The number of blue, fin, humpback, and North Pacific right whales in the western North Pacific in the JARPNII Offshore survey area

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ABSTRACT
The number of blue, fin, humpback and North Pacific right whales in the western North Pacific distributed in early and late seasons in the JARPNII offshore component were estimated based on 2008-2014 JARPNII surveys. The numbers are to be used for ecosystem modeling in the western North Pacific. Given that the area is a migration corridor of the whales, the numbers were estimated for the early season (May-June) and the late season (July-Sep.). The estimates were 38 (in 2009) and 161 (in 2011 and 2012) in the early and 958 (in 2008) in the late season for blue whales, 413 (in 2009) and 1,369 (in 2011 and 2012) in the early and 3,958 (in 2008) in the late season for the fin whales, 1,136 (in 2009) and 1,921 (in 2011 and 2012) in the early and 392 (in 2008) in the late season for the humpback whales, 1,147 (in 2011 and 2012) in early season and 416 (in 2008) in late season for the North Pacific right whales. It is important to note that these estimates should not be used for assessment purposes because the estimated figures represent only a part of the population considered.

INDTRODUCTION

Elucidation of feeding ecology and ecosystem studies is one of the main objectives of the JARPNII. It is important to develop ecosystem models. The number of whales distributed in the study area can be used as input data for ecosystem modeling. It was suggested that the main distribution area of blue, fin, humpback and North Pacific right whales moves from May to August (Miyashita *et al*., 1995; Matsuoka *et al*., 2009). Given this, the number of whales are estimated in the early (May – June) and late (July – September) seasons, respectively.

MATERIALS AND METHODS

Sighting data used in this study

Dedicated sighting surveys were conducted during 2008-2014. Among the surveys, survey data that covered the JARPNII survey area (i.e. east of Japanese coast, west of 170ºE, north of 35ºN, south of Russian and US EEZ) were used for this analysis. Survey periods and vessels used for these surveys are shown in Table 1. The numbers of whales distributed in the JARPNII survey area were estimated in the early and late seasons. Considering the survey period and survey area, there are three data sets to estimate the number of the whales distributed in the JARPNII survey area. For the early season, the numbers were estimated for the 2009 survey, and 2011 and 2012 1st surveys combined. For the late season, the numbers were estimated for the 2008 survey. Figures 1-4 show plots of primary effort and sightings for the blue, fin, humpback and North Pacific right whales in the early and late seasons, respectively.

Abundance estimation

Analytical procedures are similar to those used in Hakamada and Matsuoka (2015).

For this analysis it is assumed that g(0)=1. Detections are truncated at 3.0 n.miles for all whale species examined. Abundance and its CV were estimated based on a Horvitz-Thompson like estimator of abundance expressed by formula (1) and (2), respectively.

$$P = \frac{A}{2WL}\sum_{i=1}^{n}\frac{s_i}{p_i(z_i)}$$
$$= \frac{A}{2L}\sum_{i=1}^{n}s_i\hat{f}(0 \mid \mathbf{z}_i) \qquad (1)$$

where P is abundance estimate, A is area size of the surveyed area, W is truncation distance (3.0 n.miles), L is searching effort, n is the number of schools detected within perpendicular distance of W, s_i is school size of ith detection, $p_i(z_i)$ is the probability that school i is detected given that it is within the perpendicular distance W and given the covariate z_i. $f(0|z_i)$ is conditional probability density function of distance 0 given covariates z_i

$$\mathrm{var}(P) = \left(\frac{A}{2WL}\right)^2 \left\{ \frac{1}{L(K-1)} \sum_{k=1}^{K} l_k \left(\frac{P_{Ck}}{l_k} - \frac{P_C}{L} \right)^2 + \sum_{j=1}^{r}\sum_{m=1}^{r} \frac{\partial P_C}{\partial \theta_j} \frac{\partial P_C}{\partial \theta_m} H_{jm}^{-1}(\theta) \right\} \quad (2)$$

where K is the number of transect, l_k is searching distance in kth transect, P_{Ck} is abundance estimate in covered region (within 3 n.miles from track line surveyed) in kth transect, P_C is abundance estimate in the covered region, $H_{jm}^{-1}(\theta)$ is the jmth element of inverse of Hessian matrix of detection function for covariate θ.

Multiple Covariate Distance Sampling (MCDS) Engine in DISTANCE program was used (Thomas et al., 2010). Given previous discussions at the IA sub-committee on detection function (IWC, 2015), Half Normal and Hazard Rate models were considered as candidate models for the detection function. Full model of the detection function was provided by

$$g(x) = 1 - \exp\left\{ -\left(x \big/ a\exp(Size + Beaufort + Year) \right)^{-b} \right\} \qquad (3)$$

$$g(x) = \exp\left[-x^2 \big/ 2a^2 \exp\{2(Size + Beaufort + Year)\} \right] \qquad (4)$$

where x is perpendicular distance, a and b ($b \geqq 1$) are parameter, *Size* is observed school size, *Beaufort* is categorical variable for Beaufort sea state (good: 0-3, bad: 4-5) and *Year* is categorical variable for year. To estimate detection function, all primary sightings occurred during 2008-2014 were used.

AIC was used to select the best model to estimate detection probability of $1/Wf(0|z_i)$.

Smearing was not conducted on running MCDS because MCDS doesn't deal with smearing. Perpendicular distance was not binned on fitting detection function because selection of cut point could affect results of model selection and coefficient estimates of detection function .

Sensitivity analysis
Effect of including/excluding covariates in the detection function such as Beaufort sea state, school size and year. If difference in AIC of detection function is not substantially different among the models, weighted average by Akaile weight (Buckland *et al*, 1997; Burnham and Anderson, 2002) would be estimated.

Averaged abundance
Average over abundance estimates base case and in sensitivity analysis were also estimated. By using Akaike weight, weight is larger as model is better. Akaike weights are defined as follows;

$$w_i = \frac{\exp(-\Delta\mathrm{AIC}_i/2)}{\sum_{j=1}^{16}\exp(-\Delta\mathrm{AIC}_j/2)} \quad (5)$$

The weighted average over the abundance estimates P_w and their standard errors were estimated by equations as follows.

$$P_w = \sum_{i=1}^{16} w_i P_i \quad (6)$$

$$\mathrm{CV}(P_w) = \frac{\sqrt{\sum_{i=1} w_i^2 \ \mathrm{var}(P_i) + 2\sum_{i\neq j} w_i w_j \ \mathrm{cov}(P_i, P_j)}}{P_w} \quad (7)$$

where

$$\Delta\mathrm{AIC}_i = \mathrm{AIC}_i - \mathrm{AIC}_{\min} \quad (8)$$

RESULTS

The number of the whales distributed in JARPNII survey area

Table 2 shows AIC for each model of detection functions for blue, fin, humpback and North Pacific right whales. Half Normal model without covariates were selected for blue, fin and humback whales. Half Normal with Beaufort was selected for the NP righti whales. Figure 5 shows plot of the selected detection function for blue, fin, humpback and North Pacific right whales, respectively. Figure 6 shows qq-plot of the detection function for blue, fin, humpback and North Pacific right whales, respectively. These figures suggests the fit of the detection function good. Table 3 shows the estimated number by strata for blue, fin and humpback and North Pacific right whales. Table 4 shows abundance estimate in the early season for blue, fin, humpback and North Pacific right whales. The estimated number of the whales distributed in the early season were estimated for 2008 and 2011+ the 1st survey in 2012 combined in each stratum. Table 5 shows the estimated number of the whales distributed in the late season for blue, fin, humpback and North Pacific right whales. The numbers in the late season were estimated for 2009.

Sensitivity analysis

Table 6 shows that the number of the whales distributed shown in Tables 4 and 5 would change when applying detection functions other than the best model. For comparison, the estimated number applying the best detection function is also included in the table. Table 7 shows weighted averages using Akaike weight. CVs are under-estimates because variances of AIC are not taken into account. The difference in point estimate is small

DISCUSSION

In this analysis, sighting survey data during 2008-2014 were used to estimate detection function. There may be room to improve detection function estimation. For example, pooling sighting data during 2002-2014 JARPNII dedicated sighting surveys together to estimate detection function.

The number is larger in the early season than in the late season for humpback and North Pacific right whales whereas the number is larger in the late season for blue and fin whales. Given that from previous studies it was suggested that the main distribution area moves north from May to September (Miyashita *et al*., 1995; Matsuoka *et al*, 2009), this may suggest main distribution area of humpback and NP right whales passed through JARPNII survey area earlier than those of blue and fin whales.

The estimated number is larger in 2011 and 2012 than in 2009 for blue, fin, humpack and North Pacific right whales whereas the estimated number is larger in 2009 for common minke, Bryde's and sei whales (Hakamada and Matsuoka, 2016: SC/F16/JR12). This may be due to the distribution pattern of these whales rather than an indication that the stock size of these species has changed.

There were some primary sightings for the blue, fin and humpback whales during IWC-POWER cruise. Abundance estimation using these sighting data can be useful for further investigation of the distribution and abundance for these whale species.

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Table 1. Summary information on dedicated sighting survey under JARPNII.

Year	Vessels	Period	Survey area
2008	KK1, KS2	2Jul.-29Aug.	SA7, 8, 9
2009	KK1, YS1	23May-23Jun.	SA7, 8, 9
2011	YS1, YS2,YS3	5May-5Jun.	SA8,9
2012 1st	YS3	18May-29Jun.	SA7CS,7CN,7WR,7E

Table 2. AIC for each model of detection functions for base case. For selected model, AIC is indicated by bold letters. HR: Hazard Rate and HN: Half Normal. NC indicates that estimation was "Not Converged"

Blue whale

Model	HR	HN
School size+Beaufort+Year	115.2	112.9
School size+Beaufort	113.3	112.4
School size+Year	114.5	113.5
Beaufort+Year	113.7	111.1
School size	113.1	111.9
Beaufort	111.8	110.4
Year	112.6	111.5
No covariate	111.2	**110.0**

Fin whale

Model	HR	HN
School size+Beaufort+Year	225.6	224.4
School size+Beaufort	223.6	222.4
School size+Year	224.1	223.8
Beaufort+Year	223.7	222.5
School size	222.2	221.9
Beaufort	221.8	220.5
Year	222.4	221.8
No covariate	220.5	**219.9**

Humpback whale

Model	HR	HN
School size+Beaufort+Year	262.7	260.1
School size+Beaufort	260.8	258.1
School size+Year	261.0	258.7
Beaufort+Year	261.0	258.4
School size	259.1	256.8
Beaufort	259.1	256.5
Year	259.5	257.3
No covariate	257.6	**255.5**

Northern Pacific right whale

Model	HR	HN
School size+Beaufort+Year	NC	NC
School size+Beaufort	33.8	31.0
School size+Year	38.4	36.4
Beaufort+Year	NC	NC
School size	36.6	35.2
Beaufort	32.1	**29.3**
Year	36.8	34.7
No covariate	35.1	33.8

Table 3. Abundance estimates for the blue, fin, humpback and north Pacific right whales and their CV's for each stratum based on 2008, 2009, 2011 and 2012 JARPNII cruises for the best model of detection function. *A* is area size of the surveyed area, n_s and n_w are the number of schools detected and the number of individuals detected within perpendicular distance of 1.5 n.miles for the common minke and 3.0 n.miles for Bryde's and sei whales, L is searching distance, P is abundance estimate and CI is abbreviation for confidence interval.

Blue whale

Year	Stratum	*A*	*L*	n_s	n_w	n_w/L*100	CV(n_w/L)	***P***	CV(P)	95%LL	95%UL
2008	7	166,306	886.5	9	11	1.241	0.686	**520**	0.696	106	2,549
2008	8	162,789	1193.6	2	2	0.168	0.643	**69**	0.654	19	245
2008	9	499,235	3067.0	6	9	0.293	0.624	**369**	0.635	112	1,219
2009	7	166,306	1036.5	-	-	-	-	**-**	-	-	-
2009	8	162,789	1084.5	1	1	0.092	0.970	**38**	0.977	5	277
2009	9	362,113	2274.1	-	-	-	-	**-**	-	-	-
2011	8	162,789	1101.5	3	3	0.272	0.493	**112**	0.506	27	469
2011	9N	208,660	1496.4	-	-	-	-	**-**	-	-	-
2011	9S	290,575	1492.8	1	1	0.067	1.005	**49**	1.011	6	378
2012	7CS	26,826	850.9	-	-	-	-	**-**	-	-	-
2012	7CN	16,171	649.2	-	-	-	-	**-**	-	-	-
2012	7WRN	6,874	175.7	-	-	-	-	**-**	-	-	-
2012	7WRS	66,117	750.1	-	-	-	-	**-**	-	-	-
2012	7E	48,208	302.3	-	-	-	-	**-**	-	-	-

Fin whale

Year	Stratum	*A*	*L*	n_s	n_w	n_w/L*100	CV(n_w/L)	***P***	CV(P)	95%LL	95%UL
2008	7	166,306	886.5	27	41	4.625	0.682	**2,300**	0.686	471	11,239
2008	8	162,789	1193.6	10	12	1.005	0.478	**489**	0.484	184	1,303
2008	9	499,235	3067.0	15	24	0.783	0.410	**1,168**	0.417	514	2,657
2009	7	166,306	1036.5	1	2	0.193	1.121	**96**	1.124	11	872
2009	8	162,789	1084.5	4	6	0.553	0.748	**269**	0.752	53	1,375
2009	9	362,113	2274.1	1	1	0.044	0.975	**48**	0.978	8	288
2010	2010_1	472,100	2150.3	4	5	0.233	0.575	**328**	0.579	102	1,055
2010	2010_2	519,631	2158.4	-	-	-	-	**-**	-	-	-
2011	8	162,789	1101.5	7	8	0.726	0.513	**354**	0.518	78	1,613
2011	9N	208,660	1496.4	13	18	1.203	0.425	**751**	0.431	264	2,133
2011	9S	290,575	1492.8	1	2	0.134	0.997	**116**	0.999	15	888
2012	7CS	26,826	850.9	-	-	-	-	**-**	-	-	-
2012	7CN	16,171	649.2	1	3	0.462	1.007	**22**	1.010	3	154
2012	7WRN	6,874	175.7	1	4	2.276	0.913	**47**	0.916	2	1,292
2012	7WRS	66,117	750.1	2	3	0.400	0.645	**79**	0.649	20	319
2012	7E	48,208	302.3	-	-	-	-	**-**	-	-	-

Humpback whale

Year	Stratum	*A*	*L*	n_s	n_w	n_w/L*100	CV(n_w/L)	***P***	CV(P)	95%LL	95%UL
2008	7	166,306	886.5	1	1	0.113	0.787	**55**	1.130	5.4	567.5
2008	8	162,789	1193.6	-	-	-	-	**-**	-	-	-
2008	9	499,235	3067.0	7	7	0.228	0.468	**336**	1.003	60.4	1874.7
2009	7	166,306	1036.5	5	9	0.868	0.782	**426**	0.786	78.7	2310.6
2009	8	162,789	1084.5	11	16	1.475	0.508	**709**	0.513	219.6	2290.8
2009	9	362,113	2274.1	-	-	-	-	**-**	-	-	-
2010	2010_1	472,100	2150.3	-	-	-	-	**-**	-	-	-
2010	2010_2	519,631	2158.4	-	-	-	-	**-**	-	-	-
2011	8	162,789	1101.5	11	13	1.180	0.463	**567**	0.469	142.5	2258.5
2011	9N	208,660	1496.4	13	19	1.270	0.646	**782**	0.650	172.1	3557.6
2011	9S	290,575	1492.8	-	-	-	-	**-**	-	-	-
2012	7CS	26,826	850.9	7	9	1.386	0.578	**84**	0.583	25.9	271.1
2012	7CN	16,171	649.2	7	11	6.260	0.453	**81**	0.458	29.8	219.6
2012	7WRN	6,874	175.7	7	9	1.200	0.617	**104**	0.622	9.4	1143.8
2012	7WRS	66,117	750.1	6	8	2.646	0.635	**208**	0.639	52.6	825.0
2012	7E	48,208	302.3	2	2	0.081	0.724	**94**	0.728	12.1	733.1

North Pacific right whale

Year	Stratum	A	L	n_s	n_w	n_w/L	CV(n_w/L)	P	CV(P)	95%LL	95%UL
2008	7	166,306	886.5	-	-	-	-	-	-	-	-
2008	8	162,789	1193.6	-	-	-	-	-	-	-	-
2008	9	499,235	3067.0	5	6	0.002	0.495	**416**	0.653	123	1,402
2009	7	166,306	1036.5	-	-	-	-	-	-	-	-
2009	8	162,789	1084.5	-	-	-	-	-	-	-	-
2009	9	362,113	2274.1	-	-	-	-	-	-	-	-
2011	8	162,789	1101.5	2	2	0.002	1.101	**79**	1.134	5	1,197
2011	9N	208,660	1496.4	11	18	0.012	0.462	**1,068**	0.454	396	2,882
2011	9S	290,575	1492.8	-	-	-	-	-	-	-	-
2012	7CS	26,826	850.9	-	-	-	-	-	-	-	-
2012	7CN	16,171	649.2	-	-	-	-	-	-	-	-
2012	7WRN	6,874	175.7	-	-	-	-	-	-	-	-
2012	7WRS	66,117	750.1	-	-	-	-	-	-	-	-
2012	7E	48,208	302.3	-	-	-	-	-	-	-	-

Table 3 (Continued)

Table 4. Abundance estimate for blue, fin, humpback and north Pacific right whales in JARPNII survey area (i.e. sub-areas 7, 8 and 9 excluding foreign EEZ) in early season for 2009 and 2011+1st survey in 2012 combined assuming that g(0)=1.

Early	Blue		Fin		Humpback		NP right	
	P	CV(P)	***P***	CV(P)	***P***	CV(P)	***P***	CV(P)
2009	**38**	0.977	**413**	0.569	**1,136**	0.438	0	-
2011+2012_1st	**161**	0.474	**1,369**	0.295	**1,921**	0.318	**1,147**	0.434

Table 5. Abundance estimate for blue, fin, humpback and north Pacific right whales in the JARPNII survey area in late season for 2008 assuming g(0)=1.

Late	Blue		Fin		Humpback		NP right	
	P	CV(P)	***P***	CV(P)	***P***	CV(P)	***P***	CV(P)
2008	**958**	0.461	**3,958**	0.425	**392**	0.877	**416**	0.653

Table 6. Abundance estimate for blue, fin humpback and north Pacific right whales in JARPNII survey area in early and late seasons for sensitivity test (i.e. applying alternative detection function other than the best model). Bold letter indicates the estimate is based on the best model. It is assumed that g(0)=1.

Blue whale

Early (2009)

Model	Covariates	P	CV(P)	Model	Covariates	P	CV(P)
Hazard Rate	S+B+Y	56	1.029	Half Normal	S+B+Y	41	1.034
	S+B	57	1.030		S+B	44	0.985
	S+Y	35	0.982		S+Y	39	0.983
	B+Y	48	1.005		B+Y	42	1.034
	S	35	0.983		S	37	0.980
	B	49	1.008		B	45	1.250
	Y	36	0.981		Y	39	0.979
	None	36	0.982		None	**38**	**0.977**

Early (2011+2012_1st)

Model	Covariates	**P**	CV(P)	Model	Covariates	P	CV(P)
Hazard Rate	S+B+Y	202	0.779	Half Normal	S+B+Y	352	1.056
	S+B	185	0.594		S+B	162	0.512
	S+Y	106	0.499		S+Y	127	0.560
	B+Y	192	0.731		B+Y	352	1.057
	S	149	0.485		S	158	0.479
	B	170	0.550		B	163	0.275
	Y	106	0.500		Y	127	0.560
	None	152	0.483		None	**161**	**0.474**

Late (2008)

Model	Covariates	**P**	CV(P)	Model	Covariates	P	CV(P)
Hazard Rate	S+B+Y	1,052	0.524	Half Normal	S+B+Y	900	0.550
	S+B	1,067	0.525		S+B	1,005	0.484
	S+Y	923	0.480		S+Y	1,000	0.468
	B+Y	1,032	0.506		B+Y	883	0.528
	S	917	0.484		S	978	0.470
	B	1,058	0.507		B	1,001	0.234
	Y	907	0.468		Y	994	0.464
	None	905	0.470		None	**958**	**0.461**

Fin whale

Early (2009)

Model	Covariates	**P**	CV(P)	Model	Covariates	P	CV(P)
Hazard Rate	S+B+Y	392	0.586	Half Normal	S+B+Y	381	0.581
	S+B	384	0.577		S+B	387	0.576
	S+Y	417	0.578		S+Y	422	0.573
	B+Y	390	0.589		B+Y	383	0.578
	S	406	0.510		S	413	0.562
	B	382	0.579		B	386	0.572
	Y	420	0.583		Y	422	0.573
	None	408	0.576		None	**413**	**0.569**

Early (2011+2012_1st)

Model	Covariates	P	CV(P)	Model	Covariates	P	CV(P)
Hazard Rate	S+B+Y	1,316	0.320	Half Normal	S+B+Y	1,398	0.302
	S+B	1,342	0.301		S+B	1,378	0.287
	S+Y	1,305	0.325		S+Y	1,332	0.310
	B+Y	1,319	0.315		B+Y	1,378	0.296
	S	1,346	0.273		S	1,368	0.304
	B	1,343	0.297		B	1,368	0.284
	Y	1,312	0.323		Y	1,335	0.306
	None	1,353	0.307		None	**1,369**	**0.295**

Late (2008)

Model	Covariates	**P**	CV(P)	Model	Covariates	P	CV(P)
Hazard Rate	S+B+Y	4,016	0.447	Half Normal	S+B+Y	4,087	0.436
	S+B	3,946	0.440		S+B	4,127	0.433
	S+Y	3,965	0.444		S+Y	4,039	0.432
	B+Y	4,051	0.444		B+Y	4,041	0.433
	S	3,858	0.158		S	3,955	0.425
	B	3,980	0.437		B	4,067	0.428
	Y	4,025	0.443		Y	4,047	0.430
	None	3,911	0.434		None	**3,958**	**0.425**

Table 6 (Continued)

Humpback whale
Early (2009)

Model	Covariates	**P**	CV(P)	Model	Covariates	P	CV(P)
Hazard Rate	S+B+Y	966	0.473	Half Normal	S+B+Y	1,095	0.468
	S+B	1,030	0.444		S+B	1,099	0.438
	S+Y	968	0.474		S+Y	1,114	0.469
	B+Y	997	0.474		B+Y	1,172	0.471
	S	1,023	0.443		S	1,074	0.435
	B	1,056	0.442		B	1,145	0.439
	Y	1,005	0.475		Y	1,220	0.473
	None	1,055	0.442		None	**1,136**	**0.438**

Early (2011+2012_1st)

Model	Covariates	**P**	CV(P)	Model	Covariates	P	CV(P)
Hazard Rate	S+B+Y	1,804	0.322	Half Normal	S+B+Y	1,922	0.314
	S+B	1,788	0.319		S+B	1,921	0.312
	S+Y	1,793	0.323		S+Y	1,879	0.315
	B+Y	1,813	0.323		B+Y	1,936	0.316
	S	1,779	0.320		S	1,888	0.313
	B	1,795	0.319		B	1,948	0.314
	Y	1,802	0.326		Y	1,892	0.319
	None	1,785	0.323		None	**1,921**	**0.318**

Late (2008)

Model	Covariates	**P**	CV(P)	Model	Covariates	P	CV(P)
Hazard Rate	S+B+Y	368	0.896	Half Normal	S+B+Y	432	0.895
	S+B	393	0.884		S+B	433	0.881
	S+Y	357	0.897		S+Y	422	0.895
	B+Y	363	0.896		B+Y	435	0.894
	S	378	0.880		S	409	0.878
	B	385	0.883		B	426	0.880
	Y	347	0.896		Y	421	0.894
	None	364	0.878		None	**392**	**0.877**

North Pacific right whale
Early (2011+2012_1st)

Model	Covariates	**P**	CV(P)	Model	Covariates	P	CV(P)
Hazard Rate	S+B+Y	-	-	Half Normal	S+B+Y	-	-
	S+B	1,179	0.516		S+B	1,292	0.592
	S+Y	843	0.502		S+Y	831	0.487
	B+Y	-	-		B+Y	-	-
	S	910	0.503		S	880	0.472
	B	1,151	0.465		B	**1,147**	**0.434**
	Y	884	0.532		Y	871	0.476
	None	940	0.504		None	962	0.461

Late (2008)

Model	Covariates	**P**	CV(P)	Model	Covariates	P	CV(P)
Hazard Rate	S+B+Y	-	-	Half Normal	S+B+Y	-	-
	S+B	389	0.673		S+B	393	0.679
	S+Y	407	0.691		S+Y	463	0.629
	B+Y	-	-		B+Y	-	-
	S	356	0.557		S	347	0.517
	B	418	0.683		B	**416**	**0.653**
	Y	382	0.669		Y	476	0.640
	None	327	0.560		None	335	0.522

Table 6 (Continued)

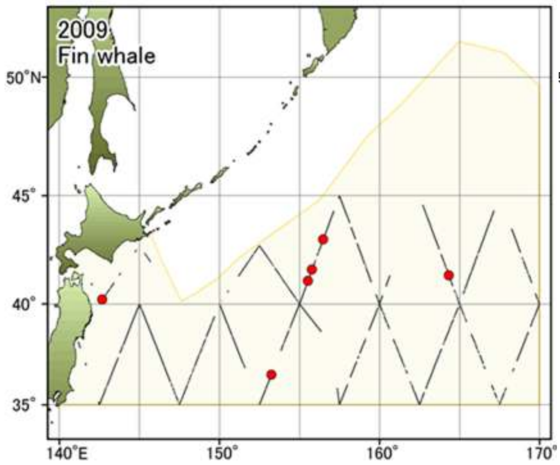
Table 7. Weighted average of abundance estimates in Table 6 by Akaike weight for sensitivity.

Early

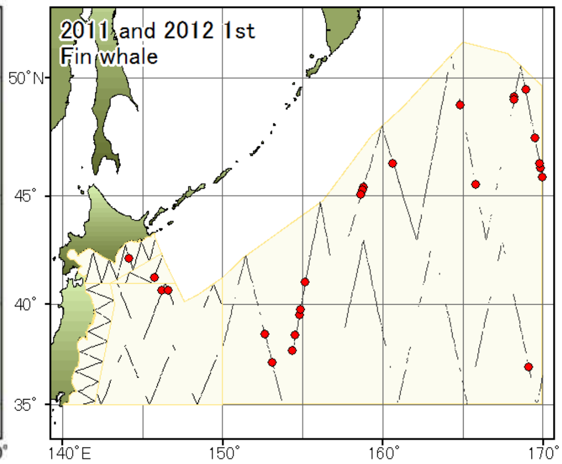
Early	Blue			Fin			Humpback			NP right		
	P	CV(P)	Change from base case	***P***	CV(P)	Change from base case	***P***	***CV(P)***	Change from base case	***P***	CV(P)	Change from base case
2009	41	0.980	9.0%	402	0.565	-2.5%	1,127	0.426	-0.7%	-	-	-
2011+2012_1st	181	0.496	12.8%	1,354	0.287	-1.1%	1,886	0.309	-1.8%	1,137	0.371	-0.9%

Late

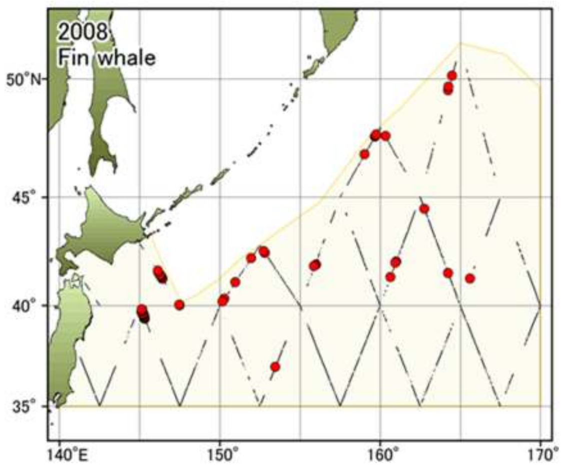
Late	Blue			Fin			Humpback			NP right		
	P	CV(P)	Change from base case	***P***	CV(P)	Change from base case	***P***	***CV(P)***	Change from base case	***P***	CV(P)	Change from base case
2008	967	0.452	0.9%	3,992	0.421	0.9%	406	0.509	3.6%	404	0.560	-2.9%



Early (2009)

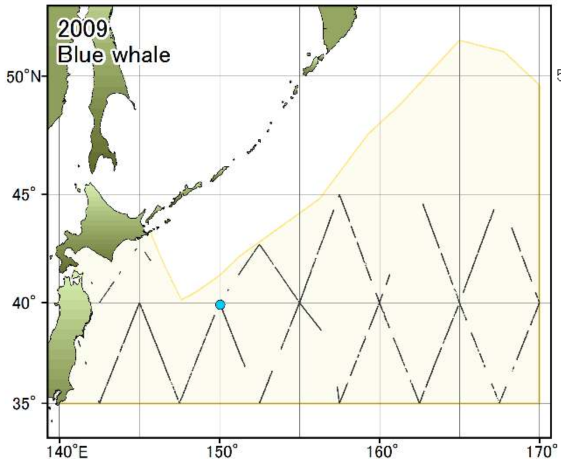


Early (2011 and 2012)

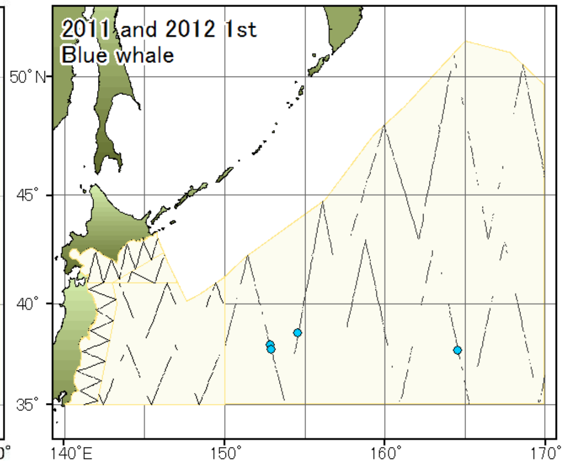


Late (2008)

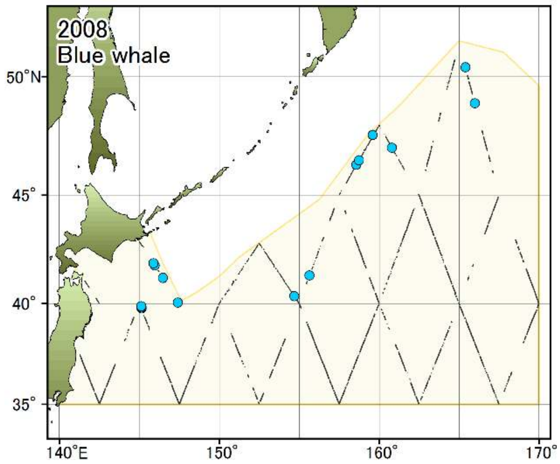
Figure 1. Plot of actually surveyed track line (black lines) and position of the fin whales (red circles) in the early and late seasons for 2008, 2009, 2011 and 2012 JARPNII surveys.



Early (2009)

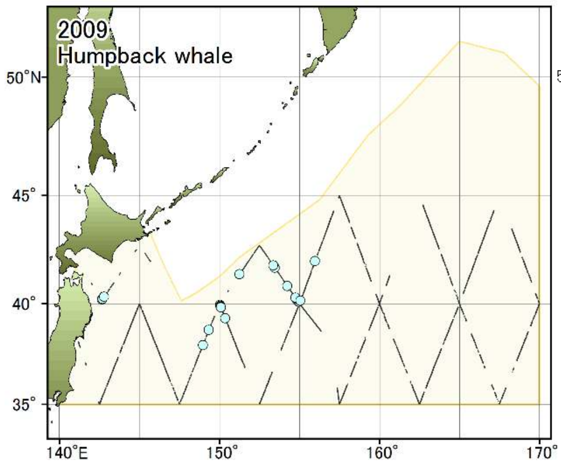


Early (2011 and 2012)

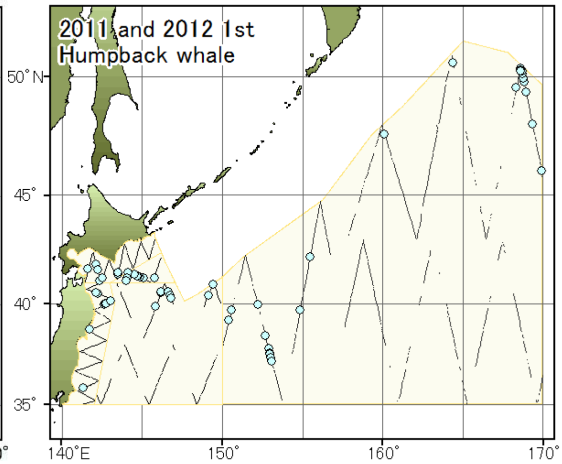


Late (2008)

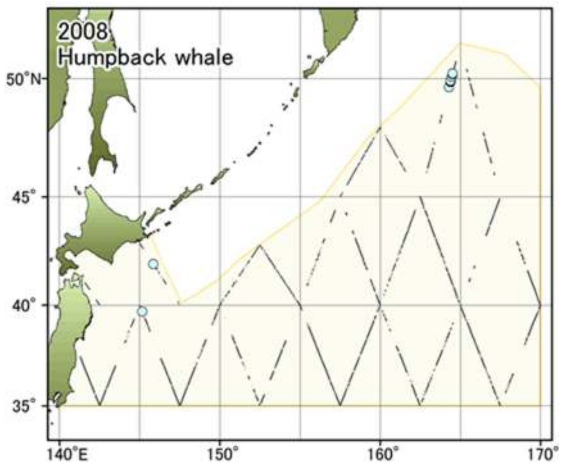
Figure 2. Plot of actually surveyed track line (black lines) and position of the blue whales (light blue circles) in the early and late seasons for 2008, 2009, 2011 and 2012 JARPNII surveys.



Early (2009)

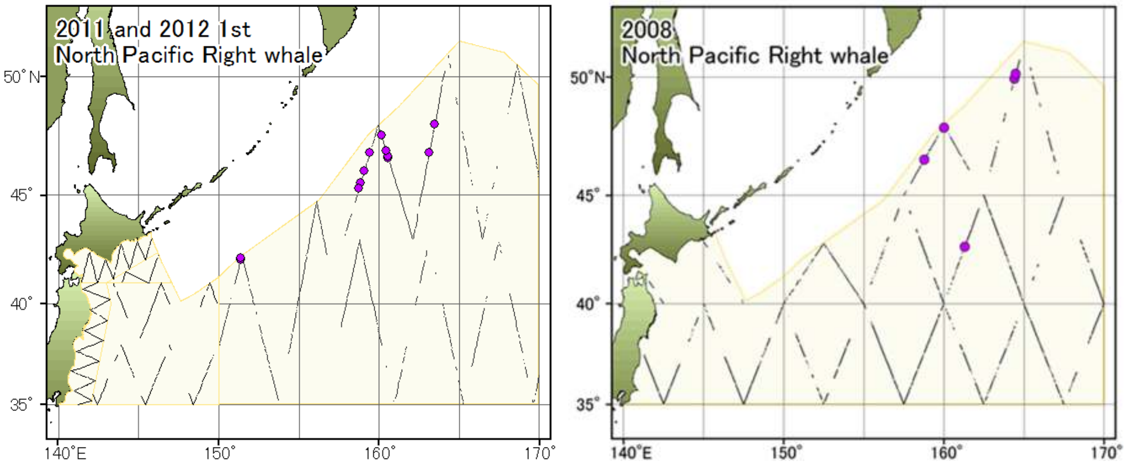


Early (2011 and 2012)



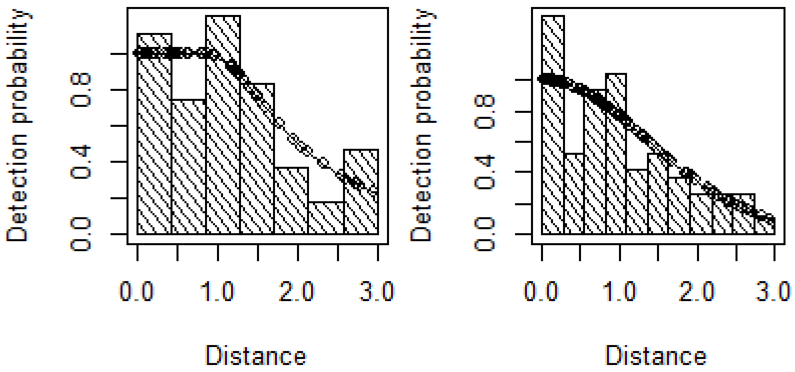
Late (2008)

Figure 3. Plot of actually surveyed track line (black lines) and position of the humpback whales (pale blue circles) in the early and late seasons for 2008, 2009, 2011 and 2012 JARPNII surveys.

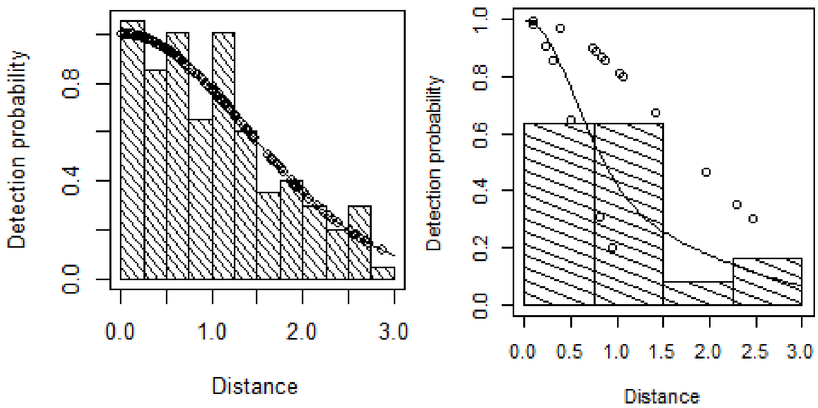


Early (2011and 2012) Late (2008)

Figure 4. Plot of actually surveyed track line (black lines) and position of the North Pacific Right whales (purple circles) in the early and late seasons for 2008, 20011 and 2012 JARPNII surveys.



Blue whale Fin whale



Humpback whale North Pacific right whale

Figure 5. Plot of the estimated detection function fitted to the number of schools as a function of perpendicular distance (n. miles) from the track line for the best model. Upper left panel is the plot for the blue whale, upper right panel is for fin whale, lower left panel is for humpback whale and lower right panel is for North Pacific right whale.

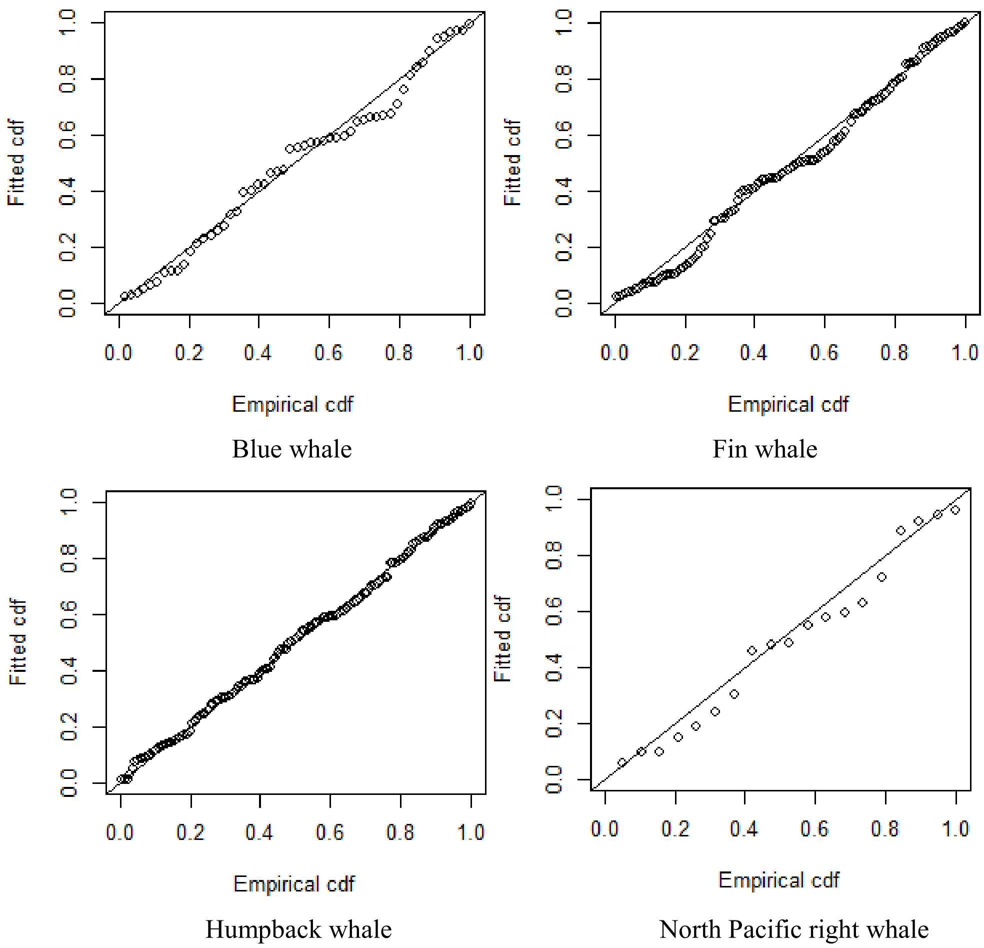


Figure 6. QQ-plot of the estimated detection function for the best model. Upper left panel is the plot for the blue whale, upper right panel is for fin whale, lower left panel is for humpback whale and lower right panel is for North Pacific right whale.