Distribution of blue (*Balaenoptera musculus*), fin (*B. physalus*), humpback (*Megaptera novaeangliae*) and north pacific right (*Eubalaena japonica)* whales in the western North Pacific based on JARPN and JARPN II sighting surveys (1994 to 2007)

Koji Matsuoka[1], Hiroshi Kiwada [1], Yoshihiro Fujise [1] and Tomio Miyashita [2]

[1] The Institute of Cetacean Research, 4-5, Toyomi, Chuo, Tokyo 104-0055, Japan
[2] National Research Institute of Far Seas Fisheries, Fisheries Research Agency, 2-12-4, Fukuura, Kanazawa, Yokohama, 236-8648, Japan
Contact e-mail:matsuoka@cetacean.jp

ABSTRACT

We report here the Density Index (DI: individuals / 100 n.miles) and monthly distribution pattern of blue, fin, humpback and right whales from May to September in the western North Pacific based on JARPN (1994-1999) and JARPN II (2000-2007) sighting data. A total of 200,317.4 n.miles were surveyed in the sub-areas 7, 8 and 9. Among four species, fin whales were most frequently sighted, and next were blue, humpback and right whales in order. Monthly maps of the DI by 1 ° X 1 ° square are provided, using all primary effort and sightings data. Northward migration pattern of whales were observed for these species. Additionally, sighting areas of these species were spread out compare to the previous information except for right whales. Blue whales were mainly distributed north of 35 ° N in the sub-areas 8 and 9 (275 schools and 387 individuals; Mean schools size (Mss) was 1.41 individuals including 17 mother and calf pairs). The DI of this species was 0.20. A high density area was observed north of 45 ° N in sub-area 9. Surface temperature (ST) ranged from 3.0 to 21.6 ° C. Fin whales were mainly sighted in sub-areas 8 and 9 (506 schools and 740 individuals; Mss: 1.46, including 28 mother and calf pairs). Distribution patterns were similar to blue whales. DI of this species was 0.38. A high density area was observed north of 45 ° N in sub-area 9. The ST ranged from 3.4 to 24.1 ° C. Humpback whales were mainly distributed north of 37 ° N in the sub-areas 7, 8 and 9 (321 schools and 473 individuals; Mss: 1.47, including 29 mother and calf pairs). DI was 0.16. The ST ranged from 3.6 to 22.7 ° C. Right whale was the most rare baleen whale species sighted in the research area. They were mainly distributed north of 37 ° N in the sub-areas 7, 8 and 9 (28 schools and 40 individuals; Mss: 1.43, including 6 mother and calf pairs. The DI was 0.02. Surface temperature ranged from 3.0 to 17.0 ° C. This new information will contribute to marine ecosystem studies in the western North Pacific where information has been lacking since the cessation of commercial whaling. Further continuation of the systematic sighting surveys including in foreign EEZ areas are required to improve information on seasonal distribution of baleen whales.

KEY WORDS: PACIFIC OCEAN, SURVEY VESSEL, DISTRIBUTION, BLUE WHALE, FIN WHALE, HUMPBACK WHALE, RIGHT WHALE

INTRODUCTION

The JARPN II (Japanese Whale Research Program under special permit in the western part of North Pacific-Phase II） was designed with the aim to elucidate the a) feeding ecology and ecosystem studies, b) Monitoring environmental pollutant in cetaceans and the marine ecosystem, c) Stock structure of large whales (Common minke, Bryde's, sei and

sperm whales).

The JARPN (1994-1999) and JARPN II (2000-2007, on going) have been conducted the systematic whale sighting survey with and without the sampling activity. Research area of the JARPN and JARPN II is the Pacific waters north of 35 ° N in sub-areas 7, 8 and 9 except the 200 n.miles EEZ of foreign countries. In the Sea of Okhotsk, it covered only sub-area 11 also except the Russian EEZ. All whale species sighted are recorded during the sighting surveys. Details of the outline of the JARPN and JARPN II surveys were reviewed by Fujise (2000), Tamura *et al*. (2008) and Kiwada *et al.*, (2008). Sighting data by JARPN for blue (*Balaenoptera musculus*), fin (*B. physalus*), humpback (*B. musculus*), right (*Eubalaena japonica*) and common minke whales (*B. acutorostrata*) were reported to the JARPN review meeting which held by the IWC/SC in 1999 (Matsuoka *et al.*, 2000, Okamura *et al.*, 2001). In this paper, we examined the blue, fin, humpback and right whale distribution patterns using the JARPN and JARPN II sighting data as a contribution other than the original objectives of JARPN II.

MATERIAL AND METHODS

Sighting data used in this analysis

In this paper, we used all JARPN (1994-1999) and JARPN II (2000-2007) systematic sighting survey data (effort and primary sightings) collected by sighting and sampling vessel (SSV) and dedicated sighting vessel (SV). Outline of sighting survey are followings;

Sighting procedure

The sighting procedure of JARPN II (2000-2007) was not largely changed during the JARPN (1994-1999) surveys with some minor changes of the sighting procedure, which were reviewed by Fujise (2000), Tamura *et al*. (2008) and Kiwada *et al*. (2008). The research vessels equipped with barrel, where three top men conducted sighting observation. On the upper bridge, a captain, a gunner, a helmsman and a researcher also conducted the sighting. The sighting activity was continued if weather permitted during daytime from 30 minutes after sunrise to 30 minutes before the sunset.

Survey modes

Searching was conducted under closing mode. Furthermore, two survey modes were adopted as NSC (Normal Search Closing, effort code was BC) mode and NSS (Normal Search closing with Special, effort code was BS) modes by taking into consideration the sea condition at the time of the searching. The NSC (BC) mode was under the normal weather conditions defined as visibility of 2 n.miles or more and wind velocity 4 or below. The NSS (BS) was under the unfavorable conditions defined as except the BC mode, but under which, the collection of whale samples was possible (Tamura *et al*. ,2008). Searching was conducted two survey modes (closing (ASP) and passing (NSP) modes) by the dedicated sighting vessel (SV) (Kiwada *et al*. 2008).

Cruise track (Main survey and SMS)

The Main survey, the zigzag-shaped track line was established to cover survey area. Furthermore, the ‘Special Monitoring Survey (SMS)’ was adopted in area where the density of whales was expected to be high in order to take sample of whales efficiently. The vessels conducted the sighting surveys 6 and 4 n.miles away from each other in the Main survey and the SMS survey, respectively.

Confirmation of the sightings

When the cetacean school of which species seemed to be minke whales or other large cetaceans was sighted in the research area, the ship closed to the school immediately in order to identify the species, estimate the school size and get other biological information (number of calf, estimated body length etc.). To improve the estimation of the distance to the school and the angle from the bow, the training was conducted in the early time of each cruise by each vessel. Distance was estimated by referring the scale in the binocular and angle was also estimated referring the angle board.

Surface temperatures were recorded by each whale sighting.

RESULTS AND DISCUSSIONS

Primary searching efforts

A total of 200,317.4 n.miles were surveyed in the sub-areas 7, 8 and 9 between 1994 and 2007. Figure 1 show the research area and the primary searching effort (n,mile) of JARPN and JARPN II by Lat.1°× Long.1°square. Research area was covered completely during the surveys.

Distribution pattern of whales in sub-areas 7, 8 and 9

Table 1 shows the summary of the primary whale sightings in the JARPN and JARPN II during 1994 to 2007. Table 2 shows the summary of primary whale sightings in each sub-area. Figures 2a and 2b show the distribution of the density index (number of the primary sightings of individuals / 100 n.miles) using primary searching efforts and number of primary sightings (individuals) of blue, fin, humpback and right whales in the research area between 1994 and 2007. Figure 3a, 3b, 3c and 3d show the monthly change in the density index of these species during the surveys.

Northward migration pattern of whales

Figures 3a to 3c show the monthly changes of the whale distributions with the search effort from May to September. As a whole, the main distribution areas of blue, fin, humpback and right whales were moved northward from 35 ° N to 45 ° N from May to August in Pacific sub-areas, which coincided with previous large-scale distribution pattern by Miyashita *et. al*. (1995).

Blue whale

Blue whales were mainly distributed north of 35 ° N in the sub-areas 8 and 9 from May to September (275 schools and 387 individuals). Density index of this species was 0.20 (DIW: individuals / 100 n.miles) during the surveys. Mean schools size was 1.41 individuals including 17 mother and calf pairs (Table 1). High density area was observed north of 45 ° N in sub-area 9. Surface temperature was ranged from 3.0 ° C to 21.6 ° C. Northward migration pattern of whales were observed. The main distribution areas from 35 ° N to 40 ° N during May to June moved northward to north of 40 ° N during July to August in the sub-areas 8 and 9.

Blue whales are previously caught around the rim of the Western North Pacific. In summer they concentrated along the edge of the continental shelf and along the south side of the Aleutian Archipelago. There was a distribution gap between sub-areas 7 and 9 for this species using previous catch data in summer (Nishiwaki, 1966). However, JARPNII data show that there is no gap between sub-areas 7 and 9. This gap may be caused by a regulation of the whaling operation between coastal (land base type) and offshore (mother ship type) whaling. Further, according to the JSV sighting data collected between 1966 and 1990, blue whales were not sighted in sub-areas 7, 8 and 9 in June. On the other hand, this species were widely distributed in these sub-areas in June between 1994 and 2007.

Fin whale

Fin whales were most frequently sighted compare to blue, humpback and right whales. This species were mainly sighted in sub-areas 8 and 9 of which distribution patterns were similar to blue whale distributions. This species were mainly distributed north of 37 ° N in the sub-areas 7, 8 and 9 from May to September (506 schools and 740 individuals). The DIW of this species was 0.38. Mean schools size was 1.46 individuals including 28 mother and calf pairs (Table 1). High density area was observed north of 45 ° N in sub-area 9. Surface temperature was ranged from 3.4 ° C to 24.1 ° C. Northward migration pattern of whales were observed. The main distribution areas from 35 ° N to 40 ° N during May to June moved northward to north of 40 ° N during July to August in the sub-areas 8 and 9.

Fin whales were widely distributed in summer in the Western North Pacific and were caught along the outer shelf and south of the Aleutian Islands, and distribution gap between sub-areas 7 and 9 was observed for this species in

summer (Nishiwaki, 1966). However, present results show that there is no gap observed between sub-areas 7 and 9. This species was widely distributed in these sub-areas between 1994 and 2007.

Humpback whale

Humpback whales were mainly distributed north of 37 ° N in the sub-areas 7, 8 and 9 from May to September (321 schools and 473 individuals). The DIW of this species was 0.16. Mean schools size was 1.47 individuals including 29 mother and calf pairs (Table 1). High density areas were observed north of 35 ° N in the sub-areas 7 and 8, and north of 45 ° N in the sub-area 9. Surface temperature was ranged from 3.6 ° C to 22.7 ° C. Northward migration pattern of whales were observed. The main distribution areas from 37 ° N to 43 ° N in the sub-area 7 during May to June moved northward to north of 45 ° N during July to August in the sub-areas 8 and 9.

Present results confirm that distribution pattern of this species is similar to the previous knowledge on distribution pattern. However, new information is provided that, although humpback whales were not sighted in sub-areas 7 and 8 in May and June by the JSV sighting data (1966-1990), but this species were widely distributed in these sub-areas in May and June between 1994 and 2007.

Right whale

Right whale was most rare baleen whale species sighted in the research area. The DIW of this species was 0.02, which is 10 % of the blue whales (Table 1). This species were mainly distributed north of 37 ° N in the sub-areas 7, 8 and 9 from May to September (28 schools and 40 individuals). Mean schools size was 1.43 individuals including 6 mother and calf pairs. Surface temperature was ranged from 3.0 ° C to 17.0 ° C. Northward migration pattern of whales were observed. The main distribution area was north of 42 ° N during July to August in the sub-area 9.

Distribution pattern of this species were reported using catch and JSV data (Omura, 1986, Miyashita and Kato, 1998, Clapham *et al*., 2006), present results confirm existence of this species in the sub-area 7, 8 and 9 during 1994-2007, and distribution pattern is similar to the previous pattern during May to September.

New information and further survey requirements

Distribution information of blue, fin, humpback and right whales in the Western North Pacific had been reported using commercial whaling catch data (e.g. Nishiwaki, 1966) and sighting survey data (e.g. JSV data; 5 ° X 5 ° square analyses; Miyashita *et al*., 1995). Present information of whale distributions provided by JARPN and JARPN II during 1994 to 2007 is valuable as new information for these species. Overall, this information is more detailed rather than previous data. These new information indicated that sighting areas of these species were expanded out compare to the previous information except right whales, and will contribute to marine ecosystem studies in the western North Pacific.

The latest sighting data of the foreign 200 n.miles EEZ in the Sea of Okhotsk and the east of Kurile Islands during July and August were reported by Buckland *et* al., (1992) using Japanese whale sighting survey data conducted by the National Research Institute of Far Seas Fisheries in Japan. Further surveys are required to improve for seasonal distribution of baleen whales.

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REFERENCES

Buckland, S.T., Cattanach, K.L. and Miyashita, T., 1992. Minke whale abundance in the Northwest Pacific and the Okhotsk Sea estimated from 1989 and 1990 sighting surveys. Rep. Int. WHal. Commn. 42:387-90.

Clapham, P.J., Good, C., Quinn, S.E., Reeves, R.R., Scarff, J.E. and Brownell, R.L. 2004. Distribution of North Pacific right whales (Eubalaena japonica) as shown by 19th and 20th century whaling catch and sighting records. *J. Cetacean Res.Manage.* 6 (1):1-6.

Fujise, Y., 2000. Outline of the research activities under the Japanese Whale Research Program under a special permit in the North Pacific (JARPN) from 1994 to 1999. Document SC/F2K/J8 submitted to JARPN review meeting.

Kiwada, H., Kumagai, S. and Matsuoka, K., 2009. Methodology and procedure of the dedicated sighting surveys in JARPN II –Offshore and coastal component of Sanriku and Kushiro-. Paper SC/J09/JR2. 16pp.

Matsuoka, K., Hakamada, T., Fujise, Y. and Miyashita, T. 2000. Distribution pattern of minke whales based on sighting data during the JARPN 1994-1999. Paper SC/F2K/J16 presented at the JARPN Review Meeting, 7-10 February 2000 (unpublished). 17pp. [Paper available from the Office of this Journal].

Miyashita, T., Kato, H. and Kasuya, T. (Eds), 1995. Worldwide Map of Cetacean Distribution based on Japanese Sighting Data (Volume 1). National Research Institute of Far Seas Fisheries, Shimizu, Shizuoka, Japan.140pp.

Miyashita, T., Kato, H. 1998. Recent data on the status of right whales in the NW Pacific Ocean. Paper SC/M98/RW11 presented to the IWC Special Meeting of the Scientific Committee towards a Comprehensive Assessment of Right Whales Worldwide, 16-25 March, Cape Town, South Africa.

Nishiwaki, M., 1966. Distribution and migration of the larger cetaceans in the North pacific as shown by Japanese whaling results. In K. S. Norris, ed., Whales, dolphins, and porpoises. University of California Press, Berkely. CA. pages 171-191.

Okamura, H, Matsuoka K, Hakamada T, Okazaki M, and Miyashita, T., 2001. Spatial and temporal structure of the western North Pacific minke whale distribution inferred from JARPN sightings data. *J. Cetacean Res. Manage.* 3: 193-200.

Omura, H. 1986. History of right whale catches in the waters around Japan. *Rep. int. Whal. Commn* (special issue) 10:35-41.

Tamura, T., Matsuoka and Fujise, Y., 2009. Methodology and survey procedure under the JARPN II - offshore component- with special emphasis on whale sampling procedures. Paper SC/J09/JR4.16pp.

Table. 1. Summary of baleen whale sightings during the JARPN and JARPNII (1994-2007). Sch.: Number of the primary sightings of schools. Ind.: Number of the primary sightings of individuals. Calf: Number of calves including Ind.. Mss: mean school size (Ind. / Sch.). DIS: Density Index (schools / 100 n.miles). DIW: Density Index (individuals / 100 n.miles). WT: Range of surface temperature of the species sighting position.

Species	Western North pacific (sub-areas 7, 8 and 9)						
	Sch.	Ind.	Calf	Mss	DIS	DIW	WT
Blue whale	281	396	17	1.41	0.14	0.20	3.0 - 21.6°C
Fin whale	514	750	28	1.46	0.26	0.37	3.4 - 24.1°C
Humpback whale	323	476	29	1.47	0.16	0.24	3.6 - 22.7°C
Right whale	28	40	6	1.43	0.01	0.02	3.0 - 17.0°C

Table. 2. Summary of baleen whale sightings by sub-area during the JARPN and JARPNII (1994-2007).

Sea	Western North pacific					
Sub-area	Sub-area 7		Sub-area 8		Sub-area 9	
Latitude	35N-43N		35N - 45N		35N - 51N	
Longitude	Japanese coast - 150E		150E - 157E		157E - 170E	
Depth (m)	200-4000m<		4000 m <		4000 m <	
Species	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Blue whale	7	8	40	59	234	329
Fin whale	34	37	140	197	340	516
Humpback whale	97	139	103	158	123	179
Right whale	6	7	4	6	18	27

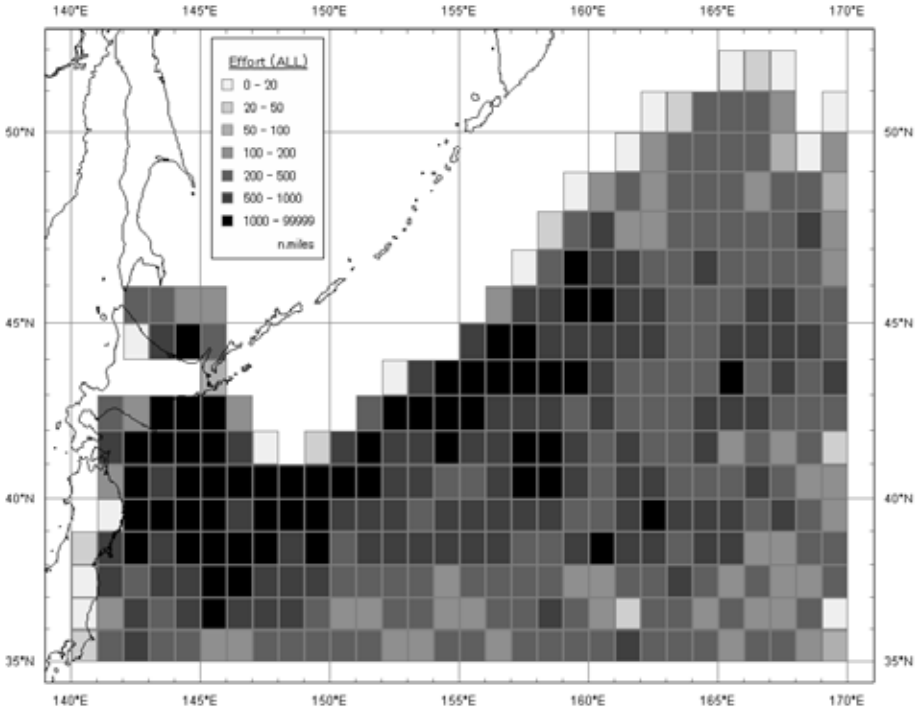

Figure 1. Distribution of the primary searching effort (n.mile) during JARPN and JARPN II (1994 to 2007) surveys by Lat.1°× Long.1°square.

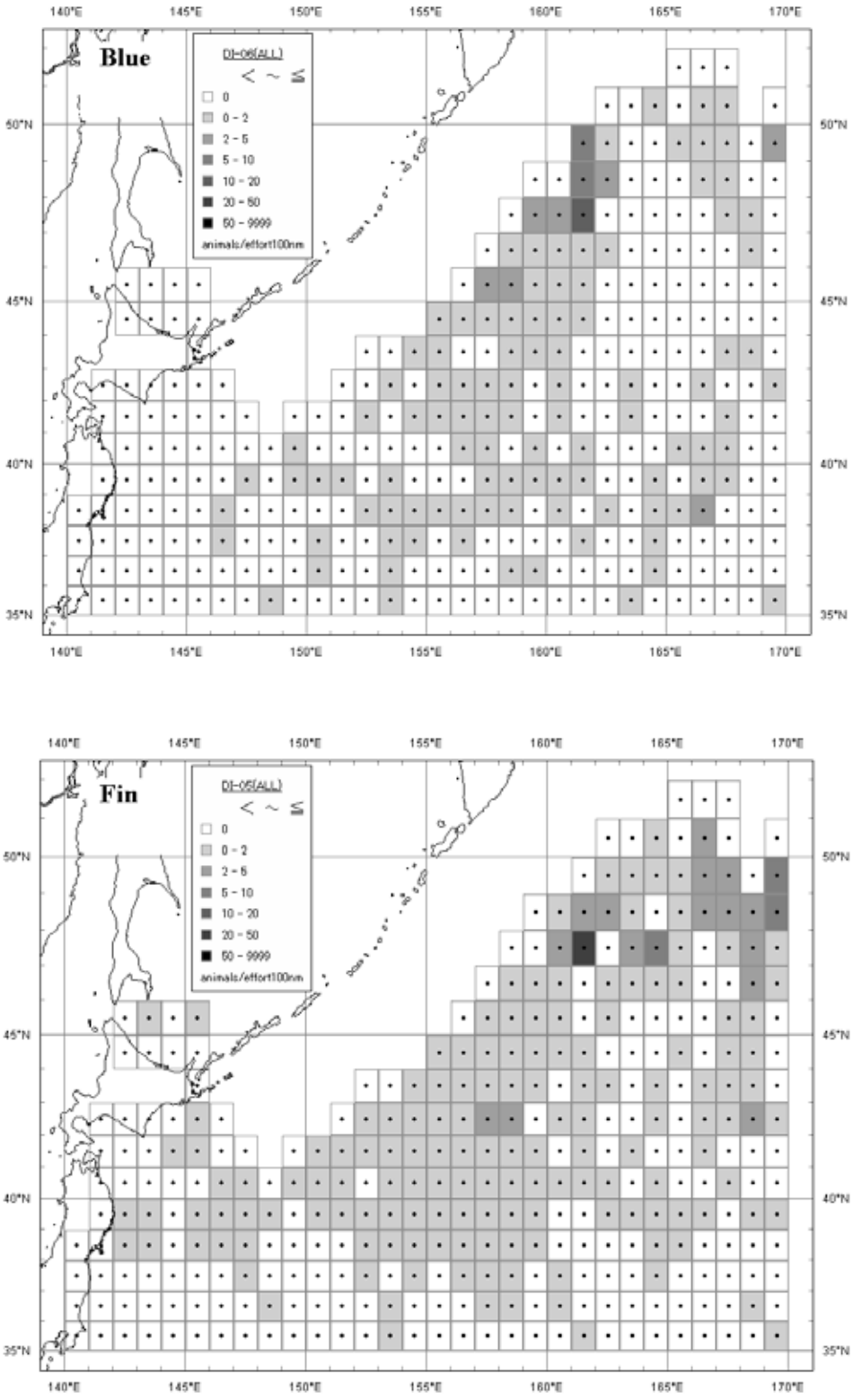

Figure 2a. Distribution of the Density Index (number of primary sightings of individuals / 100 n.mile) of whales during JARPN and JARPN II from 1994 to 2007 surveys by Lat.1°× Long.1°square.
Upper : blue whale, bottom : fin whale.

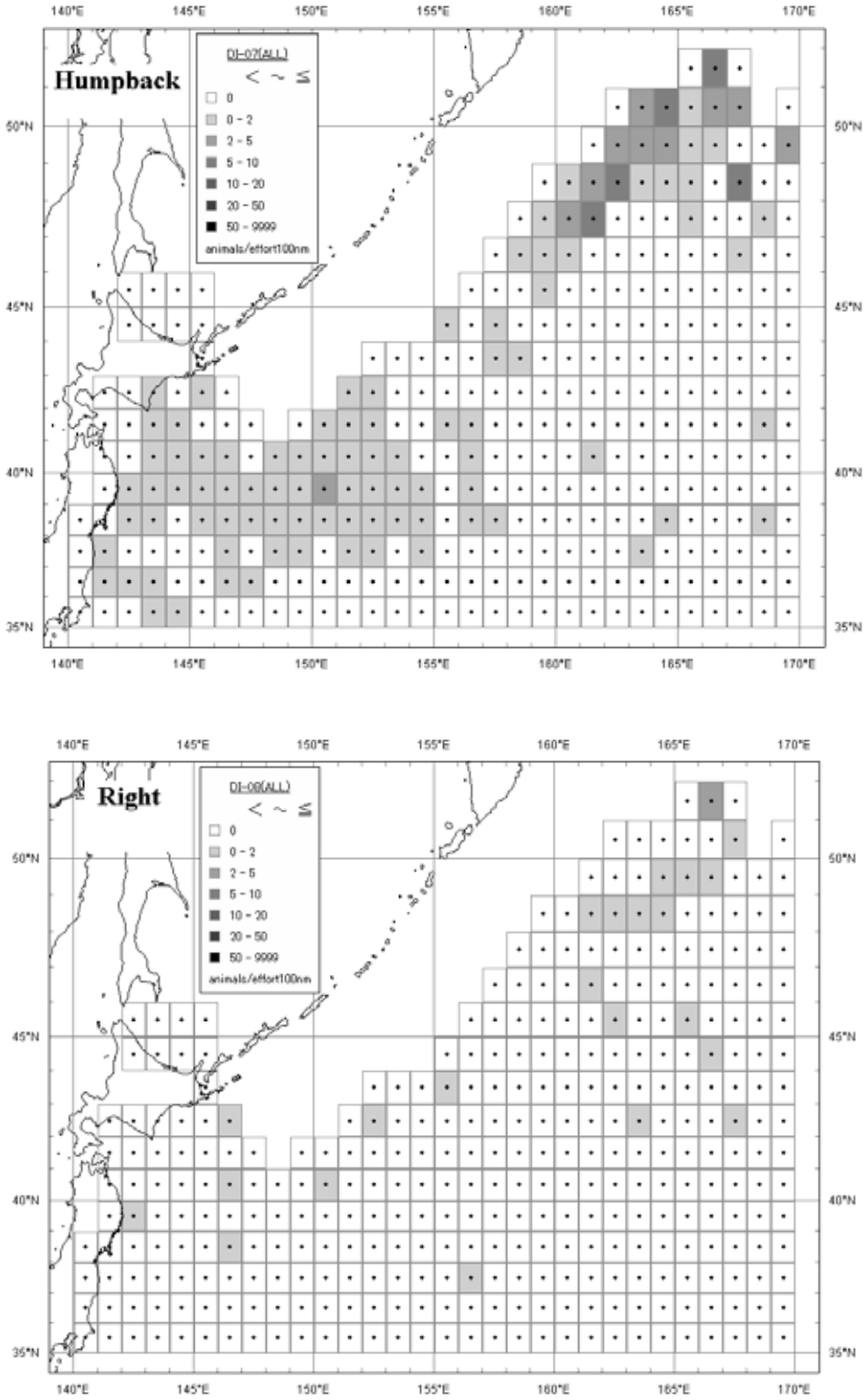

Figure 2b. Distribution of the Density Index (number of primary sightings of individuals / 100 n.mile) of whales during JARPN and JARPN II from 1994 to 2007 surveys by Lat.1°× Long.1°square.
Upper : humpback whale, bottom : right whale.

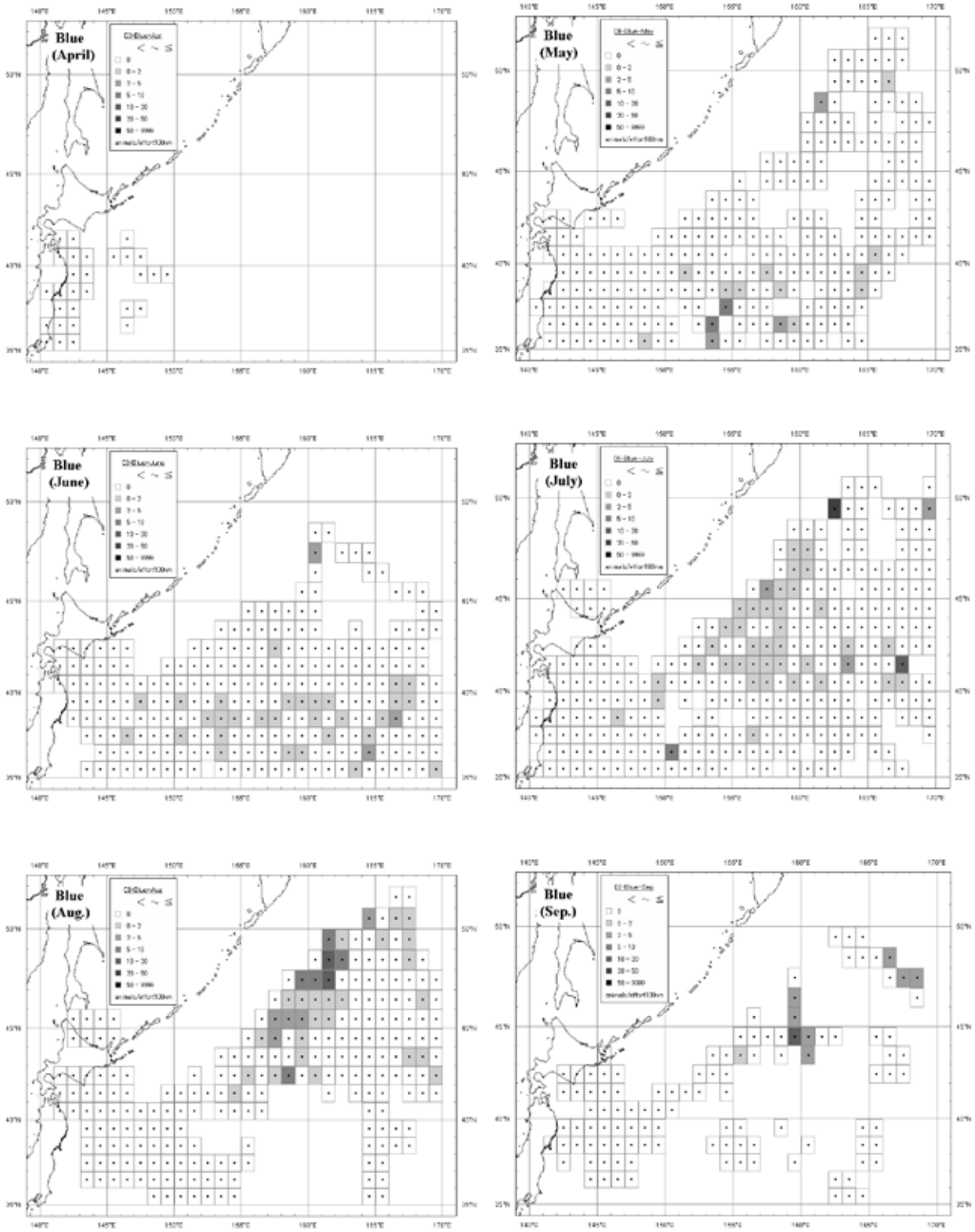

Figure 3a. Monthly change of the Density Index (number of primary sightings of whales / 100 n.mile) of blue whales during JARPN and JARPN II from 1994 to 2007 surveys by Lat.1°× Long.1°square.

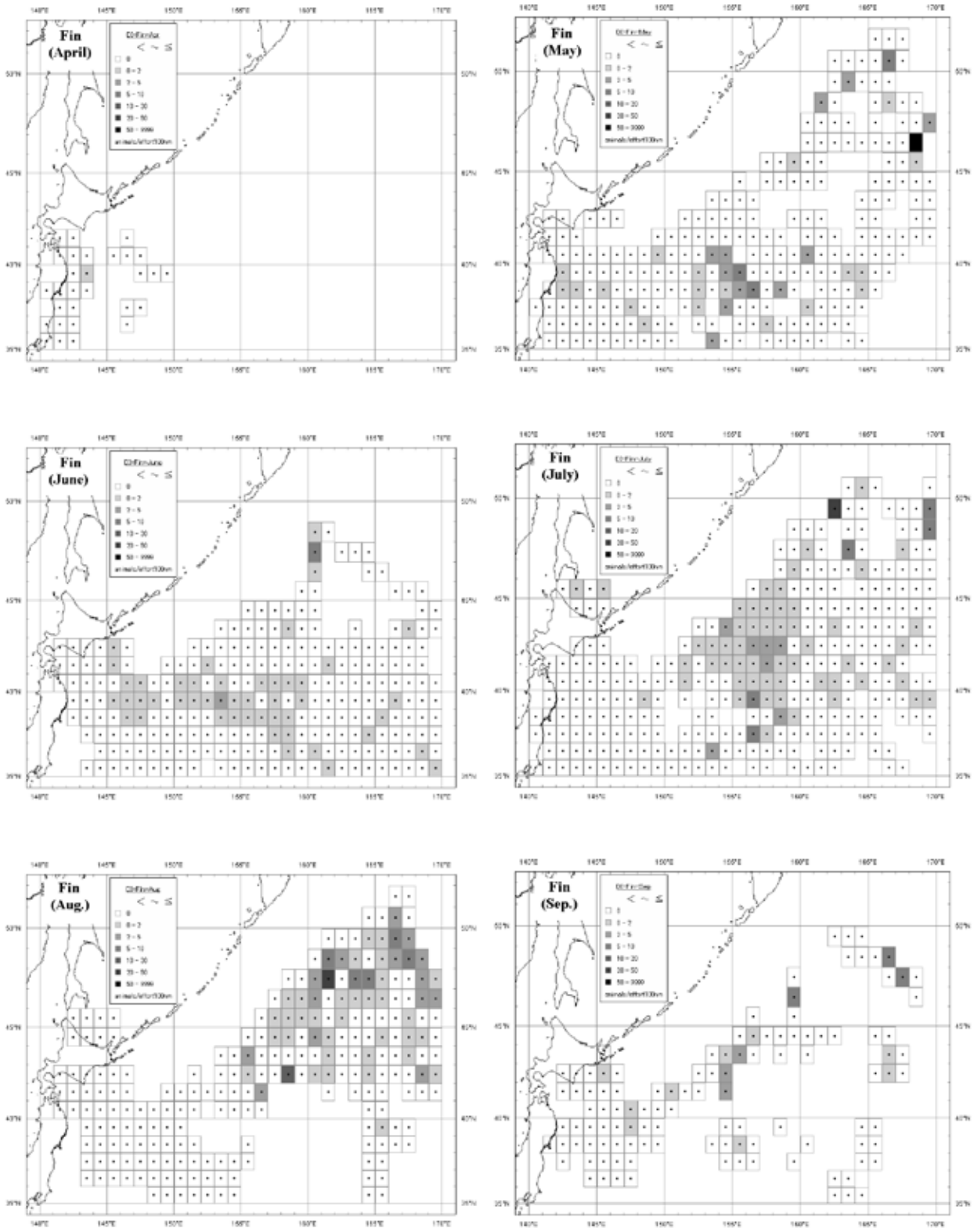

Figure 3b. Monthly change of the Density Index (number of primary sightings of whales / 100 n.mile) of fin whales during JARPN and JARPN II from 1994 to 2007 surveys by Lat.1°× Long.1°square.

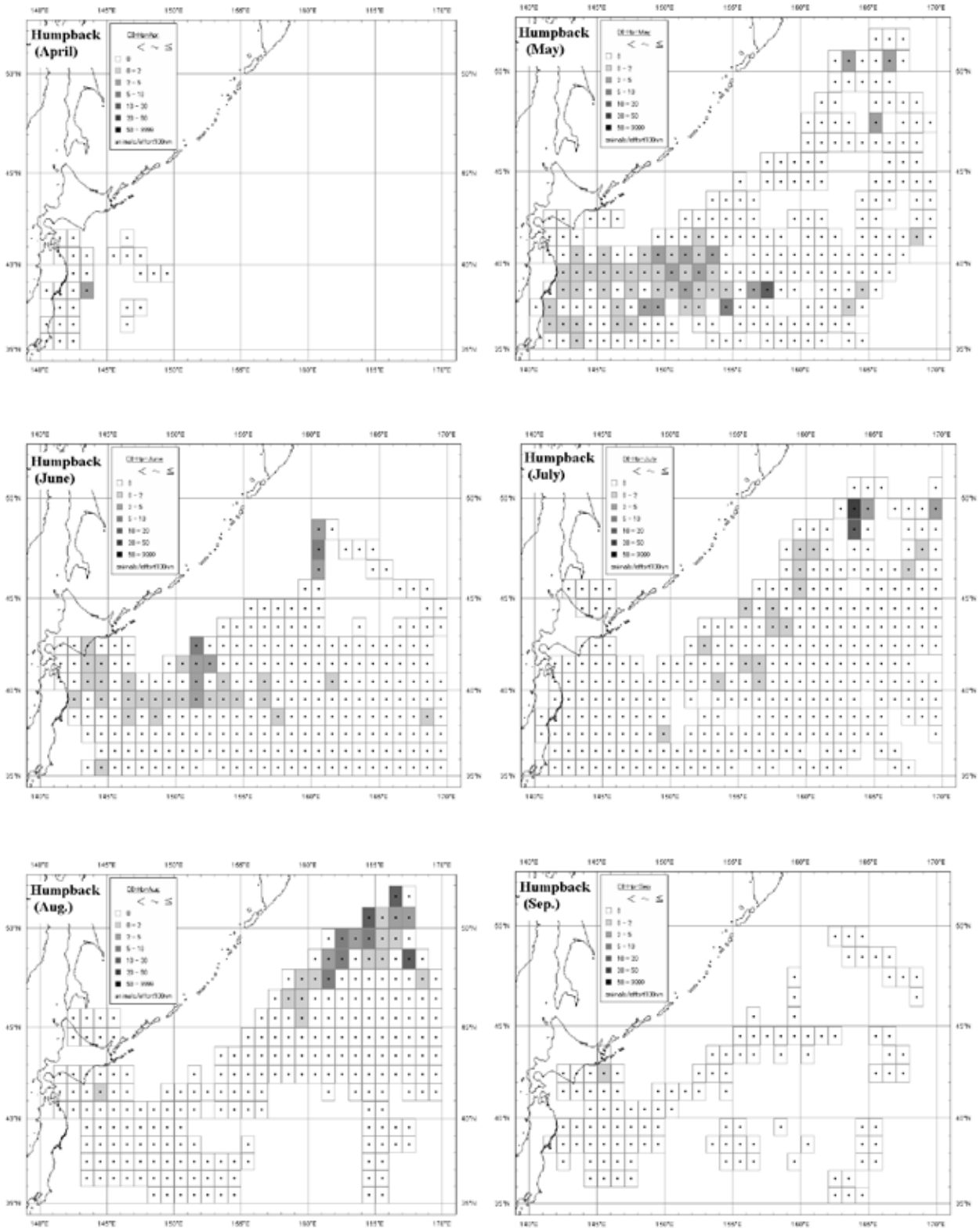

Figure 3c. Monthly change of the Density Index (number of primary sightings of whales / 100 n.mile) of humpback whales during JARPN and JARPN II from 1994 to 2007 surveys by Lat.1°× Long.1°square.

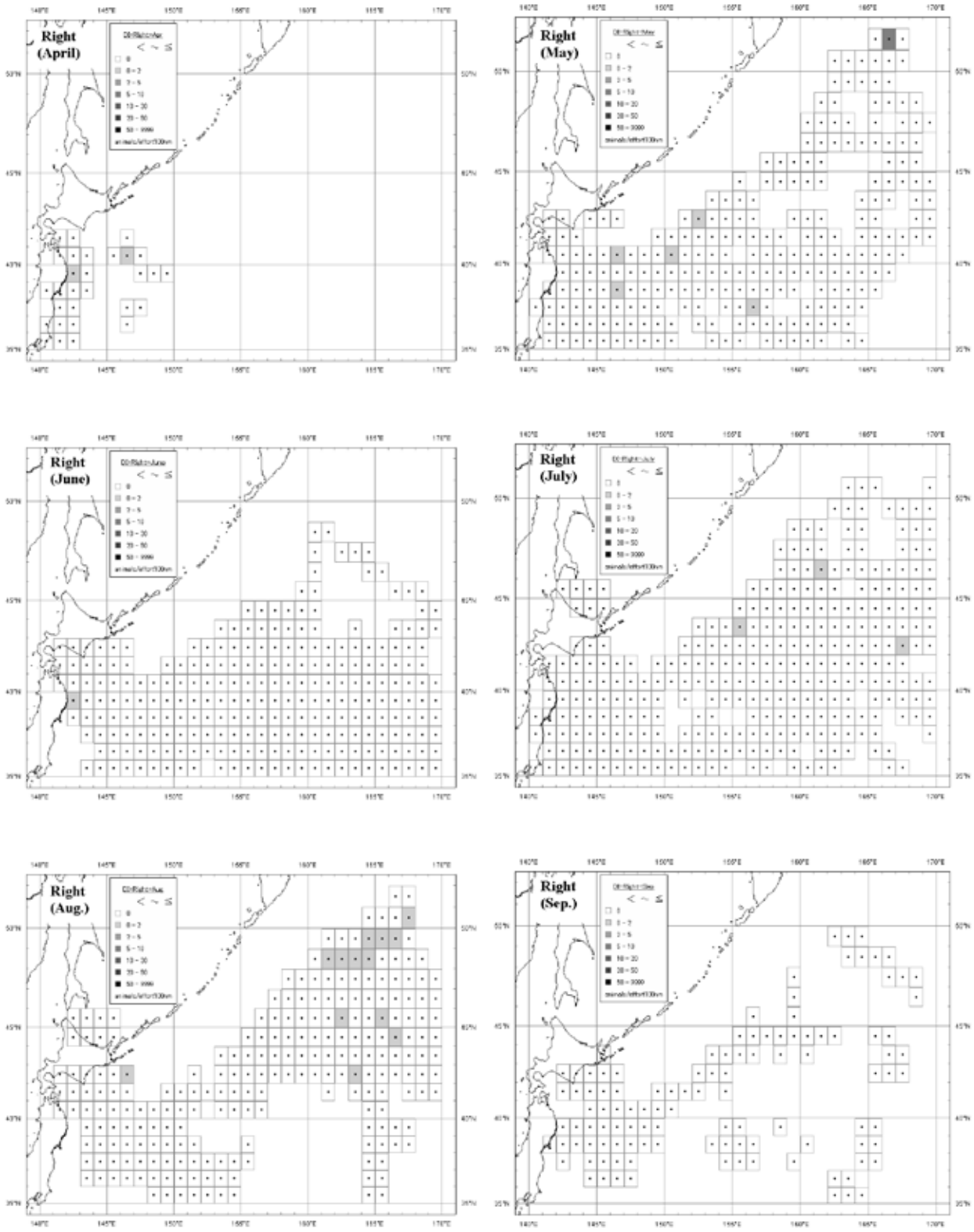

Figure 3d. Monthly change of the Density Index (number of primary sightings of whales / 100 n.mile) of right whales during JARPN and JARPN II from 1994 to 2007 surveys by Lat.1°× Long.1°square.