WHALE SIGHTING EFFICIENCY OF THE CREW ON BOARD OCEAN RESEARCH VESSELS IN BIOMASS/FIBEX*

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Abstract: Two whalers who have long experience in whaling operation were on board two ocean research vessels from Japan which participated in the BIOMASS/FIBEX project. They were engaged in the whale sightings in the navigation bridge with the crew and apprentice students to examine the whale sighting efficiency of the crew. It was found that species identification of whales was very difficult for the crew without the help of experienced whalers. Synthesizing the results on the number of whale schools sighted per unit of the research distance and per unit of the number of crew, as well as on the range of visual field of sighting and the finding rate in the course of navigation, the whale sighting efficiency of the crew of the ocean research vessels was 3.2% of the whalers of the whale scouting boats, and the efficiency of the whalers on board ocean research vessels was 50% of the whalers of the whale scouting boats.

1. Introduction

The whale sighting is one of the useful techniques for the estimation of population size of whales in the sea, and so it was adopted as one of the research items in the BIOMASS/FIBEX programme in 1980/81. However, the whale sighting requires long experience, and in the population assessment of whales the sightings by experienced whalers on board whale scouting boats have been used. On the other hand, the crew of the ocean research vessel have no professional experience in whale sighting, and so there are some doubts about the usefulness of whale sightings data which were collected by the research vessel for the purpose of population assessment of whales.

It was decided that two Japanese ocean research vessels were to participate in the FIBEX programme. We felt it was necessary to have some experienced whalers in the Japanese programme so as to help the whale sightings as well as to examine the whale sighting efficiency of the crew of the ocean research vessels, because we recognized the importance of the BIOMASS project for the study of the living resources of the Southern Ocean and the need of the knowledge of reliability of whale sight-

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ings data to be collected by the ocean research vessels which joined in the project. Thus, we dispatched one experienced whaler to each ocean research vessel to engage in whale sightings with the crew and the apprentice students.

This paper examines the efficiency of the crew and the students in the whale sightings in comparison with the results of the whalers who were on board the same vessels using the whale sightings data which were collected from the two vessels.

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2. Material and Method

The two research vessels which participated in the BIOMASS/FIBEX programme were R. V. KAIYO MARU of the Fisheries Agency, Ministry of Agriculture, Forestry and Fisheries, and R. V. UMITAKA MARU of the Tokyo University of Fisheries, Ministry of Education, Science and Culture. The principal items of the vessels are shown in Table 1.

Table 1. Principal items of two Japanese ocean research vessels which were engaged in whale sightings under the BIOMASS/FIBEX programme in 1980/81.

Items	R. V. KAIYO MARU	R. V. UMITAKA MARU
Type of vessel	Stern trawler	Stern trawler
Gross tonnage	2539.48	1828.66
Power of engine	2300 kW	3200 HP
Total length (m)	91.87	79.0
Width (m)	15.0	12.4
Depth (m)	9.2	6.0
Navigation speed (knot)	11.0	13.5
Height of navigation bridge from sea level (m)	13.0	9.9

The whale sightings on board these two vessels were carried out by observers from the bridge in the course of navigation through the research area in the daytime. The crew and the apprentice students who were on watch in the bridge engaged themselves in whale sighting independently from the crew and the students. The whale sightings data to be used in this paper are limited to those collected when both the whaler and other persons (the crew) were engaged in whale sighting at the same time.

The two whalers have 20–30 years of experience in whaling operation and they are skilled in whale sighting. On the other hand, the crew have no experience in the whaler's work, although the whalers on board the ocean research vessels trained the crew in sighting and species identification of whales on the way to the research area.

The whale sightings data including the following items were recorded on a format sheet:

1) Date
2) Note on start, end or finding of a marine mammal school
3) Positions of the above conditions
4) Times of the above conditions
5) Research distance (n. miles) in a set of whale sightings navigation
6) Weather, visibility and wind force
7) Surface water temperature
8) Species of marine mammals in the school
9) Number of individuals in the school
10) Angle of position of the school from the course of vessel
11) Distance of the school from vessel
12) Number of observers in the navigation bridge
13) Name of finder of the school.

When a number of the crew finds a marine mammal school, it is usually difficult for him to identify the species, and he informs his finding to a whaler and asks for his assistance in species identification. Thus, most of the cetacean species sighted were identified by the whalers on both vessels. Among all sightings data collected, only the data of minke whale schools were used in this paper, because this species is the most abundant in research area of both research vessels and the pattern of whale sightings may vary with species.

The research area is limited within the waters south of 60°S, for the minke whale is abundantly distributed along the pack ice edge in the summer and the distribution pattern may be different in the lower latitudinal waters. R. V. KAIYO MARU operated in the waters 30°–90°E in the periods of December 11–27, 1980 and January 16–February 9, 1981. R. V. UMITAKA MARU operated in the research area of 120°–170°E for the periods of December 29, 1980 to January 8, 1981 and January 26 to February 5, 1981.

Efficiency of whale sightings is compared between the ocean research vessel and the whale scouting boat by using the whale sightings data of the Japanese scouting boats in the Antarctic area of 120°–170°W in the 1978/79 and 1979/80 seasons. These data have been already examined by OHSUMI (1981).

3. Identification of Whale Species

According to the reports of two whalers who were on board two ocean research vessels, it was almost impossible for the crew to identify the swimming whale species. Independent record of whale species identification by the crew was not collected, because they informed the finding of a whale school to the whaler to confirm the whale species and the result was recorded in the sheets. The ocean research vessels did not approach the whale school when it was found, as the whale scouting boats usually do, because it takes a longer time for the ocean research vessel to approach the school, although it is ideal to confirm the whale species at a short distance.

4. Number of Minke Whales Sighted per Unit of Research Distance

Table 2 shows the research distance, the numbers of schools and minke whales sighted by observers and the number of observers engaged in whale sightings on watch. We think the number of whale schools sighted will be more suitable than the number of whales sighted as the indicator of whale sightings efficiency, for the school size may be different by area and the chance of finding will be represented as the unit of school.

Table 2. Minke whale schools sighted by scouting boats and ocean research vessels.

Vessel	Observer		Research distance (n. miles) (B)	Minke whale		C/B	C/B/A	D/C
	Type	Number (A)		School (C)	Number (D)			
Scouting	Whaler	2.3	3636	306	1442	0.084	0.037	4.71
R. V. KAIYO	Whaler	1	2972	108	252	0.036	0.036	2.33
	Crew	3		23	69	0.008	0.003	3.00
R. V. UMITAKA	Whaler	1	1019	19	75	0.019	0.019	3.95
	Crew	3		9	25	0.009	0.003	2.22

The number of minke whale schools sighted per one n. mile of research distance is the largest in the case of whalers on board the scouting boats as shown in Table 2, and the next is the case of whalers on board R. V. KAIYO MARU. The smallest number is the case of the crew on board the ocean research vessel. This means that the whale sightings efficiency of the whalers on board the whale scouting boats is the highest, and that of the crew on board the ocean research vessel is the lowest. The whale sightings by whale scouting boats are usually conducted by two whalers on the so-called "crow's nest" of fore-mast (top) and two whalers on the upper bridge. From comparison of the minke whale finding ratios between top-men and whalers on the upper bridge, the relative efficiency of whalers on the upper bridge is estimated to be 0.15 of those on the crow's nest. Then, the number of whalers in the case of scouting boats will be converted to be 2.3 persons. The efficiency of whale sightings is possibly related to the number of observers. If so, the high efficiency of scouting boats may be related to a large number of whalers on watch. The average number of minke whale schools sighted per one n. mile per person is shown in Table 2. The figures are similar between the scouting boats and the whaler on board R. V. KAIYO MARU. This suggests that the efficiency of whale sightings by a whaler is almost the same for both types of vessels, if the whaler on board the research vessel is experienced. However, further researches will be needed to get a conclusion on this matter, for these two vessels were not engaged in whale sightings in the same area in the same season and the density distribution may be different by area and season.

The efficiency of the whaler on board R. V. UMITAKA MARU is lower than that of the whaler on board R. V. KAIYO MARU. Two reasons can be considered for this phenomenon. One reason will be the difference of research area and periods between the two vessels, since one vessel stayed for a shorter period than the other in

the waters near the pack ice edge. Another reason will be the difference of the height of the navigation bridge where the whale sightings were carried out as shown in Table 1. The navigation bridge of R. V. KAIYO MARU is higher than that of R. V. UMITAKA MARU.

The number of minke whale schools sighted per n. mile and per person of the crew on board the ocean research vessels is much less than that of the experienced whalers on board the same vessels. In the case of R. V. KAIYO MARU the latter is 12 times larger than the former, and in the case of R. V. UMITAKA MARU the latter is 6.3 times larger than the former. When the data of both research vessels were combined, the value of minke whale schools sighted per n. mile and per person of the whalers on board the ocean research vessels is 12 times larger than that of the crew on board the same vessels.

5. Range of Sighting Angle

Table 3 shows the records of minke whale schools sighted by the whaler and the crew, respectively, on board the ocean research vessels (two vessels combined) to

Table 3. Records of minke whale schools sighted on board R. V. KAIYO MARU and UMITAKA MARU.

Distance (n. miles)	Angle from vessel (°)											
	0	10	20	30	40	50	60	70	80	90	100	Total
A. Whalers												
0.0	1	—	—	1	1	—	1	—	—	—	—	4
0.5	2	3	—	2	6	—	1	—	—	—	—	14
1.0	2	8	3	10	5	4	3	—	1	1	—	37
1.5	11	6	4	9	2	—	—	1	1	—	—	34
2.0	5	5	2	5	6	1	—	—	—	—	—	24
2.5	3	2	1	—	1	1	—	—	—	—	—	8
3.0	—	2	1	—	1	—	—	—	—	—	—	4
3.5	—	—	1	—	—	—	—	—	—	—	—	1
4.0	—	—	—	—	1	—	—	—	—	—	—	1
Total	24	26	12	27	23	6	5	1	2	1	—	127
B. Crew												
0.0	1	1	—	1	2	—	1	1	—	2	—	9
0.5	2	—	—	—	2	—	1	1	—	1	1	8
1.0	3	1	1	—	1	—	—	—	—	—	—	6
1.5	1	2	—	—	1	—	—	—	—	—	—	4
2.0	—	1	1	—	—	—	—	—	—	—	—	2
2.5	—	—	—	—	—	—	—	—	—	—	—	—
3.0	—	1	—	—	—	—	1	—	—	—	—	2
3.5	—	—	—	—	—	—	—	—	—	—	—	—
4.0	—	—	—	—	1	—	—	—	—	—	—	1
Total	7	6	2	1	7	—	3	2	—	3	1	32

express the relation between the angle and the distance from a vessel. A similar table for scouting boats was given in Table 3 of OHSUMI (1981).

Table 4 shows the frequency distribution of angle of schools found from vessels in the three cases noted above. The largest angle was 100° in the case of the crew on board the research vessels. The largest angle by the whalers both on board the scouting boats and the ocean research vessels was 90°.

Table 4. Frequency distribution of angles of minke whale schools sighted from vessels.

Vessel	Observer	Number	Angle from vessels (°)											
			0	10	20	30	40	50	60	70	80	90	100	Total
Scouting	Whaler	No.	96	44	60	54	23	24	7	8	7	8	—	331
		%	29	13	18	16	7	7	2	2	2	2	—	
R. V.	Whaler	No.	24	26	12	27	23	6	5	1	2	1	—	127
		%	19	21	9	21	18	5	4	1	2	1	—	
R. V.	Crew	No.	7	6	2	1	7	—	3	2	—	3	1	32
		%	22	19	6	3	22	—	9	6	—	9	3	

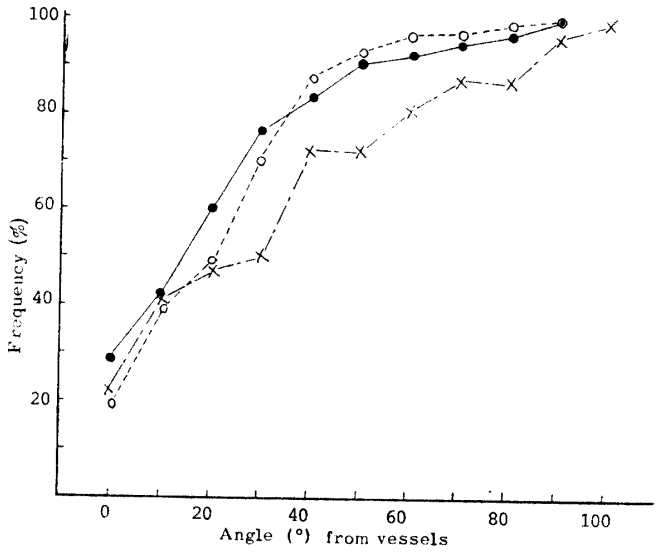

Fig. 1. Acumulated relative frequency of angle of minke whale schools sighted in the three cases of whale sightings.
Closed circle and solid line: Whalers on board whale scouting boats.
Open circle and broken line: Whalers on board ocean research vessesl.
Cross and chain line: Crew of ocean research vessels.

Figure 1 shows accumulated relative frequency of angles of minke whale schools sighted in three cases. The patterns of whalers on board both scouting boats and research vessels are similar to each other, and more than 90% of minke whale schools were sighted within 50° of both sides of the vessel in both cases. On the other hand, in the case of the crew on board the research vessels, the pattern of accumulated frequency of the angle is different from that of the former two cases. Less

than 80% of schools were sighted within 50° by the crew. These phenomena may mean that the experienced whalers have similar behaviour of movement of eyes for whale sightings on both scouting boats and ocean research vessels, and the range of sighting angle is usually 50° of both sides of the navigation course, but the unexperienced crew on board research vessels move their eyes wider than the experienced whalers. Then, it will be more efficient to move the eyes not so wide for the whale sightings, and the whalers have found the most suitable range of sighting angle through their experience.

6. Range of Sighting Distance

The range of sighting distance will vary with the height of the sighting place on the vessel, whale species, weather conditions, ability of observer, etc.

In most cases the range of sighting distance for the minke whale is shorter than the visibility, for the blow of the minke whale is less conspicuous than that of the larger baleen whales and it is rather difficult to find it because of its small size.

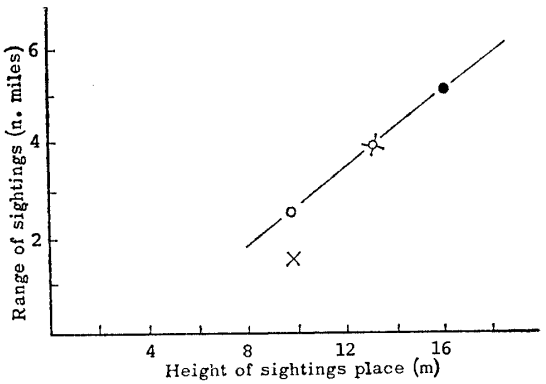

Fig. 2. Relation between the height of sightings place and the range of sighting for the minke whale schools.
Closed circle: Whalers on board whale scouting boats.
Open circle: Whalers on board ocean research vessels.
Cross: Crew of ocean research vessels.

According to OHSUMI (1981), the longest distance of minke whale schools sighted in the Antarctic was 5.0 n. miles by scouting boats. In the case of R. V. KAIYO MARU the longest distance of minke whale schools sighted was 4.0 miles by both whaler and crew. In the case of R. V. UMITAKA MARU, the longest distance was 2.5 miles by the whaler and 1.5 miles by the crew. Such differences may be related to the height of the sighting place and to the observers, experience. The scouting boat which has the highest sighting place (16 m on the crow's nest) has the longest range, but R. V. UMITAKA MARU of which navigation bridge is the lowest among three vessels as shown in Table 1 has the shortest range. This relation is illustrated in Fig. 2. The range of sighting distance increases linearly with the height of sighting place even by experienced whalers, and the range by unexperienced crew is usually shorter than that of experienced whalers at the same height of sighting place.

7. Efficiency of Whale Sightings along the Navigation Course

If all the whale schools can be found along the navigation course, there should be no difference in the average number of schools per unit of research distance in

all vessels and all persons in the waters which have the same density distribution on whales.

In practice the abundance of animals is usually estimated on this assumption by the line transect method. However, DOI (1974) is against this idea, and DOI *et al.* (1982) prove his theory by a computer simulation.

Table 5 shows the number of schools of minke whales along the navigation course (0° angle from vessel), the distance and the number of observers in several cases of whale sightings. The number of minke whale schools per unit of research distance and per person is different among 5 cases of Table 5.

Table 5. Relative efficiency of whale sightings during navigation.

Type of vessel	Scouting	R. V. KAIYO MARU		R. V. UMITAKA MARU	
Type of observer	Whaler	Whaler	Crew	Whaler	Crew
A. Number of observer	2.3	1	3	1	3
B. Distance (n. miles)	3636	2972		1019	
C. Number of minke whale school sighted	96	17	6	7	1
C/B	0.00264	0.0057	0.0020	0.0069	0.0010
C/B/A	0.0115	0.0057	0.0007	0.0069	0.0003
Relative value of C/B/A	1.0	2.0	16.4	1.7	38.3

Although these data were not obtained in the same area in the same season, the main data were collected in midsummer, and the patterns of distribution of the minke whales are not much different by area in the same season. The relative value of schools/mile/person of the whalers on board scouting boats is 1.7–2.0 times larger than that of the whalers on board ocean research vessels. This will mean that the sighting efficiency is different with the type of vessels, even if experienced whalers are on board these vessels. In the same vessel the efficiency of whale school sighting varies with the observer's experience as shown in Table 5. The rate of schools per mile and per person of whalers on board R. V. KAIYO MARU is 8.1 times larger than that of the crew on the same vessel. In the case of R. V. UMITAKA MARU the efficiency of the whaler is 23 times larger than that of the crew. The above examination proves that all vessels and all crew cannot find 100% of whale schools along the navigation course. Even in the scouting boat which was used as the standard in this examination, the efficiency is less than 100% as proved by DOI *et al.* (1982).

8. Width and Rate of Whale Sighting

The frequency of perpendicular distance of whale schools sighted by the ocean research vessels was converted from Table 3, and the results are shown in Table 6. The similar data of the whalers on board scouting boats were quoted from Table 4 of the paper by OHSUMI (1981), and they are also shown in Table 6.

The relative frequency distribution of the perpendicular distance was plotted in Fig. 3 for three cases. The patterns of the frequency of whalers both on board scouting boats and research vessels are similar to each other. As the whale sight-

Table 6. Comparison of converted distance (n. miles) of minke whale schools at rectangle among three cases.

Converted distance (n. miles)	Scouting boats		Research vessels			
	Whalers		Whalers		Crew	
	Freq.	Relative	Freq.	Relative	Freq.	Relative
0.0	136	1.000	40	0.720	16	1.000
0.5	112	0.824	55	1.000	13	0.813
1.0	57	0.419	19	0.340	1	0.063
1.5	18	0.132	10	0.182	—	—
2.0	7	0.051	2	0.036	—	—
2.5	1	0.007	1	0.018	2	0.125
Total	331		127		32	

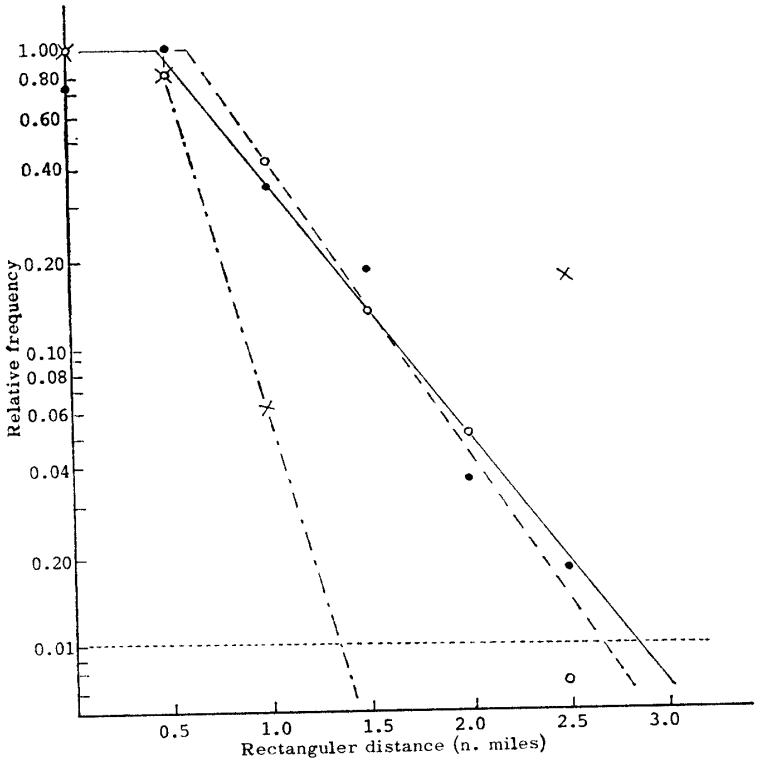

Fig. 3. Frequency distributions of perpendicular distance of minke whale schools from vessel.
Open circle and broken line: Whalers on board whale scouting boats.
Closed circle and solid line: Whalers on board ocean research vessels.
Cross and chain line: Crew on board of ocean research vessels.

ing width, the point where a line of frequency crosses the level of 0.01 of relative frequency is adopted in this paper. Then, the width of whalers on board scouting boats is 2.67 n. miles, and that of whalers on board research vessels is 2.83 n. miles. On the other hand, crew's pattern is largely different from that of whalers. Although there are two records of 2.5 n. miles of perpendicular distance, the width of whale

Table 7. Width and rate of whale sighting by three types of observers and vessels.

Items	Whalers on scouting boats	Whalers on R. V.	Crew on R. V.
Width (n. miles)	2.67	2.83	1.35
$\tilde{P}$	0.395	0.348	0.482
A. $\tilde{P}$ under width of 2.83 n. miles	0.381	0.348	0.241
B. Relative efficiency of sightings in course of navigation	1.00	0.52	0.051
A×B	0.381	0.181	0.0123

sightings by the crew on board research vessels was estimated to be 1.35 n. miles from the frequency distribution as shown in Fig. 3. Then the whale sighting width by unexperienced crew will be narrower than that by experienced whalers.

The perpendicular sighting rate is estimated from the relative frequency of perpendicular distance in Fig. 3 on three cases, and is shown in Table 7. This table also shows the converted sighting rate of each case bases on the widest width of whalers on board research vessels. Comparing the converted sighting rate, the value of whalers on board scouting boats is the largest, and that of crew on board research vessels is the smallest. This result means that the sighting efficiency of the whalers on board scouting boats is the best among three cases, and the crew on board ocean research vessels has the lowest efficiency.

9. Discussion

Many cetacean species are distributed widely in the sea, and the importance of whale sightings has been increasing larger and larger. Now many ocean and fisheries research vessels work widely in the world. In these circumstances, great hopes are placed on the whale sightings by these vessels. In practice, however, it is rather difficult for these vessels to conduct whale sightings systematically and routinely, and cetologists do not expect usually to use the whale sightings data collected by the ocean research vessesl having no experienced whale observers on board, for the use of such data involves many problems.

One of the problems is the identification of cetacean species. The identification of whale species is fundamental for whale sightings study, and cetologists are apt to hesitate to use unreliable data by the unexperienced observers. It is very difficult even for the experienced whaler to identify swimming whales far from vessels. When a whaler finds a cetacean school, the scouting boat usually approaches the school to identify the species and count the school size. In the case of ocean research vessels it is practically difficult to approach the cetacean school. According to the reports of the whalers who were on board two ocean research vessels, it was almost impossible for the crew to identify whale species during the FIBEX cruises. However, it was a good chance for the crew to be trained by the experienced whalers on the methods of identification of cetaceans with the practical samples of whale schools. A good field guidebook for the identification of cetacean species will be useful, but the

experience is more practical and important in the identification. If there is some time to spare, it will be better for an ocean research vessel to approach the whale school as close as possible to obtain reliable data.

The second problem is the lack of quantitative records of efforts made in the whale sightings. In the case of ocean research vessels the whale sighting is not included in their duty researches, and although the whale schools found may be recorded sometimes by the vessels, records of research efforts are not available usually. The sightings data without the effort records cannot be used in the quantitative analysis. The routinization of whale sightings by use of suitable formats of records in the ocean research vessel will be essential for the practical use of whale sightings data collected by the vessel.

The third problem of whale sightings by ocean research vessels will be the low efficiency of whale sightings by the crew as examined in this paper. Usually, it is thought that the whale sightings efficiency by unexperienced crew is too low to use the data recorded by the crew. In practice, the main concern of the crew on watch at the navigation bridge is to navigate the vessel safely as much as possible, and their attention is paid largely to the ice than to whales especially in the Antarctic where the present data were collected. On the other hand, the whalers on board the ocean research vessels had no duty on the safe navigation, and they worked hard only to observe whale schools. These reasons might account for the different of whale sightings efficiency between the crew and the whalers.

The present sample sizes of the whale sightings were not enough to get a conclusion on the whale sightings efficiency of the crew on board the ocean research vessels in the Antarctic. Further researches will be needed by making use of similar chances to the BIOMASS/FIBEX. If much data of whale sightings are gathered from the crew of the ocean research vessels, the necessary parameters for the abundance assessment by means of whale sightings can be estimated directly without estimation of sightings efficiency relative to the whaling scouting boats or whalers on board the same ocean research vessel.

Ocean research vessels are not built suitable for the whale sightings, so that it is inevitable for the vessels to have lower efficiency of whale sightings than that of whaling catcher boats which are built suitable for finding whales in the sea. The whale sightings on board ocean research vessels are usually conducted in the navigation bridge. The visibility from the window of the navigation bridge is not so good for the whale sightings as the crow's nest of the foremast of the whaling catcher boats. However, it has been revealed by the present study that the whale sightings efficiency on board the ocean research vessel is not so bad as expected before, if experienced whalers or scientists were on board.

We have come to think that the whale sightings by the crew of ocean research vessels can be used in the assessment of whale abundance, if the data are systematically collected. It will be ideal for the experienced crew or scientists to be on board these vessels for the whale sightings, but even if the whale sightings efficiency of the crew is low, the data will be useful as we can estimate parameters to assess the abundance from these data.

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