さけ・ます調査船とイシイルカ専門調査船の目視調査によるイシイルカの豊度推定の比較

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日本は1978年以来、調査船の目視調査資料を用いて北太平洋のイシイルカの豊度推定を行っている。調査船は2つのタイプ、さけ・ます調査船とイシイルカ専門調査船に分けられる。さけ・ます調査船では乗組員が航走時に目視調査を行うが、イシイルカ専門調査船では同様の乗組員による調査とこれと独立して専門調査員が行う場合がある。専門調査員による目視調査が最も精度が高いと考えられるが、日本の豊度推定は大部分さけ・ます調査船の目視資料を用いて行っている。1984年5月～6月にイシイルカ専門調査船が北太平洋北西部を調査する機会があり、専門調査員の目視結果と同時期・同海域におけるさけ・ます調査船のそれと比較することができた。両調査船の目視結果を比較することにより、今後のイシイルカの豊度推定法の改良に資するのがこの報告の目的である。

材料と方法

(1)　調査船

両者の資料の時期と海域をそろえるため、同一年次、同一時期に同一海域で調査した次の調査船による目視資料を用いた。目視調査の項目は加藤（1983）と同様である。

イシイルカ専門調査船：1984年5月10日～6月20日に第53宝洋丸が36°N～48°N、141°E～180°Eで囲まれた北太平洋北西部で航走距離3,836海里の目視調査を行った。この航走距離はイルカの追尾・確認及び回収中に費やしたものは除いてある。目視は専門調査員3名と他に乗組員3～4名がアパーブリッジ上で行った。

さけ・ます調査船：1984年5月～6月にさけ・ます調査船10隻が38°N～40°N、141°E～

175° Eで囲まれた海域で航走距離15,963海里の目視調査を行った。目視は2～10名の乗組員がワッチ中にブリッジ内から行った。

2　海域区分

豊度推定に先立ち、海域区分について検討した。

イシイルカ専門調査船は図1に示す海域で航走距離で3,886海里の目視調査を行い、イシイルカ(リクゼンイルカ型、イシイルカ型、型不明イシイルカを含む)351群、1,870頭を発見した。2°×5°区画別にみた航走距離100海里当りの発見群数は42°N以南の区画の90%が8以上であるのに対し、42°N以北の区画の90%が6以下であった(図2)。

さけ・ます調査船は図3に示す海域で航走距離で15,963海里の目視調査を行い、イシイルカ244群、1,008頭を発見した。2°×5°区画別にみた航走100海里当りの発見群数は42°N以南の区画の50%が2以上であるのに対し、42°N以北の区画の90%が2以下であった(図4)。

両調査船とも、イシイルカの密度は42°N付近で大きく変化した。海域を密度別にいくつかの小海域に分けることにより、より高い精度の豊度推定ができると考え、42°N線を境に南北2つの海域に分けた。また、44°N以前、155°N以西の海域にはリクゼンイルカ型が主に分布するので、この海域も他と区別した。以上のように、密度とカラータイプの要素により、調査海域を次の3海域に区分した(図5)。

海域1：38°N、44°N、155°E及び日本沿岸で囲まれた海域(面積197平方海里)。

海域2：36°N、38°N、160°E及び180°Eと38°N、42°N、155°E及び175°Eで囲まれた海域(336平方海里)。

海域3：50°N以南、175°E以西の北太平洋北西部で海域1と2を除いた海域(435平方海里)

(3)　豊度推定法

両調査船の目視資料がどの豊度推定法によりよく当てはまるかを検討した。図6には両調査船の垂直距離と群発見頻度との関係を示した。この頻度分布に対するFourier series estimator(加藤、1983)とExponential model(加藤、1984)のestimatorの適合性をX^2検定(0.05)を用いて検討した。その結果、イシイルカ専門調査船にはFourier series estimatorが、さけ・ます調査船にはExponential modelがよりよく適合すると判定された。両調査船の資料にこの2つのestimatorを用いて豊度推定を行った。

結　果

(1)　Fourier series estimator(FSE)による豊度推定

イシイルカ専門調査船による1平方海里当りのイシイルカの個体密度は海域1で1.46、海域2で1.88及び海域3で0.57であったのに対し、さけ・ます調査船によるそれは海域1で0.19、海域2で0.89及び海域3で0.32であった(表1)。イシイルカ専門調査船による密度はさけ・ます調査船にくらべ、海域1で7.7倍、海域2で2.1倍及び海域3で1.8倍大きかった。

イシイルカ専門調査船によるイシイルカの豊度は海域1で288 × 10^3 頭(95％の信頼区間で0 ～ 739 × 10^3 頭)、海域2で632 × 10^3 頭(0 ～ 1,618 × 10^3 頭)及び海域3で250 × 10^3 頭(0 ～ 724 × 10^3 頭)、計1,170 × 10^3 頭(0 ～ 3,081 × 10^3 頭)と推定された(表1)。

さけ・ます調査船によるイシイルカの豊度は海域1で37 × 10^3 頭(0 ～ 93 × 10^3 頭)、海域2で299 × 10^3 頭(0 ～ 660 × 10^3 頭)及び海域3で141 × 10^3 頭(0 ～ 392 × 10^3 頭)、計476 × 10^3 頭(0 ～ 1,145 × 10^3 頭)と推定された(表1)。

(2) Exponential model(EM)による豊度推定

イシイルカ専門調査船による1平方海里当りのイシイルカの個体密度は海域1で1.56、海域2で2.16及び海域3で1.09であったのに対し、さけ・ます調査船によるそれは海域1で0.20、海域2で1.21及び海域3で0.58であった(表2)。イシイルカ専門調査船による密度はさけ・ます調査船にくらべ、海域1で7.8倍、海域2で1.8倍及び海域3で1.9倍大きかった。

イシイルカ専門調査船によるイシイルカの豊度は海域1で307 × 10^3 頭(0 ～ 763 × 10^3 頭)、海域2で726 × 10^3 頭(0 ～ 1,752 × 10^3 頭)及び海域3で474 × 10^3 頭、計1,507 × 10^3 頭(0 ～ 3,843 × 10^3 頭)と推定された(表2)。

さけ・ます調査船によるイシイルカの豊度は海域1で39 × 10^3 頭(0 ～ 101 × 10^3 頭)、海域2で405 × 10^3 頭(0 ～ 767 × 10^3 頭)及び海域3で253 × 10^3 頭(0 ～ 637 × 10^3 頭)、計697 × 10^3 頭(0 ～ 1,504 × 10^3 頭)と推定された(表2)。

論　議

両調査船の資料とも、42°N付近を境にイシイルカの密度が異なっていることを示した。5月～6月の42°N付近は表面水温で10 ～ 15°Cの極前線海域を示す。この水温帯にイシイルカの出現頻度が高いことは加藤(1984)にすでに報告した。極前線海域は餌料環境からみれば必ずしも生産力は高くないが、冷水性魚群と暖水性魚群のどちらかが常に滞溜する場所である(谷口、1981)。イシイルカの高い出現率はこの点と関係しているものと考えられる。

イシイルカの豊度は推定法や調査船の種類により大きく異なった(表1、2)。海域別に豊度推定値の検討を以下のように行った。

海域1:豊度はイシイルカ専門調査船で288 ～ 307 × 10^3 頭に対し、さけ・ます調査船で37 ～ 39 × 10^3 頭と約8倍の大きな相異を示した。リクゼンイルカ型はこの時期、40°N以南にも多く分布するとみられるが、さけ・ます調査船の調査努力量は40°N以南でかなり小さかったのに対し、イシイルカ専門調査船では比較的多かった(図3、5)。この40°N以南の調査努力量の相異が両調査船の豊度推定値の相異に大きく影響しているものと考えられる。この海域の豊度については今後検討の余地が多い。

海域2:豊度はイシイルカ専門調査船で632(FSE)～ 726(EM)× 10^3 頭に対し、さけ・ます調査船で300(FSE)～ 405(EM)× 10^3 頭と変動した。豊度推定法の項で述べたように、

イシイルカ専門調査船の目視資料はＦＳＥに、さけ・ます調査船の目視資料はＥＭによりよく適合する。このことから、この海域の豊度は 405 〜 632 × 10^3頭が妥当な推定値と考えられる。しかし、この推定値でも、さけ・ます調査船の目視資料による豊度の方が 40％も低かった。イシイルカはこの時期、38°N 以南にも多く父布するとみられるが、さけ・ます調査船は 38°N 以南ではほとんど調査をしなかったのに対し、イシイルカ専門調査船は 38°N 以南で比較的多く調査を行った。この 38°N 以南の海域における調査努力量の相異が豊度推定値に大きく影響したものと考えられる。ゆえに、海域２の豊度としてはイシイルカ専門調査船の資料による 632 × 10^3頭が妥当と考えられる。

海域３：豊度はイシイルカ専門調査船で 250（ＦＳＥ）〜 474（ＥＭ）× 10^3頭に対し、さけ・ます調査船で 141（ＦＳＥ）〜 253（ＥＭ）× 10^3頭と変動した。前述の理由により、この海域の豊度は 250 〜 253 × 10^3頭が妥当な推定値と考えられる。両調査船ともイシイルカの分布する海域を広く調査したことが、両者の資料による豊度推定値が等しくなった理由と考えられる。

以上のことから、目視資料によく適合する推定法を用いること、イシイルカの時空間的な分布と合致した調査を行うこと等により精度の高い豊度推定が可能と考えられる。

1984 年 5 月〜 6 月の北西太平洋におけるイシイルカの豊度は 900 〜 1,200 × 10^3頭（968 × 10^3平方海里）と推定された。この値は日本による従来の北西太平洋のそれ、300 〜 700 × 10^3頭（1,258 × 10^3平方海里）（加藤、1984、1985）を大きく上回った。さけ・ます調査船は必ずしもイシイルカの主な時空間的分布と適合した目視調査を行っていない。イシイルカ専門調査船によりイシイルカの分布と合致した目視調査を行うならば、従来の北太平洋のイシイルカの豊度推定値 200 万頭は過少評価の可能性があると考えられる。

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Table 1. Abundance and density of Dall's porpoise estimated from the sighting survey of salmon research vessels and a dedicated vessel for Dall's porpoise, Hoyo-maru No.53, in the northwestern North Pacific Ocean, May-June in 1984. Estimtes based on Fourier series estimator.

Type of vessels	Area	10^3 NMI^2	Transect length (NMI)	Number of schools of porpoise	Density ($\hat{Dg}$) schools/NMI^2	$\hat{Var}(\hat{Dg})$	Mean school size ($\bar{G}$)	Coefficient of variation $\hat{Cv}(\hat{Dg})$	Density ($\hat{Di}$) indi./NMI^2	Abundance ($\hat{T}$) 10^3	95% confidence interval around ($\hat{T}$) 10^3
Dedicated vessel (Hoyo-maru No.53)	1	197	1,141	125	0.3041	0.000740	4.8080	0.0895	1.4621	287.9	0 - 739.1
	2	336	1,236	170	0.3214	0.000615	5.8563	0.0772	1.8822	632.4	0 - 1,617.7
	3	435	1,509	56	0.1105	0.000219	5.2031	0.1339	0.5749	250.1	0 - 724.0
	Total	968	3,886	351						1,170.4	0 - 3,080.8
Salmon research vessels	1	197	6,154	61	0.0467	0.000036	3.9836	0.1288	0.1860	36.6	0 - 92.0
	2	336	1,081	49	0.1669	0.001308	5.3265	0.2167	0.8890	298.7	0 - 660.4
	3	435	8,728	134	0.0862	0.000462	3.7612	0.2493	0.3242	141.0	0 - 391.5
	Total	968	15,963	244						476.3	0 - 1,144.8

Area 1: 38°N-44°N, west of 155°E of the northwestern North Pacific Ocean.

Area 2: 38°N-42°N, 155°E-175°E and 36°N-38°N, 160°E-180° of the northwestern North Pacific Ocean.

Area 3: 44°N-50°N, west of 155°E and 42°N-50°N, 155°E-175°E of the northwestern North Pacific Ocean.

Table 2. Abundance and density of Dall's porpoise estimated from the sighting survey of salmon research vessels and a dedicated vessel for Dall's porpoise, Hoyo-maru No.53, in the northwestern North Pacific Ocean, May-June in 1984. Estimates based on exponential model.

Type of vessels	Area	10^3 NMI^2	Transect length (NMI)	Number of schools of porpoise	Density ($\hat{D}g$) schools/NMI^2	$\hat{Var}(\hat{D}g)$	Mean school size ($\bar{G}$)	Coefficient of variation $\hat{Cv}(\hat{D}g)$	Density ($\hat{D}i$) indi./NMI^2	Abundance ($\hat{T}$) 10^3	95 % confidence interval around ($\hat{T}$) 10^3
Dedicated vessel (Hoyo-maru No.53)	1	197	1,141	125	0.3243	0.002485	4.8080	0.1537	1.5592	307.2	0 - 763.0
	2	336	1,236	170	0.3690	0.002258	5.8563	0.1288	2.1610	726.1	0 - 1,752.0
	3	435	1,509	56	0.2094	0.053097	5.2031	0.2115	1.0895	473.9	0 - 1,328.3
	Total	968	3,886	351						1,507.2	0 - 3,843.3
Salmon research vessels	1	197	6,154	61	0.0495	0.000094	3.9836	0.1959	0.1972	38.8	0 - 101.0
	2	336	1,081	49	0.2264	0.002171	5.3265	0.2058	1.2059	405.2	0 - 766.9
	3	435	8,728	134	0.1548	0.000574	3.7612	0.1548	0.5822	253.3	0 - 636.5
	Total	968	15,963	244						697.3	0 - 1,504.4

Area 1: 38°N-44°N, west of 155°E of the northwestern North Pacific Ocean.

Area 2: 38°N-42°N, 155°E-175°E and 36°N-38°E, 160°E-180° of the northwestern North Pacific Ocean.

Area 3: 44°N-50°N, west of 155°E and 42°N-50°N, 155°E-175°E of the northwestern North Pacific Ocean.

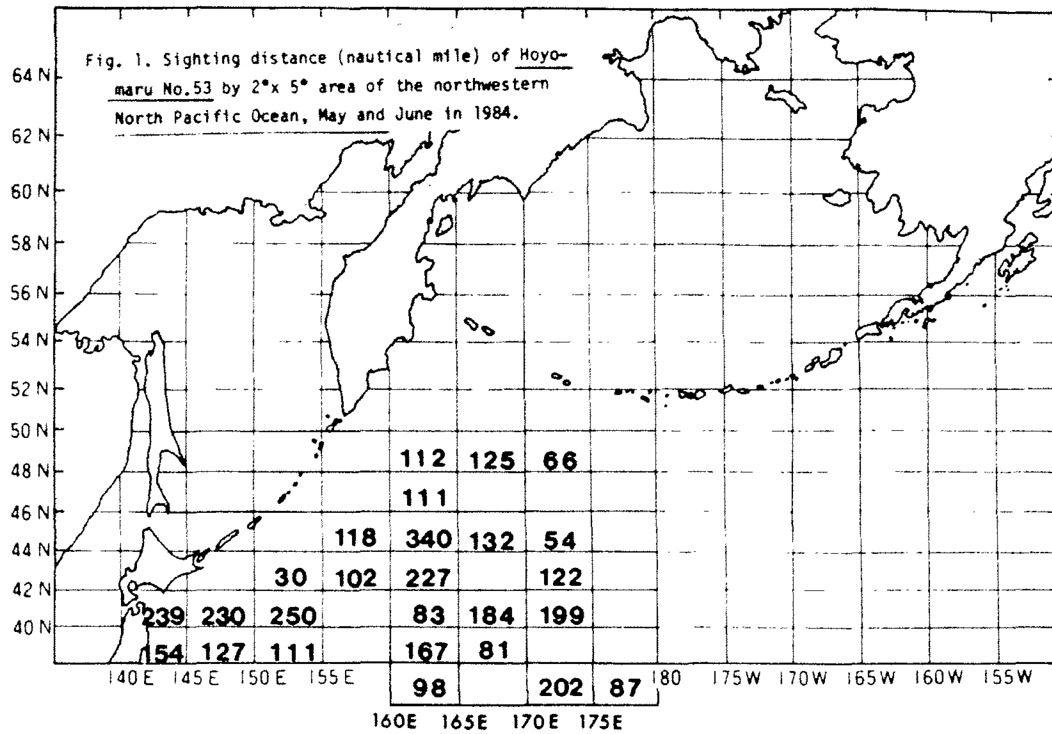

Fig. 1. Sighting distance (nautical mile) of Hoyo-maru No.53 by 2°x 5° area of the northwestern North Pacific Ocean, May and June in 1984.

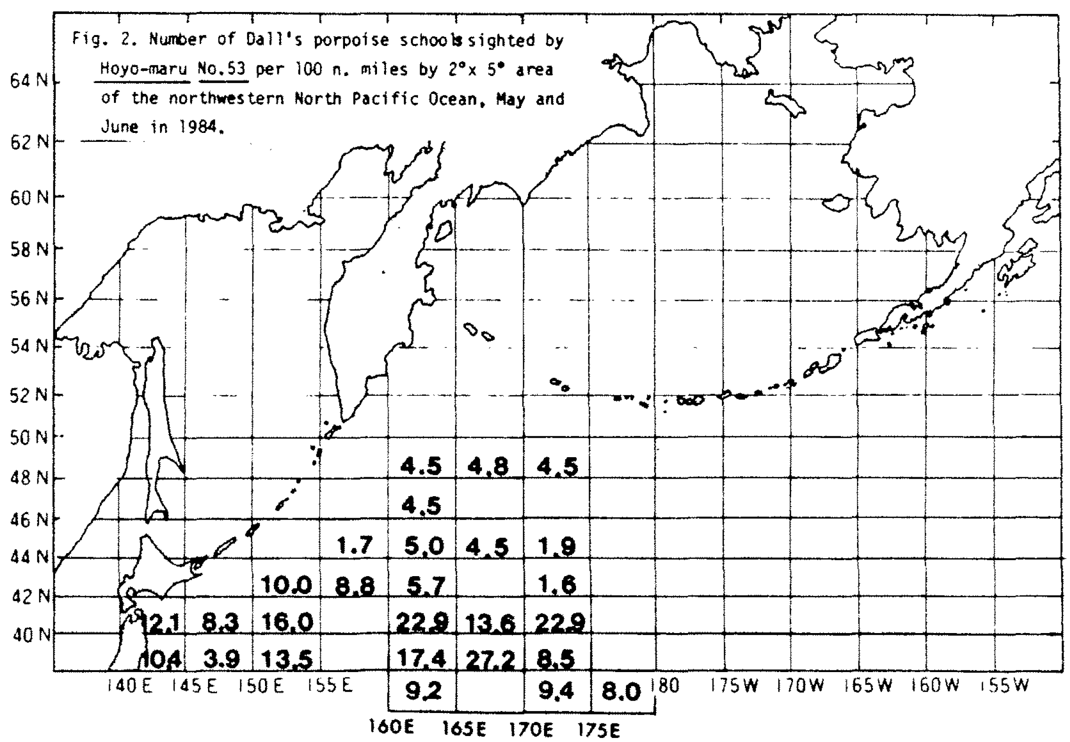

Fig. 2. Number of Dall's porpoise schools sighted by Hoyo-maru No.53 per 100 n. miles by 2°x 5° area of the northwestern North Pacific Ocean, May and June in 1984.

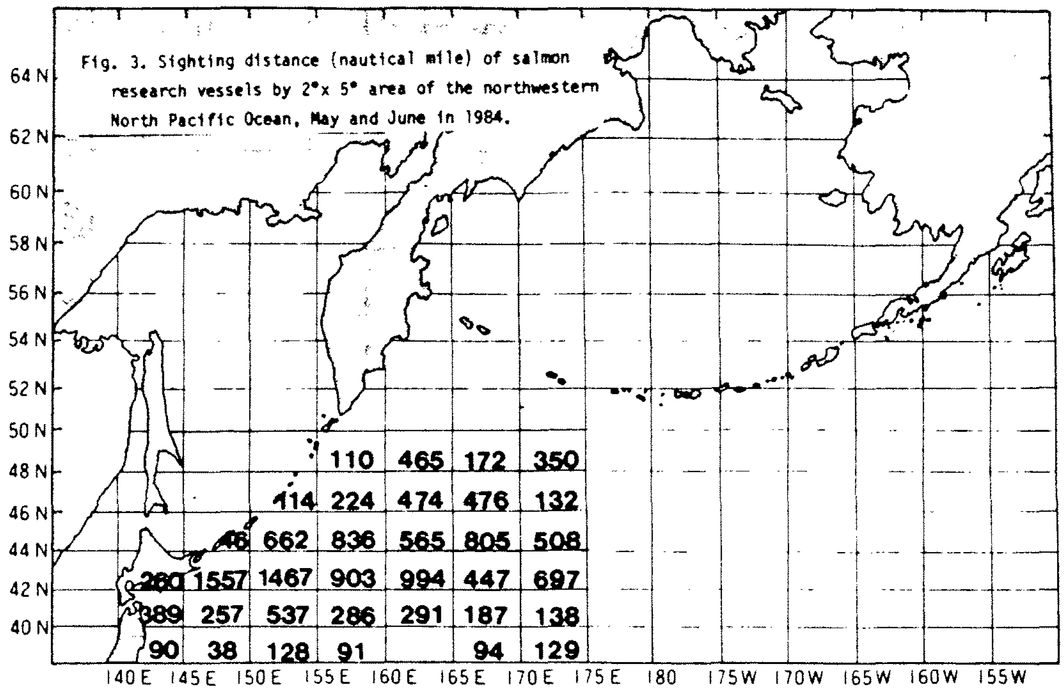

Fig. 3. Sighting distance (nautical mile) of salmon research vessels by 2°x 5° area of the northwestern North Pacific Ocean, May and June in 1984.

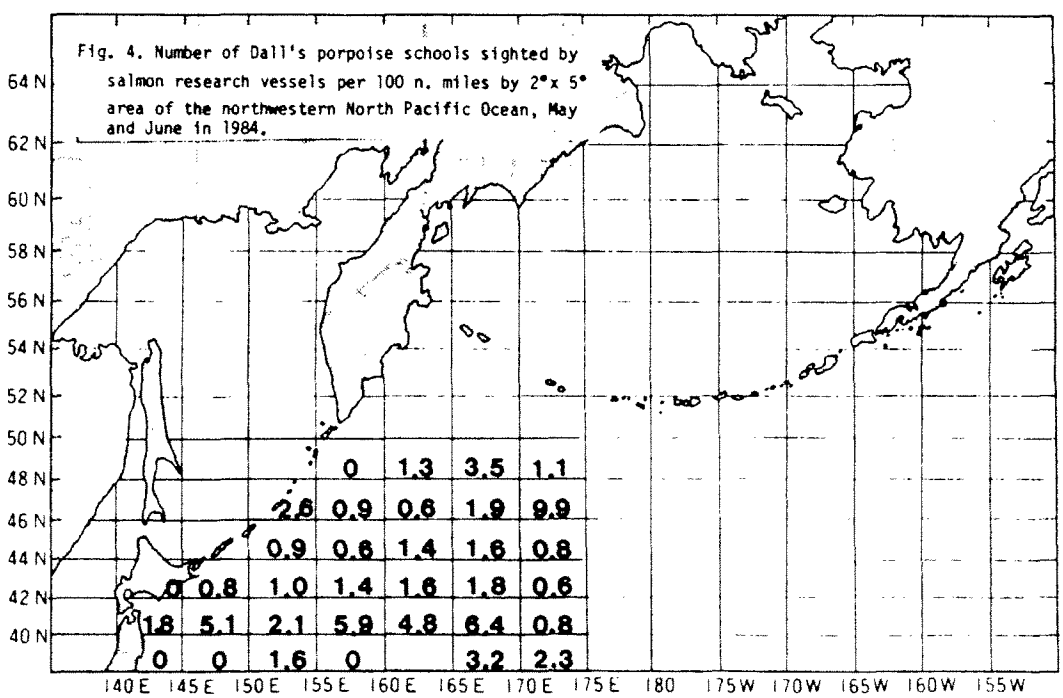

Fig. 4. Number of Dall's porpoise schools sighted by salmon research vessels per 100 n. miles by 2°x 5° area of the northwestern North Pacific Ocean, May and June in 1984.

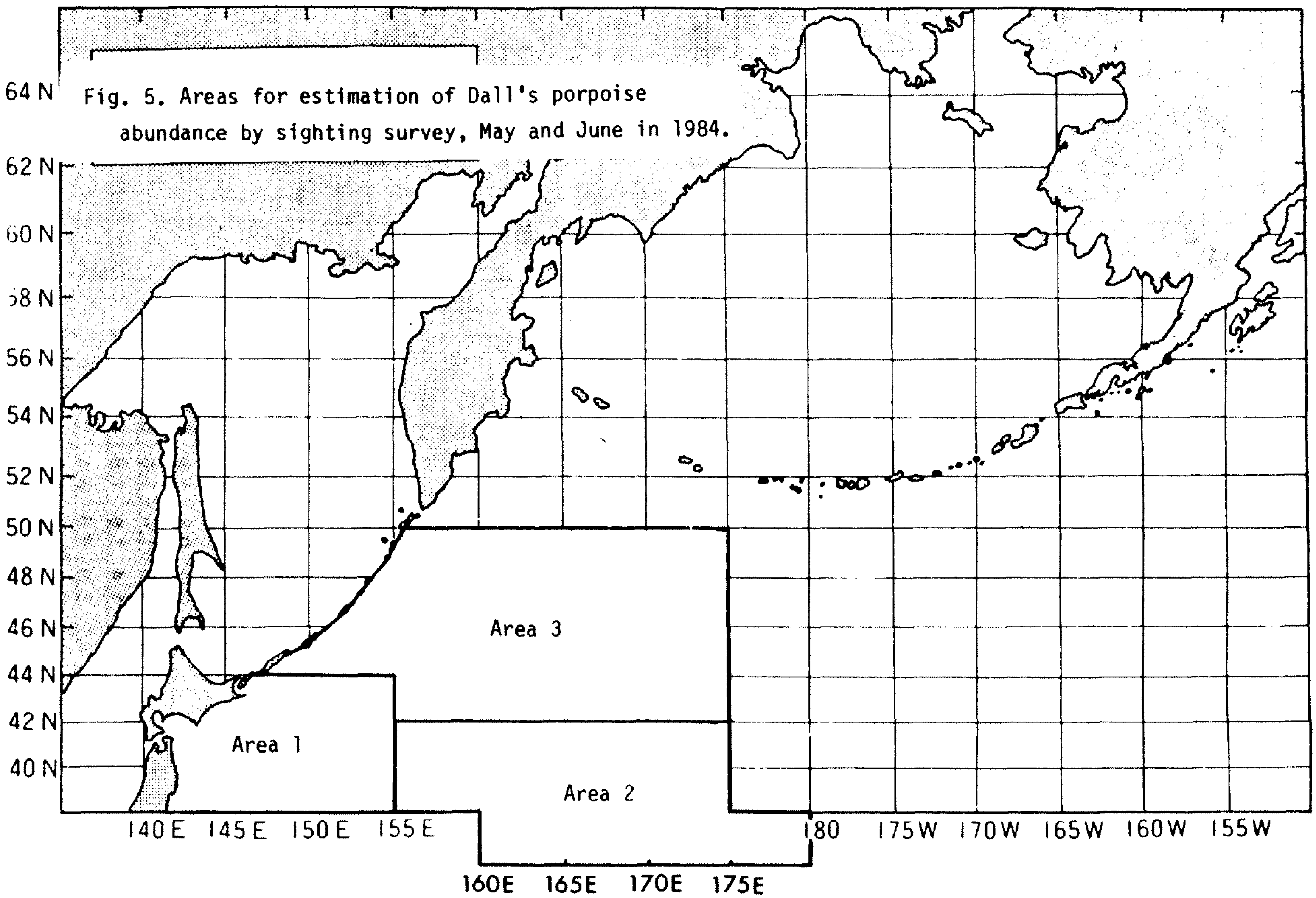

Fig. 5. Areas for estimation of Dall's porpoise abundance by sighting survey, May and June in 1984.

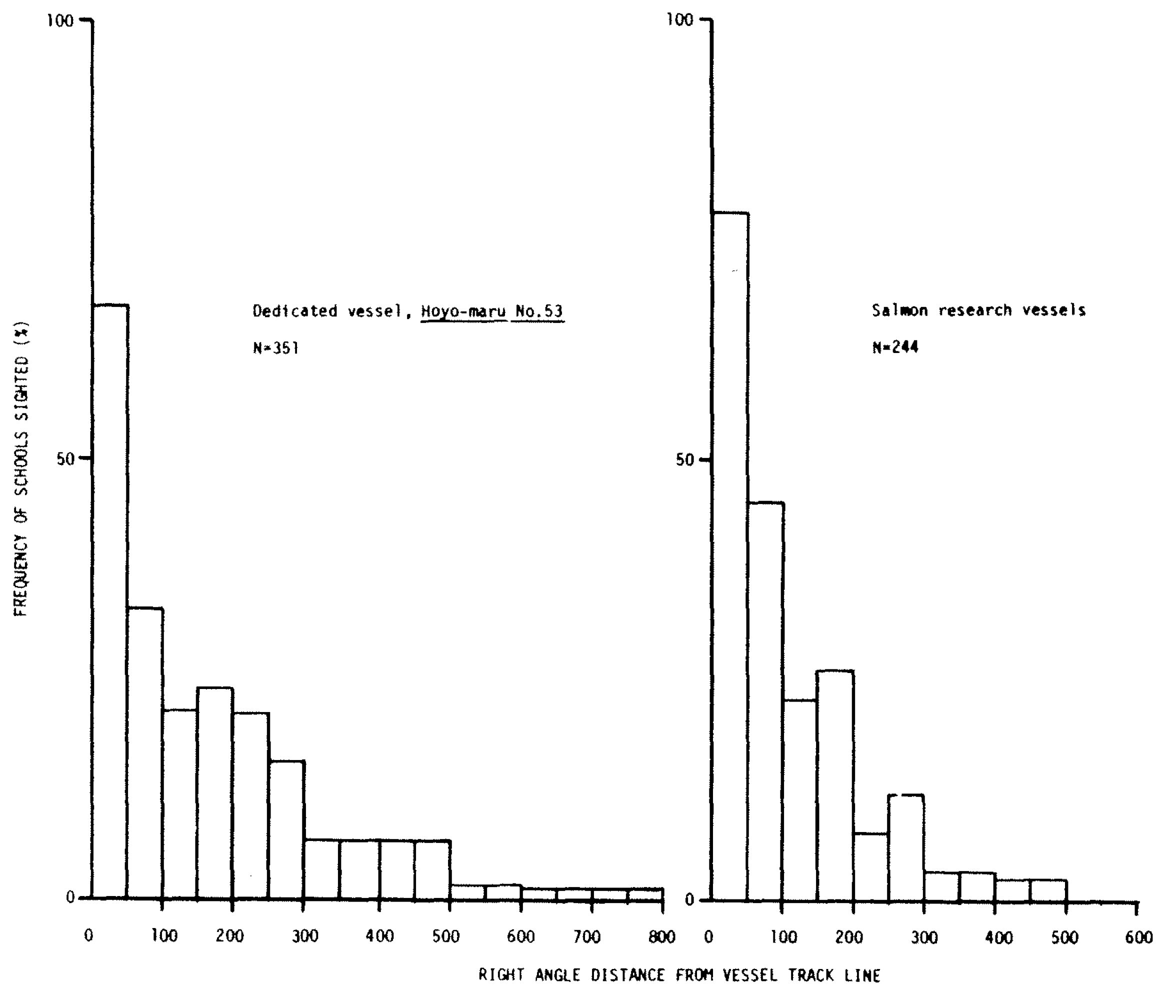

Fig. 6. Frequency distribution of Dall's porpoise schools sighted in right angle distance from vessel track lines in pooled data of Area 1, 2 and 3, 1984.

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TRANSLATION

COMPARISON OF ABUNDANCE ESTIMATION OF DALL'S PORPOISES BY SIGHTING SURVEYS BETWEEN SALMON RESEARCH VESSELS AND A VESSEL DEDICATED FOR DALL'S PORPOISE

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Since 1978, Japan has been estimating the abundance of Dall's porpoise in the North Pacific based on the sighting data obtained from research vessels. These research vessels are of two types: salmon research vessels and dedicated vessels. While all sighting surveys have been conducted by the crew of the salmon research vessels while cruising, there are two types of sighting surveys conducted by the dedicated vessels: that conducted by the crew, the same as on the salmon research vessels, and that conducted independently of these surveys by research experts specifically trained and/or experienced in this field. While it is considered that the data from the latter surveys have greater accuracy, Japan's abundance estimations have been largely based on the data from salmon research vessels. During May and June 1984 a dedicated vessel had an opportunity to conduct surveys in the northwestern North Pacific and the results of the sighting survey conducted by research experts placed on the dedicated vessel can be compared to those results from salmon research vessels which were obtained in that area during the same period. The objective of this report is to contribute to improvement of methods used to estimate the abundance of Dall's porpoise by making a comparison of results from both sighting surveys.

Materials and Methods

(1) Research vessels

In order to make equivalent the periods and areas of both data, the sighting survey data used were obtained from the following research vessels conducting surveys during the same period of the same year in the same areas. Details of the sighting surveys are the same as those of Kato (1983).

Dedicated vessel: From 1984 May 10 to June 20, the Hoyo maru No. 53 conducted a sighting survey in the northwest North Pacific enclosed by 36°N, 48°N, 141°E, and 180° with a cruise distance of 3,836 nautical miles (nm). This cruise distance did not include mileage expended to pursue, identify, and retrieve porpoise. Sightings were conducted by three research experts and three to four members of the crew on the upper bridge.

Salmon research vessels: During 1984 May and June, ten salmon research vessels conducted marine mammal sighting surveys in the area of the northwest North Pacific enclosed by 38°N, 48°N, 141°E, and 175°E with a cruise distance of a total of 15,963 nm. Sightings were conducted by two to ten members of the crew on watch on the bridge.

(2) Area division

Prior to abundance estimations, area divisions were examined. The dedicated vessel conducted sighting surveys over a total of 3,886 nm in the area shown in Fig. 1, sighting a total of 1,870 porpoise including truei, dalli, and unidentified types of Dall's porpoise in 351 schools. The number of schools sighted per 100 nm by 2°x5° area was eight or more in 90% of the areas south of 42°N and six or less in 90% of the areas north of 42°N (Fig. 2).

The salmon research vessels conducted marine mammal sighting surveys during a total of 15,963 nm cruised and sighted a total of 1,008 Dall's porpoise in 244 schools. The number of schools sighted per 100 nm by 2°x5° area was two or more for 50% of the areas south of 42°N and two or less for 90% of the areas north of 42°N (Fig. 4).

Data from both types of research vessels indicated a substantial change in distribution of Dall's porpoise around 42°N. It was assumed that an increase in accuracy of abundance estimation could be obtained by dividing the research areas into regions based on density. Accordingly, the boundary was set at 42°N, dividing the research areas into two regions latitudinally. In addition, since truei type Dall's porpoise dominate the areas southwest of 44°N and 155°E, another region was established for these areas. The research areas were divided into the following three areas as mentioned based on such factors as density and color type of Dall's porpoise (Fig. 5).

Area 1: Area enclosed by 38°N, 44°N, 155°E and the Japan coast (197×10^3 nm^2)

Area 2: Area enclosed by 36°N, 38°N, 160°E and 180°, and 38°N, 42°N, 155°E and 175°E (336×10^3 nm^2)

Area 3: Waters of northwest North Pacific, southwest of 50°N and 175°E other than Areas 1 and 2 (435×10^3 nm^2)

Method of abundance estimation

The sighting data from both types of research vessels were examined for the method of estimating abundance they are best fitted. Relationships between right angle distances from each type of research vessel and frequency distribution of Dall's porpoise schools sighted are shown in Fig. 6. The applicability of the Fourier series estimator (Kato 1983) and the estimator of Exponential model (Kato 1984) to these frequency distributions was examined by χ^2-test (0.05). As a result, it was determined that the Fourier series estimator was more applicable to the data from the dedicated vessel and the Exponential method was more applicable to the data from the salmon research vessels.

Abundance of Dall's porpoise was estimated by applying these two methods to the data obtained from both types of research vessels.

Results

(1) Abundance estimation by Fourier series estimator (FSE)

While individual density of Dall's porpoise (individual/nm^2) obtained from the dedicated vessel was 1.46 in Area 1, 1.88 in Area 2, and 0.57 in Area 3, that from the salmon research vessels was 0.19 in Area 1, 0.89 in Area 2, and 0.32 in Area 3 (Table 1). The density data from the dedicated vessel was larger: 7.7 times in Area 1, 2.1 times in Area 2, and 1.8 times in Area 3 than the data from the salmon research vessel.

The abundance of Dall's porpoise was estimated based on the dedicated vessel data to be 288 x 10^3 individuals (95% confidence interval: 0-739 x 10^3) in Area 1, 632 x 10^3 individuals (0-1,618 x 10^3) in Area 2, and 250 x 10^3 individuals (0-724 x 10^3) in Area 3, totalling 1,170 x 10^3 individuals (0-3,081 x 10^3) in these areas combined (Table 1).

The abundance was also estimated based on the salmon research vessel data to be 37 x 10^3 individuals (0-93 x 10^3) in Area 1, 299 x 10^3 individuals (0-660 x 10^3) in Area 2, and 141 x 10^3 individuals (0-1,145 x 10^3), totalling 476 x 10^3 (0-392 x 10^3) in these areas combined (Table 1).

(2) Abundance estimation by Exponential model (EM)

While individual density of Dall's porpoise (individuals/nm^2) obtained from the dedicated vessel data was 1.56 in Area 1, 2.16 in Area 2, and 1.09 in Area 3, that from the salmon research vessel data was 0.20 in Area 1, 1.21 in Area 2, and 0.58 in Area 3 (Table 2). The density from the dedicated vessel data was 7.8 times larger in Area 1, 1.8 times larger in Area 2, and 1.9 times larger in Area 3 than that from the salmon research vessel data.

The abundance was estimated based on the dedicated vessel data to be 307×10^3 individuals ($0-763 \times 10^3$) in Area 1, 726×10^3 individuals ($0-1,752 \times 10^3$) in Area 2, and 474×10^3 individuals in Area 3, totalling $1,507 \times 10^3$ individuals ($0-3,843 \times 10^3$) in these areas combined (Table 2).

Based on the salmon research vessel data, the abundance was estimated to 39×10^3 individuals ($0-101 \times 10^3$) in Area 1, 405×10^3 individuals ($0-767 \times 10^3$) in Area 2, and 253×10^3 individuals ($0-637 \times 10^3$) in Area 3, totalling 697×10^3 individuals ($0-1,504 \times 10^3$) in these areas combined (Table 2).

Discussion

Data from both types of research vessels showed that density of Dall's porpoise was different between waters north and south of 42°N. The Subarctic boundary with a surface temperature of 10° to 15°C formed around 42°N in May and June. It was reported in Kato (1984) that Dall's porpoise were sighted at a high frequency in this water temperature range. Although the food environment of the Subarctic boundary waters is not necessarily highly productive, either cold water fish schools or warm water fish schools are regularly present there (Taniguchi 1981). High sighting frequency of Dall's porpoise was considered to be related to this factor.

The abundance of Dall's porpoise varied greatly by methods of estimation and by type of research vessel (Tables 1 and 2). The examinations on values of estimate of Dall's porpoise abundance by area were as follows--

Area 1 The abundance showed an eight times larger difference between estimates obtained from the dedicated vessel data ($288-307 \times 10^3$) and from the salmon research vessel data ($37-39 \times 10^3$). While _truei_ type Dall's porpoise seem to be distributed abundantly in the waters south of 40°N in this period, the survey effort expended by the salmon research vessels was relatively small in those waters; on the other hand, effort by the dedicated vessel in these waters was relatively large (Figs. 3 and 5). It is believed that this difference in survey effort greatly affected the results of the estimates of Dall's porpoise abundance. This would suggest that abundance in this area requires further examination.

Area 2 The abundance varied as follows: while 632 (FSE) to 726 (EM) x 10^3 from the dedicated vessel data, 300 (FSE) to 405 (EM) x 10^3 from the salmon research vessel data. As mentioned in the section on the methods of abundance estimation, the sighting data from the dedicated vessels showed the FSE to be more applicable and those from the salmon research vessels showed the EM to be more applicable. Therefore, it is considered that the range of 405 to 632 x 10^3 is an appropriate estimate. The abundance based on the sighting data from the salmon research vessels was smaller by 40%. Although Dall's porpoise seem to distribute abundantly in waters south of 38°N during this period, the salmon research vessels conducted little survey effort and the dedicated vessel expended a relatively large survey effort in these waters. This difference in survey efforts was believed to greatly affect the estimates of abundance of Dall's porpoise. Therefore, the estimate of 632 x 10^3 Dall's porpoise based on the dedicated vessel data was considered to be the more appropriate figure for the abundance in Area 2.

Area 3 The abundance varied as follows: while 250 (FSE) to 474 (EM) x 10^3 from the dedicated vessel data, 141 (FSE) to 253 (EM) x 10^3 from the salmon research vessel data. For the above-mentioned reason, 250-253 x 10^3 was considered to be an appropriate estimate of the abundance in this area. It is believed that the surveys which were conducted by each type of research vessel widely covered the waters where Dall's porpoise are distributed had brought about agreement of estimate of the abundance between two types of research vessel.

Thus, using the method of estimation which is sufficiently applicable to the sighting data, conducting surveys corresponding to spacio-temporal distribution of Dall's porpoise, etc., it deemed to be able to produce an abundance estimation with a high accuracy.

The abundance of Dall's porpoise during May and June 1984 was estimated to be 900-1,200 x 10^3 (968 x 10^3 nm^2). This value exceeded greatly the abundance 300-700 x 10^3 (1,258 x 10^3 nm^2) previously estimated by Japan (Kato 1984, 1985) for the northwest areas of the North Pacific. Salmon research vessel sighting surveys have not necessarily correponded to the major spatio-temporal distribution of Dall's porpoise. If a dedicated vessel conducted the sighting surveys which corresponded to the distribution of Dall's porpoise, it may be proved that the current estimate of 2 million Dall's porpoise in the North Pacific may be an underestimate.

REFERENCES, TABLES 1 AND 2, AND FIGS. 1 TO 6
ARE IN ENGLISH IN THE JAPANESE DOCUMENT