日本さけ・ます調査船による1986年の海産哺乳動物目視調査の概要と北太平洋のイシイルカの豊度推定

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要　　約

日本は、1986年4月19日から10月5日にかけて、北太平洋北部及びベーリング海（35°～60°N、140°E～123°W）で11隻の調査船によりイシイルカを中心とした海産哺乳動物の目視調査を実施した。その航走距離は48,534海理で、イシイルカ948群3,538頭が目視された。

Beaufort scale 0－3の海況条件から得られた1980～1986年をプールした目視資料を基に、Fourier seriesとnegative exponentialをestimatorとしてイシイルカの豊度を推定した。リクゼンイルカ型の豊度は125 × 10^3頭、北太平洋のイシイルカ型の豊度は1,925～2,138 × 10^3頭及びベーリング海のそれは213～468 × 10^3頭と推定された。

はしがき

1978年以来、日本のさけ・ます調査船及びイシイルカ専門調査船は北太平洋において海産哺乳動物の目視調査を行っている。この調査の目的は海産哺乳動物、特にイシイルカの豊度を推定することにある。1986年においても、例年と同様な規模で目視調査を行った。その目視調査の概要を述べると共に、1986以前に行われた目視資料を用いてイシイルカの豊度推定を行った結果を報告する。調査船の中には、1986年の6月から8月にかけて北太平洋を横断する調査航海を行った水産庁官船照洋丸も含んでいる。イシイルカ専門調査船の第12宝洋丸航海の詳細な報告は吉岡その他（1987）を参照されたい。

1986年の目視調査の概要

1986年に9隻のさけ・ます調査船及び照洋丸は4月から8月まで北太平洋北西部、ベーリング

海及びアラスカ湾を含む北太平洋北東部で海産哺乳動物の目視調査を行った。海域別調査船数は、北太平洋北西部で9隻、ベーリング海で2隻及び北太平洋北東部で2隻であった。その調査海域は35°N～60°、140°E～123°Wに及んだ（表1）。イシイルカ専門調査船1隻は8月から10月まで北太平洋北西部及びアラスカ湾を含む北太平洋北東部で目視調査を行った。その調査海域は39°N～54°N、145°E～126°Wであった。

目視調査の項目は加藤（1983）と全く同じものである。さけ・ます調査船においては乗組員が、照洋丸及びイシイルカ専門調査船第1宝洋丸においては専門調査員が目視業務を行った。

さけ・ます調査船（照洋丸を含む）の目視調査は4月19日に開始されたが、5月中旬までの調査は日本の200海里以内（145°E以西）のみで行われた。日本の200海里以外の北太平洋海域の調査は5月中旬から開始された。調査の終了は例年通り8月中旬であった。目視調査が行われた航走距離は42,871海里、目視が行われた延べ日数は494日であった。航走距離の内訳けは165°W以西の北太平洋で35,196海里、165°W以東の北太平洋で4,087海里及びベーリング海で3,588海里であった。目視されたイシイルカは633群2,311頭であった。内訳けは、イシイルカ型が422群1,520頭（65.8％）、ソクゼンイカ型が49群165頭（7.1％）及び型不明イシイルカが192群626頭（27.1％）であった。その他、カマイルカ24群、セミイルカ4群、シャチ21群、マイルカ7群、オットセイ480群等が発見された。

イシイルカの専門調査による目視調査は8月10日に開始され、10月5日に終了した。目視調査が行われた航走距離は5,663海里、延べ日数は50日であった。目視されたイシイルカは315群1,227頭であった。内訳けは、イシイルカ型776頭（63.2％）、リクゼンイルカ型20頭（1.6％）及び型不明イシイルカが431頭（35.1％）であった。

図1－1～1－5に1986年の航走1海里当りのイシイルカの目視群数を月別（4月～8月）に示した。6月に170°E～180°付近の海域で36°以北にイシイルカが目視された。このことは従来の知見より南の海域にイシイルカの分布があることを示した。

イシイルカの豊度推定

イシイルカはイシイルカ型、リクゼンイルカ型及び型不明イシイルカの3型に分けて記録された。これらの3型の全てが豊度推定の資料として用いられた。

収集された目視資料中、乗組員が目視に不慣れであったため、調査内容が不十分であった1978及び1979年の資料を除外した。また、できるだけ広い時空間から得られた資料を用いることが、精度の高い推定値につながると考えて、1980～1986年をプールした資料で豊度推定を行った。イシイルカの捕獲を目的とした専門調査船から得られた目視資料は観測場所やイシイルカの追跡の有無を含む調査方法が異なるため、さけ・ます調査船による目視資料と同一視できないと判断し、これを資料から除外した。

海域区分

1980～1985年の6～7月をプールした航走距離当りのイシイルカの発見群数を図2に示した。これによると、イシイルカは北太平洋北西部で38°N以北に、同北東部では42°N以北に、及びベーリング海では60°以南で目視された。ベーリング海では1972～1977年のさけ・ます調査船の混獲資料（待鳥、1979）によると、7月に62°N以南にイシイルカの分布の記録がみられた。

リクゼンイルカ型は日本近海にのみ分布するので、イシイルカ型と分離して豊度推定を行うことが妥当である。リクゼンイルカ型の主な分布域は、Kasuya and Ogi（1986）によると、44°N以南、155°E以西の北太平洋北西部である。この報告ではその南限を38°Nとした。また、NOAA（1986）はベーリング海に北太平洋と別個なイシイルカ資源があることを示唆している。北太平洋北東部における目視努力量の密度分布は同北西部に比して著しく小さい。目視努力量の異った海域を区分することが、より高い精度の豊度推定につながると考えて、北太平洋を便宜的に165°W線で区切った。以上を考慮して、次のような海域区分を行った（図3）。

海域1.　38°～44°N、155°E以西の北太平洋北西部（197×10^3平方海里）

海域2.　38°以北で165°W以西の海域1を除いた北太平洋（$1,521 \times 10^3$平方海里）

海域3.　42°以北で165°W以東の北太平洋（$1,561 \times 10^3$平方海里）

海域4.　62°以南のベーリング海（567×10^3平方海里）

Kato（1986）は海況をBeaufart scale 0～3(A)と4～7(B)の2つに区分し、海況Bでは豊度が過少に評価されることを示した。この報告では、海況Aの時の目視資料のみを用いて豊度推定を行った。

豊度推定に用いたestimator

豊度推定に際し、目視資料によくフィットするestimatorを用いることが重要である。各海域において海況Aの目視資料を用い、negative exponentialとFourier seriesのフィットネスの検定を行った。有意水準95％でこの目視資料は両estimatorによくフィットすると判断された。豊度推定に当り、両estimator（Kato、1983、Kato、1984）を用いることにした。

豊度推定値

豊度推定結果を表2に示した。豊度推定に用いた航走距離と発見群数は、海域1で37,643海里、885群、海域2で99,467海里、2,064群、海域3で7,930海里、229群及び海域4で11,881海里、251群、合計156,921海里、3,429群であった。

Fourier series estimatorによる豊度推定

1平方海里当りの個体密度は海域1で0.64、海域2で0.62、海域3で0.63及び海域4で0.38であった。

豊度は海域1で126×10^3頭（95％の信頼区間で95～157×10^3頭）、海域2で936（730～1,142）$\times 10^3$頭、海域3で989（346～1,632）$\times 10^3$頭、及び海域4で213（85～340）×

10^3頭、計2,263（ 1,255～3,271 ）×10^3頭と推定された。

Negative exponential modelによる豊度推定

1平方当りの個体密度は海域1で0.64、海域2で0.66、海域3で0.72及び海域4で0.83であった。

豊度は海域1で125×10^3頭（95～156×10^3頭）、海域2で1,010（782～1,237）×10^3、海域3で1,128（416～1,841）×10^3及び海域4で468（336～601）×10^3、計2,731（1,628～3,834）×10^3と推定された。

海域1、2及び3においてはestimatorによる推定豊度の相異はほとんどなかったが、海域4において大きく相異した。

海域1の豊度は主にリクゼンイルカ型のそれを示し、125×10^3頭と推定された。海域2及び3の豊度は北太平洋のイシイルカ型のそれを示し、1,925～2,138×10^3と推定された。海域4の豊度はベーリング海のイシイルカ型のそれを示し、213～468×10^3と推定された。

加藤（1986a）はBeaufort 0～7の海況条件から得られた1980～1985年をプールした目視資料を用い、イシイルカの豊度を全海域（3,861×10^3平方海里）で200～224万頭と推定した。この報告ではBeautifort 0～3の海況条件から得られた目視資料のみを用いて、全海域（3,846×10^3平方海里）で226～273万頭と推定した。今回の推定は、海況条件が悪い時の資料を用いることによる過少推定をある程度排除しているため、前回の推定と比べ信頼性は高まっていると考えられる。この結果、イシイルカの豊度は26～49万頭の増加となった。今後さらに資料数が増大するならば、よりよい海況条件の資料を選ぶことにより、さらに信頼性の高い豊度推定が可能と考える。

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Table 1. Japanese research vessels engaged in the sighting surveys of marine mammals in 1987.

Name	Tonnage	Horse power	Cruise	Dates surveyed	Area covered	Distance sighted (nautical miles)	Days sighted
Hokushin	219.5	1,000	1	June 13 - July 15	40°N-52°N, 148°E-172°E	2,061	31
Oshoro	1,779	3,000	1	June 7 - Aug. 18	36°N-61°N, 144°E-151°W	3,848	48
Hokusei	892.5	2,100	1	June 3 - June 14	35°N-43°N, 142°E-155°E	767	12
			2	June 21 - July 2	35°N-42°N, 145°E-155°E	733	11
			3	July 12 - Aug. 9	38°N-49°N, 144°E-175°E	2,154	28
Hokko	466.5	1,800	1	June 16 - July 7	41°N-49°N, 144°E-167°E	2,023	22
Iwaki	200.0	1,300	1	June 1 - July 9	36°N-51°N, 141°E-177°W	2,549	31
Hokuho	414.4	1,300	1	April 19 - April 30	38°N-40°N, 142°E-145°E	566	11
			2	May 1 - May 29	38°N-47°N, 140°E-170°E	2,589	25
			3	June 12 - July 23	40°N-51°N, 140°E-177°W	3,317	34
Wakatake	424.0	1,500	1	April 19 - May 29	35°N-45°N, 142°E-176°E	3,249	39
			2	June 14 - July 23	40°N-60°N, 140°E-175°W	3,895	38
Kaiun	299.6	770	1	May 1 - May 19	37°N-41°N, 141°E-146°E	1,020	18
			2	June 11 - July 15	41°N-49°N, 144°E-162°E	1,803	28
Shin-riasu	471.0	1,400	1	April 19 - May 28	37°N-44°N, 142°E-176°E	3,202	35
			2	June 11 - July 19	39°N-51°N, 142°E-179°E	2,800	31
Shoyo	1,362	4,000	1	June 29 - Aug. 24	36°N-49°N, 144°E-123°W	6,295	52
Hoyo No.12	299	540	1	Aug. 10 - Oct. 5	39°N-54°N, 145°E-126°W	5,663	50
					Total	48,534	544

Table 2. Abundance and density of Dall's porpoise from the sighting survey of salmon research vessels in 1980-1986 pooled data collected in sea condition of Beaufort 0-3. Estimates based on Forier series estimator and negative exponential model.

Estimator	Area	10^3NMI^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 $\hat{Cv}(\hat{Dg})$	coefficient of variation $\hat{Cy}(\bar{G})$	Density $\hat{(Di)}$ indi./NMI^2	Abundance $\hat{(T)}_{10^3}$	95% confidence interval around $\hat{(T)}$ 10^3	
Fourier series	1	197	37,643	885	0.1592	0.000130	4.01	0.0717	0.1047	0.6384	125.8	94.5-	197.4
	2	1,521	99,467	2,064	0.1493	0.000046	4.12	0.0453	0.1028	0.6151	935.7	729.7-	1,141.5
	3	1,561	7,930	229	0.1545	0.000506	4.10	0.1456	0.2983	0.6335	988.9	345.5-	1,632.3
	4	567	11,881	251	0.0942	0.000743	3.91	0.2891	0.0997	0.3759	213.1	85.3-	340.1
	Total	3,846	156,921	3,429							2,263.4		
Negative exponential	1	197	37,643	885	0.1588	0.000104	4.01	0.0643	0.1047	0.6368	125.4	95.2-	155.6
	2	1,521	99,467	2,064	0.1611	0.000069	4.12	0.0516	0.1028	0.6637	1,009.5	782.0-	1,237.0
	3	1,561	7,930	229	0.1763	0.000462	4.10	0.1219	0.2983	0.7228	1,128.3	415.7-	1,840.9
	4	567	11,881	251	0.2111	0.000487	3.91	0.0997	0.1045	0.8254	468.0	335.5-	600.5
	Total	3,846	156,921	3,429							2,731.2		

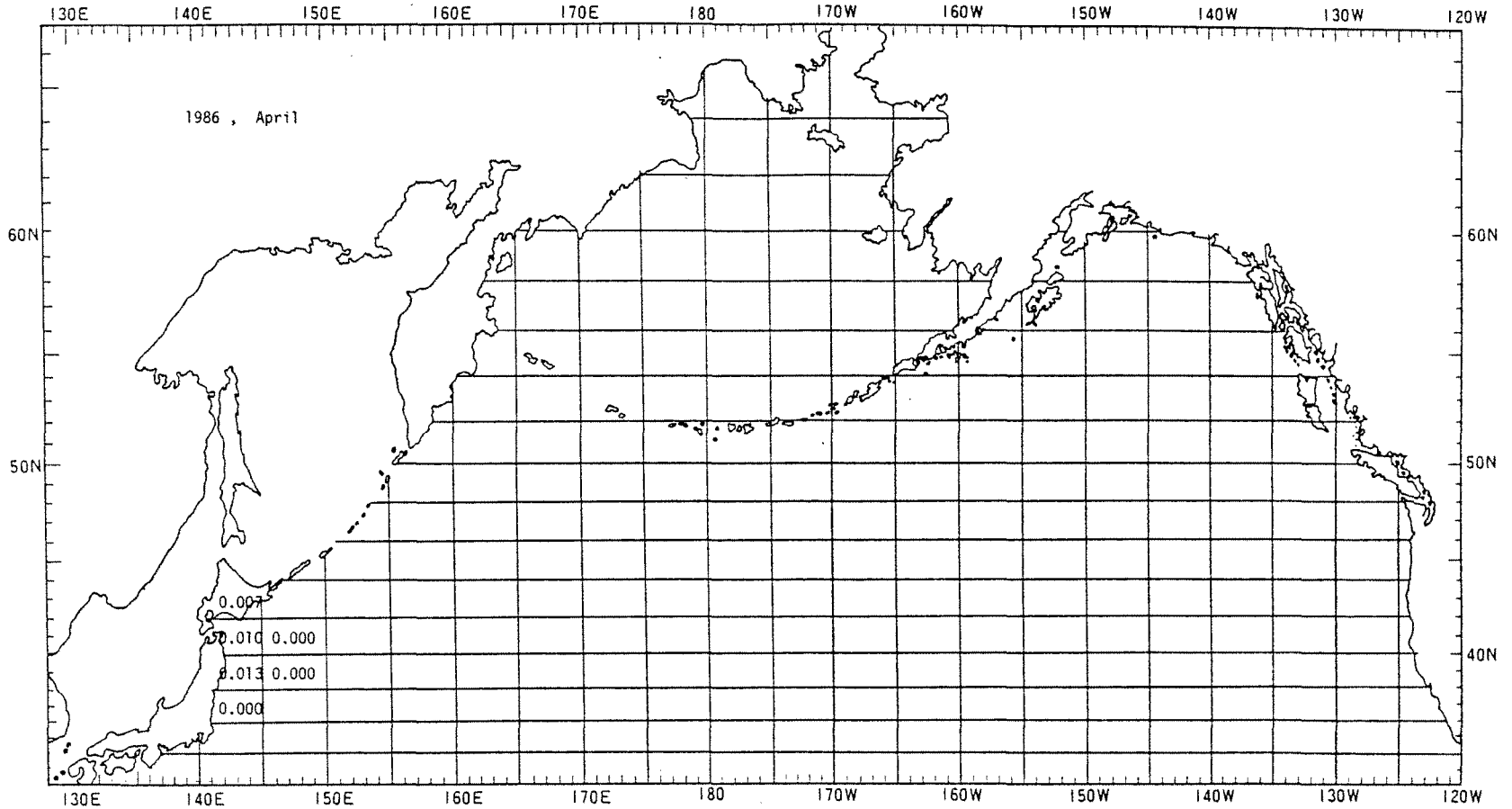

Fig. 1-1. Number of Dall's porpoise schools sighted per mile of research vessels, in April, 1986.

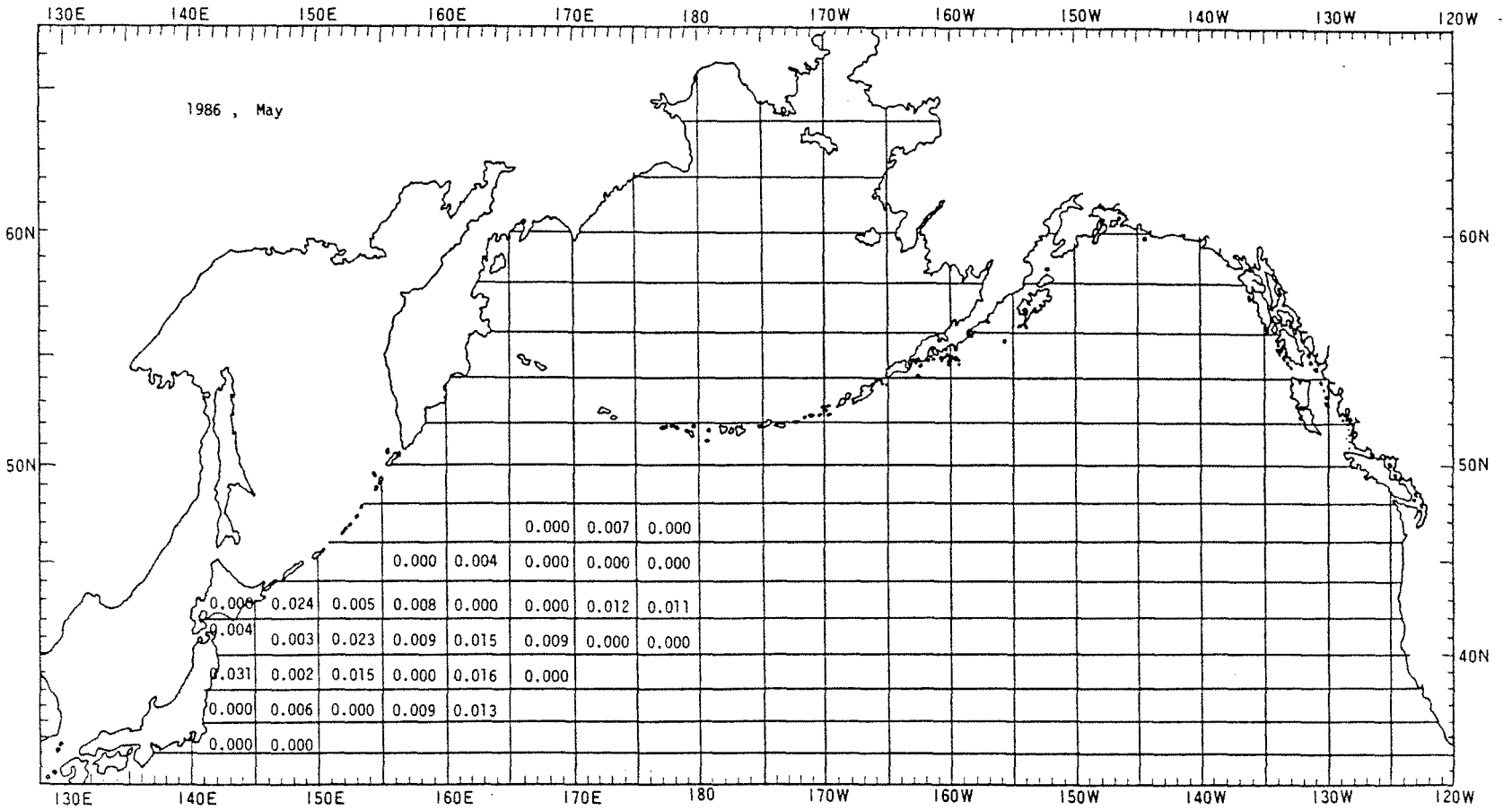

Fig. 1-2. Number of Dall's porpoise schools sighted per mile of research vessels, in May, 1986.

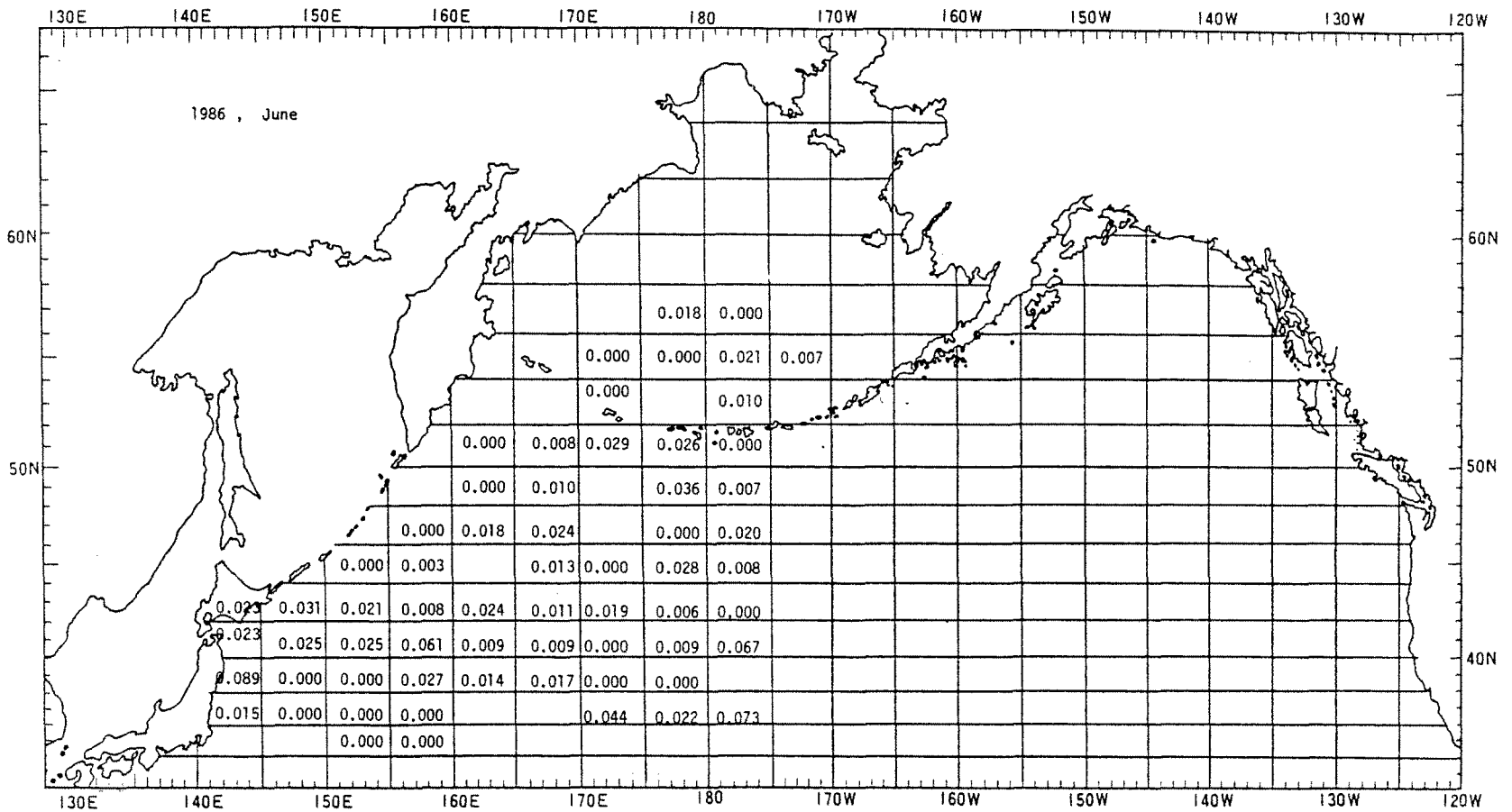

Fig. 1-3. Number of Dall's porpoise schools per mile of research vessels, in June, 1986.

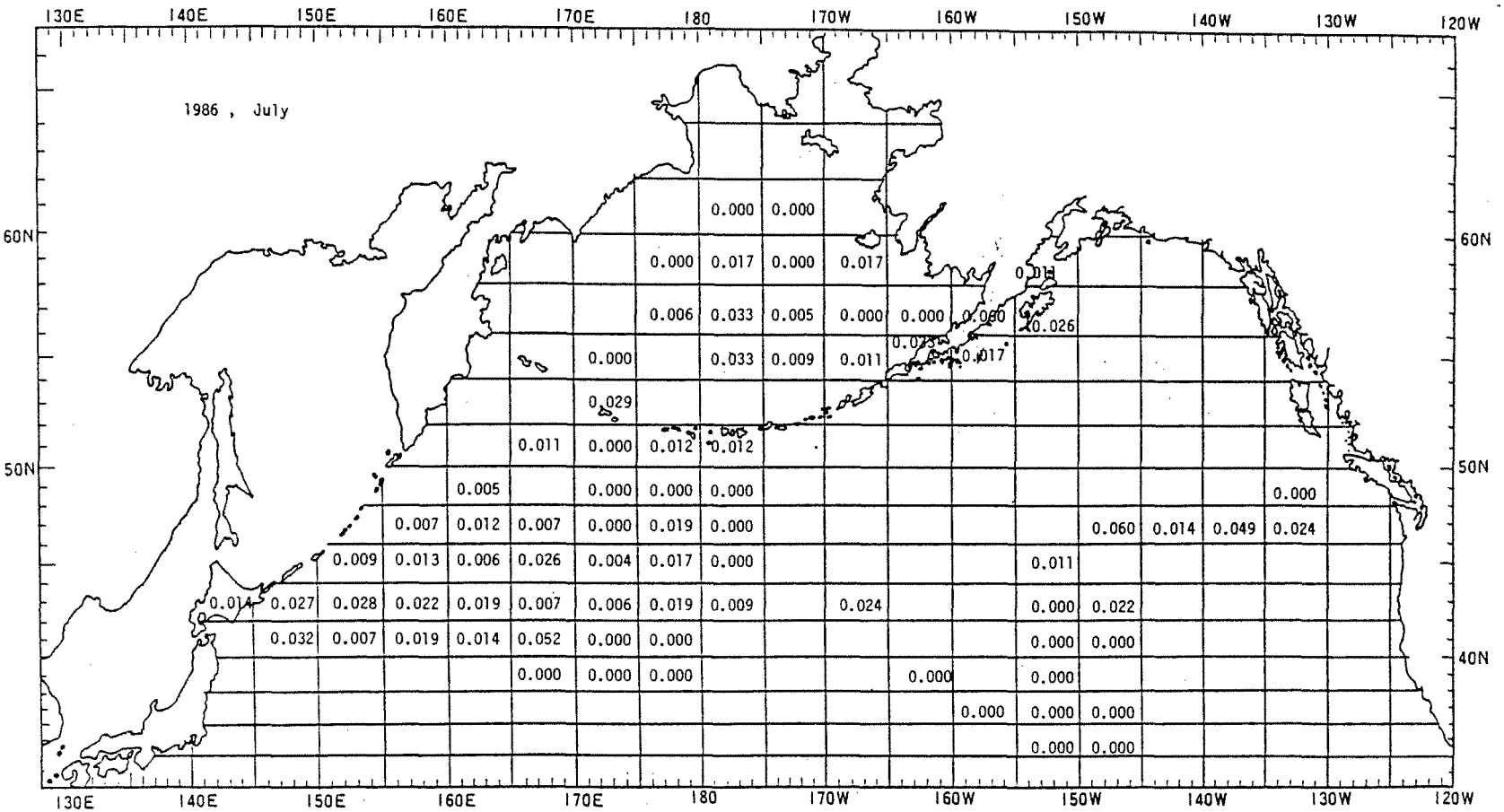

Fig. 1-4. Number of Dall's porpoise schools sighted per mile of research vessels, in July, 1986.

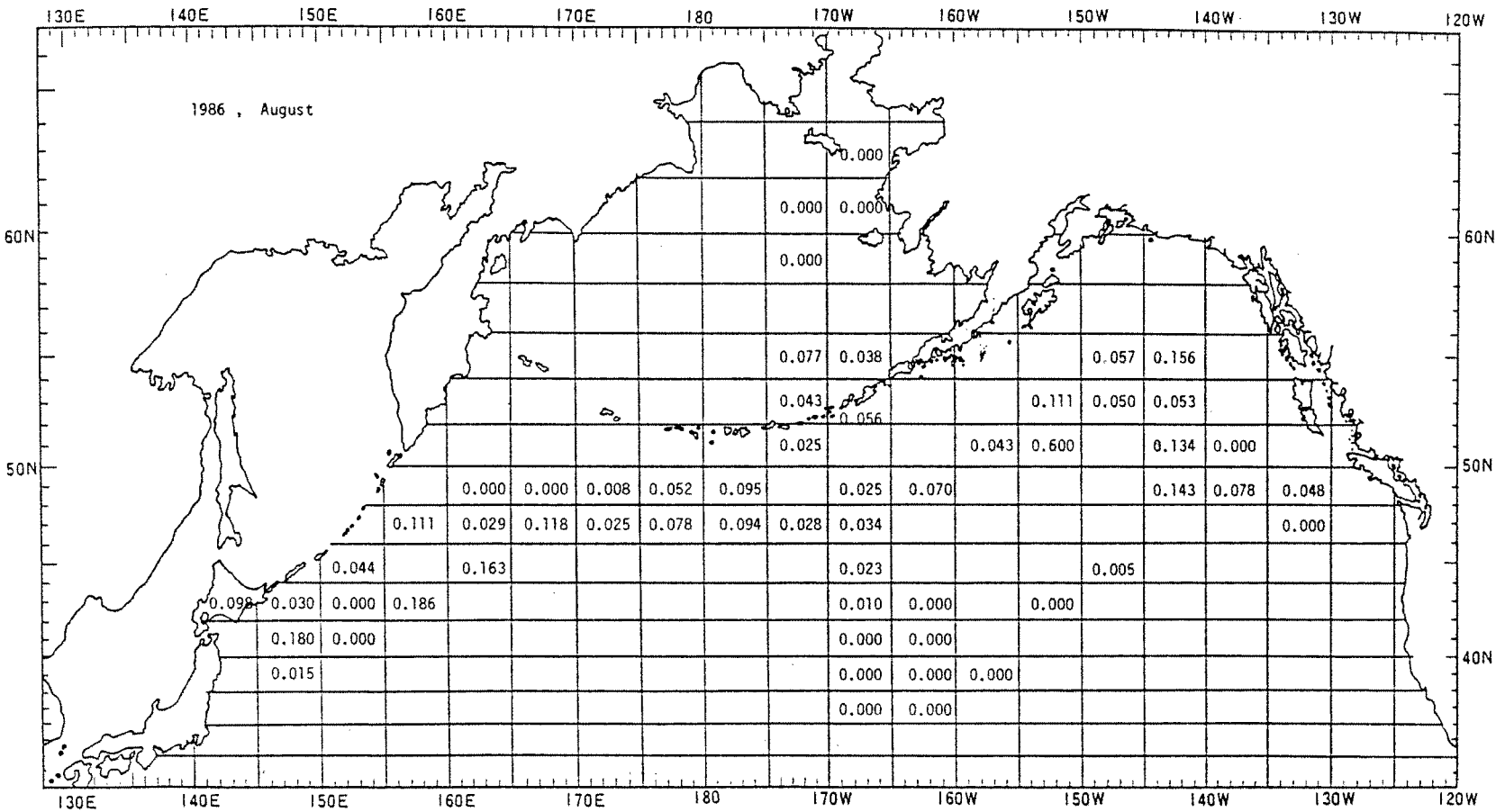

Fig. 1-5. Number of Dall's porpoise schools sighted per mile of research vessels, in August, 1986.

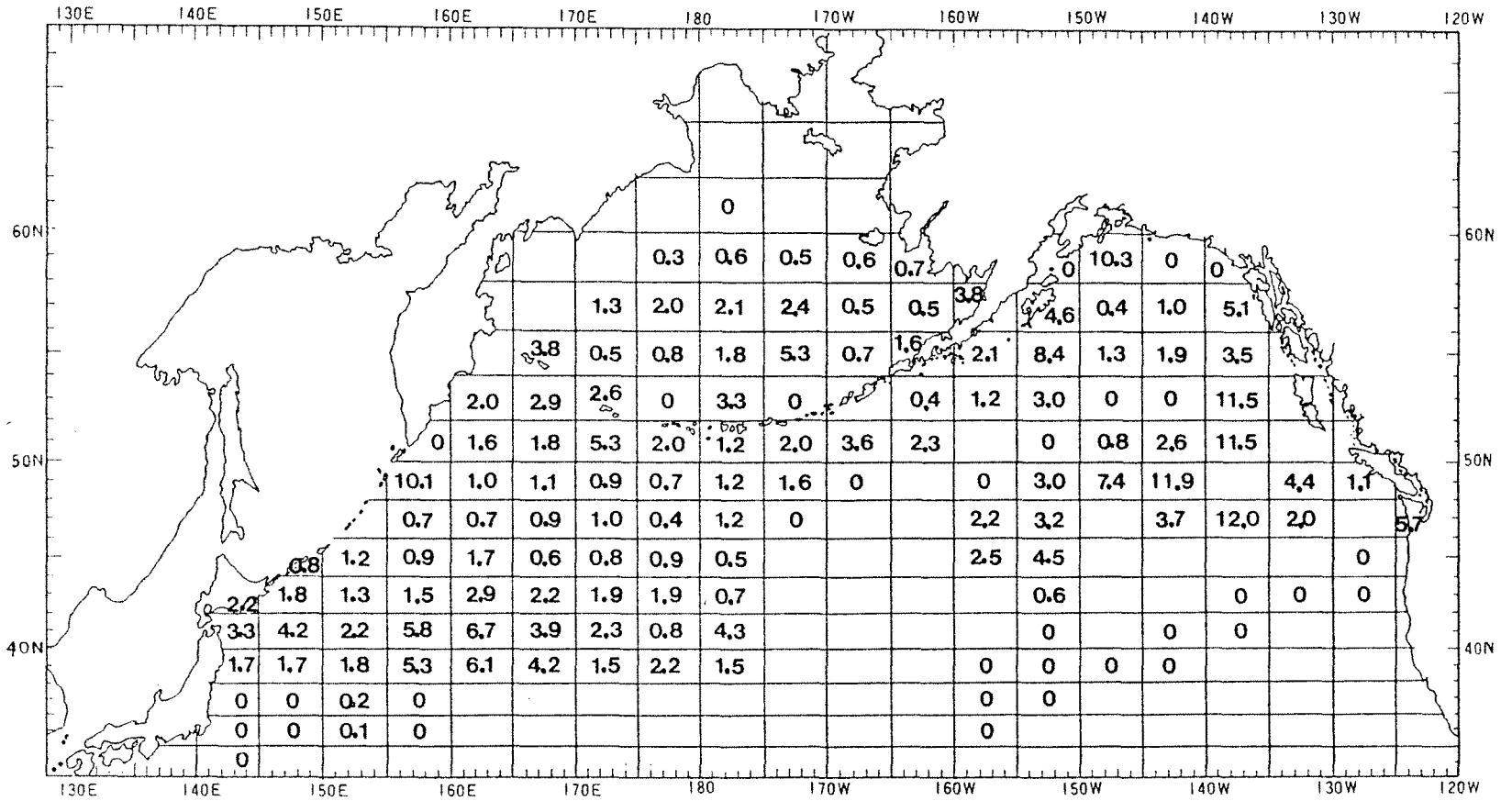

Fig. 2. Number of Dall's porpoise schools sighted per 100 miles of research vessels in June-July, 1980-1985 pooled data.

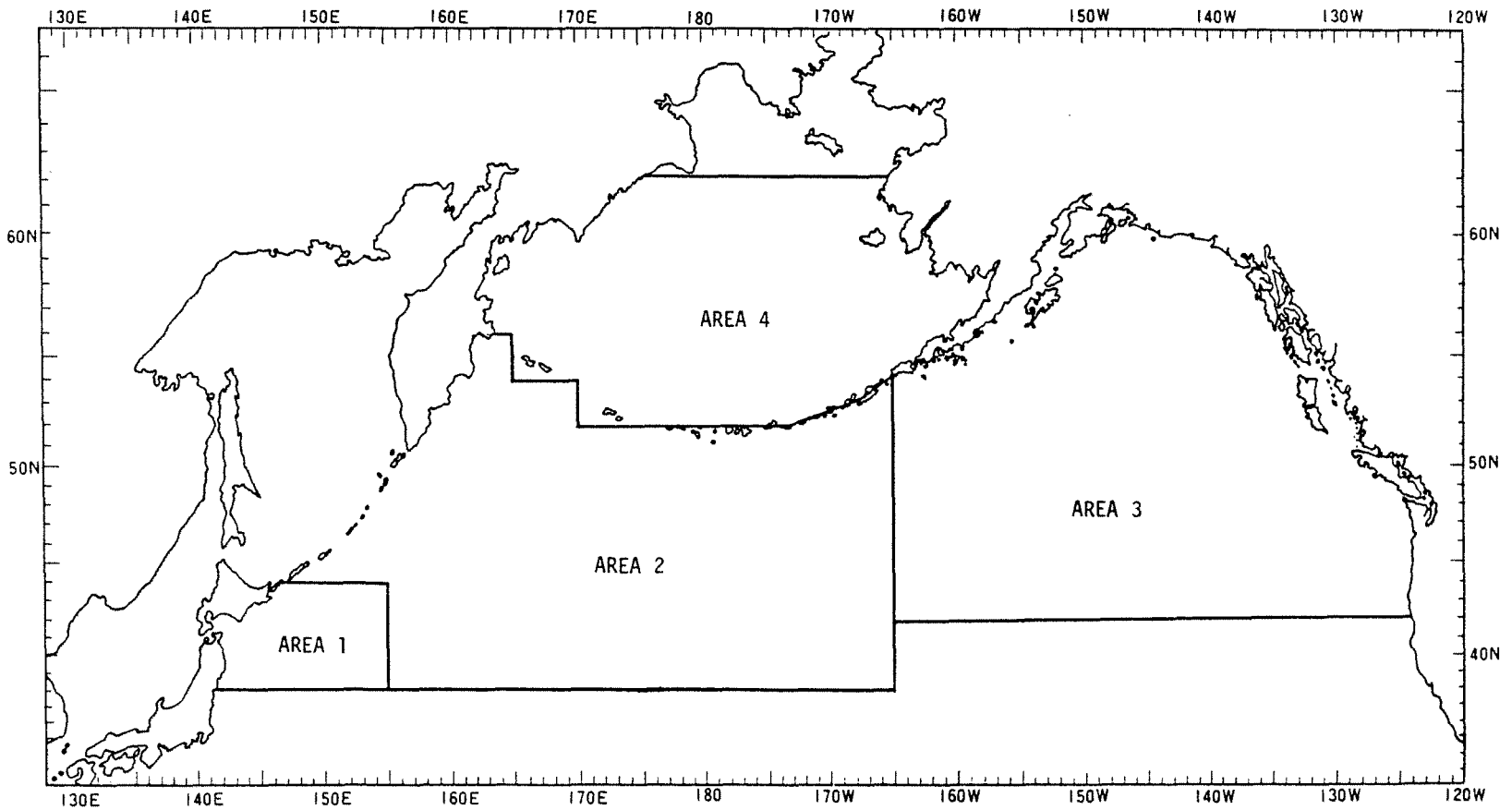

Fig. 3 . Areas for abundance estimation of Dall's porpoise.

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TRANSLATION

OUTLINE OF SIGHTING SURVEY FOR MARINE MAMMALS BY JAPANESE SALMON RESEARCH VESSELS IN 1986 AND ESTIMATION OF DALL'S PORPOISE ABUNDANCE IN THE NORTH PACIFIC OCEAN

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Summary

A total of 11 Japanese research vessels conducted a marine mammal sighting survey focusing mainly on Dall's porpoise from April 19 to October 5, 1986 in the waters of the northern North Pacific and Bering Sea ranging from 35° to 60°N and 140°E to 123°W. The distance cruised was 48,534 nmi and a total of 3,538 individuals of Dall's porpoise in 948 schools were sighted.

Based on the sighting data obtained for sea conditions of 0 to 3 on the Beaufort scale and pooled from 1980 to 1986, the abundance of Dall's porpoise was estimated using Fourier series estimator and negative exponential estimator. The abundance of truei type Dall's porpoise, dalli type in the North Pacific, and dalli type in the Bering Sea were estimated to be 125 x 10^3, 1,925 to 2,138 x 10^3, and 213 to 468 x 10^3 individuals, respectively.

Introduction

In 1978 and after, Japanese salmon research vessels and research vessels dedicated to research on Dall's porpoise have conducted marine mammal sighting surveys in the North Pacific with the object of estimating the abundance of marine mammals, particularly Dall's porpoise. In 1986, the sighting survey was conducted on the same scale as in previous years. This report describes the outline of the 1986 sighting survey and results of the abundance estimation based on the sighting data obtained from the surveys conducted until 1986. The Shoyo maru, one of the government's vessels belonging to the Fisheries Agency of Japan which conducted research cruises across the North Pacific from 1986 June to August participated in the 1986 sighting sruvey and was categorized into salmon research vessels in this report. A detailed report for the research cruise by the Hoyo maru No. 12, dedicated vessel for the Dall's porpoise research, is described by Yoshioka et al. (1987).

Outline of sighting survey in 1986

In 1986, nine salmon research vessels and the Shoyo maru conducted marine mammal sighting surveys in the northwestern North Pacific, Bering Sea, and northeastern North Pacific including the Gulf of Alaska from April to August (Table 1). Nine vessels conducted surveys in the northwestern North Pacific, two in the Bering Sea, and two in the northeastern North Pacific Ocean (Table 1). The areas in which the surveys were conducted ranged over 35° to 60°N and 140°E to 123°W (Table 1). One dedicated vessel for Dall's porpoise research conducted sighting surveys from August to October in the northwestern North Pacific and northeastern North Pacific Ocean including the Gulf of Alaska and the survey covered the area of 39° to 54°N and 145°E to 126°W.

The details of the 1986 sighting survey were identical to those reported by Kato (1983). Crew members were engaged in the sighting surveys on the salmon research vessels while research personnel assumed that duty on the Shoyo maru and Hoyo maru No. 12, the dedicated vessel.

Although sighting surveys by the salmon research vessels, including the Shoyo maru, commenced on April 19, the surveys until mid-May were all conducted within Japan's 200 mile zone (west of 145°E). Sighting surveys covering waters in the North Pacific outside Japan's 200 mile zone commenced in mid-May. The surveys were completed as usual in mid-August. The total distance cruised in which the sighting survey was conducted was 42,871 nmi for a total of 494 days. The distance cruised was 35,196 nmi in the North Pacific west of 165°W, 4,087 nmi in the North Pacific east of 165°W, and 3,588 nmi in the Bering Sea. The total number of Dall's porpoise sighted were 2,311 individuals in 633 schools. Of the Dall's porpoise sighted, dalli type accounted for 1,520 individuals in 422 schools (65.8%), truei type 165 individuals in 49 schools (7.1%), and unidentified Dall's porpoise 626 individuals

in 192 schools (27.1%). In addition, 24 schools of Pacific whitesided dolphin, four schools of northern right whale dolphin, 21 schools of killer whales, seven schools of common dolphin, 480 schools of northern fur seals, etc. were sighted.

Sighting surveys by the dedicated vessel commenced on August 10 and were completed on October 5. The total distance cruised during the sighting survey was 5,663 nmi in a total of 50 days. The total number of Dall's porpoise sighted was 1,227 individuals in 315 schools; 776 dalli type (63.2%), 20 truei type (1.6%), and 431 unidentified type Dall's porpoise (35.1%).

The number of schools sighted per one nautical mile cruising distance for the 1986 survey is shown by 2°x5° area by month (April to August) in Tables 1-1 to 1-5. In June, Dall's porpoise were sighted in the waters north of 36°N around 170°E to 180°. This indicates that Dall's porpoise are distributed further south than the previously known southern limit.

Estimation of abundance of Dall's porpoise

The number of Dall's porpoise sighted was recorded by each of three categories of dalli type, truei type, and unidentified Dall's porpoise. The data of all the three categories were used in the estimation of abundance.

Of the sighting data collected from the survey, the data collected in 1978 and 1979 were excluded from the estimation because there were some inadequacies in the survey data from these years which resulted from the unfamiliarity of the crew members with the requirements of the sighting survey.

Considering that the data obtained for a larger number of the spatio-temporal areas should produce estimates with higher accuracy, the estimation of abundance was made using the sighting data pooled

from 1980 to 1986. The sighting data obtained by the dedicated vessel were exlcuded from the estimation since these data were judged not to be in the same category as those by salmon research vessels because of differences in the survey mode including positions on the vessels where sightings were made and whether the Dall's porpoise sighted were chased by the vessel or not.

Area divisions

The number of schools of Dall's porpoise sighted per 100 nmi cruising distance was calculated from the pooled data from 1980 to 1985 for the months of June and July. Figure 2 shows that Dall's porpoise were sighted in waters north of 38°N in the northwestern North Pacific, north of 42°N in the northeastern North Pacific, and south of 60°N in the Bering Sea. The data on the incidental take collected by Japanese salmon research from 1972 to 1977 (Machidori 1979) indicate that Dall's porpoise were distributed in waters south of 62°N in July in the Bering Sea.

Since truei type are distributed only in Japanese waters, it is appropriate to make separate estimation of abundance from that for dalli type. According to Kasuya and Ogi (1986), truei type are distributed mainly in waters southwest of 44°N, 155°E in the northwestern North Pacific. In the present report, the southern limit of the distribution of truei type was assumed to be 38°N. In addition, NOAA (1986) suggests that there is a separate stock of Dall's porpoise in the Bering Sea from that in the North Pacific. The density distribution of sighting effort expended in the northeastern North Pacific has been considerably low compared to that in the northwestern North Pacific. Considering that an appropriate categorization of areas according to the intensity of the expended sighting effort should produce the estimates with higher accuracy, the North Pacific was divided with the meridian of 165°W for convenience sake. Taking the above-mentioned factors into account, areas were divided as follows (Fig. 3)--

Area 1	Northwestern North Pacific Ocean, 38° to 44°N, west of 155°E (197 x 10^3 nmi^2)
Area 2	North Pacific Ocean north of 38°N west of 165°W, excluding Area 1 (1,521 x 10^3 nmi^2)
Area 3	North Pacific Ocean north of 42°N, east of 165°W (1,561 x 10^3 nmi^2)
Area 4	Bering Sea south of 62°N (567 x 10^3 nmi^2)

Kato (1986b) divided sea conditions into two categories: Category A (Beaufort scale 0 to 3) and B (4 to 7), indicating that the abundance was underestimated from the data obtained under the sea condition Category B. In the present report, estimation of abundance was made using only the sighting data for the sea condition Category A.

Estimators used for estimation of abundance

In estimating abundance, it is important to employ an estimator which well fits the sighting data. By each Area, using the sighting data obtained under the sea condition Category A, the fitness of both the negative exponential estimator and the Fourier series estimator was tested. As a result, it was determined that the sighting data well fit both the estimators at the level of significance of 95%. Therefore, both the estimators (Kato 1983; Kato 1984) were employed in the estimation of abundance.

Estimates of abundance

The results of estimation of abundance are shown in Table 2. The cruising distance and number of schools sighted which were used in the estimation are 37,643 nmi and 885 schools for Area 1, 99,467 nmi, and

2,064 schools for Area 2, 7,930 nmi and 229 schools for Area 3, and 11,881 nmi and 251 schools for Area 4; in total: 156,921 nmi and 3,429 schools.

Abundance estimation by Fourier series estimator

Individual density of Dall's porpoise (individuals/nmi^2) was 0.64, 0.62, 0.63, and 0.38 in Areas 1, 2, 3, and 4, respectively.

The abundance was estimated to be 126 x 10^3 individuals (95% confidence interval: 95 to 157 x 10^3 in Area 1, 936 x 10^3 individuals (730 to 1,142 x 10^3) in Area 2, 989 x 10^3 individuals (346 to 1,632 x 10^3) in Area 3, and 213 x 10^3 individuals (85 to 340 x 10^3) in Area 4, totalling 2,263 x 10^3 individuals (1,255 to 3,271 x 10^3).

Abundance estimation by negative exponential model

Individual density of Dall's porpoise was 0.64, 0.66, 0.72, and 0.83 individuals/nmi^2 in Areas 1, 2, 3, and 4, respectively.

The abundance was estimated to be 125 x 10^3 individuals (95 to 156 x 10^3) in Area 1, 1,010 individuals (782 to 1,237 x 10^3) in Area 2, 1,128 individuals (416 to 1,841 x 10^3) in Area 3, and 468 individuals (336 to 601 x 10^3) in Area 4, totalling 2,731 x 10^3 (1,626 to 3,834 x 10^3).

While there were almost no differences in the estimates of abundance for Areas 1, 2, and 3 between the types of the estimators, there was a large difference in Area 4.

The abundance of Dall's porpoise in Area 1 which indicates mainly that of truei type was estimated to be 125 x 10^3 individuals. The abundance in Areas 2 and 3 combined indicates that of dalli type in

the North Pacific was estimated to be 1,925 to 2,138 x 10^3 individuals. The abundance in Area 4 which indicates that of dalli type distributed in the Bering Sea was estimated to be 213 to 468 x 10^3.

Kato (1986b) estimated the abundance of Dall's porpoise to be 2.00 to 2.24 million individuals for the whole area (3,861 x 10^3 nmi^2) using the sighting data obtained under the sea conditions of 0 to 7 on Beaufort scale and pooled from 1980 to 1985. In the present report using only the sighting data colleced under the 0 to 3 Beaufort scale sea conditions, the abundance was estimated to be 2.26 to 2.73 million individuals for the whole area (3,846 x 10^3 nmi^2). Since the procedure of the present estimation excluded to some extent underestimation resulting from the sighting data obtained under bad sea conditions, the present estimates are considered to be of higher reliability compared to the previous estimates. As a result, the abundance of Dall's porpoise increased by 0.26 to 0.49 million individuals.

It is considered that further accumulation of the sighting data will enable us to make the abundance estimation of still higher reliability by selecting the data obtained under more desirable sea conditions.

REFERENCES, TABLES 1 AND 2, AND FIGS. 1 TO 3
ARE IN ENGLISH IN THE JAPANESE DOCUMENT