Supplemental Materials

Eric Keen et al.

8/15/2022

1. Marine traffic

Table 1: Summary of 2019 marine traffic within the lower Kitimat Fjord System, as reported b

type	vids	fixes	transits	transit_rate	dates_present	present_rate	speed_mn	speed_sd	speed_max	length_mn	length_sd	length_min
Cargo ship	54	6842	157	0.43	128	0.35	12.7	1.7	17.1	159	53	26
Cargo ship:DG,HS,MP(X)	1	113	2	0.01	2	0.01	11.9	0.7	13.7	67	0	67
Diving op.	1	225	4	0.01	4	0.01	7.8	0.7	10.0	10	0	10
Dredging or underwater op.	3	360	36	0.10	7	0.02	9.7	2.4	15.0	63	34	35
Fishing	308	41943	829	2.27	284	0.78	8.4	3.2	32.2	20	9	6
HSC	3	393	8	0.02	9	0.02	13.0	8.1	28.6	25	13	7
Law enforcement	3	151	3	0.01	3	0.01	9.7	1.5	12.6	42	16	26
Local ship	2	350	10	0.03	10	0.03	12.4	6.5	26.5	13	4	10
Military op.	1	261	4	0.01	4	0.01	9.1	2.4	15.0	33	0	33
Other	22	3909	78	0.21	85	0.23	8.6	2.4	24.9	37	22	6
Passenger ship	58	27592	803	2.20	340	0.93	15.1	5.7	35.6	108	75	11
Passenger ship:DG,HS,MP(Y)	1	56	2	0.01	1	0.00	11.1	0.4	11.8	64	0	64
Pilot	2	320	6	0.02	6	0.02	19.9	3.1	25.8	19	1	17
Pleasure Craft	275	47271	1213	3.32	205	0.56	8.2	3.7	37.5	20	16	7
Port tender	1	114	2	0.01	2	0.01	7.4	1.1	8.8	26	0	26
Sailing	117	19520	426	1.17	150	0.41	6.0	1.3	12.6	14	4	8
Search/rescue	14	7719	193	0.53	162	0.44	10.3	4.0	39.2	52	15	7
Tanker	2	249	7	0.02	7	0.02	12.1	0.8	13.9	141	5	134
Towing	36	14508	356	0.98	207	0.57	7.0	1.7	21.7	27	21	6
Towing(200/25)	42	19561	382	1.05	254	0.70	8.8	1.6	13.7	32	6	12
Tug	62	37995	873	2.39	335	0.92	7.4	1.8	13.9	27	28	11

Table 2: AIS traffic within the study area in 2019, grouped into 10 vessel classes.

				Speed (kn)			Length (m)				Beam (m)				Draft (m)		
Vessel type	**IDs**	**Transits**	**Transits/day**	**mean**	**sd**	**max**	**mean**	**sd**	**min**	**max**	**mean**	**sd**	**min**	**max**	**mean**	**sd**	**min**
Cargo > 180m	38	94	0.26	13.1	1.4	17.1	193	7	180	200	31	1	28	33	9.5	1.7	6.0
Fishing < 60m	305	822	2.25	8.4	3.2	32.2	20	7	6	54	6	2	1	15	1.4	1.1	0.4
Other < 40m	70	565	1.55	11.5	7.2	39.2	23	9	6	40	6	2	2	10	1.8	1.4	0.3
Other > 100m	23	378	1.04	16.0	3.4	23.0	142	18	116	179	23	3	4	29	5.3	1.1	3.0
Other > 40m	46	340	0.93	9.5	2.6	16.6	57	14	42	100	13	3	7	22	3.9	1.3	2.0
Passenger > 180m	6	73	0.20	17.4	3.4	23.3	259	39	197	301	32	2	28	36	7.8	0.4	7.0
Pleasurecraft < 40m	263	1123	3.08	8.1	3.8	37.5	16	5	7	37	5	1	1	14	0.9	0.7	0.4
Sailing	117	426	1.17	6.0	1.3	12.6	14	4	8	35	4	1	1	8	0.7	0.3	0.4
Towing < 50m	74	738	2.02	8.0	1.9	21.7	29	9	6	41	9	2	2	12	4.1	1.7	0.3
Tug < 50m	61	835	2.29	7.3	1.8	13.9	22	8	11	41	7	2	4	12	3.0	1.8	0.6

Table 3: AIS traffic in 2019, restricted to prime fin whal
Lewis Passage and north Campania Sound (W 129.4519 -

type	vids	fixes	transits	transit_rate	dates_present	present_rate	speed_mn	speed_sd	speed_max	length_mn	lengt
Cargo > 180m	4	82	4	0.01	4	0.01	12.4	1.6	14.6	187	
Fishing < 60m	30	1889	75	0.21	56	0.15	8.2	4.3	32.2	17	
Other < 40m	6	387	20	0.05	20	0.05	8.8	4.9	31.5	26	
Other > 100m	5	172	9	0.02	9	0.02	10.4	2.0	13.5	157	
Other > 40m	13	1018	59	0.16	57	0.16	9.5	2.4	15.0	55	
Passenger > 180m	5	369	19	0.05	19	0.05	18.1	2.5	22.0	270	
Pleasurecraft < 40m	70	2295	142	0.39	87	0.24	7.4	3.6	34.4	15	
Sailing	17	766	35	0.10	32	0.09	5.6	1.4	9.0	15	
Towing < 50m	14	803	40	0.11	39	0.11	9.2	1.4	11.8	34	
Tug < 50m	17	1594	74	0.20	62	0.17	7.1	1.9	11.2	23	

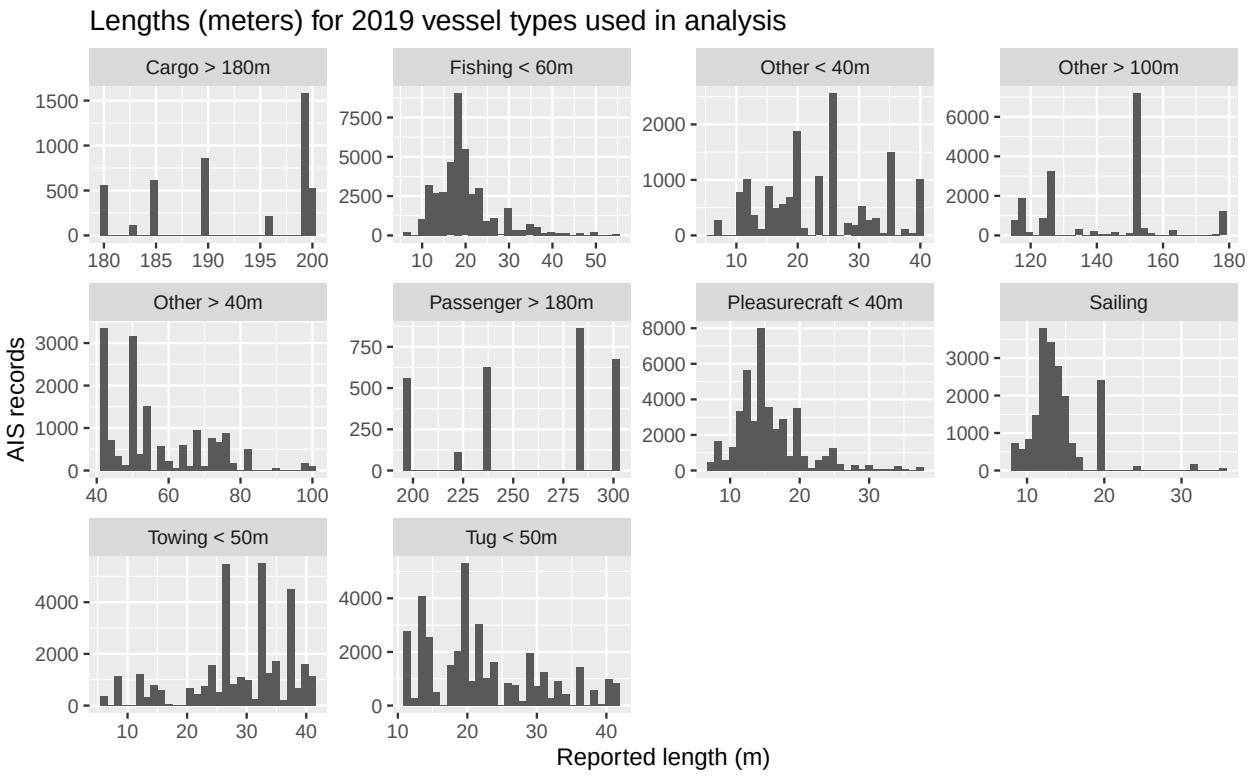

Figure 1: Length distributions of the ten vessel classes used to summarize marine traffic in 2019.

Table 4: Trends (historical and predicted) in AIS traffic, 2014 - 2030.

type	km_2014	km_2015	km_2018	km_2019	km_2030	scale_factor	rate_2019	rate_2030	pvalue
Cargo > 180m	0	0	0	9444	16943	1.79	0.15	0.08	0.30
Fishing < 60m	17165	16377	31949	45784	86437	1.89	0.12	0.06	0.05
Other < 40m	62201	87269	57399	18723	0	0.00	-0.48	-0.24	0.24
Other > 100m	25213	19011	27281	26166	33552	1.28	0.03	0.03	0.44
Other > 40m	27391	9943	23408	29184	37725	1.29	0.05	0.04	0.60
Passenger > 180m	6212	5489	10403	6168	11554	1.87	0.07	0.04	0.55
Pleasurecraft < 40m	0	0	56	51215	91952	1.80	0.15	0.08	0.30
Sailing	357	1553	12538	20934	50795	2.43	0.19	0.08	0.02
Towing < 50m	35311	15299	39409	42838	67175	1.57	0.08	0.05	0.38
Tug < 50m	30971	44685	46344	43301	61901	1.43	0.05	0.03	0.33

Table S1.x. Dimensions of the LNG Canada fleet, adapted from TERMPOL (2015). Note that in our analyses, we reduced the max Shell length to 298m, and the beam was adjusted according to the original length:beam ratio.

Joint Venture Partner	Capacity (m^3)	DWT	Gross Tonnage	Length (m)	Breadth (m)	Draught (m)
SHELL	170,000	86,000	109,000	290	45	12.0m
	215,000	107,000	136,000	315	50	12.0m
KOGAS	165,000	82,000	104,000	286	43	11.9m
MITSUBISHI	150,000	85,000	100,000	288	44	11.5m

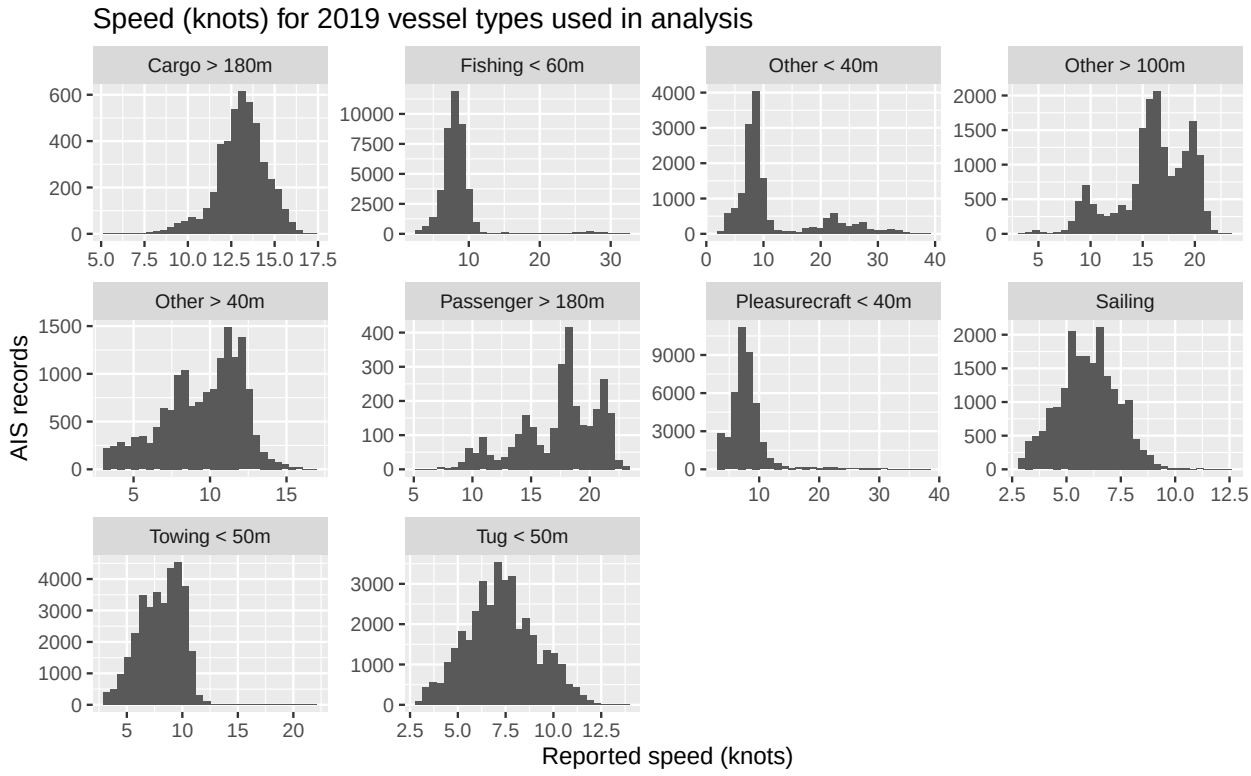

Figure 2: Speed distributions, in knots, of the ten vessel classes used to summarize marine traffic in 2019.

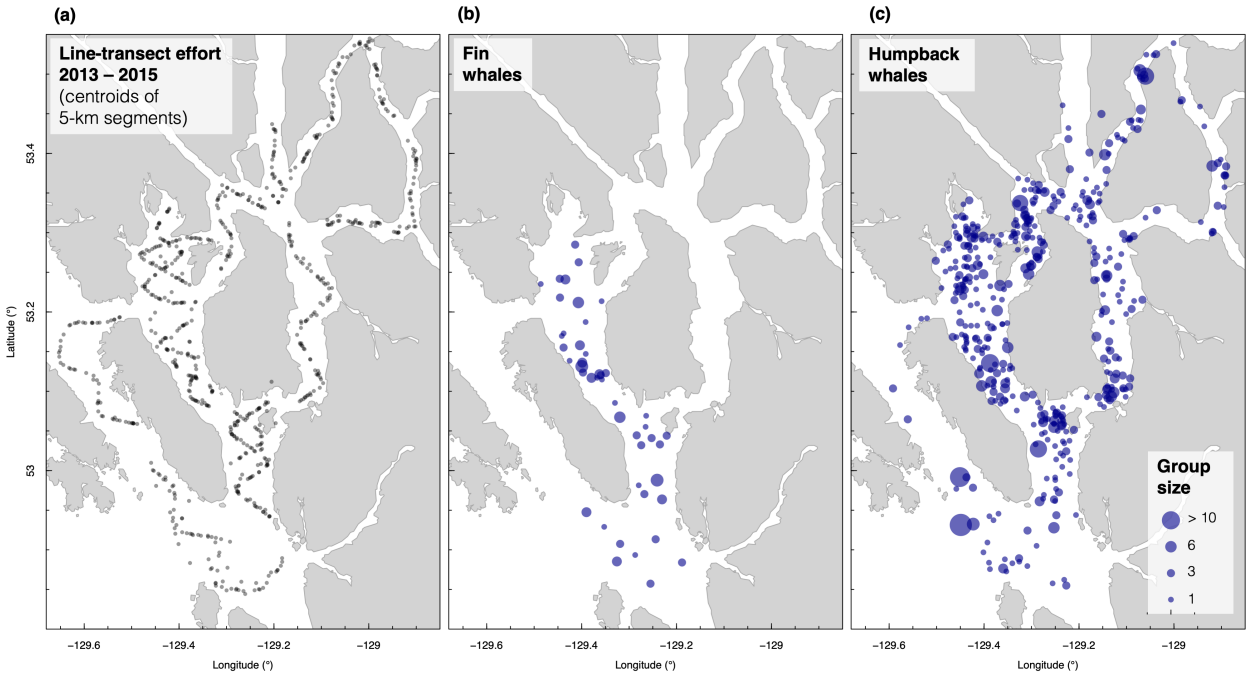

Figure S2.x. (a) Design-based line-transect survey effort throughout the central Gitga'at waters of the Kitimat Fjord System (each dot is the center of a 5-km segment of systematic effort), yielding detections of (b) fin whales and (c) humpback whales. Detection dot size reflects group size

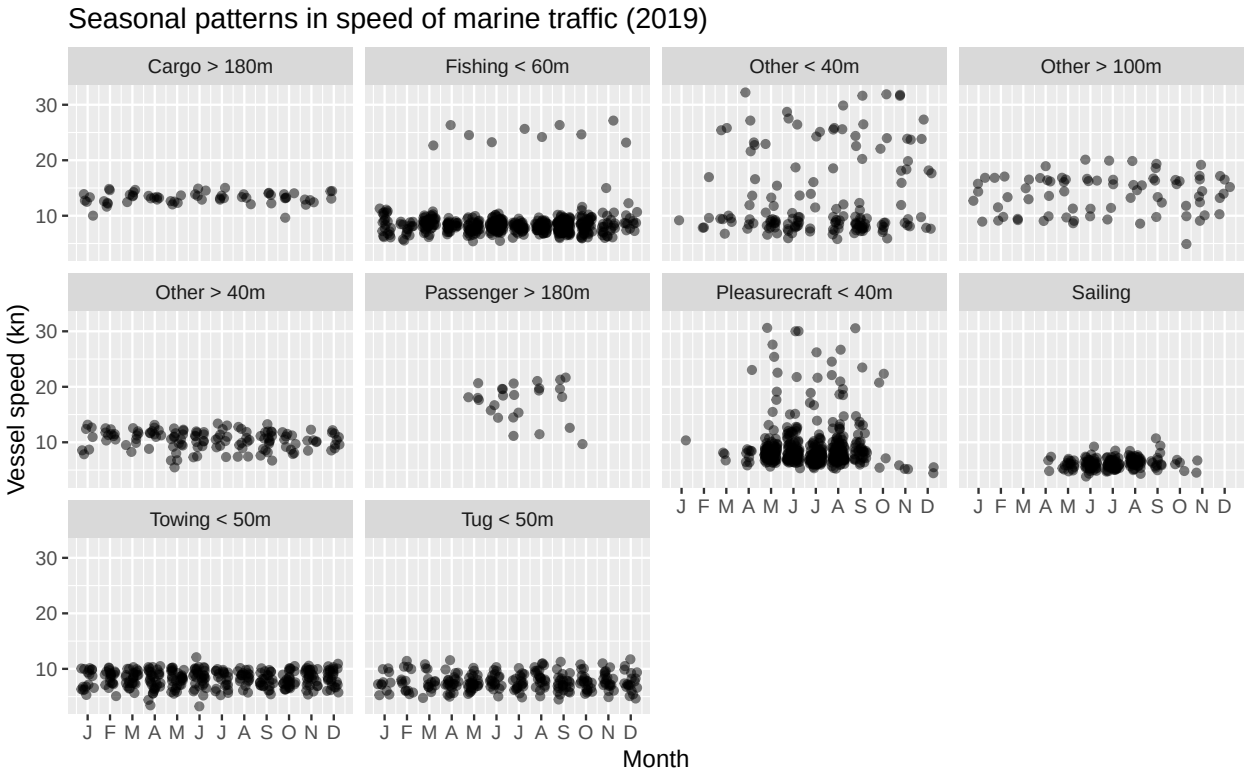

Figure 3: caption

Table 6: Best-fitting models of the detection functions for fin whales and humpback whales, based upon 2013-2015 line-transect surveys.

	Species	Model	Key function	Formula	C-vM p-value	$\hat{P_a}$	se($\hat{P_a}$)	ΔAIC
1	Fin whale	1	Half-normal	~1	0.8405095	0.5500191	0.0742873	0.0000000
3		2	Half-normal	~1 + factor(year)	0.7815848	0.5231299	0.0742940	0.3047398
2		3	Half-normal	~1 + bft	0.8250065	0.5465154	0.0793721	1.5958236
31	Humpback whale	1	Half-normal	~1 + factor(year)	0.9652267	0.5204825	0.0213641	0.0000000
21		2	Half-normal	~1 + bft	0.9637787	0.5296131	0.0215150	9.0061244
11		3	Half-normal	~1	0.9430440	0.5364511	0.0213979	15.9211900

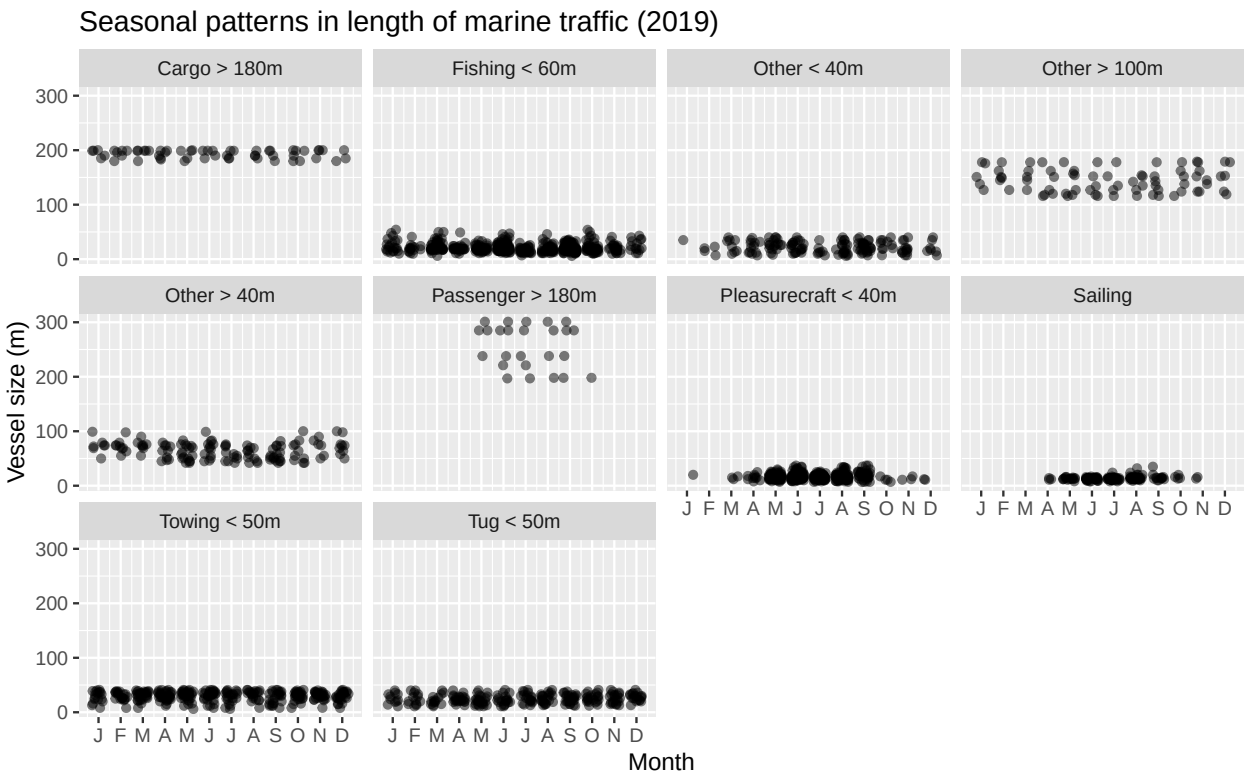

Figure 4: caption

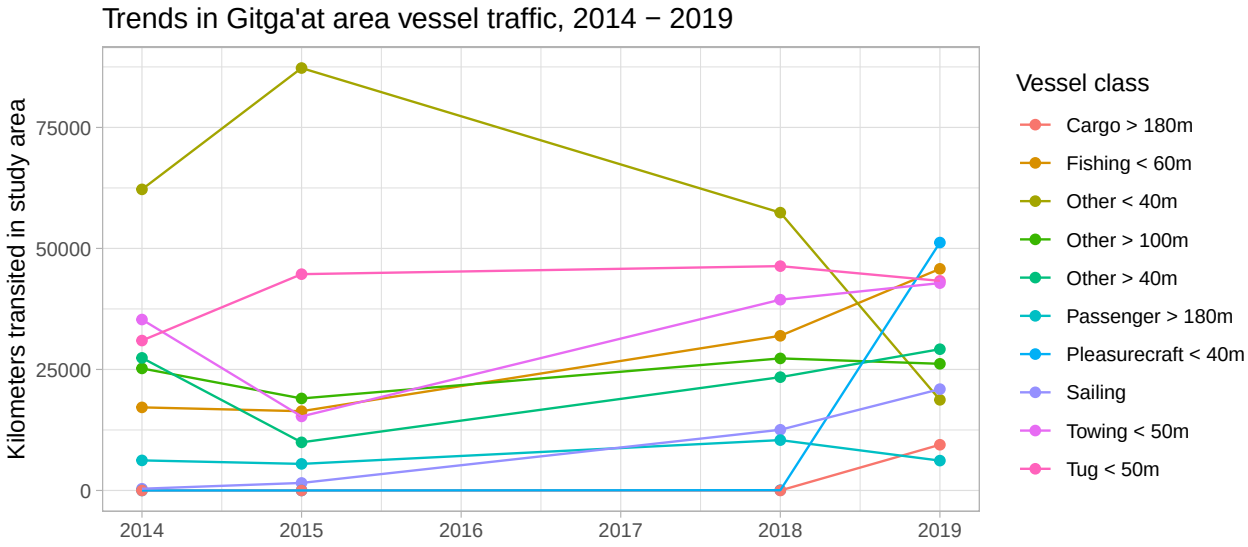

Figure 5: caption

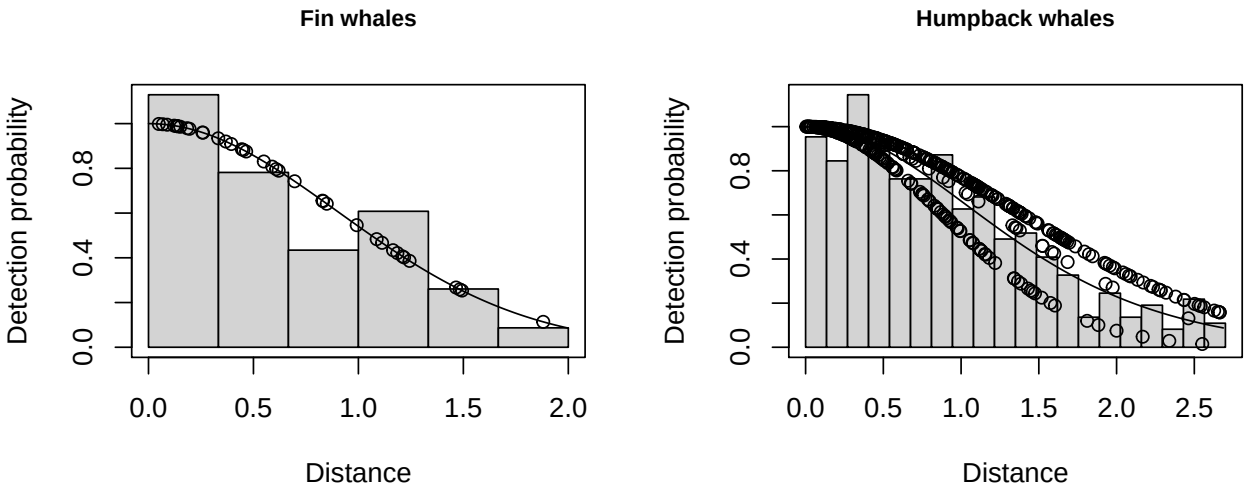

Figure 6: Detection functions.

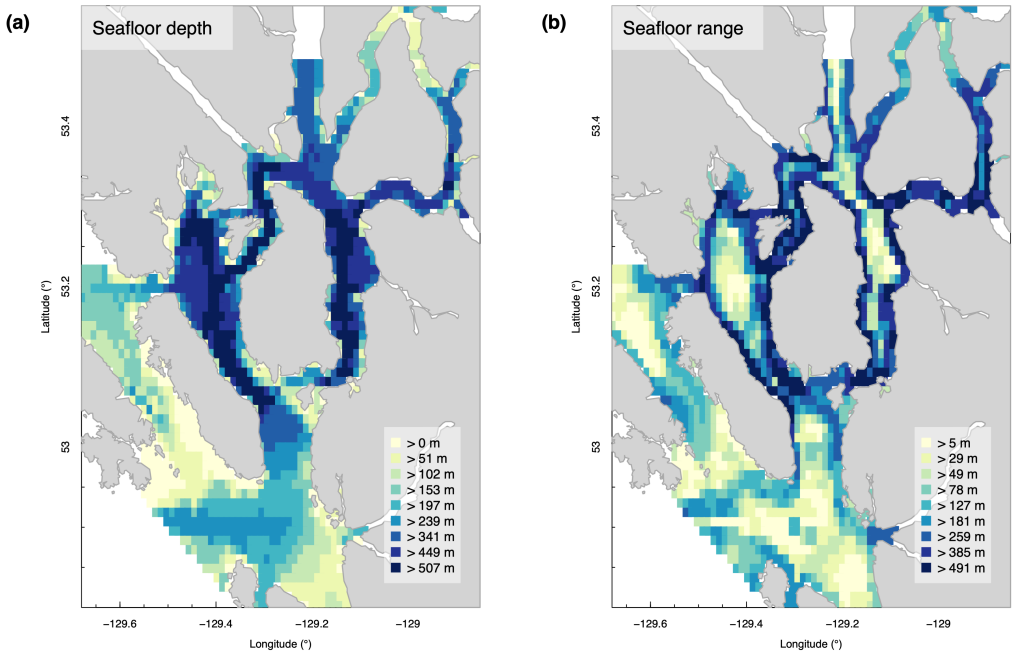

Figure S2.x. Bathymetric characteristics of the study area, as summarized for the square-kilometer grid used in density surface modeling.

Fin whale dive tag analysis

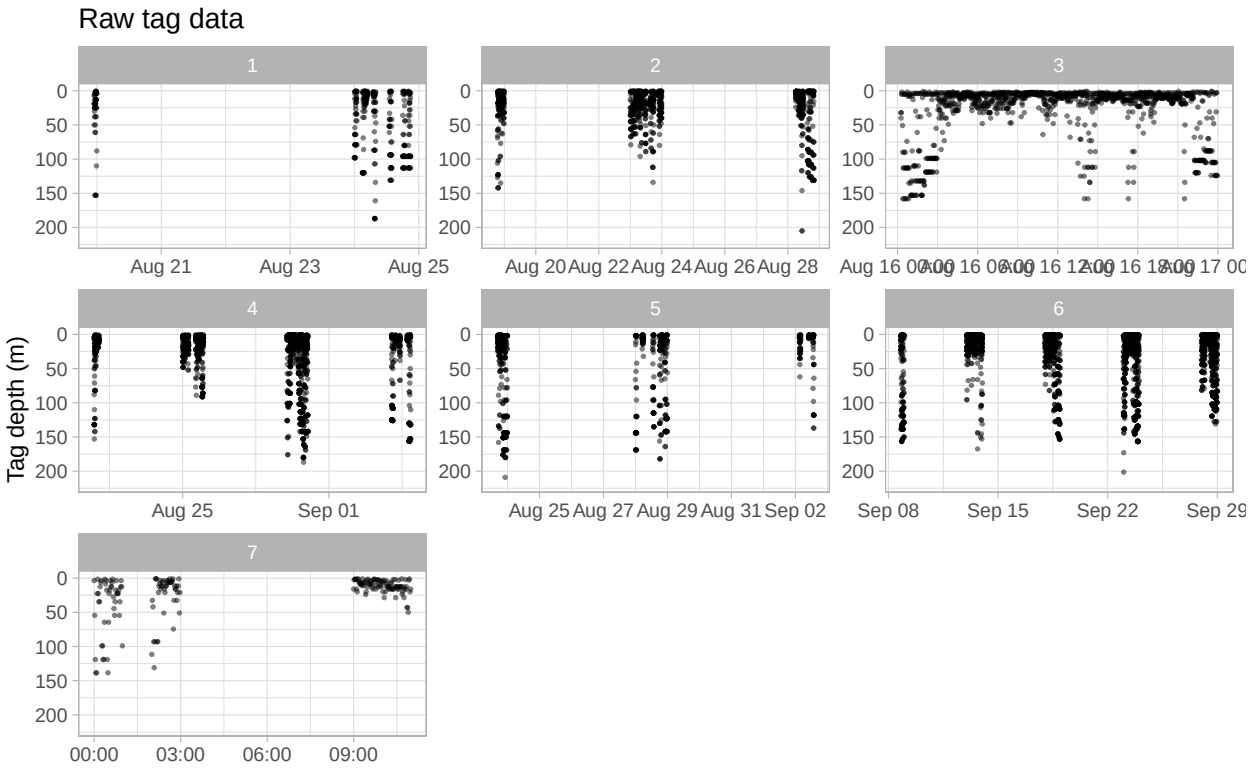

Figure 7: Raw time- and depth-distributions of depth sensor readings for each of the 7 SPLASH-10 tag deployments.

Table 7: Summary of SPLASH10 depth data used in fin whale depth distribution analysis.

id	deploy_ptt	start	stop	span	hours	n	n_day	n_night	frac_valid
1	132219-132219	2013-08-19 23:00:00	2013-08-24 20:58:45	117.97917	8.00000	384	336	48	0.07
2	132220-132220	2013-08-18 18:47:30	2013-08-28 19:57:30	241.16667	26.18750	1257	837	420	0.11
3	137684-137684	2014-08-16 00:15:00	2014-08-16 23:57:30	23.70833	23.72917	1139	835	304	1.00
4	137685-137685	2014-08-20 18:22:30	2014-09-04 21:58:45	363.60417	45.62500	2190	1720	470	0.13
5	137686-137686	2014-08-23 16:30:00	2014-09-02 13:57:30	237.45833	18.47917	887	792	95	0.08
6	142546-142546	2014-09-08 19:00:00	2014-09-28 23:58:45	484.97917	82.00000	3936	2468	1468	0.17
7	142547-142547	2014-09-14 00:00:00	2014-09-14 10:58:45	10.97917	4.00000	192	96	96	0.36

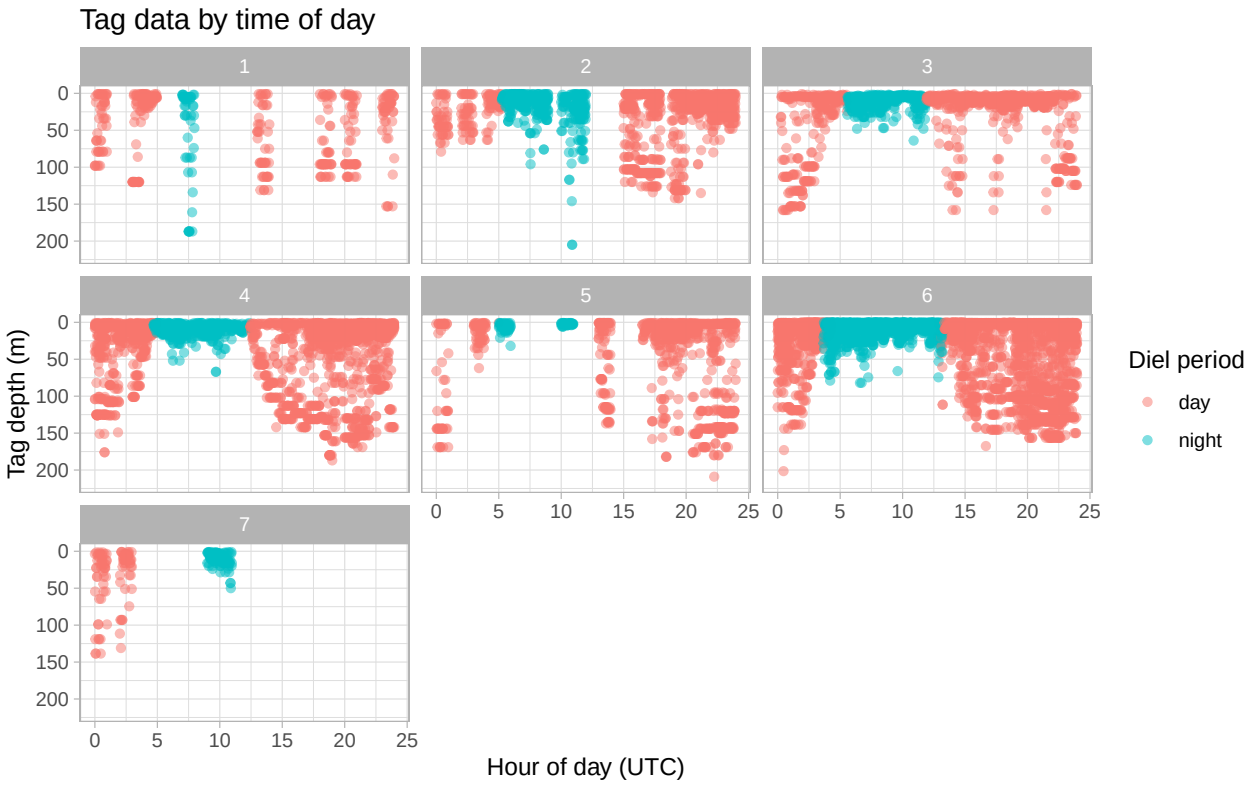

Figure 8: Time distribution (hour of day, color-coded by daytime/nighttime) of depth samples from SPLASH10 tags.

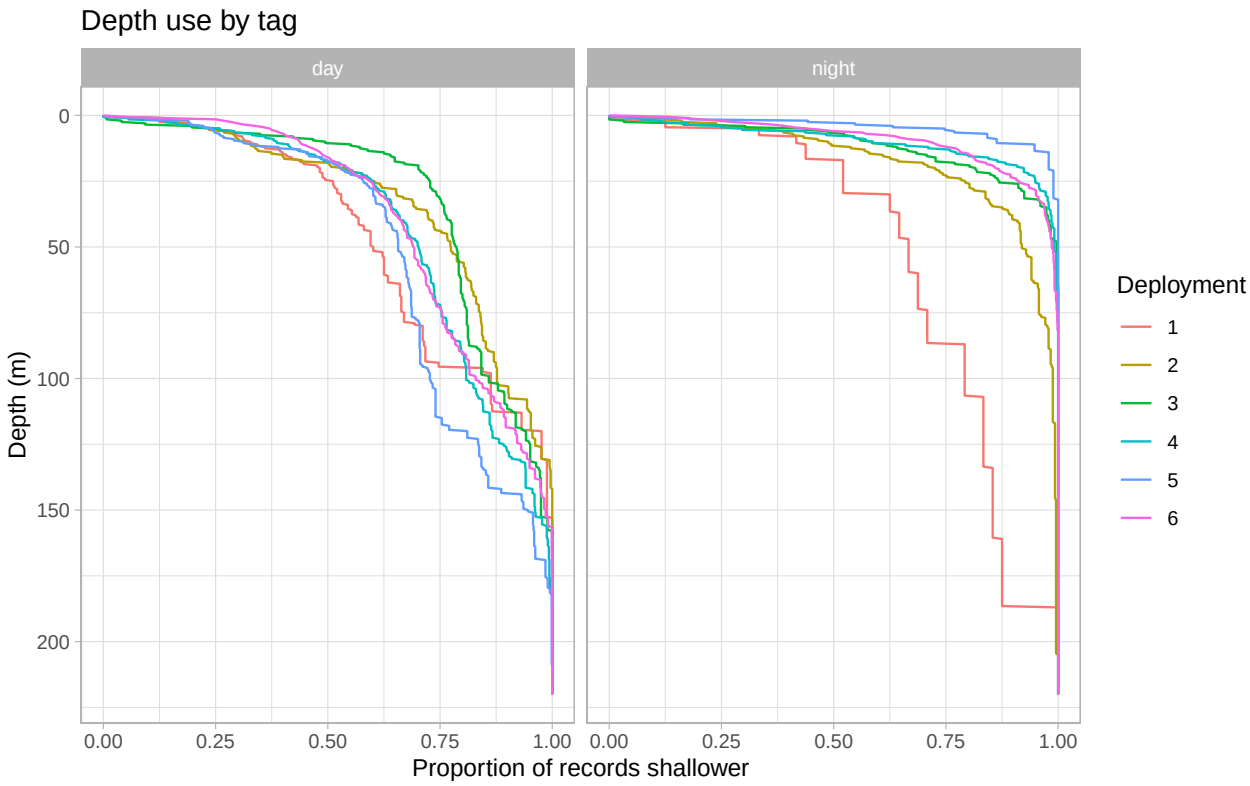

Figure 9: Daytime (left) and nighttime (right) depth distribution curves, representing the proportion of time spent above a given depth, for six SPLASH-10 deployments on fin whales (colored lines).

Collision & mortality analysis

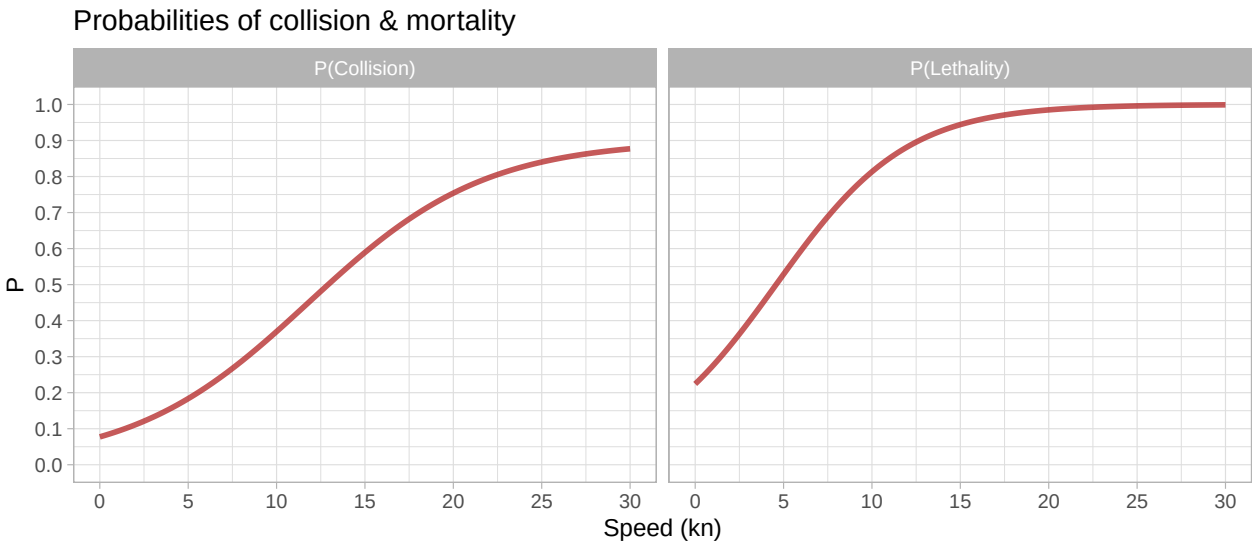

Figure 10: Probabilities of collision (left) and mortality (right) as a function of ship speed (>180m length), adapted from Gende et al. (2011).

Potential Biological Removal

Fin whales – Canadian Pacific stock (Wright et al. 2022):

```
pbr(N = 2893, CV = 0.15) %>% cbind
```

```
##          .
## PBR     15.72217
## Nmin    786.1084
## Rmax    0.08
## Fr      0.5
## Nmedian 2970.848
```

Fin whales – North Coast Sector (Wright et al. 2022):

```
pbr(N = 161, CV = 0.50)  %>% cbind
```

```
##          .
## PBR     1.304809
## Nmin    65.24043
## Rmax    0.08
## Fr      0.5
## Nmedian 162.2889
```

Fin whales – coastal (Queen Charlotte, Hecate Strait) (Nichol et al 2017):

```
pbr(N = 405, CV = 0.6)  %>% cbind
```

```
##          .
## PBR     2.729426
## Nmin    136.4713
## Rmax    0.08
```

```
## Fr      0.5
## Nmedian 412.0479
```

Humpback whales – Canadian Pacific stock (Wright et al. 2022):

```
pbr(N = 7030, CV = 0.1)  %>% cbind
```

```
##         .
## PBR     35.39261
## Nmin    1769.63
## Rmax    0.08
## Fr      0.5
## Nmedian 6903.812
```

Humpback whales – North Coast sector (Wright et al. 2022):

```
pbr(N = 1816, CV = 0.13)  %>% cbind
```

```
##         .
## PBR     10.20563
## Nmin    510.2817
## Rmax    0.08
## Fr      0.5
## Nmedian 1874.479
```

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3. Results details

Vessel traffic

Species distribution models

Table 8: Best-fitting density surface models for fin whales and humpback whales for mid-June – early-September.

Species	Formula	Trunc. dist.	Family	Link function	Delta AIC	Deviance explained
Fin whale	(Lat x Lon) + seafloor depth + seafloor range	2.0 km	Tweedie	log	104	54%
Humpback whale	(Lat x Lon x DOY) + seafloor depth + seafloor range + year	2.7 km	Tweedie	log	14	51%

Table 9: Fin whale density (95% confidence interval) by waterway (whales per square km), , as estimated from the best-fitting density surface model. Confidence intervals are estimated using a bootstrap procedure.

Waterway	Season
Caamano	0.022 (0-0.126)
Campania	0.024 (0-0.148)
Estevan	0 (0-0)

McKay	0 (0-0)
Squally	0.031 (0-0.169)
Verney	0 (0-0)
Whale	0 (0-0)
Wright	0 (0-0)
Study area	0.014 (0-0.118)

Table 10: Humpback whale density (95% confidence interval) by waterway (whales per square km), , as estimated from the best-fitting density surface model. Confidence intervals are estimated using a bootstrap procedure.

Waterway	Season	June	July	August	September
Caamano	0.059 (0.012-0.153)	0.119 (0.006-0.74)	0.057 (0.006-0.113)	0.046 (0.005-0.094)	0.049 (0.013-0.139)
Campania	0.07 (0.012-0.139)	0.056 (0.001-0.131)	0.063 (0.01-0.158)	0.071 (0.007-0.186)	0.097 (0.015-0.249)
Estevan	0.037 (0.004-0.071)	0.119 (0.006-0.153)	0.021 (0.001-0.024)	0.046 (0.006-0.121)	0.047 (0.008-0.107)
McKay	0.049 (0.003-0.112)	0.007 (0.001-0.036)	0.02 (0.001-0.04)	0.068 (0-0.134)	0.102 (0.017-0.313)
Squally	0.11 (0.025-0.251)	0.132 (0.021-0.429)	0.041 (0.002-0.099)	0.161 (0.037-0.448)	0.102 (0.01-0.2)
Verney	0.072 (0.006-0.282)	0.006 (0-0.035)	0.029 (0.001-0.108)	0.085 (0.006-0.231)	0.154 (0.004-0.786)
Whale	0.113 (0.023-0.298)	0.03 (0.003-0.111)	0.015 (0.002-0.048)	0.196 (0.026-0.502)	0.165 (0.034-0.512)
Wright	0.117 (0.007-0.308)	0.033 (0-0.139)	0.081 (0.01-0.204)	0.164 (0.034-0.566)	0.154 (0-0.425)
Study area	0.079 (0.01-0.223)	0.083 (0.001-0.417)	0.046 (0.002-0.125)	0.1 (0.007-0.359)	0.095 (0.01-0.32)

Seasonality

Table 11: Summary of GAM of seasonal fin whale abundance. This model was used to scale the June-September density estimate.

Family	Formula	edf	P-value of coefficient	Deviance explained
Negative binomial	count ~ s(doy, k=5) + offset(log(minutes))	2.803	7e-04	26%

Close-encounter rates

Table 12: Close encounter rate

	Fin whales					Humpback whales					
Vessel type	Median	Mean	SD	LCI	UCI	Median	Mean	SD	LCI	UCI	FW - HW
Cargo > 180m	0.06	0.061	0.024	0.02	0.11	0.05	0.049	0.022	0.01	0.09	0.01
Cedar LNG tanker in-heel	0.08	0.086	0.030	0.04	0.15	0.07	0.070	0.027	0.03	0.12	0.01
Cedar LNG tanker in-product	0.08	0.086	0.031	0.03	0.14	0.07	0.070	0.025	0.02	0.12	0.01
Cedar LNG tug in-heel	0.02	0.024	0.015	0.00	0.06	0.01	0.016	0.012	0.00	0.04	0.01
Cedar LNG tug in-product	0.02	0.023	0.016	0.00	0.06	0.01	0.016	0.012	0.00	0.04	0.01
Fishing < 60m	0.02	0.023	0.015	0.00	0.05	0.01	0.016	0.013	0.00	0.05	0.01
LNG Canada tanker in-heel	0.09	0.087	0.026	0.04	0.14	0.07	0.071	0.025	0.03	0.12	0.02
LNG Canada tanker in-product	0.08	0.085	0.027	0.04	0.14	0.07	0.070	0.027	0.02	0.13	0.01
LNG Canada tug in-heel	0.02	0.024	0.014	0.00	0.06	0.01	0.015	0.012	0.00	0.04	0.01
LNG Canada tug in-product	0.02	0.022	0.015	0.00	0.05	0.01	0.017	0.013	0.00	0.05	0.01
Other < 40m	0.02	0.021	0.014	0.00	0.05	0.01	0.017	0.013	0.00	0.05	0.01
Other > 100m	0.04	0.046	0.021	0.01	0.09	0.04	0.038	0.018	0.01	0.07	0.00
Other > 40m	0.03	0.033	0.017	0.01	0.07	0.02	0.025	0.015	0.00	0.06	0.01
Passenger > 180m	0.06	0.061	0.023	0.02	0.11	0.05	0.052	0.023	0.01	0.10	0.01
Pleasurecraft < 40m	0.02	0.019	0.014	0.00	0.05	0.01	0.013	0.011	0.00	0.04	0.01
Sailing	0.02	0.019	0.013	0.00	0.05	0.01	0.014	0.012	0.00	0.04	0.01
Towing < 50m	0.02	0.024	0.015	0.00	0.05	0.02	0.019	0.013	0.00	0.05	0.00
Tug < 50m	0.02	0.024	0.015	0.00	0.06	0.02	0.019	0.013	0.00	0.05	0.00

Depth distribution

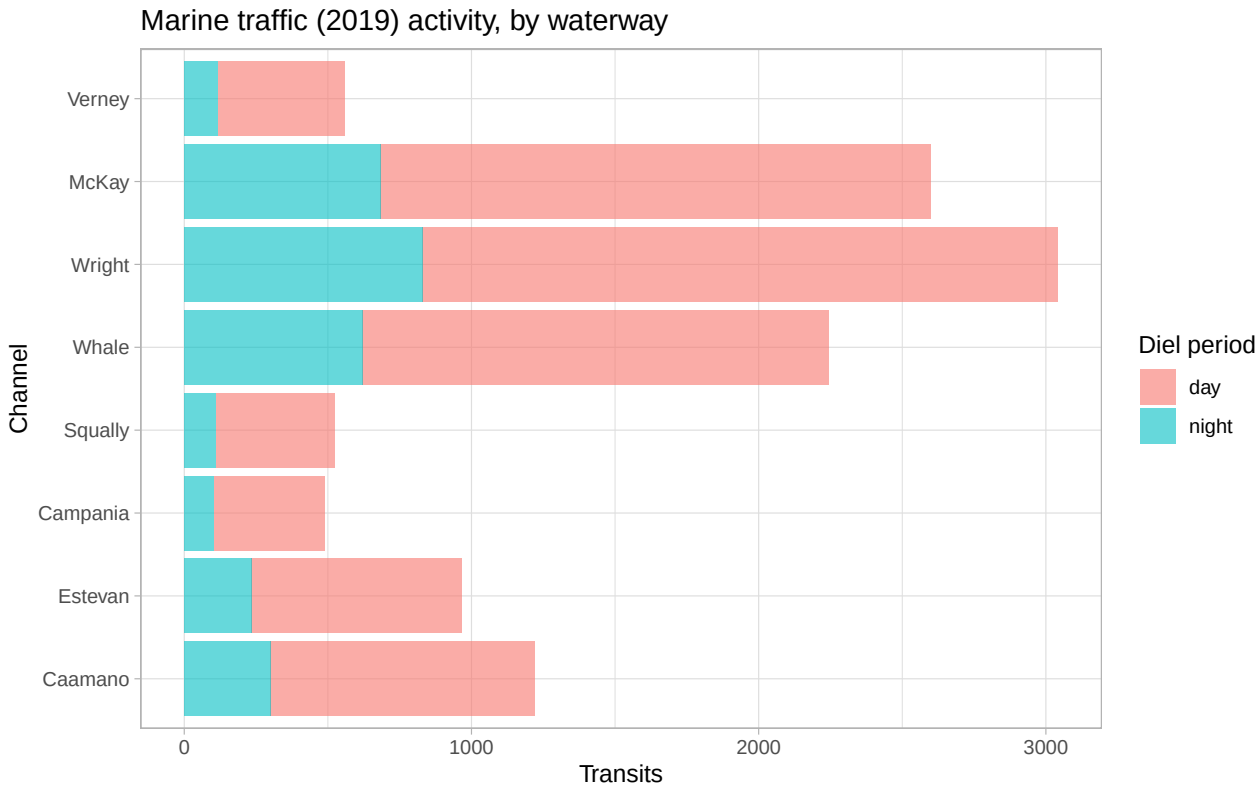


Figure 11: Distribution of 2019 marine traffic parsed by waterway and time of day.

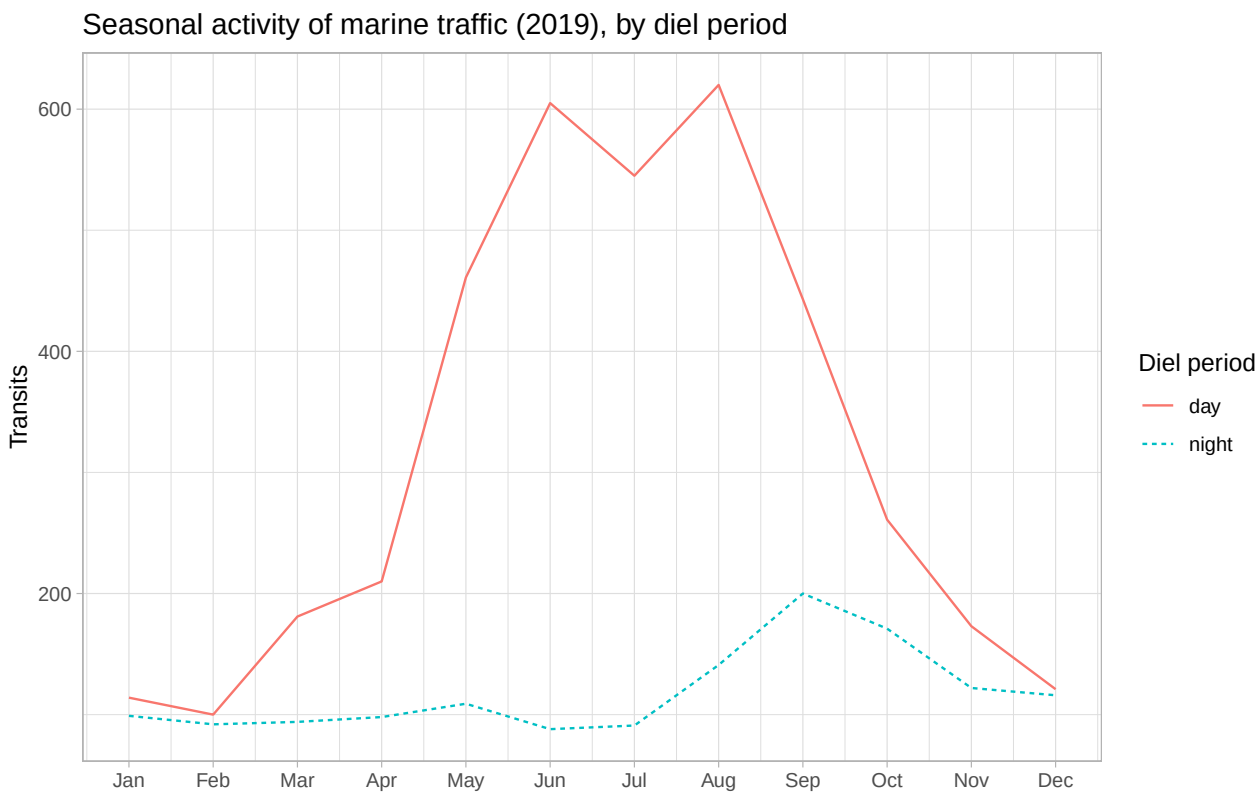


Figure 12: Monthly distribution of 2019 marine traffic, parsed by time of day.

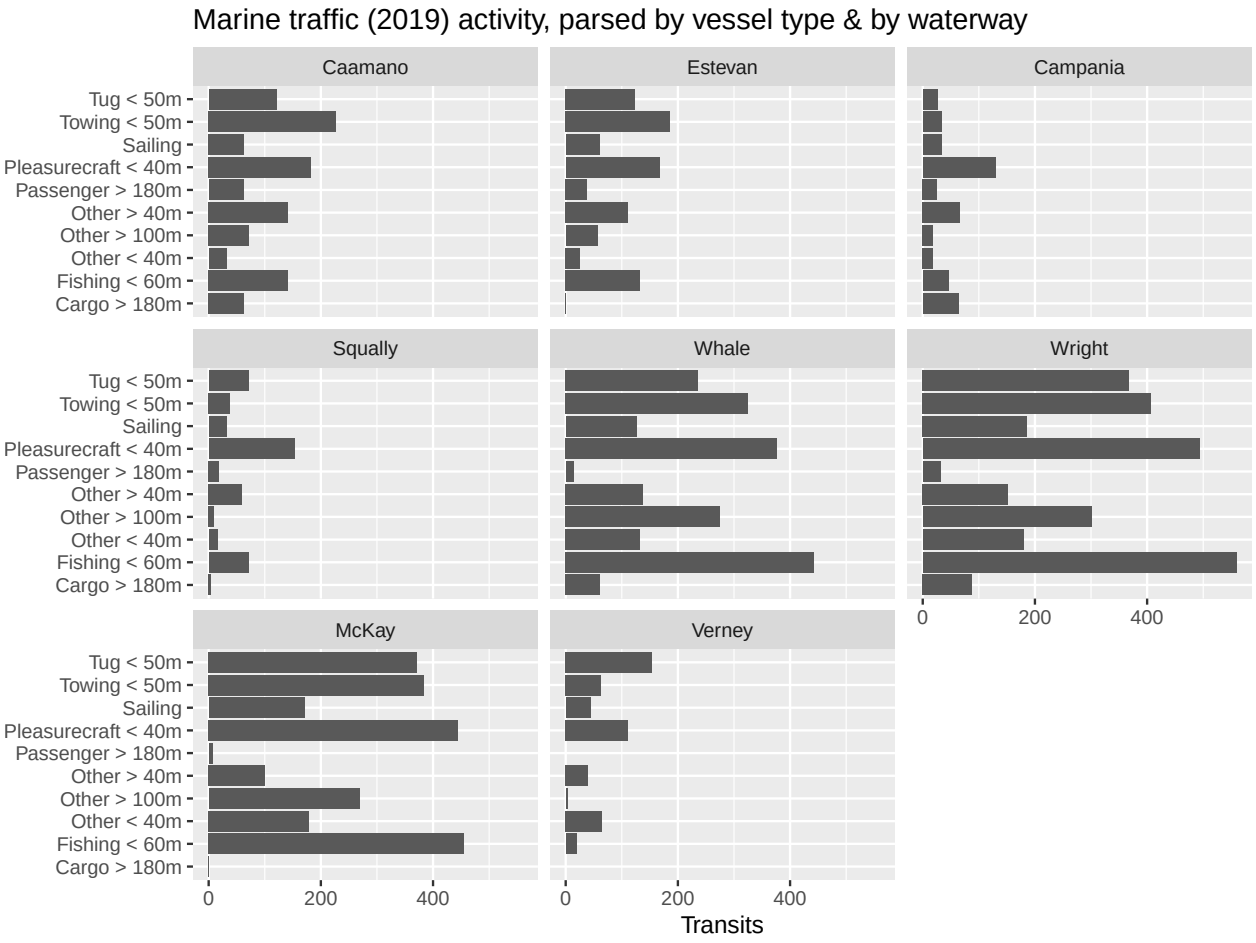


Figure 13: Counts of AIS location fixes for 10 vessel types in 2019, displayed for each waterway in the study area separately.

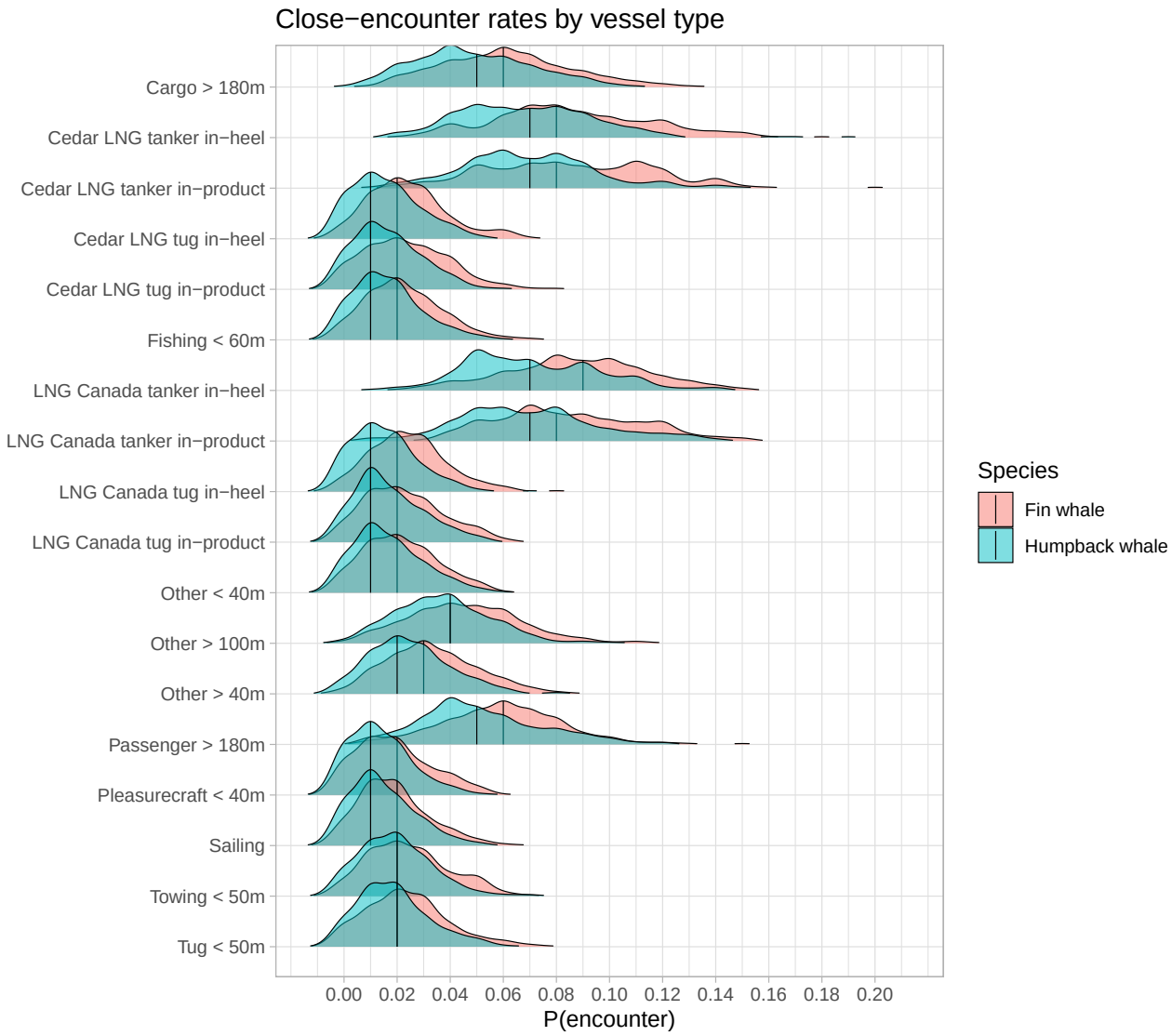


Figure 14: caption

Table 13: Proportion of time fin whale spend above various depth cutoffs (1m, 2m, . . . , 30m), estimated for day and night separately based upon the mean and SD from six SPLASH-10 tag deployments.

	Daytime		Nighttime	
Depth (m)	**Mean**	**SD**	**Mean**	**SD**
1	8.7%	4.8%	8.3%	7.5%
2	14.4%	7.2%	18.1%	13.1%
5	26%	5.2%	41.1%	16.1%
10	37.1%	7.1%	59.2%	15.3%
15	47.5%	8%	72.1%	17%
20	55.4%	6.9%	82%	15.6%
25	60.9%	6.6%	85.3%	16%
30	63.3%	6.4%	89.5%	12.9%

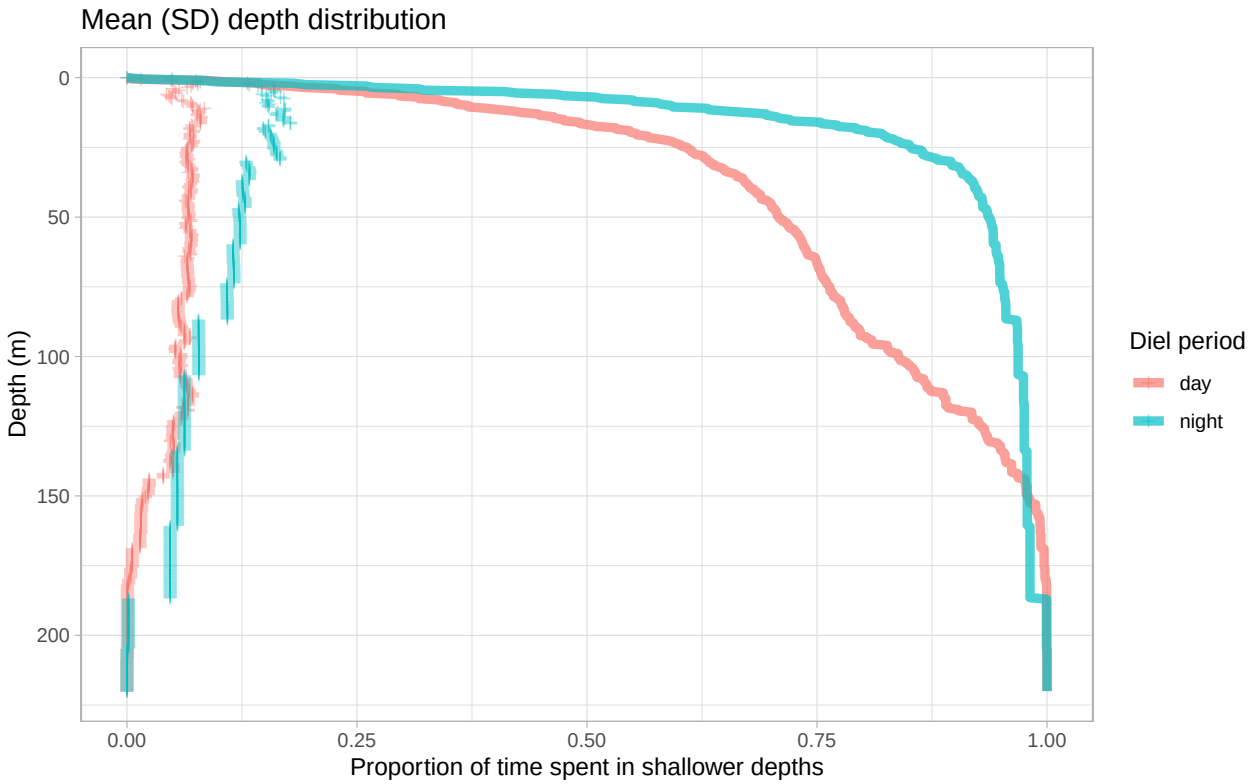


Figure 15: Daytime (pink) and nighttime (teal) depth distribution curves for fin whale in and near the Kitimat Fjord System, representing the average proportion of time spent above a given depth across all tag deployments (n=6 in 2013 and 2014). Points on the left side of the plot represent the SD at each depth.

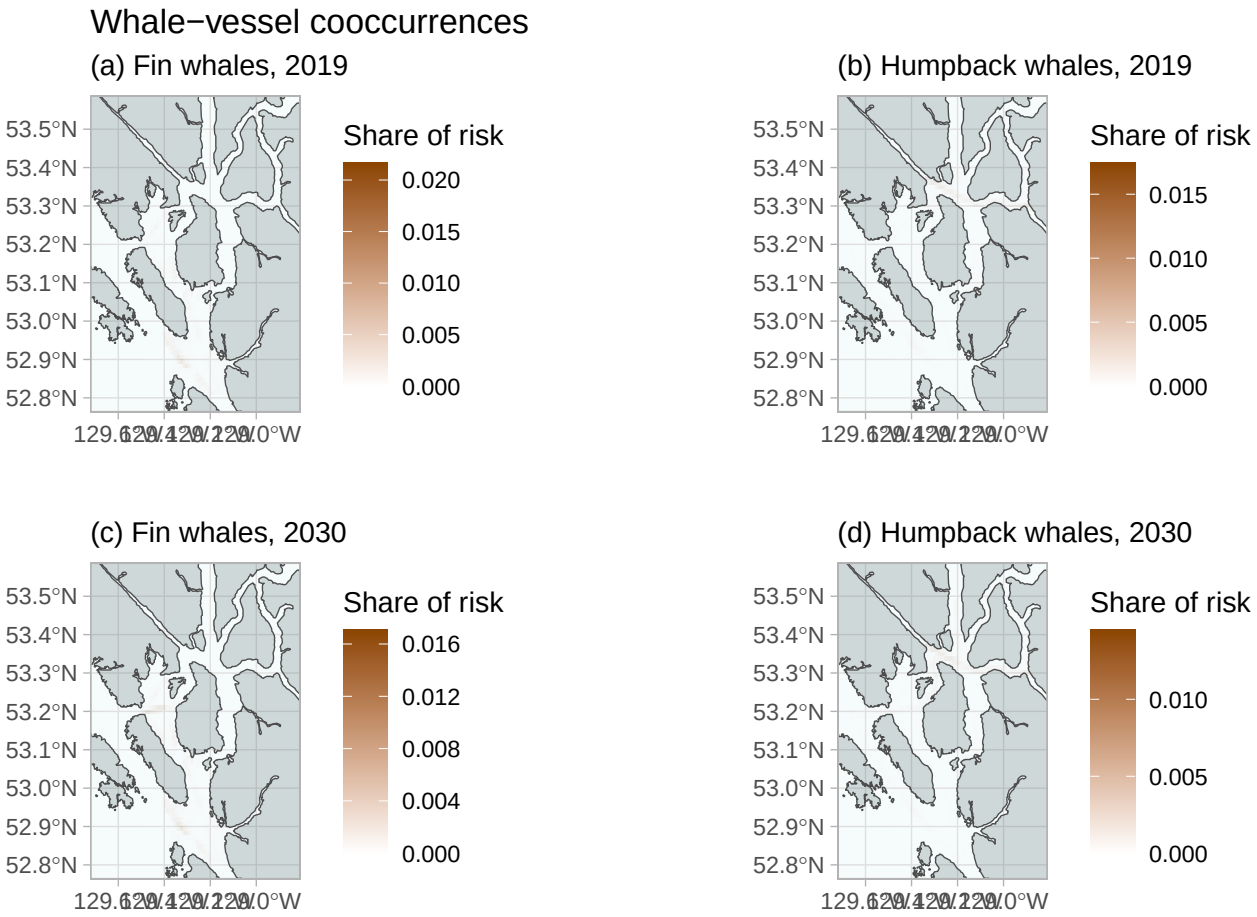
Outcome forecasts

Interaction rates

Table 14: Interaction rates.

	Fin whales	Humpback whales

Traffic scheme	Event	Mean	Median	95% CI	80% Conf.	Mean	Median	95% CI	80% Conf.
AIS 2019	Cooccurrence	509.21	509.0	471 - 549	488	5961.53	5962	5805 - 6113	5884.0
	Close encounter	13.59	13.5	8 - 19	10	117.35	117	100 - 137	108.0
	Strike-zone event	3.06	3.0	1 - 6	2	25.50	25	18 - 34	21.0
	(1.5x draft)	3.00	3.0	0 - 6	2	25.50	26	17 - 34	21.0
AIS 2030	Cooccurrence	855.99	856.0	802 - 912	827	9419.83	9413	9220 - 9646	9312.8
	Close encounter	22.79	22.5	16 - 31	19	183.13	183	161 - 205	171.0
	Strike-zone event	4.89	5.0	2 - 9	3	39.23	39	30 - 49	34.0
	(1.5x draft)	5.03	5.0	2 - 9	3	38.81	39	29 - 49	34.0
LNG Canada	Cooccurrence	137.66	137.0	116 - 161	127	1711.94	1711	1636 - 1786	1673.0
	Close encounter	7.20	7.0	3 - 12	5	73.08	73	59 - 88	66.0
	Strike-zone event	3.01	3.0	0 - 6	1	30.75	30	22 - 40	26.0
	(1.5x draft)	3.01	3.0	0 - 6	1	30.66	31	22 - 40	25.0
Cedar LNG	Cooccurrence	19.40	19.0	13 - 27	16	236.24	237	211 - 260	223.0
	Close encounter	1.06	1.0	0 - 3	0	10.02	10	5 - 15	7.0
	Strike-zone event	0.44	0.0	0 - 2	0	4.48	4	1 - 8	3.0
	(1.5x draft)	0.45	0.0	0 - 2	0	4.42	4	1 - 8	3.0
Total 2030	Cooccurrence	1013.05	1013.5	954 - 1074	981	11368.01	11360	11153 - 11599	11260.0
	Close encounter	31.05	31.0	23 - 40	26	266.24	266	239 - 294	252.0
	Strike-zone event	8.34	8.0	4 - 13	6	74.46	74	61 - 89	67.0
	(1.5x draft)	8.50	8.0	4 - 14	6	73.90	74	60 - 89	66.0



Shares of interaction risk by vessel

Table 15: Share of interactions risk attributable to each vessel type, in 2019 and in 2030.

		Fin whales			Humpback whales		
Year	Vessel	Cooccurrence	Close encounter	Strike-zone event	Cooccurrence	Close encounter	Strike-zone event
2019	Cargo > 180m	2	5	11	2	5	11
	Fishing < 60m	13	11	6	16	12	7
	Other < 40m	3	3	1	8	6	3
	Other > 100m	3	5	7	7	14	21
	Other > 40m	11	12	11	10	12	13

	Passenger > 180m	7	17	27	3	8	13
	Pleasurecraft < 40m	27	18	7	23	15	6
	Sailing	11	8	3	10	8	3
	Towing < 50m	14	12	16	9	9	12
	Tug < 50m	10	8	11	11	10	12
2030	Cargo > 180m	2	4	6	2	4	7
	Cedar LNG tanker in-heel	0	1	2	1	1	3
	Cedar LNG tanker in-product	0	1	2	1	2	3
	Cedar LNG tug in-heel	0	0	0	1	0	0
	Cedar LNG tug in-product	0	0	0	1	0	0
	Fishing < 60m	12	9	4	16	10	5
	LNG Canada tanker in-heel	3	9	17	4	11	19
	LNG Canada tanker in-product	3	9	15	4	11	19
	LNG Canada tug in-heel	3	3	2	4	2	2
	LNG Canada tug in-product	3	2	2	4	3	2
	Other < 40m	0	0	0	0	0	0
	Other > 100m	2	3	3	5	8	9
	Other > 40m	7	7	6	7	7	6
	Passenger > 180m	7	13	18	3	6	8
	Pleasurecraft < 40m	24	15	4	22	12	4
	Sailing	13	9	3	13	8	2
	Towing < 50m	11	9	9	8	6	6
	Tug < 50m	7	5	6	8	7	5

Shares of interaction risk by waterway

Table 16: Share of interactions risk attributable to each waterway, in 2019 and in 2030.

		Fin whales			Humpback whales		
Year	**Channel**	**Cooccurrence**	**Close encounter**	**Strike-zone event**	**Cooccurrence**	**Close encounter**	**Strike-zone event**
2019	Caamano	61	60	63	14	15	17
	Estevan	0	0	0	4	5	5
	Campania	15	16	17	4	5	6
	Squally	24	23	20	8	7	6
	Whale	0	0	0	39	38	37
	Wright	0	0	0	12	12	13
	McKay	0	0	0	16	15	14
	Verney	0	0	0	4	3	2
2030	Caamano	51	44	37	12	11	9
	Estevan	0	0	0	6	7	8
	Campania	13	12	10	4	4	3
	Squally	35	43	52	11	13	16
	Whale	1	1	1	43	46	49
	Wright	0	0	0	9	8	7
	McKay	0	0	0	12	10	7
	Verney	0	0	0	3	2	1

Shares of interaction risk by month

Table 17: Share of interactions risk attributable to each month, in 2019 and in 2030.

		Fin whales			Humpback whales		
Year	**Month**	**Cooccurrence**	**Close encounter**	**Strike-zone event**	**Cooccurrence**	**Close encounter**	**Strike-zone event**
2019	Jan	0	0	0	0	0	0
	Feb	0	0	0	0	0	0
	Mar	0	0	0	0	0	0
	Apr	0	0	0	0	0	0
	May	5	6	7	3	3	4
	Jun	14	15	15	16	16	17
	Jul	21	21	19	10	10	9
	Aug	37	34	31	34	32	30
	Sep	16	17	19	32	33	33
	Oct	5	6	6	4	5	6
	Nov	1	1	1	1	1	1
	Dec	0	0	0	0	0	0
2030	Jan	0	0	0	0	0	0
	Feb	0	0	0	0	0	0
	Mar	0	0	0	0	0	0
	Apr	0	1	1	0	0	0
	May	5	5	7	3	3	3
	Jun	14	15	15	16	16	16
	Jul	21	21	22	11	11	11
	Aug	37	33	27	37	35	35
	Sep	16	17	20	28	28	28
	Oct	6	6	7	4	5	6
	Nov	1	1	1	1	1	1
	Dec	0	0	0	0	0	0

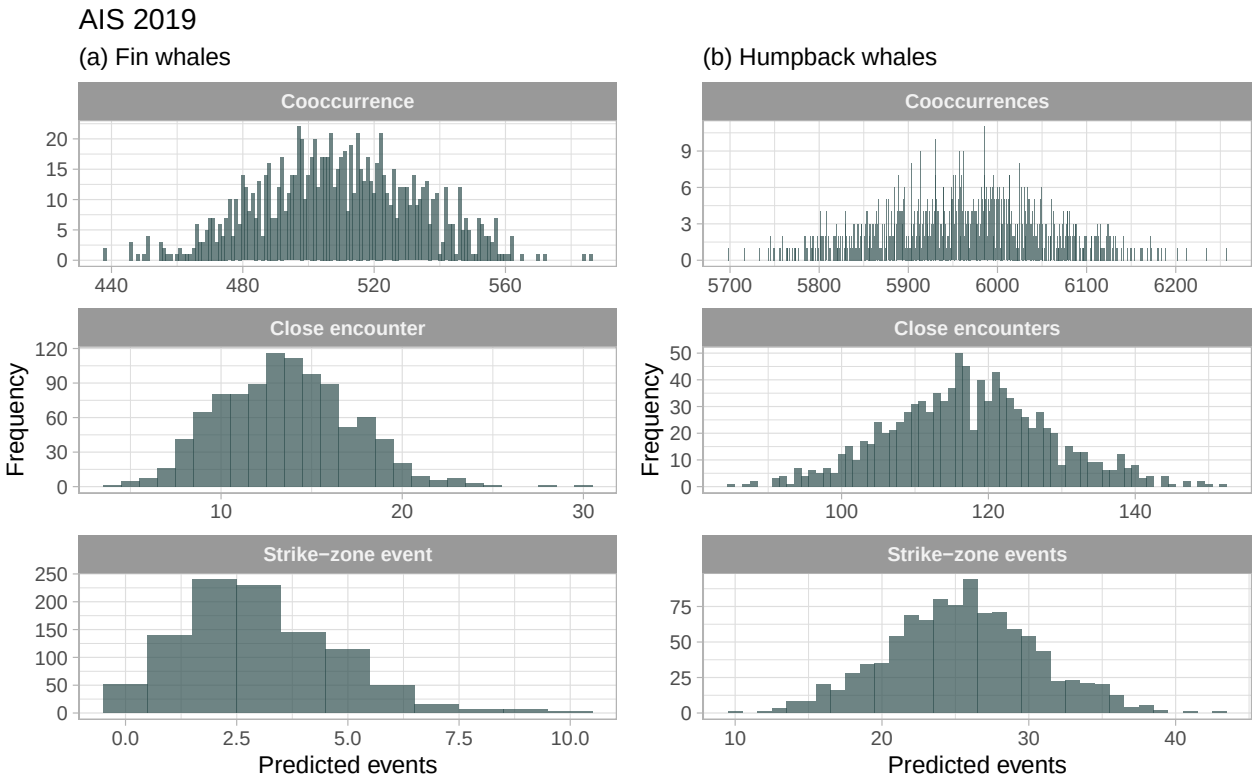
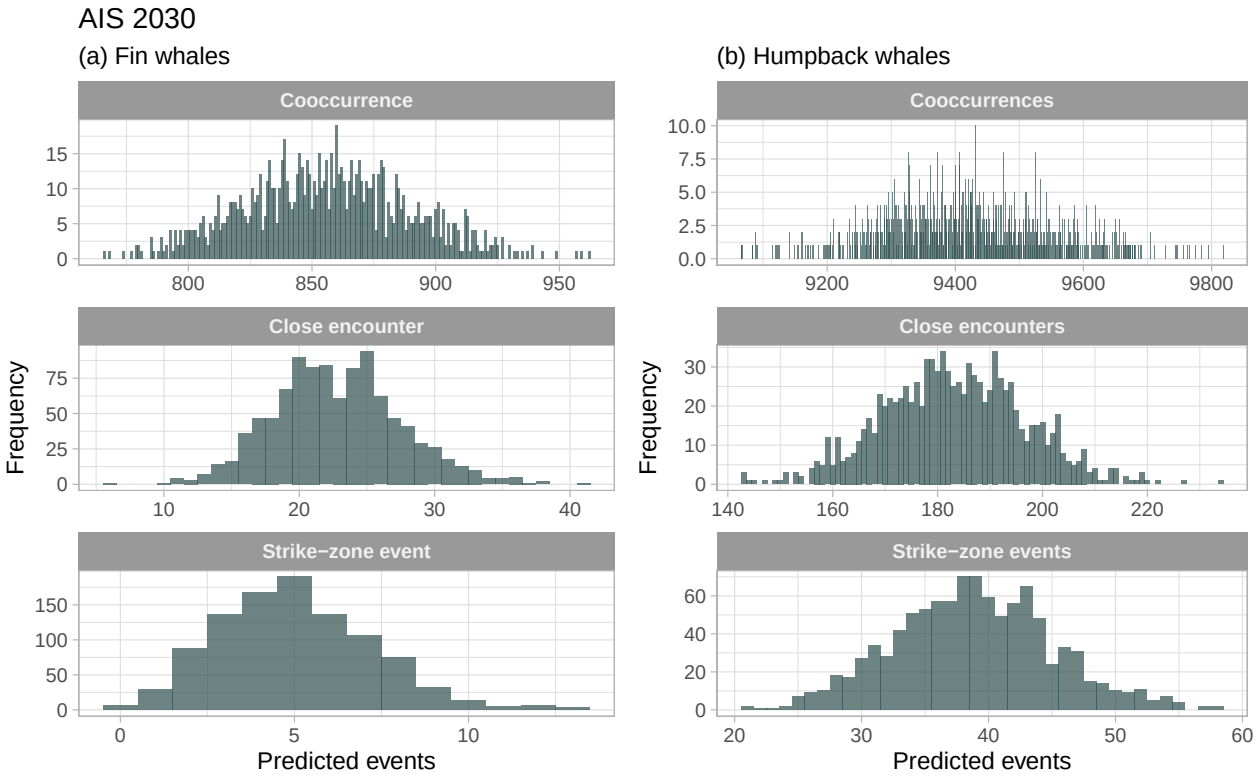


Figure 16: caption



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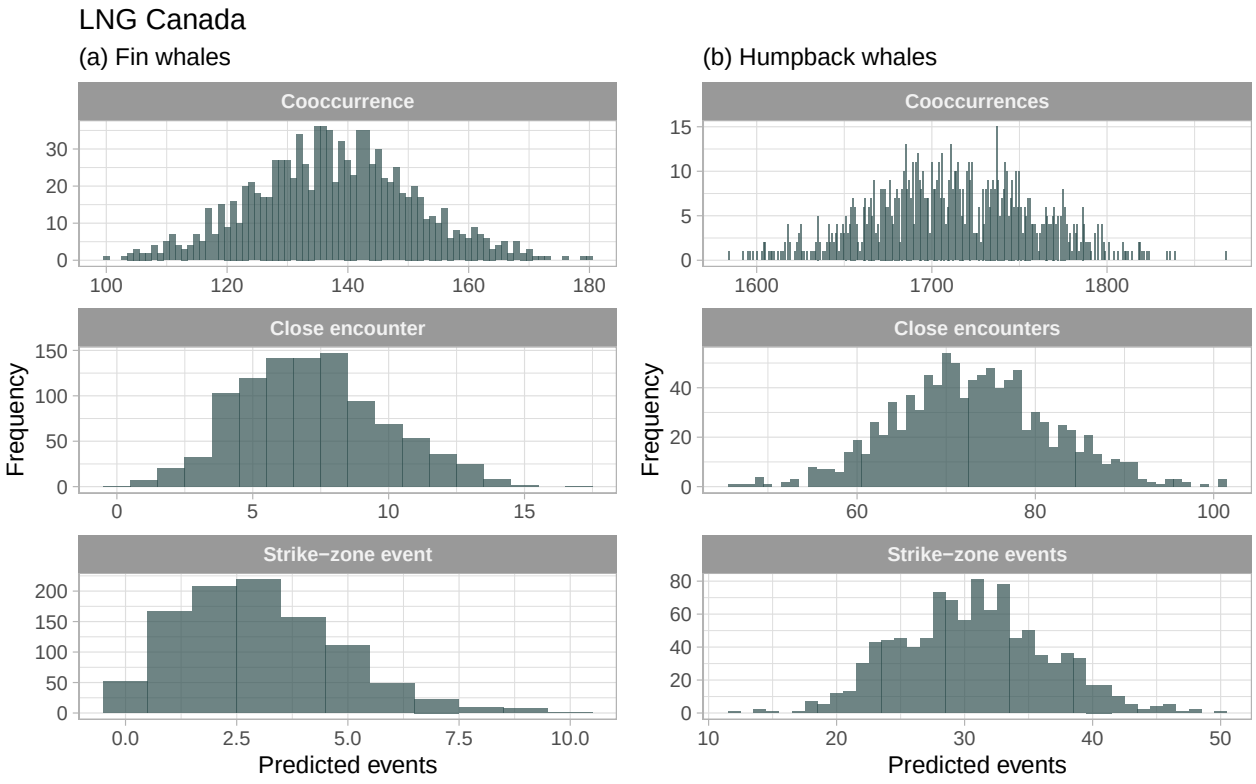

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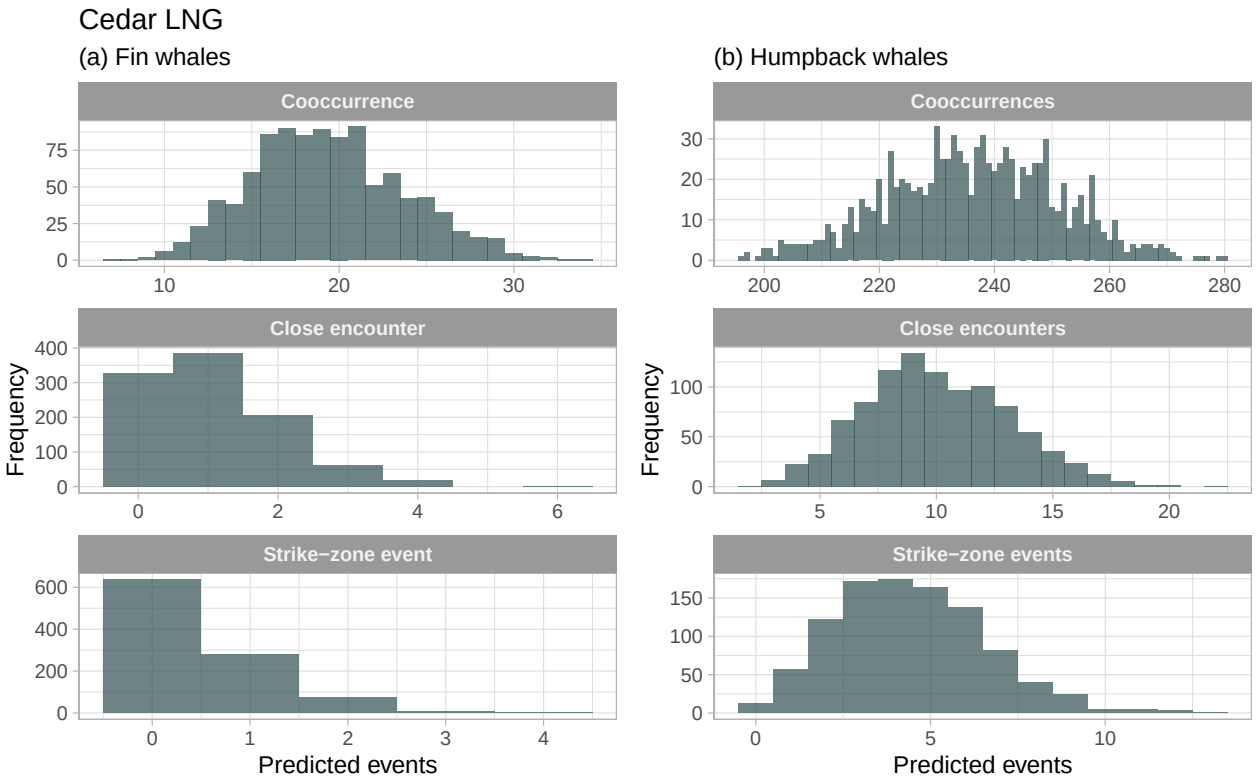

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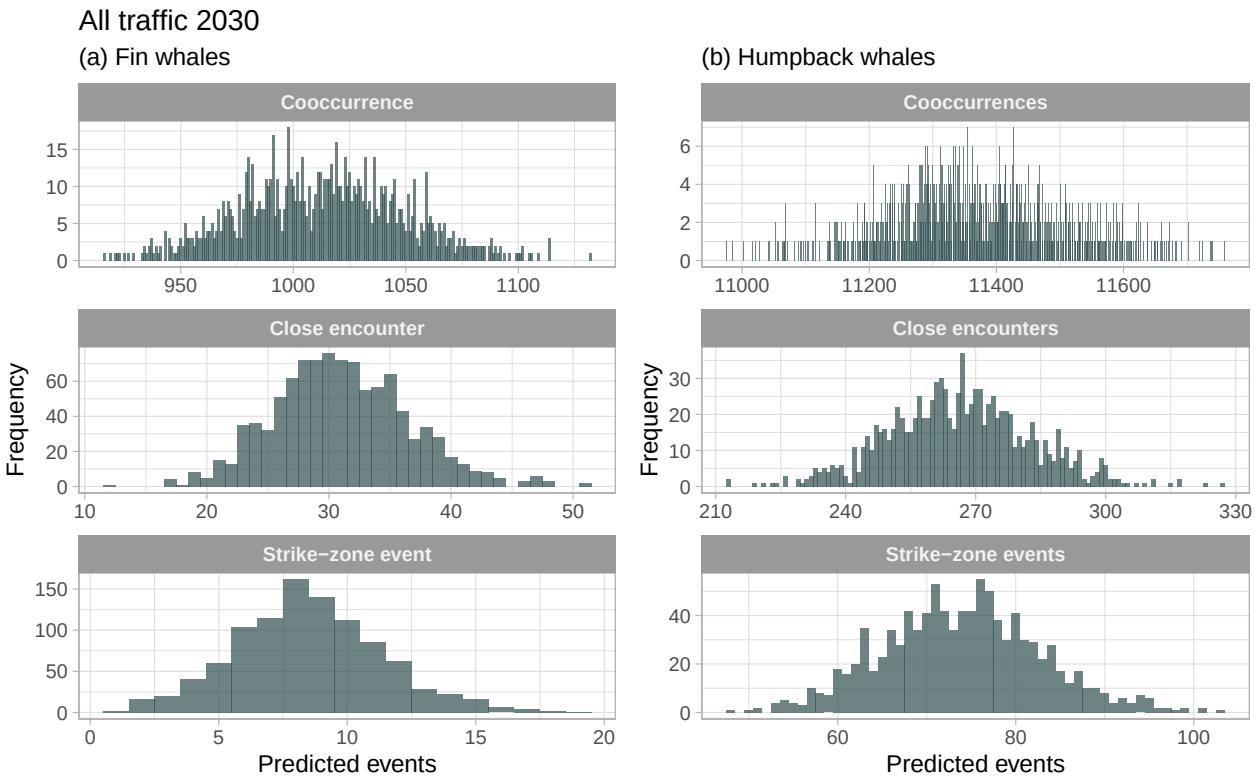

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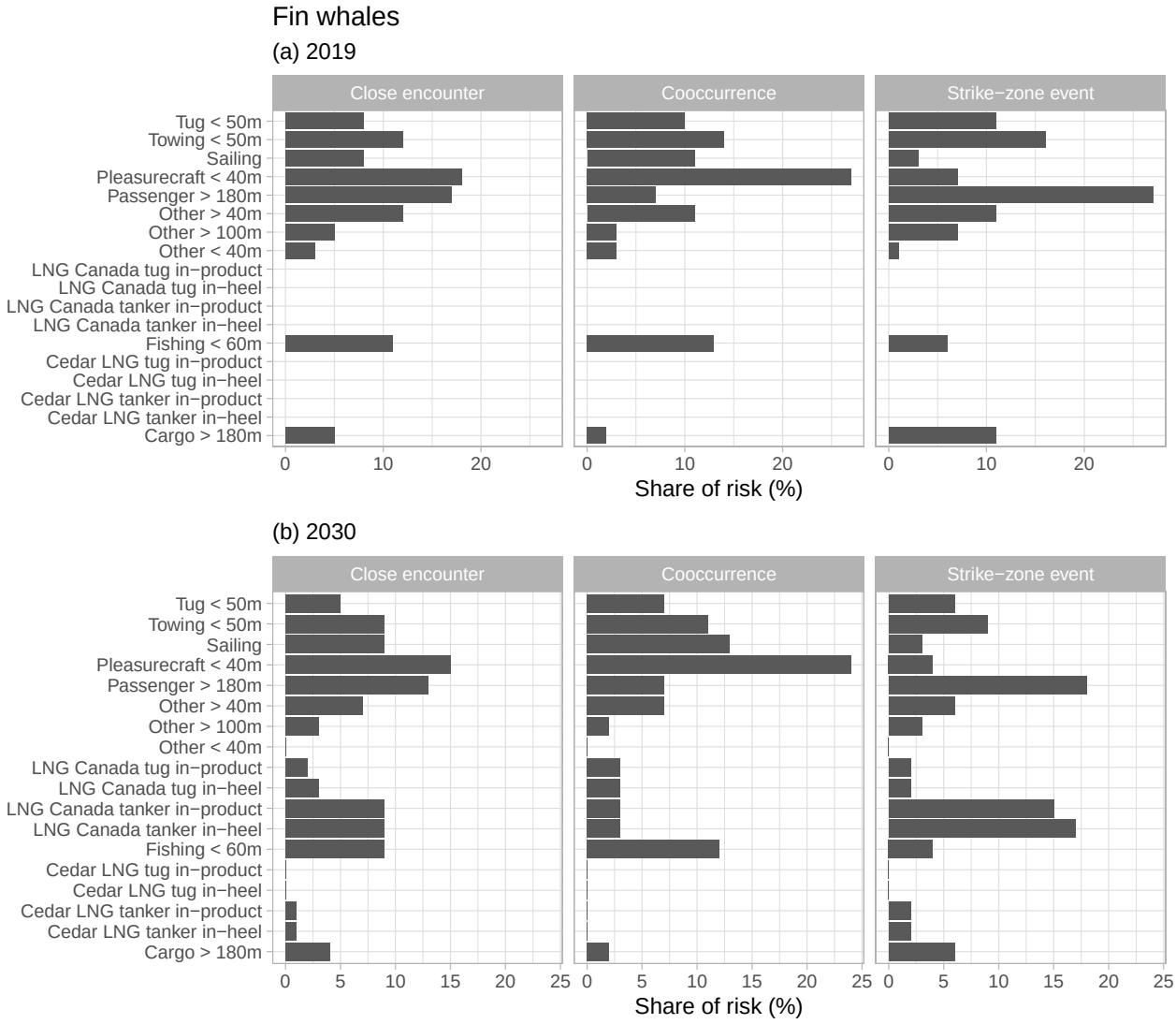

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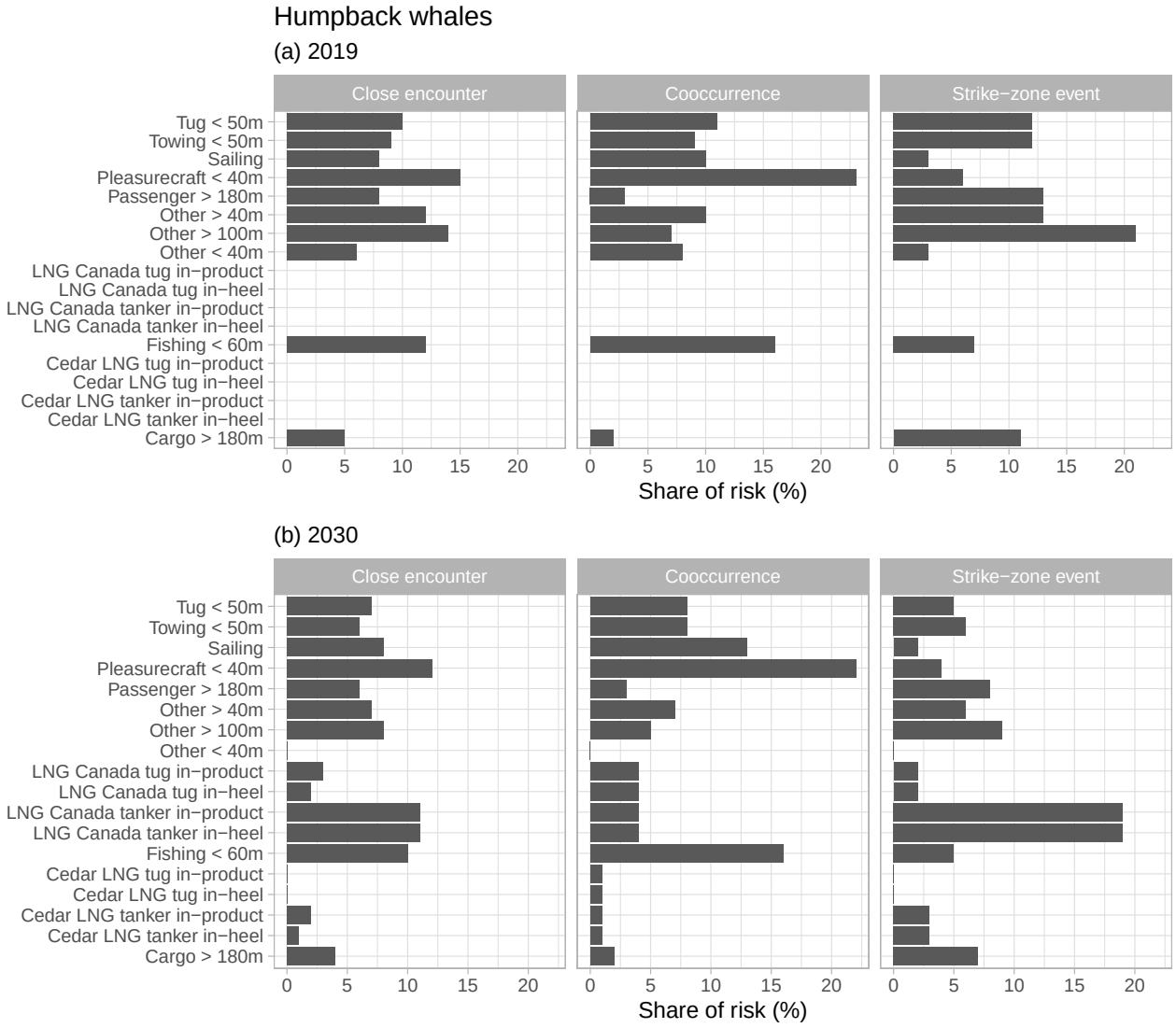

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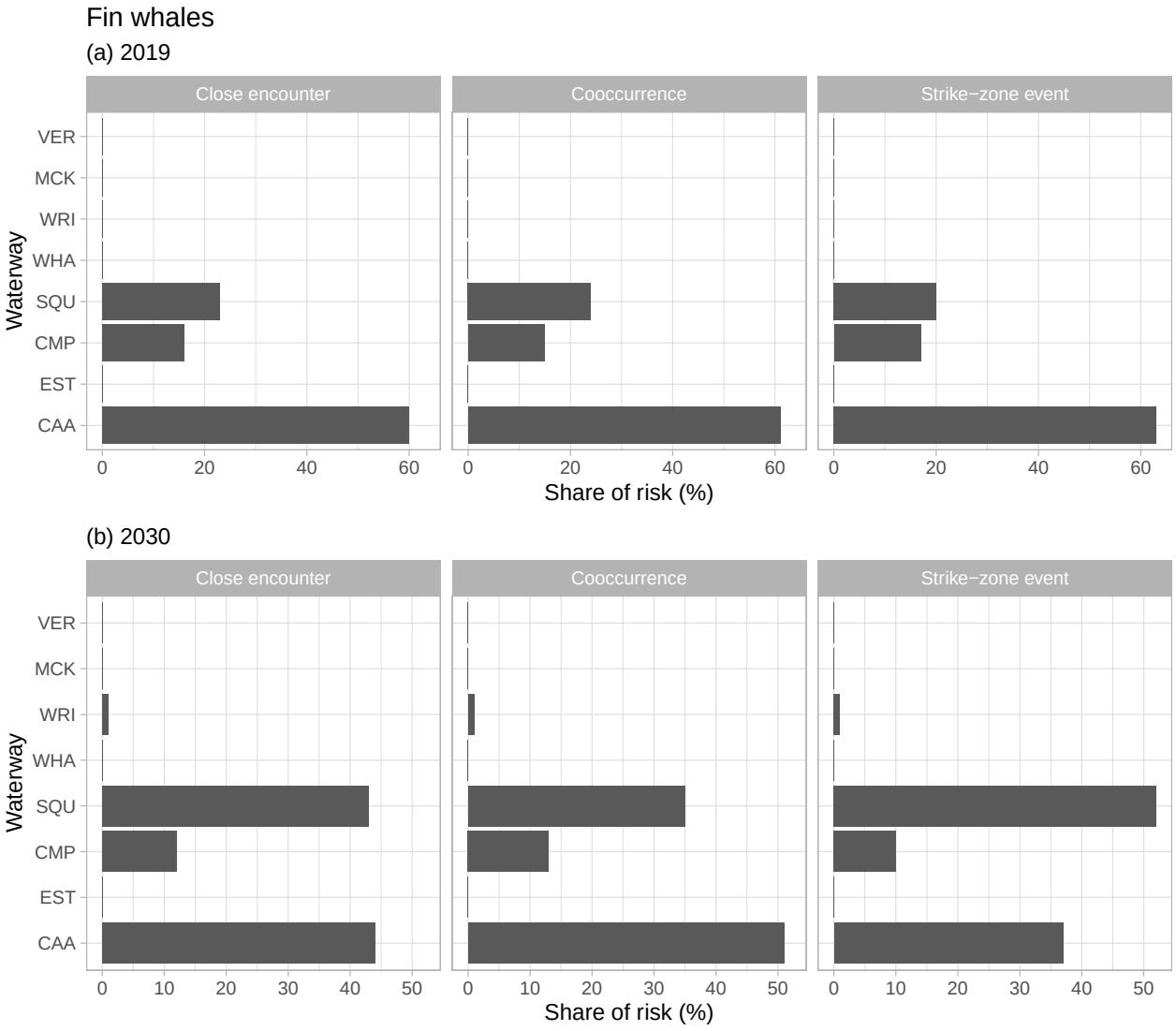

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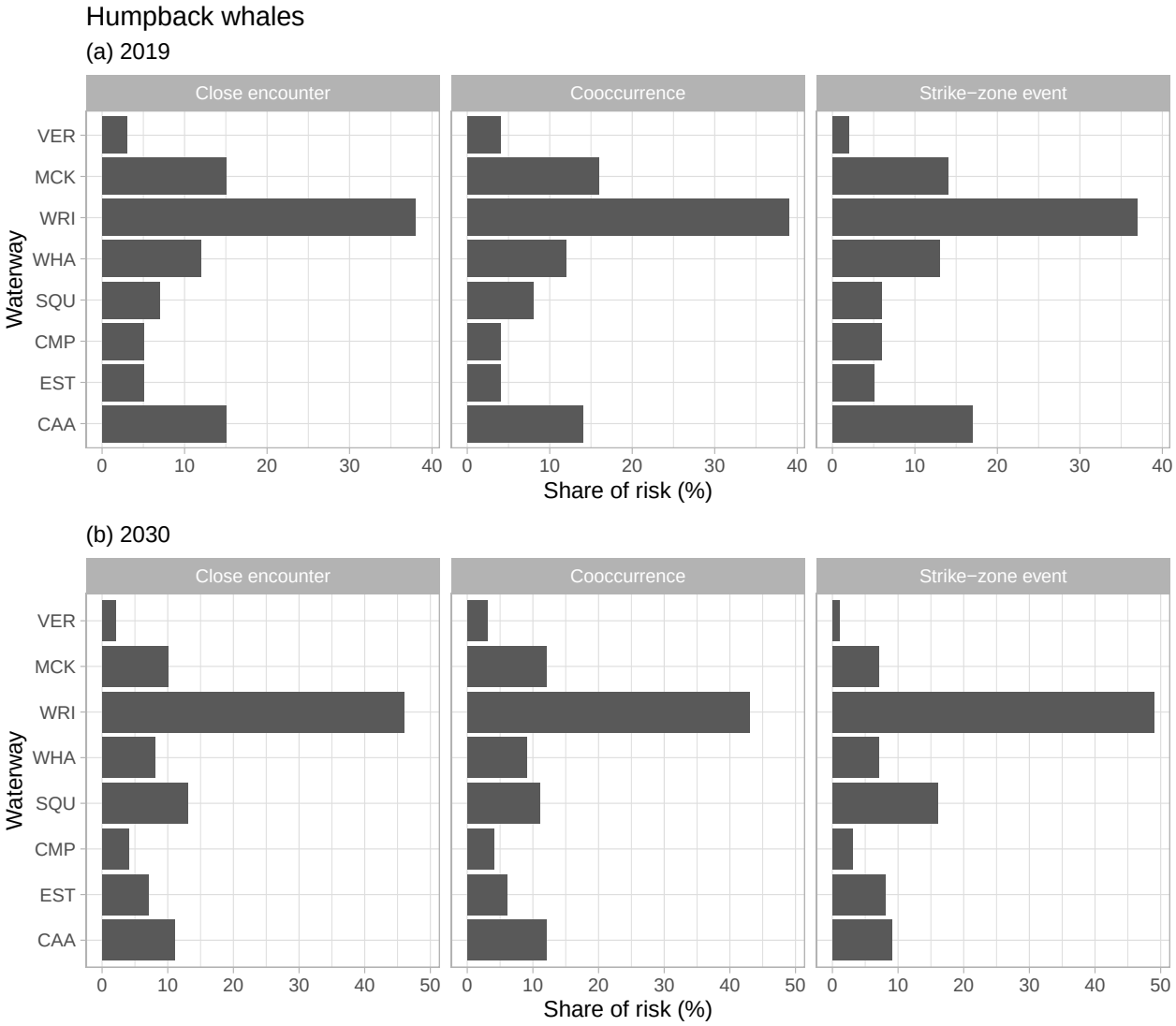

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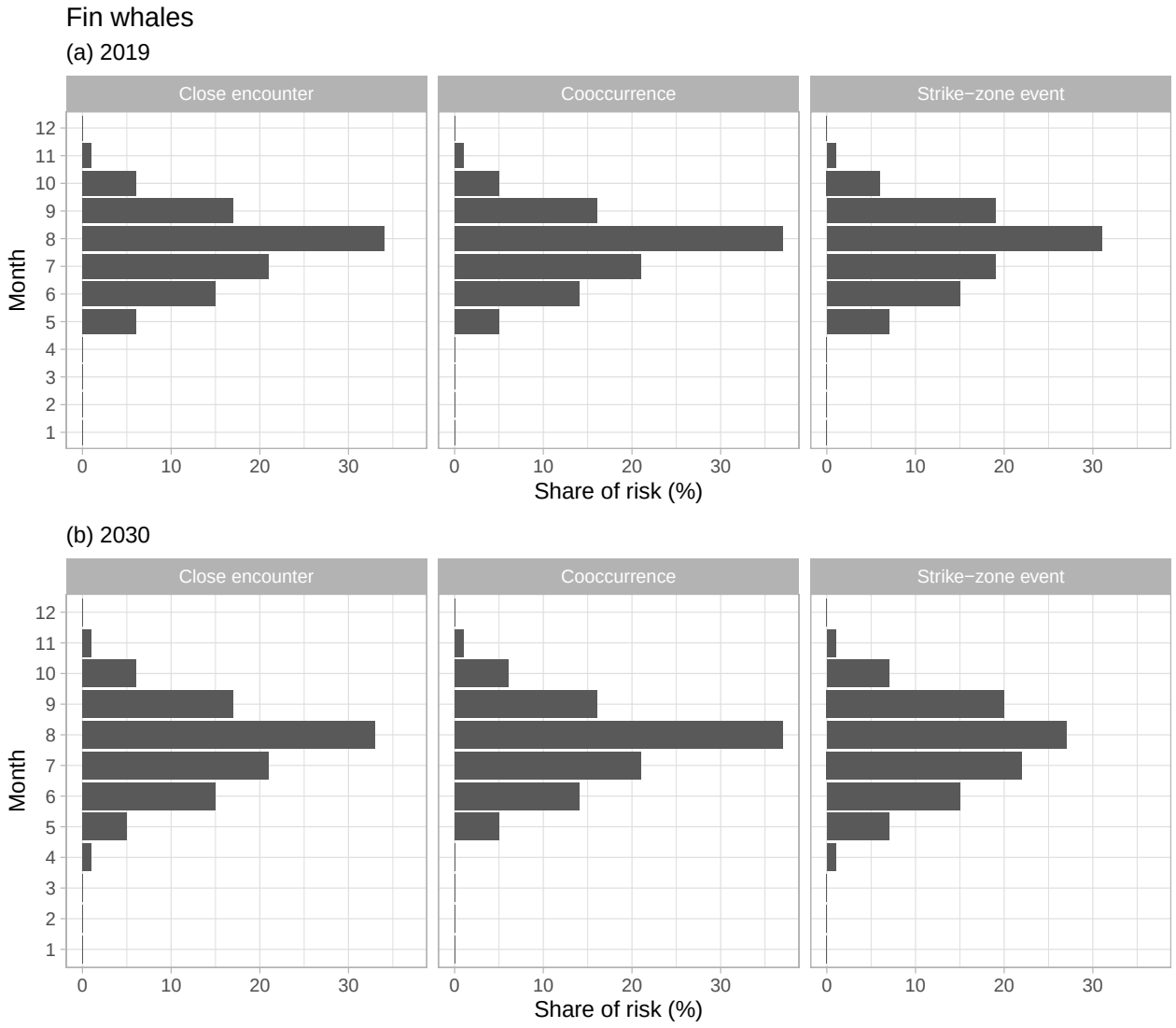

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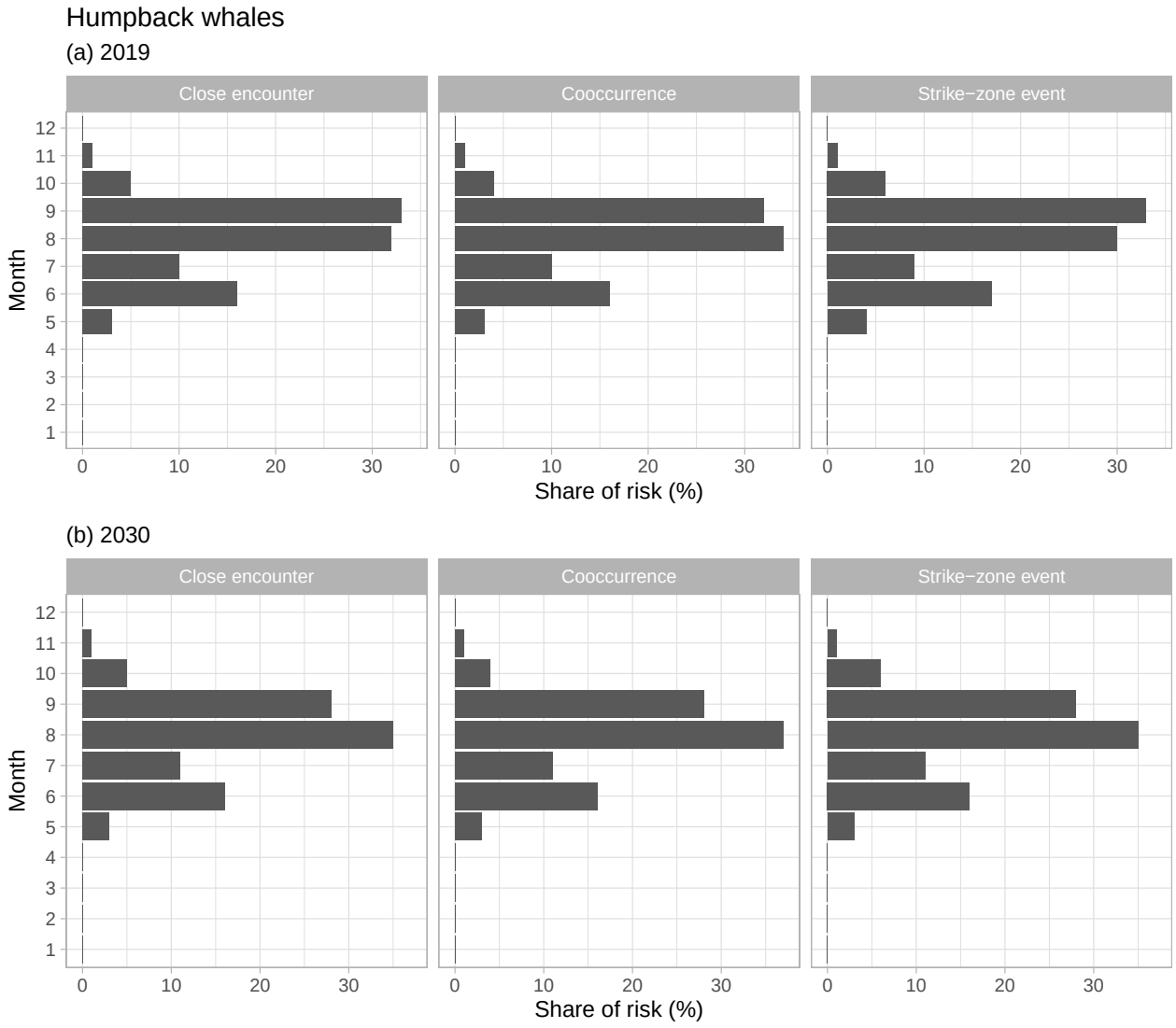


Figure 26: caption

Shares of interaction risk by diel period

Table 18: Share of interactions risk attributable to each diel period, in 2019 and in 2030.

		Fin whales			Humpback whales		
Year	**Diel period**	**Cooccurrence**	**Close encounter**	**Strike-zone event**	**Cooccurrence**	**Close encounter**	**Strike-zone event**
2019	day	89	87	78	83	79	66
	night	11	13	22	17	21	34
2030	day	87	84	71	82	78	65
	night	13	16	29	18	22	35

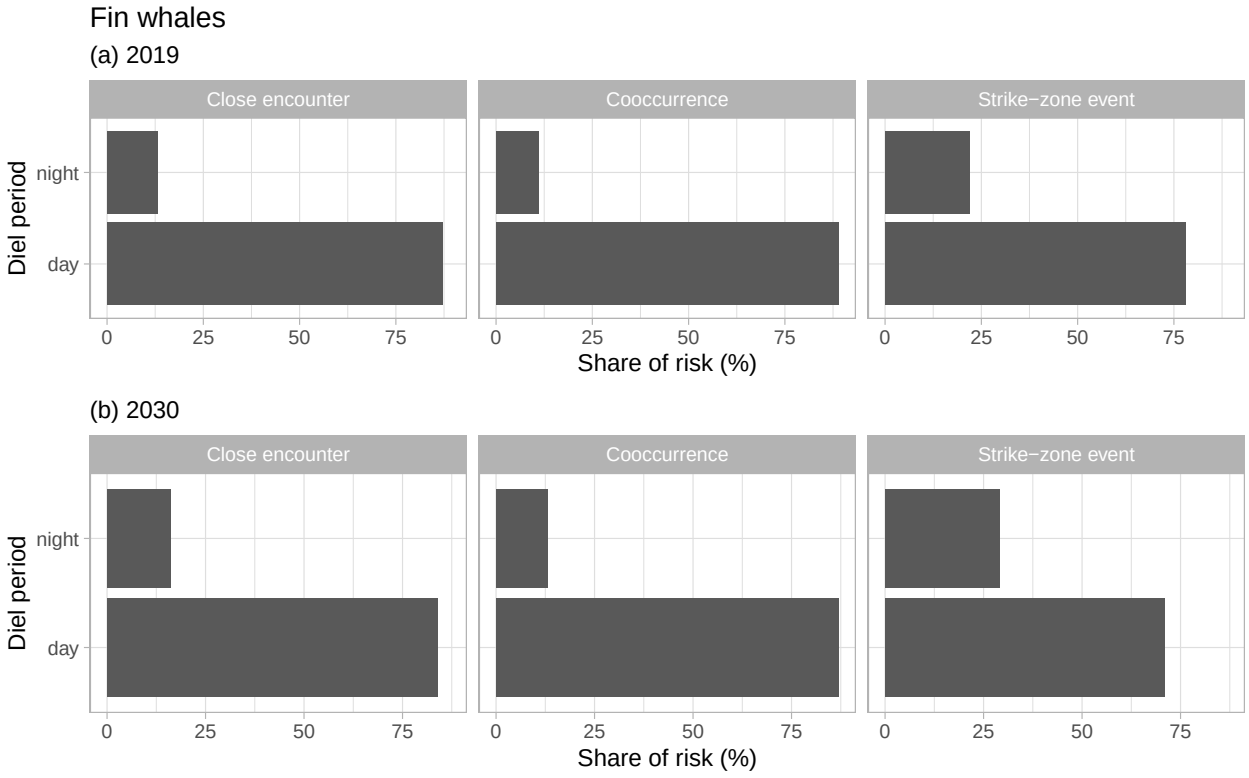


Figure 27: caption

Collisions & mortalities

Table 19: Predicted rates of collision and mortality.

			Fin whales				Humpback whales			
Traffic scheme	**Event**	**Avoidance**	**Mean**	**Median**	**95% CI**	**80% Conf.**	**Mean**	**Median**	**95% CI**	**80% Conf.**
AIS 2019	Collision	0.55	0.48	0	0 - 2	0	2.74	3	0 - 5	1
		~ Speed	0.77	1	0 - 2	0	3.56	3	1 - 7	2
		None	1.13	1	0 - 3	0	6.02	6	2 - 10	4
	Mortality	0.55	0.47	0	0 - 2	0	2.56	2	0 - 5	1
		~ Speed	0.74	1	0 - 2	0	3.36	3	1 - 7	2
		None	1.08	1	0 - 3	0	5.63	5	2 - 10	4
AIS 2030	Collision	0.55	0.86	1	0 - 3	0	5.07	5	2 - 9	3
		~ Speed	1.33	1	0 - 3	0	6.78	7	3 - 11	5
		None	1.98	2	0 - 4	1	11.24	11	6 - 17	8
	Mortality	0.55	0.82	1	0 - 2	0	4.75	5	2 - 8	3
		~ Speed	1.29	1	0 - 3	0	6.42	6	3 - 11	4
		None	1.90	2	0 - 4	1	10.54	10	6 - 16	8
LNG Canada	Collision	0.55	1.24	1	0 - 3	0	12.55	12	7 - 19	10

		~ Speed	1.18	1	0 - 3	0	11.94	12	7 - 18	9
		None	2.71	3	0 - 6	1	27.96	28	20 - 37	23
	Mortality	0.55	1.06	1	0 - 3	0	10.72	11	6 - 16	8
		~ Speed	1.00	1	0 - 3	0	10.32	10	5 - 16	8
		None	2.29	2	0 - 5	1	23.78	24	16 - 32	19
Cedar LNG	Collision	0.55	0.17	0	0 - 1	0	1.85	2	0 - 4	1
		~ Speed	0.17	0	0 - 1	0	1.63	1	0 - 4	0
		None	0.41	0	0 - 2	0	4.04	4	1 - 8	2
	Mortality	0.55	0.15	0	0 - 1	0	1.56	1	0 - 4	0
		~ Speed	0.15	0	0 - 1	0	1.38	1	0 - 3	0
		None	0.35	0	0 - 2	0	3.37	3	1 - 7	2
Total 2030	Collision	0.55	2.27	2	0 - 5	1	19.47	19	12 - 27	16
		~ Speed	2.68	3	0 - 6	1	20.36	20	13 - 28	16
		None	5.10	5	2 - 9	3	43.24	43	32 - 55	37
	Mortality	0.55	2.03	2	0 - 4	1	17.02	17	11 - 24	13
		~ Speed	2.44	2	0 - 5	1	18.12	18	11 - 26	15
		None	4.54	4	1 - 8	3	37.68	38	28 - 48	32

Table 20: Share of collision and mortality risk attributable to each vessel type, in 2019 and in 2030.

		Fin whales		Humpback whales	
Year	**Vessel**	**Collision**	**Mortality**	**Collision**	**Mortality**
2019	Cargo > 180m	26	22	41	39
	Passenger > 180m	74	78	59	61
2030	Cargo > 180m	11	11	14	14
	Cedar LNG tanker in-heel	3	3	4	3
	Cedar LNG tanker in-product	4	3	4	4
	LNG Canada tanker in-heel	24	23	30	30
	LNG Canada tanker in-product	20	19	29	27
	Passenger > 180m	39	41	20	22

Table 21: Share of collision and mortality risk attributable to each waterway, in 2019 and in 2030.

		Fin whales		Humpback whales	
Year	**Waterway**	**Collision**	**Mortality**	**Collision**	**Mortality**
2019	Caamano	59	61	26	27
	Estevan	0	0	8	7
	Campania	25	23	15	13
	Squally	15	15	7	8
	Whale	0	1	26	26
	Wright	0	0	18	17
	McKay	0	0	1	1
	Verney	0	0	0	0
2030	Caamano	29	30	8	9
	Estevan	0	0	10	9
	Campania	11	13	4	5
	Squally	59	56	20	20
	Whale	1	1	50	50
	Wright	0	0	7	6
	McKay	0	0	1	1
	Verney	0	0	0	0

Table 22: Share of collision and mortality risk attributable to each month, in 2019 and in 2030.

	Fin whales	Humpback whales

Year	Month	Collision	Mortality	Collision	Mortality
2019	Jan	0	0	0	0
	Feb	0	0	0	0
	Mar	0	0	0	0
	Apr	0	1	0	0
	May	4	5	5	4
	Jun	21	23	23	24
	Jul	19	16	9	10
	Aug	30	27	27	26
	Sep	21	23	29	29
	Oct	3	3	5	5
	Nov	0	1	1	1
	Dec	0	0	0	0
2030	Jan	0	0	0	0
	Feb	0	0	0	0
	Mar	0	0	0	0
	Apr	1	1	0	0
	May	5	5	3	3
	Jun	18	18	17	18
	Jul	21	19	11	11
	Aug	27	29	36	36
	Sep	19	21	26	25
	Oct	7	7	5	5
	Nov	1	1	1	1
	Dec	0	0	0	0

Table 23: Share of collision and mortality risk attributable to each diel period, in 2019 and in 2030.

		Fin whales		Humpback whales	
Year	Diel period	Collision	Mortality	Collision	Mortality
2019	day	80	83	69	71
	night	20	17	31	29
2030	day	73	72	65	66
	night	27	28	35	34

Chances of certain outcome severities

Table 24: Chances of various impact severities for fin whales and humpback whales, due to present-day AIS-transmitting traffic (represented by 2019 traffic), projected AIS-transmitting traffic in 2030, projected LNG Canada traffic, projected Cedar LNG traffic, then all traffic in 2030 (previous categories combined).

		AIS 2019		AIS 2030		LNG Canada		Cedar LNG		All traffic 2030	
Species	Chances (%) of...	Coll.	Mort.	Coll.	Mort.	Coll.	Mort.	Coll.	Mort.	Coll.	Mort.
Fin whale	Zero	33.1	37.7	14.0	19.1	28.5	33.7	83.4	85.6	3.8	6.0
	At least 1	66.9	62.3	86.0	80.9	71.5	66.3	16.6	14.4	96.2	94.0
	At least 2	32.9	26.6	55.0	45.8	34.8	27.1	1.3	0.9	83.7	76.0
	At least 3	11.1	7.5	27.1	20.9	13.8	9.3	0.0	0.0	65.2	52.8
	At least 4	3.4	1.6	11.7	8.5	4.8	2.1	0.0	0.0	41.9	30.9
	At least 5	0.6	0.2	5.2	2.6	0.9	0.4	0.0	0.0	24.2	16.5
Humpback whale	Zero	0.0	0.1	0.0	0.0	0.0	0.0	18.9	25.2	0.0	0.0
	At least 1	100.0	99.9	100.0	100.0	100.0	100.0	81.1	74.8	100.0	100.0
	At least 2	99.9	99.8	100.0	100.0	100.0	100.0	52.9	43.1	100.0	100.0
	At least 3	99.5	98.0	100.0	99.9	100.0	99.8	25.2	18.4	100.0	100.0
	At least 4	98.2	94.9	100.0	99.8	100.0	99.2	10.5	5.9	100.0	100.0
	At least 5	95.6	90.5	99.8	99.6	99.3	97.7	3.3	1.9	100.0	100.0

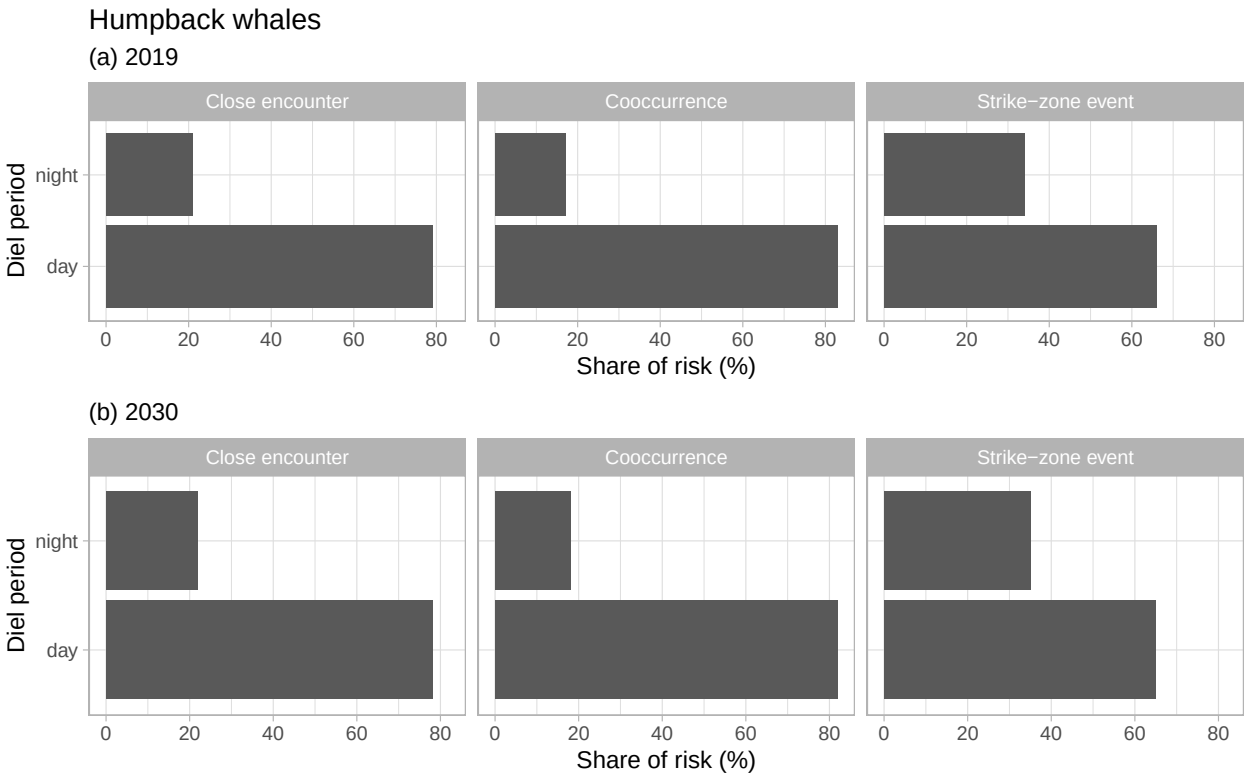


Figure 28: caption

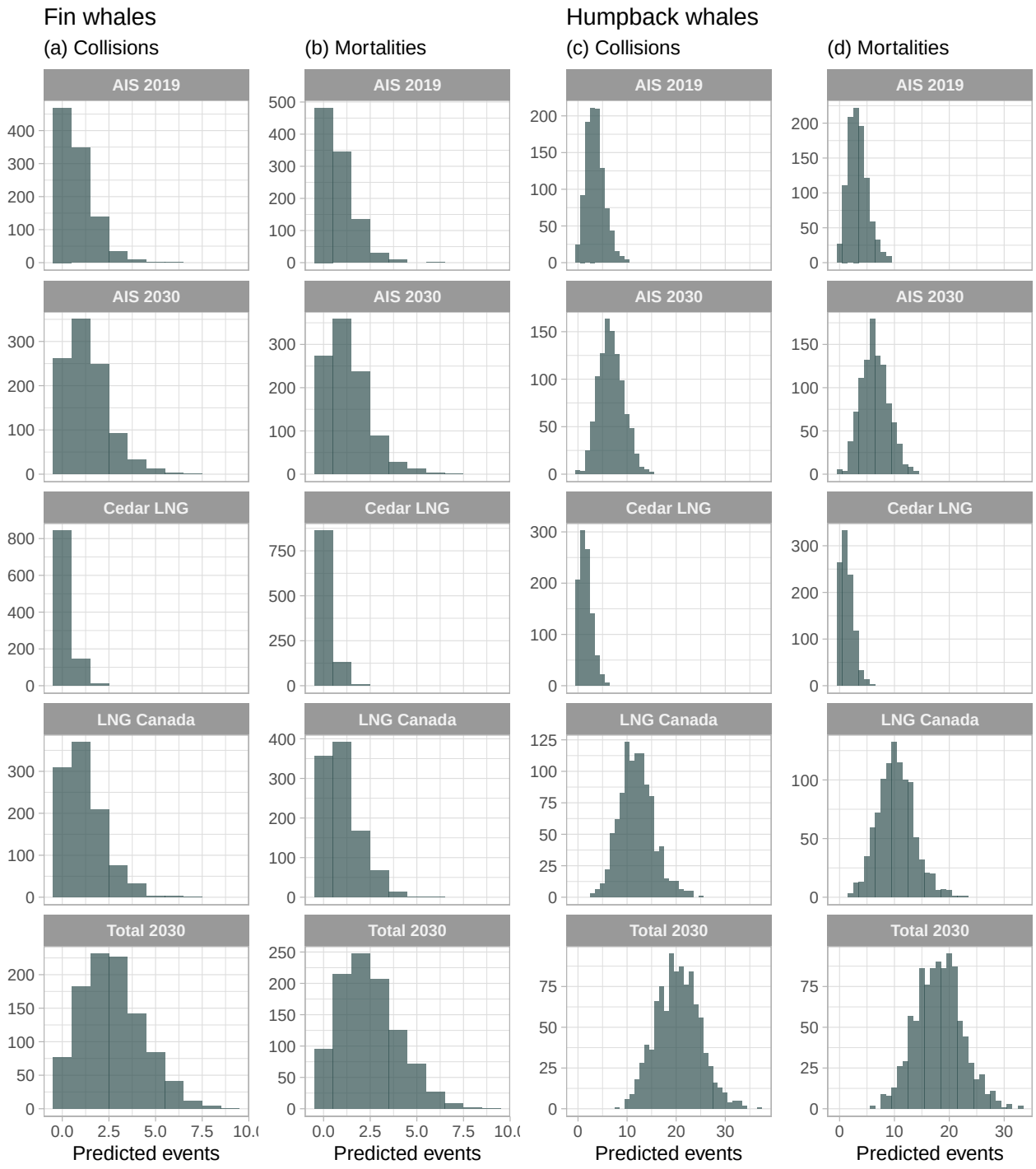


Figure 29: caption

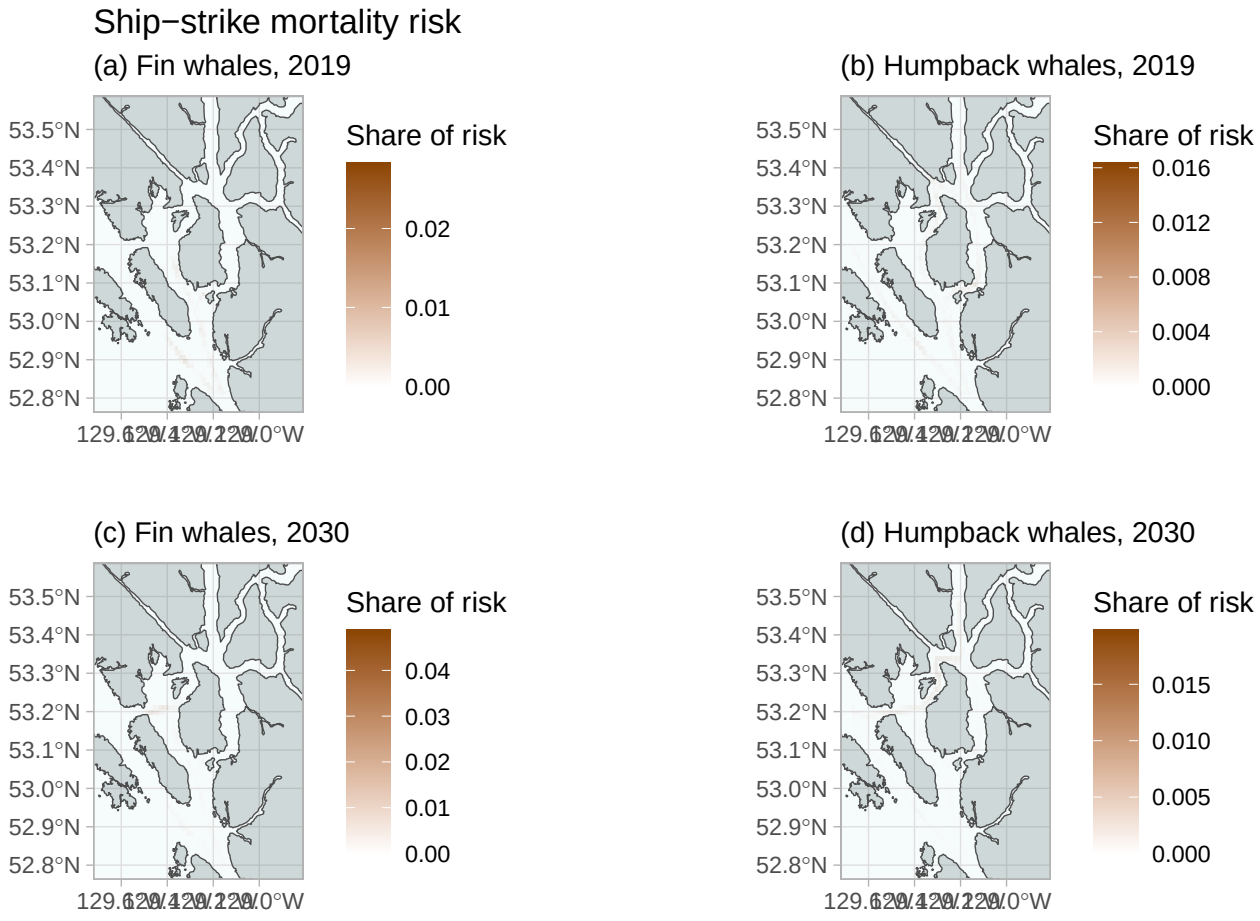


Figure 30: caption

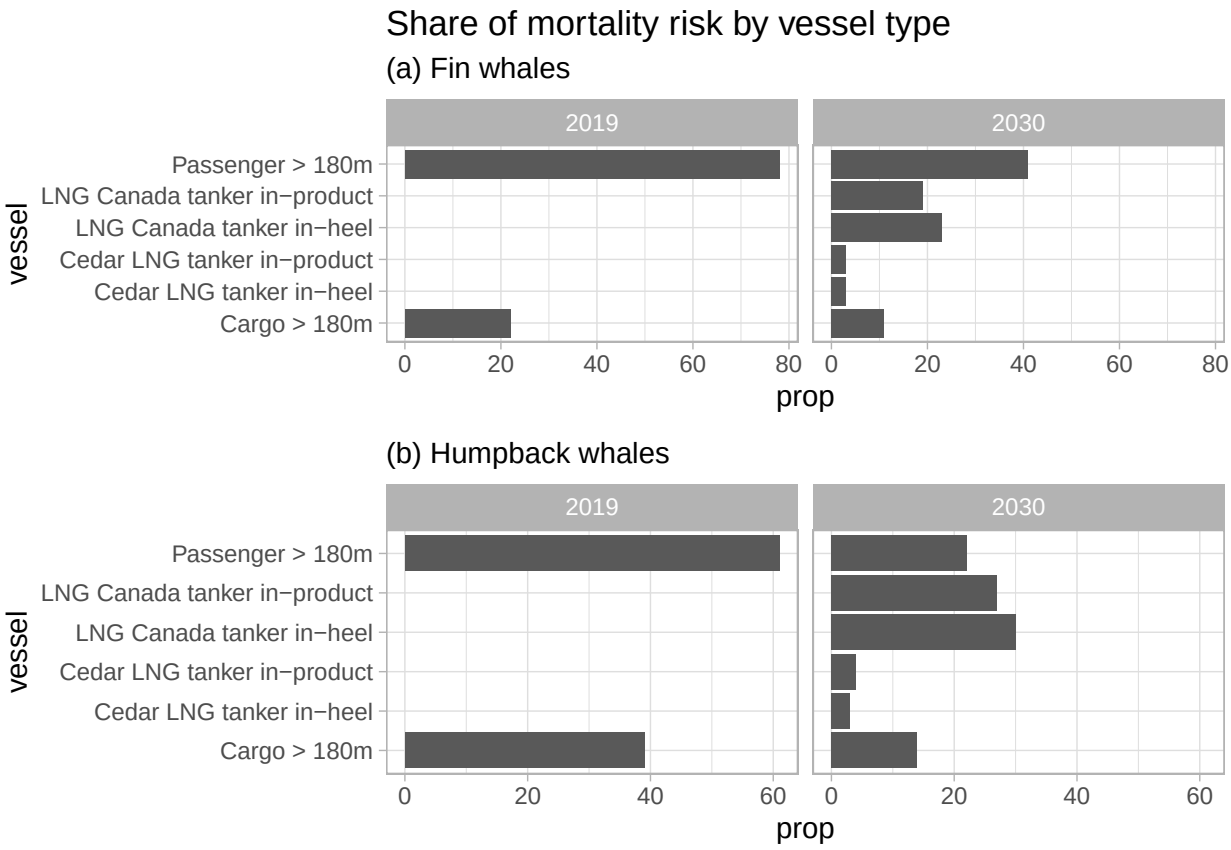


Figure 31: caption

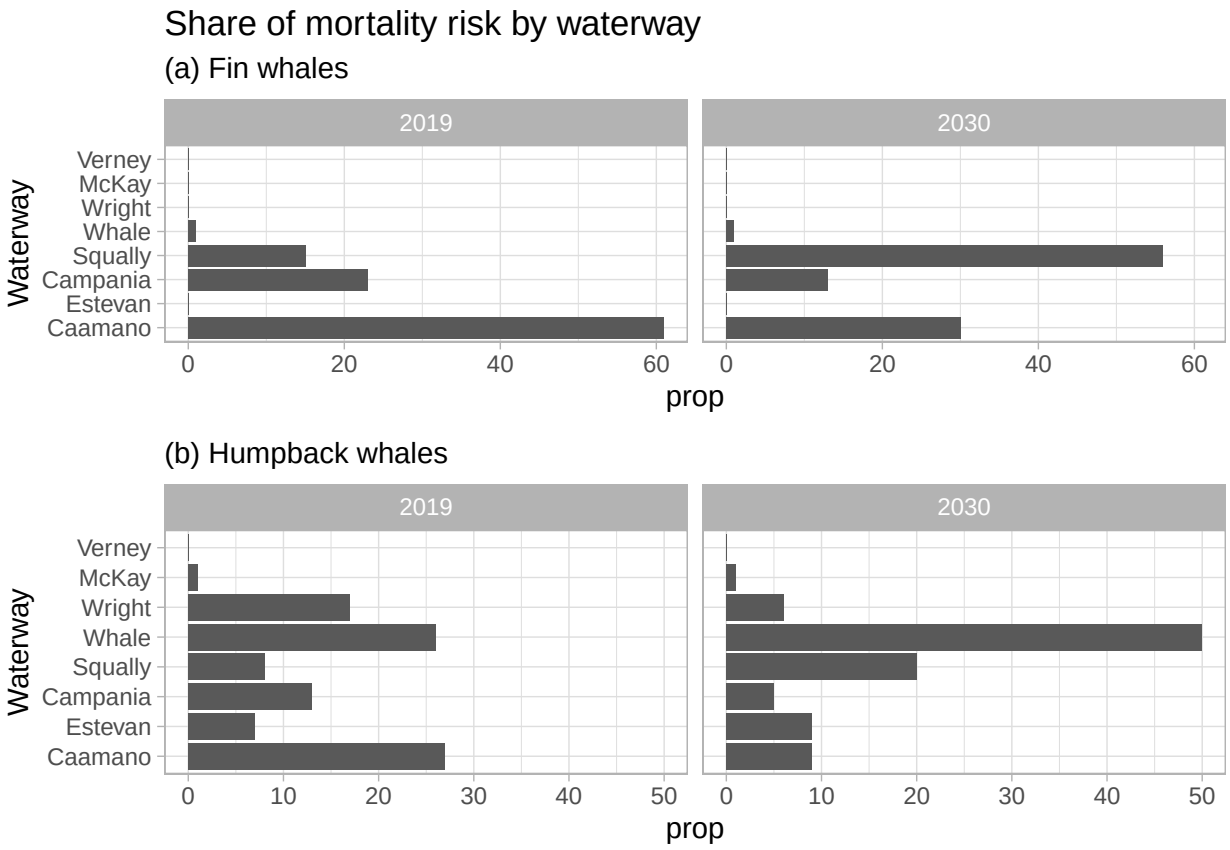


Figure 32: caption

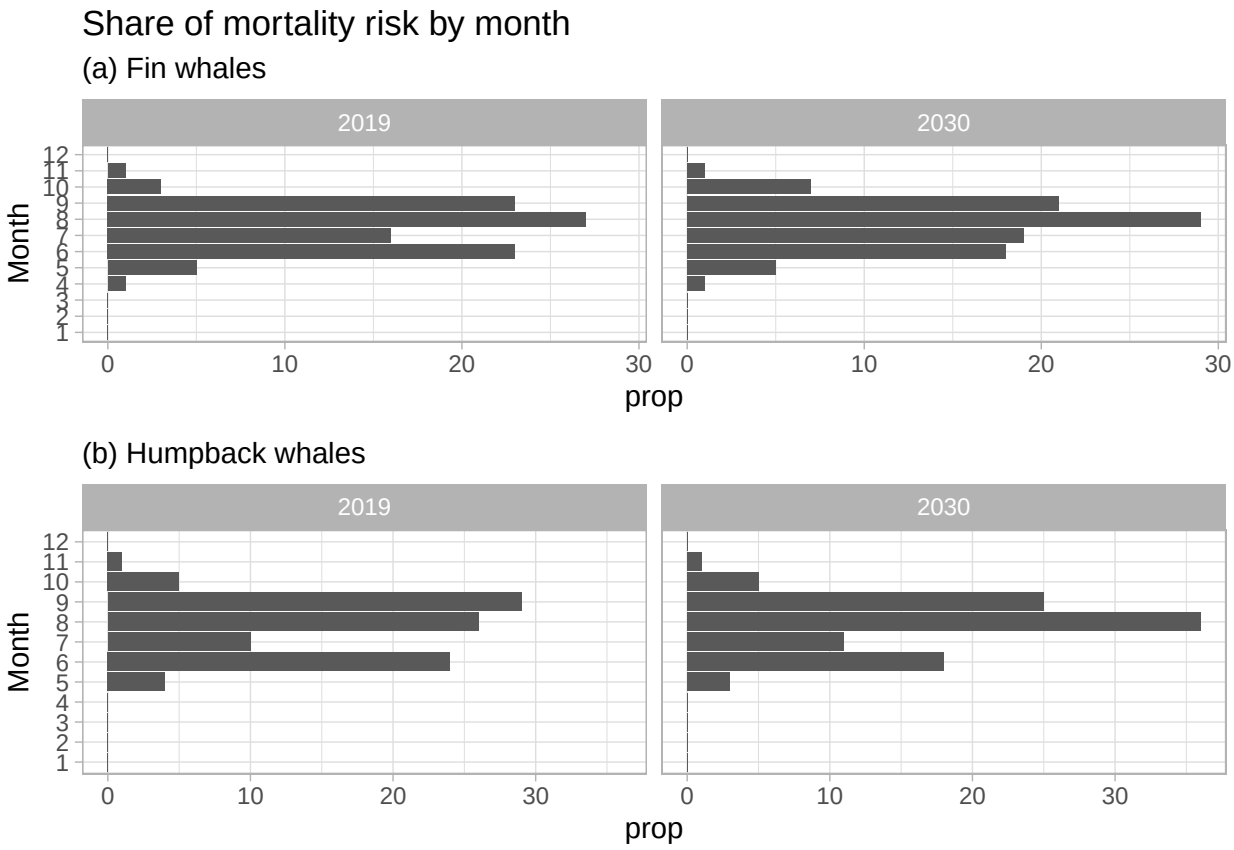


Figure 33: caption

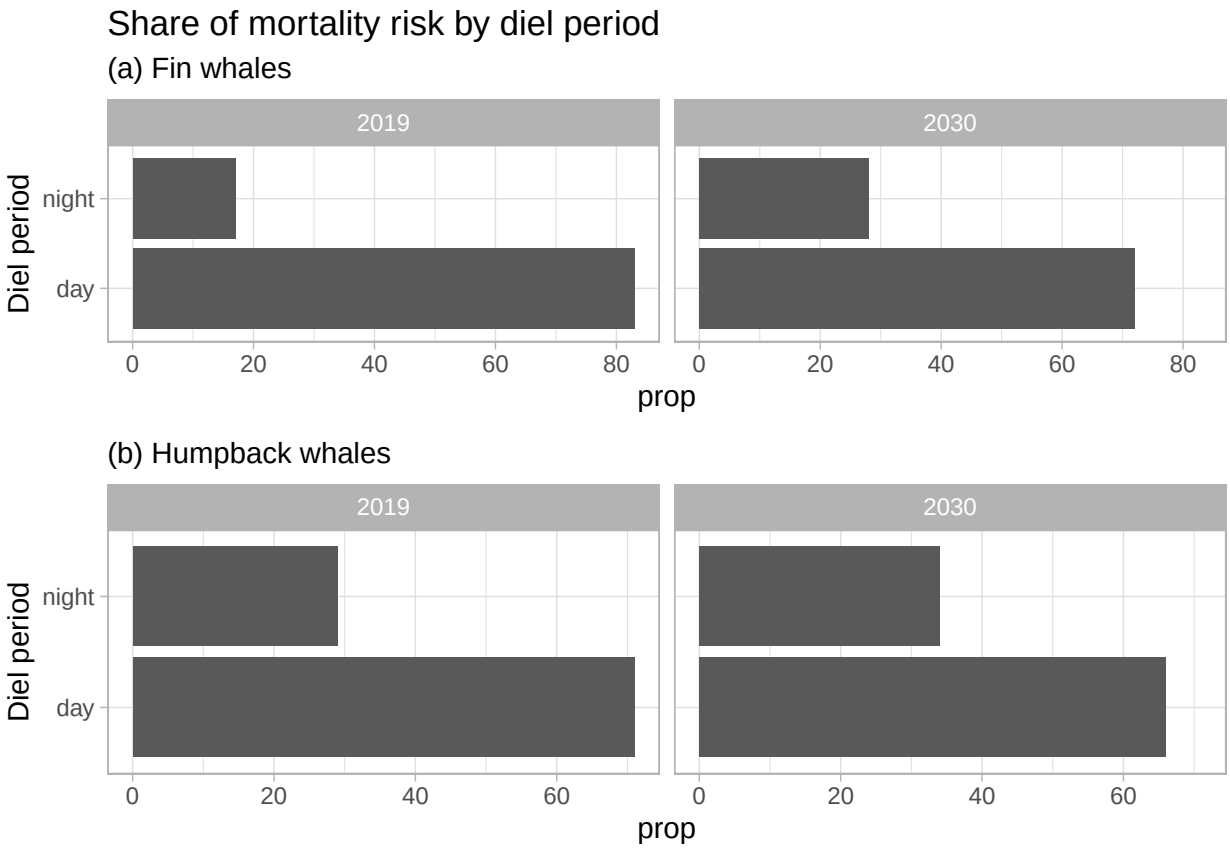


Figure 34: caption

Table 25: Chances of various impact severities for fin whales and humpback whales, similar to above, now described as the chances of experiencing *no more than* the stated number of events.

		AIS 2019		AIS 2030		Cedar LNG		LNG Canada		All traffic 2030	
Species	**Chances (%) of...**	**Coll.**	**Mort.**	**Coll.**	**Mort.**	**Coll.**	**Mort.**	**Coll.**	**Mort.**	**Coll.**	**Mort.**
Fin whale	Zero	33.1	37.7	14.0	19.1	83.4	85.6	28.5	33.7	3.8	6.0
	Max of 1	67.1	73.4	45.0	54.2	98.7	99.1	65.2	72.9	16.3	24.0
	Max of 2	88.9	92.5	72.9	79.1	100.0	100.0	86.2	90.7	34.8	47.2
	Max of 3	96.6	98.4	88.3	91.5	100.0	100.0	95.2	97.9	58.1	69.1
	Max of 4	99.4	99.8	94.8	97.4	100.0	100.0	99.1	99.6	75.8	83.5
	Max of 5	99.7	99.8	98.3	99.3	100.0	100.0	99.6	99.8	87.6	93.1
Humpback whale	Zero	0.0	0.1	0.0	0.0	18.9	25.2	0.0	0.0	0.0	0.0
	Max of 1	0.1	0.2	0.0	0.0	47.1	56.9	0.0	0.0	0.0	0.0
	Max of 2	0.5	2.0	0.0	0.1	74.8	81.6	0.0	0.2	0.0	0.0
	Max of 3	1.8	5.1	0.0	0.2	89.5	94.1	0.0	0.8	0.0	0.0
	Max of 4	4.4	9.5	0.2	0.4	96.7	98.1	0.7	2.3	0.0	0.0
	Max of 5	8.9	18.9	0.4	1.3	98.9	99.5	1.0	4.4	0.0	0.0

Validation

Fin whales

```
## Melting outcomes & prepping the posterior ...
## Determining the probability of your observations ...
## Likelihood of your observation, assuming perfect detection = 0.002
## Finding the strike detection rate (SDR) that would make your observations plausible ...
## preparing L ~ SDR plot ...
## --- SDR needed for P(Observation) of 0.05 = 0.49
## --- SDR needed for P(Observation) of 0.10 = 0.39
## --- SDR needed for P(Observation) of 0.20 = 0.255
## --- SDR needed for P(Observation) of 0.55 = 0.095
```

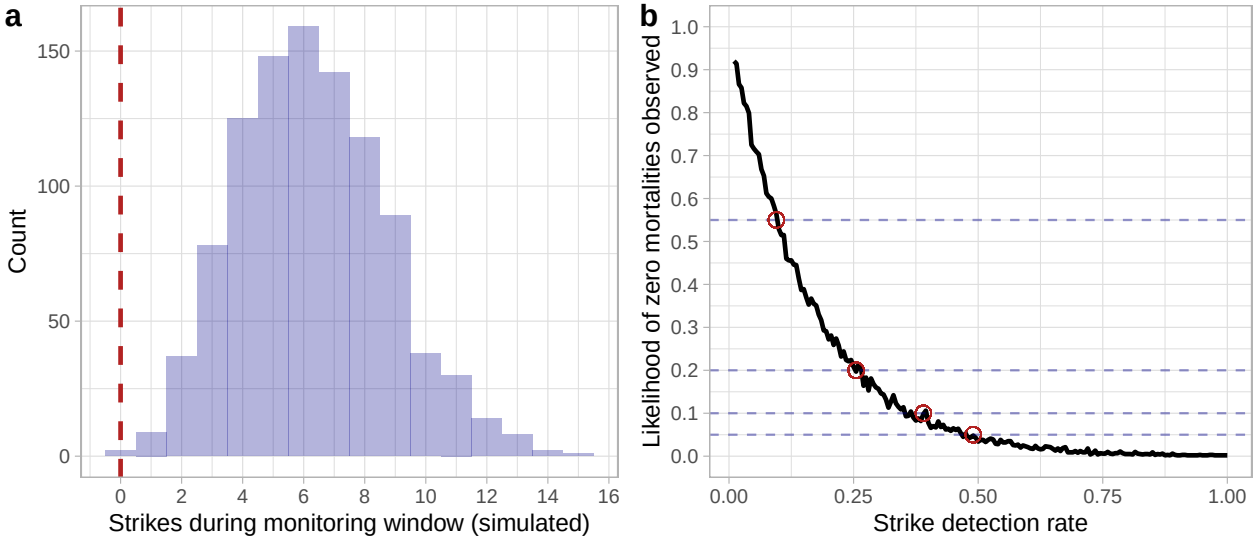
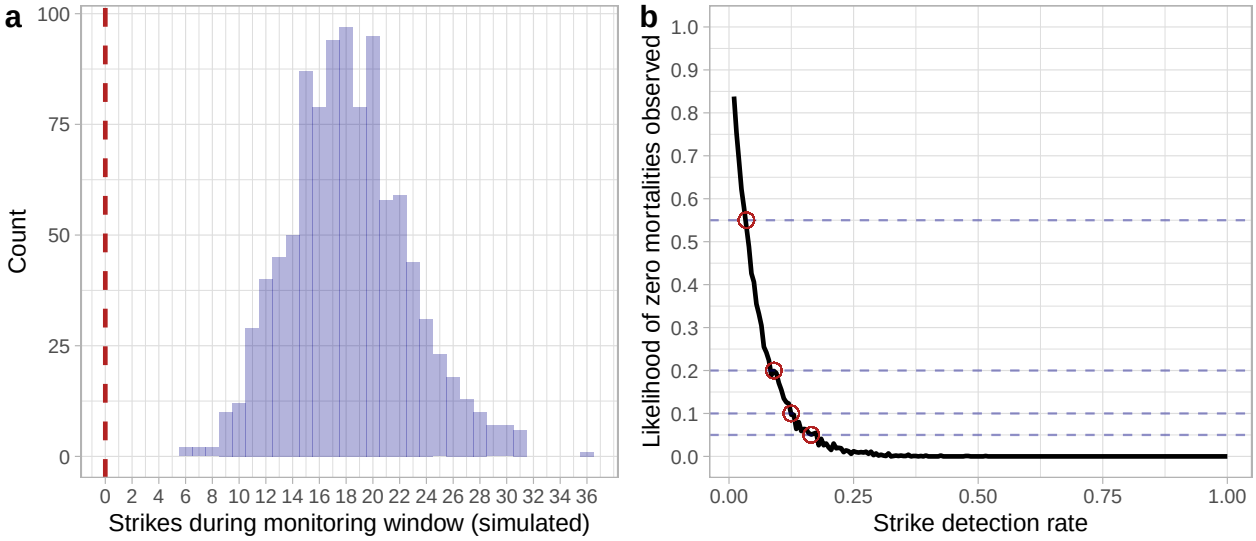


Figure 35: caption

Humpback whales

```
## Melting outcomes & prepping the posterior ...
## Determining the probability of your observations ...
## Likelihood of your observation, assuming perfect detection = 0
## Finding the strike detection rate (SDR) that would make your observations plausible ...
## preparing L ~ SDR plot ...
## --- SDR needed for P(Observation) of 0.05 = 0.165
## --- SDR needed for P(Observation) of 0.10 = 0.125
## --- SDR needed for P(Observation) of 0.20 = 0.09
## --- SDR needed for P(Observation) of 0.55 = 0.035
```



Mitigation measures

Density estimate comparison throughout region

Still to add

- Tables for humpback whale photogrammetry & track analysis