 (56.5%)	874 (25.6%)
Medium Gulls						
Black-legged Kittiwake *Rissa tridactyla*	KWBL	1,508	10,283	6,546 (63.7%)	190 (1.9%)	3,547 (34.5%)
Short-billed Gull *Larus brachyrhynchus*	GUME	111	237	24 (10.1%)	60 (25.3%)	153 (64.6%)
Small Gulls						
Bonaparte's Gull *Chroicocephalus philadelphia*	GUBO	524	5,879	2,599 (44.2%)	2,610 (44.4%)	670 (11.4%)

Flight Group, Common and Latin Name	Species Code	Effort with Presence (km^2)	Total Flux Corrected Counts[b]			
			Annual	Upwelling	Oceanic	Davidson
Sabine's Gull *Xema sabini*	GUSA	645	2,850	1,590 (55.8%)	1,253 (44.0%)	7 (0.3%)
Terns						
Arctic Tern *Sterna paradisaea*	TEAR	520	3,266	323 (9.9%)	2,943 (90.1%)	0 (0.0%)
Caspian Tern *Hydroprogne caspia*	TECA	167	254	209 (82.3%)	41 (16.1%)	4 (1.6%)
Elegant Tern *Thalasseus elegans*	TEEL	307	1,729	349 (20.2%)	1,380 (79.8%)	0 (0.0%)
Cormorants						
Brandt's Cormorant *Urile penicillatus*	COBR	2,399	19,012	9,688 (51.0%)	5,922 (31.2%)	3,402 (17. 9%)
Double-crested Cormorant *Nannopterum auritum*	CODC	150	327	140 (42.8%)	55 (16.8%)	132 (40.4%)
Pelagic Cormorant *Urile pelagicus*	COPE	272	398	247 (62.1%)	54 (13.6%)	97 (24.4%)
Large Alcids						
Common Murre *Uria aalge*	MUCO	8,725	215,044	100,286 (46.6%)	71,068 (33.1%)	43,690 (20.3%)
Tufted Puffin ** *Fratercula cirrhata*	PUTU	110	153	126 (82.4%)	24 (15.7%)	3 (2.0%)
Medium Alcids						
Rhinoceros Auklet *Cerorhinca monocerata*	AKRH	3,833	20,435	7,338 (35.9%)	5,165 (25.3%)	7,932 (38.8%)
Pigeon Guillemot *Cepphus columba*	GUPI	281	730	525 (71.9%)	47 (6.4%)	158 (21.6%)
Small Alcids						
Cassin's Auklet ** *Ptychoramphus aleuticus*	AKCA	4,282	44,631	24,342 (54.5%)	13,734 (30.8%)	6,555 (14.7%)
Marbled Murrelet* *Brachyramphus marmoratus*	MRMA	346	1,333	283 (21.2%)	323 (24.2%)	727 (54.5%)
Scripps's, Guadalupe,	MRXA	108	193	82 (42.5%)	93	18 (9.3%)

Flight Group, Common and Latin Name	Species Code	Effort with Presence (km^2)	Total Flux Corrected Counts[b]			
			Annual	Upwelling	Oceanic	Davidson
Craveri's Murrelet * *Synthliboramphus* spp.					(48.2%)	
Loons, Grebes, Ducks						
Grebes *Aechmophorus* spp.	GREB	2,150	69,665	21,057 (30.2%)	17,013 (24.4%)	31,595 (45.4%)
Surf Scoter *Melanitta perspicillata*	SCSU	904	27,581	3,314 (12.0%)	3,626 (13.2%)	20,641 (74.9%)
Pacific Loon *Gavia pacifica*	LOPA	1,301	6,570	3,741 (56.9%)	1,207 (18.4%)	1,622 (24.7%)
Common Loon ** *Gavia immer*	LOCO	562	1,327	436 (32.9%)	241 (18.2%)	650 (49.0%)
Red-throated Loon *Gavia stellata*	LORT	400	750	209 (27.9%)	82 (10.9%)	459 (61.2%)

[a] For inclusion, at least one individual for each taxa had to be observed in at least 100 km^2 units of effort) across the full 26,319 km^2 of standardized at-sea survey effort. Taxa have been organized by flight-style grouping (indicated in bold) and the January 2024 nomenclature recommended by the American Ornithologists Union. Consistent 4-letter codes assigned to each seabird type as follows: first two letters related to a broader common identity (e.g., all loons were assigned 'LO') and second two related to the specific identity (e.g., the Pacific Loon was assigned 'PA').

[b] The summation of individuals counted, after correcting for flux, for the full extent of at-sea survey effort in total (Annual) and by season (Upwelling, Oceanic and Davidson Current). Percent of counts per season for each taxon provided in parentheses after seasonal flux corrected counts.

* Indicates species that have additional protections and may be of regulatory concern. MRXA are threatened under the CA Endangered Species Act (ESA). MRMA are endangered under CA ESA and threatened under the federal ESA.

** Indicates that species are designated by the CA Department of Fish and Wildlife as State Species of Special Concern. These species have less regulatory constraints compared to species listed under the CA or federal ESA

TABLE A3

Seabird Species Excluded Due to Insufficient Observations (< 100 km² of 26,319 km² survey effort with presence)

Flight-Style Grouping	Name	Effort with Presence (km²)	Total Flux Corrected Count
Large Albatross	Wandering Albatross *Diomedea exulans*	1	1
	Chatham Albatross *Thalassarche eremita*	1	1
	Short-tailed Albatross *Phoebastria albatrus*	1	1
Fulmars	Parkinson's Petrel *Procellaria parkinsoni*	2	2
Large Gadfly Petrels	Murphy's Petrel *Pterodroma ultima*	28	28
	Hawaiian Petrel *Pterodroma sandwichensis*	15	15
	Juan Fernandez Petrel *Pterodroma externa*	10	12
	White-necked Petrel *Pterodroma cervicalis*	4	6
	Tahiti Petrel *Pseudobulweria rostrata*	2	2
	Kermadec Petrel *Pterodroma neglecta*	1	1
	Phoenix Petrel *Pterodroma alba*	1	1
Small Gadfly Petrels	Cook’s Petrel *Pterodroma cooki*	117	193
	Mottled Petrel *Pterodroma inexpectata*	54	61
	Bulwer's Petrel *Bulweria bulwerii*	11	13
	Black-winged Petrel *Pterodroma nigripennis*	11	11
	Collared Petrel *Pterodroma brevipes*	1	1
	Stejneger's Petrel *Pterodroma longirostris*	1	1
Surface-Feeding Shearwater	Wedge-tailed Shearwater *Ardenna pacifica*	79	159
	Flesh-footed Shearwater *Puffinus carneipes*	23	23
	Streaked Shearwater *Calonectris leucomelas*	2	23
Smaller Diving Shearwater	Manx Shearwater *Puffinus puffinus*	20	23
	Christmas Shearwater *Puffinus navitatus*	4	4
	Newell's Shearwater *Puffinus newelli*	1	1
Storm-Petrels	Black Storm-Petrel *Hydrobates melania*	93	155
	Least Storm-Petrel *Hydrobates microsoma*	18	130
	Band-rumped Storm-Petrel *Hydrobates castro*	1	1
Oceanites	Wilson's Storm-Petrel *Oceanites oceanicus*	2	2
Tropicbirds	Tropicbirds *Phaethon* spp.	54	62

Flight-Style Grouping	Name	Effort with Presence (km^2)	Total Flux Corrected Count
Pelicans	American White Pelican *Pelecanus erythrorhynchos*	3	76
Boobies	Brown Booby *Sula leucogaster*	13	30
	Masked Booby *Sula dactylatra*	7	8
	Red-footed Booby *Sula sula*	7	41
Large Larid	Thayer's Gull *Larus glaucoides thayeri*	41	41
	Glaucous Gull *Larus hyperboreus*	10	12
Medium Larid	Ring-billed Gull *Larus delawarensis*	17	19
	Red-legged Kittiwake *Rissa brevirostris*	1	1
Sternid	Forster's Tern *Sterna forsteri*	98	342
	Common Tern *Sterna hirundo*	61	213
	Royal Tern *Thalasseus maximus*	45	65
	Sooty Tern *Onychoprion fuscatus*	27	100
	White Tern *Gygis alba*	7	18
	Brown Noddy *Anous stolidus*	6	25
	Noddy spp. *Anous* spp.	2	7
	Least Tern *Sternula antillarum*	1	1
Large Alcid	Horned Puffin *Fraterula corniculata*	28	40
Medium Alcid	Parakeet Auklet *Aethia psittacula*	26	29
Small Alcid	Ancient Murrelet *Synthliboramphus antiquum*	86	302
	Kittlitz's Murrelet *Brachyramphus brevirostris*	1	2
Loon, Grebe, Duck	Eared Grebe *Podiceps nigricollis*	69	328
	Horned Grebe *Podiceps auritus*	21	33
	Red-necked Grebe *Podiceps grisegena*	3	6
	Yellow-billed Loon *Gavia adamsii*	2	2
	White-winged Scoter *Melanitta deglandi*	67	280
	Black Brandt *Branta bernicla*	53	868
	Red-breasted Merganser *Mergus serrator*	9	9
	Black Scoter *Melanitta americana*	7	48
	Scaup spp. *Aythya* spp.	6	41
	Bufflehead *Bucephala albeola*	3	5

Flight-Style Grouping	Name	Effort with Presence (km^2)	Total Flux Corrected Count
	Long-tailed Duck *Clangula hyemalis*	3	7
	Common Merganser *Mergus merganser*	2	10
	Canada Goose *Branta canadensis*	1	1
	Snow Goose *Anser caerulescens*	1	1
	Northern Pintail *Anas acuta*	1	20
Frigatebird	Magnificent Frigatebird *Fregata magnificens*	1	1

TABLE A4

Logistic Regression Parameters Defining Probability of Flying at Least 10 m as a Function of Wind Speed for Each Seabird Flight-Style Group[a]

Flight-Style Group	Species Included in Logistic Regression	Observations by Flight-Style Grouping (#)	Intercept (Log Odds When Wind Speed is Zero)	Coefficient for Wind Speed Parameter
Small Albatross	Laysan and Black-footed Albatross	2,085	-3.87	0.130
Fulmar	Northern Fulmar	2,757	-5.04	0.091
Surface-feeding Shearwater	Buller's and Pink-footed Shearwater	2,409	-4.23	0.126
Larger Diving Shearwater	Sooty and Short-tailed Shearwater	15,840	-5.16	0.269
Smaller Diving Shearwater	Black-vented Shearwater	156	-6.74	0.093
Storm-Petrel	Ashy, Fork-tailed, Leach's and Black Storm-Petrel	10,586	-8.62	0.066
Pelican	Brown Pelican	490	-1.65	0.079
Phalarope	Unidentified Phalarope	2,596	-4.60	0.025
Skua	South Polar Skua and Unidentified Jaeger	1,054	-1.43	0.018
Large Gull	California, Western, Herring, and Glaucous-winged Gull	10,487	-0.66	0.010
Medium Gull	Black-legged Kittiwakes	1,177	-0.48	-0.005
Small Gull	Bonaparte's and Sabine's Gull	597	-1.02	-0.039
Tern	Arctic Tern	323	-0.05	-0.040
Cormorant	Double-crested, Pelagic, and Brandt's Cormorant	1,527	-3.87	0.023
Large Alcid	Common Murre, Tufted Puffin	5,783	-6.21	0.186
Medium Alcid	Rhinoceros Auklet, Pigeon Guillemot	3,303	-7.61	0.095
Small Alcid	Cassin's Auklet, Unidentified Murrelet	5,783	-7.78	0.087

Flight-Style Group	Species Included in Logistic Regression	Observations by Flight-Style Grouping (#)	Intercept (Log Odds When Wind Speed is Zero)	Coefficient for Wind Speed Parameter
Loon, Grebe, Duck	Common and Red-throated Loon, Western Grebe	465	-3.00	0.084

[a] Detailed information about the species contributing to each Flight-style Group, along with the total number of observations in each group. These observations support a mixed-effects logistic regression aimed at quantifying probability curves that link the windscape to the likelihood of flying above 10 m ASL. The provided intercept corresponds to the predicted probability and log odds of a given flight group exceeding 10 m ASL when wind speeds are 0 m/s. In this model, wind speed serves to indicate the rate of change by which the log odds of a flight group exceeding 10 m varies with wind speed. Positive coefficients for wind speed suggest an increased probability of a flight group exceeding 10 m as wind speeds increase.

Appendix A References

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