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CONTENTS OF NUMBER 25

目　　次

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CONTENTS OF NUMBER 25

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THE INSTITUTE OF CETACEAN RESEARCH

SYSTEMATIC CONSIDERATION OF RECENT TOOTHED WHALES BASED ON THE MORPHOLOGY OF TYMPANO-PERIOTIC BONE

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ABSTRACT

The tympano-periotic bones of recent Odontoceti have attained wide variety of morphological peculiarities. The individual and sexual variations, and the bilateral asymmetry of this part are considered to be small. Though it is possible to identify most of Odontoceti species based on the morphology of tympano-periotic bones, it is usually difficult to do the Delphininae species. Considering the several series of specialization observed in various characteristics of tympano-periotic bone, its process of evolution and the phylogenetic relationships of Odontoceti species are discussed.

CONTENTS

INTRODUCTION

Though the taxonomical or morphological study of tympano-periotic bone have been made on some fossil species (Kellogg, 1931, 1955, 1957, 1965) or on recent species (Yamada, 1953) and the morphological variety is reported, the systematics of the toothed whales have been based mainly on the skeletal and external characteristics and less importance was put on the morphology of tympano-periotic bone. However, as the tympano-periotic bones of toothed whales are considered to have established a special adaptation for the underwater acoustics and have attained various morphological peculiarities, the morphology of this part seems to be useful in the taxonomy of Odontoceti.

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No. 25, 1973, 1–103.

The present study intends to re-examine the systematics of toothed whales based on the morphology of the tympano-periotic bones, and to throw some light upon the classification of toothed whales. The knowledge on the morphology and individual variation of tympano-periotic bone, obtained in this study, will offer some key to identify the species or genus by means of tympano-periotic bone.

MATERIALS AND METHOD

The materials used in this study are shown in Table 2, which comprise 313 individuals in 30 genera. They are mostly composed of the specimens collected by me or prof. M. Nishiwaki of the Ocean Research Institute, and are kept in the Ocean Research Institute, University of Tokyo. Other than these specimens, some were kindly offered by various persons and institutes shown in Table 1.

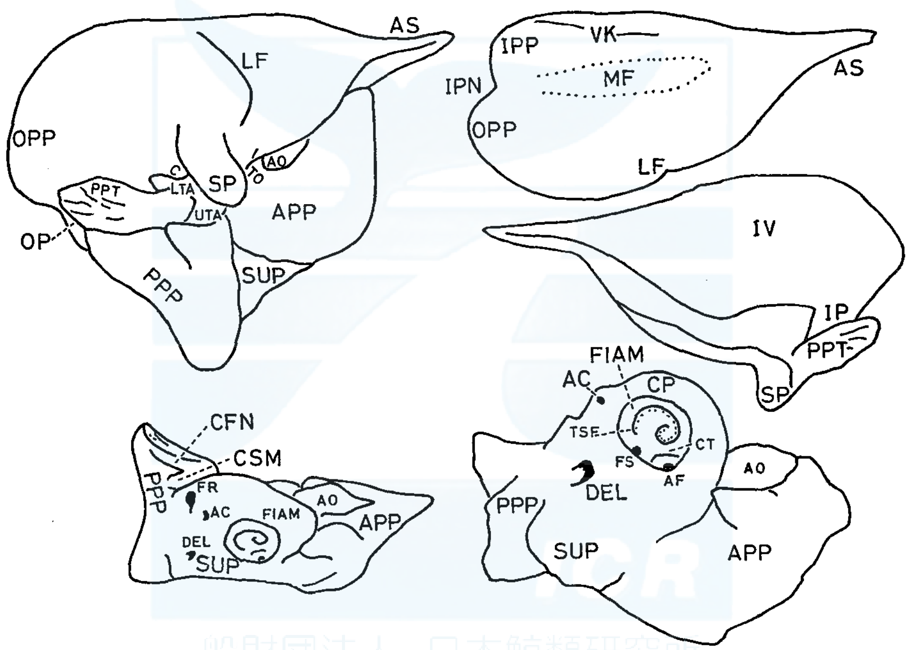

Fig. 1. Tympano-periotic bone of *Platanista gangetica*, showing the morphological terms used in this report. AC, Aperture of aquaeductus cochleae. AF, Internal aperture of aquaeductus Fallopii. AO, Accessory ossicle. APP, Anterior process of periotic. AS, Anterior spine. C, Conical process. CP, Cochlear portion. CFN, Canal for facial nerve. CSM, Canal for stapedial muscle. CT, Crista transversa. DEL, Aperture of ductus endolymphaticus. EF, Elliptical foramen (see Fig. 2). FIAM, Fundus of internal auditory meatus. FR, Foramen rotunda. FS, Foramen singulare. IP, Inner pedicle. IPN, Interprominential notch. IPP, Inner posterior prominence. IV, Involucrum. LF, Lateral furrow. LTA, Lower tympanic aperture. MF, Median furrow. OP, Outer pedicle. OPP, Outer posterior prominence. PPP, Posterior process of periotic. PPT, Posterior process of tympanic bulla. SP, Sigmoid process. SUP, Superior process. TO, Triangular opening. TSF, Tractus spiralis foraminosus. UTA, Upper tympanic aperture. VK, Ventral keel.

TABLE 1. LIST OF INSTITUTES AND PERSONS, WITH ABBREVIATIONS, WHO OFFERED THEIR SPECIMENS FOR THE PRESENT STUDY

AMNH	American Museum of Natural History, New York C. USA, R. G. Van Gelder
AWM	Ayukawa Whale Museum, Ayukawa Japan, N. Kimura
CLH	Carl L. Hubbs, Scripps Inst. Oceanography, Univ. of Calif., San Diego USA
CNHM	Chicago Natural History Museum, Chicago USA, J. C. Moore
DWR	Dale W. Rice, Fish and Wildlife Service, Seattle USA
EML	Enoshima Marineland, Enoshima Japan, M. Nakajima
HCY	Hung-cha Yang, Taiwan Fisheries Res. Inst., Formasa.
NSM	National Science Museum, Tokyo Japan, Y. Imaizumi
LACM	Los Angeles County Museum of Natural History, Los Angeles USA, D. K. Caldwell
MVZ	Museum of Vertebrate Zoology, Univ. of Calif., Berkeley USA, S. B. Benson
NUF	Faculty of Fisheries, Nagasaki Univ., Nagasaki Japan, K. Mizue
NUMS	Faculty of Medical Science, Nagasaki Univ., Nagasaki Japan, K. Mizue
SDNHM	Natural History Museum, San Diego USA, R. D. Mason
TK	Ocean Research Inst. Univ. of Tokyo, Tokyo Japan, M. Nishiwaki and T. Kasuya
TWM	Taiji Whale Museum, Taiji Japan, T. Higashi
USNM	United States National Museum, Washington D. C. USA, C. O. Handley
WAW	Marineland of the Pacific, Los Angeles USA, W. A. Walker
ZSI	Zoological Survey of India, Calcutta India, D. K. Ghosal

TABLE 2. LIST OF MATERIALS USED IN THIS STUDY

No.	Species	Number of individuals
1	*Platanista gangetica*	5 from the Brahmaputra (4TK and 1ZSI specimens)
		2 from India (USNM 172409, 23459)
2	*Inia geoffrensis*	5 from the Amazon (LACM19588, 19589, 19590, USNM239667, 45982)
3	*Lipotes vexillifer*	1 from Tunting Lake (AMNH57333)
4	*Pontoporia blainvillei*	1(USNM 49494)
5	*Neophocaena phocaenoides*	16 from Japan (14NUMS and 2TK specimens)
		1 from China (USNM 240862)
		2 no locality (AMNH57332, USNM239990)
6	*Phocoena ph. vomerina*	3 from the North Pacific (MVZ21509, 97900, USNM274588)
7	*Phocoena ph. phocoena*	3 from the North Atlantic (AMNH21514, TK84, USNM36591)
8	*Phocoena sinus*	1 from California Bay (SDNHM20688)
9	*Phocoenoides dalli*	6 from Japan (6 TK specimens)
10	*Phocoenoides truei*	6 from Japan (6 TK specimens)
11	*Delphinus bairdi*	5 from California (DWR988, TK150, SDNHM 20140, 21204, 21209)
		1 from Formosa (TK255)
12	*Delphinus delphis*	2 from the Atlantic (USNM21525, 1 TK specimen)
13	*Lagenorhynchus obliquidens*	11 from north east Japan (TK sepcimens)
		3 from California (DWR3768, LACM F355, USNM21218)
14	*Lagenorhynchus acutus*	3 from the west Atlantic (USNM14229, 14265, 20960)
15	*Lagenorhynchus albirostris*	3 from the west Atlantic (AMNH143520, CNHM 30522, TK87)
16	*Lagenorhynchus obscurus*	1 from New Zealand (AMNH34935)
17	*Lagenorhynchus australis*	1 from Chiloe I., Chile (CHNHM22248)
18	*Steno bredanensis*	7 from Japan (TK specimens)
19	*Lissodelphis borealis*	3 from Japan (TK205, 257, 258)
		3 from the north east Pacific (DWR1965–2, 1965–3, USNM270981)
20	*Stenella caeruleoalba*	15 from Japan (TK specimens)
21	*Stenella styx*	1 from the Atlantic (TK specimen)

TABLE 2. (continued)

22	(?) *Stenella roseiventris* (Hawaiian spinner dolphin)	4 from Japan (NUF specimens) 2 from Hawaii (DWR1194, TK50)
23	(?) *Stenella longirostris* (Eastern Pacific spinner dolphin)	2 from the east Pacific (SNHM21199, WAW52)
24	*Stenella attenuata*	7 from Japan (TK specimens)
24a	*Stenella graffmani*	3 from the east Pacific (DWR1965–1, SENHM 20637, WAW44)
24b	*Stenella plagiodon*	3 from the north Atlantic (AMNH38206, 63779, USNM292070)
25	*Tursiops truncatus*	43 from Japan (19 EML specimens, 24 TK specimens)
25a	*Tursiops truncatus*	3 from the west Atlantic (MVZ23705, 23708, USNM16504)
26	*Tursiops gilli*	2 from California (SDNHM20143, 20144)
27	*Cephalorhynchus* spp.	1 from Forkland (USNM252568), 1 from Chile (USNM 21167)
28	*Sotalia* spp.	1 from the Amazon (AMNH94169, *S. fluviatilis*) 1 (CNHM34907, *S. guianensis*)
29	*Sousa teuszii*	1 from Senegal (TK260)
30	*Pseudorca crassidens*	2 from the north Atlantic (USNM11320, 218360) 2 from the north Pacific (TK specimens)
31	*Orcinus orca*	5 from the north Pacific (DWR832, 986, 2TK specimens, TWM specimen), 2 no locality (LACM781, USNM219326)
32	*Peponocephala electra*	6 from Japan (TK specimens)
33	*Feresa attenuata*	7 from Japan (TK specimens)
34	*Globicephala melaena*	4 from the north Atlantic (AMNH180143, USNM14044, 20457, 1TK specimen)
35	*Globicephala macrorhyncha*	26 from Japan (TK specimens)
36	*Grampus griseus*	11 from Japan (8EML specimens, 3 TK specimens) 1 from the Atlantic (USNM22446)
37	*Orcaella brevirostris*	1 from Borneo (USNM199743), 1 no locality (ZSI274)
38	*Delphinapterus leucas*	4 (AMNH180017, SDNHM20046, USNM7536, 215015)
39	*Monodon monoceros*	4 (AMNH63987, 73318, SDNHM7096, USNM267960)
40	*Berardius bairdi*	5 from the north Pacific (LACM1964, MVZ125602, TK299, 300, USNM49727)
41	*Berardius arnouxi*	1 from New Zealand (USNM21511)
42	*Hyperoodon ampullatus*	1 from Norway (USNM14449)
43	*Mesoplodon stejnegeri*	7 specimens (AMNH185311, 143829, MVZ130250, TK97, 365, USNM143132, 286826)
44	*Mesoplodon densirostris*	4 specimens (AMNH139931, 69579, TK256, HCY specimen)
45	*Mesoplodon ginkgodens*	2 specimens (NSM specimen, HCY specimen)
46	*Mesoplodon europaeus*	3 specimens AMNH121894, 90051, USNM306302)
47	*Mesoplodon carlhubbsi*	2 specimens (AWM specimen, USNM274591)
48	*Mesoplodon mirus*	1 specimen (AMNH174293)
49	*Ziphius cavirostris*	6 from the north Pacific (MVZ129645, SDNHM 19558, USNM 20993, 3TK specimens), 1 no locality (USNM21975)
50	*Kogia breviceps*	5 specimens (CHL specimen, LACM RLB145, TK244, SDNHM 20139, SDNHM—)
51	*Kogia simus*	5 specimens (LACM RLB240. TK47, 49, TK specimen, USNM 22015)
52	*Physeter catodon*	8 specimens (3 NUMS specimens, TK301, 302, 303, 304, USNM 49488)

The materials are usually grouped into the species, but in some cases into smaller units considering the locality. In the genera as *Cephalorhynchus* and *Sotalia*, where only few samples are obtained and the taxonomy is not fully established, the samples are dealt combining into the genus.

The measurement and general observation were made on 21 points shown in Fig. 2 and Table 3. The measurements are usually made on a straight line connecting the two points to nearest 1/10 mm, with a caliper of 1/20 mm accuracy, and if available on both sides. In the calculation of the mean value and other statistical analysis of the measurements, measurements of one side were randomly selected. But in the analyses of *Growth and bilateral symmetry* and of the largest and smallest range of the measurement, all the available measurements were included.

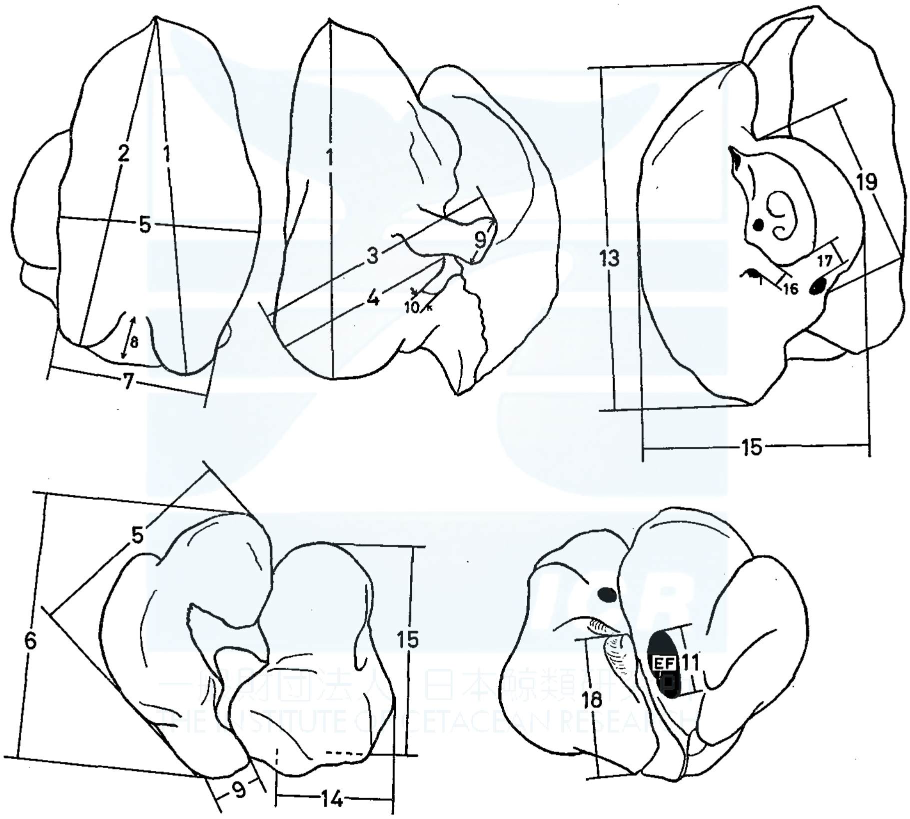

Fig. 2. Measurements used in this report, for the explanation see Table 3. The contour of the tympano-periotic bone is based on that of *Stenella*. For EF see Fig. 1.

The anatomical terms are conformed mainly to Kellogg (1936) and partly to Yamada (1953), but some terms are newly introduced in this report. All of these terms are shown in Figs. 1 and 2.

TABLE 3. POINTS OF MEASUREMENTS AND OF OTHER GENERAL OBSERVATIONS

Tympanic bulla

1. Standard length of tympanic bulla, distance from anterior tip to posterior end of outer posterior prominence
2. Distance from anterior tip to posterior end of inner posterior prominence
3. Distance from postero-ventral tip of outer posterior prominence to tip of sigmoid process
4. Distance from postero-ventral tip of outer posterior prominence to tip of conical process
5. Width of tympanic bulla at the level of the sigmoid process
6. Height of tympanic bulla, from tip of sigmoid process to ventral keel
7. Width across inner and outer posterior prominences
8. Greatest depth of interprominential notch
9. Width of upper border of sigmoid process
10. Width of the posterior branch of lower tympanic aperture
11. Presence of elliptical foramen. If present, its greatest diameter
12. The thicker side between outer and inner posterior prominences

Periotic

13. Standard length of periotic, from tip of anterior process to posterior end of posterior process, measured on a straight line parallel with cerebral border
14. Thickness of superior process at the level of upper tympanic aperture
15. Width of periotic across cochlear portion and superior process, at the level of upper tympanic aperture
16. Least distance between the margins of fundus of internal auditory meatus and of aperture of ductus endolymphaticus
17. Least distance between the margins of fundus of internal auditory meatus and of aperture of aquaeductus cochleae
18. Length of the articular facet of the posterior process of periotic for the posterior process of tympanic bulla
19. Antero-posterior diameter of cochlear portion
20. Presence of sutural connection between the posterior processes of tympanic bulla and of periotic
21. Presence of the sutural connection between posterior process of tympanic bulla and squamosal
22. Length of periotic shown by the percentage of length of tympanic bulla

GROWTH AND BILATERAL SYMMETRY

Bilateral symmetry

The bilateral comparizon of tympano-periotic bones was made on 6 species of Delphinoidea, *Neophocaena phocaenoides*, *Stenella caeruleoalba*, *Lagenorhynchus obliquidens*, *Tursiops truncatus* (from the coast of Japan), and *Grampus griseus*, on the standard length (measurement nos. 1 and 13) and on the other measurements shown by the percentage of the standard length.

On each particular points, mean of the remainder of the right value minus the left were calculated, then the significance of its deviation from 0 was examined with t table. This result shows that most of the observed bilateral asymmetry is not significant. But as shown in Table 4, the bilateral deviation in some measurements is so large that can be expected with the probability less than 2% and is suggested to be significant. But if the deviation between the mean values of both sides are examined, neglecting the individuals, there can be expected no significant bilateral asymmetry. This is because the bilateral asymmetry in each individuals is smaller comparing with the individual variation. As the result it is concluded that, in spite of the possibility of bilateral asymmetry on some part of the tympano-periotic bone, it will not lead to the erroneous result to neglect it and to select randomly the right or left side in the calculation.

TABLE 4. SOME MEASUREMENTS OF TYMPANO-PERIOTIC BONES WHERE BILATERAL ASYMMETRY IS EXPECTED. FOR MEASUREMENT NO. SEE TABLE 3.

Species	No. of the measurement	Sample size	Range of measurement	Mean of the right minus left	Probability
N. phocaenoides	3	11	74.8–83.2	−0.773	0.02–0.01
N. phocaenoides	8	14	10.4–17.8	−0.564	0.01>
S. caeruleoalba	10	7	2.2– 5.8	0.421	0.02–0.01
T. truncatus	13	37	31.7–37.8	−0.908	0.02–0.01
Gl. macrorhyncha	3	23	57.1–73.6	−2.165	0.02–0.01
Gr. griseus	17	4	46.8–58.6	1.150	0.02–0.01

Growth of tympano-periotic bone

To obtain a general feature of the growth of tympano-periotic bone of toothed whales, the growth of tympano-periotic bone accompanied with the growth of the animal and its relative growth were studied on 4 species of Delphinoidea, or *Globicephala macrorhyncha*, *Tursiops truncatus*, and *Neophocaena phocaenoides*. In Figs. 3–57, if available, the measurements of the both sides are plotted.

Generally speaking the standard length of tympanic bulla slightly increases in parallel with the growth of the animal, but that of periotic shows almost no increase. The proportional dimensions of tympano-periotic bone show rather wide individual variation. As observed in these figures, the sexual difference is not expected.

Globicephala macrorhyncha

Tympano-periotic bones from 26 individuals are used here, among which the sex and body length are known on 23 individuals.

The tympanic bulla of this species has conspicuous anterior spine, ventral keel, and posterior process. These characters seem to be formed soon after birth. As shown in Pl. XXVII the anterior margin of the tympanic bulla of adult individual has a plate-like anterior spine. The corresponding part of two newborn calves of 138 cm (♂) and 141 cm (♂) in body length is smooth and has no anterior spine. But the spine is formed on a juvenile female of 203 cm in body length. In the two newborn calves, the ventral keel is not developed, but retains only a granulated structure. But this granulated area is changed, in the 203 cm female, into a usual ventral keel observed in the adult. The shape of the posterior process of the newborn calves is short, and round and resembles that of adult *Phocoenidae*. But it develops longer, in the 203 cm female, and attains the form of a long spongy process directing postero-laterally.

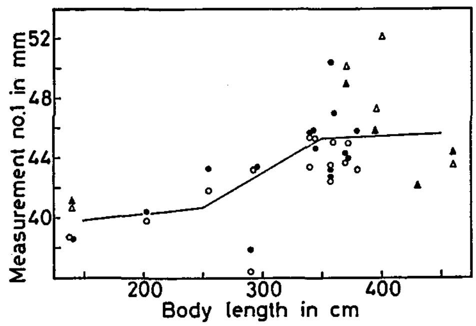

Fig. 3. *Globicephala macrorhyncha*. Relation between body length and length of tympanic bulla (measurement no. 1). Triangle indicates male, circle female. In both sexes closed mark indicates the left side, and open the right.

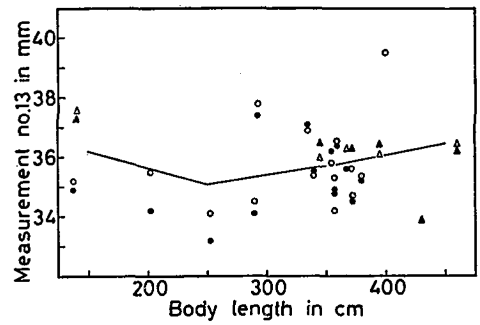

Fig. 4. *G. macrorhyncha*. Relation between body length and length of periotic (measurement no. 13). For marks see Fig. 3.

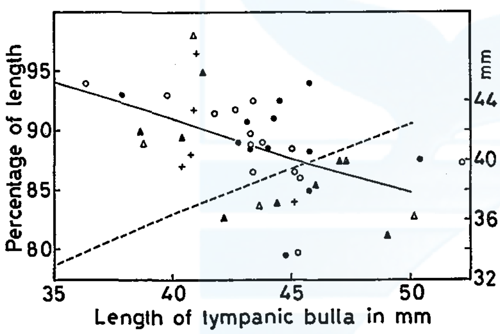

Fig. 5. *G. macrorhyncha*. Measurement no. 2 Anterior tip of tympanic bulla to inner posterior prominence. Cross mark indicates the sex unknown, solid line average percentage, and dotted line the length re-calculated from the average percentage. For other marks see Fig. 3.

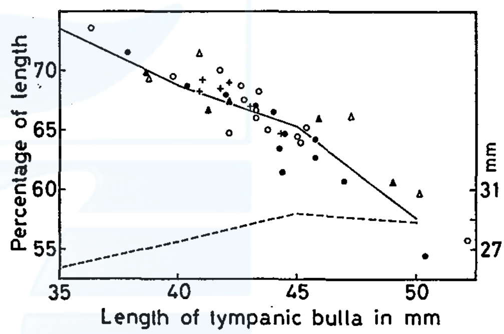

Fig. 6. *G. macrorhyncha*. Measurement no. 3 Tip of sigmoid process to outer posterior prominence. For marks see Fig. 5.

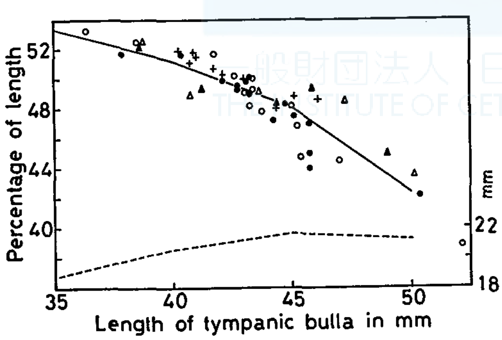

Fig. 7. *G. macrorhyncha*. Measurement no. 4 Tip of conical process to outer posterior prominence. For marks see Fig. 5.

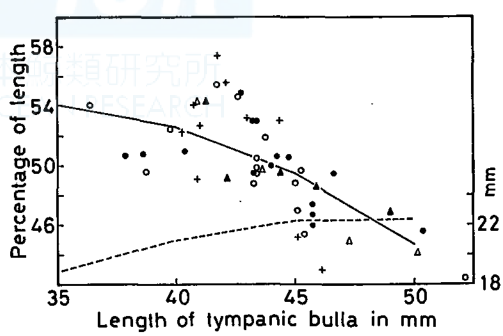

Fig. 8. *G. macrorhyncha*. Measurement no. 5 Width of tympanic bulla. For marks see Fig. 5.

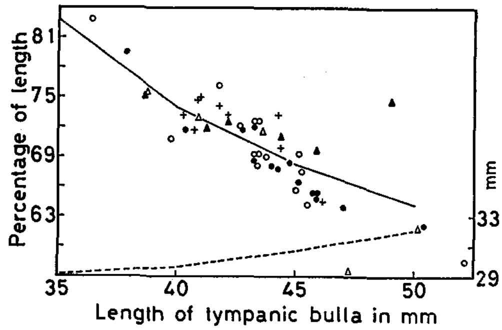

Fig. 9. *G. macrorhyncha.* Measurement no. 6 Height of tympanic bulla. For marks see Fig. 5.

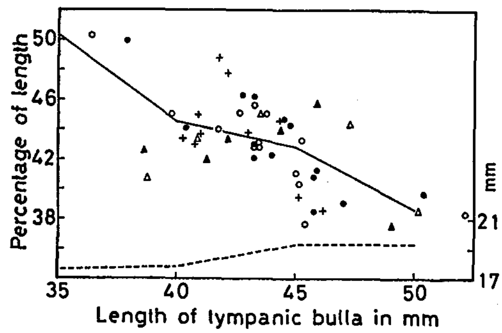

Fig. 10. *G. macrorhyncha.* Measurement no. 7 Width across posterior prominences. For marks see Fig. 5.

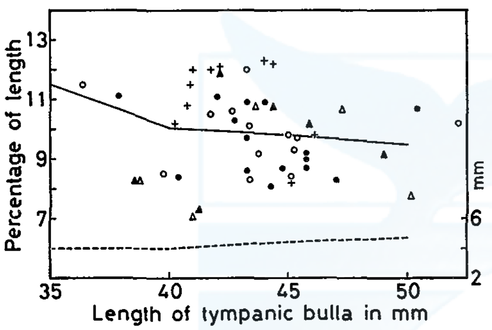

Fig. 11. *G. macrorhyncha.* Measurement no. 8 Depth of interprominential notch. For marks see Fig. 5.

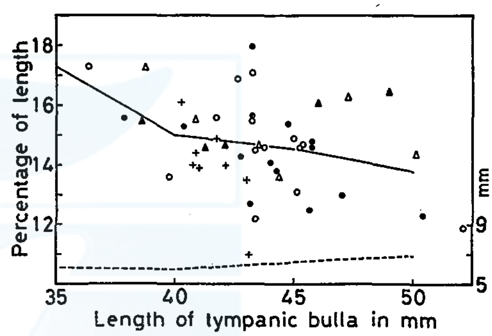

Fig. 12. *G. macrorhyncha.* Measurement no. 9 Width of upper border of sigmoid process. For marks see Fig. 5.

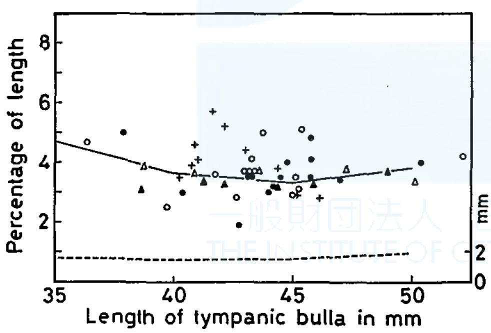

Fig. 13. *G. macrorhyncha.* Measurement no. 10 Width of posterior branch of lower tympanic aperture. For marks see Fig. 5.

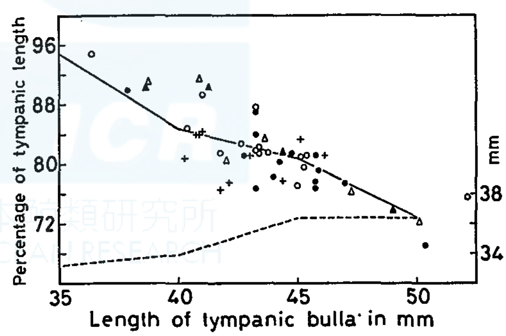

Fig. 14. *G. macrorhyncha.* Measurement no. 13 Length of periotic shown in percentage of measurement no. 1. For maeks see Fig. 5.

On the periotic, the needle-shaped processes on the dorsal surface of superior process and around the fundus of internal auditory meatus are one of the characteristic features of this species. This structur is considered to be formed in the latter

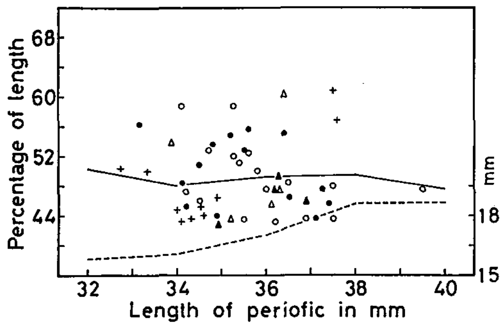

Fig. 15. *G. macrorhyncha.* Measurement no. 14 Thickness of periotic. For marks see Fig. 5.

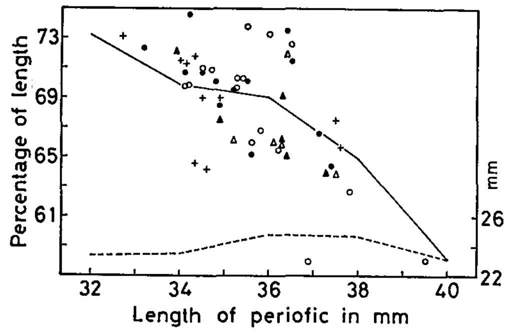

Fig. 16. *G. macrorhyncha.* Measurement no. 15 Width of periotic. For marks see Fig. 5.

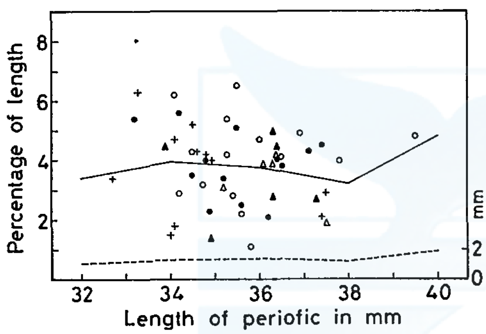

Fig. 17. *G. macrorhyncha.* Measurement no. 16 Fundus of internal auditory meatus to ductus endolymphaticus. For marks see Fig. 5.

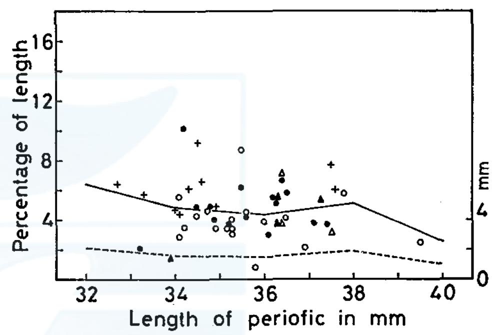

Fig. 18. *G. macrorhyncha.* Measurement no. 17 Fundus of internal auditory meatus to aquaeductus cochleae. For marks see Fig. 5.

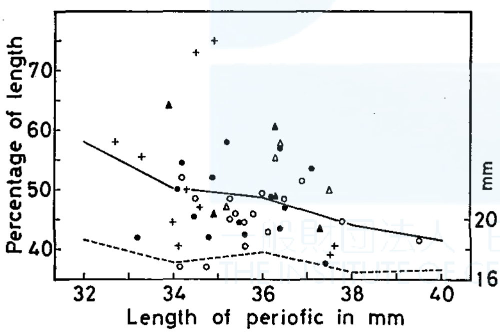

Fig. 19. *G. macrorhyncha.* Measurement no. 18 Length of facet on posterior process of periotic. For marks see Fig. 5.

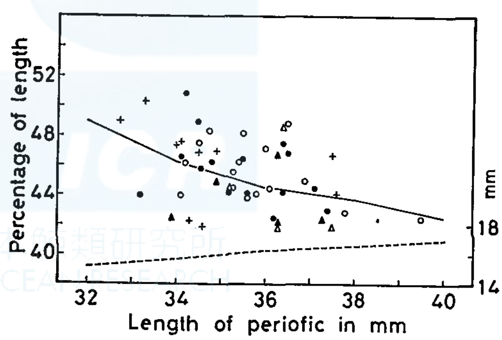

Fig. 20. *G. macrorhyncha.* Measurement no. 19 Diameter of cochlear portion. For marks see Fig. 5.

part of the growth, as this is observed, in the females, on the animal more than 350 cm in body length.

The relations between body length and length of tympano-periotic bone are shown in Figs. 3 and 4, and those between the lengths of tympano-periotic bone

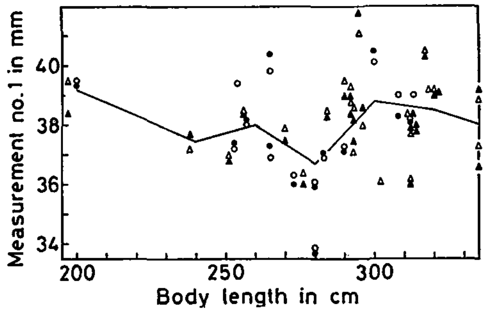

Fig. 21. *Tursiops truncatus*. Relation between body length and length of tympanic bulla (measurement no. 1). For marks see Fig. 3.

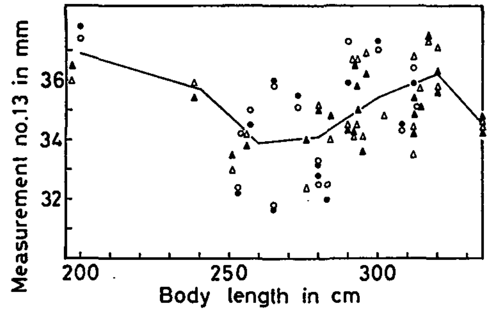

Fig. 22. *T. truncatus*. Relation between body length and length of periotic (measurement no. 13). For marks see Fig. 3.

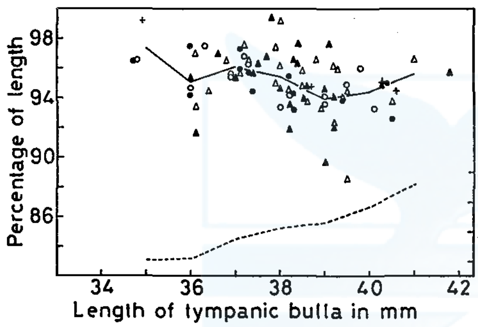

Fig. 23. *T. truncatus*. Measurement no. 2 Anterior tip of tympanic bulla to inner posterior prominence. For marks see Fig. 5.

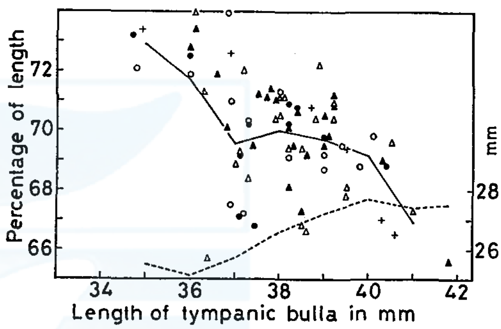

Fig. 24. *T. truncatus*. Measurement no. 3 Tip of sigmoid process to outer posterior prominence. For marks see Fig. 5.

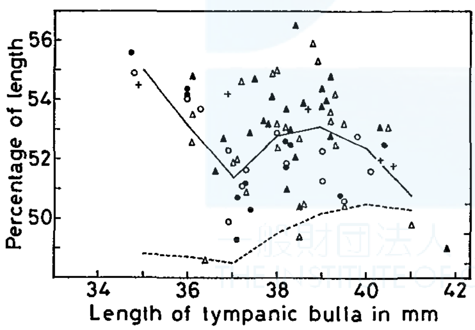

Fig. 25. *T. truncatus*. Measurement no. 4 Tip of conical process to outer posterior prominence. For marks see Fig. 5.

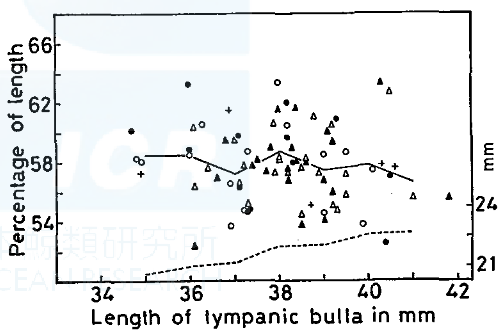

Fig. 26. *T. truncatus*. Measurement no. 5 Width of tympanic bulla. For marks see Fig. 5.

and their proportional dimensions are shown in Figs. 5–20 and Table 5. Though the length of periotic bone does not increase after the birth, that of tympanic bulla increases about 6 mm in the adult than the new born animal. As the result, the ratio of the periotic bone to the tympanic bulla decreases with the growth of the animal.

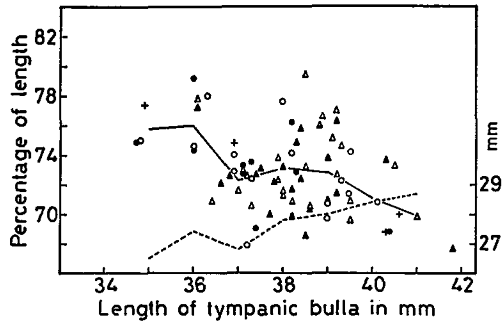

Fig. 27. *T. truncatus*. Measurement no. 6 Height of tympanic bulla. For marks see Fig. 5.

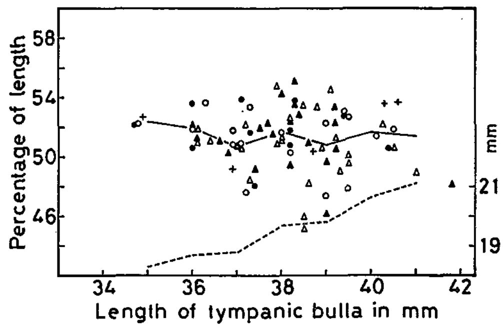

Fig. 28. *T. truncatus*. Measurement no. 7 Width across posterior prominences. For marks see Fig. 5.

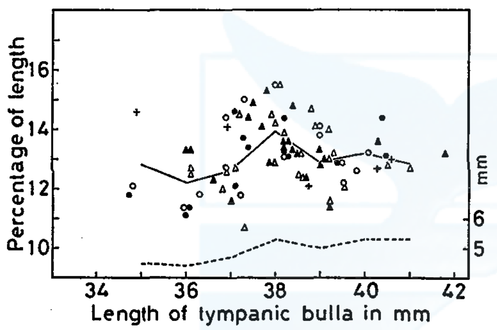

Fig. 29. *T. truncatus*. Measurement no. 8 Depth of interprominential notch. For marks see Fig. 5.

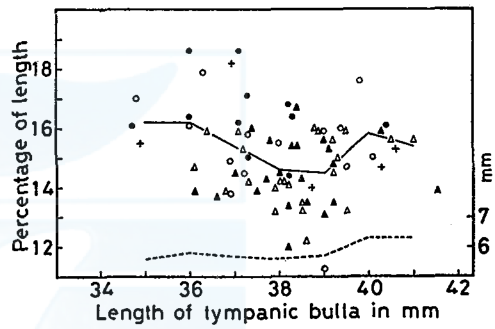

Fig. 30. *T. truncatus*. Measurement no. 9 Width of upper border of sigmoid process. For marks see Fig. 5.

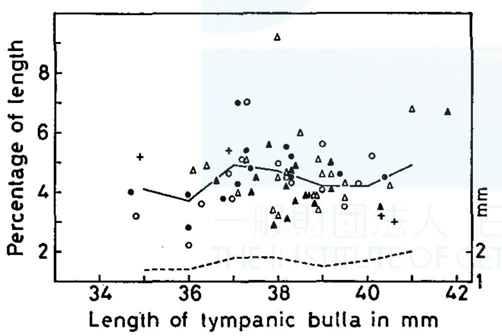

Fig. 31. *T. truncatus*. Measurement no. 10 Width of posterior branch of lower tympanic aperture. For maeks see Fig. 5.

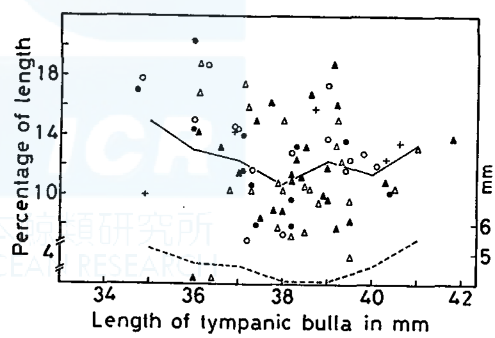

Fig. 32. *T. truncatus*. Measurement no. 11 Length of elliptical foramen. For marks see Fig. 5.

Tursiops truncatus

The tympano-periotic bones of 43 individuals caught in the Pacific coast of Japan are used here. Among them the body length and sex are known on 38 in-

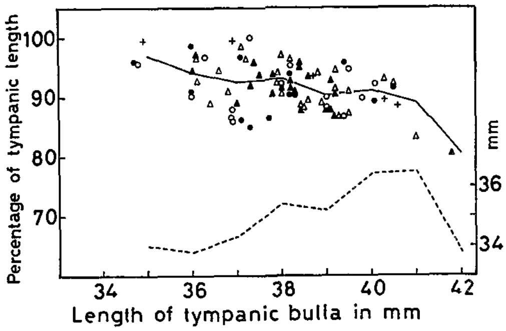

Fig. 33. *T. truncatus.* Measurement no. 13 Length of periotic shown in percentage of measurement no. 1. For marks see Fig. 5.

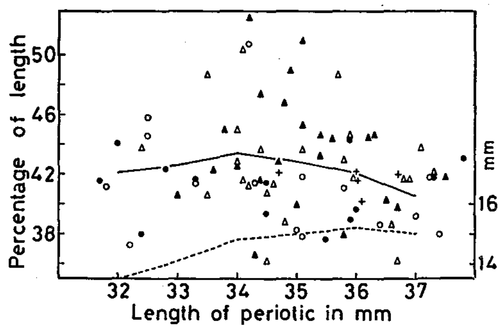

Fig. 34. *T. truncatus.* Measurement no. 14 Thickness of periotic. For marks see Fig. 5.

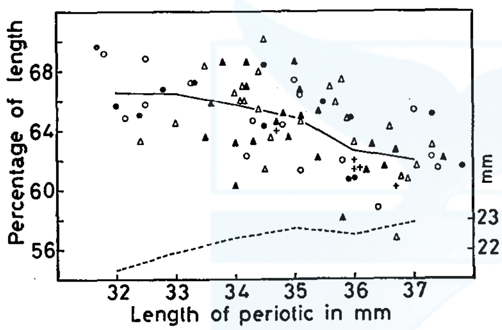

Fig. 35. *T. truncatus.* Measurement no. 15 Width of periotic. For marks see Fig. 5.

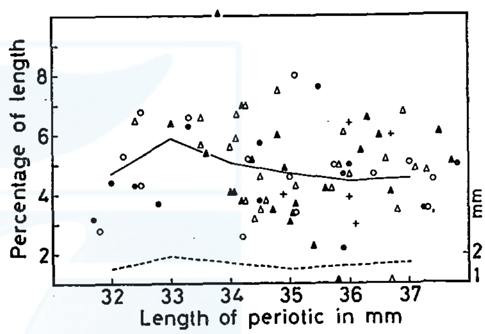

Fig. 36. *T. truncatus.* Measurement no. 16 Fundus of internal auditory meatus to ductus endolymphaticus. For marks see Fig. 5.

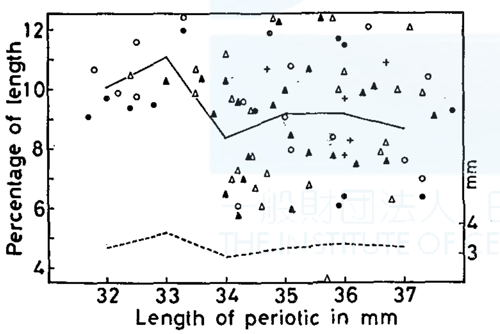

Fig. 37. *T. truncatus.* Measurement no. 17 Fundus of internal auditory meatus to aquaeductus cochleae. For marks see Fig. 5.

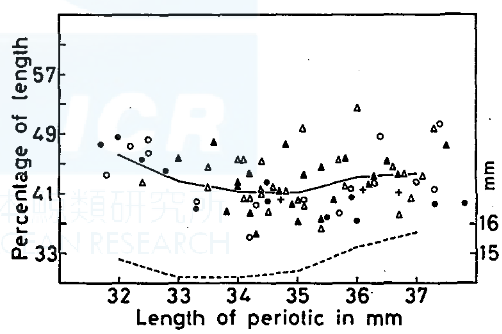

Fig. 38. *T. truncatus.* Measurement no. 18 Length of facet on posterior process of periotic. For marks see Fig. 5.

dividuals. Though the morphological feature of tympano-periotic bone of this species is the typical of Delphininae, it resembles that of *Globicephala* in the presence of needle-shaped processes on the superior process of periotic of the adult, and in the developed ventral keel of tympanic bulla.

The relation between body length and length of tympano-periotic bone are shown in Figs. 21 and 22. There is observed almost no increase of the length of tympanic bulla accompanied with the growth of the animal. This is different from the case of *Globicephala*, and will be related with the weak development of anterior spine in *Tursiops*.

The average length of periotic shows the increase of only about 2 mm in the body length range between 250 cm and 320 cm. But this growth is considered to be negligible in the latter discussion. The ratio of periotic length to the length of tympanic bulla slightly decreases with the increase of the latter (Fig. 33).

As shown in Figs. 23–39 and Table 5, the proportional dimensions of tympano-periotic bone are stable in most of measurements. But in the measurements nos.

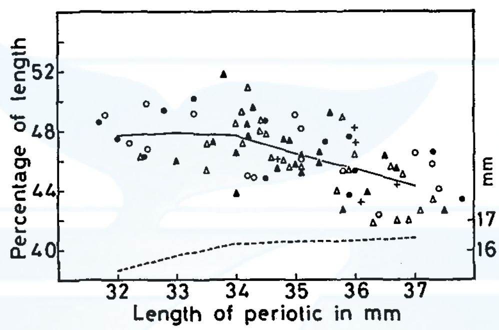

Fig. 39. *T. truncatus*. Measurement no. 19 Diameter of cochlear portion. For marks see Fig. 5.

TABLE 5. CHANGE OF THE PROPORTION OF TYMPANO-PERIOTIC BONES, WITH THE INCREASE OF TYMPANO-PERIOTIC OR BODY LENGTH. A INDICATES INCREASING TENDENCY, B STEADY, C DECREASING.

Measurements	*G. macrorchyncha*	*T. truncatus*	*N. phocaenoides*
1	A	B	A
2	C	B	A
3	C	C	A or B
4	C	B or C	A or B
5	C	B	A or B
6	C	C	B or A
7	C	B	A or B
8	B	B	A or B
9	C or B	B	B
10	B	B	C or B
11	B	B	B
13	B	B	B
14	B	B	C
15	C	C	C or B
16	B	B	B
17	B	B	B
18	C	B	A
19	C	B or C	B
22	C	C	C

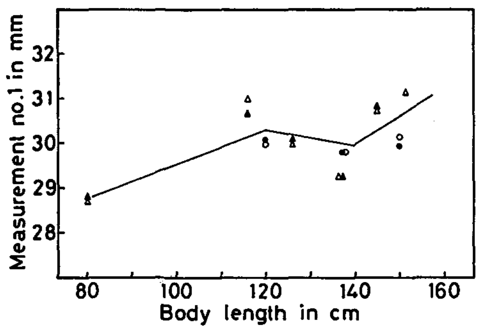

Fig. 40. *Neophocaena phocaenoides*. Relation between body length and length of tympanic bulla (measurement no. 1). For marks see Fig. 3.

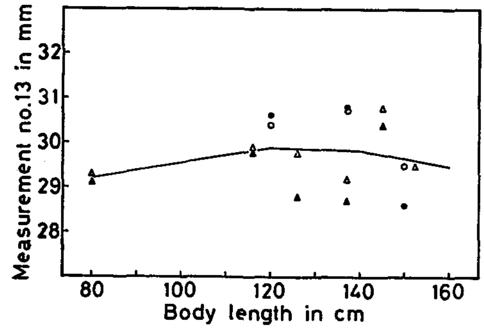

Fig. 41. *N. phocaenoides*. Relation between body length and length of periotic (measurement no. 13). For marks see Fig. 3.

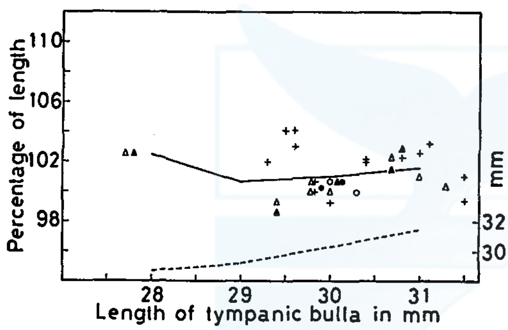

Fig. 42. *N. phocaenoides*. Measurement no. 2 Anterior tip of tympanic to inner posterior prominence. For marks see Fig. 5.

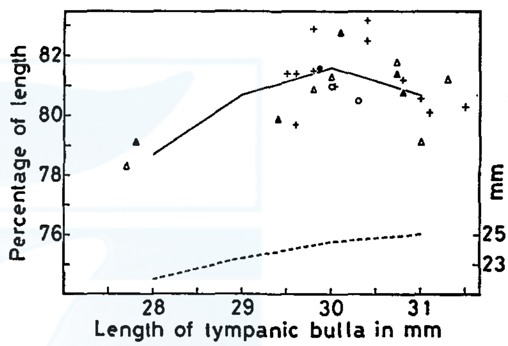

Fig. 43. *N. phocaenoides*. Measurement no. 3 Tip of sigmoid process to outer posterior prominence. For marks Fig. 5.

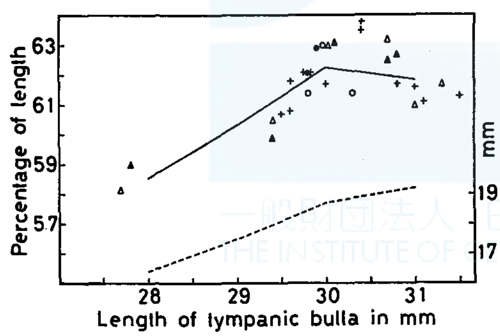

Fig. 44. *N. phocaenoides*. Measurement no. 4 Tip of conical process to outer posterior prominence. For marks see Fig. 5.

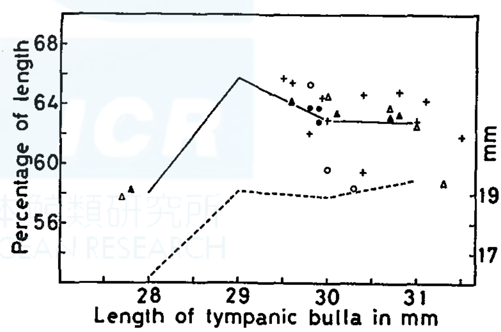

Fig. 45. *N. phocaenoides*. Measurement no. 5 Width of tympanic bulla. For marks see Fig. 5.

3, 4, 6, 15, and 19, the ratio decreases with the increase of the length of tympanic bulla or that of periotic. This will indicate that the growth of inner posterior prominence and cochlear portion is not parallel with the increase of standard length.

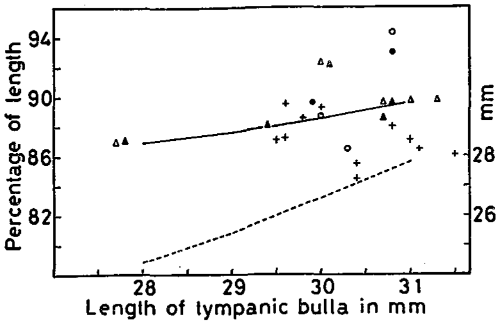

Fig. 46. *N. phocaenoides*. Measurement no. 6 Height of tympanic bulla. For marks see Fig. 5.

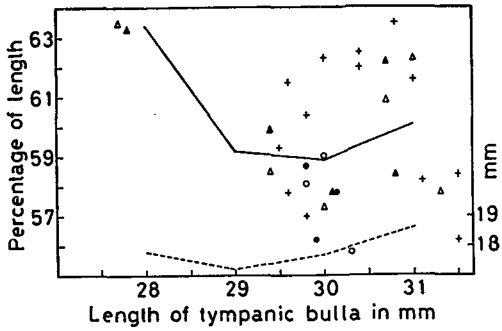

Fig. 47. *N. phocaenoides*. Measurement no. 7 Width across posterior prominences. For marks see Fig. 5.

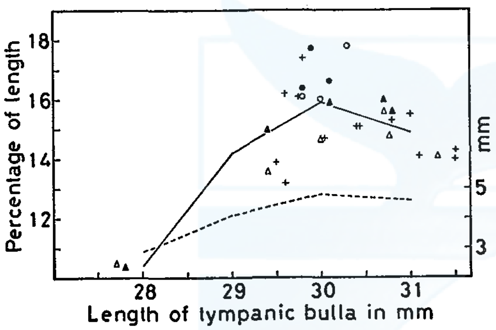

Fig. 48. *N. phocaenoides*. Measurement no. 8 Depth of interprominential notch. For marks see Fig. 5.

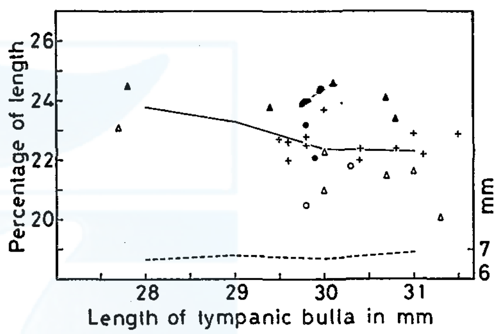

Fig. 49. *N. phocaenoides*. Measurement no. 9 Width of upper border of sigmoid process. For marks see Fig. 5.

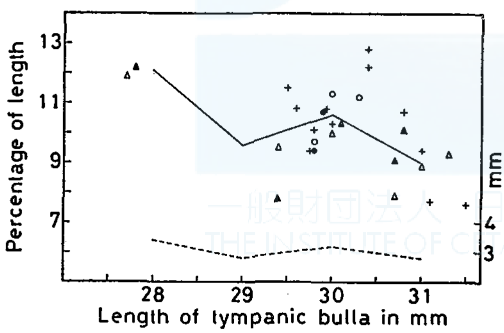

Fig. 50. *N. phocaenoides*. Measurement no. 10 Width of posterior branch of lower tympanic aperture. For marks see Fig. 5.

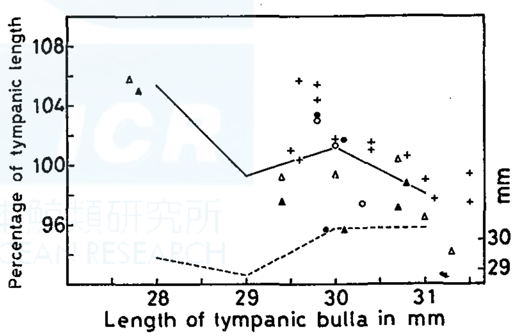

Fig. 51. *N. phocaenoides*. Measurement no. 13 Length of periotic shown in percentage of measurement no. 1. For marks see Fig. 5.

Neophocaena phocaenoides

The tympano-periotic bone of this species shows the typical features of that of Phocoenidae. In this chapter samples from 19 individuals, including 16 from the

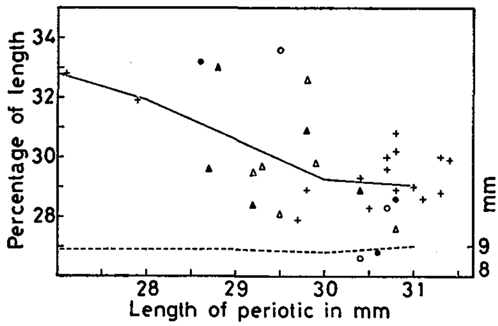

Fig. 52. *N. phocaenoides.* Measurement no. 14 Thickness of periotic. For marks see Fig. 5.

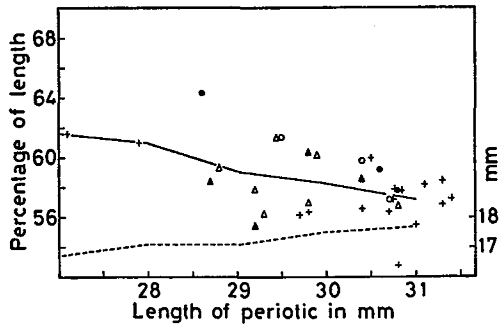

Fig. 53. *N. phocaenoides.* Measurement no. 15 Width of periotic. For marks see Fig. 5.

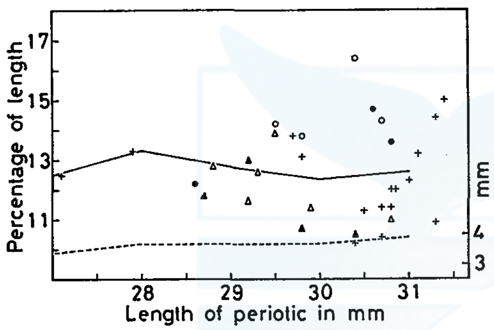

Fig. 54. *N. phocaenoides.* Measurement no. 16 Fundus of internal auditory meatus to ductus endolymphaticus. For marks see Fig. 5.

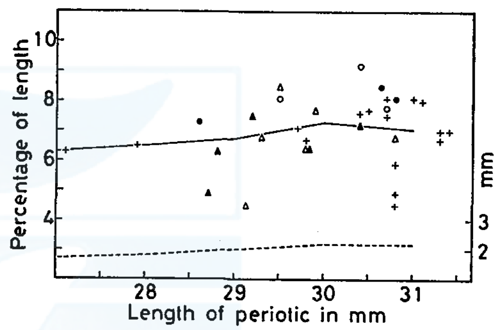

Fig. 55. *N. phocaenoides.* Measurement no. 17 Fundus of internal auditory meatus to aquaeductus cochleae. For marks see Fig. 5.

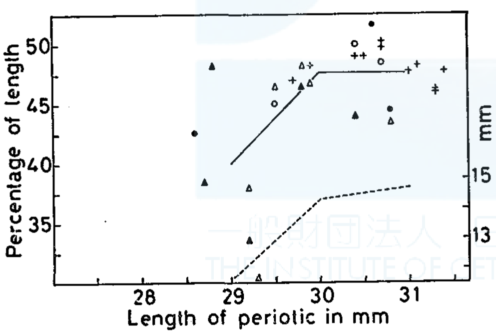

Fig. 56. *N. phocaenoides.* Measurement no. 18 Length of facet on posterior process of periotic. For marks see Fig. 5.

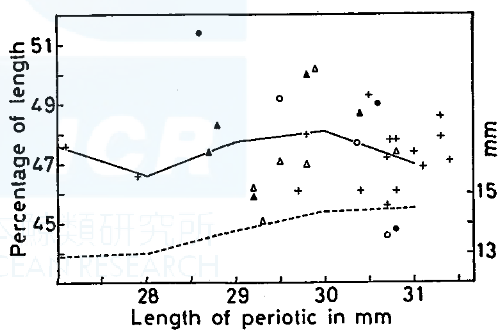

Fig. 57. *N. phocaenoides.* Measurement no. 19 Diameter of cochlear portion. For marks see Fig. 5.

adjacent waters of Japan, are used.

As shown in Fig. 40, there is observed slight increase in the length of tympanic bulla accompanied with the growth of the animal. The increase is about 2 mm when the body length increases from 80 cm to 150 cm. The length of periotic bone seems not to increase after birth (Fig. 41). As the result the ratio of the periotic length to the tympanic length decreases with the increase of the latter (Fig. 51).

The relative growth of tympano-periotic bone is shown in Figs. 42–57 and Table 5. The proportional dimensions of the tympanic bulla are increasing or stable in relation to the length of tympanic bulla. The posterior branch of lower tympanic aperture (measurement no. 10), which is large in this species, decreases the relative width in the larger tympanic bulla (Fig. 50). The thickness of periotic bone (measurement no. 14) is nearly constant (Fig. 52). The length of the facet on posterior process of periotic is proportionally large in the larger periotic (Fig. 56). This seems to be related with the fact that, in this species, the posterior process of periotic is directed toward posterior direction, and the length of periotic is directly influenced by this process.

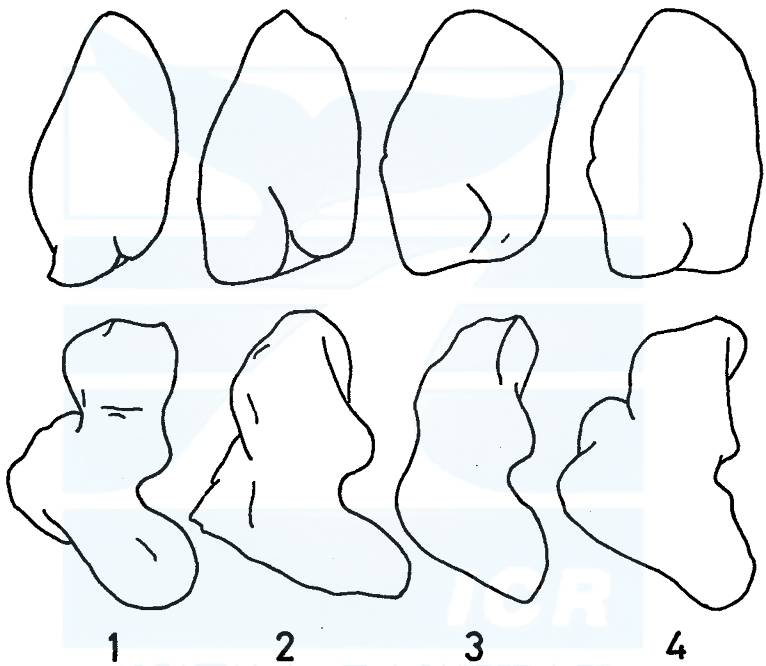

Fig. 58. Contour of ventral view of tympanic bulla and of lateral view of periotic. 1, *Ziphius cavirostris*. 2, *Berardius bairdi*. 3, *Hyperoodon ampullatus*. 4, *Mesoplodon ginkgodens*.

MORPHOLOGY OF TYMPANO-PERIOTIC BONE

It is intended, in this chapter, to show the diagnostic characteristics of the tympano-periotic bones of each species and taxa. The taxa used here is based on the classification considered from the morphology of tympano-periotic bone (Table 15).

The discussions on these morphological characteristics from the evolutional point of view, or on the interrelationships of each taxa is made in the latter chapter.

Physeteroidea

The most conspicuous feature of the tympano-periotic bones of this superfamily is observed on the posterior process of tympanic bulla. It has large laminated or spongy element elongated and expanded distally, which is wedged between exoccipital and squamosal. Posterior process of periotic is usually sutured, not so firmly, to the base of posterior process of tympanic bulla. Main part of accessory ossicle is moved toward the tympanic cavity from the position between lateral wall of tympanic bulla and anterior process of periotic.

Sigmoid process is square or globular and large in size, cochlear portion inclines anteriorly.

Ziphiidae

In the members of this family, the anterior part of the ventral wall of tympanic bulla is cylindrical and is lacking in anterior spine. Involucrum is shorter than the lateral wall. Both posterior prominences are thick and short. Deep lateral furrow is prominent on the lateral wall of tympanic bulla. Sigmoid process is square and rather thin, and its lateral border is twisted posteriorly. Elliptical foramen is present.

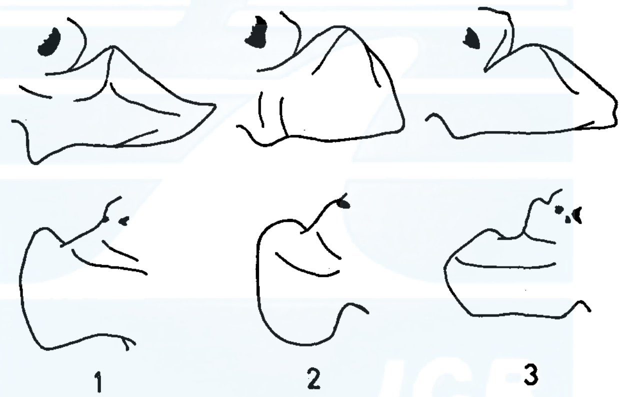

Fig. 59. Contour of the lateral view of anterior process of periotic (top), and of the dorsal view of posterior process of periotic. 1, *Berardius bairdi*. 2, *Ziphius cavirostris*. 3, *Mesoplodon ginkgodens*.

On the periotic, anterior process, superior process, and posterior process are arranged, when seen from the dorsal, nearly on a straight line and the three parts are clearly distinguished. Anterior process is shaped of triangular pyramid and has a wide contact with the dorsal border of the lateral wall of tympanic bulla. The posterior process is short, and flat at the distal end. Its facet for the posterior process of tympanic bulla is almost smooth. Fundus of internal auditory meatus is usually slender. Tractus spiralis foraminosus is separated by a developed septum from the area containing foramen singulare and aperture of aquaeductus Fallopii. There are two cases in the opening of foramen singulare, in one case it opens near aquaeductus Fallopii (*Ziphius*, *Berardius*, *Hyperoodon*), and in the other case it openes near tractus spiralis foraminosus (*Mesoplodon stejnegeri*). The dorsal area of superior process between fundus of internal auditory meatus and aperture of ductus endolymphaticus is highly protruded. Accessory ossicle is, different from that of *Physeter*, small and does not entirely cover the anterior part of dorsal opening of tympanic cavity.

1. *Ziphius cavirostris* (Pl. II)

As shown in Table 6, the size of tympano-periotic bone of this species is intermediate of *Mesoplodon* and *Berardius*.

The tympanic bulla is more flat and its ventral wall is narrower than those of *Berardius*. The rugose area on the ventral surface of tympanic bulla starts from interprominential notch and reaches the anterior margin of the bulla. The posterior prominences, especially the inner, are small and interprominential notch is rudimental. There is formed a wedge-shaped protuberence at the postero-lateral tip of outer posterior prominence (Fig. 58). The posterior branch of lower tympanic aperture is narrower in this species than in *Berardius bairdi* and *Mesoplodon* spp. (Table 6).

TABLE 6. MEASUREMENTS OF TYMPANIC BULLA OF ZIPHIOID SPECIES.

Species		*Ziphius cavirostris*	*Berardius bairdi*	*Mesoplodon stejnegeri*	*Mesoplodon ginkgodens*
Sample size		7	6	7	2
1. Standard length (mm)		51.8–59.7	63.1–70.4	46.9–49.0	39.8–44.1
5. Width (%),	range	52.1–64.9	57.1–67.7	67.0–70.2	69.0–70.4
	mean	61.3	64.5	67.1	69.7
7. W. across post. prom. (%)	range	38.6–50.2	52.6–57.0	48.2–55.8	51.0–64.6
	mean	41.6	54.5	50.8	57.8
10. W. post. branch of LTA (%),	range	3.8– 4.0	9.1– 9.6	7.6–13.0	6.6
	mean	3.9	9.3	8.2	—

TABLE 7. MEASUREMENTS OF PERIOTIC OF ZIPHIOID SPECIES (mm)

Species		*Ziphius cavirostris*	*Berardius bairdi*	*Mesoplodon stejnegeri*	*Mesoplodon ginkgodens*
Sample size		7	6	4	2
13. Standard length		54.0–62.4	66.9–75.8	44.3–50.9	41.0–42.3
14. Thickness,	range	22.3–27.0	29.0–38.1	16.4–18.3	20.4–20.6
	mean	24.0	32.9	17.8	20.5
15. Width,	range	29.5–34.1	34.7–37.2	26.9–29.1	22.3–23.1
	mean	31.7	36.4	27.7	22.7

Though the periotic resembles that of *Berardius bairdi*, it is distinguished by the short and round anterior process and shorter posterior process (Fig. 59). There is sometimes observed a transverse groove on the lateral surface of the base of anterior process. But this occurs on some periotic bones of other Ziphioid species.

2. *Berardius bairdi* (Pl. III)

The tympano-periotic bones of this species is the largest in this family (Table 6). The anterior part of the ventral wall of tympanic bulla is narrow and triangular (Fig. 58). Both inner and outer posterior prominences swell well as in the case of *Mesoplodon*.

Periotic is characteristic, other than the size, in the long and slender anterior process, wider upper tympanic aperture, and slender and long posterior process.

On *Berardius arnouxi* (Pl. IV), only one sample from New Zealand was observed. It was indistinguishable from *B. bairdi*.

3. *Hyperoodon ampullatus* (Pl. IV)

The length of tympano-periotic bone is nearly same with that of *Ziphius cavirostris*. The tympanic bulla is cylindrical and the contour of anterior portion of the ventral wall is not triangular, which condition is different from the case of *Berardius bairdi*. Anterior margin of the ventral wall of tympanic bulla concaves slightly. Though outer posterior prominence is thick, interprominential notch is shallow as in the case of *Ziphius cavirostris* (Fig. 58).

On the periotic, anterior process is shorter than *Berardius* but not so round as *Ziphius* and *Mesoplodon*. The opening of fundus of internal auditory meatus is round and the margin of the openning provides a circular keel. The upper tympanic aperture is wide but shallow (Fig. 58).

4. *Mesoplodon*

The tympanic bulla of this genus is characterized by the thick posterior prominences and deep interprominential notch as those of *Berardius*, the flatness of the bulla, wide posterior branch of the lower tympanic aperture which is different from that of *Ziphius*, and square-shaped ventral view of tympanic bulla. Posterior process of tympanic bulla is shorter and thicker than that of *Berardius*.

The surface of the periotic is smooth and the contour is roundish in general. Anterior process is rather hemispherical than triangular pyramidal. Posterior process is slender and not so strongly fan-shaped as *Ziphius*. Upper tympanic aperture is smaller than those of other Ziphioid species. The size of tympano-periotic bone is small.

Mesoplodon stejnegeri (Pl. IV). The ranges of the length of tympanic bulla and periotic of seven individuals are between 46.9 mm and 49.0 mm, and 44.3 mm and 50.9 mm respectively. These values are smaller than those of *Berardius bairdi* or *Ziphius cavirostris*.

On the tympanic bulla the both posterior prominences and interprominential notch develop well. The anterior extension of the latter opens on the lateral wall of tympanic bulla encircling the anterior base of globular outer posterior prominence. Ventral keel, originating at the anterior base of inner posterior prominence and passing the inner side of the center of the ventral wall of tympanic bulla, reaches to the anterior end of involucrum. The rugose area on the ventral wall occupies wide area between ventral keel and the lateral border of ventral wall (Fig. 60).

On the periotic, anterior process is slightly flat hemispherical with a small conical protuberence on the anterior tip. Posterior process of periotic is slender than that of *M. densirostris*, *M. carlhabbsi*, and *M. europaeus*. Though there is a deep furrow on the lateral surface of superior process, connecting the upper tympanic aperture and base of cochlear portion, this is observed also on other *Mesoplodon* species. The protuberence on the superior process is not developed. The canal for stapedial muscle is shallow.

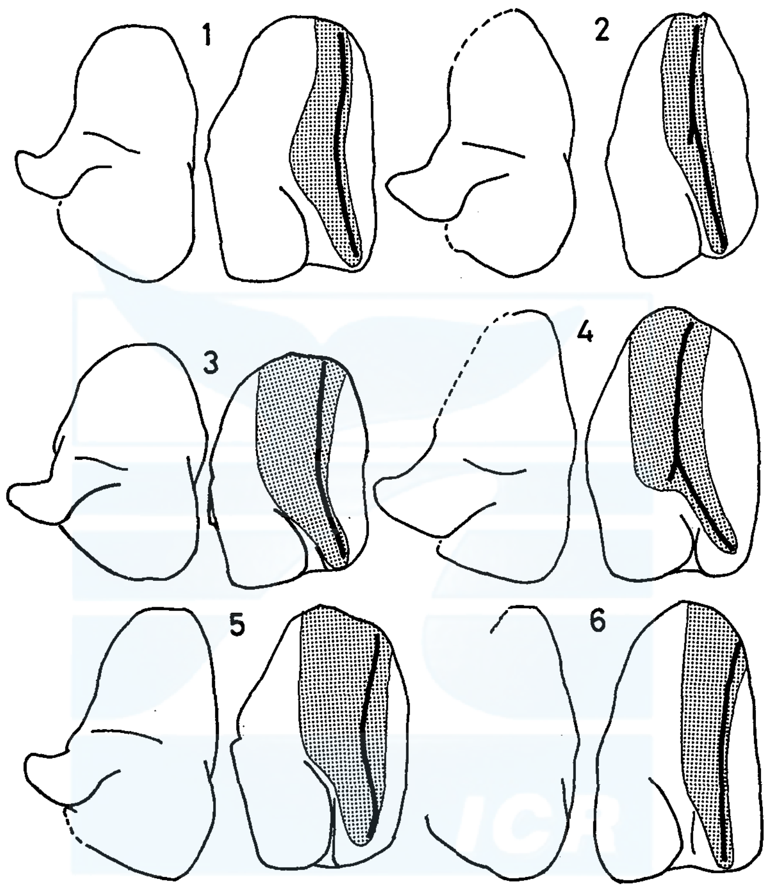

Fig. 60. Contour of the ventral and lateral aspect of tympanic bulla of *Mesoplodon*. Black line and dotted area indicate ventral keel and rugose area surrounding it. 1, *Mesoplodon europaeus*. 2, *M. densirostris*. 3, *M. mirus*. 4, *M. ginkgodens*. 5, *M. stejnegeri*. 6, *M. carlhubbsi*.

Mesoplodon densirostris (Pl. V). 4 tympanic bullae and 1 periotic were studied. Their size is slightly larger than those of other *Mesoplodon* species.

The ventral keel situates on the center, and the smooth area in the involucrum side is wide, which feature is different from that of *M. stejnegeri*. As the inner posterior prominence is thin, the interprominential notch situates at the inner side. Interprominential notch is shallow.

The dorsal surface of periotic is smooth, and the lateral contour is arc shaped. There is no furrow on the bases of anterior and posterior processes nor upper area of upper tympanic aperture. The canal for stapedial muscle forms a deep crescent furrow. Anterior process is of trigonal pyramid, and has a small conical protuberence on the anterior tip. Cochlear portion is flat, and pentagonal.

Mesoplodon europaeus (Pl. V). Tympanic bullae of 3 individuals and periotic of an individual were studied. Their sizes are smaller than those of other species of this genus.

The tympanic bulla resembles that of *M. stejnegeri* in the situation of ventral keel, and in the globular and protruding outer posterior prominence, but differs from it in the thin inner posterior prominence which is similar to that of *M. densirostris*.

The most conspicuous feature of the periotic is the presence of a cylindrical protuberence on the dorsal surface of superior process (Pl. V). Though the similar structure is also observed on *M. ginkgodens*, *M. europaeus* can be distinguished from it by the shallower canal for stapedial muscle and the shape of cochlear portion in which the anterior and posterior margin is not in parallel. There is a vertical furrow on the superior process near upper tympanic aperture.

Mesoplodon ginkgodens (Pl. VI). Tympano-periotic bones from two individuals were studied. Its size is nearly same with that of *M. europaeus*. The flatness of tympanic bulla is weaker than any species of *Mesoplodon* mentioned before. Outer posterior prominence is very low and its apex is flat and oval in the contour. Inner posterior prominence is higher but thinner than the outer. Prominent ventral keel situates at the center of ventral wall of tympanic bulla and reaches the anterior tip of the bulla. The area inside of ventral keel is occupied by a wide smooth area continuing to involucrum as in the case of *M. densirostris*. The rugose area is restricted in the narrow part between ventral keel and lateral wall of tympanic bulla (Fig. 60). The anterior part of interprominential notch is not smoothly connected to the lateral wall.

Periotic resembles to that of *M. europaeus*. The base for stapedial muscle seems to be wide and shallow as in the case of *Ziphius cavirostris*, but in *M. europaeus* it forms a narrow furrow encircling the cochlear portion different from *M. ginkgodens*. Cochlear portion is approximately square.

Mesoplodon mirus (Pl. III). Only one tympanic bulla was observed. The ventral keel situates at the inner side of the center of ventral wall of the bulla as in the case of *M. stejnegeri* and *M. europaeus*, but is characteristic in the strong elevation at the anterior part of the keel. The smooth area inside of the ventral keel is wide (Fig. 60). Outer posterior prominence is thick and high. Inner posterior prominence is small.

Mesoplodon carlhabbsi (Pl. VI). The size of tympano-periotic bone is nearly similar to that of *M. stejnegeri*. On the tympanic bulla, the posterior prominences especially the outer develops well. Interprominential notch is wide and smoothly continues to the slope of lateral wall of tympanic bulla. Ventral keel continues from the base of inner posterior prominence to the point near the anterior border of the bulla. It situates at the inner side of the center of ventral wall, and its highest point at the middle of tympanic bulla. The smooth area on the inner side of ventral keel is narrow (Fig. 60).

When seen from the cerebral side of periotic, the front border of anterior process, lateral border of superior process, and posterior border of posterior process cross in a right angle (Pl. VI Fig. 15). Anterior process is large and conical with the apex on the cerebral side. Though there is a slight protuberence on the superior process near the fundus of internal auditory meatus, it is not so conspicuous as that of *M. europaeus* or *M. ginkgodens*. The cochlear portion, which contour is round, has a wide fossa at the mesial side of the opening of fundus of internal auditory meatus. The furrow of the base for stapedial muscle is wide and deep. The furrow on the lateral surface of superior process is shallow.

Physeteridae

This family includes only one species *Physeter catodon*. The tympano-periotic bone of this species was precisely described by Yamada (1953). Several important diagnostic features of the ear bones of *Physeter catodon* (Pl. VII) are described below in comparison with other Physeteroidea species.

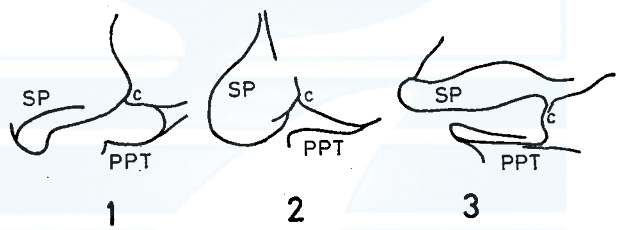

Fig. 61. Schematic figure of the lower tympanic aperture of Physeteroidea. C, Conical process. SP, Sigmoid process. PPT, Posterior process of tympanic bulla. 1, Ziphiidae. 2, Kogiidae. 3, Physeteridae.

The tympano-periotic bone of *Physeter catodon* is massive and the largest in Physeteroidea. On the tympanic bulla, in spite of the strong development of involucrum and inner posterior prominence, outer posterior prominence and interprominential notch are greatly reduced. As the result of this modification, outer and inner posterior prominences and lateral border of sigmoid process situate nearly on one plane (Pl. VII Fig. 5). Though the sigmoid process is thin and square as in the case of Ziphiidae, the width is larger than the length. Its lateral margin is not twisted posteriorly. Conical process and posterior branch of lower tympanic aperture are almost disappeared (Fig. 61). Accessory ossicle is large and roofs the anterior part of tympanic cavity. Posterior process of tympanic bulla is long and composed of thin laminated plates. In one example, a tympanic bulla of 59.3 mm in standard length had the posterior process of 175 mm in length (Pl. VII Fig. 11). The facet for the connection between posterior process of tympanic bulla and that of periotic has vague keels and grooves, and not so smooth as Ziphiidae and Kogiidae. The tympanic bulla of *Physeter* differs in these features from those of Ziphiidae and Kogiidae, but it resembles to that of Kogiidae in the U shaped anterior openning of tympanic bulla, swallen involucrum and its " 3 " shaped dorsal margin, absence of lateral furrow, and in the closed elliptical foramen.

The superior process of periotic is massive, and continuous in structure with anterior and posterior processes. Anterior process is shaped of a curved slender rod. Posterior process is cylindrical and tapered distally, which is connected to superior process at a right angle and bent to downward. The posterior surface of posterior process of periotic is rugose suggesting a sutural connection with squamosal. Aquaeductus Fallopii, foramen singulare, ductus endolymphaticus, and tractus spiralis foraminosus opens in one openning of fundus of interal auditory meatus (Pl. VII Fig. 9).

Kogiidae

This family is composed of two species in one genus *Kogia*. The diagnostic features of the ear bones are as follows.

The size of tympanic bulla is one of the smallest among the toothed whales. The smaller size is only found in *Pontoporia blainvillei*. The ventral wall of tympanic bulla is flat and crosses with the lateral wall at a right angle, and there is observed no lateral compression of tympanic bulla nor deformation of posterior prominences.

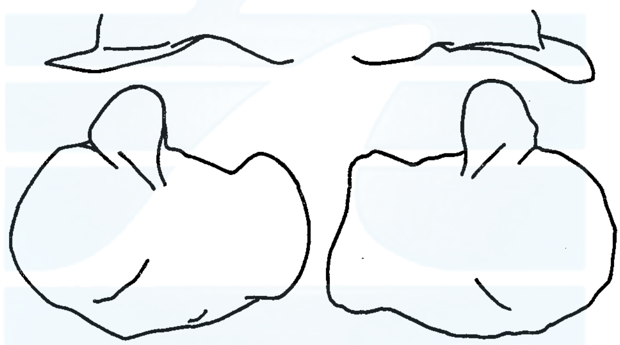

Fig. 62. Schematic figure showing the difference of antero-lateral border of tympanic bulla, and of upper tympanic aperture between *Kogia breviceps* (1), and K. simus (2). Anterior direction is at the center.

Inner and outer posterior prominences developes well, and the latter protrudes posteriorly and the former postero-mesial direction at nearly a right angle with the latter. Interprominential notch opens only posteriorly, and does not extend on the ventral wall of tympanic bulla. As sigmoid process is not twisted, the anterior surface is exactly directed toward antero-posterior axis of tympanic bulla. The tip of sigmoid process is spheric. The distal portion of posterior process of tympanic bulla is funnel shaped. The facets for the connection between the two posterior processes are smooth.

The anterior process of periotic is flat and rectangular with the concaved margins, which is different from other Physeteroidea species. On the thick superior process, thin plate-like posterior process extends posteriory. Aquaeductus Fallopii and ductus endolymphaticus opens outside of the opening of fundus of internal auditory meatus inside of which foramen singulare opens.

Kogia simus and *K. breviceps* (Pl. VIII)

Though the ear bones of the two species is quite similar, they can be distinguished by several characteristics. On the tympanic bulla, the anterior margin of the lateral wall is concaved in *K. simus* but is convex in *K. breviceps*. In this respect the ear bone reported by Yamada (1953, Fig. 13) is classified into *K. simus*. On the tympanic bulla of 3 *K. simus*, conical process is hidden inside of the sigmoid process and cannot be observed from outside. But on one example of *K. breviceps* it is observed from outer side. This will probably be a specific difference. The upper tympanic aperture is large in *K. breviceps* and small in *K. simus* (Fig. 62).

Platanistoidea

This superfamily includes the three families, Platanistidae, Iniidae, and Pontoporiidae. There are found some common features in the morphology of their ear bones as mentioned below. On the tympanic bulla, the swollen base of outer posterior prominence, the existance of median and lateral furrow, no lateral compression, and thick and square sigmoid process are common in Platanistoidea. On the periotic, the opening of fundus of internal ausitory meatus is characteristic in the roundness. The posterior processes of both tympanic bulla and periotic are very small in size and the latter is bent downward.

TABLE 8. MEASUREMENTS OF TYMPANO-PERIOTIC BONES OF PLATANISTOIDEA, SHOWN IN MM OR PERCENTAGE OF THE STANDARD LENGTH.

	Species	*P. gangetica*	*I. geoffrensis*	*L. vexillifer*	*P. blainvillei*
	Sample size	7	5	1	1
1.	Length of tympanic bulla (mm)	47.1–63–5	38·2–45.6	47.1	24.3
5.	Width of tympanic bulla (%)	44.3–54.4	60.3–70.3	51.7	61.3
6.	Height of tympanic bulla (%)	61.3–74.8	74.0–81.4	58.0	83.0
13.	Length of periotic (mm)	33.4–42.3	25.7–30.4	52.0	20.0
14.	Thichness of periotic (%)	23.9–35.9	41.6–58.3	26.9	47.5
15.	Width of periotic (%)	55.3–66.5	79.6–90.0	46.2	81.0
19.	Diameter of cochlear portion (%)	38.3–44.8	54.3–68.5	37.5	68.0
—.	FIAM, Width/Length	0.79–1.33	0.40–0.60	0.88	0.37

Platanistidae

This family includes only one species *Platanista gangetica*. The most conspicuous feature of the ear bone of this species is in the relation to the skull (see page 48).

The anterior part of tympanic bulla is cylindrical and smoothly changes into anterior spine, which length increases with the growth of animal. There is formed small irregular needle-shaped processes in the median furrow, and gives the base of ligament connecting the tympanic bulla and basioccipital. The lateral wall is highly convex. The width of tympanic bulla is smaller than that of *Inia geoffrensis* (Table 8). This is related with the shape of involucrum. Sigmoid process, which situates at a right angle to the long axis of the bulla, is large in both thickness and width. Lateral furrow is weaker than that of *Inia*. The elliptical foramen opens, but the shape is irregular. The facet for the posterior process of periotic has weak longitudinal grooves and ridges.

Though the periotic is larger than that of *Inia geoffrensis*, cochlear portion is smaller than it in both thickness and diameter. The apex of cochlear portion touches the involucrum. Round opening of fundus of internal auditory meatus is surrounded by a circular keel. The apertures of aquaeductus Fallopii and foramen sigulare open at a close distance in the opening of fundus of internal auditory meatus. Anterior process is slender and curves along cochlear portion. At the dolsal base of anterior process there is usually a small pillar shaped process directing toward cochlear portion (Pl. IX Figs. 8–10). As there is usually attached one or two ossicles on the anterior process, the shape of this part varies between individuals (Pl. IX Figs. 12–13). Accessory ossicle touches the anterior base of cochlear portion. Superior process is thin and is clearly separated by the grooves from the anterior and posterior processes. The antero-dorsal corner of the posterior process of periotic forms a nodular protuberence. A small rod shaped downward protuberence is on the posterior wall of upper tympanic aperture (Pl. IV Fig. 7), this structure strengthens the mechanical connection between posterior process of periotic and squamosal.

Iniidae

This family includes two genera *Inia* and *Lipotes*. One of the two features of tympano-periotic bones distinguishing this family from other Platanistoidea is that the posterior processes of tympanic bulla and of periotic are not sutured to the skull. And the other is the relatively strong sutural connection between both posterior processes. The former structure is also observed in *Pontoporia blainvillei*, and the latter in *Platanista gangetica* but the suture is stronger in *Inia* and *Lipotes*. Lateral margin of sigmoid process is strongly convexed posteriorly. Elliptical foramen opens.

1. *Inia geoffrensis* (Pl. X)

The ear bones of this species is smaller than those of *Platanista* and *Lipotes*. As the involucrum expands to the inside, the width of tympanic bulla is large. Lateral furrow is prominent. Median furrow is nallow and shallow, and situates at slightly outer side of the center of tympanic bulla. The size of two posterior prominences are nearly same, which is different from the case of *Lipotes*. The short posterior process of tympanic bulla extends posteriorly. Its length is from 20.8% to 24.8% of the length of bulla.

On the periotic, the anterior and posterior processes are smaller in comparison with the size of cochlear portion, as in the case of *Pontoporia blainvillei*.

Anterior process is square and short, but small process sometimes attaches on the tip. The thickness (measurement no. 14) and breadth (no. 15) of periotic is larger than the corresponding values of *Lipotes* and *Platanista* (Table 8). The opening of fundus of internal auditory meatus is usually round.

2. *Lipotes vexillifer* (Pl. X)

The length of tympanic bulla of this species is intermediate of *Inia* and *Platanista*, but that of periotic is larger than any of the two genera.

As involucrum of tympanic bulla does not expand to the inner side, the width of tympanic bulla is smaller than that of *Inia* but resembles to that of *Platanista* (Table 8). The anterior part of tympanic bulla is conical and posseses no anterior spine. Median furrow reaches to a shallow hollow near the anterior end of the bulla. Outer posterior prominence is large and spherical, but the innerposterior prominence is thin. Ventral keel is low and narrow, and curves to the outer side at the middle of the length. The diameter of cochlear portion is 19.2 mm, which is nearly same with that of *Inia* and larger than *Platanista*. But its ratio to periotic length is far smaller than both of them. The opening of fundus of internal auditory meatus is nearly round (14.5 mm $\times$13.5 mm) as in the case of *Platanista*. Anterior process of periotic can be clearly distinguished from superior process, and its slender tip extends along the supero-lateral border of tympanic bulla. This feature is similar to *Platanista* rather than *Inia*. Posterior process of periotic is also distinguished from superior process as in the case of anterior process.

Pontoporiidae

This family includes only one species *Pontoporia blainvillei* (Pl. IX). Most conspicuous feature of this family is the almost smooth articular facets on both posterior processes, but more perfect smoothness is found in Phocoenidae. Following descriptions on the ear bones are for this species.

The tympano-periotic bone of this species is the smallest among the observed Odontoceti. The ventral view of tympanic bulla is convexed laterally. Anterior spine is absent. Median furrow developes well and is in parallel with the concaved involucrum. Both posterior prominences are slightly large and nearly in same size. It is a characteristic feature of this species that the lateral wall between base of outer posterior prominence and the lateral furrow greatly swells. Lateral furrow is inconspicuous. Sigmoid process is square in the anterior view and its thickness is large. Elliptical foramen is closed. The posterior branch of lower tympanic aperture (measurement no. 10) is larger than any other species of Platanistoidea. The posterior process of tympanic bulla and the tip of posterior process of periotic is directed to the posterior.

The anterior process of periotic is short and pointed. The posterior and anterior processes are continuous with superior process, which is similar to *Inia* and different from *Platanista* and *Lipotes*. Cochlear portion is proportionally large as in the case of *Inia*. This seems to have a relation with the shorter anterior and posterior processes. The openings of aquaeductus cochleae and ductus endolymphaticus are widely separated from the opening of fundus of internal auditory meatus.

Delphinoidea

In this superfamily, the posterior process of tympanic bulla is relatively large, and not sutured with the skull. Sigmoid process is small and thin, and L-shaped in the lateral view. Lateral furrow is almost completely disappeared. Outer posterior prominence is round or flat, and projects postero-ventrally. Interprominential notch is deep. Elliptical foramen is closed in some species.

On the periotic, the anterior, posterior, and superior processes are continuous. Accessory ossicle lies between anterior process and lateral wall of tympanic bulla, separating the two parts. Anterior process is thick and square. Anterior margin of cochlear portion does not touch the anterior process.

This superfamily includes Delphinapteridae, Phocoenidae, Delphinidae, and Monodontidae.

Delphinapteridae

This family includes *Delphinapterus leucas* and *Orcaella brevirostris*. The common features of tympano-periotic bones are as follows.

The outer and inner posterior prominences are developed well, and the width across these prominences is large. The posterior branch of lower tympanic aperture opens wide as in the case of Pontoporiidae and Phocoenidae. Elliptical foramen is

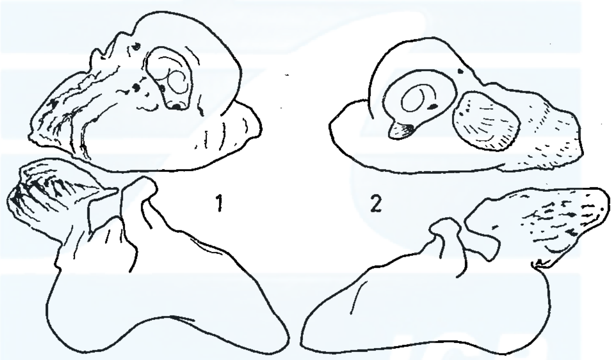

Fig. 63. Schematic figure of tympanic bulla and periotic of *Delphinapterus leucas* (1) and *Orcaella brevirostris* (2).

TABLE 9. WIDTH OF TYMPANIC BULLA SHOWN IN PERCENTAGE OF THE LENGTH, IN *ORCAELLA*, *DELPHINAPTERUS*, AND *MONODON*.

Species	*O. brevirostris*	*D. leucas*	*M. monoceros*
Sample size	2	4	4
Range of the width	52.0–57.5	58.0–59.0	37.5–41.4
Mean	54.8	58.9	39.6

closed. Bilateral compression of tympanic bulla is not occurred (Table 9, Fig. 63). The posterior processes of tympanic bulla and of periotic are large and extend straightly to the posterior direction. The suture between both posterior processes is rigid by the existence of deep ridges and grooves.

1. *Delphinapterus leucas* (Pl. XI)

The anterior margin of tympanic bulla is lacking of anterior spine, and round in the contour. Because of the low ventral keel and highly projected outer posterior prominence, the ventral contour of tympanic bulla is saddle shaped when seen from the lateral side. Involucrum is strongly projecting to inner side. The tip of posterior process of tympanic bulla is highly thickened.

The posterior process of periotic is thick and wide at the base, but thin at the tip to form a wedge shape. On the dorsal surface of the posterior process there are irregular grooves (Fig. 63). Periotic of this species is sutured by this structure to the squamosal (Pl. I Fig. 8, and Kleinenberg *et al* 1964). Superior process is thick and have a flat elevation higher than the opening of the fundus of internal auditory meatus. The opening of the fundus of internal auditory meatus is surrounded by a circular crest. The opening of aquaeductus Fallopii is separated from foramen singulare and tractus spiralis foraminosus by a developed crista transversa.

2. *Orcaella brevirostris* (Pl. XI)

The tympano-periotic bone of this species is nearly similar in size to that of *Delphinapterus leucas.*

When seen from the lateral side the ventral contour of tympanic bulla is flat, which is greatly different from *D. leucas.* The low ventral keel reaches slightly beyond the midpoint of tympanic bulla. Shallow median furrow is formed along the ventral keel. The outer posterior prominence, which is flat in *D. leucas*, is cylindrical in this species. The projection of involucrum to the inner side is observed on ZSI 274 in a same form as *D. leucas*, but weaker on USMN 199743. The posterior process of tympanic bulla is larger than that of *D. leucas* in both thickness and length, and possesses a large part of spongy structure.

The posterior process of periotic is also large and have a spongy structure. The USNM specimen had larger posterior process than the ZSI specimen. Probably this will be related with the age of the animal. Opening of ductus endolymphaticus is surrounded by a large shallow funnel shaped area. Superior process is slender than that of *D. leucas.*

Phocoenidae

The diagnostic features of the tympano-periotic bones of this family are in the direction of the posterior processes and in the smooth facets for the connection between both posterior processes. The former is similar to Delphinapteridae, but the latter differs from it. The posterior process of tympanic bulla is large, but that of the periotic is smaller and shaped of a rod. The both posterior processes have no spongy structure (Fig. 64).

Other characteristics common in the tympanic bulla of this family are observed in the developed posterior prominences, deep interprominential notch, wide posterior branch of lower tympanic aperture, existence of a vague median furrow reaching nearly anterior part of the bulla, absence of anterior spine, elevated anterior end of the ventral wall, closed elliptical foramen, and in the absence of lateral compression of tympanic bulla. But most of these characteristics are common to Delphinapteridae.

The characteristic features of the periotic of this family are the linear arrangement of anterior, superior, and posterior processes, the triangular shape of cochlear portion, and low crista transversa. The lengths of tympano-periotic bones are small and approximately in the range between 27 mm and 34 mm.

1. *Neophocaena phocaenoides* (Pl. XII)

The outer posterior prominence is cylindrical and far thicker than the inner posterior prominence. The posterior process of tympanic bulla is thick and spindle-shaped in lateral view. Ventral keel is high as in the case of *Phocoenoides*. Posterior process of periotic is shaped of a slender rod with the pointed tip (Fig. 64).

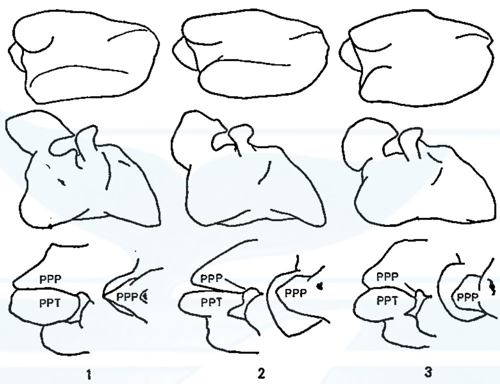

Fig. 64. Schematic figure of tympano-periotic bones of Phocoenidae, ventral (top) and lateral view (middle) of tympanic bulla, and lateral and dorsal views of posterior processes (bollom). PPP, Posterior process of periotic. PPT, Posterior process of tympanic bulla. 1, *Neophocaena phocaenoides*. 2, *Phocoenoides* spp. 3, *Phocoena phocoena*.

TABLE 10. RANGE OF THE MEASUREMENTS OF TYMPANO-PERIOTIC BONES OF PHOCOENIDAE, SHOWN BY THE PERCENTAGE OF THE STANDARD LENGTH.

Species	*N. phocaenoides*	*P. phocoena*	*Phocoenoides* spp.
Sample size	19	6	12
Tympanic bulla			
2. Tip to inner post. prom.	98.7–108.0	89.3–97.9	89.2–97.2
6. Height	81.5– 94.3	75.2–87.3	67.9–82.5
Periotic			
14. Thickness	26.6– 33.6	32.6–39.0	35.8–39.4
19. Diameter of cochlear portion	45.1– 51.4	38.9–44.6	37.5–43.5

This species differs from other two genera of Phocoenidae in the following measurements, or the distance from anterior tip of tympanic bulla to posterior end of inner posterior prominence (measurement no. 2), height of the bulla (no. 6), thickness of periotic (no. 14), and diameter of cochlear portion (no. 19) (Tables 10 and 16).

2. *Phocoena phocoena* (Pl. XII)

The outer posterior prominence of the tympanic bulla is flat as in the case of

Phocoenoides. Ventral keel is low and most inconspicuous among the three genera of Phocoenidae. The central area of the ventral wall of tympanic bulla is flat and is not concaved as that of *Neophocaena* and *Phocoenoides.* The posterior process of tympanic bulla is similar to that of *Phocoenoides.* The tip of posterior process of periotic is robust as in the case of *Phocoenoides,* but it differs in the existance of a weak constriction at the base.

The observation of each 3 specimens of *Ph. phocoena phocoena* and *Ph. phocoena vomerina* could not find the difference between the two subspecies. One tympano-periotic bone of *Ph. sinus* did not show any difference from *Ph. phocoena.*

3. *Phocoenoides* (Pl. XIII)

The shape of outer posterior prominence and of posterior process of tympanic bulla differs from that of *Neophocaena* but resembles to *Phocoena.* The presence of the high ventral keel and the deep concavity at the middle area of ventral wall of the bulla differs from *Phocoena.* Though the periotic of *Phocoenoides* resembles to that of *Phocoena,* it may be distinguished by the shape of the posterior process (Fig. 64).

There is found no morphological difference between the tympano-periotic bone of *Ph. dalli* and that of *Ph. truei.*

Delphinidae

One of the characteristic features of this family is found in the posterior processes of tympanic bulla and of periotic. The posterior processes project laterally or postero-laterally, and their connection forms the suture with the longitudinal grooves and ridges on the facets. But these features are observed also in Monodontidae. Other characteristics of this family are the larger or equal thickness of outer posterior prominence in comparison with that of the inner, the narrow posterior branch of lower tympanic aperture, the low crista transversa, and aquaeductus Fallopii openning in the same base with tractus spiralis foraminosus.

The presence of elliptical foramen, median furrow, and of anterior spine, height of ventral keel, and strength of lateral compression of tympanic bulla show wide variation between taxa.

This family is divided, in this study, into 4 subfamilies or Sotaliinae, Delphininae, Orcininae, and Globicephalinae.

Sotaliinae

The characteristics of the tympanic bulla of this subfamily are the presence of median furrow (*Sotalia* and *Sousa*) or similar longitudinal furrow (*Cephalorhynchus*), swallen outer posterior prominence, weak ventral keel, usually closed elliptical foramen, no lateral compression of the bulla, and absence of anterior spine.

On the periotic, there is no common characteristics except the slenderness of the superior process.

1. *Sotalia* spp. (Pl. XV)

Only two specimens from a *S. guianensis* and a *S. fluviatilis* are measured. The size of ear bone is nearly same with that of *Stenella* or *Delphinus.*

The anterior margin of ventral wall of tympanic bulla is nearly symmetrical and oval-shaped. Shallow median furrow, starting from the wide interprominential notch, reaches near the anterior end of tympanic bulla. The rugose area on the ventral surface of tympanic bulla is restricted to the inner side of median furrow. Ventral keel is not so developed as *Tursiops* and *Stenella*. The inner posterior prominence is short and its tip does not project posteriorly beyond its posterior base. This condition is not observed in *Sousa* and *Cephalorhynchus*. As the outer posterior prominence, especially its anterior base swells well, the highest point is at the point corresponding to the base of sigmoid process when seen from the lateral side. The periotic is characteristic in the two longitudinal keels on the superior process (Fig.

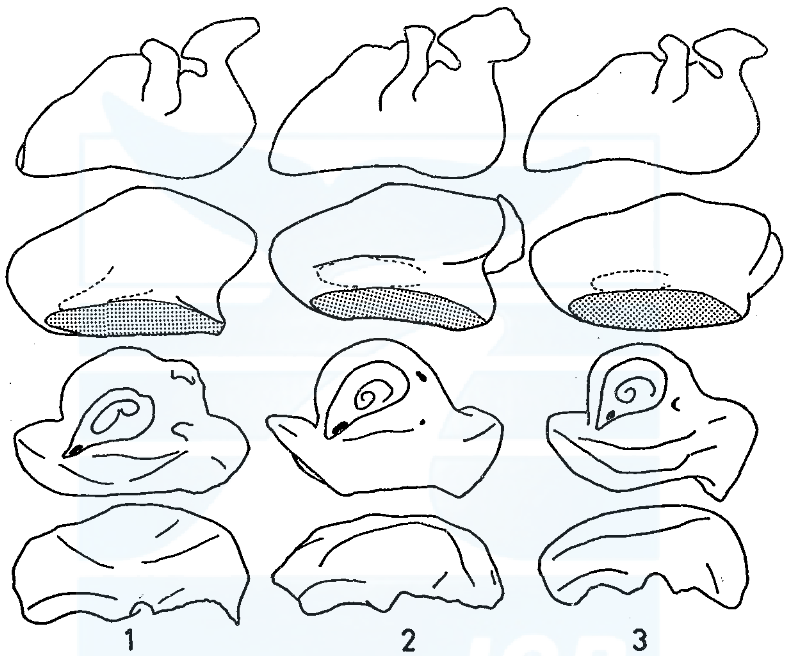

Fig. 65. Schematic figure of tympano-periotic bones of Sotaliinae. Dotted area indicates ventral keel, and the dotted line Median furrow or similar structure. 1, *Cephalorhynchus*. 2, *Sousa*. 3, *Sotalia*.

TABLE 11. RANGE OF THE MEASUREMENT OF TYMPANO-PERIOTIC BONES OF SOTALIINAE, SHOWN BY THE PERCENTAGE OF THE STANDARD LENGTH.

Species	*Sotalia* spp.	*Sousa t.*	*Cephalorhynchus* spp.
Sample size	2	1	2
Tympanic bulla			
2. Tip to inner prost. prom.	91.3–91.4	97.4	89.2–90.9
5. Width	56.2–57.3	57.3	57.2–58.2
7. Width across post. prominences	48.6–49.4	54.1	44.6–46.4
10. Width of post. branch of LTA	5.4	7.3	4.0
Periotic			
17. Aquaeductus cochleae to FIAM	5.7– 6.8	5.4	17.9

65). According to the observation on several *Sotalia* specimen in Museo de Zoologia de la Univ. de Sao Paulo, the opening of elliptical foramen is not rare.

There was observed no significant difference between *S. guianensis* and *S. fluviatilis*.

2. *Sousa teuszii* (Pl. XIV)

Only one specimen from Senegal was studied. The size of ear bone is slightly larger than that of *Sotalia*. The form of the anterior tip of tympanic bulla is, different from *Sotalia* and *Cephalorhynchus*, asymetric and outer margin projects laterally. There is a clear median furrow along the outer base of low ventral keel. Its width is largest at the middle of tympanic bulla. The lateral border of median furrow is bounded by a weak keel. The tip of inner posterior prominence projects posteriorly beyond the base. The width across posterior prominences (measurement no. 7) is slightly larger than the other species of this subfamily (Table 11). Posterior process of tympanic bulla is square.

The superior process of periotic is slender and divided into lateral and dorsal planes by a longitudinal keel (Fig. 65). The opening of fundus of internal auditory meatus is slender and separated from the triangular hollow surrounding the opening of ductus endolymphaticus by a keel on its lateral margin.

3. *Cephalorhynchus* spp. (Pl. XIV)

Only two individuals were studied. The size of ear bone is nearly same with that of *Stenella*.

Anterior margin of the ventral wall of tympanic bulla is oval. The ventral wall is elevated at the anterior part. The inner posterior prominence is thin and the tip projects beyond the posterior base. Interprominential notch opens wide. The median furrow like structure extend to the anterior margin of the bulla, but it opens to the lateral wall of the bulla at its middle. The inner margin of involucrum is straight. Posterior process is square.

The superior process of periotic has no prominent keel observed in *Sousa* and *Sotalia*. The distance between aquaeductus cochleae and the opening of fundus of internal auditory meatus is markedly large (Table 11). Opening of fundus of internal auditory meatus is surrounded by irregular small processes.

Delphininae

Wide variation is observed in the morphology of tympanic bulla among the members of this subfamily. The lengths of tympanic bulla and of periotic are found between 28.0 mm and 41.5 mm, and 25.4 mm and 37.8 mm respectively. On the tympanic bulla of this subfamily the bilateral compression is not occurred, elliptical foramen is open, median furrow is absent, and inner posterior prominence projects posteriorly beyond the base. The shape of ventral keel of tympanic bulla can be used as the diagnostic characteristics of the genera. It is highest in *Tursiops* and varies in the order of *Tursiops*, *Stenella*, *Lissodelphis*, *Delphinus*, *Lagenorhynchus*, and *Steno*. A low hemispheric prominence is present on the ventral wall of tympanic bulla near the anterior end of involucrum (Fig. 66).

1. *Tursiops truncatus* in the Japanese waters (Pl. XVI)

The taxonomical position of *Tursiops* in the coastal waters of Japan is not fixed yet. In this paper the name *T. truncatus* is tentatively applied for it after Ogawa (1938) and Rice and Scheffer (1968).

The ear bones of this species are the largest in the Delphininae. Ventral keel develops high and reaches to the anterior margin of the bulla. Interprominential notch is deep, and opens on the lateral wall of tympanic bulla in front of outer posterior prominence. The both posterior prominences are nearly equal in the thickness. In the ventral aspect of tympanic bulla the anterior margin is oval and symmetrical (Fig. 66).

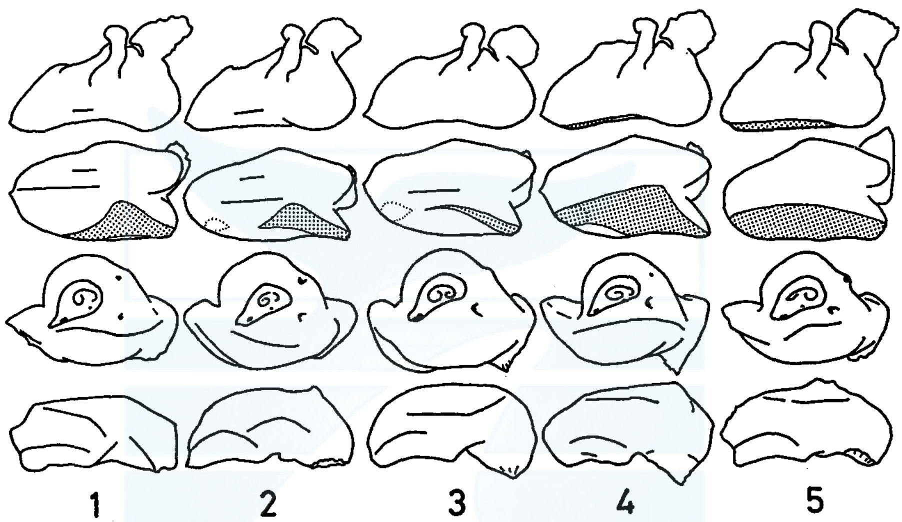

Fig. 66. Schematic figure of tympano-periotic bones of Delphininae. Dotted area indicates ventral keel, and dotted line the hemispheric protuberance. 1, *Steno*. 2, *Lagenorhynchus*. 3, *Delphinus*. 4, *Lissodelphis*. 5, *Tursiops*.

On the periotic, it is characteristic that the posterior margin of the posterior process is smoothly bent to the lateral direction. In other species of this subfamily this part usually forms a clear angle. Fundus of internal auditory meatus opens at the same level with superior process, where small needle-shaped processes are usually formed in the adult individual.

T. gill from the eastern Pacific and *T. truncatus* from the north Atlantic could not be distinguished from *Tursiops* in the Japanese waters.

2. *Stenella caeruleoalba* (Pl. XVII)

Though ventral keel is high and straight as in the case of *Tursiops*, the tympano-periotic bone of this species are far smaller. The inner posterior prominence is thinner than the outer, and the ventral view of the anterior margin of tympanic bulla is not oval but possesses a short semicylindrical anterior spine. The antero-lateral part of ventral wall of tympanic bulla slopes laterally, and shows a slight flattening of the bulla.

On the periotic of *Stenella*, the posterior process, anterior process, superior process, and the opening of fundus of internal auditory meatus show wide individual variation, and the identification of the species in this genus is difficult. But the presence of an angle on the border between the dorsal and the posterior margins of posterior process, of a flat area on the superior process which are present also in some Globicephalinae may be used as one of the characteristics of *Stenella*.

One tympano-periotic bone of presumably young *Stenella styx* from the north Atlantic was indistinguishable from that of young *Stenella caeruleoalba*.

(?) *Stenella roseiventris* (Pl. XIX). This means the Hawaiian spinner dolphin. The ventral keel of tympanic bulla is slightly lower than that of *S. caeruleoalba*, and scatters a irregular tubercles on it. Ventral keel is convexed to outer side. Its

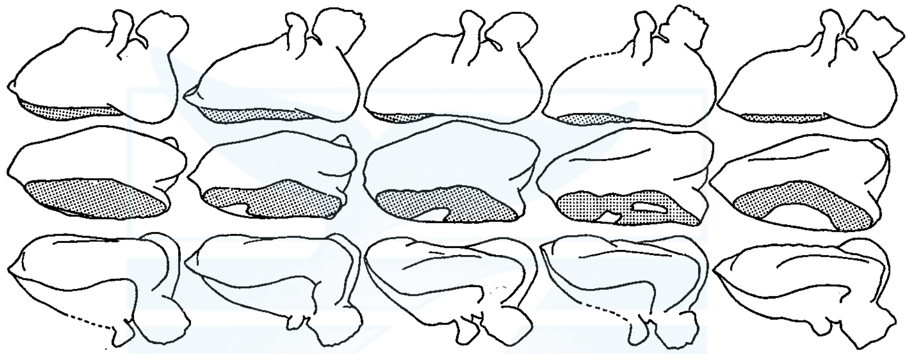

Fig. 67. Schematic figure showing the variation of ventral keel in *Stenella*. Dotted area indicates ventral keel. 1 is observed in *S. caeruleoalba*, 2 in *S. attenuata* and *S. caeruleoalba*, 3 in *S. graffmani*. 4 in *S. longirostris*, 5 in *S. roseiventris*. In the last three species, sample is scarce to find the range of individual variation.

inside slopes to the involucrum (Fig. 67). Though this convexity is also observed on *Delphinus* and *S. longirostris*, the length and width of ventral keel differ between *Delphinus* and *Stenella* (Fig. 66). The swelling at the anterior end of ventral keel is of long oval in the contour. The ventral view of the anterior margin of tympanic bulla is of slender triangle with the anterior spine at slightly outer part (Fig. 67). This species and *S. longirostris* show a common feature in the presence of a low keel on the outer border of ventral surface of tympanic bulla.

(?) *Stenella longirostris* (Pl. XIX). This means the eastern Pacific spinner dolphin, only two specimens are used here. Though the general feature of ventral keel resembles that of *S. roseiventris*, its height is smaller and nearly same with that of *Lissodelphis*. The hemispheric swelling at the anterior end of ventral keel was round in the contour and higher than the ventral keel.

The flat area on the dorsal surface of superior process seems to be larger than that of *S. roseiventris*, but it may be in the range of individual variation.

Stenella attenuata (Pl. XVII). This is the spotted dolphins in the Pacific coast of Japan. I hope to reserve the conclusion on the validity of several species of spotted dolphins in the genus *Stenella*. The tympanic bulla and periotic bone of this species resemble those of *S. caeruleoalba*, and the discrimination of tympano-periotic bone of the two species is difficult. The ventral keel is conspicuously high. The round prominence at the anterior end of ventral keel is flat and inseparable from ventral keel.

Stenella graffmani (Pl. XVIII) This species indicates the spotted dolphin distributing in the eastern Pacific. The tympanic bulla of this species closely resembles that of *S. attenuata*. But the ventral keel seems to be slightly lower than that of *S. attenuata* or of *S. caeruleoalba* (Fig. 67). The thickness of periotic (measurement no. 14) is slightly smaller in this species than *S. attenuata* and *S. caeruleoalba*, but further confirmation will be necessary.

Stenella plagiodon This includes the spotted dolphin in the Atlantic. The tympano-periotic bone resembles that of *S. caeruleoalba* and of other species of spotted dolphins in the Pacific.

3. *Lissodelphis borealis* (Pl. XX)

The size of tympano-periotic bone is similar to that of *Stenella*. On the surface of ventral keel of tympanic bulla distributes a longitudinal fine reticular grooves. Though the ventral keel is long and wide, its height is smaller than that of *Stenella* spp. (Fig. 66). The hemispheric prominence at the anterior end of ventral keel continues to low ventral keel. Inner posterior prominence is thinner than that of *Stenella*, *Delphinus*, and *Tursiops*, and its tip is pointed.

The periotic is characteristic in the flatness of the area surrounded by the posterior margin of the opening of fundus of internal auditory meatus, aperture of ductus endolymphaticus, and aperture of aquaeductus cochleae. The base for the stapedial muscle is concaved, and the aquaeductus cochleae opens on the same plane with the opening of fundus of internal auditory meatus. The last feature is observed also on *Steno*, but in other delphininae species it opens near the posterior wall of cochlear portion (Pl. XX Figs. 4 and 10, and Text Fig. 66). Anterior process is square and slender.

4. *Delphinus bairdi* (Pl. XX)

Banks and Brownell (1969) distinguished the Common dolphin in the eastern Pacific into two species of *D. bairdi* and *D. delphis*, and showed the difference of the habitat. According to my unpublished data, each one specimen from Formosa and Kyushu in southern Japan have the feature of skull coinciding to *D. bairdi*. Probably this *D. bairdi* distributes widely in the warmer warters in the North Pacific. Present specimens includes this Formosa specimen. The Kyushu specimen was used for reference.

The size of tympano-periotic bone is same with that of *Stenella*. The ventral keel of tympanic bulla is so low as that of *Lissodelphis* and inconspicuous especially in the anterior part, where only slender low keel continues to the base of the round hemispheric protuberence at the antero-mesial corner of tympanic bulla (Fig. 66). The inner area of this ventral keel, where fine tubercles are scattered, is wide and slopes to the involucrum. In the ventral view, the anterior border is more acute at the mesial side than the lateral side. The interprominential notch is wider than *Stenella* and *Lissodelphis*, and the bottom is U shaped. A vague longitudinal keel is present along the middle line of ventral wall of tympanic bulla.

The aquaeductus cochleae opens on the posterior wall of cochlear portion as in the case of *Stenella*.

Delphinus delphis (Pl. XXI). The thickness of sigmoid process seems slightly larger in this species than in the *D. bairdi*. Similar difference is also observed in the width of the head of sigmoid process (Table 12). Other features are same with *D. bairdi*.

TABLE 12. RANGE OF THE MEASUREMENT NO. 9, WIDTH OF UPPER BORDER OF SIGMOID PROCESS, IN *DELPHINUS*.

Species	*D. bairdi*	*D. delphis*
Sample size	6	2
Range in mm	4.1– 5.0	4.8– 5.7
Range in % of standard length	13.2–15.2	14.0–17.0
Mean in%	14.4	16.0

TABLE 13. RANGE OF THE MEASUREMENT NO. 7, WIDTH OF TYMPANIC BULLA ACROSS POSTERIOR PROMINENCES, IN *LAGENORHYNCHUS*

Specie	Sample size	Range in mm	Range in % of standard length	Mean in %
L. obliquidens	14	14.2–17.7	42.0–49.4	45.5
L. acutus	3	16.0–16.5	48.0–49.6	49.0
L. albirostris	3	20.1–20.5	54.2–56.0	54.9
L. obscurus	1	16.5	49.2	49.2
L. australis	1	15.5	47.4	47.4

5. *Lagenorhynchus obliquidens* (Pl. XXI)

The length of tympano-periotic bone is intermediate of *Tursiops* and *Delphinus*. The height and width of the ventral keel of tympanic bulla exceed those of *Delphinus*, but it fades at or slightly beyond the middle of tympanic bulla. Two vague longitudinal keels are on the ventral surface of the bulla as in the case of *Steno bredanensis* (Figs. 66 and 68). In the ventral view of tympanic bulla the anterior margin is round and has inconspicuous anterior spine which situates slightly outer side. The dorsal contour of the periotic is of arc, this feature is common to all species of *Lagenorhynchus* (Pl. XXI Figs. 15 and 16).

Lagenorhynchus acutus (Pl. XXII). A smooth area in the mesial side of ventral keel is wide in this species (Pl. XXII Fig. 1). In the ventral view, the anterior margin of the bulla is triangular and has an anterior spine.

Lagenorhynchus albirostris (Pl. XXIII). Tympano-periotic bone of this species is slightly larger than that of *L. obliquidens*.

As the both posterior prominences of tympanic bulla are thick and their tips diverge, the width across the posterior prominences (measurement no. 7) is large (Table 13). Sigmoid process is peculiar in the posteriorly convexed lateral margin

(Fig. 68). The ventral view of anterior part of tympanic bulla is strongly asymmetric.

In the lateral view of periotic, the contour of anterior process, superior process, and posterior process shapes of a arc. Though this feature is common in all Lagenorhynchi species, it is most conspicuous in this species.

Lagenorhynchus obsculus and *L. australis* (Pl. XXII). Observation is based on only each one specimen. Though the anterior margin of the ventral view of tympanic bulla is symmetric in both species, the former differs in the presence of a short anterior spine from the latter, in which it is round lacking in the anterior spine. The sigmoid process is thicker in *L. australis* than in *L. obsculus* (Fig. 68).

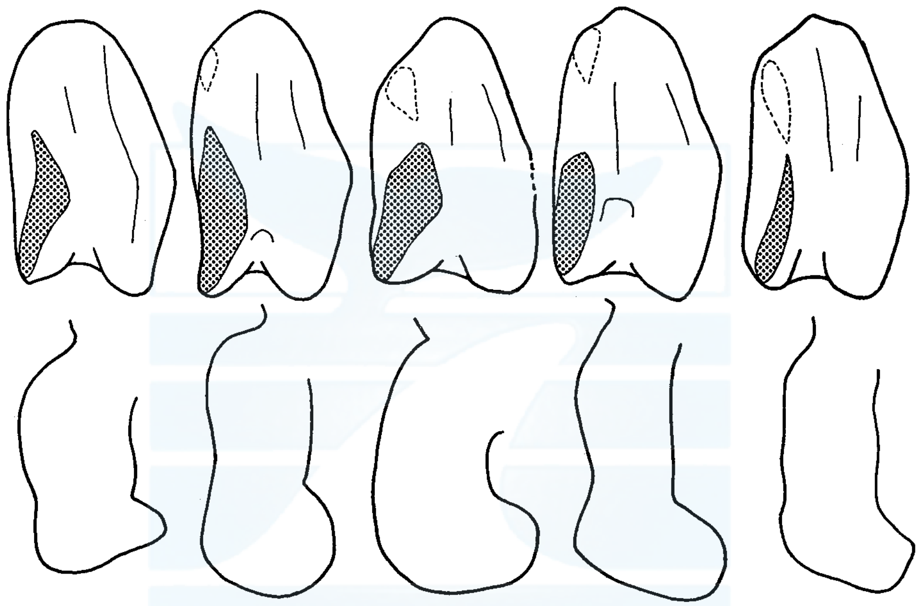

Fig. 68. Schematic figure of the ventral view of tympanic bulla and of lateral view of sigmoid process of *Lagenorhynchus*. 1, *L. australis*. 2, *L. obliquidens*. 3, *L. albirostris*. 4, *L. obscurus*. 5, *L. acutus*. For the dotted area and dotted line see Fig. 66.

In *L. obsculus*, the interprominential notch is closed at the anterior base of posterior prominences. Though the similar structure is also often observed in *L. obliquidens*, it is more conspicuous in *L. obsculus*.

6. *Steno bredanensis* (Pl. XXIII)

The size of tympano-periotic bone is nearly same with that of *Tursiops*. The ventral keel is developed both in the length and height, but it never reaches to the anterior tip (Fig. 66). The anterior half of ventral wall is cylindrical and presents a deep groove at the antero-lateral border of ventral keel. The ventral view of anterior margin of tympanic bulla is round lacking in the anterior spine. There are observed two low longitudinal keels on the ventral wall of tympanic bulla, as in the case of *Lagenorhynchus*.

The dorsal and posterior surfaces of posterior process of periotic cross at a right angle. On the cochlear portion, the area posterior of the opening of fundus of internal auditory meatus is flat and wide. The aquaeductus cochleae opens in this plane as in the case of *Lissodelphis borealis* (Fig. 66).

Orcininae

The tympanic bulla of this group is characteristic in the large size, atrophied ventral keel, no bilaternal compression, and cylindrical anterior portion. Inner posterior prominence is long. Anterior spine is absent.

1. *Pseudorca crassidens* (Pl. XXIV)

The lengths of the tympanic bulla and periotic are in the range between 47.7 mm and 50.5 mm, and 42.8 mm and 49.0 mm respectively. The tympanic bulla of this size with no trace of bilateral compression is found only in this species.

Fig. 69. Contour of the ventral view of tympanic bulla of *Orcinus orca* (1) and that of *Pseudorca crassidens* (2).

The ventral keel is slightly observed in the posterior half of the bulla. On the inner part of anterior margin of the bulla, there are sometimes observed short needle-shaped processes. The direction of posterior prominences is parallel or slightly converging distally (Fig. 69). Interprominential notch is wide and U-shaped. Though the elliptical foramen was present on all the 4 specimens, some were nearly closing.

The anterior process of periotic is straight and narrow. On the dorsal surface of superior process there is a long longitudinal keel. The area lateral of this keel forms a wide flat area.

2. *Orcinus orca* (Pls. XXIV and XXV)

The tympano-periotic bone of this species is the largest among the recent Odontoceti. On the tympanic bulla, ventral keel is entirely disappeared and the ventral surface is rugose with many scattered tubercles. The inner posterior prominence is smaller than the outer, and the two prominences diverge posteriorly at the angle of about 45°. The bottom of interprominential notch is narrow and V-shaped. Elliptical foramen is completely closed.

On the periotic bone, the superior and anterior processes are massive. In comparizon with other parts of periotic, cochlear portion is small and its diameter (measurement no. 19) is only from 31.8% to 38.6% of the standard length of periotic. Superior process protrudes higher than the opening of fundus of internal auditory meatus, and on its dorsal surface short needle-shaped processes are present.

Globicephalinae

The tympanic bulla of this subfamily is strongly flattened laterally. As the result, the lateral and ventral walls cross at a shallow angle, and the distinction of the two parts is not clear. The ventral keel develops well. The inner posterior prominence is short, and its posterior tip does not project posteriorly beyond the base. Anterior process develops in various degree. The frequency of the individuals where elliptical foramen opens varies among the genera. The posterior branch of lower tympanic aperture is narrow.

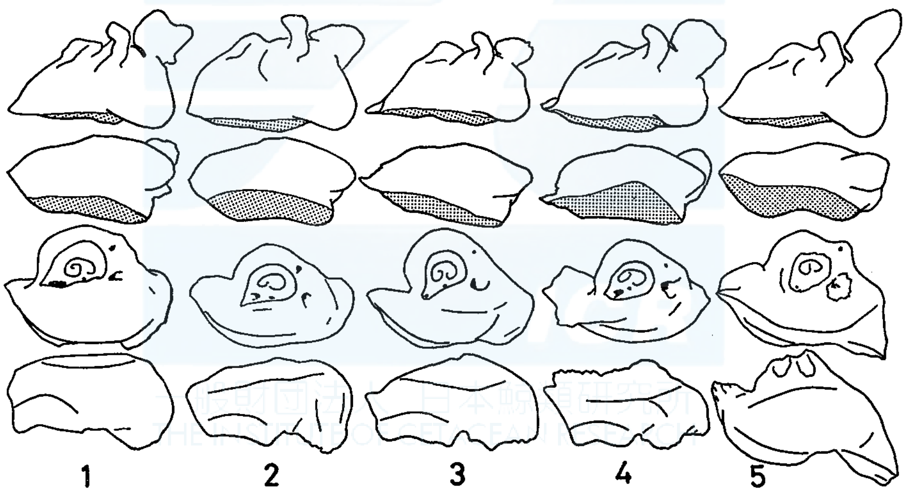

Fig. 70. Schematic figure of tympano-periotic bones of Globicephalinae and *Monodon*. For the dotted area see Fig. 66. 1, *Peponocephala electra*. 2, *Feresa attenuata*. 3, *Globicephala macrorhyncha*. 4, *Grampus griseus*. 5, *Monodon monoceros*.

Usually there is a plateau-like flat area on the dorsal surface of superior process of periotic. In some cases needle-shaped processes are formed on this plateau.

The lengths of tympanic bulla and periotic were observed in the range from 34.0 mm to 52.1 mm and from 30.8 mm to 45.2 mm respectively.

1. *Peponocephala electra* (Pl. XXV)

The lateral compression of tympanic bulla is developed less strongly than other Globicephalinae species (Table 17, Fig. 75). Elliptical foramen of tympanic bulla was present on all 6 individuals studied. The outer slope of ventral keel does not smoothly continue to the ventral surface of tympanic bulla, which condition is different from *Feresa*. The mesial contour of involucrum is straight.

The plateau on the dorsal surface of superior process is wide (Fig. 70), but in lesser degree than *Grampus*. No needle-shaped process is formed on the superior process.

2. *Feresa attenuata* (Pl. XXVI)

The tympano-periotic bone is larger in this species than *Peponocephala*. As the mesial border of involucrum concaves and the outer posterior prominence is directed to postero-mesial direction, the general contour of the ventral view of tympanic bulla convexes externally (Pl. XXVI Fig. 4). The involucrum is short. Anterior spine is short and situates at the center of the bulla. The anterior part of the lateral wall is wide (Fig. 70, top). Similar feature is seen on the tympanic bulla of *Grampus*. The lateral slope of ventral keel smoothly merges into the ventral surface of the bulla. Elliptical foramen was open on the 2 among 7 individuals studied.

The characteristic features of periotic are in the relatively smaller cochlear portion, narrow but thick anterior process, and in the straight contour of the dorsal surface of anterior process and superior process (Fig. 70). The dorsal plane of superior process, on which no needle-shaped process is formed, is not clearly separated from the lateral surface.

3. *Globicephala macrorhyncha* (Pl. XXVII)

On the tympanic bulla of this species, the anterior spine situates slightly at the inner side, and its length increases with the growth of animal. Inner posterior prominence is shorter than the former two species. The lateral view of outer posterior prominence is more stumpy in *Globicephala* and *Grampus* than the former two globicephalids. The height of ventral keel is lower at the middle of the length. The outer slope of the ventral keel is not continuous to the ventral surface of tympanic bulla. As the anterior part of the lateral wall of tympanic bulla is narrow, its lateral view is triangular. Elliptical foramen was present, among 26 animals studied, on only one adult male of 431 cm in body length. The presence of this foramen is considered to be individual variation.

When seen from the lateral side, the dorsal contour of anterior, superior, and posterior process of periotic is round. Anterior process is thin. Superior process is not wide. Needle-shaped processes are sometimes formed on the dorsal surface of superior process.

The ear bone of *Globicephala melaena* (Pl. XXVII) was not distinguished from that of *G. macrorhyncha*.

4. *Grampus griseus* (Pl. XXVI)

The tympanic bulla is characteristic, as *G. macrorhyncha*, in the strong flatness, short inner posterior prominence, and stumpy outer posterior prominence. But it differs from *G. macrorhyncha* in anteriorly expanded anterior border of lateral wall of tympanic bulla, and the shape of ventral keel. In *Grampus* the ventral keel is not low at the middle but shows the same height from the posterior end to the anterior. But its height and width show wide individual variation. The outer slope of ventral keel is not continuous to the ventral surface of the bulla. Anterior spine is on the anterior end of involucrum, but is lacking in rare case. Elliptical foramen was found on one among 12 individual.

Periotic is massive. A conspicuous semicircular plateau project on the dorsal surface of superior process. But on some individual, crowded needle-shaped processes conceal this plateau. Anterior process of periotic is short (Fig. 70).

Monodontidae

This family includes only one species *Monodon monoceros.* The following description is for it (Pl. XVIII).

The tympano-periotic bone is larger than those of Globicephalinae. The tympanic bulla is strongly flattened. Its width is only from 37.5% to 41.4% of the tympanic length (Table 17, Fig. 75). Ventral keel is high and sigmoidal. Involucrum strongly increases the thickness near the anterior end. Inner posterior prominence is thin and very short. Outer posterior prominence is long. Elliptical foramen was closed on all observed specimens. Anterior spine is short. The width of the posterior branch of lower tympanic aperture is wider than those of Globicephalinae (Table 14).

TABLE 14. RANGE AND MEAN OF THE MEASUREMENTS OF TYMPANO-PERIOTIC BONES IN SOME DELPHINOIDEA SPECIES, SHOWN BY THE PERCENTAGE OF THE STANDARD IENGTH.

Species	Measurement No. 10	Measurement No. 18	Sample size
Monodon monoceros	5.2- 9.7, 7.5	51.3-68.4, 63.3	4
Globicephala macrorhyncha	2.5- 5.7, 3.8	37.0-74.8, 48.5	26
Tursiops truncatus	2.2- 9.2, 4.5	35.1-52.8, 43.0	43
Phocaenoides spp.	7.7-12.6, 9.7	37.9-44.4, 40.7	12
Delphinapterus leucas	10.1-11.8, 10.8	44.4-53.0, 48.9	3

Measurement no. 10: Width of posterior branch of lower tympanic aperture.
Measurement no. 18: Length of the facet on posterior process of periotic.

On the periotic, the opening of fundus of internal auditory meatus is surrounded by the thick needle-shaped processes. Crista transversa is inconspicuous. The contour of the opening of fundus of internal auditory meatus shows wide individual variation, but it is usually round.

The long posterior processes of tympanic bulla and of periotic are firmly sutured and project laterally. Their lengths are nearly same.

BIOMETRICAL BETWEEN-SPECIES SIMILARITY OF TYMPANO-PERIOTIC BONES

The between-species similarity indices of tympano-periotic bones were calculated from the 18 measurements and 4 morphological characteristics shown in Table 3. As this is not to study the taxonomy of individuals but the systematic relationships of species, species are used for the unit of discussion. As shown in Figs. 71 and 72, the 29 species were compared. The numbers of individuals in one species are between 4 and 43 with the average of 9.1 individuals (Table 2).

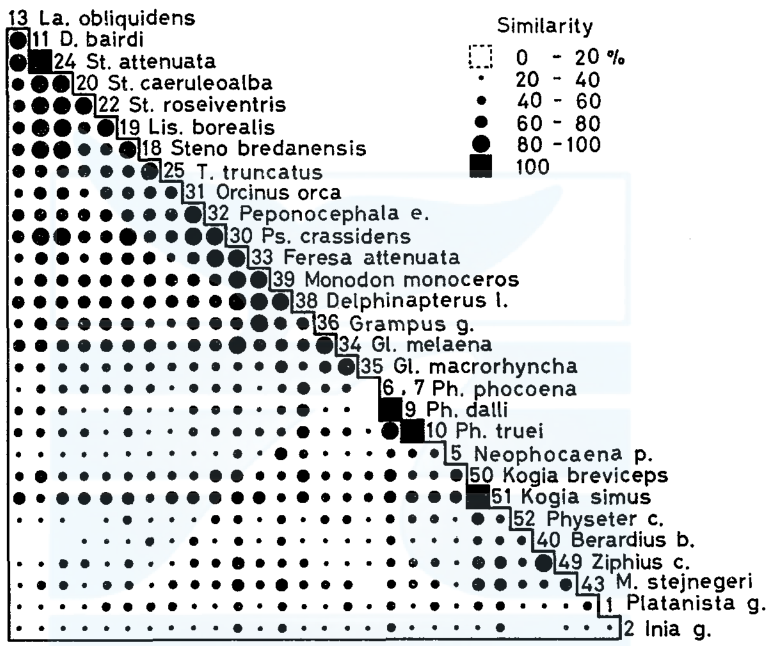

Fig. 71. Matrix of similarity coefficient calculated from morphological measurement of tympano-periotic bones of recent toothed whales. On the scale, the upper limits are not included in the range. The numbers coincides with those shown in Table 2. For other explanation see text.

In the calculation of the similarity indices, the standard lengths (measurement nos. 1 and 13) were compared in the value shown in mm but other measurements were calculated into the percentage of the standard length and then compared, because it is not desirable to compare repeatedly the size of the tympano-periotic bone by using the actual measurements. The 95% confidence limit of the mean value were calculated in each measurement and species. Then the ranges were compared between the selected two species. The number of overlapped measurements shown by the percentage of compared characteristics was used as the similarity index between the two species. Same comparizon was made between each combination of the species. For the non-numerical characteristics, nos. 11, 12, 20, and 21, the calcula-

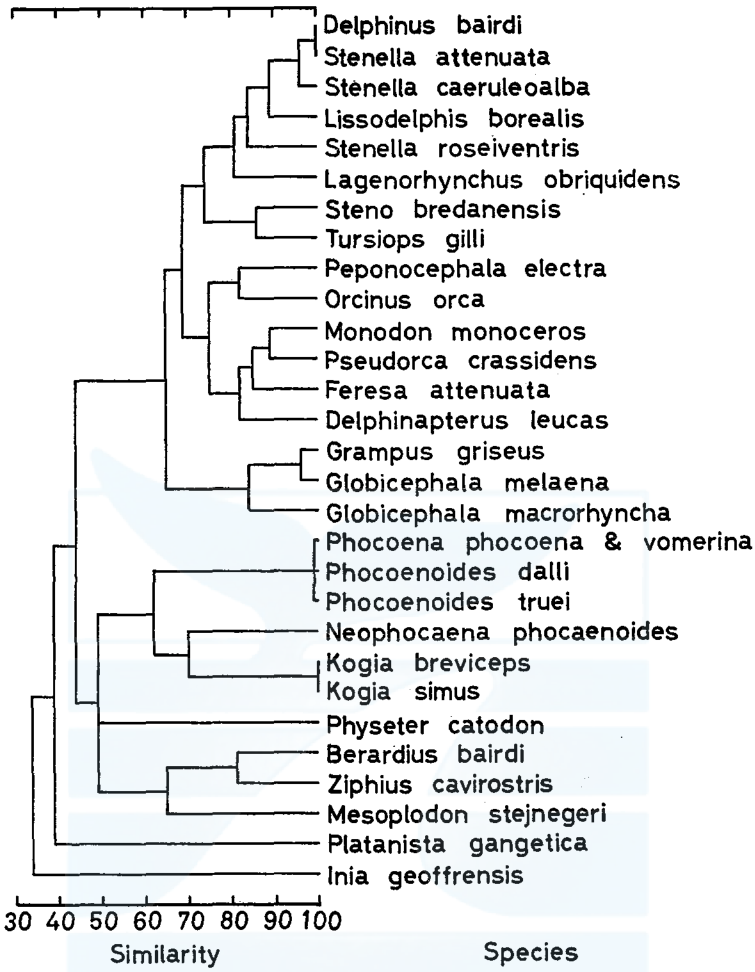

Fig. 72. Phenogram calculated from the matrix in Fig. 71. For explanation see text.

tion of the confidence limits was not made but compared in the similar manner mentioned above. This resut is shown by the matrix in Fig. 71. The phenogram shown in Fig. 72 was obtained from this matrix combining repeatedly the species of higher similarity with the average linkage method (Sokal and Sneath 1963).

The result obtained here is influenced by the number of samples in each unit, especially when the number of sample is small. And even when this result correctly indicates the morphological resemblance of tympano-periotic bone, it is incorrect to consider that it shows perfectly the phylogenetic relationships of the species, because the compared organ is very limitted.

In Fig. 71, the species from *Lagenorhynchus* to *Globicephala* show a higher similarity, which are species included into Delphinoidea in this study. In the Delphinoidea, *Delphinus*, *Lagenorhynchus*, *Stenella*, *Lissodelphis*, *Steno*, and *Tursiops* show the higher similarity than the other genera of Delphinoidea. The former group coincides with Delphininae, but the latter includes not only Globicephalinae and Orcininae but also *Monodon* and *Delphinapterus*. This will mean that Globicephalinae, Orcininae, Monodontidae, and Delphinapteridae can not be separated by the similarity index.

As shown in the matrix the tympano-periotic bone of Phocoenidae shows large morphological distance from that of other members of Delphinoidea. And the phenogram in Fig. 72 shows the higher similarity between the genera of Phocoenidae and *Kogia*. But as indicated in the latter chapter their tympano-periotic bones have a fundamental structural difference in the connection to the skull, and those of Phocoenidae seems to be the very specialized of Delphinoidea type tympano-periotic.

The low similarity between *Platanista* and *Inia* suggests their low phylogenetic affinity. The species of Physeteridae and Ziphiidae show a low similarity to other taxa.

EVOLUTION OF THE TYMPANO-PERIOTIC BONE

When the morphology of tympano-periotic bone is compared between the taxa of toothed whales, there are found various kind of morphological pecuriorities which are common to several taxa, show successive change from one taxon to another, or can be lead from that of another taxon. These characteristics are considered to have been attained as the result of evolution of toothed whales. And their analysis will reveal the process of specialization of tympano-periotic bone which have occurred in the history of Odontoceti. This chapter is to consider the process of the evolution of some important morphological features of tympano-periotic bone of toothed whales.

Interrelationships between tympanic bulla, periotic, and skull

In the land mammals the pars tympanic and pars petrosa, which correspond to the tympanic bulla and periotic of Cetacea, are connected to squamosal and exoccipital by processus mastoideus, and form a part of cranial wall. But in the toothed whales the tympano-periotic bone does not form a part of cranial wall. I consider that the pars mastoidea or mastoid process is fused to tympanic bulla and corresponds to the posterior process of tympanic bulla.

Fraser and Purves (1960, p. 77) classified the interrelationships between mastoid process and skull into the following 3 types, or the type where all the element of mastoid process is fused to tympanic bulla (*Kogia*), the type where all the element of mastoid process is fused to squamosal (*Platanista*, Delphinoidea) and the intermediate type where part of mastoid process is fused to tympanic bulla and the remaining to squamosal (*Physeter*, Ziphiidae).

But on my observation on *Physeter catodon* and other Physeteroid species, another interpretation is possible. On the skull of smaller fetus of *Physeter catodon* (Pl. I Fig. 1), mastoid process (posterior process of tympanic bulla) is imperfect, and the " mastoid element " of Fraser and Purves (1960) on the posterior region of squamosal

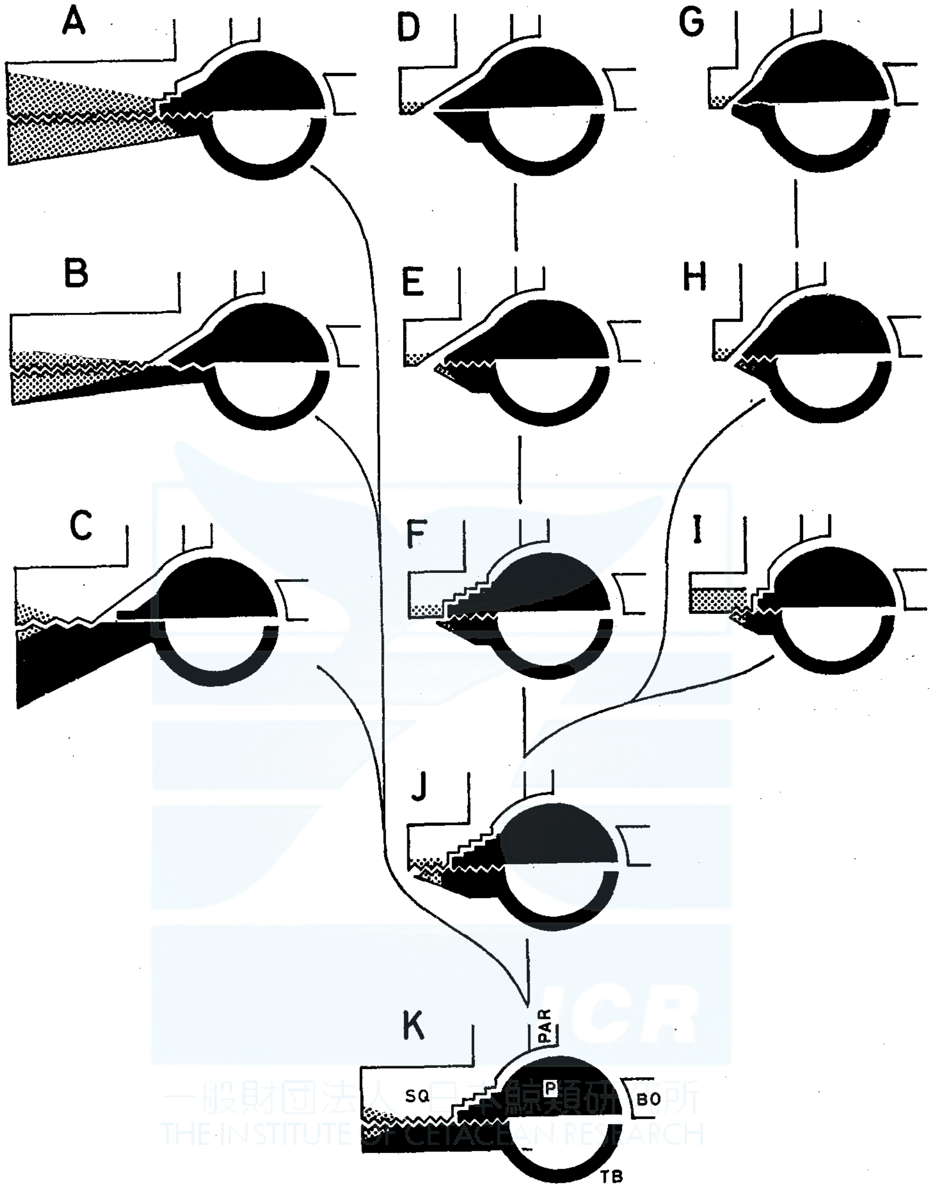

Fig. 73. Tympano-periotic bones of toothed whales, arranged according to the degree of specialization of the connection between tympanic bulla, periotic, and skull. Waved edge indicates suture or tight connection of bones, and dotted area the laminated structure. A, *Physeter*. B, Ziphiidae. C, *Kogia*. D, Phocoenidae. E, Delphinoidea except D and F. F, *Delphinapterus*. G, *Pontoporia*. H, Iniidae. I, *Platanista*. J and K, Hypothetical primitive toothed whale. BO, Basioccipital. P, Periotic. PAR, Parietal. SQ, Squamosal. TB, Tympanic bulla.

is less developed and its structures is continuous to squamosal. The size and laminated structure of this part becomes larger on 5.0 m newborn calf (Pl. I Fig. 2), and finally in the adult attains the similar laminated structure as that of posterior process of tympanic bulla (Pl. I Fig. 3). The vague laminated structure is observed on the posterior region of squamosal even on *Kogia* and Ziphioid species which posterior process scarcely shows the laminated structure (Pl. I Figs. 4 and 5). Accordingly I consider that the posterior region of squamosal suturing to posterior process of tympanic bulla have developed the similar laminated structure, in the toothed whales, accompanied with the development of laminated structure on the posterior process of tympanic bulla. This hypothesis can explain more simply the evolution of the interconnection of tympanic bulla and skull.

Though there are observed, in the recent toothed whales, various patterns of interrelationship between tympano-periotic bone and the skull. They are continuous in some point of view, and can be classified into the following 7 patterns.

Platanista-type

This type is observed only in *Platanista gangetica*. It resembles *Physeter*-type but differs in the posterior process of tympanic bulla.

The small posterior process of tympanic bulla is loosely sutured to squamosal and exoccipital with about 2/3 area of the distal lateral portion of the process. The remaining inner proximal 1/3 area forms the loose suter with posterior process of periotic (Pl. I Fig. 7). There is developed a fine laminated structure, as in the case of *Physeter*, on the postero-ventral portion of squamosal to which the posterior process of tympanic bulla attaches. This laminated portion of squamosal is separated by a slit extending from the postero-dorsal margin, and has a connection with the main part only at the antero-ventral part (Pl. I Fig. 6). The posterior process of tympanic bulla is slightly seen on the surface of skull in the jevenile, but is hidden in the adult. The dorsal and posterior surface of the posterior process of periotic have a contact with the squamosal. One of the peculiar feature of this species is the small conical process projecting from the postero-dorsal wall of upper tympanic aperture. This process, posterior process of tympanic bulla, and squamosal interlock each other. As the result it is impossible to separate the three, without destroying one of them. This structure may have developed as the result of the specialization of *Platanista*.

The fossil Platanistid, *Zarhachis flagellator* (Kellogg 1924) belongs to this type. It is supposed from its shape that the posterior process of periotic of some of Eurhinodelphinid species (*Shizodelphis sulcatus*, Van Beneden and Gervaise 1868–1879) had the connection with squamosal but not in another species (*Eurhinodelphis longirostris*, Abell 1902). Anyway they differs from *Platanista* in the larger size of posterior process of periotic.

Physeter-type

This type is found only in *Physeter*, and differs from the former type in the large and highly laminated posterior process of tympanic bulla and weaker connection of periotic and squamosal.

The long and strongly laminated posterior process of tympanic bulla is wedged between squamosal and exoccipital. The postero-ventral portion of squamosal is also strongly laminated, and to this part the posterior process of tympanic bulla sutures. Though the suture is loose, it is impossible to separate the two part without destroying some of the suture.

The posterior surface of posterior process of periotic is rugose suggesting a contact with squamosal. On the miocene Physeteroid species, the periotic bone of *Orycterocetus crocodilinus* (Kellogg 1965) is supposed from the long posterior process and the rugosity to have had a stronger connection with squamosal, but *Aurophyseter morricei* in the same age (Kellogg 1931) had the smaller posterior process of periotic, which suggest the probable variety of posterior process of periotic among Physeteroid species.

There are observed longitudinal shallow grooves and ridges of the similar intensity as that of *Platanista* on the facets of posterior processes of tympanic bulla and of periotic, which does not form such a strong suture found on Delphinidae.

Ziphius-type

This type is observed on all the Ziphioid species. The interrelationships between squamosal, exoccipital, and posterior process of tympanic bulla is same with the *Physeter*-type. But this differs from it in the less developed laminated structure of squamosal and of the posterior process of tympanic bulla, in the separation of periotic and squamosal, and in the almost smooth facets on both posterior processes.

There is not observed such a highly laminated structure of squamosal and of posterior process of tympanic bulla as found in *Physeter*, but the laminated structure is restricted on their suturing surfaces. The posterior process of tympanic bulla is slender. This type is considered to be the intermediate of *Physeter*-type and *Kogia*-type.

Kogia-type

This is found on *Kogia*. The posterior process of tympanic bulla is short and the distal end is widely expanded in a funnel shape. The laminated structure of posterior process of tympanic bulla and of squamosal is restricted to the narrow area on the surface of the skull (Pl. I Fig. 5). The facets on the both posterior processes are perfectly smooth and forms no suture. Posterior process of periotic has no contact with squamosal.

Delphinapterus-type

This type is represented by only one species *Delphinapterus leucas*. The posterior process of periotic is firmly sutured with squamosal (Pl. I Fig. 8, Kleinenberg *et al.* 1964). On the removed periotic bones (AMNH 180017 and USNM 275075), the dorsal surface of the posterior process of periotic has the irregular deep grooves which are considered to help the connection between periotic and squamosal. But this structure is not observed on the juvenile specimen (USNM 7356). The connection between the posterior process of tympanic bulla and squamosal was not confirmed. Other characteristics are same with the *Delphinus*-type.

Probably this type will retain the more primitiveness than the next *Delphinus*-type.

Delphinus-type

This type is represented by all the species of Iniidae and Delphinoidea except those of Phocoenidae. The tympano-periotic bone looses the direct sutural connection with the surrounding elements of the skull, but is fixed with ligament in the cavity formed by basioccipital, exoccipital, and squamosal.

The posterior process of tympanic bulla is usually longer than that of periotic. At the tip of the former there is a small spongy structure, which will probably be the remaining of the laminated or spongy structure found in the proceeding types. The postero-ventral part of squamosal also retaines the small laminated structure. The both posterior processes are, as mentioned by Yamada (1953), firmly sutured by the help of ridges and grooves on the facets.

Phocoena-type

This type is seen in *Pontoporia* and all the species of *Phocoenidae*. This is characterized by the absence of the spongy osseous tissue at the tip of posterior process of tympanic bulla, and by the smooth or almost smoth facets of the posterior processes of tympano-periotic bone. Other features are same with the former *Delphinus*-type.

Relationships between the types

Fig. 73 shows the various types of the relation between tympanoperiotic bone and skull arranged in accordance with the degree of the specialization. This indicates that there are three main series of evolution in the tympano-periotic bone of recent toothed whales. The tendency of the degeneration of sutural connection between tympanic bulla, periotic, and squamosal is observed in every three series. It is also passible to say that the connection between skull and periotic through the tympanic bulla is getting weaker. This specialization may have some relation with the adaptation of acoustic systems into the water.

In the first series, or that of Physeteroidea, the posterior process of tympanic bulla is not atrophied but attained the increase of the size, and in some species high specialization of the structure of posterior process of tympanic bulla and of squamosal is observed. This does not necessarily mean the rigid connection between skull and tympano-periotic bone, but it is becoming weaker in the Physeteroidea series as in the case of other series. Though the connection between the periotic and squamosal seems to be rather strong in *Physeter catodon*, the connection between squamosal and posterior process of tympanic bulla is not strong as the result of the development of the laminated structures on the corresponding portion. And the connection between the both posterior process is also not strong. These are considered to have produced in some degree the weaker connection between skull and periotic through the posterior process of tympanic bulla. In *Kogia*, on the other hand, the structure of posterior process of tympanic bulla and squamosal is not so specialized, but the connection between the two parts, and that between both posterior processes have become very weak. These features suggest that the two genera of Physeteroidea, or *Kogia* and *Physeter* have attained slightly different modes of specialization. Ziphiidae shows the intermediate character of *Physeter* and *Kogia* in this point of view.

The second series, or the types found in Delphinoidea are considered to have derived from an ancestral type common with that of Physeteroidea, where the connection between skull and tympano-periotic bone was present. The both posterior processes of tympanic bulla and of periotic are atrophied in size. And there are observed various stages of specialization from the most primitive *Delphinapterus* to the most specialized Phocoenidae. Probably the tympano-periotic bone of the most of the species in the recent Delphinoidea may have attained the present condition, in which it is usually separated from the skull, through the stage found in *Delphinapterus leucas*.

The 3rd series is formed by the species of Platanistoidea. Though the ralation between skull, tympanic bulla, and periotic of *Inia*, *Lipotes*, and *Pontoporia* belongs to the *Delphinus*-type or to *Phocoena*-type, they should be separated from the 2nd series because of the stronger atrophy of the size of the posterior processes which is found also in *Platanista*, and of other morphological features common to Platanistoidea. Among the 4 species of Platanistoidea, the relationships between tympanic bulla, periotic, and skull is most specialized in *Pontoporia* and least in *Platanista*. As *Platanista* has too highly specialized structure of squamosal, the ear bone of two other families can not be directly led from *Platanista*. The structure of ear bones of the two families may have derived from a original type which is probably close to the ear bone of primitive *Platanista*. There is expected hypothetical type which connects the 2nd and 3rd series, where the decrease of the length of posterior process is started but the connection between the two processes and squamosal is retained together with the small part of laminated structure.

Platanista and *Physeter*, and in lesser degree all Physeteroidea species, retain the primitiveness in having the connection between skull and tympano-periotic bone. But their skulls show high specialization in the developed maxillary or premaxillary crests. If these crests have the relation with the acoustics (Norris 1968), it may be presumed that these species have developed a mechanism of hearing slightly different from other species.

As mentioned in the former chapter, the specialized posterior processes of periotic and tympanic bulla observed in Phocoenidae and Pontoporiidae resemble that of juvenile individuals of less specialized Delphinidae. This suggests that the specialization occured on the posterior processes of tympanic bulla and of periotic of Platanistoidea and Delphinoidea is one of the neoteny.

Sigmoid process and lateral furrow

The sigmoid process is a prominent plate projecting dorsally on the lateral wall of tympanic bulla and forming the anterior wall of lower tympanic aperture. This process is observed in all the species of Cetacea, and shows the pecuriorities in each taxa. Lateral furrow is a groove found on the lateral wall of tympanic bulla in front of sigmoid process. Here is discussed the morphological variations and the interrelationships.

In Physeteroidea the sigmoid process is square and the length of the dorsal margin is not less than that of lateral margin. The lateral furrow varies among the three families. In Ziphiidae, as the lateral margin of sigmoid process is twisted posteriorly, its front surface is directed antero-laterally. The lateral margin is not longer than the dorsal and the thickness is thin. The lateral furrow is deep and conspicuous. On the other hand, in *Physeter*, the lateral furrow is entirely disappeared. And the dorsal margin of sigmoid process is so long as 1.7 times of the lateral, and the front surface is exactly directed to the anterior axis of tympanic bulla. The thickness of sigmoid process of *Physeter* is thin as in the case of Ziphiidae. The sigmoid process of *Kogia* is globular, but it is not twisted. As seen in Pl. VII Fig. 5 and Pl. VIII Figs. 2 and 17, the contour and direction of sigmoid process of *Kogia* resembles those of *Physeter*.Lateral furrow is absent in *Kogia*.

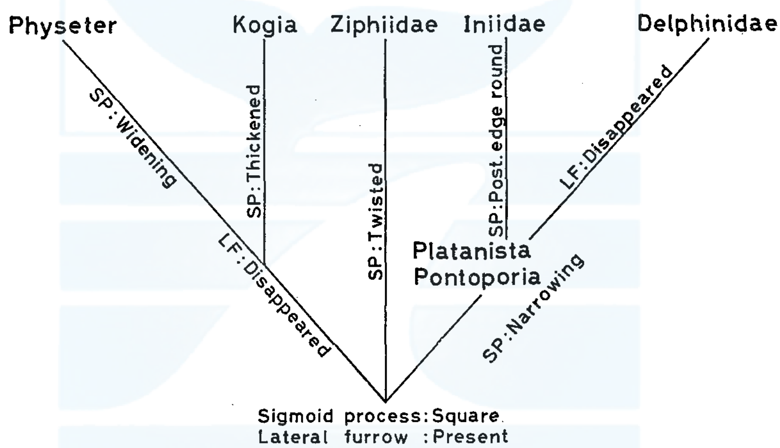

Fig. 74. Diagram showing the specialization of the sigmoid process (SP) and lateral furrow (LF) in recent toothed whales.

Though Platanistoidea resembles Physeteroidea in the wide sigmoid process, its lateral margin is parallel to the lateral wall of tympanic bulla similar with that in Delphinoidea. Lateral furrow is present in all species of Platanistoidea. In *Platanista* the front surface of sigmoid process is placed to coincide with the antero-posterior direction of tympanic bulla, and the lateral margin and the dorsal margin cross at a right angle. The sigmoid process of *Pontoporia* is similar with that of *Platanista*, but the thickness is slightly larger. In both genera the lateral furrow is shallow. In two genera of Iniidae, *Lipotes* and *Inia*, the lateral margin of sigmoid process is round and twisted to the posterior. This feature can be lead from that of *Platanista*. The lateral furrow is deep.

The sigmoid process of the species in Delphinoidea coincides with that of *Platanista* in important features, but differs from it in the smaller thickness and width.

The lateral view is L-shaped. The lateral furrow is usually absent, but in some cases it remains vestigeally. These features are able to be lead from those of *Platanista* by small modification.

In the fossile species, the sigmoid processes of *Zygorhyza kochii* and *Dorudon osiris* of Archaeoceti which may not be the direct ancestor of Odontoceti, are thin and square with long dorsal margin (Kellogg 1936) as that of *Physeter catodon*. The lateral furrow was vaguely present on the both Archaeoceti species. But, of course, it is not impossible to lead the sigmoid process of Mysticeti from that of Archaeoceti. The tympanic bulla of upper miocene Odontoceti, *Phocageneus venustus* (Kellogg 1957) and *Zarhachis flagellator* (Kellogg 1924) resemble that of *Platanista* in the wide and thick sigmoid process and in the presence of shallow lateral furrow. An Eurphinodelphinid species *Schizodelphis sulcatus* has the sigmoid process similar to that of *Platanista*, but it seems not to have retained the lateral furrow. The moderm delphinid species *Kentriodon pernix* (Kellogg 1927) has the lateral furrow.

From the comparison of the sigmoid process of Odontoceti species described in the above, the following consideration is possible. The sigmoid process of the three species of platanistoidea can easily be led from that of *Platanista gangetica*, and even that of Delphinoidea from that of *P. gangetica* in another process.

The various shape of sigmoid process observed in Physeteroidea seems to have originated from a common type which is square, flat, not twisted, and prepared a lateral furrow in front of it. The sigmoid process of *Platanista gangetica* also able to be led from this imaginative original type through the decrease of the width. This original type may probably derived in Oligocene or earlier ages from some species of Agorophiidae or Squalodontidae, on which sigmoid process I have no information.

Fig. 74 shows one of the most probable procedure which may have happened in the process of evolution of sigmoid process and lateral furrow of tympanic bulla.

Elliptical foramen

The elliptical foramen (Yamada 1953) and vertical cleft of Archaeoceti and Mysticeti (Kellogg 1936) are homologous. In the Mysticeti, by the absence of inner pedicle of tympanic bulla the vertical cleft forms a concavity connected to lower tympanic aperture. But in Archaeoceti and Odontoceti, as posterior process of tympanic bulla is connected by outer and inner pedicles to conical process and in-involucrum respectively, vertical cleft is separated from lower tympanic aperture, and the elliptical foramen is formed.

In some taxa of recent Odontoceti, the elliptical foramen is closed or going to be closed. This tendency seems to have happened independently in various small taxa. Its featurs are as follows.

Physeteroidea

Elliptical foramen is perfectly disappeared in Physeteridae and Kogiidae. The elliptical foramen exists in all species of Ziphiidae, but the opening is irregularly shaped and sometimes narrowed by a thin plate of bone. This indicates that the elliptical foramen of Ziphiidae is on an earlier stage of the closure.

Platanistoidea

In the two species of Iniidae the elliptical foramen opens round except one individual of *Inia*. On this individual of *Inia geoffrensis* (LACM 19588) elliptical foramen opened only on the right side. In *Platanista gangetica* elliptical foramen was present on all individuals observed. But its opening is constricted by thin bone tissue and it opens only through several small holes penetrating it. Probably the elliptical foramen of this species is also on the process of the closure. Elliptical foramen is perfectly disappeared on *Pontoporia blainvillei*.

Delphinoidea

In all the species constituting Delphinapteridae and Phocoenidae elliptical foramen is closed. In Delphinoidea its condition varies among the subfamilies. The elliptical foramen is oval and its margin is thickened in all the species of Delphininae. But the percentage of the opened elliptical foramen varies in the species of Globicephalinae. In *Peponocephala electra* it was present on all the 6 animals studied, in *Feresa attenuata* on 2 individuals among 7 studied, in *Globicephala macrorhyncha* on 1 among 26, in *Grampus griseus* on 3 among 12. This observation suggests that Globicephalinae is a group of species where the closure of elliptical foramen is progressing in various degree.

In Orcininae *Pseudorca crassidens* has the elliptical foramen opened, but it is closed in *Orcinus orca*. This indicates that tympanic bulla of *Orcinus* is more specialized than that of *Pseudorca*. *Sousa teuszii*, *Sotalia* spp., and *Cephalorhynchus* spp., which are included tentatively into Sotaliinae, usually have the elliptical foramen entirely closed.

The elliptical foramen of *Monodon monoceros*, included into Monodontidae, was open on 1 individual among 4 animals studied.

Flatness, Ventral keel, and median furrow of tympanic bulla

The flatness of tympanic bulla mentioned below is the characteristics concerning the angle at which the lateral wall and ventral wall cross. This feature is prodused, in Delphinoidea, by the bilateral compression of tympanic bulla. On primitive tympanic bulla the two walls crosses at nearly a right angle, but on some specialized or flat one they cross at larger angle. The developement of ventral keel and the disappearence of median furrow are observed often in accompanied with the progress of flattening.

The tympanic bullae of the two species of Archaeoceti mensioned in the chapter of "sigmoid process and lateral furrow", and of three fossile Odontoceti *Phocageneus venustus*, *Zarhachis flagellator*, and *Schizodelphis sulcatus* have the ventral wall crossing with the lateral wall at about 90° or slightly smaller angle, and the median furrow extending anteriorly from the interprominential notch. And ventral keel is not developed on these species. But in *Kentriodon pernix*, though the bilateral compression is not developed, the median furrow is almost disappeared and ventral keel is developed.

These observations suggest that the primitive tympanic bulla shows no flattening and no development of ventral keel but possesses the median furrow, and that the tympanic bulla of recent Odontoceti attained, starting from the primitive type, various combination of the specialization in median furrow, ventral keel, and the bilateral compression. Discussions on the process of these specialization are made below.

Physeteroidea

Median furrow is entirely lost in Physeteridae and Ziphiidae, but in two species of Kogiidae is retained the slight vestige of the furrow. On the tympanic bulla of *Kogia* the ventral keel is not developed and the lateral and ventral walls cross at a right angle, which is one of the characteristics showing the primitiveness of the tympanic bulla.

The dorsal part of the lateral wall of tympanic bulla is, in Ziphiidae, strongly rolled into the inner direction, and the inner posterior prominence moved to the reverse. This modification is quite different from the usual bilateral compression observed in other famillies of Odontoceti, but produces one of the flat feature of the bulla. This flatness is strongest in *Ziphius* in which the lateral wall and ventral wall form nearly continuous arc, and gradually decreases in the order of *Mesoplodon*, *Berardius*, and *Hyperoodon*. The ventral keel is inconspicuous in all Ziphioid species, and especially in *Ziphius*.

The tympanic bulla of *Physeter catodon* is cylindrical and shows a pecurior transformation of the both posterior prominences (see page 23). This shape can be led from the tympanic bulla of primitive *Kogia* as a result of the reduction of outer posterior prominence and the movement of inner posterior prominence toward the direction reverse of that occurred in Ziphiidae.

Platanistoidea

The tympanic bullae of the species of this superfamilly show no flattening. Median furrow is observed in all species. The tympanic bullae of *Platanista gangetica*, *Inia geoffrensis* and *Lipotes vexillifer* have common features in the weak ventral keel, swollen base of outer posterior prominence, and the conical anterior tip.

The general shape of the tympanic bulla of *P. gangetica* shows close resemblance to that of the fossile species *Phocageneus venustus*, *Shizodelphis sulcatus*, and *Zarhachis flagellator*, except for the many needle-shaped processes in the ventral furrow of *P. gangetica*.

The tympanic bulla of *Pontoporia blainvillei* slightly differs from that of other Platanistoidea species in the slight development of ventral keel and the shape of anterior tip.

Delphinoidea

In this superfamily, the flattening or bilateral compression of tympanic bulla is well observed in the species included into Monodontidae and Globicephalinae. The median furrow is found clearly only on some species included into Sotaliinae, but ventral keel on various species of Delphinoidea. Further explanation is made below on each families or subfamilies.

In *Delphinapterus leucas* and *Orcaella brevirostris*, which constitute Delphinapteridae, the tympanic bulla is not flattened and ventral keel is low.

In Phocoenidae, rudimental median furrow is present in all species, and flattening is not observed. The ventral keel is not conspicuous in *Phocoena*, but develops well in *Neophocaena* and highest in *Phocoenoides*.

The tympanic bulla of *Monodon monoceros* shows the strong flatness and has developed ventral keel. In these respect it looks like to situate at the extremity of Globicephalinae series (Fig. 75).

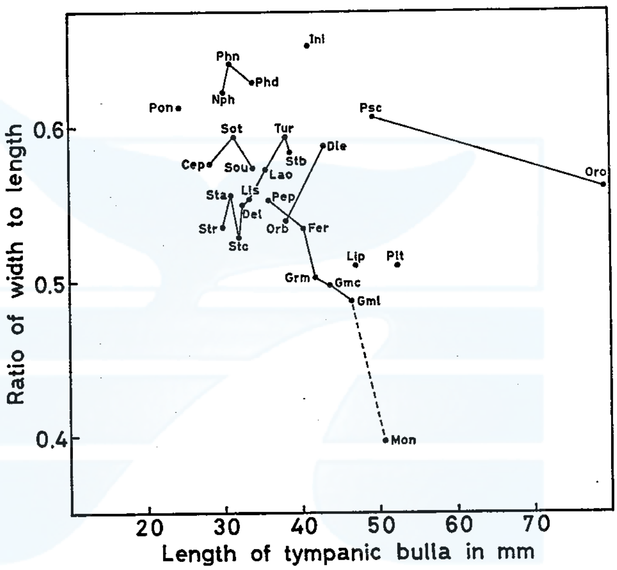

Fig. 75. Relation between mean length of tympanic bulla and mean ratio of the width to the length. Cep, *Cephalorhynchus* spp. Del, *Delphinus bairdi*. Dle, *Delphinapterus leucas*. Fer, *Feresa attenuata*. Gmc, *Globicephala macrorhyncha*. Gml, *Globicephala melaena*. Grm, *Grampus griseus*. Ini, *Inia geoffrensis*. Lao, *Lagenorhynchus obliquidens*. Lip, *Lipotes vexillifer*. Lis, *Lissodelphis borealis*. Nph, *Neophocaena phocaenoides*. Mon, *Monodon monoceros*. Oro, *Orcinus orca*. Orb, *Orcaella brevirostris*. Pep, *Peponocephala electra*. Phd, *Phocoenoides* spp. Phn, *Phocoena phocoena*. Plt, *Platanista gangetica*. Pon, *Pontoporia blainvillei*. Psc, *Pseudorca crassidens*. Sot, *Sotalia* spp. Sou, *Sousa teuszii*. Sta, *Stenella attenuata*. Stb, *Steno bredanensis*. Stc, *Stenella caeruleoalba*. Str, *Stenella roseiventris*. Tur, *Tursiops truncatus* (W. Pacific). Solid lines connect the members in a family or subfamily.

In Delphinidae, the morphology of tympanic bulla shows several characteristic features in each subfamily or lesser taxa. In the three genera tentatively included into Sotaliinae, the tympanic bulla is not flattened and ventral keel is slightly developed. Shallow median furrow is observed in *Sotalia* and *Sousa*, but inconspicous in *Cephalorhynchus*. This is one of the primitive features of the tympanic bulla of these species.

In Delphininae there is not observed the flattening of tympanic bulla nor median furrow. The genera of this subfamily is divided into two groups by the character of ventral keel. The first group includes *Tursiops*, *Stenella*, and *Lissodelphis*. Their ventral keel is long and reaches the anterior part of ventral wall of tympanic bulla. Its height is largest in *Tursiops* and lowest in *Lissodelphis*. The second group includes *Delphinus*, *Lagenorhynchus*, and *Steno*. In these genera the ventral keel does not reach the anterior part, but disappears near the middle of tympanic bulla. As the result the anterior part of tympanic bulla is cylindrical. Among the latter group the height of ventral keel is smallest in *Delphinus* and largest in *Steno*, but its length is in the reverse. This characteristics is considered to be continuous between the two genera situating at the extremities or *Lissodelphis* and *Delphinus*.

In Orcininae, the tympanic bulla shows no trace of flattening as in the case of Sotaliinae and Delphininae. The median furrow is absent. Though the low atrophied ventral keel is observed in *Pseudorca* in the posterior region of the tympanic bulla, it is almost entirely disappeared in *Orcinus*. These features resembles the tympanic bulla of *Delphinus* and *Lagenorhynchus*, and can be led from them.

In Globicephalinae the ventral keel develops well and ventral furrow is absent. The flattness is strong in all genera of this subfamily, but its degree varies between the genera (Fig. 75).

The posterior process of periotic

As mentioned in the former chapter, the posterior process of periotic is considered to have had the connection with squamosal in the primitive form. In these primitive Odontoceti the posterior process of periotic is bent to ventral direction at

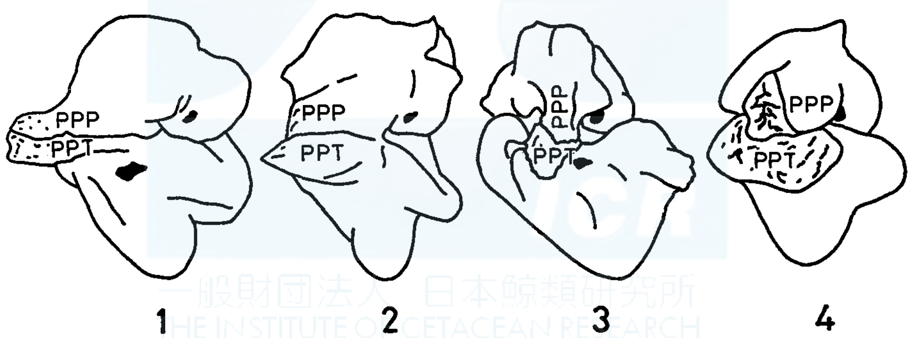

Fig. 76. Posterior view of tympano-periotic bone, showing the direction of the posterior processes. Lateral side is at the left. 1, *Peponocephala electra*. 2, *Monodon monoceros*. 3, *Platanista gangetica*. 4, *Orcaella brevirostris*.

a right angle with the antero-posterior axis of superior process. The facet for posterior process of tympanic bulla is situated on its tip. In the recent Odontoceti, this structure is observed on *Physeter catodon* and *Platanista gangetica*. I consider that various types of posterior process of periotic of other Odontoceti may have derived from the primitive type now found only in *Physeter* and *Platanista*.

In other two families of Physeteroidea the direction of posterior process of periotic is same with that of *Physeter* in principle. But the length is shorter, and the distal tip is widened in Ziphiidae, or changed into thin plate in Kogiidae.

Though the posterior process in Iniidae and Pontoporiidae is continuous to superior process and shorter than that of *Platanista*, the direction is similar to *Platanista*. The atrophy of the posterior process is stronger in Pontoporiidae. *Platanista* and *Lipotes* show the same feature where posterior process and superior process of periotic are clearly distinguished externally.

The posterior process of periotic of Delphinoidea is thicker and longer than that of Platanistoidea. Its direction is classified into two types (Fig. 76). In one type the posterior process is extended to the posterior in parallel with the axis of superior process. All species of Delphinapteridae and Phocoenidae are included in this type. This type may have derived from the primitive type mentioned in the above. In another type the posterior process is bent laterally or postero-laterally. Delphinidae and Monodontidae are included in this type. Though it is not impossible to lead this type from the former, it may be more reasonable to lead directly from the primitive type seen in *Platanista* or *Physeter*.

In the miocene Delphinids, *Kentriodon pernix* belongs to the latter type, but its posterior process of tympanic bulla is directed posteriorly retaining the primitive character. *Delphinodon dividum* (True 1912) belongs to the former type. The posterior process of periotic of *Lophocetus* spp. (Kellogg 1955, Pl. 5–6) is extending to the ventral and connection with squamosal is expected.

In Platanistoidea and Delphinoidea the direction of the posterior process of tympanic bulla coincides with that of the periotic. But in Physeteroidea they do not necessarily coincide because the posterior process of tympanic bulla is usually bent at the distal part.

Anterior process of periotic

In all the species which have the primitive posterior process of periotic mentioned in the preceding chapter, or several species of Squalodontidae, Physeteridae, and Platanistidae, the anterior process of periotic is shaped of a rod tapering at the tip. And this type of anterior process is found only on the species which have primitive posterior process of periotic or on its allied species. From these facts, it is suggested that the rod-shaped anterior process of periotic retains the primitive form, and that the various forms found in the recent Odontoceti may have derived from it. In this chapter the probable process of specialization of the anterior process of periotic is discussed.

The anterior process of *Berardius bairdi* is most slender among the species of Ziphiidae and retains the most primitive feature, the trigonal pyramidal or hemispheric anterior process of other species of this family is considered to have originated from this slender type seen in *Berardius*. The anterior process of periotic of *Kogia* may have been formed through another process by loosing the length and thickness.

In *Platanista gangetica*, though the slenderness of the anterior process of periotic shows the primitiveness, there are observed some specialization in usually observed small protuberence on the dorsal surface of the base of the anterior process (Pl. IX Fig. 9). The anterior process of periotic of *Lipotes vexillifer* resembles that of *Platanista* in the curved and pointed shape, but its proportional length is shorter. In *Inia geoffrensis* the length is shorter and the anterior margin is square, showing a slight resemblance to that of Delphinoidea. In *Pontoporia blainvillei* the process is strongly shortened.

The anterior process of Delphinoidea is shaped of thick plate and anterior margin is square. Its length is short. In the fossile species, the anterior process of periotic of the miocene *Kentriodon pernix* (Kellogg 1927) and *Delphinodon dividum* (True 1912) had attained the feature similar to that of recent Delphinoidea. Though that of *Lophocetus* spp. (Kellogg 1955) is also same, its posterior process of periotic slightly differes from that of recent Delphinoidea.

CONCLUSION

The classification of recent toothed whales used in this report is shown in Table 15. This classification is based mainly on the morphology of the tympano-periotic bone, paying the attention not to largely modify the classification generally have been accepted. But the classification of Delphinoidea is slightly modified, affected by the wide variation of the morphology of the tympano-periotic bones.

This chapter considers the phylogenetic interrelationships of the taxa of recent toothed whales based on the morphology of tympano-periotic bones.

Interrelationships among Archaeoceti, Mysticeti, and Odontoceti

According to the description of Kellogg (1936) and his photographs, the tympano-periotic bones of *Zygorhiza kochii* and *Dorudon osiris* show the following character.

The ventral wall of tympanic bulla is flat and wide, with which the lateral wall crosses at a right angle. The inner border of ventral wall is straight. The anterior border of tympanic bulla or opening of Eustachian tube is partly closing and resembles that of Mysticeti than that of Odontoceti. Sigmoid process is square as in the case of *Physeter*. Posterior process of tympanic bulla is fixed to tympanic bulla with the inner and outer pedicles, and here opens an elliptical foramen (vertical cleft) on the posterior wall of tympanic bulla. These features are similar with that of Odontoceti. But the outer pedicle is reported to be smaller than the inner (Kellogg 1936). Though the both posterior prominences are prominent, the outer posterior prominence is larger than the inner. Interprominential notch is shallow, and median furrow is inconspicuous.

The periotic is sutured to squamosal and exoccipital at the anterior, superior and posterior processes forming a part of cranial cavity as in the case of Mysticeti. The long posterior process of periotic is wedged between squamosal and exoccipital, and its tip reaches to the external surface of the skull. The ventral surface of the posterior process of periotic prepares longitudinal shallow grooves and keels to which the posterior process of tympanic bulla sutures. Though the posterior process of tympanic bulla is thinner than that of periotic, the lengths are nearly same. Judging from the large width of the posterior process of tympanic bulla and the structure of the corresponding part of squamosal (Kellogg 1936, Pls. 15, 20, 24, 25, and 28), I consider that its anterior part may have sutured with squamosal as in the case of recent Physeteroidea and *Platanista* (Fig. 77).

In all the recent Mysticeti the involucrum of tympanic bulla is highly developed. There are found two types in the shape of posterior prominences. In all the species other than Balaenidae, as the outer posterior prominence is strongly atrophied or disappeared, the tympanic bulla is nearly hemispheric. But in Balaenidae outer and inner posterior prominences clearly exist, and the ventral side of tympanic bulla is shaped of a flat square (*Balaena*) or of a triangle (*Eubalaena*). Though in recent Mysticeti the interprominential notch is absent, the *Isocetus* sp. from tertiary (Kellogg 1944) retains both the posterior prominences and interprominential notch. I consider that this condition is more primitive than that observed in recent Mysticeti. The sigmoid process is flat and shaped of a semicircular (Balaenidae) or of a triangle (other than Balaenidae). The tympanic bulla is connected to posterior process of tympanic bulla only by the inner pedicle, which is a feature entirely different from the condition in Archaeoceti and Odontoceti (Kellogg 1936).

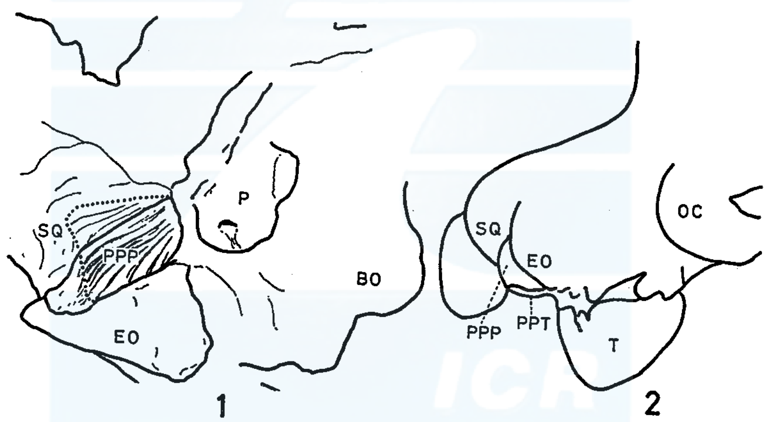

Fig. 77. Skull of Archaeoceti showing the connection between ear bone and skull, drawn based on Kellogg 1936, Pl. 15, Fig. 1, and Pl. 25, Fig. 2. Dotted line indicates the presumed area to which the posterior process of tympanic bulla was sutured. 1, *Zygorhyza kochii*, ventral aspect. 2, *Dorudon stromeri*, posterior aspect. BO, Basioccipital. EO, Exoccipital. OC, Occipital condyle. P, Periotic. PPP, Posterior process of periotic. PPT, Posterior process of tympanic. SQ, Squamosal. T, Tympanic bulla.

As in the case of Archaeoceti, the periotic bone of Mysticeti forms a part of the brain cavity, and the anterior and posterior processes are elongated in rod shape and the latter is wedged between squamosal and exoccipital. Its distal tip nearly reaches to the outer surface of the skull. Though Yamada (1953) showed another opinion, it is clear on a fetus *B. borealis* (Pl. I Fig. 9) that the posterior process of Mysticeti is

TABLE 15. CLASSIFICATION OF RECENT TOOTHED WHALES BASED ON THE MORPHOLOGY OF TYMPANO-PERIOTIC BONES.

Suborder	Odontoceti
Superfamily	Physeteroidea
Family	Physeteridae
Subfamily	Physeterinae
Genus	*Physeter*
Family	Ziphiidae
Subfamily	Ziphiinae
Genus	*Mesoplodon, Berardius, Tasmacetus, Ziphius, Hyperoodon*
Family	Kogiidae
Subfamily	Kogiinae
Genus	*Kogia*
Superfamily	Platanistoidea
Family	Platanistidae
Subfamily	Platanistinae
Genus	*Platanista*
Family	Iniidae
Subfamily	Iniinae
Genus	*Inia, Lipotes*
Family	Pontoporiidae
Subfamily	Pontoporiinae
Genus	*Pontoporia*
Superfamily	Delphinoidea
Family	Delphinapteridae
Subfamily	Delphinapterinae
Genus	*Delphinapterus*
Subfamily	Orcaellinae
Genus	*Orcaella*
Family	Phocoenidae
Subfamily	Phocoeninae
Genus	*Phocoena, Neophacoena, Phocoenoides*
Family	Delphinidae
Subfamily	Sotaliinae
Genus	*Sotalia, Sousa, Cephalorhynchus*
Subfamily	Orcininae
Genus	*Orcinus, Pseudorca*
Subfamily	Delphininae
Genus	*Steno, Lagenorhynchus, Delphinus, Lissodelphis, Stenella, Tursiops*
Subfamily	Globicephalinae
Genus	*Peponocephala, Feresa, Globicephala, Grampus*
Family	Monodontidae
Subfamily	Monodontinae
Genus	*Monodon*

composed of the elements of posterior process of tympanic bulla and of posterior process of periotic. But the relative ratio of the two elements in adult individual is not clear.

When the above features are compared with that of *Platanista gangetica* and *Physeter catodon* which are considered to retain the primitive condition in the interrelationships between skull and tympano-periotic bone, Archaeoceti has some common features both with Mysticeti and Odontoceti, but shows no perfect coincidence. In order to lead the structure seen in Mysticeti from that of Archaeoceti, only the disappearence of the outer pedicle of tympanic bulla which is smaller than the inner, and the fusion of the posterior process of tympanic bulla and that of periotic are the fundamental modification needed to Archaeoceti (Fig. 78). But to lead the ear bone of some primitive Odontoceti, at first the periotic bone must be freed from the wall of cranial cavity and at secand the posterior process of periotic must greatly degenerate to loose the strong connection with squamosal and exoccipital and to leave the sutural connection between the posterior process of tympanic bulla, squamosal, and exoccipital.

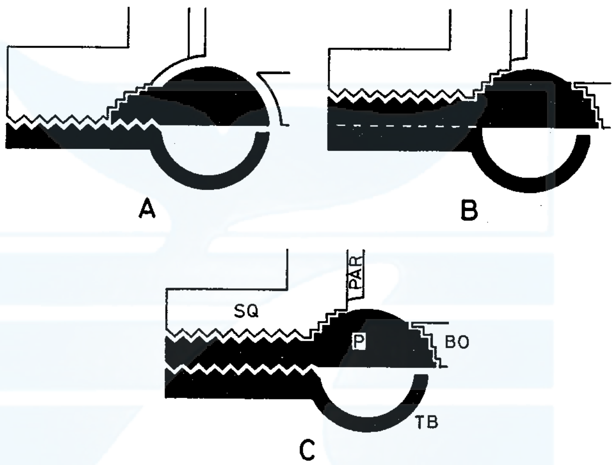

Fig. 78. Schematic diagrams showing the connection between tympano-periotic bone and skull. Waved edge indicates the tight connection or suture of bones, and dotted line the fused bone. A, Hypothetical primitive Odontoceti. B, Mysticeti. C, Archaeoceti, in which the connection between squamosal and posterior process of tympanic bulla is not shown. For other marks see Fig. 73.

As the reduction of the outer pedicle of tympanic bulla had already started in Archaeoceti, I consider that it is easier to lead the ear bone of Mysticeti from that of Archaeoceti than to do that of Odontoceti, which will suggest that Archaeoceti has closer relationship with Mysticeti than with Odontoceti. This coincides with the conclusions obtained by Miller (1923) and Slijper (1946). But this does not necessarily mean that Mysticeti had originated from Archaeoceti.

Squalodontidae

According to Kellogg (1928) Squalodontidae is known in oligocene and miocene, and its primitive relative is in lower eocene. The description of the two periotic bones of Squalodontidae is based on the drawings and photographs reported by Kellogg (1923, 1931). No information on the tympanic bulla was obtained.

On the periotic bone of *Squalodon calvertensis*, the anterior process and posterior process are long and separated from the superior process by the grooves at the bases. And when seen from the lateral side the dorsal borders of the anterior and posterior processes cross at a right angle. The former feature resembles that of *Platanista* and *Lipotes*, and the latter that of *Physeter* and many Ziphiids. As the posterior process of periotic is slender at the tip and has the rugose area on the posterior surface, it is supposed that it had the similar connection with squamosal seen in *Physeter catodon*. The slenderness of the anterior process resembles both *P. catodon* and *P. gangetica*. But the flat and low cochlear portion and slit-like opening of fundus of internal auditory meatus is peculiar.

On the other hand, the periotic bone of *Squalodon errabundus* has the swallen anterior process resembling that of recent Ziphiidae. The large round cochlear portion and the round opening of the fundus of internal auditory meatus are different from those of *S. calvertensis* but resemble that of Platanistidae and Physeteridae. Anterior process is continuous to superior process. On the reffered specimen the posterior process was lost.

Above discussion shows that the periotic bone of Squalodontidae have many characteristics common with that of Physeteroidea or Platanistoidea, though it is suggested that there exist some differentiation among the periotics of Squalodontidae. As the conclusion it is suggested from the morphology of periotic that the recent Odontoceti at least Physeteridae and Platanistidae had derived, as *Squalodon*, from a primitive *Squalodon*-like species.

Physeteroidea

One of the most conspicuous features of the tympano-periotic bone of Physeteroidea is the developed structure connecting it to skull. The similar but less developed structure is found even in some species of Platanistidae, Delphinapteridae and Eurhinodelphinidae. This suggest that, though there is found wide variation in the morphology of the tympano-periotic bone of recent Odontoceti, all of them have derived from one primitive type.

Though there are observed wide difference in the morphology of tympano-periotic bones of the three families constituting the Physeteroidea, there is observed some continuity in several features which permits the following discussion on the interrelationships of these families.

When the tympano-periotic bones of the three families are compared, the morphology of the anterior and posterior processes of periotic, and the connection between both posterior processes are most specialized in *Kogia* and least in *Physeter*. But the laminated structure of posterior process of tympanic bulla is most developed in Physeter and less in *Kogia* and Ziphiidae. The arrangement of posterior prominences and the shape of sigmoid process show the most primitive condition in *Kogia*, and the greatly modified in *Physeter*. But in Ziphiidae they have changed the relative position in a way different from that occurred in *Physeter*. On this point of view, the tympanic bullae of Physeteridae and of Ziphiidae seems to have been specialized in different direction probably starting from the common original type.

Accordingly it is considered that the three families had differentiated in the early stage of history of Physeteroidea and the specializations of the anterior and posterior processes of periotic and posterior process of tympanic bulla mentioned above might have been attained as the result of evolution happened independently. The features of sigmoid process, lateral furrow, and elliptical foramen of Kogiidae resembles more to those of Physeteridae than those of Ziphiidae. Though it is one of the pecuriority of the periotic of recent *Physeter* that the aquaeductus Fallopii and ductus endolymphaticus open inside of the opening of fundus of internal auditory meatus, in the miocene Physeterid species *Aurophyseter morricei* (Kellogg 1931) and *Orycterocetus crocodilinus* (Kellogg 1965) they open independently as in the case of recent *Kogia*. These resemblances of tympano-periotic bone between Kogiidae and Physeteridae will indicate the slightly closer phylogenetic relationships between Kogiidae and Physeteridae. But it is of course sure that the phylogenetic distance between Physeteridae and Kogiidae is not small as indicated by the difference of general featurs of tympano-periotic bone, the process of telescoping of the skull (Miller 1923), and by the condition of the fusion of the cervical vertebrae (Nishiwaki 1963, 1964).

Among several genera of Ziiphiidae, *Berardius* and *Mesoplodon* have well developed posterior prominences of tympanic bulla and interprominential notch. But on the tympanic bulla of *Ziphius*, the outer posterior prominence has a wedge-shaped keel on its postero-lateral part, and both posterior prominences are thin. Its interprominential notch is almost disappeared. In *Tasmacetus*, though the outer posterior prominence retains the thick cylindrical form, there is observed the similar keel found in *Ziphius* (Oliver 1937, Pl. III). *Hyperoodon* also resembles to *Ziphius* in the atrophied inner posterior prominence and interprominential notch.

Based on these characteristics, the genera of Ziphiidae are divided into two groups. One has less specialized tympanic bulla and includes *Berardius* and *Mesoplodon*, the other has the more specialized and includes *Ziphius*, *Tasmacetus* and *Hyperoodon*. The former is composed of the species which retain developed tooth even on the part of mandible other than anterior tip (with an exception of *M. mirus*), and the latter only at the tip of mandible. Though the phylogenetic relarelationships among the species of *Mesoplodon* can not be presumed from the morphology of tympano-periotic bone, it should be noted that *M. ginkgodens* and *M. europaeus* show a common feature in the pecuriority of the superior process of periotic.

Platanistoidea

The tympano-periotic bones of this taxon show the common primitive features of unflattened tympanic bulla, existance of median and lateral furrows, large posterior prominences, and the shape of anterior, superior and posterior processes of periotic, together with the specialized feature of the degenerated size of posterior process.

As mentioned before the tympano-periotic bone of *Platanista gangetica*, which retains the most primitive features among the recent species of this family, shows some resemblance to that of *Physeter*. Furthermore the arrangement of anterior and posterior processes of periotic and the constrictions at their bases suggest the probable relationships to Squalodontidae.

The miocene Eurhynodelphinid species *Schizodelphis sulcatus* (Van Beneden and Gervais 1868–1879) has the tympanic bulla highly resembling that of *P. gangetica* except the existance of needle-shaped processes in the median furrow. Its periotic bone also resembles that of *P. gangetica* in the shape of cochlear portion especially the opening of fundus of internal auditory meatus, and in the relationships with the skull. But it greatly differs from *P. gangetica* in the larger size of the posterior process of periotic. When the skull of *S. sulcatus* is compared with that of *Platanista*, the former has larger brain case and weaker intertemporal constiction, and the proximal part of maxillae is expanded horizontally and covers the temporal fossa. As these features are similar to the modern Delphinoidea and different from Platanistoidea, it is unreasonable to lead Platanistoidea directly from the Eurhyodelphinids. Probably the two taxa had originated from a same origin, and Platanistoidea attained the tendency to form the maxillary crest through the vertical extension of the lateral margin of the proximal part of maxillae.

The tympano-periotic bone of a miocene Platanistoid species, *Zarhachis flagelator* (Kellogg 1924), is almost perfectly coincides with that of *Platanista gangetica* except the needle-shaped processes in the median furrow of *Platanista*, but the maxillary crest of *Z. flagelator* is far smaller than that of *P. gangetica*. This suggests that *Platanista* did not gain large specialization of the tympano-periotic bone in the process of evolution, but did the strong modification on the maxillae and on the pterygoid (Miller 1923; Fraser and Purves 1960).

The tympano-periotic bone of Iniidae is more specialized than that of Platanistidae in the degeneration of the connection with skull and in the shape of the sigmoid process, median furrow, and of the three processes of periotic. Between the two genera of Iniidae, *Lipotes* is considered to be more primitive in the form of the tympano-periotic bone.

The strength of the development of the maxillary crest decreases in the order of *Platanista*, *Zarhachis*, *Inia*, and *Lipotes*. This order is rather reverse of the degree of the specialization of the tympano-periotic bones. This will indicate that the three genera had been separeted at the very early stage of the evolution.

There have been reported two different consideration on the taxonomical position of *Pontoporia blainvillei*. The one considers *Pontoporia* close to Delphinoidea (Gray 1866; Kellogg 1928; Miller 1923), and the other to Platanistoidea (Flower 1867; Winge 1918; Fraser and Purves 1960; Nishiwaki 1963). Though the interrelationships between skull and tympano-periotic bone and the square-shaped anterior border of the tympanic bulla are the very specialized features not observed in Platanistidae or in Iniidae, all the primitive features concerning the sigmoid process, shape of outer posterior prominence, median furrow, unflattened tympanic bulla, and round opening of fundus of internal auditory meatus are common to Platanistidae and Iniidae. and the specialized characteristics such as wide lower tympanic aperture can be led from the primitive condition found in Platanistidae and Iniidae. As the conclusion, when based on the morphology of tympano-periotic bone, *Pontoporia blainvillei* is considered to situate at the extremity of the specialization occurred in Platanistoidea. Furthermore the shape of anterior and posterior processse of periotic resembles that of *Inia*, and the development of the vertical maxillary crest and the horizontal spreading of the proximal part of maxilla are intermediate of *Inia* and *Lipotes*. A tympanic bulla reportedly belonging to iniid species *Kampholophos serrulus* (Rensberger 1969) is much similar, except the size, to that of *Pontoporia* than *Inia*. They might suggest that *Pontoporia* is a relative of the Iniidae. But *Pontoporia* should be separated from Iniidae considering the high specialization of the tympano-periotic bone.

Delphinoidea

The features of the tympano-periotic bones of this superfamily are described in the preceeding chapters. As the relatives of this modern dolphins, *Delphinodon dividum* (True 1912) and *Kentriodon pernix* (Kellogg 1927) are known from middle miocene. Their tympano-periotic bones are, same as the features of the skull, resembles to the recent Delphinoidea and differs from those of Eurhynodelphinidae. But their tympanic bulla still retains the primitive features in the presence of median furrow, lateral furrow (no data on *Delphinodon*) and swallen inner posterior prominence.

Though, other miocene species *Lophocetus* spp. (Kellogg 1955) have the tympanic bulla and the anterior process of periotic resembling those of the former *Delphinodon* and *Kentriodon*, its posterior process of periotic shows the primitiveness suggesting the connection between posterior process of periotic and squamosal as observed in recent *Delphinapterus*.

Though the tendency of the separation of the tympano-periotic bone and skull is also observed in Platanistoidea it cannot be considered to be the direct ancestor of the Delphinoidea, because the strong reduction of the posterior process of periotic is not observed in Delphinoidea. On the other hand the posterior process of periotic bone of *Shizodelphis sulcatus* (Eurhynodelphinidae) is large enough to lead that of recent Delphinoidea. And its shape of the maxillae shows the similar specialization to that of recent Delphinoidea. Accordingly it is reasonable to think that the recent Delphinoidea had originated from a close ancestor of Eurhynodelphinidae. As there had been established in the middle miocene both Eurhynodelphinid and Delphinid species (Kellogg 1928), it seems to be in lower miocene or earlier date when the primitive Delphinoids started.

In this study, the recent Delphinoidea is divided into Delphinapteridae, Phocoenidae, Monodontidae, and Delphinidae. These four families are classified into two groups by the shape and the direction of the posterior process of periotic. One includes Delphinapteridae and Phocoenidae, and the other Delphinidae and Monodontidae.

The first two families seem to have derived from a common origin, in which posterior extension of posterior process of periotic and possibly the tendency of widening of rostrum will be attained. I consider that this group constitutes one of the three groups in Delphinoidea which have attained the wide rostrum. Other two groups with wide rostrum are Orcininae and Globicephalinae. Though there is observed a strong resemblance between the two species constituting Delphinapteridae in the morphology of tympano-periotic bones, the sutural connection between squamosal and periotic observed in *Delphinapterus leucas* will be a good reason to separate them into two subfamilies or Delphinapterinae and Orcaellinae. Probably, after the differentiation from the stock common with that of Phocoenidae, *Delphinapterus* and *Orcaella* might have differentiated in the arctic and tropical waters respectively.

In spite of the resemblance of the external appearance of Delphinapteridae and Globicephalinae, it is reasonable to consider that they are not in close relatives when considered from the morphology of tympano-periotic bones. Because, other than the difference of the direction of the posterior processes, all the characteristic features of the tympanic bulla of Globicephalinae, or bilateral compression of tympanic bulla, conspicuous ventral keel, anterior spine, short inner posterior prominence, and narrow posterior branch of lower tympanic aperture lack in both *Orcaella* and *Delphinapterus*. Though Fraser and Purves (1960) found a resemblance of the air sinus system between *Orcaella* and *Orcinus-Globicephala* group, the morphology of tympano-periotic bones of the three genera is quite different. Miller (1923) indicated the resemblance of the pterygoid among *Orcaella*, *Monodon*, and all species of Delphinidae. But this will indicate only that the pterygoid of *Delphinapterus* is specialized, and not the close phylogenetic relationships of *Orcaella* and *Monodon* to Delphinapteridae.

TABLE 16. COMPARISON OF THE MORPHOLOGY OF TYMPANO-PERIOTIC BONES IN PHOCOENIDAE

Genus	*Phocoena*	*Neophocaena*	*Phocoenoides*
High ventral keel	+	++	+++
Wide LTA	+	++	++
Outer post. prominence	Flat, Thick	Cylindrical	Flat, Thin
Post. proc. of tympanic bulla	Square, Thick	Conical	Square, Thin
Post. proc. of periotic	Thick	Slender	Thick

LTA: Lower tympanic aperture

The tympano-periotic bone of Phocoenidae is characteristic in the direction and structure of posterior processes of tympanic bulla and of periotic. The structure of posterior processes is more specialized than that of Delphinapteridae. Similar tendency of higher specialization of Phocoenidae is observed also in the degeneration of tooth and fusion of cervical vertebrae. Many other features of tympanic bulla are common to those of Delphinapteridae. Among the three genera of Phocoenidae the tympano-periotic bone of *Phocoena* retains the most primitive features in all the characteristics compared, especially in the condition of the ventral keel, but the mode of specialization of outer posterior prominence, posterior process of tympanic bulla, and of posterior process of periotic differ between *Neophocaena* and *Phocoenoides*. And the tympanic bulla of the one genus cannot be led from that of the other. This will suggest that these two genera have independently derived from a stock which is close to *Phocoena*.

The family Delphinidae contains most numerous and wide variety of species. This group will have originated from a same stock with that of Delphinapteridae and Phocoenidae, and attained the character in which the posterior process of periotic extends to the lateral direction. There is a decreasing tendency in the width of the posterior branch of lower tympanic aperture. This family is divided into 4 subfamilies of Sotaliinae, Delphininae, Orcininae, and Globicephalinae based on the morphology of tympanic bulla.

Sotaliinae includes *Sotalia*, *Sousa*, and *Cephalorhynchus*. The closure of their elliptical foramen indicates one of the specialization, but the existance of median furrow or similar structure, weak ventral keel, and no bilateral compression of tympanic bulla indicate the primitiveness. Their posterior branch of lower tympanic aperture is wider than those of other 3 subfamilies. This feature is also considered to be a primitive character, showing no extraordinary widened status found in Pontoporiidae, Phocoenidae, and Delphinapteridae, nor the narrowed condition of other subfamilies of Delphinidae. As this subfamily is established based on many primitive features and modification of elliptical foramen which is very variable, there remains a question on the phylogenetic uniformity of this group. Among the three genera of this subfamily, *Sotalia* and *Sousa* show the higher resemblance in the morphology of tympano-periotic bone. Anyway the tympano-periotic bone of these genera shows higher resemblance to that of Delphininae.

The tympanic bulla of Delphininae is weakly specialized, and retains the most primitive condition in Delphinidae. This subfamily includes *Steno*, *Lagenorhynchus*, *Delphinus*, *Lissodelphis*, *Stenella*, and *Tursiops*. They are classified into two groups by the feature of the ventral keel of tympanic bulla, the one includes the first three genera and the other the last three. On the two genera at the boundary, *Delphinus* and *Lissodelphis*, the height of ventral keel is the smallest, which will probably retain the unspecialized original feature of the tympanic bulla of Delphininae. In Fig. 78, these two groups are shown in *Delphinus* group and *Tursiops* group. The genus *Stenella* includes many species which varidity is not established yet. When considered from the morphology of tympanic bulla, the North Pacific species *S. longirostris* and *S. roseiventris*, and *S. attenuata* and *S. graffmani* seems to be in close relations respectively. And *S. caeruleoalba* is in closer affinity with the latter pair of species than the former.

Oricininae is constituted by *Orcinus orca* and *Pseudorca crassidens*. As their tympanic bullae show the resemblance to those of *Delphinus* and *Lagenorhynchus*, this subfamily seems to have derived from the stock which has such an unspecialized tympanic bulla. The tympano-periotic bone of *Orcinus orca* shows the higher specialization in the perfect disappearance of ventral keel, closure of elliptical foramen, and the massiveness of anterior and superior process of periotic.

The two species included here in Orcininae have been often included in the Globicephalinae here adopted. Though they resembles in the width of rostrum, Orcininae greatly differs from Globicephalinae in the features of tympanic bulla and periotic. In other characteristics of skull, Orcininae seems to have developed the augmentation of tooth together with the decrease of tooth number. On the other hand, in Globicephalinae, the number of tooth seems to be decreasing without accompanied by the much increase of size, and the function of the tooth in taking the food is decreasing. Accordingly, I consider that the resemblance of the width of the rostrum between Orcininae and Globicephalinae is not significant.

Globicephalinae includes *Peponocephala*, *Feresa*, *Globicephala*, and *Grampus*. They are distinguished from other genera of Delphinidae by the morphology of tympanic bulla, especially by the bilateral compression, presence of anterior spine and ventral keel, and the closing tendency of elliptical foramen. In the least specialized species *Peponocephala electra*, the flatness of tympanic bulla is not strong and all individuals retain the elliptical foramen open. This suggests that Globicephalinae derived from a primitive Delphinidae which possessed such a tympanic bulla now found in Delphininae, and diverged to wide variety of species.

TABLE 17. COMPARISON OF THE MORPHOLOGY OF TYMPANO-PERIOTIC BONES AND OTHER TAXONOMICAL CHARACTERS.

Species	Mean tympanic width (%)	Opened elliptical foramen (%)	*Rostrum length /width	*No. of upper tooth	*No. of united cervicals
Peponocephala electra	55.3	100	1.83	21–25	3
Feresa attenuata	53.5	28.6	1.58	8–11	3–4
Globicephala macrorhyncha	49.8	3.8	1.16	6– 9	5–6
Grampus griseus	50.1	8.3	1.04	0	6
Monodon monoceros	39.6	25.0	1.31	0– 1	0
Pseudorca crassidens	60.6	100	1.49	8–11	6
Orcinus orca	56.1	0	1.36	10–13	4
Delphinapterus leucas	58.9	0	1.50	8–10	0
Orcaella brevirostris	54.9	0	1.10	15–17	2
Neophocaena phocaenoides	64.4	0	1.03	15–19	5
Phocoena phocoena	62.3	0	1.39	23–27	6
Phocoenoides spp.	62.3	0	1.47	23–27	7

* Refered from Nishiwaki (1963, '64), Nakajima and Nishiwaki (1965), Nishiwaki *et al* (1965), and Kasuya (unpublished).

As shown in Table 17, there is observed a correlation between the strength of specialization of tympanic bulla and that of other taxonomical characteristics of Globicephalinae. But this correlation can not be extended to other taxa of Delphinoidea. This will indicate that Globicephalinae should be separated from other taxa which have wide rostrum. Among the species constituting Globicephalinae, *Peponocephala electra* was indicated to have a strong resemblance to Delphinidae in the morphology of skull (True 1889; Nakajima and Nishiwaki 1965). And True (1889) included this species into *Lagenorhynchus*. Though its tympanic bulla retains the most primitive condition in the Globicephalinae species, it surely shows the taxonomical characteristics of Globicephalinae and quite different from the tympanic bulla of *Lagenorhynchus*. Accordingly *Peponocephala* should be included into Globicephalinae.

The specialized features of tympanic bulla of *Monodon monoceros* are seen in the strong bilateral compression, short inner posterior prominence, high ventral keel,

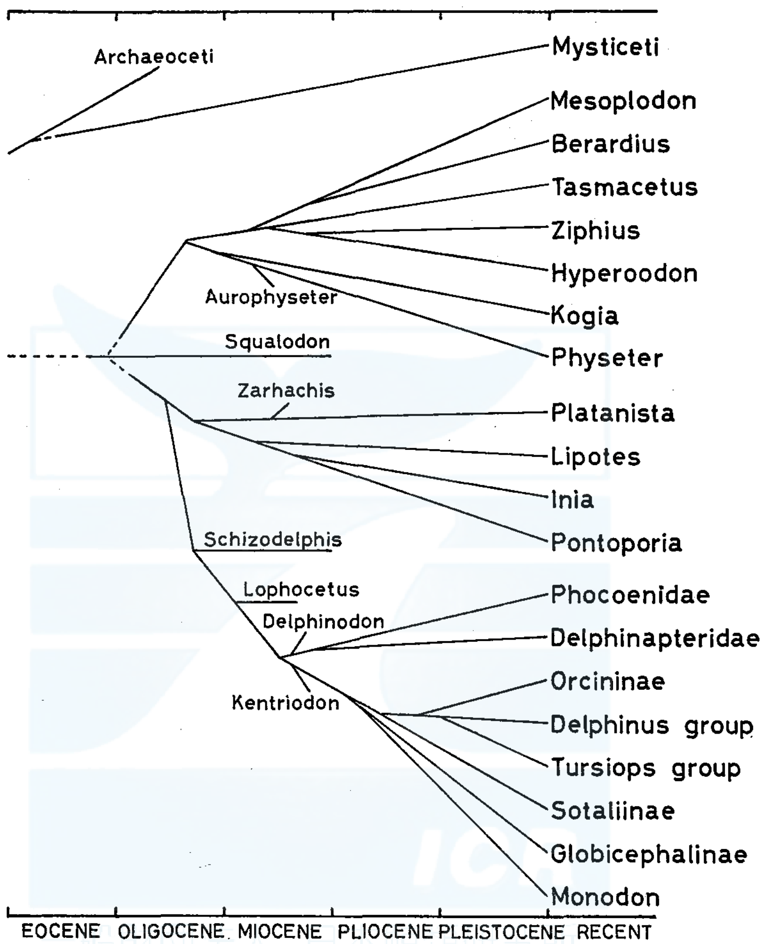

Fig. 79. Dendrogram of the recent Odontoceti considered from the morphology of tympano-periotic bone. For other explanation see text.

and in sigmoidally curved inner margin of the involucrum. These characteristics are not found in *Delphinapterus leucas*, but show higher resemblance to Globicephalinae, especially with *Grampus*. However, different from the general feature of Globicephalinae, tympanic bulla of *Monodon* has no anterior spine and the compression of the bulla is stronger than any Globicephalinae species. The periotic of *Monodon* shows specialization in the presence of thick and wide anterior process and postero-laterally directed long posterior process of periotic. The former resembles more to *Globicephala* and *Grampus* than *Delphinapterus*, and the latter especially its direction is quite different from *Delphinapterus* but is common to all Delphinidae. On the other hand tympano-periotic bone of *Monodon* retains some primitive features of slightly wide posterior branch of lower tympanic aperture, round opening of fundus of internal auditory meatus, and of elliptical foramen opened in higher frequency than in some Globicephalinae. But they are not of great importance in taxonomical point of view.

As the conclusion, though tympano-periotic bone of *Monodon monoceros* has some primitive features not observed in Globicephalinae, most of features are considered to be common to Globicephalinae or are the specialized form of it. This will suggest that *M. monoceros* and Globicephalinae derived from a common stock which had started the specialization for *Globicephala* group, or the various modification of tympano-periotic bone, and the decrease in number of tooth, and increase in the width of rostrum. The presence of a conspicuous tusk on the male *Monodon* is one of the extremity of the decrease of the tooth. But in this study *Monodon* is classified into Monodontidae considering the slightly primitive features in the tympano-periotic bone and in the cervical vertebrae, and the specialized tooth.

In the past, *Monodon* was included in one group together with *Delphinapterus* (Winge 1918; Nishiwaki 1963), based mainly on the condition of the cervicals. But the condition where all the 7 cervicals are separated is commonly observed in the miocene dolphins, and it will not be necessarily correct to conclude the phylogenetic relationships based on this kind of primitive characteristics.

Fig. 79 shows the phylogenetic relationships of the recent toothed whales presumed in the above discussions. Some fossile species refered in this study are also shown in it. The geological age is based on Kellogg (1923) and adaptable mainly to the fossile species.

SUMMARY

The tympano-periotic bone of toothed whales has attained the peculiar morphological features and between species differences suggesting the probable efficiency as the taxonomical characteristics. This study intends, at first, to clarify the morphology of tympano-periotic bones of recent toothed whales, and then to discuss the phylogenetic relationships of the genera of recent Odontoceti based on the tympano-periotic bones representing 313 individuals in 30 genera.

In the preliminary morphological study of the tympano-periotic bones, the following results were obtained.

1. The bilateral difference of tympano-periotic bones between the both sides of one individual was studied on 6 species of Delphinoidea. Though most of measurements showed no bilateral asymmetry, the asymmetry was expected in few points. But it is small enough compared with the range of individual variation to be neglected in the present study.

2. The growth of tympano-periotic bone accompanied with the growth of the animal was studied on 3 species of Delphinoidea. The length of tympanic bulla

shows slight increase after the birth, but the length of periotic does almost no increase. The proportional dimensions of tympanic bulla or of periotic vary in relation to their lengths and in species.

3. It is usually possible to identify the genus with hte morphology of tympanic bulla or of periotic, but sometimes difficult to identify the species. The morphological characteristics of tympano-periotic bone for the identification of the species or genus are described.

4. A similarity coefficient of the tympano-periotic bone was calculated based on the 22 morphological characteristics. By this coefficient, Delphinidae, Phocoenidae, Kogiidae, Physeteridae, Ziphiidae, Platanistidae, and Iniidae are separated, but Monodontidae and Delphinapteridae are not separated from Delphinidae.

The following results were obtained on the probable processes of the specialization of several morphological characteristics, through the comparizon of the tympano-periotic bones of various taxa of recent toothed whales and fossil species.

1. In the primitive condition, the posterior process of tympanic bulla, posterior process of periotic, and squamosal are considered to have been sutured each other. But in the specialized species, these connections are disappearing in various degree.

2. The most primitive condition concerning the above characteristics is found, in the recent Odontoceti, on *Physeter catodon* and *Platanista gangetica*. But these species show the higher specialization on the structure of the postero-ventral region of squamosal where the posterior process of tympanic bulla sutures.

3. The degeneration of sutural connection between skull and tympano-periotic bone is considered to have advanced independently in Physeteroidea, Platanistoidea, and Delphinoidea. The suture between squamosal and posterior process of tympanic bulla is retained in all species of Physeteroidea. In Platanistoidea and Delphinoidea the connection between squamosal and posterior process of tympanic bulla is disappearing in various degree. Pontoporiidae and Phocoenidae situate at the extremity where the suture is fully lost.

4. The primitive form of sigmoid process is considered to be of a thin square, which is retained better in *Physeter catodon*. The form of sigmoid process found widely in Delphinoidea seems to have derived from this primitive type through the condition of *Platanista*. The lateral furrow seems to have disappeared in several taxa.

5. The closure of elliptical foramen is considered to have occurred parallelly in various taxa, and to be still progressing in some taxa. The elliptical foramen is perfectly retained in Delphininae.

6. In primitive tympanic bulla, the ventral wall and the lateral wall cross at a right angle. In Physeteridae, Ziphiidae, Monodontidae, and in Globicephalinae their relation is modified. The median furrow is retained well in Platanistoidea, but only slightly in Kogiidae, Delphinapteridae, Phocoenidae, and Sotaliinae.

7. There are observed two cases in the mode of specialization of ventral keel which afford a base for the ligament connecting the tympanic bulla and basioccipital crest, in one case it increases in height and in the other decreases.

8. In the primitive condition, the posterior process of periotic is directed to postero-ventral direction. This condition is observed in some species of Physetero-

idea and Platanistoidea. In one of the specialized type it is directed to the posterior direction, which is observed in Delphinapteridae and Phocoenidae. And in the other it is directed to postero-lateral or to lateral direction, which is observed in Monodontidae and Delphinidae.

9. The anterior process of periotic seems to have changed from the primitive rod-shape which is observed in *Physeter*, *Platanista*, and *Lipotes*, to the triangular pyramid shape of Ziphiidae, to spool shape of *Kogia*, or to square shape of Delphinoidea, and *Inia*.

The following conclusions on the phylogenetic relationships of the taxa of recent Odontoceti were obtained from the consideration of the process of the evolution of tympano-periotic bone.

1. The fundamental structure of tympano-periotic bones of Archaeoceti coincides neither with that of Mysticeti nor that of Odontoceti, but it shows higher resemblance with the former.

2. The recent Odontoceti is considered to have derived from a primitive *Squalodon* group, and classified into two groups. One is Physeteroidae, and the other includes Platanistoidea and Delphinoidea.

3. The group of Physeteroidea retains the suture between squamosal and posterior process of tympanic bulla, and shows a conspicuous specialization of these parts. In its early stage of evolution, Kogiidae, Ziphiidae, and Physeteridae seems to have been separated.

4. The recent Ziphiidae is classified by tympanic bulla into two groups, one indludes *Berardius* and *Mesoplodon*, and the other *Ziphius*, *Hyperoodon*, and *Tasmacetus*.

5. The 2nd group of recent Odontoceti shows the tendency of the separation of tympano-periotic bone from the skull, accompanied with the degeneration of posterior processes of tympanic bulla and of periotic. This group is devided into Platanistoidea and Delphinoidea, which are presumed to have derived from a common origin.

6. In Platanistoidea, the regression of the size of posterior processes is stronger but retains many primitive features of tympano-periotic bones than those of Delphinoidea. The differentiation of Platanistidae, Iniidae, and Pontoporiidae seems to have occurred in the early period of evolution of Platanistoidea.

7. Delphinoidea is composed of the two groups. One includes Delphinapteridea and Phocoenidae, and the other Delphinidae and Monodontidae. These two groups in Delphinoidea had originated from a common stock.

8. Delphinidae is composed of Sotaliinae, Delphininae, Oricininae, and Globicephalinae.

9. It is presumed from the morphology of tympanic bulla that Orcininae may have derived from a stock which is close to that of *Delphinus* or *Lagenorhynchus*.

10. Globicephalinae and Monodontidae show some resemblance in the mo·phology of tympano-periotic bone.

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APPENDIX I

Key to genus or species by means of the morphology of tympanic bulla or periotic.

Tympanic bulla

a¹ Sigmoid process is globular. Tympanic bulla is not compressed laterally. Anterior spine and elliptical foramen are absent. Posterior process is large and funnel shaped. Interprominential notch is wide and opens posteriorly. Involucrum is thick. Length of tympanic bulla 24 to 39 mm.
.... *Kogia*

b¹ Anterior margin of the lateral wall is convexed.
.... *K. breviceps*

b² Anterior margin of the lateral wall is concaved.
.... *K. simus*

a² Sigmoid process is of a large square and thin. Its dorsal margin is longer than the lateral.

c¹ Lateral furrow is absent. Outer and inner posterior prominences are small, and they situate on a plane including the lateral margin of sigmoid proces. Involucrum is thick. Elliptica lforamen is absent. Posterior process is long and finely laminated. Length of tympanic bulla 55 to 63 mm.
.... *Physeter catodon*

c² Lateral furrow is conspicuous. Lateral margin of sigmoid process is twisted posteriorly.
.... Ziphiidae

d¹ Posterior prominences are large. Interprominential notch is wide.

e¹ In the ventral view the anterior part of tympanic bulla is triangular and narrow. Length of tympanic bulla 63 to 71 mm.
.... *Berardius*

e² In the ventral view the anterior part of the outer and inner border is nearly parallel.

f¹ A small crest is present on the postero-lateral tip of outer posterior prominence.
.... *Tasmacetus*

f² Outer posterior prominence is globular or cylindrical. Length of tympanic bulla 39 to 54 mm.
.... *Mesoplodon*

g² Ventral keel situates on the line extended from inner posterior prominence.
.... *M. carlhubbsi*, *M. stejnegeri*, *M. europaeus*, *M. mirus*

g² Ventral keel situates outer side of the line extended from inner posterior prominence.
.... *M. densirostris*, *M. ginkgodens*

d² Interprominential notch is shallow and narrow.

h¹ Outer posterior prominence is thin and has a small keel on the posterolateral tip. Tympanic bulla is flat. Length of tympanic bulla 51 to 60 mm.
.... *Ziphius cavirostris*

h² Outer posterior prominence is thick and has no keel on the postero-lateral tip. Tympanic bulla is cylindrical. Length of tympanic bulla 54 mm (1 example).
.... *Hyperoodon*

a³ Dorsal margin of sigmoid process is equal or shorter than the lateral margin.

i¹ Lateral and median furrows are present. Sigmoid process is thick.

j¹ Anterior part of the ventral wall is conical. Elliptical foramen usually opens.

k¹ Median furrow is wide and deep, and has fine needle-like processes in it. Anterior spine is long. Lateral margin of sigmoid process is straight. Length of tympanic bulla 47 to 64 mm.
.... *Platanista gangetica*

k² No needle-like process in the median furrow. Lateral margin of sigmoid process convexes posteriorly.

l¹ Tympanic bulla is wide (63 to 71% of the length) with the inner projection of involucrum. Median furrow is narrow. Length of tympanic bulla 38 to 46 mm.
.... *Inia geoffrensis*

l² Involucrum does not project interiorly. Width of tympanic bulla is 51% of the length (1 example). Length of tympanic bulla 47 mm (1 example).
.... *Lipotes vexillifer*

j² Inner border of ventral wall is concaved, and the anterior part is square. Posterior branch of lower tympanic aperture is wide (17.7% of the length, 1 example). Elliptical foramen closed. Length of tympanic bulla 24 mm (1 example).
.... *Pontoporia blainvillei*

i² Lateral furrow is absent. Median furrow is absent or vaguely present. Sigmoid process is thin and long.

m¹ Posterior process of tympanic bulla extends posteriorly. Posterior branch of lower tympanic aperture is wide. Tympanic bulla is not compressed bitaterally. Anterior spine is absent.

n¹ Facet for posterior process of periotic has ridges and keels. Involucrum convexes.

o¹ Anterior tip of tympanic bulla and outer posterior prominence project ventrally, and when seen from the lateral side the ventral contour is saddleshaped. Length of tympanic bulla 40 to 45 mm.
.... *Delphinapterus leucas*

o² When seen from the lateral side, the ventral contour is nearly straight. Shallow median furrow is present. Length of tympanic bulla 36 to 40 mm.
.... *Orcaella brevirostris*

n² Facet for posterior process of periotic is smooth. Weak median furrow is present.

p¹ Outer posterior prominence is cylindrical. Posterior process is thick and spindle-shaped. Length of tympanic bulla 27 to 32 mm.
.... *Neophocaena phocaenoides*

p² Outer posterior prominence is flat. Posterior process is flat and square.

q¹ Ventral keel is high. Length of tympanic bulla 30 to 37 mm.
.... *Phocoenoides*

q² Ventral keel is low. Length of tympanic bulla 28 to 34 mm.
.... *Phocoena*

m^2 Posterior process of tympanic bulla extends to postero-lateral or lateral direction. Anterior spine is usually present. Posterior branch of lower tympanic aperture is not wide.

r^1 Tympanic bulla is strongly compressed laterally. Inner posterior prominence is short, and not extended posteriorly beyond the base. Ventral keel is prominent. Median furrow is absent.

s^1 Width of tympanic bulla is 37 to 42% of the length. Ventral keel is high and sigmoidal. Anterior spine is absent and elliptical foramen is usually absent. Length of tympanic bulla 50 to 51 mm.

.... *Monodon monoceros*

s^2 Width of tympanic bulla is more than 42% of length. Anterior spine is present.

t^1 In the ventral view anterior margin is triangular, and the anterior spine situates at the center. Anterior part of lateral wall is narrow. Inner margin of ventral wall is straight. Surface of ventral keel is smooth. Length of tympanic bulla 34 to 38 mm.

.... *Peponocephala electra*

t^2 Inconspicuous anterior spine situates nearly at the center. Anterior part of lateral wall is wide. Involucrum is short. Inner margin of the bulla concaves. Length of tympanic bulla 39 to 42 mm.

.... *Feresa attenuata*

t^3 A plate-like or semitubal anterior spine situates in front of ventral keel. Anterior parts of ventral wall and of lateral wall are narrow and pointed. Inner margin of ventral wall is slightly convexed. Ventral keel is lower at the center. Length of tympanic bulla 36 to 52 mm.

.... *Globicephala*

t^4 Anterior spine situates in front of involucrum. Anterior part of the lateral wall is wide. Ventral keel is conspicuous. Inner margin of the ventral wall slightly concaves. Length of tympanic bulla 38 to 47 mm.

.... *Grampus griseus*

r^2 Tympanic bulla is not compressed laterally.

u^1 Ventral keel continues from inner posterior prominence to anterior end of involucrum. Inner posterior prominence projects posteriorly beyond the base. Median furrow is absent. Length of tympanic bulla is less than 45 mm.

v^1 Contour of anterior margin of ventral wall is oval. Ventral keel is high. The thickness of inner posterior prominence is nearly same with that of outer posterior prominence. Length of tympanic bulla 34 to 42 mm.

.... *Tursiops*

v^2 Contour of anterior margin of ventral wall is rectangular, and has small tubal anterior spine at the center. Ventral keel is high. Inner posterior prominence is thinner than outer posterior prominence. Length of tympanic bulla 28 to 35 mm.

.... *Stenella*

v^3 Contour of anterior margin of ventral wall is narrow rectangular. Ventral keel is wide and flat. Length of tympanic bulla 32 to 35 mm.

.... *Lissodelphis borealis* u² Ventral keel does not reach the anterior end of tympanic bulla. Inner posterior prominence projects posteriorly beyond the base. Median furrow absent.

w¹ Ventral keel is inconspicous and fades at slightly anterior of the middle of the bulla. Ventral wall is nearly smooth except a hemispheric prominence at the antero-mesial corner. Interprominential notch is wide and U shaped. Length of tympanic bulla 30 to 35 mm.
.... *Delphinus*

w² Ventral keel is high only at the posterior part, and ends nearly at the middle of the bulla. Two vague longitudinal keels are present on the median line and in front of outer posterior prominence. Length of tympanic bulla 32 to 39 mm.
.... *Lagenorhynchus*

w³ Ventral keel is high and reaches at the point about 1/3 from the anterior. There is a deep groove on the ventral surface along the anterior end of ventral keel. Anterior part of the bulla is cylindrical. Vague longitudinal keels are observed same with *Lagenorhynchus*. Length of tympanic bulla 36 to 42 mm.
.... *Steno bredanensis*

u³ Ventral keel is almost absent. Median furrow absent. Tympanic bulla is cylindrical. Length of tympanic bulla is more than 45 mm.

x¹ Both posterior prominences are arranged in parallel. Inner margin of the bulla is straight. Length of tympanic bulla 49 to 51 mm.
.... *Pseudorca crassidens*

x² Posterior prominences opens posteriorly at the angle of about 45°. Elliptical foramen is absent. Length of tympanic bulla 70 to 85 mm.
.... *Orcinus orca*

u⁴ Median furrow or similar structure is present. Ventral keel low. Elliptical foramen is usually absent. Small in size.

y¹ Inner posterior prominence projects posterioly beyornd the base. Vague keels is present at the outer border of median furrow. The inner angle on the anterior border of ventral wall is steep. Length of tympanic bulla 34 mm (1 example).
.... *Sousa teuszii*

y² Inner posterior prominence projects posteriorly beyond the base. Anterior base of outer posteriorly prominence swells. Anterior margin of ventral wall is oval. Length of tympanic bulla 27 to 29 mm.
.... *Cepholorhynchus*

y³ Inner posterior prominence does not project posteriorly beyond the base. Anterior margin of ventral wall is oval. Length of tympanic bulla 31 to 32 mm.
.... *Sotalia*

Periotic

a¹ Anterior process is shaped of a curved rod. Posterior process is bent postero-bentrally at a right angles with superior process. Facet for posterior process of tympanic bulla is small, and has weak keels and grooves.

b¹ Large accessory ossicle touches the cochlear portion and covers the dorsal part of tympanic cavity. Superior process is massive and continuous in structure to the base of posterior process. Aquaeductus Fallopii, foramen singulare, and ductus endolymphaticus open in the fundus of internal auditory meatus. Length of periotic 57 to 69 mm.

.... *Physeter catodon*

b² Accessory ossicle is small. Superior process is slender. Slender posterior process is separated from superior process by a groove. Ductus endolymphaticus opens outside of the opening of fundus of internal auditory meatus.

c¹ Cochlear portion is flat. Anterior process is separated from superior process by a groove. A protuberance projects postero-ventrally from the antero-ventral base of posterior process. Length of periotic 33 to 43 mm.

.... *Platanista gangetica*

c² Cochlear portion is globular. Anterior process is continuous to superior process. No protuberence at the antero-ventral base of posterior process. Length of periotic 52 mm (1 example).

.... *Lipotes vexillifer*

a² Anterior process is hemispheric or triangular pyramidal. Anterior and Posterior processes are distinct from superior process. Posterior process is short. Facet for posterior process of tympanic bulla is almost smooth.

d¹ Tip of posterior process is fan shaped.

e¹ Anterior process is elongted triangular pyramidal. Length of periotic 66 to 76 mm.

.... *Berardius*

e² Anterior process is short, and the triangular pyramidal part is roundish. Length of periotic 54 to 63 mm.

.... *Ziphius cavirostris*

d² Posterior process is slender, and not wide.

f¹ Anterior process forms a long triangular pyramid with the clear ridges. Length of periotic 61 mm (1 example).

.... *Hyperoodon*

f² Anterior process is hemispheric, and has a small protuberance at the anterior tip. The surface of periotic is smooth and roundish. Small in size, 41 to 52 mm.

.... *Mesoplodon*

g¹ Dome shaped protuberance is formed on the dorsal surface of superior process. Length of periotic 41 to 45 mm.

.... *M. europaeus*
M. ginkgodens

g² No dome shaped protuberance on the superior process. Length of periotic 44 to 52 mm.

.... *M. densitostris*
M. carlhabbsi
M. stejnegeri

a³ Anterior process is flat and spool shaped. A plate-like protuberance is on the tip of posterior process. Aquadeuctus Fallopii opens out side of the opening of fundus of internal auditory meatus.

.... *Kogia*

h¹ Dorsal contour of upper tympanic aperture forms small semicircle. Length of periotic 24 to 31 mm.

.... *K. breviceps*

h² Dorsal contour of upper tympanic aperture is nearly straight. Length of periotic 22 to 30 mm.

.... *K. simus*

a⁴ Anterior process is flat, and its anterior margin is rectangular.

i¹ Posterior process is short. Cochlear portion is spheric, and its diameter is more than 54% of the tympanic length.

j¹ Periotic is short. Anterior process very short. Length of periotic 20 mm (1 example).

.... *Pontoporia blainvillei*

j² Periotic is large. Length of periotic 25 to 31 mm.

.... *Inia geoffrensis*

i¹ Posterior process extends posteriorly and not short. Cochlear portion is less than 53% of periotic length.

k¹ Facet for posterior process of tympanic bulla is smooth. Posterior process is rod shaped. Length of periotic 26 to 32 mm.

l¹ Posterior process is slender and conical, and the tip is pointed.

.... *Neophacaena phocaenoides*

l² Tip of posterior process is blunt. Faint constriction is on the base of posterior process.

.... *Phocoenoides*

l³ Tip of posterior process is blunt. No constriction on the base of posterior process.

.... *Phocoena*

k² Facet for posterior process of tympanic bulla has ridges and grooves. Posterior process is stout.

m¹ Posterior process is wedge-shaped. Irregular grooves are present on the dorsal surface of posterior process. Length of periotic 37 to 41 mm.

.... *Delphinapterus leucas*

m² Posterior process is of triangular rod with spongy structure on the tip. Length of periotic 34 to 41 mm.

.... *Orcaella brevirostris*

i³ Posterior process extends laterally or postero-laterally and is not short.

n¹ Periotic is large. Anterior, posterior, and superior processes are very massive, but cochlear portion is relatively small (diameter is 31 to 39% of periotic length). Periotic length 73 to 88 mm.

.... *Orcinus orca*

n² Periotic is small, less than 50 mm in length. *Monodon* and most of the genera of Delphinidae are included, and their identification is usually difficult.

o¹ Needle-shaped processes are formed on the dorsal surface of superior process. They are conspicuous in older individuals, and weaker in the following order.

p¹ Opening of fundus of internal auditory meatus is round. Crista transversa is high (characteristics found only in this genus among the following 4 genera). No flat area is on the dorsal surface of superior process. Length of periotic 37 to 50 mm.

.... *Monodon monoceros*

p² Wide and elevated flat area is conspicuous on the dorsal surface of superior process. Posterior process is thick and short, and has the spongy structure on the tip (found only in this genus among the 4 genera). Length of periotic 34 to 46 mm.

.... *Grampus griseus*

p³ Flat area on the superior process is low, and distinguished unclearly from the rest of the part. Tip of posterior process is thin. The contour of anterior, superior, and posterior processes is smoothly round. Length of periotic 33 to 44 mm.

.... *Globicephala*

p⁴ Flat area on the dorsal surface of superior process is oblique and not elevated from the rest of the area. Longitudinal keel is present on the inner side of dorsal surface of superior process. Opening of fundus of internal auditory meatus is long. Length of periotic 31 to 38 mm.

.... *Tursiops*

o² No needle-shaped process is formed on the dorsal surface of superior process. Crista transversa is low.

q¹ Longitudinal keel is conspicuous on the dorsal surface of superior process, and its outer area forms a flat slope. Anterior process is nearly straight. Length of periotic 42 to 49 mm.

.... *Pseudorca crassidens*

q² Anterior process is thick. In the lateral view, the dorsal contour of anterior and superior processes is straight. Dorsal surface of superior process is not wide. Length of periotic 35 to 38 mm.

.... *Feresa attenuata*

q³ Dorsal surface of superior process is wide and flat. Length of periotic 30 to 35 mm.

.... *Peponocephala electra*

q⁴ The area posterior of the opening of fundus of internal auditory meatus is wide and flat. Length of periotic 33 to 36 mm.

.... *Steno bredanensis*

q⁵ Aquaeductus cochleae and ductus endolymphaticus are surrounded by a flat area, and open in a same plane. Length of periotic 30 to 33 mm.

.... *Lissodelphis borealis*

q⁶ In the lateral view, the dorsal contour of anterior, superior, and posterior processes is round. Length of periotic 28 to 33 mm.

.... *Lagenorhynchus*

q⁷ Superior process is slender, and surrounded by two planes of dorsal and and lateral sides. Length of periotic 33 mm (1 example).

.... *Sousa teuszii*

q⁸ Superior process is slender, and surrounded by three planes. Length of periotic 27 mm (1 example).

.... *Sotalia*

q⁹ Opening of aquaeductus cochleae projects posteriorly. One longitudinal keel is present on the dorsal surface of superior process. Length of periotic 26 mm (1 example).

.... *Cephalorhynchus*

q¹⁰ Small periotics (24 to 32 mm in length) other than the above genera probably belong to *Delphinus* or *Stenella*. As the individual variation is large, the identification is most difficult in these genera.

APPENDIX II. TABLE OF MEASUREMENTS AND SOME CHARACTERISTICS OF TYMPANO-PERIOTIC BONE.

A	1 *Platanista gangetica* B	C	D	E	2 *Inia geoffrensis* B	C	D	E	3 *Lipotes vexillifer* B	C	D	4 *Pontoporia blainvillei* B	C	D
1	7	47.1, 63.5	100	52.4	5	38.2, 45.6	100	41.1	1	47.1	100	1	24.3	100
2	7	43.7, 58.3	90.0, 91.8	91.3	5	32.0, 41.1	83.8, 91.5	88.0	1	44.4	94.3	1	21.9	90.0
3	7	34.3, 37.2	58.6, 73.2	68.2	5	25.3, 28.1	59.4, 68.5	64.5	1	29.3	62.3	1	17.1	70.3
4	7	27.3, 30.1	47.4, 59.6	54.6	5	16.6, 18.9	39.1, 44.8	42.7	1	22.4	47.6	1	13.2	54.3
5	7	24.7, 29.2	44.3, 54.4	50.9	5	25.5, 28.0	60.3, 70.3	65.3	1	24.0	51.0	1	14.9	61.3
6	7	33.3, 38.9	61.3, 74.8	69.2	5	29.8, 34.8	74.0, 81.4	77.4	1	27.3	58.0	1	20.1	83.0
7	7	*			5	*			1	24.1	51.2	1	13.5	55.5
8	7	2.4, 3.6	4.5, 5.7	5.3	5	2.8, 3.4	6.3, 8.5	7.8	1	4.8	10.2	1	3.0	12.4
9	7	11.0, 13.1	20.3, 25.9	23.4	5	9.7, 10.2	22.6, 27.5	25.1	1	5.0	10.6	1	6.0	24.6
10	7	2.7, 4.3	4.7, 9.1	6.4	5	3.5, 4.2	7.9, 11.5	9.5	1	1.3	2.8	1	4.3	17.7
11	6	0.9, 4.5	1.9, 8.2	4.9	5	1.9, 5.0	4.3, 11.0	8.5	1	2.2	6.0	1	0	0
12	7	Inner			5	Outer≑Inner			1	Outer		1	Inner	
13	7	33.4, 42.3	100	37.6	5	25.7, 30.4	100	26.9	1	52.0	100	1	20.0	100
14	7	9.4, 15.2	23.9, 35.9	30.3	5	10.7, 15.6	41.6, 58.3	48.7	1	14.0	26.9	1	9.5	47.5
15	7	21.9, 24.8	55.3, 66.5	61.7	5	21.4, 25.2	79.6, 90.0	87.0	1	24.0	46.2	1	16.2	81.0
16	7	3.6, 5.3	9.9, 13.7	11.8	5	3.8, 4.8	14.7, 18.3	15.2	1	3.0	5.8	1	4.0	20.0
17	7	2.2, 3.8	5.6, 9.8	8.1	5	2.6, 3.6	9.7, 13.6	11.7	1	3.0	5.8	1	2.8	14.0
18	6	10.0, 13.0	26.3, 35.0	30.8	5	8.2, 11.1	31.9, 36.6	34.3	1	10.0	19.2	1	8.4	42.0
19	7	14.5, 16.2	38.3, 44.8	41.7	5	14.2, 18.2	54.3, 68.5	63.7	1	19.5	37.5	1	13.6	68.0
20	7	+			5	+			1	+		1	—	
21	7	+			5	—			1	—		1	—	
22	7		64.7, 77.0	71.4	5		60.8, 67.6	65.7	1		110.4	1		82.3

* Unmeasurable

A : Position of measurement or observed characters (see Table 3 in the text).
B : Number of individuals observed.
C : Observed minimum and maximum in mm.
D : Observed minimum and maximum in percentage of the standard length.
E : Mean value in mm (positions 1 and 13) or in percentage of the standard length.

APPENDIX II. Continued.

A	5 *Neophocaena phocaenoides*				6 *Phocoena ph. vomerina*				7 *Phocoena ph. phocoena*			
	B	C	D	E	B	C	D	E	B	C	D	E
1	19	27.7, 31.5	100	30.1	3	30.5, 33.7	100	31.9	3	28.4, 31.4	100	29.5
2	19	28.4, 32.1	98.7, 108.0	101.7	3	28.3, 30.3	89.3, 92.8	91.6	3	27.8, 30.1	95.9, 97.9	97.0
3	17	21.7, 25.4	74.8, 83.2	80.4	3	23.2, 24.4	70.3, 77.4	74.6	3	21.9, 22.5	71.7, 77.5	75.3
4	17	16.1, 19.4	56.1, 63.2	61.1	3	17.7, 18.0	53.1, 58.0	56.0	3	15.7, 16.3	52.0, 56.3	54.4
5	18	16.0, 20.0	57.8, 65.8	62.3	3	19.4, 21.0	62.8, 63.7	63.4	3	18.5, 19.9	59.0, 70.1	65.3
6	17	24.1, 28.1	81.5, 94.3	88.3	3	24.2, 25.0	75.2, 80.3	77.1	3	22.7, 24.9	79.3, 87.3	82.0
7	19	16.7, 19.3	56.2, 63.5	59.4	3	15.2, 17.0	49.1, 50.4	49.5	3	14.8, 16.9	51.7, 55.3	53.6
8	19	2.9, 5.4	10.4, 17.8	14.1	3	4.6, 5.4	13.6, 17.7	16.2	3	3.6, 4.9	12.6, 15.6	14.6
9	17	6.1, 7.4	20.1, 24.6	22.0	3	5.1, 5.8	16.7, 18.0	17.4	3	5.3, 5.9	18.2, 20.8	19.2
10	18	2.4, 3.9	7.6, 12.8	10.3	3	3.1, 3.9	9.2, 12.8	10.6	3	2.7, 3.3	9.5, 10.8	10.3
11	19	0	0	Closed	3	0	0	Closed	3	0	0	Closed
12	19	Outer			3	Inner			3	Inner		
13	19	27.1, 31.4	100	29.9	3	26.9, 30.0	100	28.3	3	28.2, 30.4	100	29.0
14	19	8.1, 9.9	26.6, 33.6	29.7	3	10.1, 10.6	34.2, 39.0	36.8	3	9.4, 9.8	32.6, 34.8	33.7
15	19	16.2, 18.4	55.5, 64.3	58.5	3	15.2, 16.4	52.7, 57.6	54.9	3	15.3, 16.1	53.0, 56.9	54.8
16	19	3.1, 5.0	10.2, 16.4	12.7	3	3.3, 4.8	11.8, 16.2	13.7	3	3.6, 4.3	12.8, 15.2	13.7
17	19	1.4, 2.8	4.5, 9.2	7.0	3	2.5, 3.7	10.0, 12.3	11.4	3	2.8, 3.4	9.9, 12.0	11.0
18	15	8.9, 15.8	30.4, 51.6	47.3	1	8.6	32.0		3	10.8, 11.8	37.6, 41.8	39.7
19	19	13.2, 15.2	45.1, 51.4	47.3	3	12.0, 12.6	40.0, 44.6	43.0	3	11.2, 11.9	38.9, 42.0	40.8
20	19	—			3	—			3	—		
21	19	—			3	—			3	—		
22	19		93.7, 105.8	99.7	3		87.0, 91.0	88.7	3		96.8, 99.6	98.3

APPENDIX II. Continued.

A	8 *Phocoena sinus* B	C	D	9 *Phocoenoides dalli* B	C	D	E	10 *Phocoenoides truei* B	C	D	E
1	1	29.5	100	6	32.1, 36.9	100	33.9	6	30.9, 34.1	100	32.3
2	1	27.8	94.3	6	29.4, 34.2	90.9, 97.2	92.9	6	27.5, 31.5	89.0, 93.9	91.1
3	1	23.0	78.0	6	24.1, 26.9	72.9, 77.5	75.4	6	23.4, 25.7	68.5, 81.9	75.4
4	1	16.1	54.5	6	19.4, 21.0	54.2, 60.8	58.7	6	17.8, 19.4	54.0, 61.8	58.0
5	1	17.0	57.6	6	19.1, 22.5	59.0, 69.8	63.0	6	18.5, 20.5	55.4, 60.8	61.6
6	1	22.8	77.3	6	25.3, 29.2	76.4, 82.4	79.2	6	22.8, 25.9	67.9, 82.5	74.5
7	1	15.6	63.0	6	15.1, 18.3	44.9, 52.4	48.2	6	12.9, 16.8	37.8, 53.5	45.4
8	1	4.3	14.6	6	4.9, 6.7	14.7, 20.8	17.6	6	4.4, 6.4	12.9, 20.4	17.0
9	1	6.1	20.6	6	5.4, 8.0	16.8, 21.7	19.8	6	6.4, 7.3	19.6, 23.6	20.8
10	1	2.2	7.5	5	2.5, 3.7	7.7, 11.5	8.9	6	2.8, 4.3	9.1, 12.6	10.5
11	1	0	0	5	0	0	Closed	6	0	0	Closed
12	1	Outer≑Inner		6	Inner			6	Inner		
13	1	26.8	100	6	28.7, 33.2	100	31.2	6	29.0, 31.6	100	30.1
14	1	10.3	38.4	6	10.9, 12.5	35.8, 39.4	37.5	6	10.8, 11.7	36.4, 38.6	37.3
15	1	15.2	56.7	6	15.7, 17.5	50.9, 56.5	53.8	6	15.7, 17.1	52.8, 54.1	53.6
16	1	3.4	12.7	6	2.9, 4.6	8.7, 16.0	12.6	6	3.1, 5.5	10.2, 18.7	13.2
17	1	2.7	10.4	6	1.9, 3.2	7.3, 11.2	8.6	6	2.4, 3.6	8.3, 12.4	10.1
18				5	11.4, 14.4	38.8, 44.4	41.7	5	11.7, 12.1	37.9, 41.4	39.6
19	1	12.6	47.0	6	11.9, 13.8	37.5, 43.5	40.7	6	12.2, 13.2	41.5, 43.2	42.3
20	1	—		6	—			6	—		
21	1	—		6	—			6	—		
22	1		91.0	6		86.2, 97.8	92.0	6		89.0, 100.6	93.5

APPENDIX II. Continued.

A	11 *Delphinus bairdi* B	C	D	E	12 *Delphinus delphis* B	C	D	13 *Lagenorhynchus obliquidens* B	C	D	E
1	6	30.5, 35.0	100	32.6	2	31.8, 34.4	100	14	33.0, 38.4	100	35.4
2	6	28.3, 33.5	92.9, 97.5	95.8	2	29.5, 31.8	91.2, 93.7	14	30.9, 36.8	92.0, 98.8	96.0
3	6	20.4, 22.9	64.0, 70.0	67.6	2	22.1, 22.9	66.3, 69.5	14	22.4, 25.2	64.0, 70.3	67.4
4	6	16.1, 17.5	48.4, 53.8	51.7	2	16.2, 17.6	48.4, 53.8	14	17.2, 19.8	49.3, 54.8	52.3
5	6	16.8, 18.6	50.9, 58.0	55.0	2	18.6, 19.7	55.6, 58.4	14	18.8, 22.2	53.2, 64.1	57.3
6	6	21.4, 22.4	64.0, 70.2	67.9	2	22.1, 23.2	66.1, 72.0	14	22.1, 25.2	64.4, 71.2	67.8
7	6	15.0, 15.9	44.6, 49.5	47.8	2	15.2, 16.4	44.2, 49.8	14	14.2, 17.7	42.0, 49.4	45.5
8	6	4.0, 5.2	12.5, 16.0	14.4	2	4.6, 4.8	13.7, 15.1	14	4.3, 5.7	12.5, 16.8	14.4
9	6	4.1, 5.0	13.2, 15.2	14.4	2	4.8, 5.7	14.0, 17.0	14	4.2, 6.1	12.5, 17.1	14.8
10	6	0.9, 1.4	3.0, 4.5	3.6	2	0.8, 1.0	2.3, 3.1	14	0.6, 2.1	1.7, 5.9	3.9
11	6	3.4, 6.3	10.7, 18.5	15.6	2	4.9, 6.2	14.6, 18.1	14	4.0, 6.3	10.4, 18.4	14.0
12	6	Outer			2	Outer		14	Outer		
13	6	27.4, 31.1	100	28.6	2	27.9, 30.1	100	14	29.0, 32.7	100	30.6
14	6	10.0, 11.6	35.8, 38.6	37.4	2	10.0, 11.0	33.7, 39.4	14	10.9, 14.0	37.1, 43.1	40.0
15	6	18.9, 20.4	65.6, 72.6	68.7	2	19.0, 19.8	63.1, 68.1	14	18.6, 21.7	61.5, 70.5	66.4
16	6	1.2, 2.6	4.1, 9.5	7.0	2	1.2, 2.2	4.0, 7.9	14	1.3, 3.8	4.4, 12.2	9.4
17	6	1.3, 3.0	4.2, 10.9	7.7	2	1.6, 3.4	5.4, 12.2	14	2.0, 3.8	6.7, 12.3	9.1
18	6	10.3, 14.0	37.3, 46.8	44.1	2	12.2, 12.2	43.7, 43.7	14	10.9, 16.4	37.2, 54.5	42.4
19	6	12.1, 13.8	42.8, 48.6	45.5	2	13.4, 14.1	45.2, 49.1	14	13.3, 14.5	44.6, 49.5	46.1
20	6	+			2	+		14	+		
21	6	—			2	—		14	—		
22	6		85.4, 92.0	88.1	2		83.3, 92.8	14		78.4, 91.8	86.4

APPENDIX II. Continued.

A	14 *Lagenorhynchus acutus*				15 *L. albirostris*				16 *L. obscurus*			17 *L. australis*		
	B	C	D	E	B	C	D	E	B	C	D	B	C	D
1	3	32.3, 33.4	100	33.0	3	36.6, 37.6	100	37.1	1	33.5	100	1	32.7	100
2	3	30.6, 31.6	91.7, 98.0	94.7	3	35.0, 35.8	94.3, 98.0	96.2	1	32.8	98.0	1	30.9	94.5
3	2	22.4, 23.3	69.5, 69.6	69.6	1	24.5	65.0		1	23.3	69.5	1	22.5	69.0
4	3	16.6, 17.3	51.5, 51.7	51.6	2	19.1, 19.3	51.4, 51.5		1	23.2	69.3	1	16.8	51.4
5	2	17.4, 18.0	54.0, 54.0	54.0	2	22.3, 22.4	59.4, 60.4		1	19.1	57.0	1	19.0	58.0
6	2	22.3, 23.3	69.0, 69.7	69.4	1	27.8	74.0		1	23.7	70.7	1	13.1	40.1
7	3	16.0, 16.5	48.0, 49.6	49.0	3	20.1, 20.5	54.2, 56.0	54.9	1	16.5	49.2	1	15.5	47.4
8	3	4.0, 4.4	12.0, 13.6	12.5	3	5.0, 5.7	13.7, 15.2	14.6	1	4.2	12.5	1	4.7	14.4
9	2	5.5, 6.2	16.5, 19.2	17.9	1	5.7	15.2		1	5.5	16.4	1	4.8	14.7
10	2	0.9, 0.9	2.7, 2.8	2.7	1	1.1	2.9		1	1.1	3.3	1		
11	3	3.1, 4.4	9.6, 13.2	11.7	2	1.7, 2.7	4.6, 7.2		1	4.0	11.9	1	0	0
12	3	Outer			2	Outer			1	Outer		1	Outer	
13	3	28.4, 30.0	100	29.1	2	31.8, 32.4	100		1	31.6	100	1	30.1	100
14	3	10.8, 11.8	37.2, 29.4	38.6	2	13.5, 14.1	42.5, 43.5		1	12.7	40.2	1	13.9	46.2
15	3	17.9, 19.5	63.0, 67.3	64.6	2	20.9, 21.4	65.8, 66.0		1	22.0	69.8	1	19.7	65.5
16	3	1.1, 1.3	3.9, 4.3	4.1	2	1.8, 1.8	5.6, 5.7		1	1.7	5.4	1	1.5	5.5
17	3	1.8, 2.2	6.3, 7.6	6.8	2	2.9, 3.3	7.7, 10.4		1	2.8	8.9	1	1.8	6.0
18	3	13.4, 14.3	46.2, 47.6	47.1	2	15.5, 15.6	48.1, 48.8		1			1		
19	3	13.1, 14.0	46.2, 48.3	46.9	2	14.2, 14.3	43.8, 45.0		1	15.0	47.6	1	12.8	42.6
20	3	+			3	+			1	+		1	+	
21	3	—			3	—			1	—		1	—	
22	3		87.0, 90.0	88.3	2		85.8, 88.5		1		94.5	1		92.0

APPENDIX II. Continued.

A	18 Steno bredanensis				19 Lissodelphis borealis				20 Stenella caeruleoalba			
	B	C	D	E	B	C	D	E	B	C	D	E
1	7	36.8, 41.8	100	38.5	6	32.6, 34.1	100	33.4	14	28.9, 34.3	100	32.0
2	7	35.7, 40.8	96.5, 99.7	98.0	6	32.1, 34.3	96.5, 100.3	99.0	14	28.0, 34.3	90.0, 95.5	93.1
3	7	25.5, 27.7	66.3, 72.0	69.4	6	22.0, 23.5	65.6, 71.2	68.8	14	19.9, 22.9	62.4, 72.4	68.6
4	7	18.8, 21.5	51.3, 55.0	52.9	6	16.5, 18.1	49.2, 55.4	52.5	14	15.8, 17.8	49.3, 55.8	52.7
5	7	20.3, 25.0	55.3, 60.3	58.5	6	17.8, 19.6	53.0, 58.9	55.3	14	15.4, 18.8	49.0, 55.8	52.8
6	7	25.5, 28.7	67.7, 74.9	71.5	6	23.1, 25.1	68.3, 75.0	70.9	13	20.9, 24.4	63.3, 74.7	70.2
7	7	19.1, 21.7	50.7, 57.2	53.2	6	14.0, 15.9	42.0, 48.5	45.5	14	12.9, 16.0	41.5, 47.6	44.1
8	7	4.3, 5.6	11.3, 14.7	12.9	6	5.1, 6.3	15.4, 18.9	16.6	14	3.1, 5.1	11.9, 15.2	13.1
9	7	4.5, 6.3	12.2, 17.2	14.4	6	4.7, 5.3	13.8, 16.0	14.7	13	4.6, 5.6	13.6, 17.9	15.9
10	7	1.1, 2.5	2.6, 6.4	4.4	6	0.9, 1.3	2.6, 3.9	3.2	14	0.7, 1.8	2.2, 5.8	3.7
11	7	3.4, 6.1	9.0, 16.6	12.0	6	2.6, 4.3	7.8, 12.9	10.4	14	3.0, 5.6	8.8, 17.7	14.5
12	7	Outer			6	Outer			14	Outer		
13	7	33.1, 36.0	100	34.3	6	30.2, 32.5	100	30.9	15	28.0, 31.9	100	29.7
14	7	11.3, 13.6	32.1, 40.7	36.3	6	10.4, 11.8	34.2, 39.1	36.7	15	10.8, 14.1	36.2, 45.6	40.0
15	7	21.2, 24.3	62.0, 73.5	67.2	6	19.3, 20.4	62.5, 64.3	63.3	15	18.3, 20.6	60.3, 69.1	65.6
16	7	1.0, 2.3	3.0, 6.8	5.4	6	1.4, 2.4	4.6, 7.8	6.3	15	0.7, 2.1	2.4, 8.1	4.5
17	7	2.4, 3.8	7.2, 11.3	9.1	6	2.0, 2.9	6.1, 9.3	7.9	15	1.1, 4.0	3.9, 12.7	8.0
18	6	13.7, 17.8	41.1, 52.3	48.0	6	10.2, 13.5	33.4, 44.8	39.3	15	9.0, 14.0	30.4, 47.6	37.5
19	7	15.5, 18.3	46.4, 54.5	49.6	6	13.0, 14.9	41.8, 48.8	44.9	15	13.5, 14.3	43.2, 47.6	46.7
20	7	+			6	+			15	+		
21	7	—			6	—			15	—		
22	7		84.7, 98.0	89.2	6		90.0, 97.5	92.7	14		88.1, 102.1	92.8

APPENDIX II. Continued.

A	21 *Stenella styx*			22 (?) *Stenella roseiventris*				23 (?) *Stenella longirostris*			24 *Stenella attenuata*			
	B	C	D	B	C	D	E	B	C	D	B	C	D	E
1	1	32.1	100	6	28.0, 30.8	100	29.9	2	28.4, 30.4	100	7	30.1, 33.8	100	31.3
2	1	30.5	95.0	6	27.5, 29.2	93.5, 96.9	94.8	2	27.2, 28.4	93.4, 95.8	7	28.2, 32.8	89.7, 105.0	95.4
3	1	27.0	84.1	6	19.4, 22.1	65.8, 71.8	68.8	2	20.3, 24.6	69.1, 72.1	7	21.0, 22.5	62.4, 73.5	68.6
4	1	17.6	54.8	6	14.9, 16.7	50.7, 54.2	52.4	2	15.8, 16.0	51.9, 56.0	7	15.3, 17.3	45.2, 54.5	51.7
5	1	18.6	57.9	6	15.0, 16.9	50.8, 55.0	53.6	2	15.9, 17.0	55.4, 57.4	7	17.1, 18.1	51.0, 59.0	55.6
6	1	23.1	72.0	6	20.1, 22.2	68.5, 72.1	70.7	2	20.0, 21.5	70.4, 70.7	7	22.0, 23.9	68.3, 77.0	71.4
7	1	14.8	46.1	6	12.6, 15.5	43.3, 50.4	46.4	2	14.1, 15.2	46.4, 53.5	7	14.3, 15.6	42.9, 49.4	46.8
8	1	4.3	13.4	6	3.3, 4.7	11.2, 15.8	13.5	2	4.2, 4.5	13.8, 15.7	7	4.2, 5.6	12.8, 17.6	14.9
9	1	5.3	16.5	6	3.6, 4.5	12.2, 14.7	13.9	2	4.3, 4.7	14.5, 16.5	7	4.0, 5.7	14.0, 18.7	15.7
10	1	1.2	3.7	6	0.8, 1.4	2.7, 4.8	3.5	2	0.8, 1.0	2.8, 3.3	7	0.5, 1.2	1.5, 4.0	2.5
11	1	5.5	17.1	6	2.8, 5.3	9.5, 18.1	11.7	2	2.1, 4.0	6.9, 14.1	7	0.7, 4.7	2.3, 14.1	7.2
12	1	Outer		6	Outer			2	Outer		7	Outer		
13	1	28.8	100	6	25.4, 28.5	100	27.0	2	24.3, 24.4	100	7	26.2, 29.6	100	28.2
14	1	11.5	39.9	6	9.5, 10.9	34.9, 41.3	37.9	2	9.4, 9.5	38.5, 39.1	7	9.8, 12.4	36.3, 42.5	38.3
15	1	19.1	66.3	6	17.0, 18.8	58.1, 67.9	64.8	2	16.7, 17.0	68.4, 70.0	7	18.0, 20.0	61.9, 69.5	66.6
16	1	1.3	4.5	6	1.7, 3.1	6.7, 11.6	8.2	2	1.9, 2.0	7.8, 8.2	7	0.9, 1.8	3.1, 4.9	4.7
17	1	1.7	5.9	6	1.2, 2.8	4.8, 10.3	7.6	2	1.7, 2.0	7.0, 8.2	7	2.2, 3.4	7.5, 12.5	9.7
18	1	10.9	37.8	6	9.0, 11.8	33.1, 44.9	38.9	2	8.3, 8.3	34.0, 34.2	7	11.0, 14.5	35.3, 49.6	46.1
19	1	13.2	45.8	6	12.4, 13.5	43.9, 53.2	47.6	2	12.3, 12.3	50.4, 50.6	7	13.0, 14.0	46.9, 50.5	48.5
20	1	+		6	+			2	+		7	+		
21	1	—		6	—			2	—		7	—		
22	1		89.7	6		85.1, 97.9	90.1	2		84.7, 85.9	7		80.5, 95.7	88.0

APPENDIX II. Continued.

A	24a *Stenella graffmani*			24b *Stenella plagiodon*				25 *Tursiops truncatus* (w. Pacific)			
	B	C	D	B	C	D	E	B	C	D	E
1	2	29.8, 32.0	100	3	33.8, 34.4	100	34.1	43	34.7, 41.5	100	38.1
2	2	27.4, 29.8	91.5, 93.1	3	31.2, 32.2	90.6, 95.2	92.6	43	33.1, 40.0	80.6, 99.2	95.2
3	2	21.0, 21.3	65.9, 71.1	2	22.5, 22.6	65.6, 66.5	66.1	42	23.9, 28.1	65.6, 74.0	69.8
4	2	15.9, 16.4	51.1, 53.6	3	16.8, 17.3	49.1, 50.3	49.8	43	17.7, 21.7	48.6, 55.9	52.6
5	2	17.8, 18.3	55.6, 60.7	3	17.6, 19.8	51.4, 54.9	53.6	43	18.9, 25.5	52.5, 63.4	59.3
6	2	21.1, 21.7	65.9, 72.6	2	23.4, 23.6	68.0, 69.8	68.9	42	25.3, 30.2	65.4, 79.2	72.8
7	2	14.5, 15.7	48.6, 50.8	3	15.0, 15.7	43.6, 46.4	45.1	43	17.4, 21.3	45.2, 55.6	51.1
8	2	4.1, 4.8	13.7, 15.0	3	4.3, 5.0	12.5, 14.8	13.6	43	4.0, 5.9	10.7, 15.5	13.1
9	2	4.5, 4.7	14.1, 15.7	2	4.7, 4.9	13.9, 14.2	14.1	42	4.6, 6.9	11.3, 18.6	15.0
10	2	0.8, 1.0	2.5, 3.2	3	0.8, 1.2	2.3, 4.1	3.3	43	0.8, 3.5	2.2, 9.2	4.5
11	2	3.5, 4.3	11.1, 14.4	3	3.4, 4.0	9.9, 11.6	11.0	43	0 , 7.3	3.8, 20.3	12.1*
12	2	Outer		3	Outer			43	Outer		
13	3	25.9, 27.2	100	3	28.9, 29.6	100	29.1	43	31.7, 37.8	100	35.0
14	3	8.3, 9.6	30.6, 36.2	3	10.4, 12.1	36.0, 41.9	38.4	43	12.0, 18.0	36.2, 52.6	42.0
15	3	16.6, 18.4	64.0, 69.4	3	18.9, 19.9	63.8, 68.9	66.5	43	20.5, 24.3	56.7, 70.1	64.3
16	2	0.6, 1.0	2.3, 3.7	3	1.3, 1.4	4.4, 4.8	4.7	43	0.4, 3.4	2.8, 10.1	4.9
17	2	2.1, 2.7	7.9, 10.1	3	2.0, 2.3	6.8, 8.0	7.4	43	1.2, 4.7	3.4, 14.1	9.1
18	2	10.4, 12.1	39.2, 44.6	3	10.8, 13.6	36.5, 47.0	40.3	42	12.0, 19.0	35.1, 52.8	43.0
19	2	13.4, 13.6	49.4, 51.3	3	12.8, 13.9	43.6, 47.7	45.2	43	14.9, 17.5	41.9, 52.8	46.3
20	2	+		3	+			43	+		
21	2	—		3	—			43	—		
22	2		84.6, 89.2	3		81.5, 85.5	83.7	43		80.4, 99.5	91.9

* Closed on 1

APPENDIX II. Continued.

A	25a *Tursiops truncatus* (Atlantic)				26 *T. gilli* (e. Pacific)			27 *Cephalorhynchus spp.*			28 *Sotalia spp.*		
	B	C	D	E	B	C	D	B	C	D	B	C	D
1	3	38.3, 39.2	100	38.6	2	37.5, 38.9	100	2	27.8, 28.7	100	2	31.4, 31.7	100
2	3	36.6, 38.8	95.9, 99.0	97.5	2	36.6, 37.4	96.5, 97.5	2	24.8, 26.1	89.3, 90.9	2	28.7, 28.9	91.3, 91.4
3	3	25.4, 26.2	64.8, 68.3	67.3	2	25.3, 26.4	67.5, 68.0	2	18.4, 19.4	66.2, 67.6	1	21.0	67.0
4	3	18.3, 19.0	45.2, 48.6	47.3	2	18.8, 20.6	50.1, 53.0	2	14.5, 14.8	51.6, 52.2	2	15.7, 16.0	49.6, 51.0
5	3	20.5, 21.0	53.2, 54.0	53.5	2	20.8, 23.5	55.4, 60.5	2	15.9, 16.7	57.2, 58.2	2	17.8, 18.0	56.2, 57.3
6	3	26.2, 27.2	68.3, 69.5	68.9	2	27.7, 28.1	72.3, 74.0	2	18.3, 19.8	65.8, 69.0	1	22.1	70.4
7	3	18.2, 19.5	46.4, 51.0	49.1	2	16.7, 20.5	44.6, 52.8	2	12.8, 12.9	44.6, 46.4	2	15.3, 15.7	48.6, 49.4
8	3	4.4, 5.0	11.2, 13.0	12.6	2	3.9, 4.8	10.4, 12.3	2	2.8, 3.2	10.1, 11.1	2	3.3, 4.3	10.3, 13.5
9	3	4.9, 6.5	12.8, 16.6	14.6	2	4.8, 6.1	12.3, 16.3	2	4.4, 4.8	15.3, 17.3	1	4.1	13.0
10	3	1.6, 2.3	4.2, 6.0	5.2	2	2.6, 2.8	6.9, 7.2	1	1.1	4.0	1	1.7	5.4
11	3	2.3, 5.2	6.0, 13.6	10.5	2	2.8, 5.4	7.2, 5.4	2	0	0	2	0 , +	0 , +
12	3	Outer			2	Outer		2	Outer		2	Outer	
13	3	31.9, 33.6	100	33.1	2	33.4, 34.4	100	1	25.7	100	2	26.5, 26.7	100
14	3	11.7, 13.7	36.6, 41.3	37.4	2	14.0, 14.0	40.7, 42.0	1	10.1	40.9	2	8.4, 9.4	31.5, 35.5
15	3	21.1, 22.2	62.8, 66.5	66.9	2	20.8, 23.9	62.3, 69.5	1	16.6	64.6	2	18.1, 19.5	67.9, 73.5
16	3	0.5, 1.9	1.5, 5.7	3.5	2	1.2, 2.2	3.6, 6.4	2	2.6, 3.0		2	1.4, 1.5	5.3, 5.7
17	3	3.0, 3.8	8.9, 11.2	10.2	2	2.1, 2.6	6.1, 7.8	2	3.6, 4.6		2	1.5, 1.8	5.7, 6.8
18	3	14.7, 19.9	44.2, 59.2	42.2	1	15.2	45.4	1	9.5	37.0	1	12.9	48.4
19	3	15.8, 17.0	49.4, 50.3	49.9	2	15.3, 15.9	44.5, 47.6	2	12.1, 13.9		2	12.2, 12.8	45.8, 48.3
20	3	+			2	+		2	+		2	+	
21	3	—			2	—		2	—		2	—	
22	3		83.3, 87.5	85.7	2		88.5, 89.0	1		92.5	2		83.5, 85.0

APPENDIX II. Continued.

A	29 Sousa teuszii			30 Pseudorca crassidens				31 Orcinus orca				32 Peponocephala electra			
	B	C	D	B	C	D	E	B	C	D	E	B	C	D	E
1	1	34.2	100	4	47.7, 50.5	100	49.5	7	70.2, 85.0	100	79.2	6	34.0, 37.9	100	35.9
2	1	33.3	97.4	4	42.3, 46.0	88.7, 90.9	90.3	7	62.1, 76.0	83.8, 90.8	87.2	6	30.3, 33.8	88.1, 93.4	89.8
3	1	23.4	68.4	2	32.5, 36.6	68.1, 72.5		5	50.3, 62.7	68.2, 74.5	71.6	6	25.4, 26.7	67.0, 73.7	71.8
4	1	17.9	52.3	3	25.6, 28.8	53.7, 58.0	55.6	6	38.5, 46.9	49.6, 55.8	53.6	6	19.2, 20.9	53.6, 58.3	56.1
5	1	19.6	57.3	2	28.5, 31.1	59.7, 61.8		6	39.8, 49.4	52.5, 58.8	56.1	6	19.1, 20.6	50.4, 58.9	55.3
6	1	24.1	70.5	2	34.9, 38.3	73.2, 75.8		6	50.9, 63.7	67.3, 75.8	71.8	6	26.8, 28.1	69.7, 80.3	75.7
7	1	18.5	54.1	4	21.6, 24.5	43.5, 49.3	46.3	7	34.7, 46.9	47.3, 55.8	51.5	6	16.0, 18.1	42.2, 53.2	47.5
8	1	4.0	11.7	4	6.5, 7.7	13.3, 15.2	14.1	7	7.6, 16.1	10.8, 19.8	15.6	6	4.7, 5.3	12.6, 15.6	13.9
9	1	4.6	13.5	2	6.2, 10.2	12.9, 20.2		5	7.3, 10.9	9.5, 13.8	12.3	6	4.7, 6.0	12.9, 17.6	14.6
10	1	2.5	7.3	3	2.0, 2.3	4.0, 4.8	4.3	6	2.2, 3.8	3.2, 4.9	4.2	6	1.0, 1.7	2.7, 4.0	3.6
11	1	0	0	4	2.1, 8.0	4.2, 16.1	12.8	7	0	0	Closed	6	4.0, 5.2	9.7, 14.7	12.5
12	1	Outer		4	Outer			7	Outer			6	Outer		
13	1	33.3	100	4	42.8, 49.0	100	45.4	7	73.6, 87.5	100	79.8	6	30.8, 34.2	100	32.1
14	1	10.8	32.4	4	17.2, 18.9	38.6, 42.1	40.1	6	30.0, 36.0	38.0, 48.6	42.1	6	13.5, 15.7	40.6, 48.9	45.0
15	1	20.0	60.1	4	27.8, 33.4	64.7, 70.9	67.6	7	46.8, 57.3	53.5, 70.8	65.3	6	21.3, 22.8	65.5, 69.8	67.8
16	1	3.2	9.6	4	2.1, 2.5	4.6, 5.4	5.0	7	1.2, 3.2	1.4, 7.9	3.1	6	0.4, 1.2	1.6, 3.9	2.4
17	1	1.8	5.4	4	0.8, 2.4	1.6, 5.6	4.1	7	1.9, 5.2	2.2, 6.1	4.6	6	0.4, 1.9	1.2, 5.6	3.0
18	1	14.8	44.4	4	20.5, 25.2	42.5, 58.7	49.1	6	33.1, 46.3	43.5, 62.6	48.0	3	14.5, 16.0	45.4, 51.9	49.3
19	1	15.6	46.8	4	18.4, 20.5	41.1, 43.0	42.1	6	25.8, 32.6	31.8, 38.6	34.6	6	14.2, 15.9	43.8, 49.0	46.3
20	1	+		4	+			7	+			6	+		
21	1	—		4	—			7	—			6	—		
22	1		97.4	4		86.7, 98.5	91.9	7		94.0, 105.0	100.9	6		81.3, 93.8	89.5

APPENDIX II. Continued.

A	33 *Feresa attenuata*				34 *Globicephala melaena*				35 *Globicephala macrorhyncha*			
	B	C	D	E	B	C	D	E	B	C	D	E
1	7	39.3, 41.2	100	40.3	4	46.2, 49.7	100	46.7	26	36.4, 52.1	100	43.7
2	7	33.5, 36.4	84.5, 90.5	87.6	4	37.6, 42.5	83.0, 85.5	84.4	26	34.2, 44.1	79.6, 98.0	88.4
3	7	28.2, 29.8	71.0, 73.5	72.5	4	30.1, 31.9	64.2, 69.0	66.6	26	26.8, 30.3	52.1, 73.6	65.9
4	7	20.3, 22.2	51.7, 55.4	53.7	4	23.3, 23.9	47.6, 52.9	50.7	26	19.6, 22.9	38.8, 53.3	48.7
5	7	20.8, 22.6	50.6, 57.5	53.5	4	21.7, 23.2	46.8, 51.3	48.9	26	19.2, 23.5	42.4, 55.5	49.8
6	7	29.4, 31.8	73.5, 77.6	75.9	4	31.1, 33.9	67.3, 71.6	69.2	26	28.2, 32.1	58.5, 82.7	70.0
7	7	17.5, 19.6	42.6, 49.6	46.1	4	18.8, 20.4	40.7, 43.8	42.1	26	15.8, 21.0	37.6, 50.3	43.1
8	7	4.5, 6.4	11.3, 16.1	13.5	4	4.2, 5.1	9.3, 11.0	10.0	26	2.9, 5.4	7.1, 12.3	10.0
9	7	5.4, 7.1	13.1, 17.6	15.1	4	5.9, 8.2	11.9, 18.1	15.0	26	4.9, 8.1	11.0, 18.0	14.8
10	7	0.4, 2.7	1.8, 6.7	3.0	4	1.4, 1.8	3.1, 3.7	3.4	26	0.8, 2.4	2.5, 5.7	3.8
11	7	0 , 2.8	0 , 6.9	1.5*	4	0	0	Closed	26	0 , 1.3	0 , 3.1	0.1**
12	7	Outer			4	Outer			26	Outer		
13	7	35.3, 37.8	100	36.3	4	36.8, 43.4	100	39.1	26	33.2, 39.5	100	35.7
14	7	15.1, 16.4	40.2, 46.2	43.1	4	16.7, 23.9	41.2, 64.9	52.0	26	14.7, 22.8	43.1, 60.8	49.2
15	7	23.3, 27.2	63.0, 73.5	70.3	4	23.0, 25.0	57.6, 64.5	61.6	26	22.2, 26.5	58.0, 74.6	68.8
16	7	0.9, 2.4	2.6, 6.5	4.8	4	1.2, 3.0	3.3, 8.1	4.6	26	0.4, 2.3	1.1, 6.5	4.0
17	7	1.2, 2.3	3.3, 6.3	5.3	4	0.2, 1.5	0.5, 3.8	2.5	26	0.3, 3.5	0.8, 10.2	4.4
18	7	12.9, 17.4	35.9, 49.3	40.4	4	14.9, 22.4	40.1, 52.4	47.2	26	12.6, 25.1	37.0, 74.8	48.5
19	7	13.8, 16.6	37.6, 45.6	41.9	4	16.5, 17.6	40.0, 45.8	44.0	26	14.5, 17.8	41.9, 50.9	45.6
20	7	+			4	+			26	+		
21	7	—			4	—			26	—		
22	7		86.5, 94.0	90.2	4		79.7, 87.5	83.8	26		69.2, 94.8	82.0

* Closed on 5   ** Closed on 25

APPENDIX II. Continued.

A	36 *Grampus griseus* B	C	D	E	37 *Orcaella brevirostris* B	C	D	38 *Delphinapterus leucas* B	C	D	E
1	12	38.7, 46.8	100	41.9	2	36.9, 39.2	100	4	40.7, 45.0	100	42.9
2	12	31.8, 39.9	76.5, 88.9	34.2	2	34.5, 37.5	93.5, 96.3	4	39.7, 42.7	93.0, 98.4	96.6
3	11	27.6, 30.8	62.4, 75.4	70.1	1	24.1, 24.7	63.0	2	32.2, 33.1	78.4, 79.3	78.9
4	12	20.8, 24.0	46.8, 58.6	53.1	2	16.0, 17.4	42.9, 45.6	4	24.1, 24.9	54.2, 61.2	57.0
5	11	19.0, 23.9	43.8, 58.7	50.1	2	20.0, 21.2	52.0, 57.5	3	24.0, 26.0	58.0, 59.0	58.9
6	11	28.5, 31.0	64.8, 78.1	72.8	1	26.5, 26.8	67.6, 70.0	2	32.7, 33.9	80.3, 80.4	80.4
7	12	16.5, 22.0	36.1, 52.1	43.8	2	18.7, 21.5	50.7, 55.0	4	20.0, 21.5	47.8, 49.8	48.8
8	12	2.7, 6.7	6.1, 14.3	10.3	2	3.2, 4.3	8.2, 11.7	4	6.1, 6.8	14.2, 16.1	15.1
9	12	4.9, 9.2	12.1, 20.2	15.8	1	3.9	10.0, 10.2	2	6.0, 6.9	14.8, 16.3	15.6
10	12	0.7, 2.0	1.8, 5.1	3.0	2	1.9, 3.8	5.1, 9.7	3	4.1, 5.3	10.1, 11.8	10.8
11	12	0 , 4.0	0 , 9.9	0.7*	2	0	0	4	0	0	Closed
12	12	Outer			2	Outer		4	Outer		
13	12	34.8, 45.2	100	38.5	2	34.3, 40.7	93.0, 103.8	4	37.7, 40.4	100	39.0
14	12	11.7, 25.0	31.1, 55.3	43.4	2	12.7	31.2, 37.0	4	13.9, 16.2	36.9, 42.2	39.4
15	12	23.6, 28.0	56.0, 75.9	67.3	2	20.5, 21.2	52.1, 59.8	3	26.4, 27.4	65.3, 72.8	69.5
16	12	0.5, 2.7	1.3, 7.1	4.3	2	0.9, 1.4	2.2, 4.1	3	1.2, 2.8	3.0, 7.3	5.0
17	12	0.8, 3.5	1.8, 7.2	4.1	2	1.7, 2.0	4.2, 5.8	3	2.5, 3.1	6.2, 8.1	7.4
18	11	13.4, 18.4	34.3, 47.5	40.9	1	17.0	49.6	3	16.8, 21.4	44.6, 53.0	48.9
19	12	15.4, 18.5	37.0, 48.9	43.3	2	15.1, 15.2	37.3, 44.0	4	19.2, 20.3	47.0, 52.9	49.9
20	12	+			2	+		4	+		
21	12	—			2	—		4	—		
22	12		86.6, 100.0	92.4	2		93.0, 103.8	4		87.6, 94.5	90.4

* Closed on 11

APPENDIX II. Continued.

A	39 *Monodon monoceros*				40 *Berardius bairdi*				41 *B. arnouxii*			42 *Hyperoodon ampullatus*		
	B	C	D	E	B	C	D	E	B	C	D	B	C	D
1	4	50.1, 50.9	100	50.7	5	63.1, 70.4	100	66.7	1	63.2	100	1	54.5	100
2	4	42.8, 46.2	84.4, 90.8	87.2	5	50.3, 61.2	78.9, 84.6	81.0	1	47.5	75.0	1	47.3	86.8
3	4	36.8, 39.0	72.5, 76.6	74.8	5	47.0, 53.1	72.6, 76.7	74.7	1	47.4	75.3			
4	4	26.0, 27.8	51.3, 55.5	53.7	5	35.3, 40.8	54.3, 58.8	57.2	1	36.2	57.2			
5	4	19.0, 20.9	37.5, 41.4	39.6	5	38.7, 45.5	57.1, 67.7	64.3	1	44.1	69.8			
6	4	36.3, 38.6	71.6, 76.0	73.7	5	46.0, 51.2	70.0, 73.6	71.9	1	45.0	71.2			
7	4	20.8, 23.8	40.8, 46.8	44.0	5	33.6, 40.1	52.6, 57.0	54.5	1	36.5	58.0			
8	4	6.3, 7.8	12.4, 15.3	13.9	5	1.4, 3.8	21.4, 5.4	4.7	1	3.3	5.2			
9	4	7.1, 8.1	14.0, 15.9	15.0	5	18.8, 21.0	29.0, 31.4	29.7	1	21.6	30.2	1	16.5	30.3
10	4	2.0, 4.9	5.2, 9.7	7.5	4	5.9, 6.5	9.1, 9.6	9.3						
11	4	0 , 3.1	0 , 6.1	1.5*	5	0 , 14.5	0 , 20.9	5.9**	1	0	0			
12	4	Outer			5	Outer			1	18.8	29.8	1	Outer	
13	4	37.0, 49.4	100	42.3	5	66.9, 75.8	100	71.0				1	61.1	100
14	4	20.4, 23.5	41.3, 59.7	53.2	5	29.0, 38.1	43.4, 50.3	46.9				1	20.3	33.2
15	4	25.4, 30.9	62.7, 68.8	66.5	5	34.7, 37.2	49.6, 54.1	51.7				1	33.0	54.0
16	4	2.0, 3.1	4.1, 6.2	4.8	5	0.8, 4.8	1.2, 6.9	3.1				1	0.5	0.8
17	4	2.5, 4.1	5.5, 9.5	7.4	5	1.9, 5.1	2.8 , 7.4	4.9				1	1.5	2.5
18	4	25.5, 27.7	51.3, 68.4	63.3	5	23.4, 26.0	31.4, 37.1	33.3				1	25.2	41.2
19	4	17.2, 20.9	40.1, 48.6	45.2	5	23.2, 25.1	33.1, 37.5	34.5				1	23.0	37.6
20	4	+			5	—			1	—		1	—	
21	4	—			5	+			1	+		1	+	
22	4		73.6, 98.6	83.5	5		101.0, 113.4	106.6				1		112.0

* Closed on 3 ** Closed on 1

APPENDIX II. Continued.

A	43 *Mesoplodon stejnegeri*				44 *M. densirostris*				45 *M. ginkgodens*		
	B	C	D	E	B	C	D	E	B	C	D
1	7	46.9, 49.0	100	47.7	4	49.7, 54.2	100	51.8	2	39.8, 44.1	100
2	7	42.2, 47.2	88.8, 97.5	94.8	4	47.0, 49.5	90.0, 95.6	93.4	2	37.4, 41.6	94.0, 94.5
3	6	33.0, 35.1	69.0, 74.9	72.0	3	36.1, 38.4	72.5, 73.5	72.9	2	30.3, 34.1	76.1, 77.3
4	6	25.3, 27.0	52.8, 56.6	54.1	1	29.4	54.2		1	24.7	56.0
5	5	27.8, 33.9	67.0, 70.2	67.1	1	32.1	59.2		2	28.0, 30.4	69.0, 70.4
6	5	37.8, 39.2	78.5, 82.0	80.5	3	39.8, 42.7	72.1, 80.5	75.3	2	31.6, 35.2	79.4, 79.9
7	7	23.1, 27.0	48.2, 55.8	50.8	4	22.9, 28.3	45.7, 52.2	49.2	2	20.3, 28.5	51.0, 64.6
8	7	2.5, 4.4	5.2, 9.1	7.2	4	1.7, 4.0	3.1, 8.1	6.3	2	1.7, 3.5	4.3, 7.9
9	6	14.8, 16.6	31.4, 34.8	32.2	3	15.3, 17.2	30.5, 34.6	32.0	2	14.0, 15.6	35.2, 35.4
10	3	3.7, 6.1	7.6, 13.0	8.2					1	2.9	6.6
11	7	6.1, 8.4	13.2, 17.6	10.5	4	+	+		2	+	+
12	7	Outer			4	Outer			2	Outer	
13	4	44.3, 50.9	100	47.5	1	52.2	100		2	41.0, 42.3	100
14	4	16.4, 18.3	33.4, 41.3	37.0	1	20.1	38.5		2	20.4, 20.6	48.2, 50.2
15	4	26.9, 29.1	56.9, 61.3	59.2	1	28.0	53.6		2	22.3, 23.1	54.4, 54.6
16	4	0.2, 1.7	0.4, 3.3	1.7	1	1.4	2.7		2	0 , 0.4	0 , 0.9
17	4	2.6, 3.3	5.5, 6.5	6.1	1	4.3	8.2		2	2.2, 3.0	5.4, 7.1
18	4	15.4, 17.7	34.8, 41.6	37.5	1	16.9	32.4		2	13.8, 15.4	32.6, 37.6
19	4	19.0, 20.9	40.3, 43.0	41.5	1	22.0	42.1		2	16.0, 17.8	39.0, 42.1
20	4	—			4	—			2	—	
21	4	+			4	+			2	+	
22	4		92.8, 104.0	98.8	1		96.3		2		96.0, 103.0

APPENDIX II. Continued.

A	46 *Mesoplodon europaeus* B	C	D	E	47 *M. carlhubbsi* B	C	D	48 *M. mirus* B	C	D	49 *Ziphius cavirostris* B	C	D	E
1	3	41.1, 45.7	100	44.1	2	48.4, 49.4	100	1	41.0	100	6	51.8, 59.7	100	55.9
2	3	38.4, 43.2	93.4, 95.0	94.1	2	46.2, 46.8	94.7, 95.5	1	37.1	90.5	5	43.8, 50.1	83.0, 93.3	87.8
3	3	34.2, 35.5	75.0, 86.4	79.5	1	34.6	71.5	1	32.7	79.5	6	41.9, 44.3	72.4, 81.0	77.3
4	3	25.8, 26.5	56.8, 64.5	59.6	1	21.8	44.1	1	23.8	58.0	5	32.6, 36.3	56.5, 66.4	61.7
5	1	30.3	66.3		1	31.9	65.9	1	25.8	63.0	6	27.0, 37.6	52.1, 64.9	61.3
6	3	34.8, 38.7	79.3, 85.0	83.0	1	40.6	83.9	1	35.2	86.0	6	38.6, 44.8	72.8, 77.9	76.4
7	3	23.4, 23.9	52.5, 57.0	55.0	2	27.4, 28.7	56.6, 58.1	1	20.8	50.8	5	21.2, 26.0	38.6, 50.2	41.6
8	1	3.3	7.2		1	3.8	7.7	1	13.9	9.5	5	1.0, 2.4	1.8, 4.6	3.0
9	3	13.8, 16.9	32.2, 37.1	34.1	1	14.8	30.6	1	15.6	38.0	6	15.1, 17.8	25.3, 31.7	29.6
10											2	2.1, 2.2	3.8, 4.0	
11	3	+	+		1	7.5	15.2	1	8.7	21.2	7	+	+	
12	3	Outer			1	Outer		1	Outer		7	Outer		
13	1	44.5	100		1	49.4	100				7	54.0, 62.4	100	57.6
14	1	18.5	41.6		1	20.9	41.9				7	22.3, 27.0	38.5, 45.0	41.7
15	1	25.0	56.2		1	17.6	35.6				7	29.5, 34.1	50.0, 58.0	55.1
16	1	0	0		1	0.8	1.6				7	0.4, 3.8	1.6, 6.9	3.7
17	1	2.8	6.3		1	1.9	3.8				7	1.2, 5.6	2.1, 10.4	6.8
18	1	16.7	37.6		1	17.7	35.8				7	20.5, 23.8	36.0, 39.6	38.2
19	1	16.0	36.0		1	20.0	40.4				7	18.8, 22.6	33.6, 40.1	36.6
20	3	—			1	—		1	—		7	—		
21	3	+			1	+		1	+		7	+		
22	1		97.5		1		100.0				6		92.5, 116.0	103.6

APPENDIX II. Continued.

A	50 Kogia breviceps B	C	D	E	51 K. simus B	C	D	E	52 Physeter catodon B	C	D	E
1	5	26.2, 38.5	100	30.1	3	24.2, 27.5	100	26.2	8	55.4, 62.8	100	59.8
2	5	20.8, 24.1	61.0, 85.5	77.0	3	18.5, 25.0	89.8, 94.2	92.3	8	45.5, 57.1	75.8, 91.2	84.2
3	4	21.2, 22.5	76.3, 81.0	78.5	3	19.9, 21.9	74.0, 84.7	79.4	7	41.2, 44.4	68.3, 75.5	71.1
4	4	14.0, 16.5	50.3, 56.5	54.0	2	12.8, 14.5	47.6, 52.9		6	30.1, 34.3	50.2, 56.9	53.6
5	4	12.0, 15.7	46.0, 56.3	50.4	3	14.3, 16.4	53.5, 66.1	59.7	8	33.4, 39.5	37.0, 66.5	59.6
6	4	23.6, 26.2	84.6, 93.2	88.4	3	22.9, 23.9	85.1, 97.5	89.8	8	47.7, 51.8	77.1, 87.2	79.1
7	5	17.4, 18.5	48.1, 66.5	61.3	3	14.4, 18.4	52.4, 64.9	60.1	7	24.1, 27.7	38.4, 46.2	42.8
8	2	1.2, 1.9	4.1, 6.8		2	1.2, 2.1	6.5, 8.7		7	1.5, 2.9	2.5, 4.9	3.4
9	4	7.8, 10.5	27.8, 37.6	31.6	3	7.4, 9.3	27.6, 33.8	31.6	8	25.5, 28.2	41.6, 48.9	45.4
10	4	0.5, 1.5	1.8, 5.7	4.1	2	0.7, 1.8	2.9, 6.5		8	—	—	—
11	5	0	0	Closed	3	0	0	Closed	8	0	0	Closed
12	5	Outer≒Inner			3	Outer≒Inner			8	Inuer		
13	4	24.0, 30.5	100	26.2	4	22.7, 29.2	100	26.6	8	57.7, 68.9	100	63.6
14	4	8.5, 11.5	29.2, 47.9	40.8	4	8.2, 11.4	31.1, 40.6	36.6	8	32.2, 36.8	50.2, 60.3	54.0
15	4	18.0, 20.9	59.7, 87.0	77.0	4	17.0, 19.2	63.0, 75.5	68.7	8	34.2, 42.1	53.0, 64.6	59.3
16	3	0.5, 1.0	1.6, 3.9	2.9	4	0 , 1.0	0 , 3.9	0 in 3	8	0	0	0
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18	4	12.6, 16.0	45.2, 61.8	53.8	3	11.6, 13.9	41.4, 49.6	46.2	7	24.3, 30.1	37.6, 46.6	42.1
19	4	12.7, 14.4	41.6, 58.4	53.1	4	11.0, 12.8	41.7, 53.4	46.1	8	23.2, 28.8	36.0, 45.9	41.7
20	5	—			4	—			8	—		
21	5	+			4	+			8	+		
22	4		83.4, 109.3	93.6	2		106.2, 109.1		8		94.1, 116.5	106.7

EXPLANATION OF PLATES

PLATE I

Posterior process of tympanic bulla and that of periotic, and their connection with the skull. BO, Basioccipital. EO, Exoccipital. P, Periotic. PPP, Posterior process of periotic. PPT, Posterior process of tympanic bulla. SQ, Laminated portion of squamosal. T, Tympanic bulla.

Fig. 1. *Physeter catodon*, TK85, fetus, skull length 75 cm, ventro-lateral view, right side.
Fig. 2. *Physeter catodon*, TK165, 5.0 m female, skull length 115 cm, same view.
Fig. 3. *Physeter catodon*, TK261, adult female, same view.
Fig. 4. *Mesoplodon densirostris*, TK256, 356 cm female, postero-lateral view, left side.
Fig. 5. *Kogia breviceps*, TK244, 197 cm female, postero-ventral view, right side.
Fig. 6. *Platanista gangetica*, TK363, 122 cm (juvenile) male, same view.
Fig. 7. *Platanisata gangetica*, TK 357, 200 cm male, ventral view of skull and periotic. Dotted area indicates the facet for posterior process of tympanic bulla.
Fig. 8. *Delphinapterus leucas*, SDNHM20046, ventral view, right side.
Fig. 9. *Balaenoptera borealis*, fetus, lateral view of right tympano-periotic bone.

PLATE II

Ziphius cavirostris, TK296, tympano-periotic bone, left side.

PLATE III

Tympano-periotic bones.
Figs. 1–10. *Berardius bairdi*, TK299, right side.
Figs. 11–13. *Mesoplodon mirus*, AMNH174293, right side.
Two black spots on Fig. 8 are artificial and insignificant.

PLATE IV

Tympano-periotic bones.
Figs. 1– 9. *Mesoplodon stejnegeri*, TK97, right side.
Figs. 10–16. *Hyperoodon ampullatus*, USNM14449, left side.
Figs. 17–20. *Berardius arnouxi*, USNM21511, left side.

PLATE V

Tympano-periotic bones.
Figs. 1–10. *Mesoplodon densirostris*, TK256, 356 cm female, right side.
Figs. 11–16. *Mesoplodon europaeus*, USNM306302, right side.

PLATE VI

Tympano-periotic bones.
Figs. 1–10. *Mesoplodon ginkgodens*, HCY specimen, left side.
Figs. 11–18. *Mesoplodon carlhubbsi*, USNM274591, right side.

PLATE VII

Tympano-periotic bones.
Figs. 1–10. *Physeter catodon*, NUMS specimen, left side.
Fig. 11. *Physeter catodon*, TK304, left side.

PLATE VIII

Tympano-periotic bones.
Figs. 1–9. *Kogia simus*, TK47, 245 cm, right side.
Figs. 10–18. *Kogia breviceps*, TK244, 197 cm female, left side.
Figs. 10–18. *Kogia breviceps*, TK244, 197 cm female, left side. In Figs. 5 and 14, part of posterior process of tympanic bulla is removed.

PLATE IX

Tympano-periotic bones.
Figs. 1–11. *Platanista gangetica*, TK357, 200 cm male, left side.
Figs. 12–13. *Platanista gangetica*, TK351, 171.5 cm male, right side, showing the ossicles attaching to anterior process of periotic.
Figs. 14–23. *Pontoporia blainvillei*, USNM49494 right side.

PLATE X

Tympano-periotic bones.
Figs. 1–8. *Inia geoffrensis*, LACM19589, left side.
Figs. 9–15. *Inia geoffrensis*, LACM19590, left side.
Figs. 16–20. *Lipotes vexillifer*, AMNH57333, left side.

PLATE XI

Tympano-periotic bones.
Figs. 1–10. *Orcaella brevirostris*, USNM199743, left side.
Figs. 11–13. *Orcaella brevirostris*, ZSI 274, right side.
Figs. 14–20. *Delphinapterus leucas*, AMNH180017, right side.

PLATE XII

Tympano-periotic bones, shadow lines on the tympanic bullae indicate contour lines.
Figs. 1–9. *Neophocaena phocaenoides*, TK95, right side.
Figs. 10–18. *Phocoena phocoena phocoena*, TK84, left side.

PLATE XIII

Tympano-periotic bones, shadow lines on the tympanic bullae indicate contour lines.
Figs. 1–9. *Phocoenoides truei*, TK113, right side.
Figs. 10–18. *Phocoenoides dalli*, TK129, 186 cm female, left side.

PLATE XIV

Tympano-periotic bones.
Figs. 1–13. *Sousa teuszii*, TK260, 191 cm female, left side.
Figs. 14–20. *Cephalorhynchus* sp. USNM252568, left side.

PLATE XV

Tympano-periotic bones.
Figs. 1–8. *Sotalia guianensis*, CNHM 34907, left side.
Figs. 9–12. *Sotalia fluviatilis*, AMNH94169, left side.
Figs. 13–15. *Tursiops gilli*, SDNHM20144, right side.

PLATE XVI

Tympano-periotic bones.

Figs. 1–9. *Tursiops truncatus*, 292 cm male, right side, from the coast of Japan.

Figs. 10–14. *Tursiops truncatus*, 335 cm male, right side, same locality.

PLATE XVII

Tympano-periotic bones.

Figs. 1–8. *Stenella caeruleoalba*, adult, right side.

Fig. 9. *Stenella caeruleoalba*, 92 cm male, fetus, left side.

Fig. 10. *Stenella caeruleoalba*, adult, right side.

Figs. 11–18. *Stenella attenuata*, TK103, right side, from the coast of Japan.

Fig. 19. *Stenella attenuata*, TK60, right side, same locality.

Fig. 20. *Stenella attenuata*, TK61, left side, same locality.

PLATE XVIII

Tympano-periotic bones.

Figs. 1–9. *Stenella graffmani*, WAW44, 179 cm female, left side, 12°08′N, 105°46′W.

Figs. 10–12. *Stenella styx*, left side, from the north Atlantic.

PLATE XIX

Tympano-periotic bones.

Figs. 1–8. (?) *Stenella roseiventris* (Hawaiian spinner dolphin), TK50, 180 cm male, left side.

Figs. 9–10. (?) *Stenella roseiventris* (Hawaiian spinner dolphin), TK295, 195 cm male, left side, from Hawaii.

Figs. 11–19. (?) *Stenella longirostris*, WAW52, 168 cm male, left side, 21°06′N, 106°16′W.

PLATE XX

Tympano-periotic bones.

Figs. 1–9. *Lissodelphis borealis*, TK257, 245 cm male, left side.

Figs. 10–11. *Lissodelphis borealis*, TK258, 224 cm female, right side.

Figs. 12–19. *Delphinus bairdi*, TK255, 204 cm female, right side, from Formosa.

PLATE XXI

Tympano-periotic bones.

Figs. 1–8. *Delphinus delphis*, TK specimen, left side, from the north Atlantic.

Figs. 9–16. *Lagenorhynchus obliquidens*, TK229, left side.

Figs. 17–19. *Lagenorhynchus obliquidens*, TK230, left side.

PLATE XXII

Tympano-periotic bones.

Figs. 1–8. *Lagenorhynchus acutus*, USNM14265, right side.

Figs. 9–11. *Lagenorhynchs obsculus*, AMNH34935, left side.

Figs. 12–17. *Lagenorhynchus australis*, CNHM22248, left side.

PLATE XXIII

Tympano-periotic bones.

Figs. 1–9. *Lagenorhynchus albirostris*, TK87, left side.

Figs. 10–18. *Steno bredanensis*, TK73, left side.

PLATE XXIV

Tympano-periotic bones.
Figs. 1–13. *Pseudorca crassidens*, TK specimen, left side.
Figs. 14–17. *Orcinus orca*, TK specimen, left side, (continue to Pl. XXV).

PLATE XXV

Tympano-periotic bones.
Figs. 1– 2. *Orcinus orca*, TK specimen (continued from Pl. XXIV).
Figs. 3–15. *Peponocephala electra*, TK32, left side.

PLATE XXVI

Tympano-periotic bones.
Figs. 1–10. *Feresa attenuata*, TK27, 214 cm male, left side.
Figs. 11–19. *Grampus griseus*, TK101, left side.
Figs. 20–22. *Grampus griseus*, TK specimen, left side.

PLATE XXVII

Tympano-periotic bones.
Figs. 1–11. *Globicephala melaena*, TK specimen, left side, from the north Atlantic.
Figs. 12–20. *Globicephala macrorhyncha*, TK287, 358 cm female, left side.
Figs. 21–22. *Globicephala macrorhyncha*, TK292, 203 cm female, right side.
Figs. 23–24. *Globicephala macrorhyncha*, TK291, 141 cm male, left side.

PLATE XXVIII

Tympano-periotic bones.
Figs. 1–10. *Monodon monoceros*, SDNHM7096, right side.
Figs. 11–13. *Monodon monoceros*, AMNH73318, left side.

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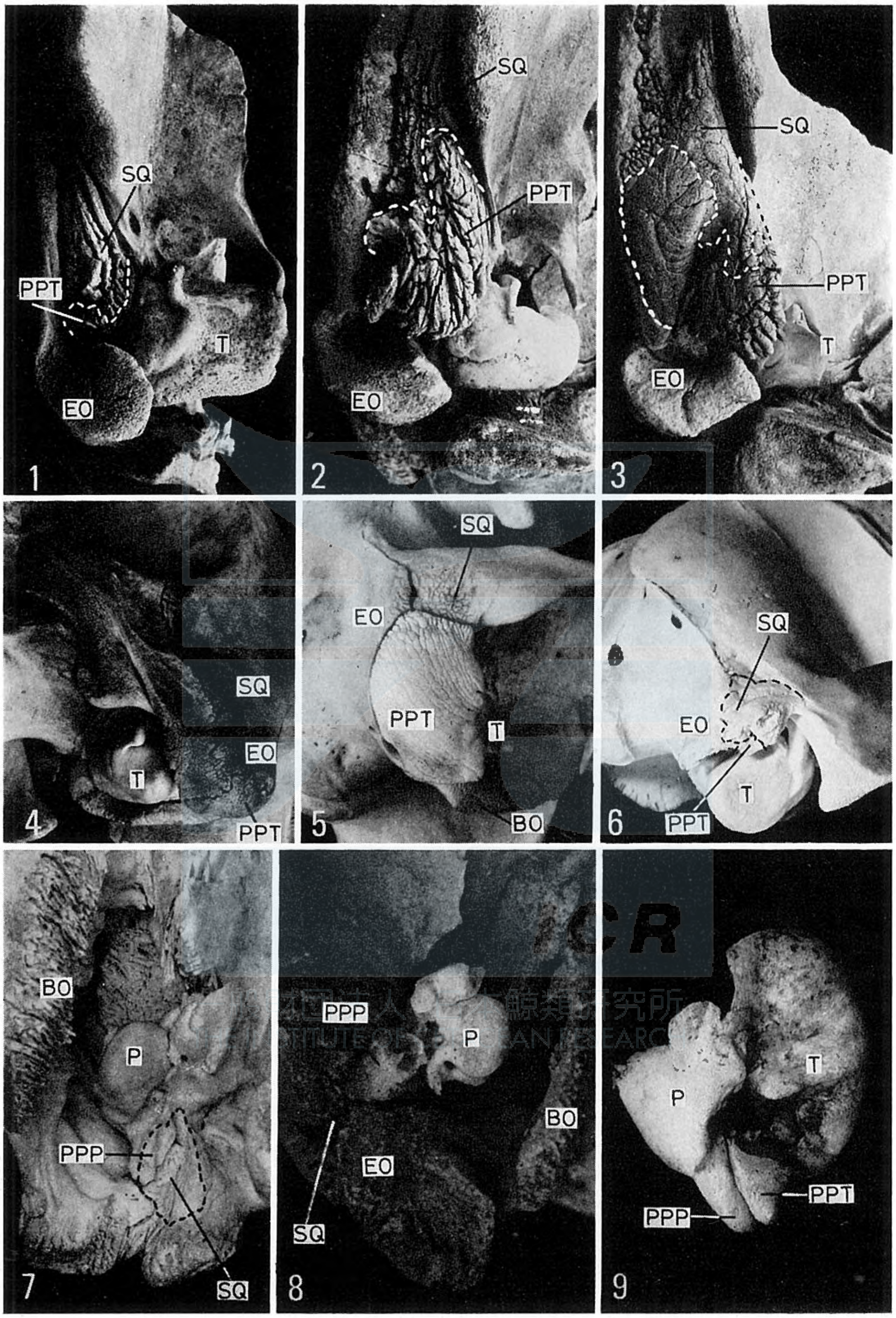
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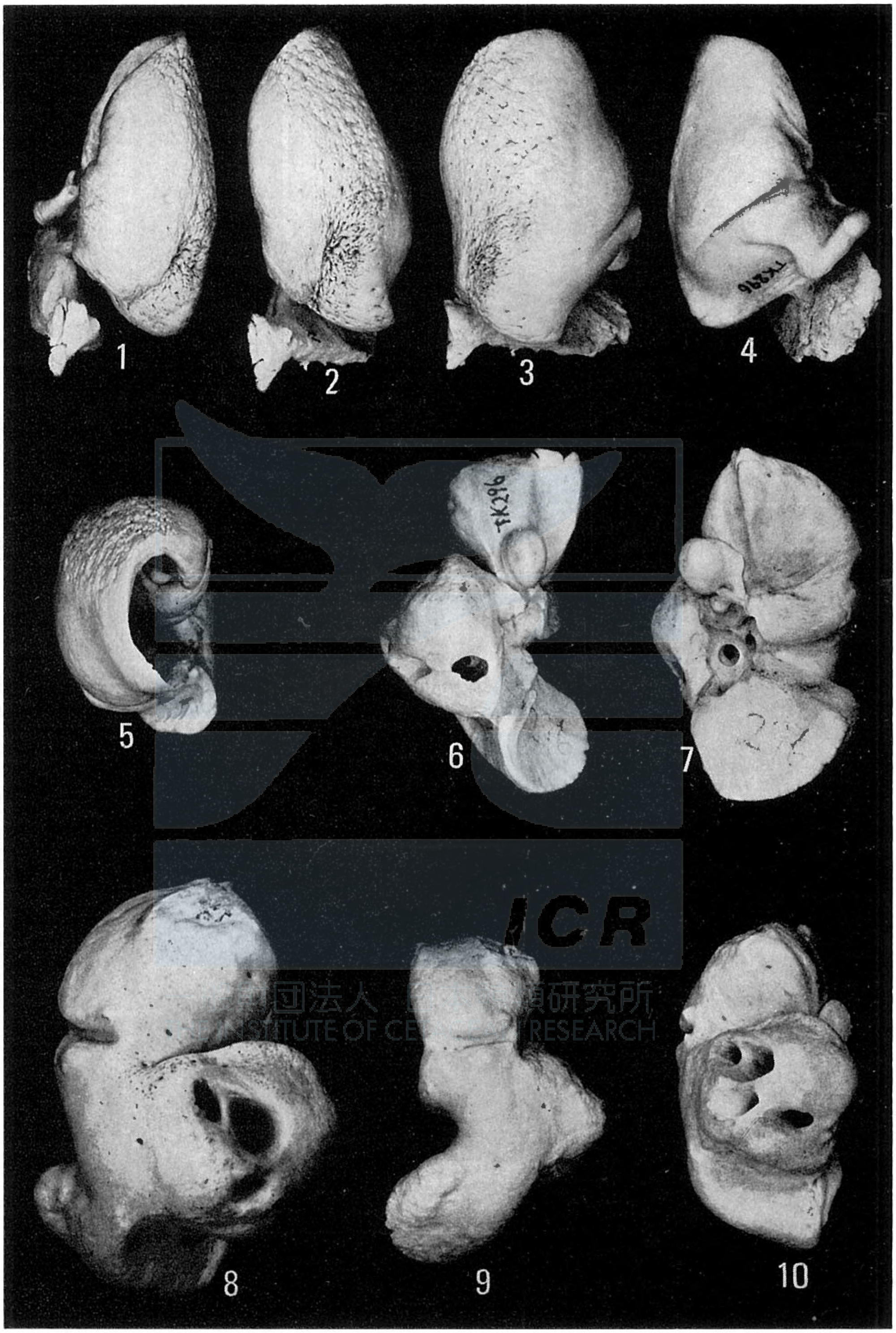
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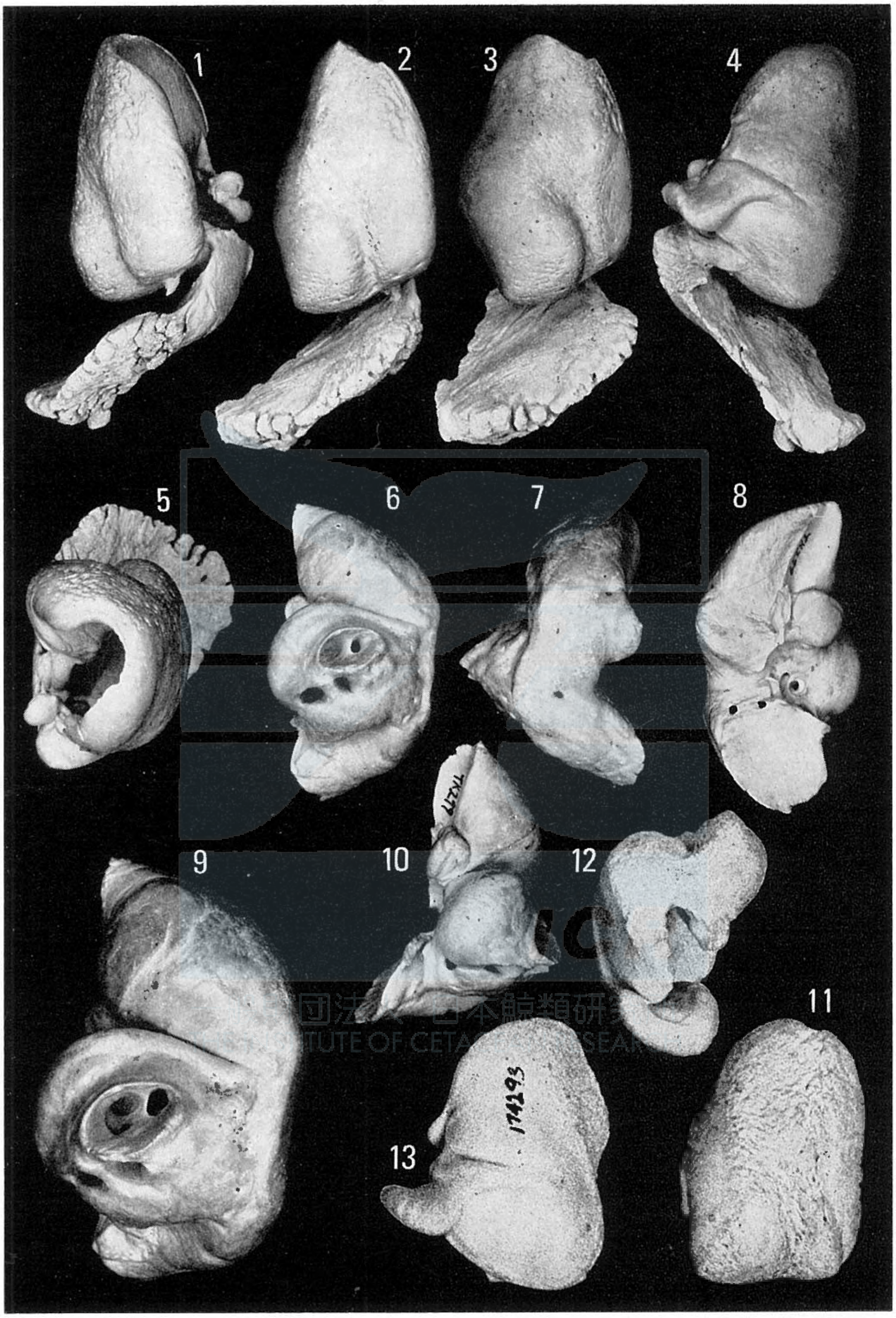
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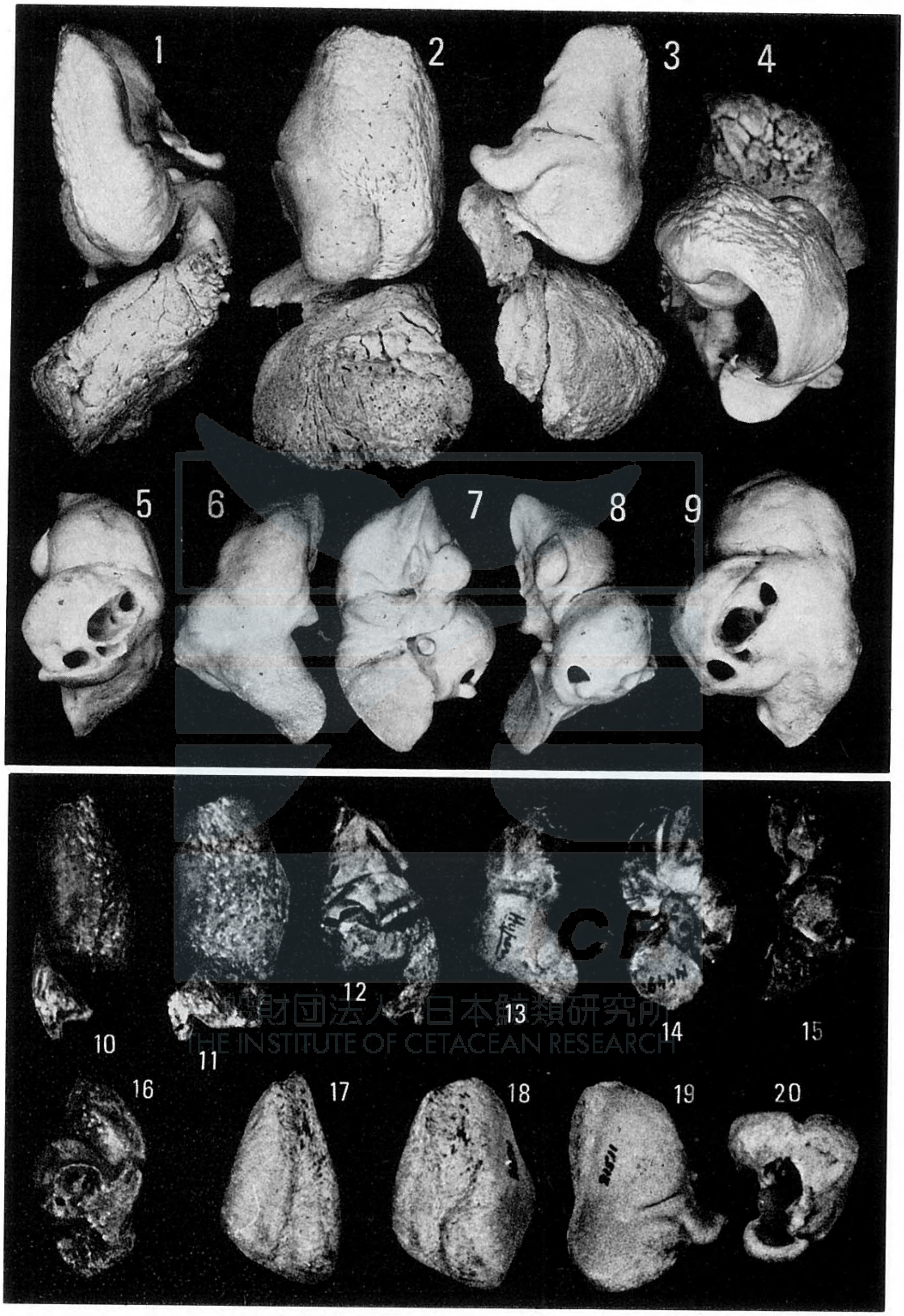
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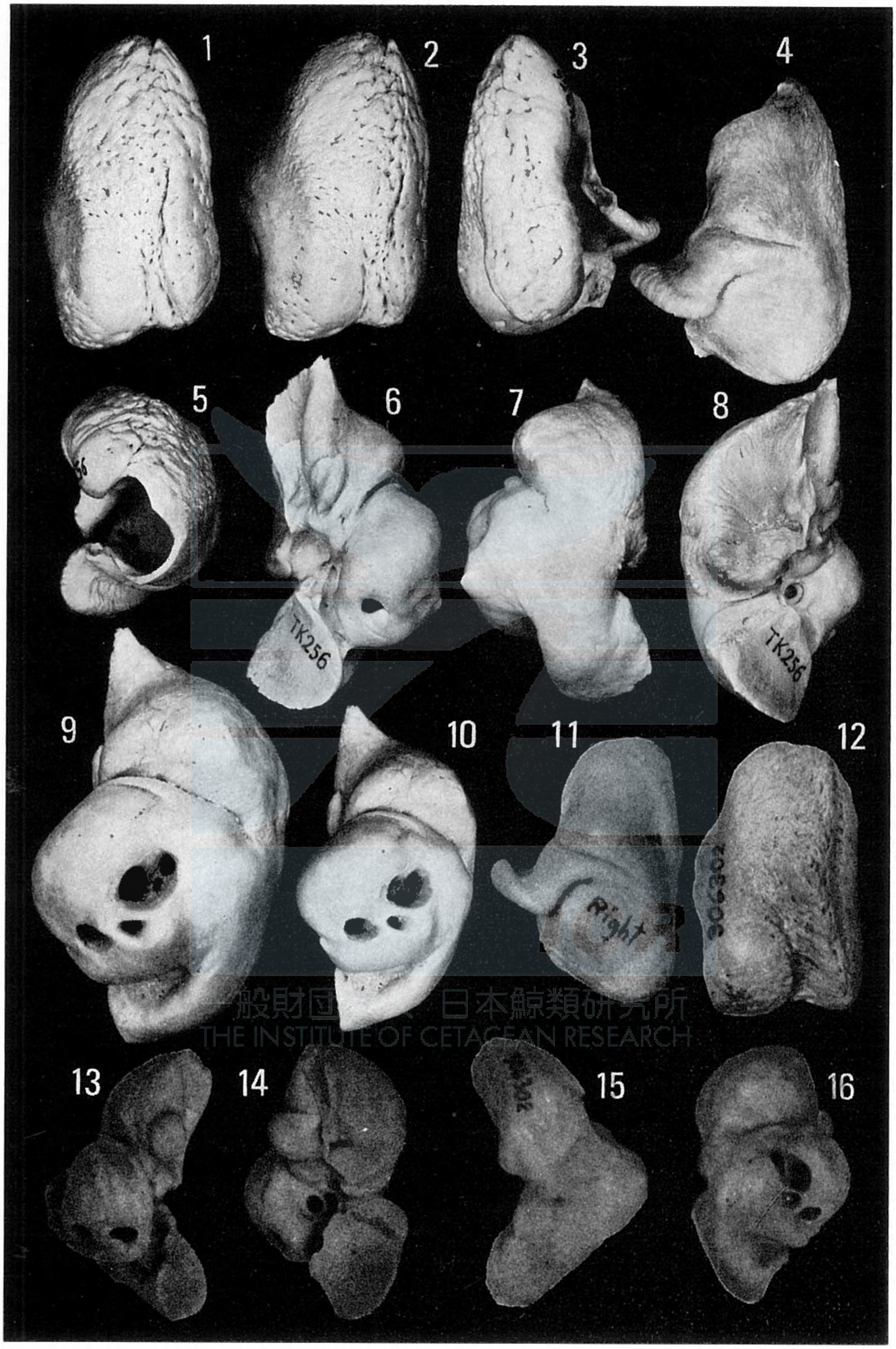
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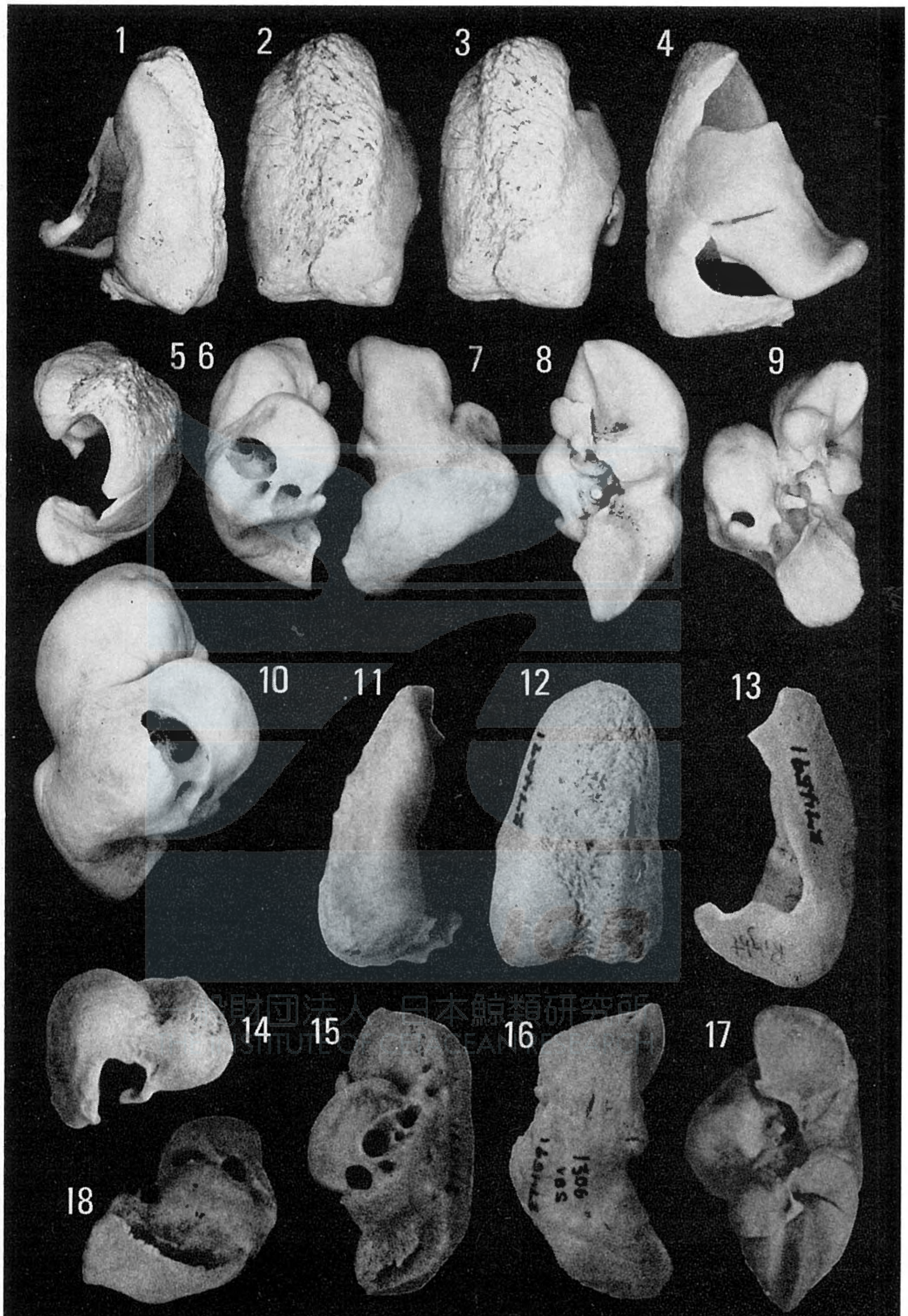
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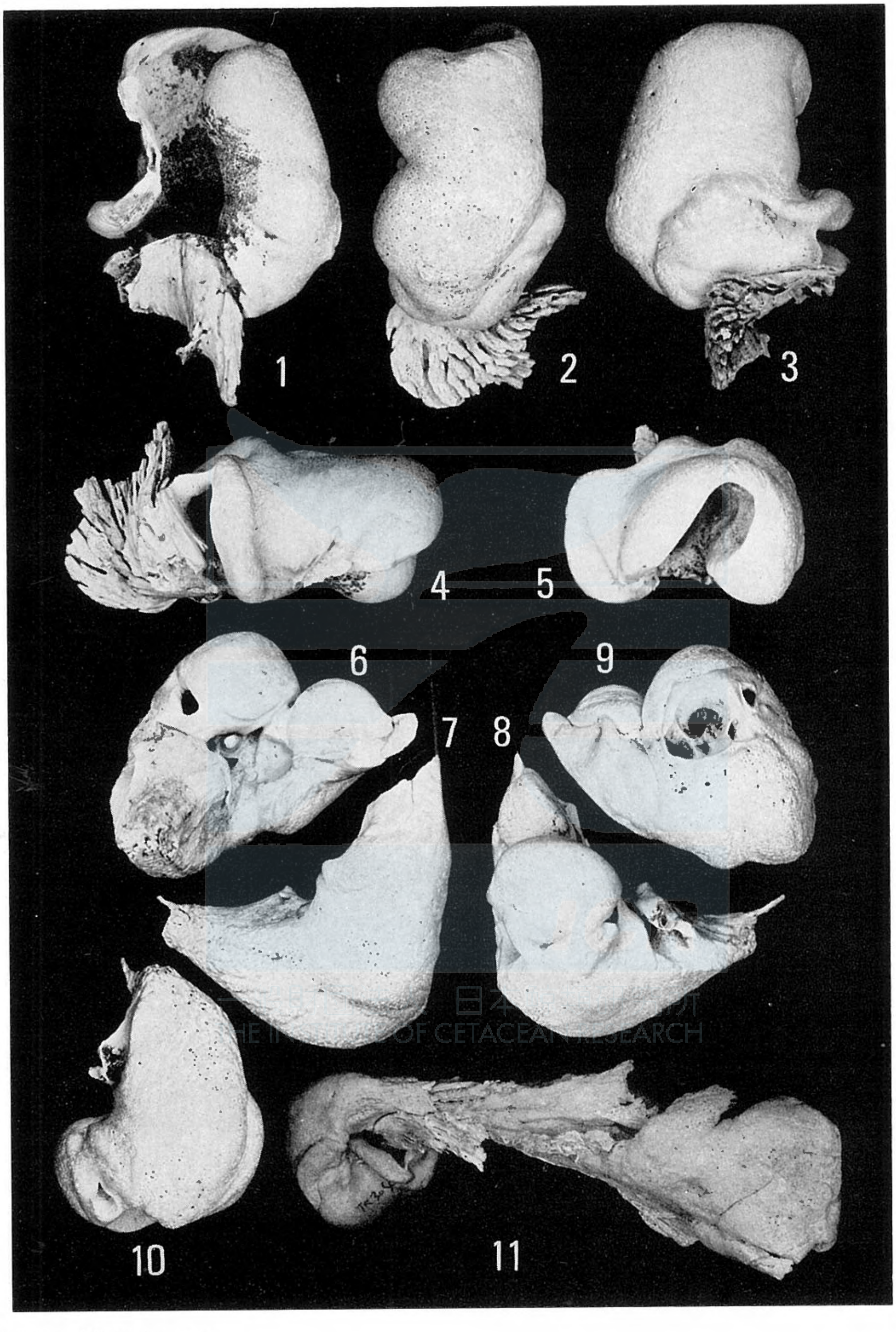
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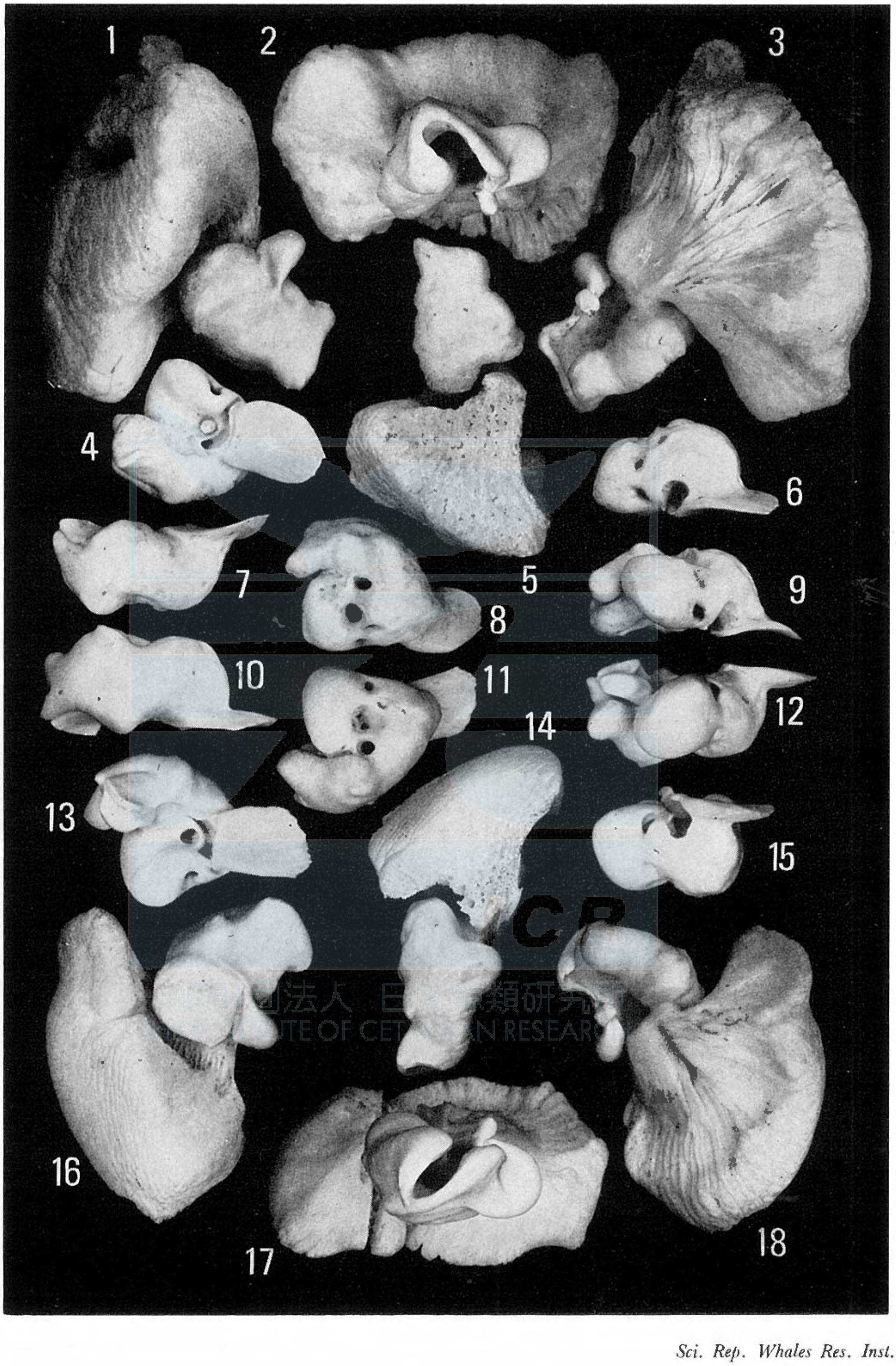
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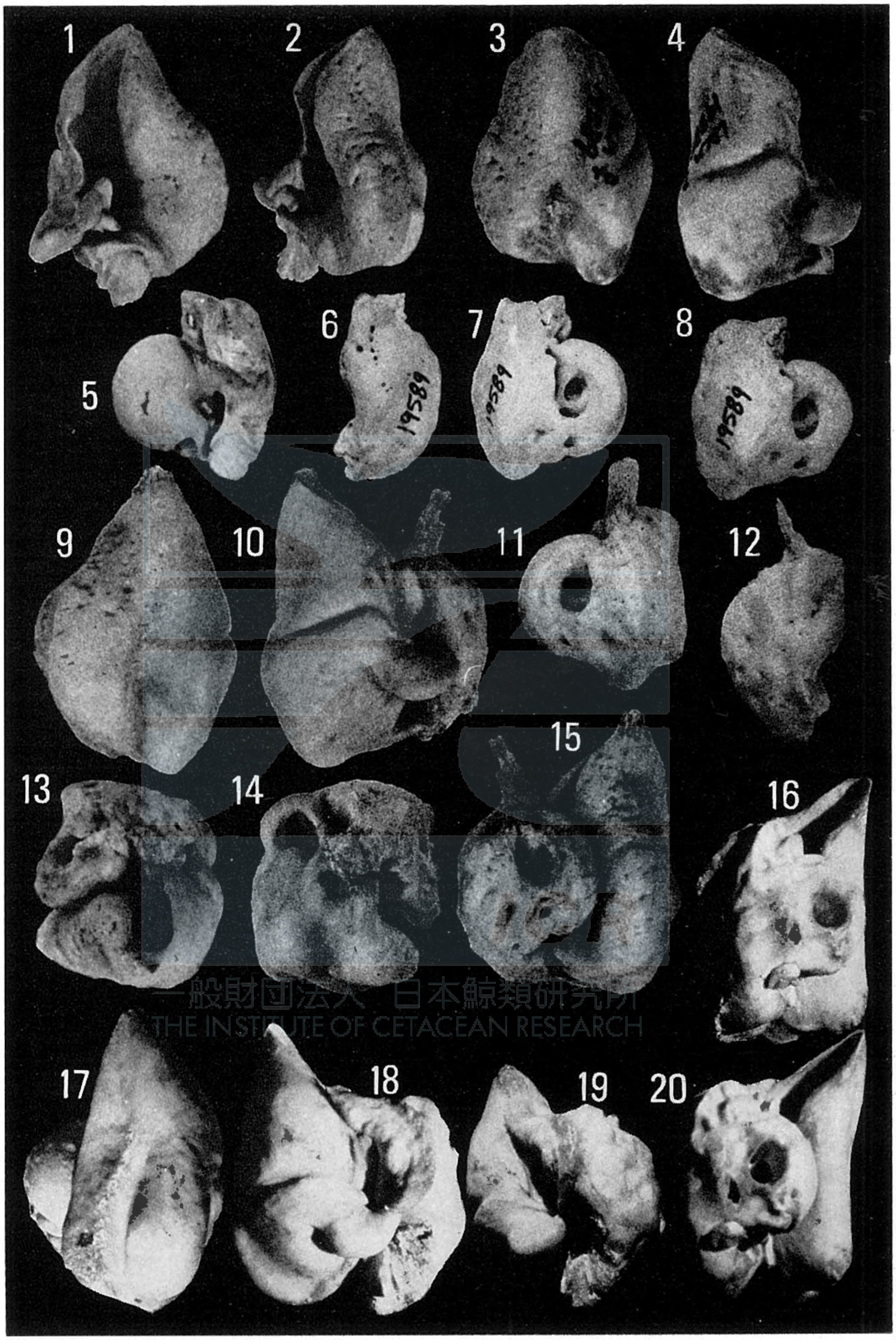
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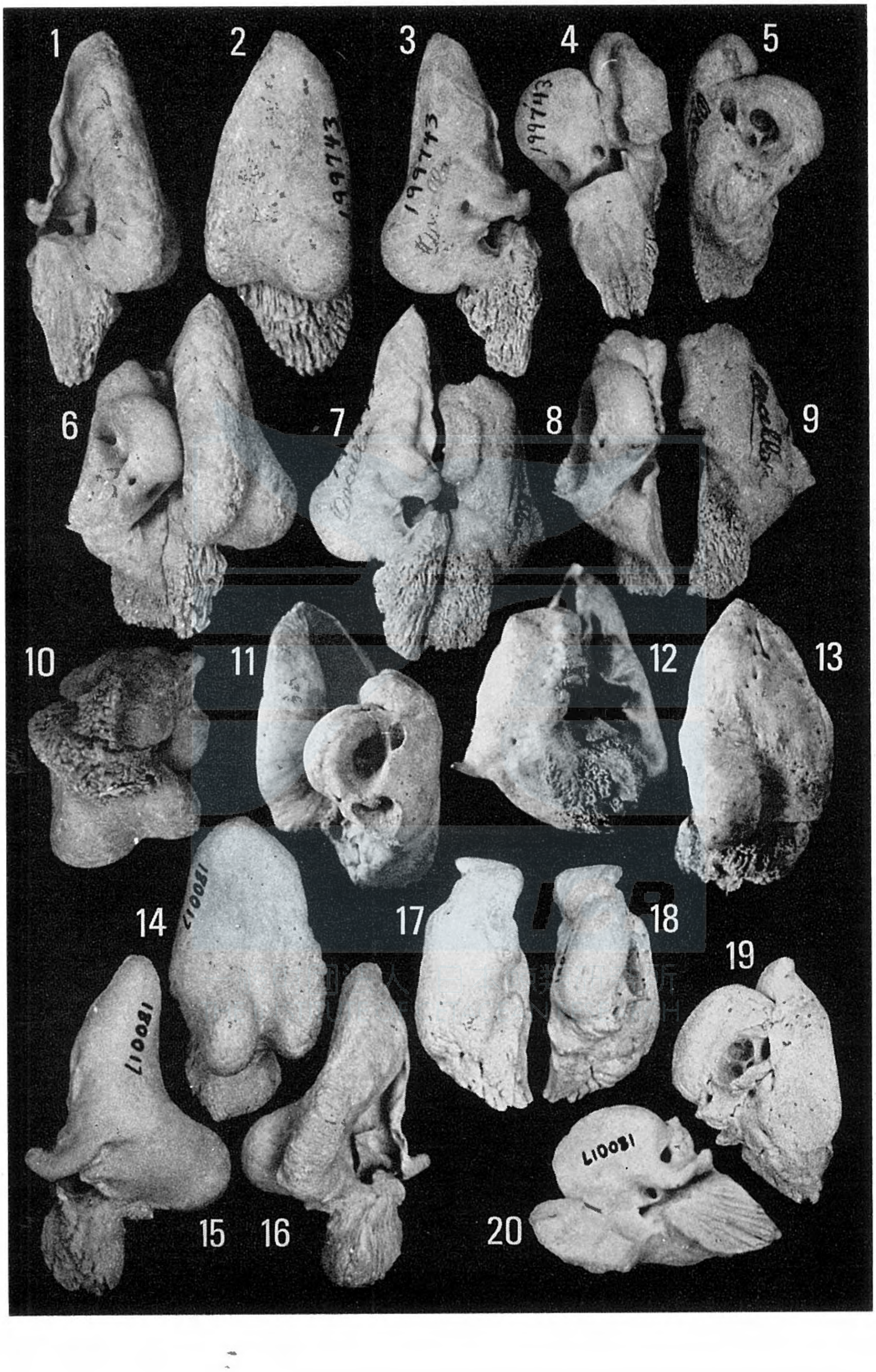
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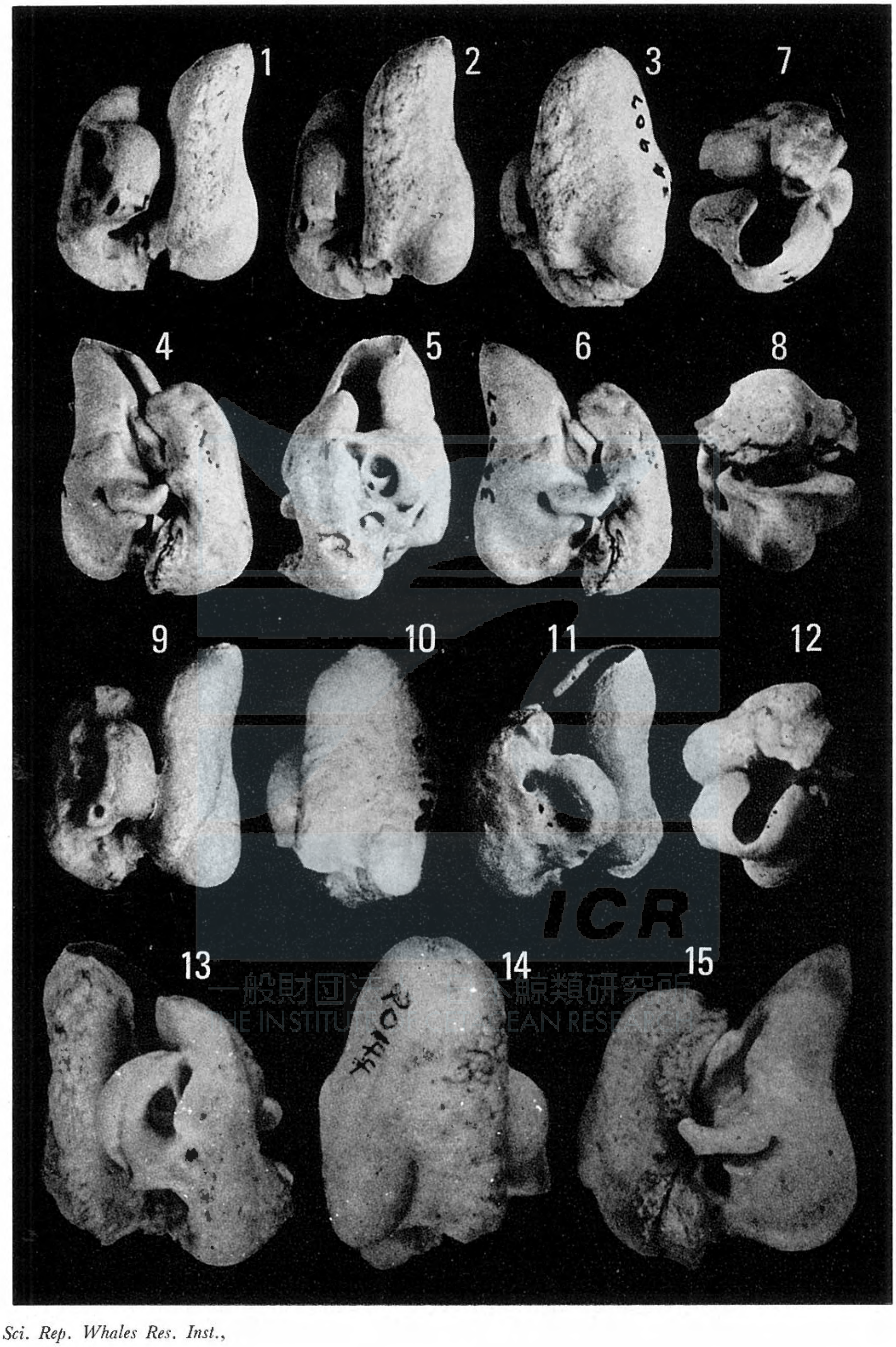
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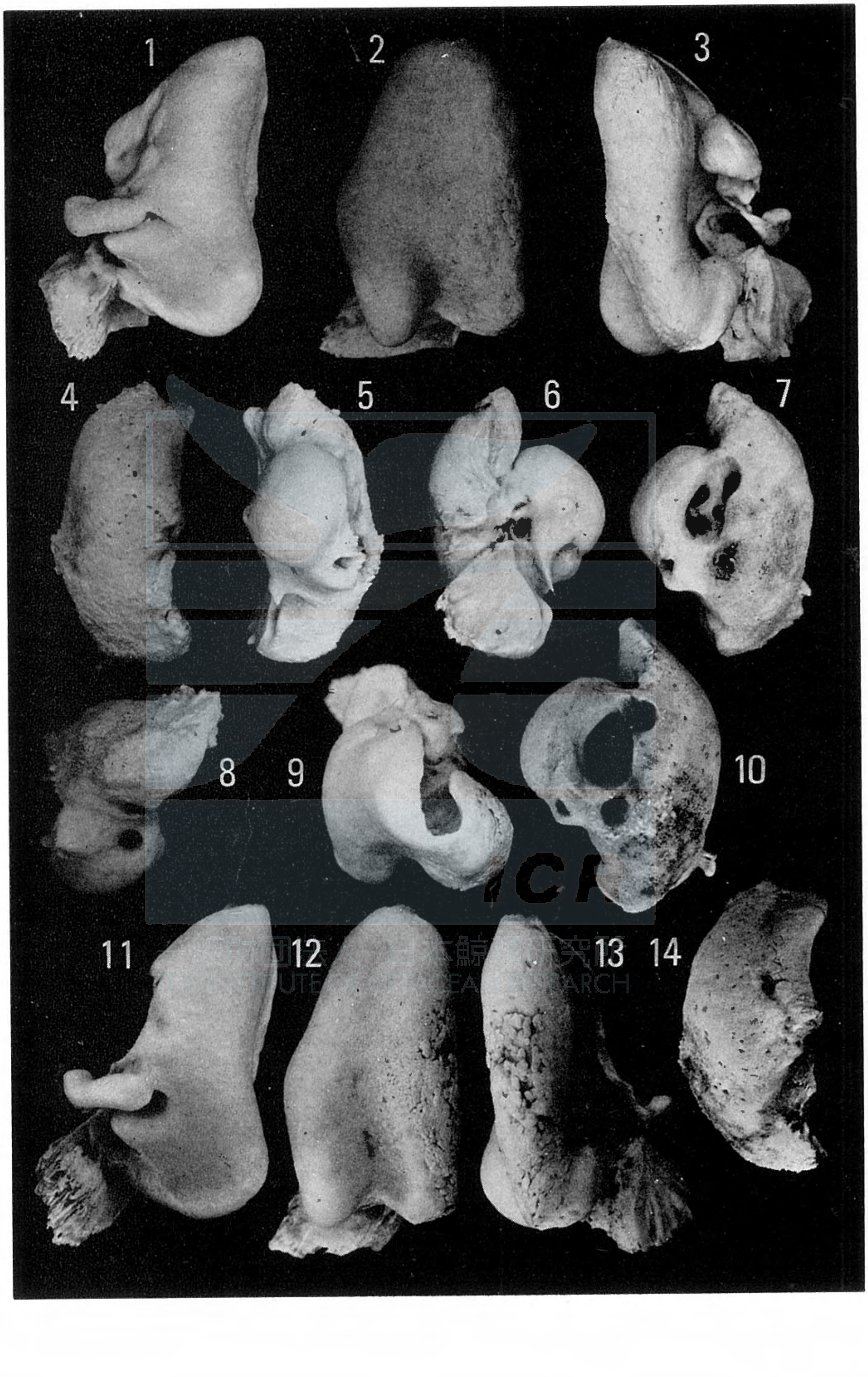
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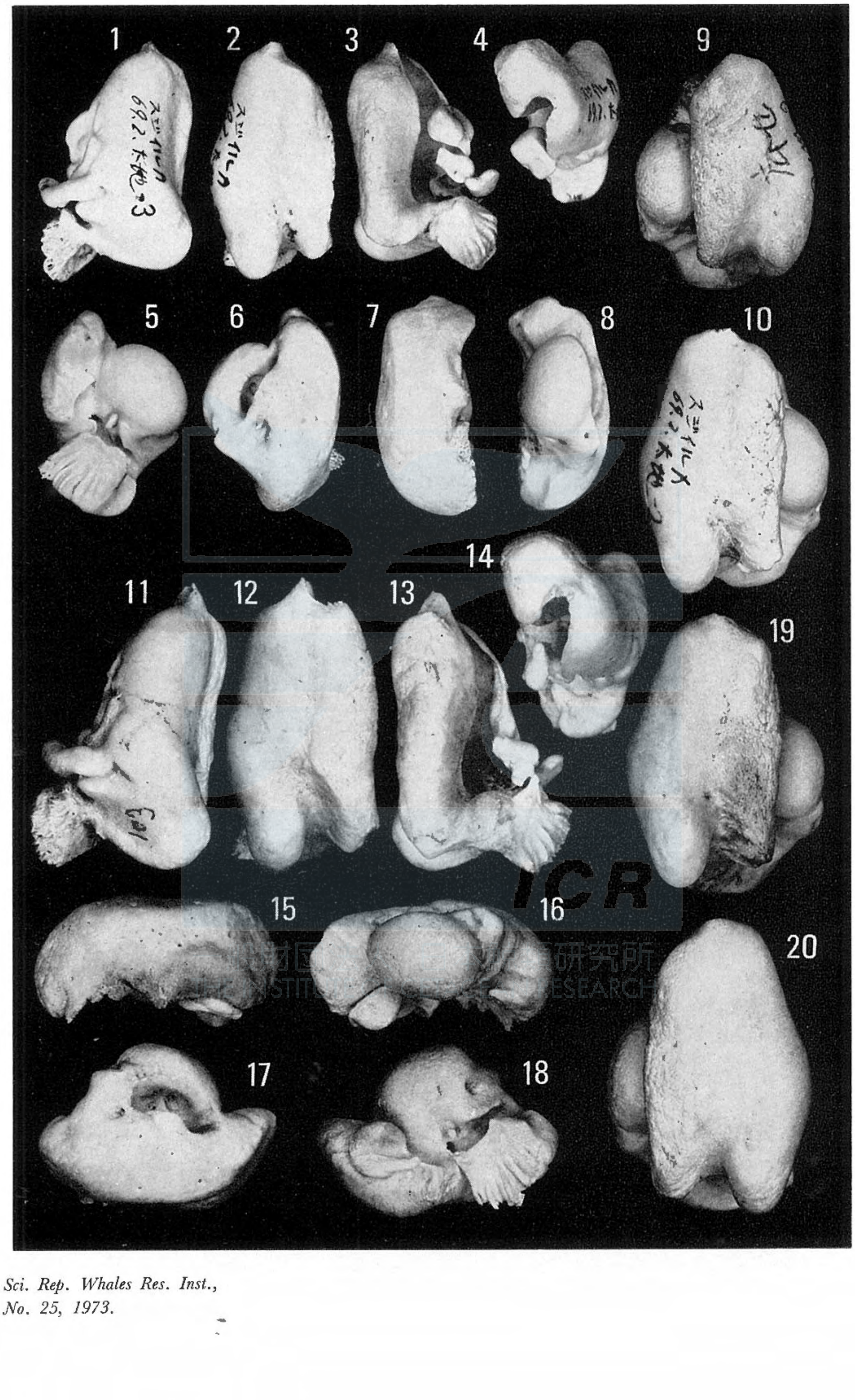
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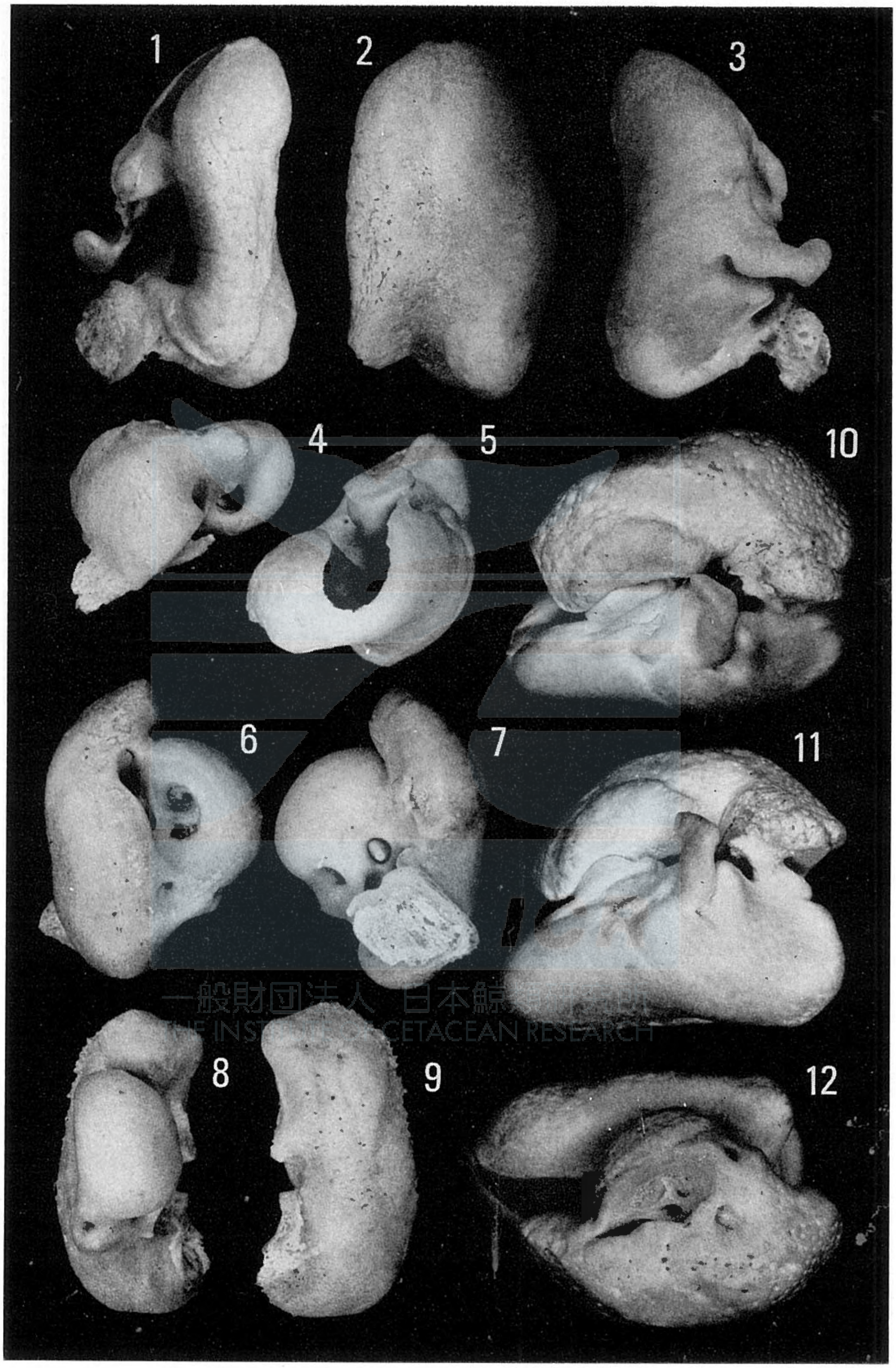
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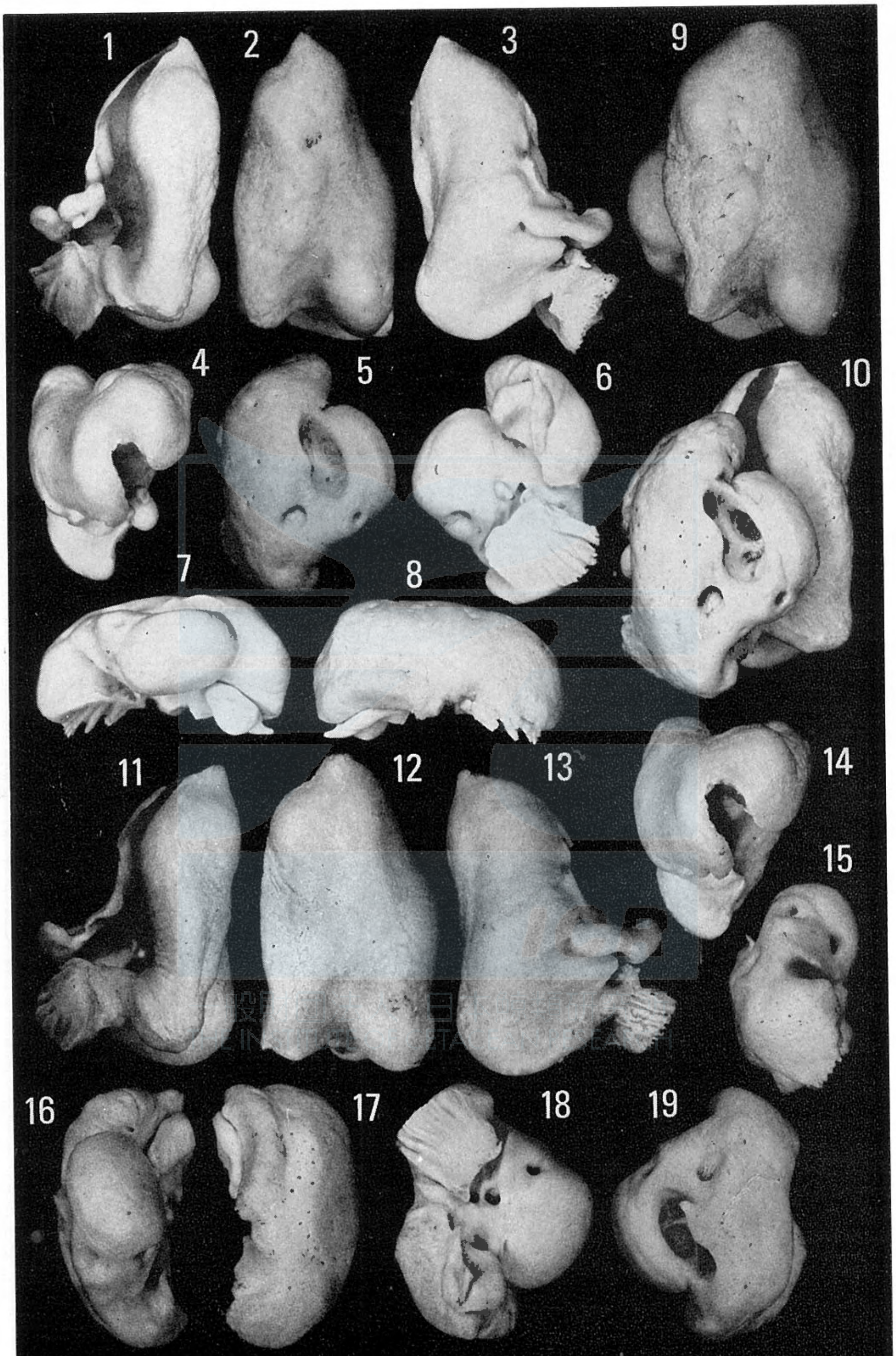
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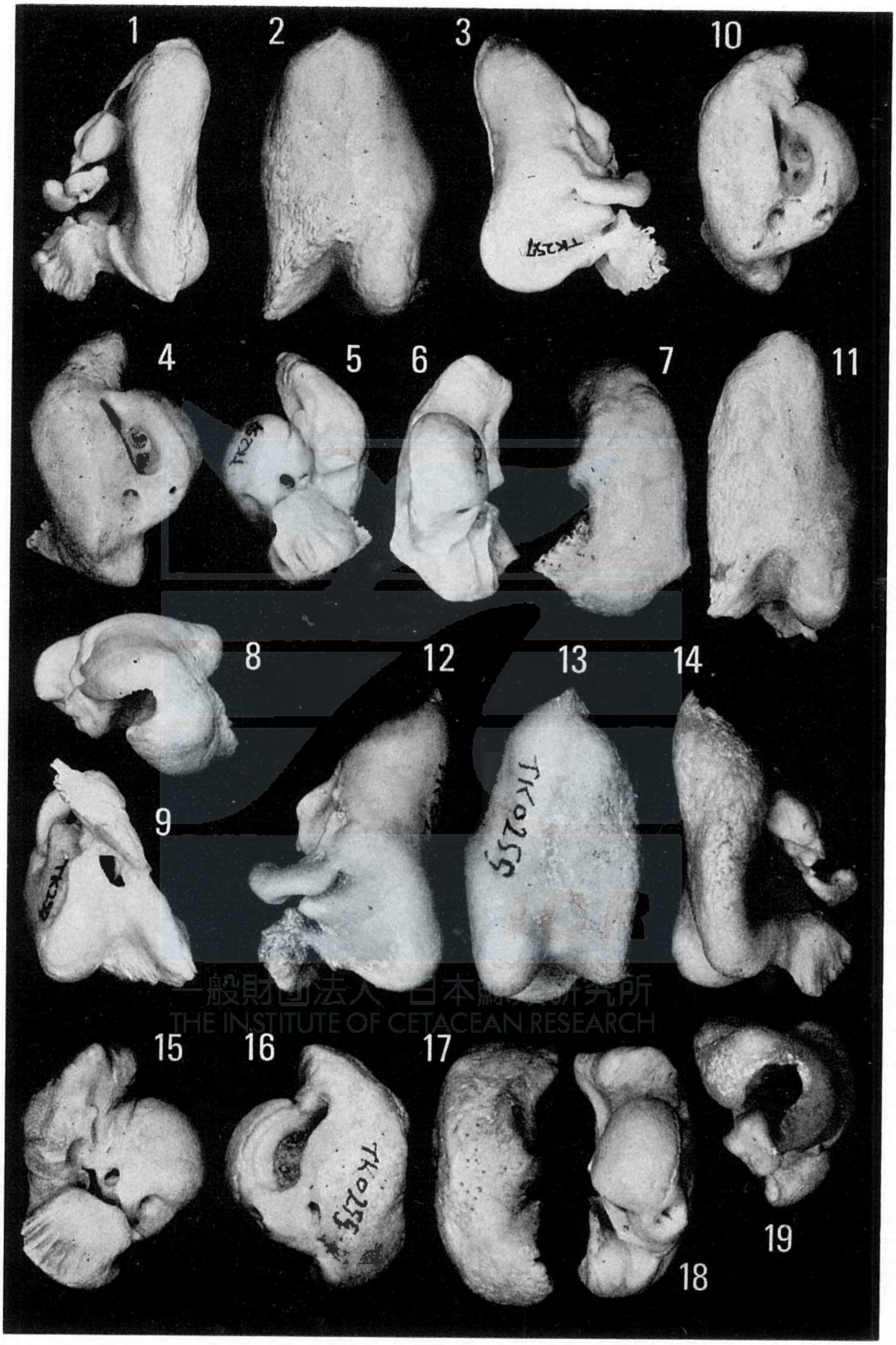
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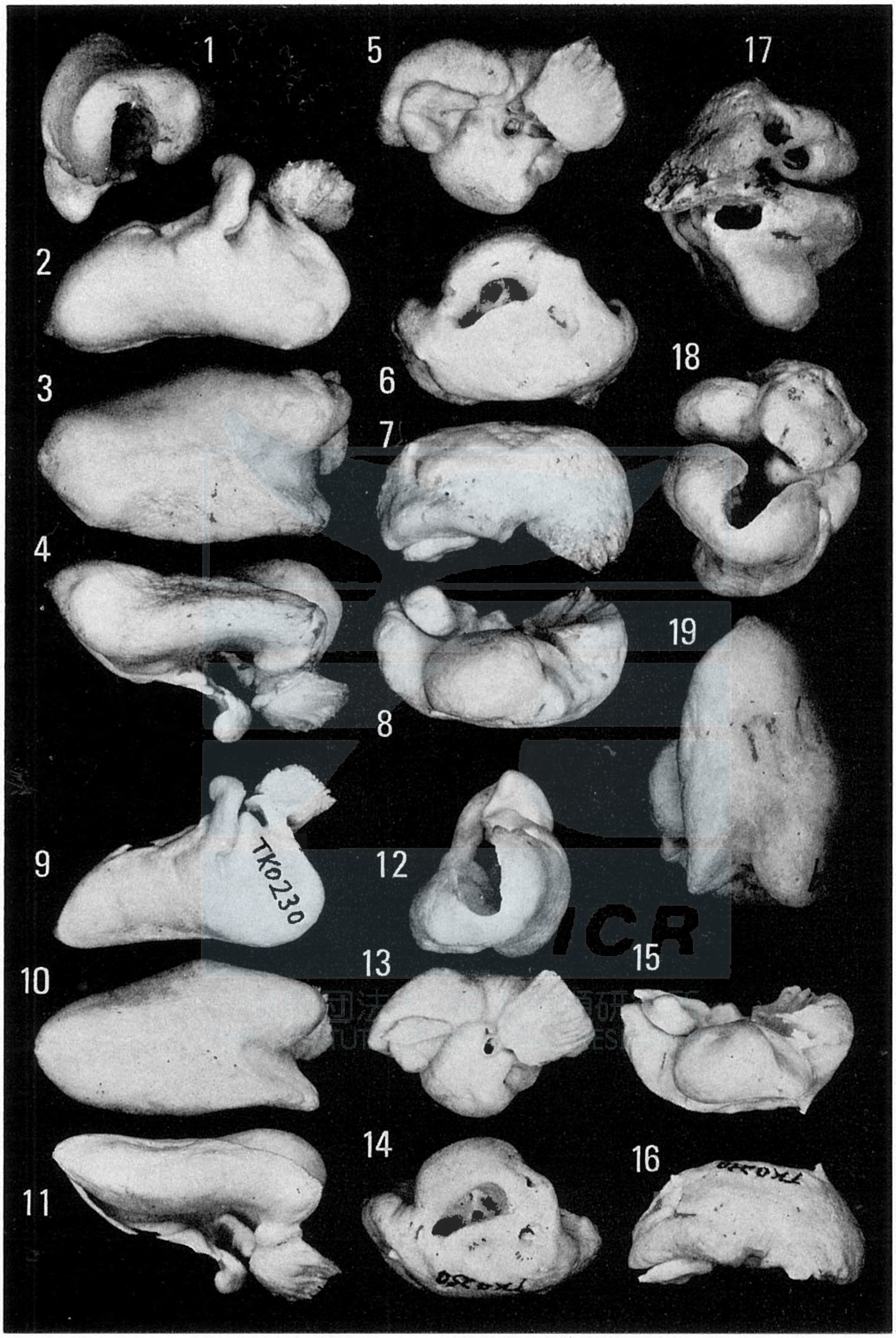
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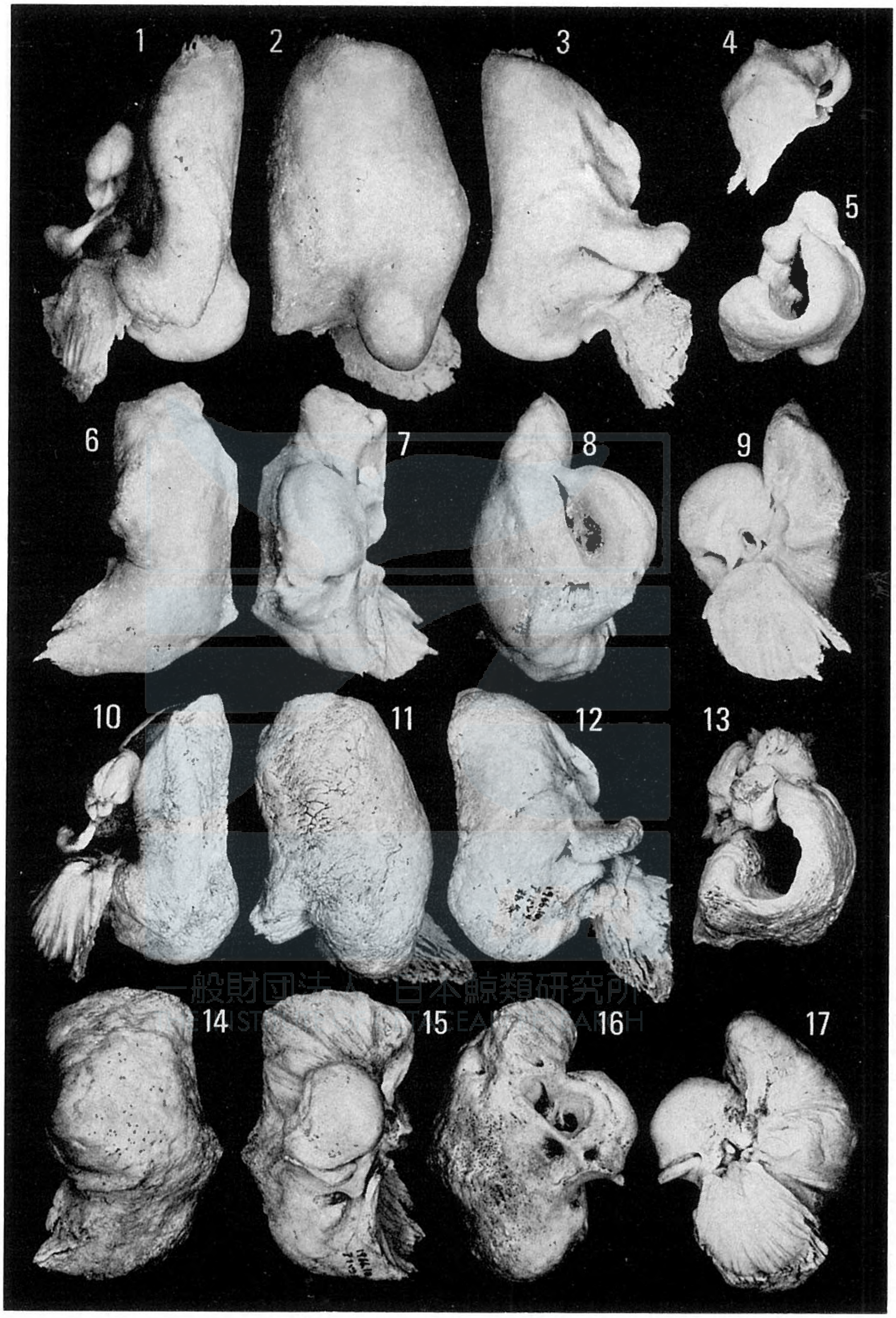
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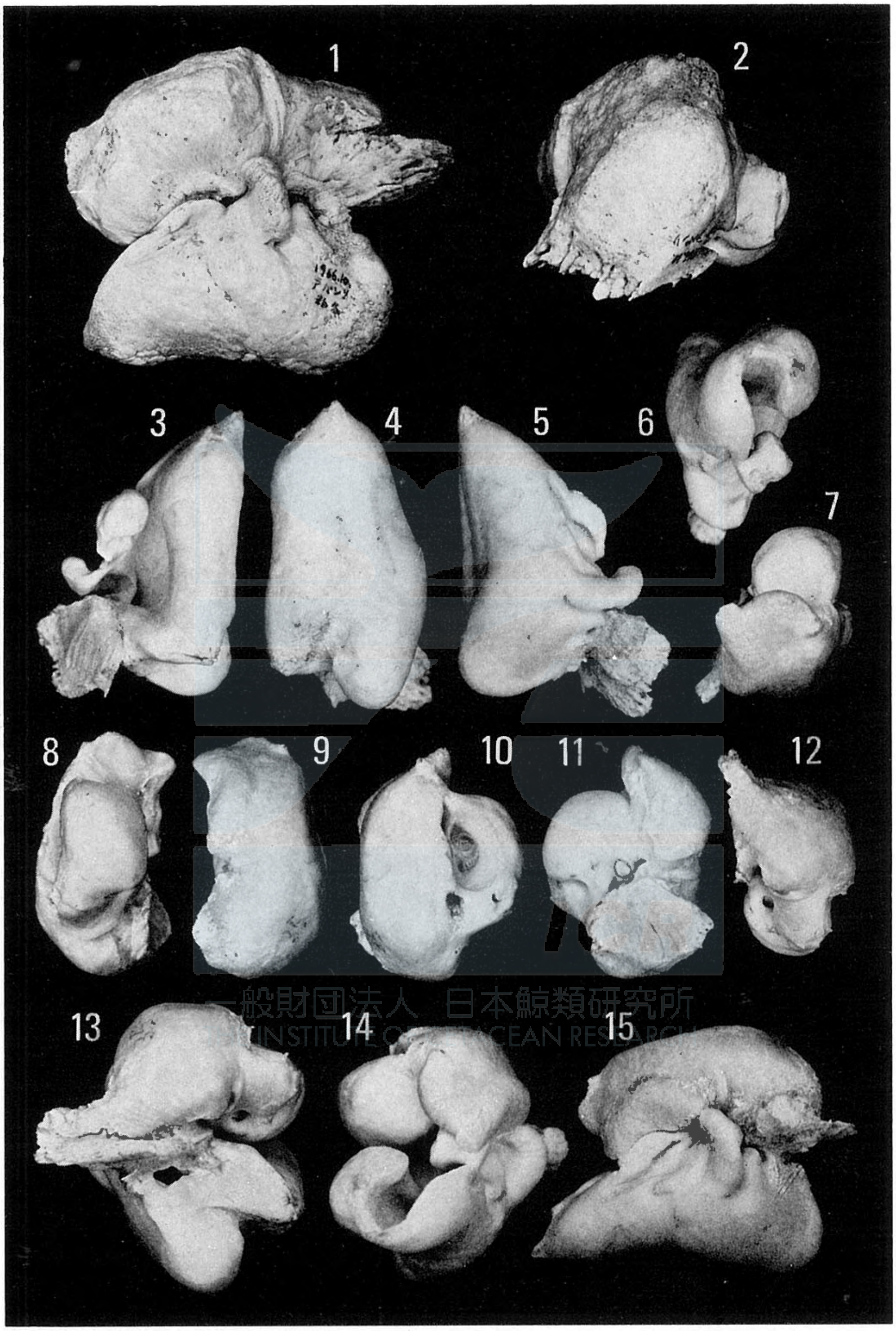
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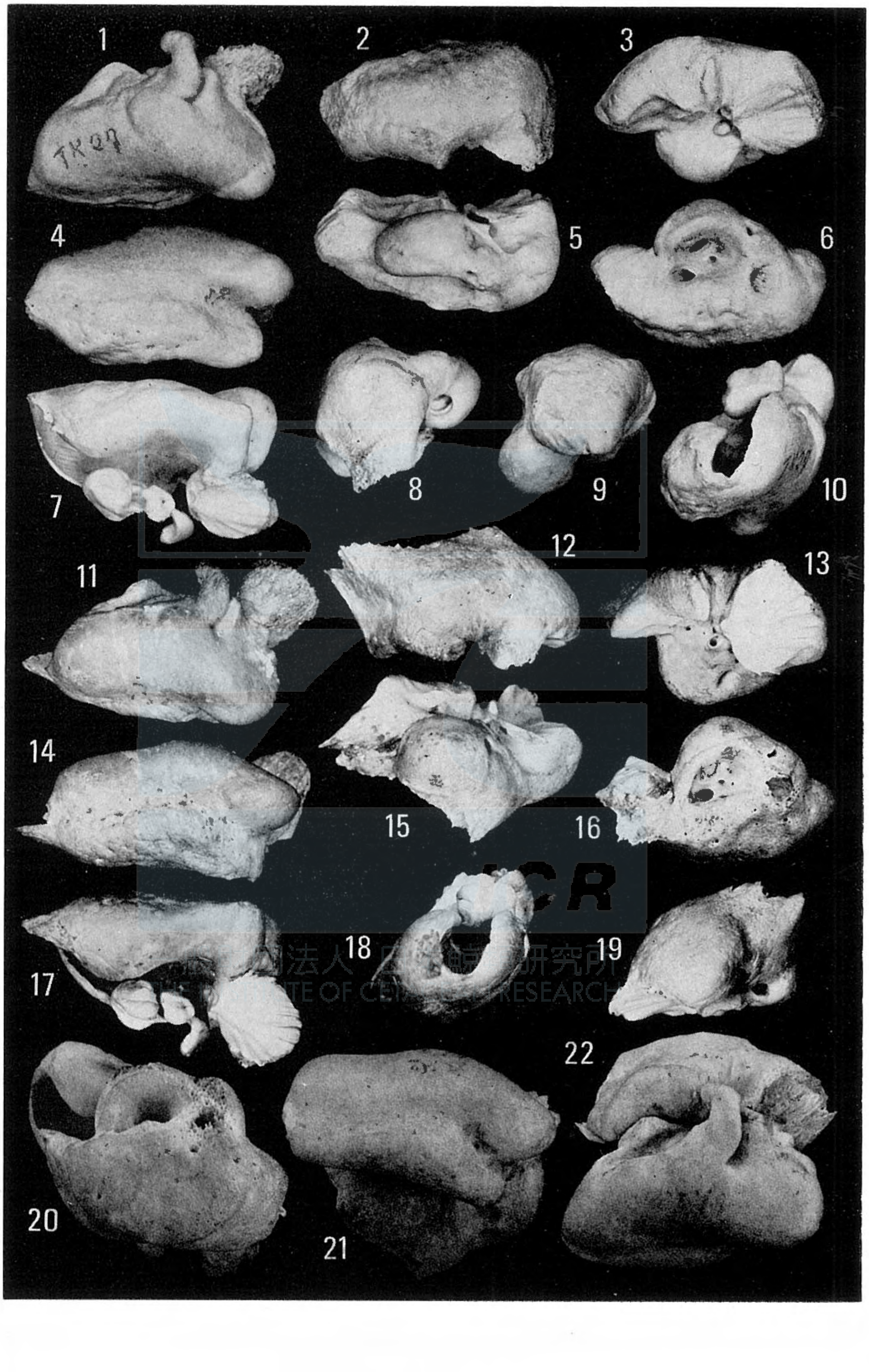
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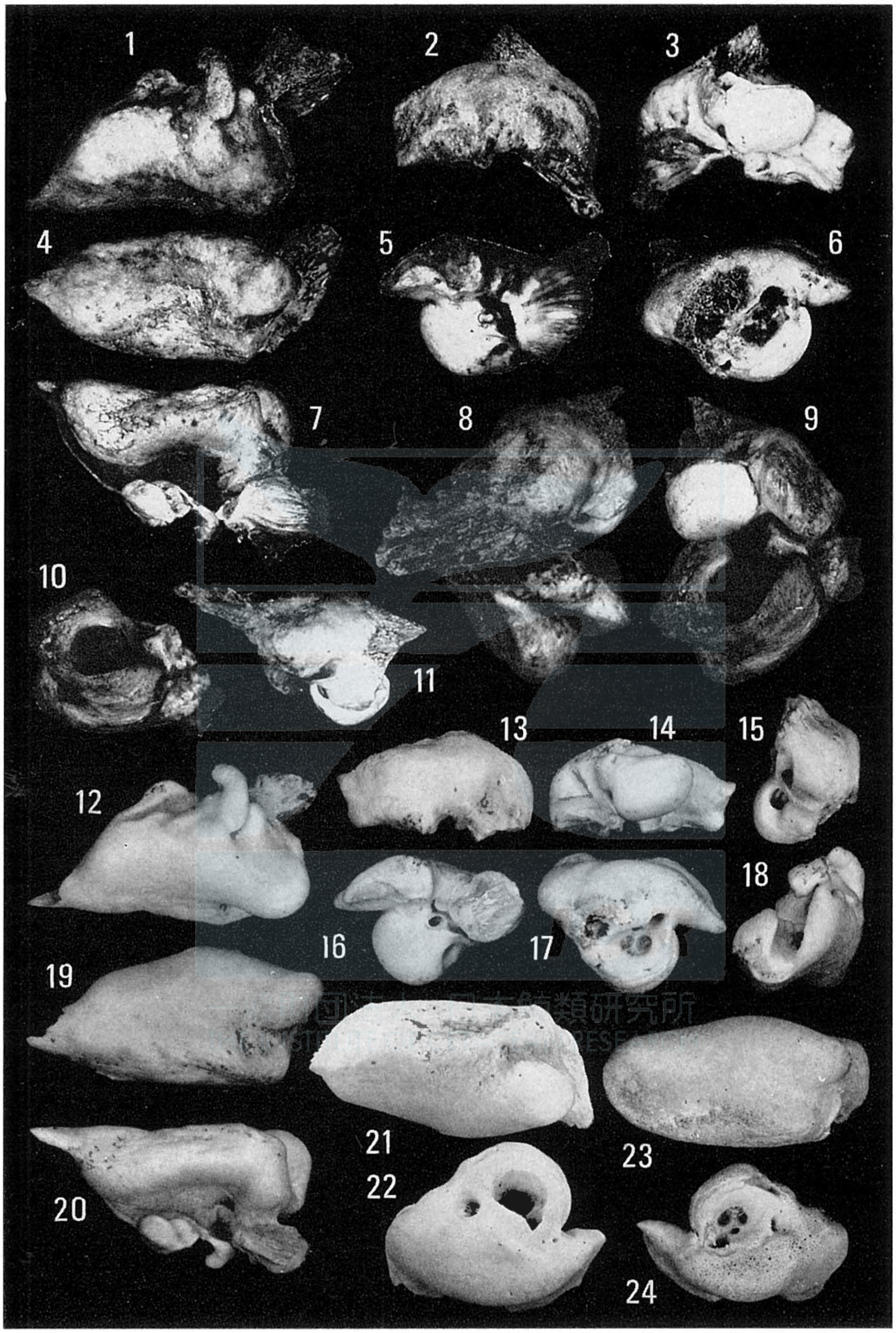
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A REVIEW OF PELAGIC WHALING OPERATIONS IN THE ANTARCTIC BASED ON THE EFFORT AND CATCH DATA IN 10° SQUARES OF LATITUDE AND LONGITUDE

HIDEO OMURA

Whales Research Institute, Tokyo

ABSTRACT

Effort and catch data in 10° squares of latitude and longitude of the pelagic whaling operations in the Antarctic in the past 35 seasons from 1931–32 to 1971–72 were summed up and briefly analyzed. Bigger concentrations of the baleen whales were in the Weddell (II), Bouvet (III) and Kerguelen (IV) areas. In the Pacific areas the catch was far smaller than in these areas. More than two million tons of baleen whales in weight were produced in each of four squares during these 35 seasons, three in area III and one in area IV.

Further analyses were made dividing whole period into four, a prewar period and three periods in the postwar.

INTRODUCTION

Hjort, Lie and Ruud (1932) analyzed the material obtained from the Norwegian whaling expeditions during the seasons 1929–30 and 1930–31, dividing the sea into a number of small areas measuring 10 degrees of latitude by 10 degrees of longitude, which was termed " squares ". The region round the South Polar continent then separated into three distinct series of such squares, viz.:

Series A, the zone between 50° and 60°S
„ B, „ „ 60° „ 70°S
„ C, „ „ 70° „ 80°S

Within these Series the squares were numbered consecutively in an eastward direction from the square between 50° and 60°W (No. 1). Further they defined the following more extensive areas:

I. The area of land stations in the Falkland's Dependencies.
II. The Weddell Sea from 0° to 60° West excepting the zones within which the boats from the land stations are working.
III. The Bouvet-area from 0° to 70° East.
IV. The Kerguelen-area from 70° to 130° East.
V. The Ross Sea area from 130° East to 170° West.

To date these divisions of whaling ground are in practice in analyzing the

Sci. Rep. Whales Res. Inst.,
No. 25, 1973, 105–203

catch and effort material, with slight change and addition of area and zone due to the opening of the sanctuary in the South Pacific sector in 1955 and shifting of expeditions to north towards the beginning of 1960's, viz.:

The original area I was abolished and re-designated to the sea area from 120°W to 60°W, and the area from 170°W to 120°W was defined area VI in 1955. The series D, the zone between 40° and 50°S was added in 1962.

Further Hjort, Lie and Ruud (1933) had introduced a concept of "catch per boat per day" and in this connection they used the expression "catcher's day's work" (CDW) in measuring effort.

The catch figures of blue, fin, humpback, and sei whales by pelagic operations and the amount of effort expended, expressed as catcher's day's work, in each 10° square in each month are available for 35 seasons since 1931–32 season. These material are being kept at the Whales Research Institute. Some of them were supplied by The Late Professor Johan T. Ruud personally (before the war seasons), some were distributed at meetings of the International Whaling Commission, some were supplied from the Bureau of the International Whaling Statistics. In addition Mr. E. Vangstein of the BIWS had kindly sent me material for lacking 10 seasons upon my request.

These materials were firstly tabulated in the form shown in Appendices Tables and then briefly analyzed, dividing into following four periods.

1. 1931–32 to 1938–39 seasons. Prewar seasons.
2. 1945–46 to 1954–55 seasons. From the first postwar season to the opening of the sanctuary.
3. 1955–56 to 1961–62 seasons. From the opening of the sanctuary to the period of expansion into D series.
4. 1962–63 to 1971–72 seasons. Recent ten seasons.

Finally all these data were summed up in order to get some idea on the concentration of each species of baleen whales as a whole and hence some suggestions on their stock units.

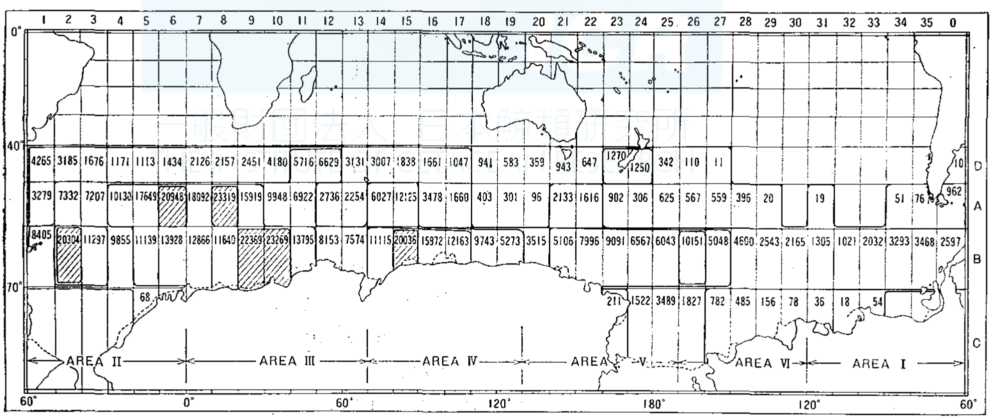

Fig. 1. Total catcher's day's works expended in each square during 35 seasons from 1931–32 to 1971–72.

TOTALS OF 35 SEASONS

Catcher's day's work. Total catcher's day's works expended during 35 seasons from 1931–32 to 1971–72 in each 10° square are shown in Fig. 1. The contour lines drawn in the figure denote 1,000, 5,000, 10,000 and 20,000 CDWs and the squares in which CDW exceed 20,000 are shown with hatched lines. As shown in this figure the most frequently operated squares are B2, A6 (area II), B9, B10, A8 (area III) and B15 (area IV) in which total efforts exceeded 20,000 CDWs. In areas V, VI and I lower figures are seen in general, especially in the latter two areas, excepting the square B26 in which CDW exceeds 10,000. In these two areas figures in the series D and A are negligible in squares eastwards from the square 28.

Fig. 1 reflects well the geographical abundance of baleen whales in the Antarctic, which is shown in Fig. 2.

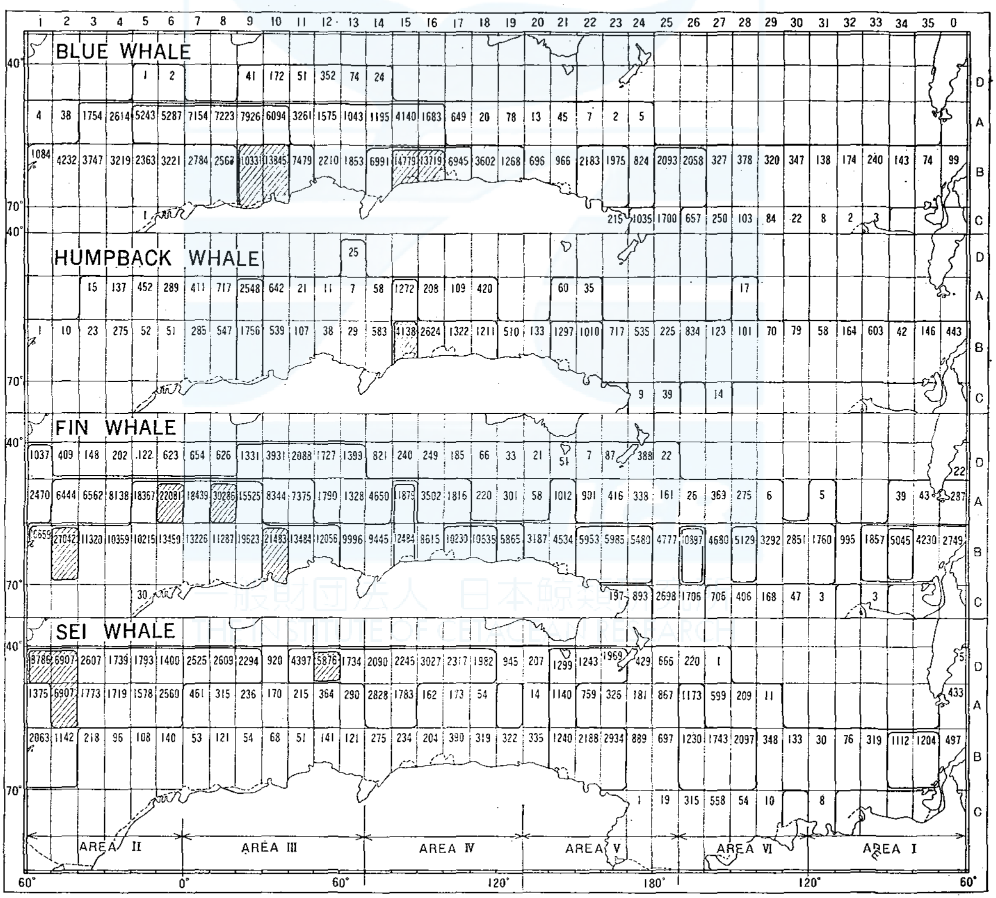

Fig. 2. Number of blue, humpback, fin and sei whales taken in each square during 35 seasons from 1931–32 to 1971–72.

Catch of baleen whales. The numbers of the blue, humpback, fin and sei whales taken in each square during 35 seasons from 1931–32 to 1971–72 are shown in Fig. 2. Contour lines and hatched lines were also drawn in order to show their concentrations.

In the series B the bigger concentrations of the blue whale catch are seen in squares B9 and B10 in area III and B15 and B16 in area IV. In each of these squares the catch exceeds 10,000 whales and with neighboring squares they are forming two big concentrations, one each in the areas III and IV. But in the A series from the square 5 eastwards through square 10 the catches of the blue whale are all exceed 5,000 and there seems no boundary between the areas II and III stocks.

For the humpback whale three concentrations of the catch are observed in the figure, suggesting each one stock in areas III, IV and V. These are A9 and B9 in the area III, A15 and from B15 through B18 in the area IV, and B21 and B22 in the area V. In the area II the catch of humpbacks is rather few in each of the squares, but the fact should be reminded in this connection that this species was hunted intensively at South Georgia and South Shetland in the years prior to the introduction of pelagic operation (International Whaling Statistics).

The fin whale is distributed more abundantly than any of other species in each square, but the bigger concentrations in the series B are B2 (area II) and B10 (area III), and in the series A are A6 (area II) and A8 (area III). In squares from B1 to B12 and A5 to A9 the catches are comparatively high and it is suggested that there is no definite distinction between the areas II and III stocks. In area IV B15 is also has a concentration of the catch, as in the case of blue and humpback whales, but in the fin whale it extends north to the square A15. In the other areas the biggest concentration is seen in B26 in area VI. In the series D the catch is less than 1,000 in squares excepting D1 (area II) and D9-D13 (area III) in which it exceed 1,000. Fujino (1964) reports the presence of low latitudinal fin whale subpopulation in area III and this will support his finding (See also Fig. 15).

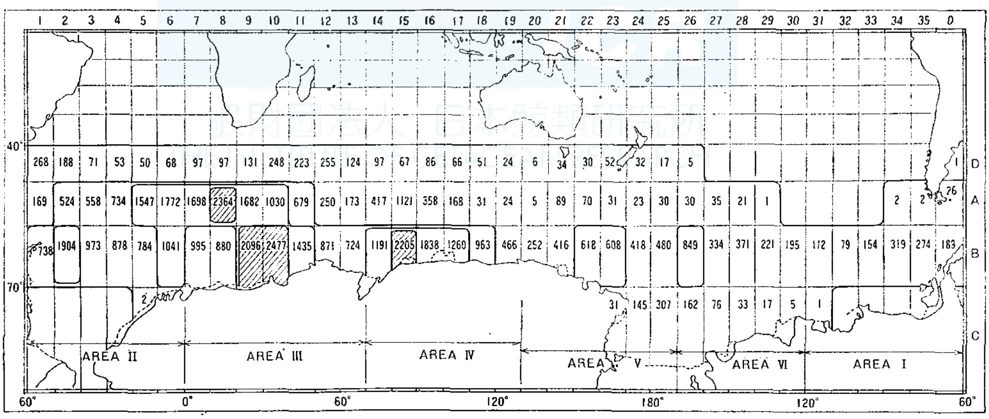

Fig. 3. Total weight of baleen whales taken in each square during 35 seasons from 1931–32 to 1971–72. Unit 1,000 metric tons.

The sei whale seems to have five concentrations as shown by contour lines of 1,000 whales, viz.:

1. Area formed by the squares D1-D9, A1-A6 and B1-B2, with center D1, D2 and A2.
2. Area formed by the squares D11-D18, B14 and B15, with center D12.
3. Area formed by the squares D21-D23, A21 and B21-B23.
4. Area formed by the squares A26 and B26-B28.
5. Area formed by the squares B34 and B35.

Whether or not each of these concentrations of the catch represents separate stock unit of the sei whales is naturally dependent on future study.

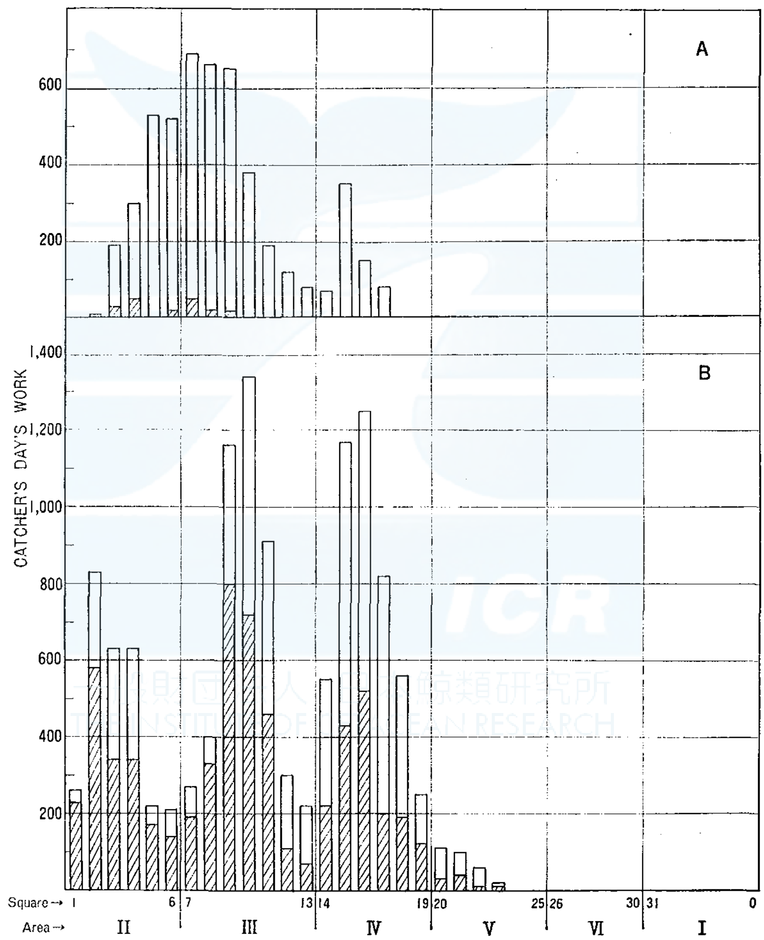

Fig. 4. Average number of catcher's day's work in each square during 8 seasons from 1931–32 to 1938–39. The white area denotes fore-half and the hatched area latter-half of the season. This also applies for Figs. 5–16.

Biomass of the catches. Crisp (1962) and Mackintosh (1970) have converted the number of each species taken into weight in a series of seasons. I also made similar calculations in order to know how the biomass of the catches of baleen whales are distributed geographically in the Antarctic. The average body weights of the blue, humpback, fin and sei whales used in this calculation are 92, 37, 55 and 24 metric tons respectively. These figures are based on the calculation by Crisp (1962), but 10% was added as weight of blood. For the pygmy blue whale the same weight of 55 tons of the fin whale was used and all catches of the blue whale in the series D and

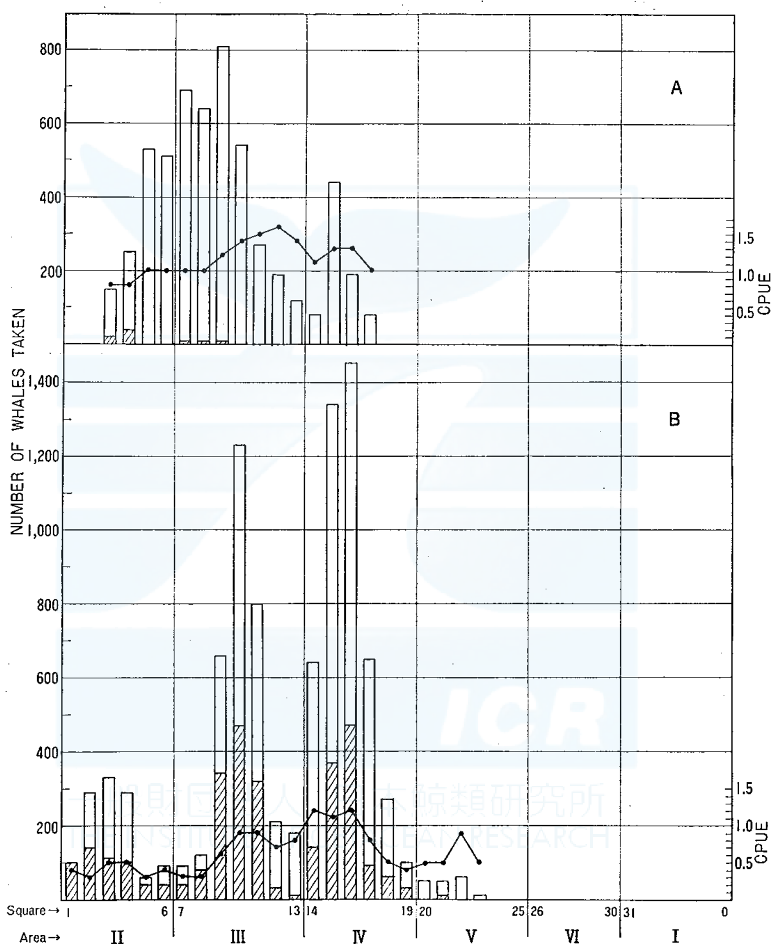

Fig. 5. Average number of blue whale catch and CPUE in each square during 8 seasons from 1931–32 to 1938–39.

those taken since 1959–60 season in the areas II, III and IV in the series A are all deemed as pygmy blue whales.

In Fig. 3 the results of the calculation are shown in order to get some idea, even very rough, concerning the productivity of the Antarctic ocean. As shown in this figure the squares in which more than two million tons of baleen whales were produced in the past 35 seasons are B9, B10, B15 and A8. In general it will be concluded that the productivity is far greater in the areas III, IV and II than in the other areas.

PERIOD 1 (8 SEASONS FROM 1931–32 TO 1938–39)

In the analysis of each period, average figures per season were calculated for the catcher's day's work and catches of various species of baleen whales in each square. Gross CPUE (catch per unit of effort), not corrected for the tonnages of catcher boats, was also calculated. Further the CDW and catch were divided into fore and latter halves of the season. The actual date so dividing is not definite one, because the opening date was changed frequently even under the control of the present convention (International Whaling Commission. Reports). But arbitrarily 1st of February was chosen as such date and compilation was made before and after that date.

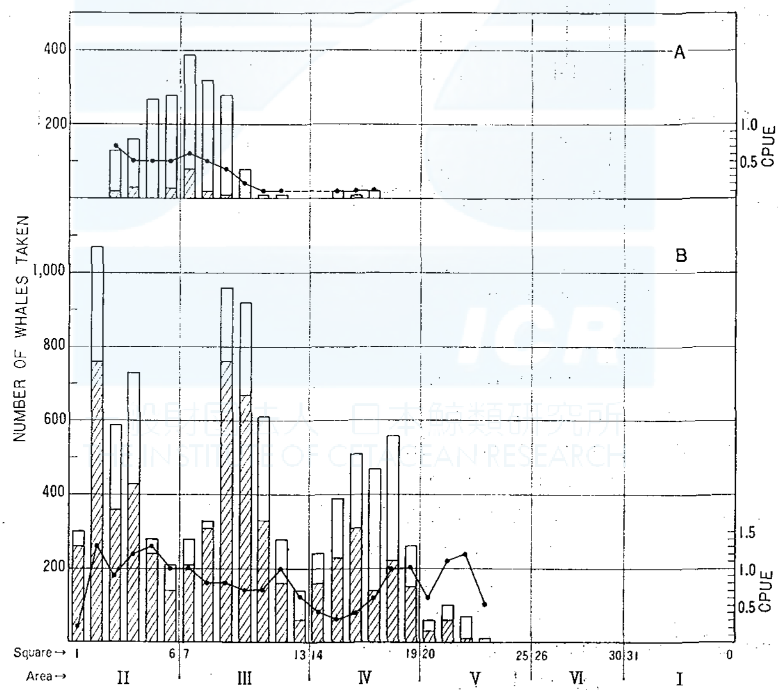

Fig. 6. Average number of fin whale catch and CPUE in each square during 8 seasons from 1931–32 to 1938–39.

In Fig. 4 the average number of CDW in each square during 8 seasons from 1931–32 to 1938–39 are shown, separately by the series A and B. The white area in the graph denotes CDW expended in the fore-half and the hatched area those in the latter-half of the season. As seen in this figure most of the expeditions have worked mainly in the areas II, III and IV, especially in the B series. In the series A almost all CDW were expended in the fore-half of the season, before February. In the series B areas are well defined, having their peak towards the middle. In general CDW is greater in the fore-half than in the latter-half of the season, but this is due to the earlier opening of the season than in the latter periods.

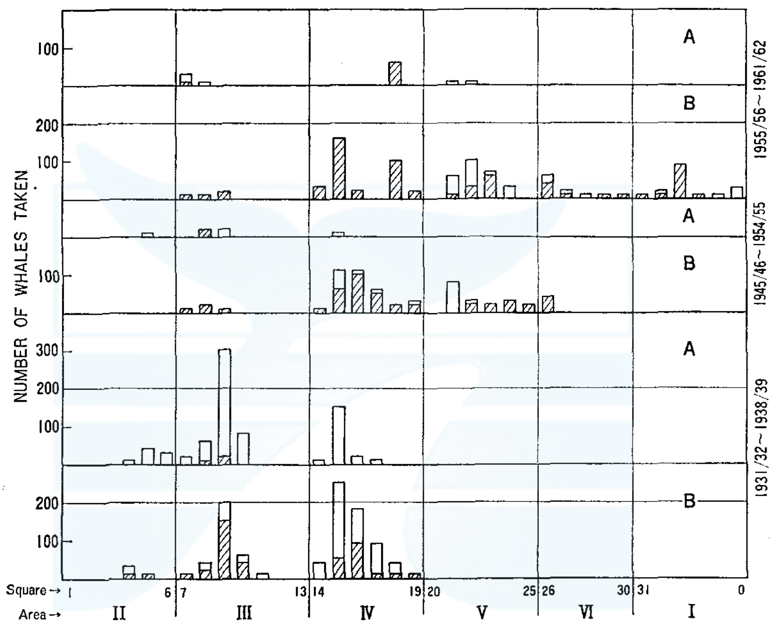

Fig. 7. Average number of humpback whale catch in each square during 8 seasons from 1931–32 to 1938–39, 10 seasons from 1945–46 to 1954–55, and 7 seasons from 1955–56 to 1961–62.

In Fig. 5 are shown the average number of blue whale catch and gross CPUE in each square during 8 seasons from 1931–32 to 1938–39. It might be useful to compare this figure with Fig. 6, a corresponding figure for the fin whale. In both species the shape of the histograms are similar in general. In the A series there are no distinction between the areas II and III, but the boundary is quite distinct in the series B, both having peaks towards their center. In comparing these two figures it is suggested that the blue whales are taken first, hence mostly in the fore-half of the season and then the expeditions turned to the fin whales, hence more abundantly in the latter-half of the season. In the case of the blue whale CPUE is greater in the series A than in the series B, whereas in the case of the fin whale this is quite reverse. The fin whale is more abundant than blue whale in the Area II, contrary to area IV.

The catch of the humpback whale in each square is shown in Fig. 7. In this figure are also shown of the figures in the later periods for convenience. In the prewar seasons the catch of the humpbacks was mostly conducted in the areas III and IV, but in the postwar seasons it shifted eastwards and the catch in the area III is negligible. The humpback whale has been protected completely since 1963 in the southern hemisphere.

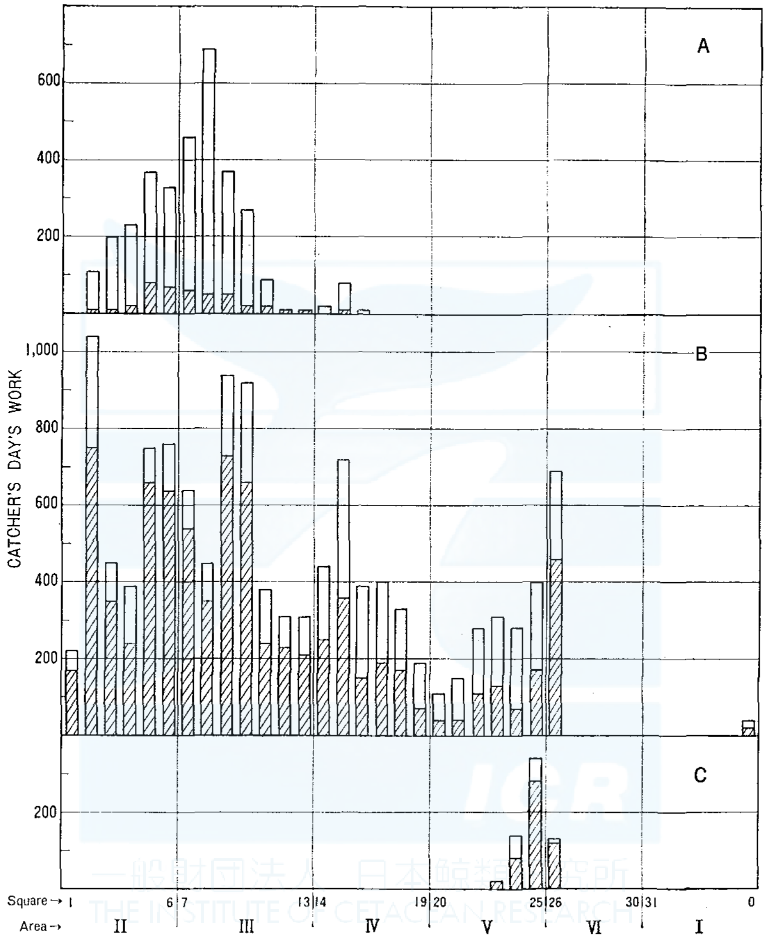

Fig. 8. Average number of catcher's day's work in each square during 10 seasons from 1945–46 to 1954–55.

PERIOD 2 (10 SEASONS FROM 1945–46 TO 1954–55)

Average CDW in each square during this period is shown in Fig. 8. As seen in this figure, in the series B too no distinct boundary is observed between areas II and III, possibly due to the fact that expeditions turned to prefer more fin than blue whale. In the series B no distinct feature is seen compared with the prewar season. The most frequently visited square is B2, but they also shifted eastwards until B26, the next square to the sanctuary. Also in the series C some expeditions operated, but these are in squares 23–26, the Ross Sea.

The average catch of the blue whale and its CPUE in each square in this period are shown in Fig. 9, which shows marked drop in the catch as well as in CPUE, though the operation has expanded geographically. In this figure are also shown the catch figures in the 3rd period (from 1955–56 to 1961–62). The catches are distributed widely in the series B, but they are so small to calculate CPUE. As shown in this figure all whales were taken in the latter-half of the season. This is because of a different opening date from fin and sei whales was imposed for blue whale by the International Whaling Commission. The decisions made by IWC were 16 January in 1953, 21 January in 1954, 1 February in 1955 and 14 February in 1960 (IWC. Report). In the catch in the series A are included the pygmy blue whale, which was taken since 1959–60 season in numbers in the seas north of 55°S (Ichihara, 1966). The taking of the blue whale was prohibited in 1963, excepting a small area for pygmy blue whale, and completely in 1965 by the International Whaling Commission (IWC. Report).

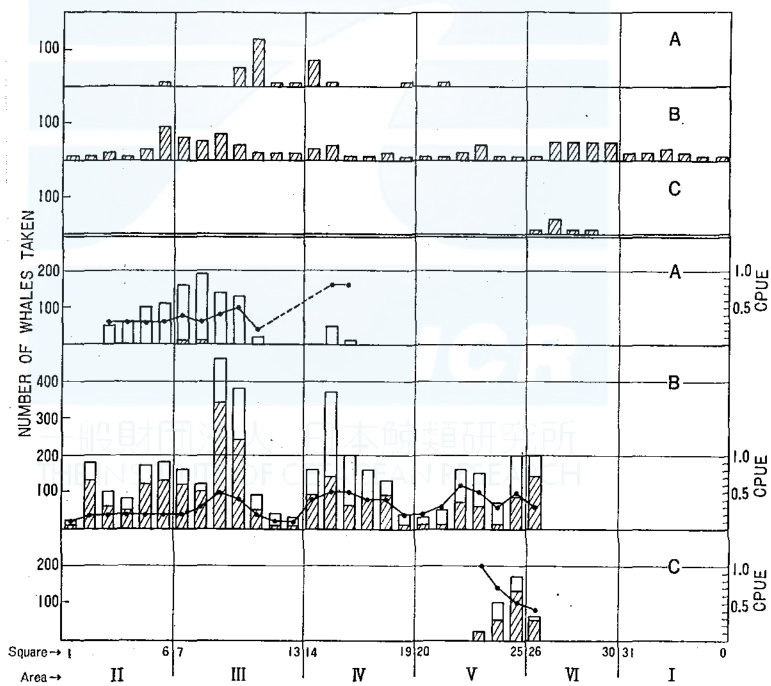

Fig. 9. Average number of blue whale catch and CPUE in each square during 10 seasons from 1945–46 to 1954–55 (lower figures) and average number of catch during 7 seasons from 1955–56 to 1961–62 (upper figures).

In Fig. 10 are shown the average catch and CPUE for the fin whale in each square during this period. The biggest catch was attained in the square B2 where more than 1,300 whales were harvested annually in average during these 10 seasons. A good numbers were also taken in B26, the next square to the sanctuary. The explanation of this may be in that that expeditions took whales waiting, which moved from the sanctuary westwards. CPUE is higher in general than in the previous period, showing the preference of expedition for the fin than the blue, contrary to the prewar seasons.

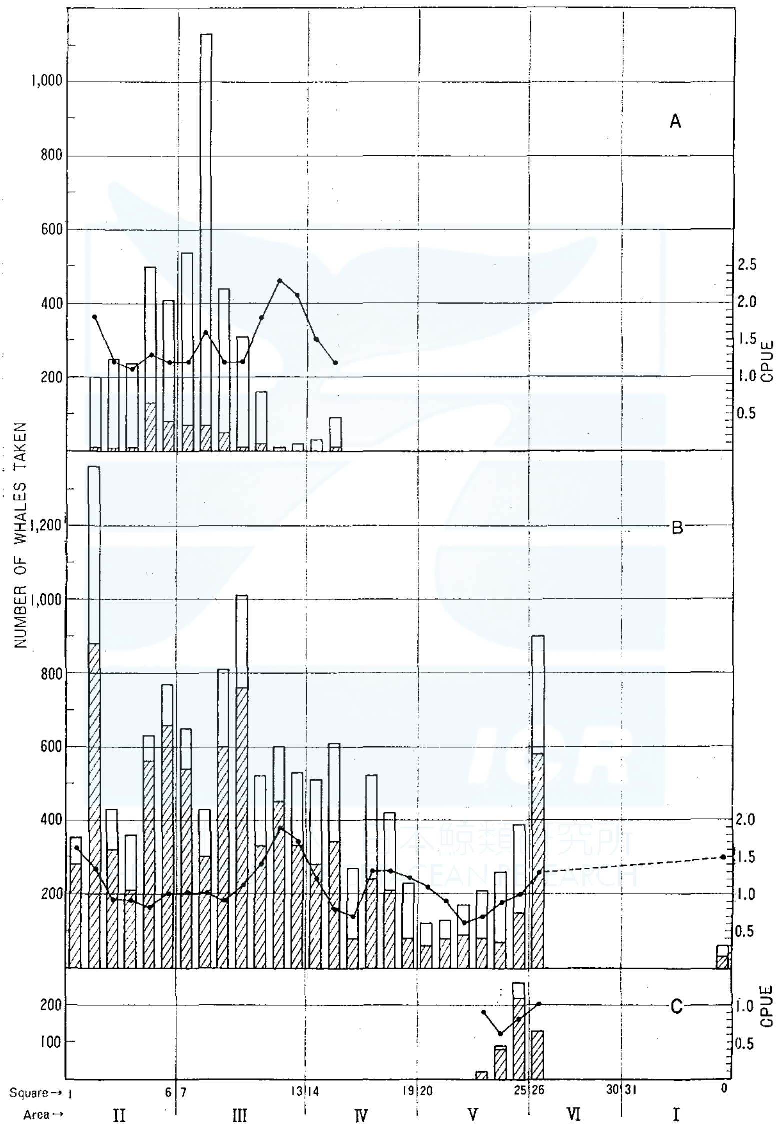

Fig. 10. Average number of fin whale catch and CPUE in each square during 10 seasons from 1945–46 to 1954–55.

PERIOD 3 (7 SEASONS FROM 1955–56 TO 1961–62)

The average number of CDW in each square during 7 seasons from 1955–56 to 1961–62 is shown in Fig. 11. As seen from this figure in the series B expeditions shifted eastwards and the efforts were distributed rather evenly in the whole of the areas. But in the series A efforts were mostly expended in areas II, III and IV, and in the other areas they are negligible. This is of course due to the oceanographic condition of the sea that the Antarctic convergence is lying more southerly in the

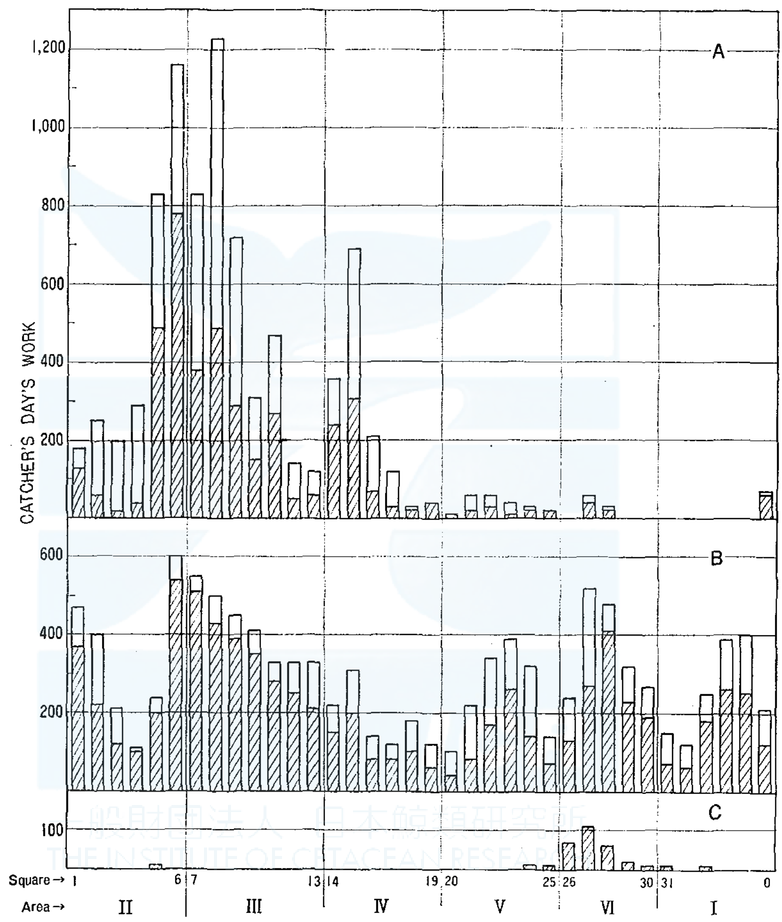

Fig. 11. Average number of catcher's day's work in each square during 7 seasons from 1955–56 to 1961–62.

Pacific sector than in the other areas. Fig. 11 also shows a tendency of expeditions working more frequently in the series A, compared with previous two periods, especially in the squares around the boundary of areas II and III. In fact in the seasons 1960–61 and 1961–62 some expeditions had worked also in the series D and the Bureau of the International Whaling Statistics clarifies these figures, but in this paper they are included in series A.

The catch of the fin whale and its CPUE in each square are shown in Fig. 12. In the series B the catch is distributed in all squares and in this period the biggest catch is no longer attained in the square B2. The catch of fin whale is shifted to the north in general and the square where the biggest catch was attained in average

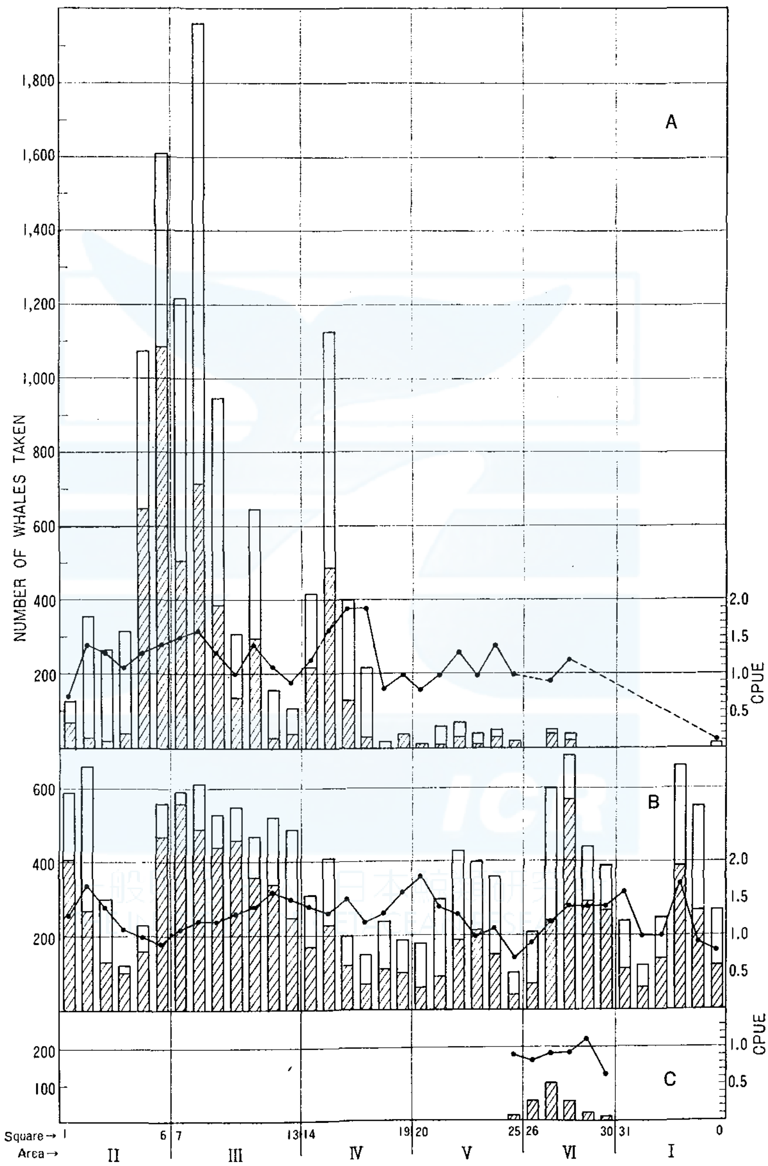

Fig. 12. Average number of fin whale catch and CPUE in each square during 7 seasons from 1955–56 to 1961–62.

during these 7 seasons is A8 (area III), exceeding 1,900 whales. Next to it is the square A6 (area II) where the average catch is about 1,600. In the squares A5, A7 and A15 more than 1,000 whales were taken, whereas in the series B the catch is below 700 whales in all of the squares. The average gross CPUE is still high and no

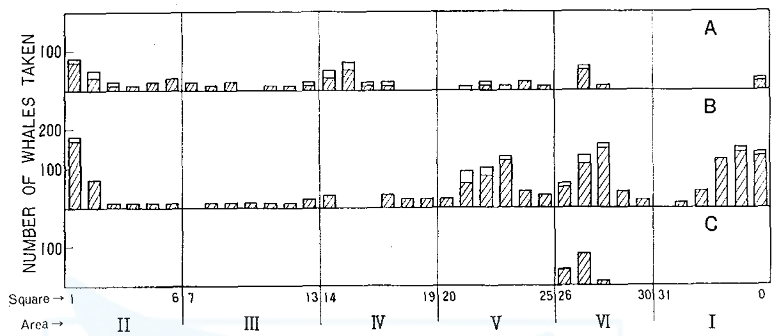

Fig. 13. Average number of sei whale catch in each square during 7 seasons from 1955–56 to 1961–62.

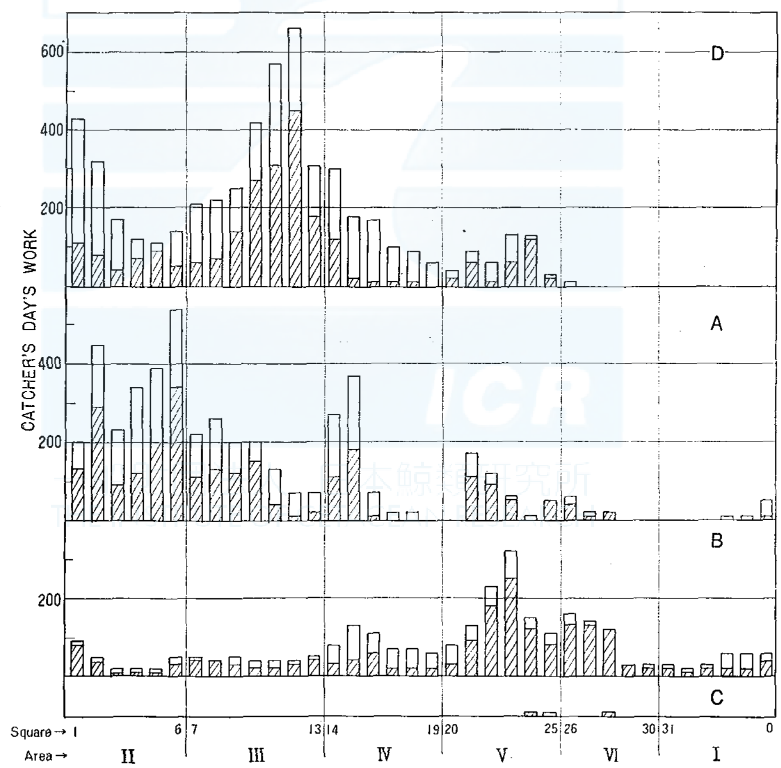

Fig. 14. Average number of catcher's day's work in each square during 10 seasons from 1962–63 to 1971–72.

decline compared with the previous period is observed. But during this period the indices of abundance of fin whale or CPUE corrected for gross tonnages of catcher boats had dropped sharply from 3.29 in the 1955–56 season to 1.34 in the 1961–62 season (Gulland, 1972). This means that the catch was supported by increased efficiency of the catchers.

In Fig. 13 are shown the catches of the sei whale in each square during this period. The catch of this species of whales was negligible in the previous two periods. In this period too the sei whale was not the main object of expeditions. It was taken mainly in the latter-half of the season.

PERIOD 4 (10 SEASONS FROM 1962–63 TO 1971–72)

During this period heavy reductions of the global quota for baleen whales were made by the International Whaling Commission, from 15,000 BWU (Blue Whale Unit) for the season 1962–63 to 2,300 BWU for the season 1971–72 (IWC. Report). Total number of whale catchers has also dropped sharply from 201 in the season 1962–63 to 88 in the season 1971–72 (International Whaling Statistics).

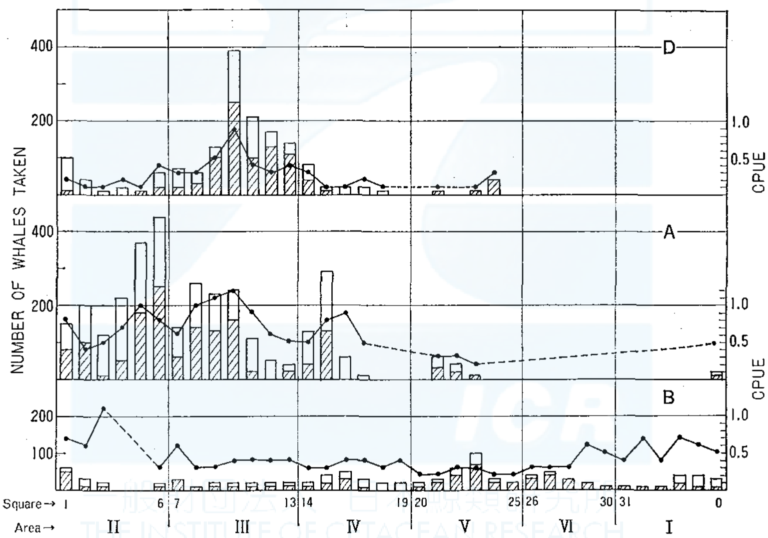

Fig. 15. Average number of fin whale catch and CPUE in each square during 10 seasons from 1962–63 to 1971–72.

In Fig. 14 is shown the average number of catcher's day's work in each square during 10 seasons from 1962–63 to 1971–72. As seen in this figure expeditions have most frequently operated in the series D and the peak is seen in the square D12 (area III), where CDW exceeds 600, but in other series none exceeds this figure. In the series B higher figures are seen in area V than in other areas, contrally to the previous period.

The catch of fin whale and CPUE are shown in Fig. 15. In the series B both figures were dropped sharply compared with the previous period, though in almost all squares operation was conducted. In the series A CPUE in each square are higher in general than in other series, but they are lower than in the previous period. In the series D the square D10 shows highest value, both in the actual number of catch and CPUE. This may support the presence of the low latitudinal stock in this area, as stated already.

The corresponding figures for the sei whale are shown in Fig. 16. The sei whale was taken most abundantly in the squares D1, D2 and A2 in the area II, and in D12 in the area III. In the squares D1 and D2 they were mostly taken in the two consecutive seasons 1964–65 and 1965–66, and in the square A2 in a single season 1964–65.

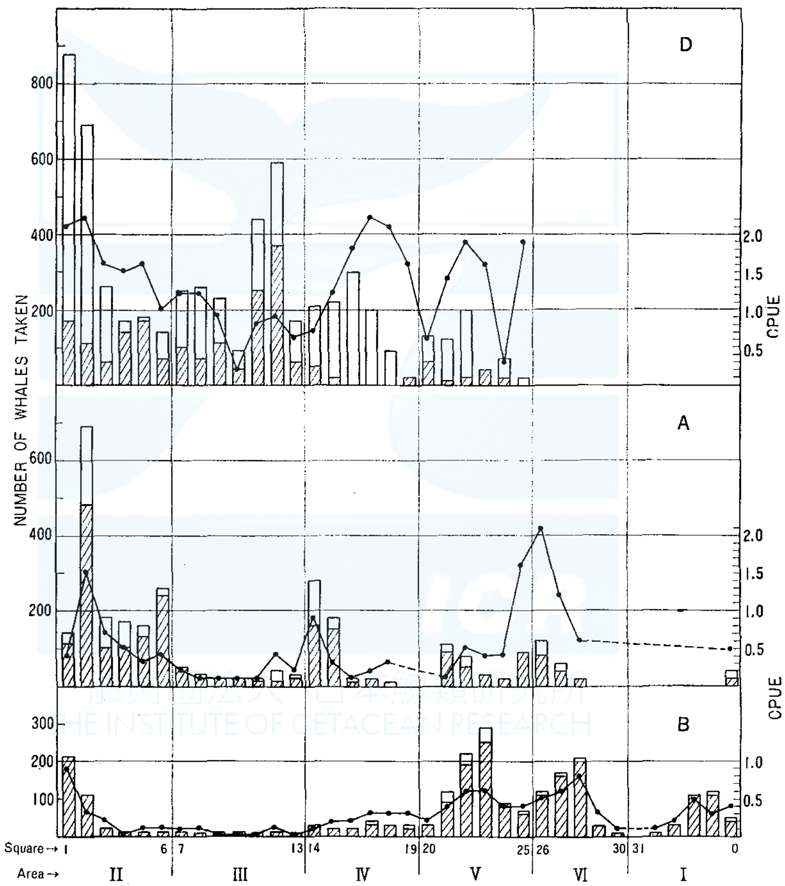

Fig. 16. Average number of sei whale catch and CPUE in each square during 10 seasons from 1962–63 to 1971–72.

Another one interesting feature in this figure is that in the squares D16, D17 and D18 the sei whales were only taken in the fore-half of the season. It is suggested from this fact that the main food of sei whale in this region is *Calanus tonsus*, and since copepodite V of this species leave the surface water in late summer for wintering in deep water, the whaling ground formed by this copepode would last for but relatively short period than that formed by another kind of food organisms (Kawamura, 1970).

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LIST OF APPENDICES TABLES SHOWING CATCHER'S DAY'S WORK AND CATCHES OF BLUE, HUMPBACK, FIN, AND SEI WHALES BY MONTH IN EACH SQUARE DURING 35 SEASONS FROM 1931-32 TO 1971-72.

* Since 1953-54 season different CDW are given for the blue whale due to later opening date than other species, but in these tables only total CDW are given.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1931/32																	
Oct.	—	—	—	90	28	49	—	—	—	—	56	16	8	56	112	—	—
Nov.	—	—	—	104	100	133	173	—	—	—	—	—	—	8	328	80	—
Dec.	—	—	52	72	—	—	221	182	—	—	—	—	—	—	—	—	—
Jan.	—	—	92	—	—	—	12	26	74	12	6	—	—	—	—	—	—
Feb.	—	—	125	105	—	—	—	—	—	—	—	—	—	—	—	—	—
Mar.	—	—	—	35	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	269	406	128	182	406	208	74	12	62	16	8	64	440	80	—
1932/33																	
Oct.	—	—	—	108	57	72	141	104	48	56	80	48	63	—	63	—	—
Nov.	—	—	—	147	147	240	383	326	501	77	299	393	60	49	175	—	—
Dec.	—	—	—	56	77	84	336	426	273	293	186	24	—	—	—	—	—
Jan.	—	—	—	72	25	97	48	150	—	—	18	—	—	—	—	—	—
Apr.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	—	383	306	493	908	1,006	822	426	583	465	123	49	238	—	—
1933/34																	
Oct.	—	—	—	20	57	—	15	50	87	36	29	139	84	7	181	—	—
Nov.	—	—	—	5	78	100	312	90	399	287	287	162	450	211	648	267	14
Dec.	—	—	—	—	60	317	91	10	110	220	130	118	—	32	95	—	—
Jan.	—	—	—	—	261	90	—	—	10	—	—	—	—	—	—	—	—
Feb.	—	5	15	35	5	—	—	—	—	—	—	—	—	—	—	—	—
Mar.	—	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	5	20	60	461	507	418	150	606	543	446	419	534	250	924	267	14
1934/35																	
Oct.	—	—	—	—	—	—	—	—	—	—	—	—	—	16	178	40	—
Nov.	—	—	—	—	—	—	—	7	77	42	—	—	—	—	—	255	79
Dec.	—	—	96	183	216	251	115	120	314	268	248	10	—	36	210	35	47
Jan.	—	—	138	174	47	174	—	—	170	86	36	—	7	—	—	—	—
Feb.	—	—	—	—	—	6	—	—	—	—	6	18	—	3	15	3	—
Apr.	—	—	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—
May.	—	—	50	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	309	357	263	431	115	127	561	396	290	28	7	55	403	333	126
1935/36																	
Dec.	—	—	—	28	745	377	135	933	755	213	—	—	—	60	238	126	—
Jan.	—	—	—	109	708	321	341	226	56	—	—	—	—	—	26	44	—
Feb.	—	—	23	206	8	—	—	—	—	—	—	—	—	—	—	—	—
Mar.	—	—	—	18	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	23	361	1,461	698	476	1,159	811	213	—	—	—	60	264	170	—
1936/37																	
Oct.	—	—	—	14	—	—	—	—	—	—	—	—	—	—	—	—	—
Nov.	—	—	—	18	187	140	21	—	—	—	—	—	—	—	—	81	40
Dec.	—	—	34	341	582	442	348	196	718	440	—	—	—	—	15	—	—
Jan.	—	—	14	135	137	239	453	265	539	47	—	—	—	—	—	—	—
Feb.	—	—	—	12	6	19	232	86	77	—	—	—	—	—	—	—	—
Mar.	—	14	—	—	—	19	12	—	—	—	—	—	—	—	—	—	—
T	—	14	48	520	912	859	1,066	547	1,334	487	—	—	—	—	15	81	40
1937/38																	
Nov.	—	—	—	—	—	—	—	—	—	120	94	—	—	8	436	78	40
Dec.	—	—	—	60	261	277	503	378	399	468	—	—	—	84	72	111	196
Jan.	—	—	—	—	63	154	665	639	222	—	—	—	—	—	—	—	—
Feb.	—	—	—	24	8	20	151	38	21	—	—	—	—	—	—	—	—
Mar.	—	—	—	—	—	—	—	20	27	—	—	—	—	—	—	—	—
T	—	—	—	84	332	451	1,319	1,075	669	588	94	—	—	92	508	189	236
1938/39																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	58	166
Dec.	—	21	721	216	281	224	654	336	146	288	8	—	—	—	8	40	32
Jan.	8	7	128	40	72	185	110	648	168	49	—	—	—	—	24	—	—
Feb.	—	14	—	—	—	109	15	—	—	—	—	—	—	—	—	—	—
Mar.	—	—	—	—	—	16	—	—	—	—	—	—	—	—	—	—	—
T	8	42	849	256	353	534	779	984	314	337	8	—	—	—	32	98	198

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
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Table 1. Continued.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1945/46																	
Nov.	—	—	—	—	32	6	—	—	16	—	—	—	—				
Dec.	—	38	127	377	144	109	130	232	32	—	—	—	—				
Jan.	—	48	—	98	481	38	8	177	297	16	—	—	—				
Feb.	—	—	34	180	12	—	—	—	63	—	—	—	—				
Apr.	—	25	—	—	—	—	—	—	—	—	—	—	—				
T	—	111	161	655	669	153	138	409	408	16	—	—	—				
1946/47																	
Dec.	—	—	190	20	93	133	120	—	247	641	189	—	—	9	292	72	—
Jan.	—	—	—	30	81	—	88	81	201	337	9	—	—	—	93	—	—
Feb.	—	—	—	—	—	—	63	117	—	—	—	—	—	—	—	—	—
T	—	—	190	50	174	133	271	198	448	978	198	—	—	9	385	72	—
1947/48																	
Nov.	—	—	—	—	—	—	—	8	—	—	—	—	—	—	—	—	—
Dec.	—	—	—	—	176	340	108	170	520	515	—	—	—	9	24	12	9
Jan.	—	—	—	—	408	366	41	402	34	—	—	—	—	—	—	—	—
Feb.	—	—	—	—	50	—	16	—	—	—	—	—	—	—	—	—	—
Mar.	—	—	—	—	269	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	—	—	903	706	165	580	554	515	—	—	—	9	24	12	9
1948/49																	
Dec.	—	—	12	194	—	52	625	323	355	270	—	—	—	—	13	39	—
Jan.	—	—	247	39	200	386	729	48	72	24	31	—	—	—	—	—	—
Feb.	—	—	—	—	—	42	94	—	33	—	—	—	—	—	—	—	—
Mar.	—	56	—	—	—	—	33	—	—	—	—	—	—	—	—	—	—
T	—	56	259	233	200	480	1,481	371	460	294	31	—	—	—	13	39	—
1949/50																	
Dec.	—	14	126	13	283	109	65	154	381	60	—	—	—	—	45	—	—
Jan.	—	252	78	271	99	—	507	864	285	60	—	—	—	—	—	—	—
Feb.	—	—	—	—	—	30	89	153	28	—	—	—	—	—	—	—	—
Mar.	—	—	—	—	84	—	—	—	—	—	—	—	—	—	77	—	—
T	—	266	204	284	466	139	661	1,171	694	120	—	—	—	—	122	—	—
1950/51																	
Dec.	—	—	75	237	124	90	60	154	36	—	—	—	—				
Jan.	—	24	235	365	150	140	40	379	48	—	—	—	—				
Mar.	—	15	—	45	—	—	—	—	—	24	—	—	—				
T	—	39	310	647	274	230	100	533	84	24	—	—	—				
1951/52																	
Jan.	—	336	466	83	15	—	348	980	—	—	—	—	48	114	60	—	15
Feb.	—	—	28	—	—	30	15	47	—	—	—	—	—	—	—	—	—
T	—	336	494	83	15	30	363	1,027	—	—	—	—	48	114	60	—	15
1952/53																	
Jan.	—	—	—	34	184	423	709	583	313	16	—	—	40	39	—	—	—
Feb.	—	—	—	—	—	144	36	—	—	—	—	—	—	—	—	—	—
Mar.	—	—	—	—	—	—	—	—	105	—	—	—	—	—	—	—	—
T	—	—	—	34	184	567	745	583	418	16	—	—	40	39	—	—	—
1953/54																	
Jan.	—	211	401	281	182	11	221	1,023	59	104	260	—	—	61	175	—	—
Feb.	—	26	—	—	—	33	—	—	10	—	65	52	—	—	—	—	—
Mar.	—	—	—	—	—	—	—	—	169	39	26	—	—	—	—	—	—
T	—	237	401	281	182	44	221	1,023	238	143	351	52	—	61	175	—	—
1954/55																	
Jan.	—	13	13	36	227	375	182	822	317	502	248	—	—				
Feb.	—	—	—	—	219	45	155	143	46	90	76	—	—				
Mar.	—	—	—	—	179	382	110	—	—	—	—	—	—				
T	—	13	13	36	625	802	447	965	363	592	324	—	—				
1955/56																	
Jan.	—	130	—	—	13	103	415	264	8	—	—	20	—	26	26	—	—
Feb.	—	—	—	—	—	—	—	—	32	—	—	—	—	—	48	—	—
Mar.	—	—	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	130	—	20	13	103	415	264	40	—	—	20	—	26	74	—	—

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
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Table 1. Continued.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1956/57																	
Jan.	10	82	322	60	96	477	54	27	165	102	48	30	—				
Feb.	—	—	—	72	687	819	138	—	—	—	—	12	—				
Mar.	—	—	—	—	31	142	140	84	—	—	—	—	—				
T	10	82	322	132	814	1,438	332	111	165	102	48	42	—				
1957/58																	
Jan.	—	274	434	366	291	463	538	459	24	—	—	—	—	—	—	—	—
Feb.	—	—	—	—	30	373	378	206	12	—	—	—	—	56	95	120	24
Mar.	—	—	—	—	—	200	24	678	72	—	—	—	—	141	205	48	—
T	—	274	434	366	321	1,036	940	1,343	108	—	—	—	—	197	300	168	24
1958/59																	
Jan.	—	—	24	96	466	226	799	555	12	—	—	—	44	343	404	240	120
Feb.	—	—	12	24	48	500	334	188	36	—	—	—	—	61	61	22	—
Mar.	—	—	—	12	20	300	—	48	192	—	—	—	—	—	—	18	9
T	—	—	36	132	534	1,026	1,133	791	240	—	—	—	44	404	465	280	129
1959/60																	
Dec.	44	36	50	54	44	—	—	176	168	—	36	—	—	—	204	72	—
Jan.	76	223	218	258	321	106	258	793	166	90	432	—	—	192	600	501	354
Feb.	—	99	11	18	542	182	85	204	73	81	453	8	—	270	228	216	144
Mar.	9	9	—	36	503	126	54	166	54	45	54	—	24	372	480	—	—
Apr.	45	—	—	—	27	76	63	145	—	36	—	—	—	—	—	—	—
T	174	367	279	366	1,437	490	460	1,484	461	252	975	8	24	834	1,512	789	498
1960/61																	
Nov.	—	—	—	—	—	—	—	—	42	—	—	—	—	—	—	—	—
Dec.	11	58	—	—	40	30	110	296	154	—	160	72	—	11	33	58	82
Jan.	42	221	74	111	218	184	450	1,247	965	318	296	196	55	92	225	58	84
Feb.	44	99	44	42	287	424	237	242	182	418	728	33	12	180	144	—	—
Mar.	18	11	55	11	610	367	322	316	285	48	274	35	45	135	216	—	—
Apr.	29	—	—	—	74	31	110	135	75	—	—	—	—	—	—	—	—
T	144	389	173	164	1,229	1,036	1,229	2,236	1,703	784	1,458	336	112	418	618	116	166
1961/62																	
Dec.	108	221	87	197	380	476	169	327	656	302	108	266	234	52	495	—	—
Jan.	27	117	63	656	497	617	360	984	630	372	276	103	101	126	634	—	—
Feb.	343	87	—	11	428	455	337	612	591	180	120	—	39	179	584	91	—
Mar.	357	85	—	—	175	1,187	414	428	312	155	218	169	276	156	134	—	—
Apr.	85	—	—	—	—	257	16	—	128	57	60	69	12	132	—	—	—
T	920	510	150	864	1,480	2,992	1,296	2,351	2,317	1,066	782	607	662	645	1,847	91	
1962/63																	
Dec.	49	131	127	285	278	180	128	65	282	194	352	156	34	72	132	—	—
Jan.	38	93	273	90	549	359	196	211	125	197	218	39	80	140	327	48	72
Feb.	—	32	80	115	211	515	134	253	110	441	12	12	58	—	—	—	—
Mar.	288	58	24	40	62	44	82	183	421	475	128	—	—	36	125	—	—
Apr.	87	9	—	56	—	—	—	92	—	—	—	—	—	38	—	—	—
T	462	323	504	586	1,100	1,098	540	804	938	1,307	710	207	172	286	584	48	72
1963/64																	
Dec.	—	155	217	486	152	95	211	225	263	89	—	190	67	57	20	30	10
Jan.	36	176	371	725	651	696	134	121	—	—	55	30	81	47	105	—	—
Feb.	237	260	202	543	631	403	193	465	110	22	19	49	106	76	76	—	—
Mar.	107	58	78	47	573	432	134	187	322	264	76	—	—	85	68	—	—
Apr.	—	—	—	—	53	150	102	22	—	—	—	—	—	—	85	—	—
T	380	649	868	1,801	2,060	1,776	774	1,020	695	375	150	269	254	265	354	30	10
1964/65																	
Dec.	134	21	67	313	129	272	104	299	36	—	121	152	62	47	—	—	—
Jan.	188	921	130	148	65	85	16	16	—	—	—	—	—	—	—	68	34
Feb.	197	1,260	138	157	201	192	—	—	—	—	102	—	—	68	—	—	—
Mar.	123	698	148	159	120	415	55	9	19	—	—	—	—	51	34	—	—
Apr.	—	—	51	—	—	54	—	—	—	—	—	—	—	—	1	—	—
T	642	2,900	534	777	515	1,018	175	324	55	—	223	152	62	166	35	68	34

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
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48	—	—	—	—	—	—	—											
120	216	—	—	—	—	—	—											
—	72	48	72	48	24	—	—											
168	288	48	72	48	24	—	—											
—	—	—	—	—	32	—	—											
—	—	—	156	28	—	—	—											
—	—	—	24	24	—	—	—											
—	—	—	36	96	—	18	153											
—	—	—	—	—	—	—	—											
—	—	—	216	148	32	18	153											
—	—	—	—	—	—	—	—	—	—	—	—	—						
—	—	—	—	—	18	36	—	—	—	—	—	—						
60	—	16	136	174	154	52	—	—	60	36	—	—						
—	—	—	—	18	54	126	—	—	—	48	—	—						
—	—	—	—	—	—	—	—	—	300	120	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
60	—	16	136	192	226	214	—	—	360	204	—	—						
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—	—							—	—	—	—	—	—	—	—	—	19	76
—	—							—	—	19	—	—	—	—	—	—	—	—
—	—							—	—	—	—	—	—	—	—	—	—	30
—	—							—	—	—	—	—	—	—	—	—	—	15
—	—							—	—	19	—	—	19	—	—	38	76	292
—	—	—	—	—	—	—	—						—	—	—	—	—	—
68	—	—	124	231	84	—	—						—	—	—	—	—	—
—	—	—	—	63	31	—	—						—	—	—	—	—	22
—	—	—	—	21	369	—	—						—	—	—	—	—	—
—	—	—	—	—	—	—	—						—	—	—	—	—	—
68	—	—	124	315	484	—	—						—	—	—	—	—	22
—	—	—	—	—	—	—	—						—	—	—	—	—	—
42	—	—	275	32	—	—	—						—	—	—	—	—	42
—	—	—	250	50	—	—	—						—	—	—	—	—	22
—	—	—	462	275	—	—	—						—	—	—	—	—	—
—	—	—	—	—	—	—	—						—	—	—	—	—	—
42	—	—	987	357	—	—	—						—	—	—	—	—	64

Table 1. Continued.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1965/66																	
Dec.	—	—	75	75	35	30	90	16	32	—	—	—	—				
Jan.	90	60	90	30	—	—	—	—	54	18	—	—	—				
Feb.	—	—	—	—	11	41	45	—	—	—	—	—	—				
Mar.	—	50	40	20	105	347	90	45	36	—	—	—	—				
Apr.	—	—	—	—	20	135	—	—	—	—	—	—	—				
T	90	110	205	125	171	553	225	61	122	18							
1966/67																	
Dec.	40	—	—	—	—	45	120	135	—	—	—	—	—	57	133	57	—
Jan.	—	—	—	—	—	63	60	30	—	—	—	—	—	48	—	—	—
Feb.	—	—	—	—	—	76	—	—	—	—	—	—	—	370	174	—	—
Mar.	—	—	—	—	—	—	—	—	—	30	—	—	—	40	156	—	—
T	40	—	—	—	—	184	180	165	—	30	—	—	—	515	463	57	—
1967/68																	
Dec.	—	—	—	—	—	—	26	65	26	—	—	—	—	—	—	—	—
Jan.	—	—	—	—	—	—	—	—	—	91	54	57	91	548	95	—	—
Feb.	—	—	—	—	—	117	78	—	—	13	13	—	12	96	72	—	—
Mar.	—	—	—	—	—	364	26	—	—	—	—	—	—	55	232	—	—
T	—	—	—	—	—	481	130	65	26	104	67	57	103	699	399	—	—
1968/69																	
Dec.	—	—	—	—	—	—	48	36	—	—	—	—	—	—	—	—	—
Jan.	—	—	—	17	17	51	17	58	—	—	—	—	—	299	521	372	58
Feb.	—	—	—	—	—	—	—	—	—	—	12	24	12	24	24	—	—
Mar.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	—	17	17	51	65	94	—	—	12	24	12	323	545	372	58
1969/70																	
Jan.	—	—	—	—	—	—	—	—	—	—	—	—	—	87	272	36	—
Feb.	—	—	—	—	—	—	—	—	—	—	—	—	26	36	217	—	13
Mar.	—	—	—	—	—	—	—	—	—	—	—	—	—	13	156	—	—
T	—	—	—	—	—	—	—	—	—	—	—	—	26	136	645	36	13
1970/71																	
Dec.	—	—	48	24	24	84	—	—	—	—	—	—	—	—	—	—	—
Jan.	—	—	—	—	—	—	—	—	—	—	—	—	—	160	278	17	—
Feb.	120	132	—	—	—	—	—	—	—	—	—	—	—	53	94	17	34
Mar.	120	204	—	—	—	—	—	—	—	24	—	—	—	—	—	—	—
T	240	336	48	24	24	84	—	—	—	24	—	—	—	213	372	34	34
1971/72																	
Dec.	91	39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	65	—	—	—	—	—	—	—	—	—	51	34	—	34	51	—	—
Feb.	13	78	52	26	—	65	119	90	140	101	—	—	—	41	77	48	—
Mar.	—	26	52	—	26	78	—	—	51	85	59	—	23	23	181	—	—
T	169	143	104	26	26	143	119	90	191	186	110	34	23	98	309	48	—

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
		—	185	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	38	36	54	—	—	—	—	—	—	—	—	—	—	—	45
		—	76	58	80	20	40	—	—	—	—	—	—	—	—	—	—	—
		—	38	—	—	—	60	59	20	20	20	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	299	96	116	74	100	59	20	20	20	—	—	—	—	—	—	45
—	—	—	—	—	—	—	—											
—	—	19	19	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	20	—	—											
—	—	19	19	—	20	—	—											
27	—	—	—	—	—	—	—	—	—	—	—	—						
—	—	—	—	9	—	—	—	110	—	—	—	—						
—	—	—	9	9	—	—	315	139	—	72	—	—						
—	—	—	—	—	—	—	29	209	—	36	—	—						
27	—	—	9	18	—	—	344	458	—	108	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
—	—	—	—	—	—	—	—	11	77	—	—	—						
—	—	—	136	34	—	—	11	22	66	11	—	—						
—	—	—	17	374	—	—	—	—	—	—	—	—						
—	—	—	153	408	—	—	11	33	143	11	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
13	13	13	94	34	—	—	—	—	—	—	—	—						
—	—	—	24	—	—	—	—	—	—	34	—	—						
13	13	13	118	34	—	—	—	—	—	34	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
17	—	—	—	—	—	—	—	—	—	—	—	—						
—	—	—	—	—	—	—	17	17	—	—	—	—						
17	—	—	—	—	—	—	17	17	—	—	—	—						
—	—												—	—	—	—	—	26
—	—												—	—	—	—	—	—
—	—												—	—	—	13	—	13
—	—												—	—	—	—	—	—
—	—												—	—	—	13	—	39

Table 2. Series A. Catch of blue whale

Area	II						III							IV			
Square	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1931/32																	
Oct.	—	—	—	53	16	17	—	—	—	—	11	—	—	62	116	—	—
Nov.	—	—	—	65	116	151	244	—	—	—	—	—	—	—	418	72	—
Dec.	—	—	89	81	—	—	342	314	—	—	—	—	—	—	—	—	—
Jan.	—	—	141	—	—	—	1	30	12	24	—	—	—	—	—	—	—
Feb.	—	—	87	106	—	—	—	—	—	—	—	—	—	—	—	—	—
Mar.	—	—	—	33	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	317	338	132	168	587	344	12	24	11	—	—	62	534	72	—
1932/33																	
Oct.	—	—	—	84	38	61	127	99	72	62	119	46	57	—	62	—	—
Nov.	—	—	—	150	99	270	474	398	721	100	471	777	67	43	213	—	—
Dec.	—	—	—	29	132	84	529	528	476	563	281	66	—	—	—	—	—
Jan.	—	—	—	95	1	108	28	214	—	—	18	—	—	—	—	—	—
T	—	—	—	358	270	523	1, 158	1, 239	1, 269	725	889	889	124	43	275	—	—
1933/34																	
Oct.	—	—	—	24	59	—	8	15	109	13	16	190	123	6	269	—	—
Nov.	—	—	—	3	117	101	541	126	582	438	362	208	711	274	1, 149	426	23
Dec.	—	—	—	—	56	449	97	3	171	387	150	209	—	63	113	—	—
Jan.	—	—	—	—	360	137	—	—	14	—	—	—	—	—	—	—	—
Feb.	—	—	10	16	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	10	43	592	687	646	144	876	838	528	607	834	343	1, 531	426	23
1934/35																	
Oct.	—	—	—	—	—	—	—	—	—	—	—	—	—	3	194	67	—
Nov.	—	—	—	—	—	1	2	2	104	35	4	2	3	—	—	475	124
Dec.	—	—	119	199	131	291	88	222	643	638	527	19	—	22	236	61	69
Jan.	—	—	74	130	28	308	—	—	361	119	42	—	2	—	—	—	—
Feb.	—	—	—	—	—	11	—	—	—	—	1	2	—	1	5	—	—
T	—	—	193	329	159	611	90	224	1, 108	792	574	23	5	26	435	603	193
1935/36																	
Nov.	—	—	—	—	2	2	—	—	—	—	—	—	—	—	—	—	—
Dec.	—	—	—	48	1, 248	476	161	1, 280	980	357	—	—	—	43	304	197	—
Jan.	—	—	—	165	757	250	241	118	46	—	—	—	—	—	34	49	—
Feb.	—	—	27	136	4	—	—	—	—	—	—	—	—	—	—	—	—
Mar.	—	—	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	27	357	2, 011	728	402	1, 398	1, 026	357	—	—	—	43	338	246	—
1936/37																	
Oct.	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Nov.	—	—	—	6	102	42	7	—	—	—	—	—	—	—	—	50	21
Dec.	—	—	13	229	482	492	457	208	995	611	—	—	—	—	13	—	—
Jan.	—	—	5	85	75	279	538	263	289	61	—	—	—	—	—	—	—
Feb.	—	—	—	3	1	13	89	36	27	—	—	—	—	—	—	—	—
T	—	—	18	326	660	826	1, 091	507	1, 311	672	—	—	—	—	13	50	21
1937/38																	
Nov.	—	—	1	—	—	—	—	—	—	182	163	—	—	1	376	32	18
Dec.	—	—	3	36	193	221	593	500	530	477	—	—	—	123	13	57	197
Jan.	—	—	—	—	16	83	436	287	62	—	—	—	—	—	—	—	—
Feb.	—	—	—	3	—	—	8	4	22	—	—	—	—	—	—	—	—
Mar.	—	—	—	—	—	—	—	3	11	—	—	—	—	—	—	—	—
T	—	—	4	39	209	304	1, 037	794	625	659	163	—	—	124	389	89	215
1938/39																	
Nov.	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	34	145
Dec.	—	11	575	179	129	95	460	357	179	238	11	—	—	—	1	39	35
Jan.	4	6	67	17	47	110	29	301	63	22	—	—	—	—	24	—	—
Feb.	—	7	—	—	—	4	—	—	—	—	—	—	—	—	—	—	—
T	4	24	642	199	176	209	489	658	242	260	11	—	—	—	25	73	180

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1945/46																	
Nov.	—	—	—	—	10	4	—	—	7	—	—	—	—				
Dec.	—	—	8	62	18	94	110	357	30	—	—	—	—				
Jan.	—	—	—	12	38	5	—	165	362	16	—	—	—				
Feb.	—	—	—	27	—	—	—	—	42	—	—	—	—				
T	—	—	8	101	66	103	110	522	441	16	—	—	—				
1946/47																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
Dec.	—	—	128	21	130	120	48	—	199	557	178	—	—	2	429	72	—
Jan.	—	—	—	15	30	—	55	72	65	210	3	—	—	—	53	—	—
Feb.	—	—	—	—	—	—	26	6	—	—	—	—	—	—	—	—	—
T	—	—	128	36	160	120	129	78	264	767	181	—	—	2	483	72	—
1947/48																	
Nov.	—	—	—	—	—	—	1	—	—	—	—	—	—	1	—	—	—
Dec.	—	—	—	—	153	371	81	123	356	272	—	—	—	6	13	4	2
Jan.	—	—	—	—	102	76	5	22	2	—	—	—	—	—	—	—	—
Feb.	—	—	—	—	5	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	—	—	260	447	87	145	358	272	—	—	—	7	13	4	2
1948/49																	
Dec.	—	—	11	182	—	49	452	145	183	187	—	—	—	—	4	28	—
Jan.	—	—	202	14	186	134	272	10	26	8	3	—	—	—	—	—	—
Feb.	—	—	—	—	—	—	2	—	1	—	—	—	—	—	—	—	—
Mar.	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	1	213	196	186	183	726	155	210	195	3	—	—	—	4	28	—
1949/50																	
Dec.	—	—	14	8	65	27	52	84	97	13	—	—	—	—	4	—	—
Jan.	—	—	3	133	80	—	252	377	27	14	—	—	—	—	—	—	—
Feb.	—	—	—	—	—	1	46	73	—	—	—	—	—	—	—	—	—
T	—	—	17	141	145	28	350	534	124	27	—	—	—	—	4	—	—
1950/51																	
Dec.	—	—	46	95	54	32	51	66	2	—	—	—	—				
Jan.	—	7	92	51	16	5	7	48	2	—	—	—	—				
T	—	7	138	146	70	37	58	114	4	—	—	—	—				
1951/52																	
Jan.	—	—	23	—	—	—	8	196	—	—	—	—	3	33	3	—	9
Feb.	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—
Mar.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	23	—	—	3	8	196	—	—	—	—	3	33	3	—	9
1952/53																	
Nov.	—	—	—	—	—	1	—	—	—	—	—	—	—				
Dec.	—	—	—	—	3	1	1	1	—	—	—	—	—				
Jan.	—	—	—	4	102	214	124	25	12	11	—	—	1				
Feb.	—	—	—	—	—	1	—	—	—	—	—	—	—				
T	—	—	—	4	105	217	125	26	12	11	—	—	1				
1953/54																	
Dec.	—	—	—	—	—	—	—	—	1	—	—	—	—				
Jan.	—	4	16	—	—	—	23	62	3	—	1	—	—				
T	—	4	16	—	—	—	23	62	4	—	1	—	—				
1954/55																	
Jan.	—	—	—	—	—	10	16	27	1	9	7	—	—				
Feb.	—	—	—	—	—	—	7	19	1	—	1	—	—				
Mar.	—	—	—	—	1	—	1	—	—	—	—	—	—				
T	—	—	—	—	1	10	24	46	2	9	8	—	—				
1955/56																	
Dec.	—	—	—	1	—	—											
T	—	—	—	1	—	—											

Table 2. Continued.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1956/57																	
Dec.	—	—	—	—	—	1	—	—	—	—	—	—	—				
Jan.	—	—	—	—	—	1	—	—	—	—	—	—	—				
Feb.	—	—	—	—	29	50	1	—	—	—	—	—	—				
T	—	—	—	—	29	52	1	—	—	—	—	—	—				
1957/58																	
Jan.							—	1	—	—	—	—	—	—	—	—	—
Feb.							3	9	—	—	—	—	—	4	1	—	—
Mar.							—	4	—	—	—	—	—	1	—	—	—
T							3	14	—	—	—	—	—	5	1	—	—
1958/59																	
Feb.	—	—	—	—	1	10	6	1	—	—	—	—	—	—	1	—	—
Mar.	—	—	—	—	—	2	—	—	1	—	—	—	—	—	—	—	—
T	—	—	—	—	1	12	6	1	1	—	—	—	—	—	1	—	—
1959/60																	
Feb.	—	1	—	—	1	9	—	—	25	—	9	—	—	6	23	17	6
Mar.	—	—	—	—	1	—	—	—	—	11	—	—	6	304	15	—	—
Apr.	—	—	—	—	—	—	—	—	—	4	—	—	—	—	—	—	—
T	—	1	—	—	2	9	—	—	25	15	9	—	6	310	38	17	6
1960/61																	
Dec.	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—
Feb.	—	—	—	—	2	1	—	2	—	228	528	17	30	84	3	—	—
Mar.	—	—	—	—	2	1	—	1	—	—	167	—	13	59	5	—	—
T	—	—	—	—	4	2	—	4	—	228	695	17	43	143	8	—	—
1961/62																	
Jan.	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Feb.	—	—	—	—	2	—	1	12	6	91	120	—	—	9	39	3	—
Mar.	—	—	—	—	2	5	1	2	—	6	58	2	13	13	2	—	—
Apr.	—	—	—	—	—	—	—	—	—	11	6	37	10	27	—	—	—
T	—	1	—	—	4	5	2	14	6	108	184	39	23	49	41	3	—
1962/63																	
Feb.	—	—	—	—	1	3	—	—	1	31	—	—	4	—	—	—	—
Mar.	—	—	—	—	—	—	—	—	2	86	4	—	—	—	3	—	—
T	—	—	—	—	1	3	—	—	3	117	4	—	4	—	3	—	—
1963/64																	
Feb.							2	3	2	1	—	—	—				
Mar.							—	1	1	1	—	—	—				
T							2	4	3	2	—	—	—				
1964/65																	
Mar.														5	—	—	—
Apr.														—	1	—	—
T														5	1	—	—

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—																	
—	—																	
—	—																	
—	—																	
20	65	—	—	—	—	—	—											
—	13	13	45	7	2	—	—											
20	78	13	45	7	2	—	—											
—	—																	
—	—																	
—	—																	
—	—																	
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	5	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	5	—											
—	—												—	—	—	—	—	—
—	—												—	—	—	—	—	—
—	—												—	—	—	—	—	—
—	—												—	—	—	—	—	3
—	—												—	—	—	—	—	3
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	

Table 3. Series A. Catch of humpback whale

Area	II						III							IV			
Square	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1931/32																	
Oct.	—	—	—	—	—	—	—	—	—	—	—	—	—	10	5	—	—
Nov.	—	—	—	—	1	—	—	—	—	—	—	—	—	—	36	1	—
Dec.	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—
Jan.	—	—	2	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Feb.	—	—	6	2	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	8	2	1	—	2	—	—	1	—	—	—	10	41	1	—
1932/33																	
Nov.	—	—	—	4	—	3	5	—	4	1	—	1	—	1	23	—	—
Dec.	—	—	—	—	1	2	4	—	5	3	—	—	—	—	—	—	—
Jan.	—	—	—	5	—	2	—	—	—	—	—	—	—	—	—	—	—
T	—	—	—	9	1	7	9	—	9	4	—	1	—	1	23	—	—
1933/34																	
Oct.	—	—	—	—	—	—	—	—	2	—	—	—	—	—	32	—	—
Nov.	—	—	—	—	2	2	4	—	—	4	12	10	3	14	321	15	—
Dec.	—	—	—	—	2	25	7	—	—	—	—	—	—	2	28	—	—
Jan.	—	—	—	—	32	8	—	—	—	—	—	—	—	—	—	—	—
Feb.	—	—	3	14	1	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	3	14	37	35	11	—	2	4	12	10	3	16	381	15	—
1934/35																	
Nov.	—	—	—	—	—	1	—	—	—	—	1	—	1	—	—	3	—
Dec.	—	—	—	11	7	5	—	2	12	2	—	—	—	25	300	7	4
Jan.	—	—	3	6	7	16	—	—	57	—	—	—	—	—	—	—	—
T	—	—	3	17	14	22	—	2	69	2	1	—	1	25	300	10	4
1935/36																	
Dec.	—	—	—	—	124	46	5	58	208	163	—	—	—	1	233	70	—
Jan.	—	—	—	—	75	33	12	51	98	—	—	—	—	—	29	40	—
Feb.	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	—	3	199	79	17	109	306	163	—	—	—	1	262	110	—
1936/37																	
Nov.	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	2
Dec.	—	—	—	14	42	38	1	37	938	158	—	—	—	—	—	—	—
Jan.	—	—	—	32	33	13	21	188	786	65	—	—	—	—	—	—	—
Feb.	—	—	—	—	1	1	26	59	102	—	—	—	—	—	—	—	—
Mar.	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—
T	—	—	—	46	79	53	49	284	1, 826	223	—	—	—	—	—	—	2
1937/38																	
Nov.	—	—	—	—	—	—	—	—	—	14	3	—	—	—	166	19	—
Dec.	—	—	—	1	18	40	21	17	68	189	—	—	—	2	35	21	40
Jan.	—	—	—	—	7	1	28	48	42	—	—	—	—	—	—	—	—
Feb.	—	—	—	3	3	—	4	1	24	—	—	—	—	—	—	—	—
Mar.	—	—	—	—	—	—	—	7	31	—	—	—	—	—	—	—	—
T	—	—	—	4	28	41	53	73	165	203	3	—	—	2	201	40	40
1938/39																	
Nov.														—	—	15	35
T														—	—	15	35
1947/48																	
Nov.	—	—	—	—	—	—								1	—	—	—
Dec.	—	—	—	—	1	—								—	—	—	—
Jan.	—	—	—	—	—	—								—	—	—	—
Feb.	—	—	—	—	—	—								—	—	—	—
Mar.	—	—	—	—	—	—								—	—	—	—
T	—	—	—	—	1	—								1	—	—	—
1948/49																	
Nov.							—	—	1	—	1	—	—				
Dec.							—	—	5	—	—	—	—				
Jan.							2	—	—	—	—	—	—				
T							2	—	6	—	1	—	—				

Table 3. Continued.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1949/50																	
Dec.	—	—	1	18	92	40	5	29	127	32	—	—	—	—	59	—	—
Jan.	—	—	—	21	—	—	15	10	20	10	—	—	—	—	—	—	—
T	—	—	1	39	92	40	20	39	147	42	—	—	—	—	59	—	—
1951/52																	
Feb.	—	—	—	—	—	3	—	44	—	—	—	—	—				
T	—	—	—	—	—	3	—	44	—	—	—	—	—				
1952/53																	
Dec.							2	—	—	—	—	—	—				
T							2	—	—	—	—	—	—				
1953/54																	
Feb.	—	—	—	—	—	4											
T	—	—	—	—	—	4											
1954/55																	
Dec.	—	—	—	—	—	—	3	—	—	—	—	—	—				
Jan.	—	—	—	—	—	2	—	—	—	—	—	—	—				
Feb.	—	—	—	—	—	—	—	110	—	—	—	—	—				
T	—	—	—	—	—	2	3	110	—	—	—	—	—				
1955/56																	
Feb.							—	—	2	—	—	—	—				
T							—	—	2	—	—	—	—				
1956/57																	
Feb.							5	—	—	—	—	—	—				
T							5	—	—	—	—	—	—				
1957/58																	
Feb.							9	—	—	—	—	—	—				
T							9	—	—	—	—	—	—				
1958/59																	
Feb.							68	5	—	—	—	—	—	—	—	—	—
T							68	5	—	—	—	—	—	—	—	—	—
1959/60																	
Jan.							43	28	8	—	—	—	—	—	4	13	28
Feb.							—	1	5	—	—	—	—	—	—	—	—
T							43	29	13	—	—	—	—	—	4	13	28
1960/61																	
Dec.	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	4	—
Jan.	—	—	—	—	—	—	102	11	—	—	—	—	—	—	—	—	—
Feb.	—	—	—	—	—	—	—	4	—	—	—	—	—	—	—	—	—
T	—	—	—	3	—	—	102	15	—	—	—	—	—	—	—	4	—
1961/62																	
Dec.	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Jan.	—	—	—	—	—	3	13	7	3	—	—	—	—	—	1	—	—
Apr.	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—
T	—	—	—	—	—	3	14	7	3	—	—	—	—	2	1	—	—
1962/63																	
Jan.							—	—	—	—	4	—	3				
T							—	—	—	—	4	—	3				
1963/64																	
Apr.							2	—	—	—	—	—	—				
T							2	—	—	—	—	—	—				

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—																	
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—	—																	
420	—																	
420	—																	
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—	—	—	—	—	—	—	—	—	—	—	—	—						
—	—	—	60	35				—	—	17								
—	—	—	—	—				—	—	—								
—	—	—	60	35				—	—	17								
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Table 4. Series A. Catch of fin whale

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1931/32																	
Oct.	—	—	—	3	—	—	—	—	—	—	—	—	—				
Nov.	—	—	—	60	2	7	—	—	—	—	—	—	—				
Dec.	—	—	6	24	—	—	—	2	—	—	—	—	—				
Jan.	—	—	37	—	—	—	—	1	8	—	—	—	—				
Feb.	—	—	65	40	—	—	—	—	—	—	—	—	—				
Mar.	—	—	—	18	—	—	—	—	—	—	—	—	—				
T	—	—	108	145	2	7		3	8								
1932/33																	
Oct.	—	—	—	26	1	1	2	—	—	—	—	—	—				
Nov.	—	—	—	110	4	27	8	—	2	—	—	—	—				
Dec.	—	—	—	44	20	10	15	—	1	15	4	—	—				
Jan.	—	—	—	32	—	56	—	1	—	—	—	—	—				
T	—	—	—	212	25	94	25	1	3	15	4	—	—				
1933/34																	
Oct.	—	—	—	3	9	—	—	—	11	—	—	—	—	—	6	—	—
Nov.	—	—	—	—	15	1	1	—	17	29	11	—	—	4	9	56	—
Dec.	—	—	—	—	18	34	1	—	1	—	1	7	—	2	17	—	—
Jan.	—	—	—	—	236	92	—	—	—	—	—	—	—	—	—	—	—
Feb.	—	—	48	25	6	—	—	—	—	—	—	—	—	—	—	—	—
Mar.	—	—	16	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	64	28	284	127	2	—	29	29	12	7	—	6	32	56	—
1934/35																	
Nov.	—	—	—	—	6	25	4	—	16	17	5	8	7	—	—	1	—
Dec.	—	—	16	133	30	23	2	3	40	2	11	—	—	3	81	3	6
Jan.	—	—	125	61	12	83	—	—	128	29	15	—	15	—	—	—	—
Feb.	—	—	—	—	—	3	—	—	—	—	10	32	—	1	—	1	—
T	—	—	141	194	48	134	6	3	184	48	41	40	22	4	81	5	6
1935/36																	
Nov.	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
Dec.	—	—	—	8	352	152	3	119	298	82	—	—	—	1	5	14	—
Jan.	—	—	—	118	777	419	495	194	32	—	—	—	—	—	1	—	—
Feb.	—	—	6	125	14	—	—	—	—	—	—	—	—	—	—	—	—
Mar.	—	—	—	9	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	6	260	1,144	571	498	313	330	82	—	—	—	1	6	14	—
1936/37																	
Oct.	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Nov.	—	—	—	1	—	5	1	—	—	—	—	—	—	—	—	—	—
Dec.	—	—	18	78	148	76	93	129	336	45	—	—	—	—	1	—	—
Jan.	—	—	22	201	105	194	438	222	450	21	—	—	—	—	—	—	—
Feb.	—	—	—	11	3	17	415	101	113	—	—	—	—	—	—	—	—
Mar.	—	24	—	—	—	5	1	—	—	—	—	1	—	—	—	—	—
T	—	24	40	292	256	297	948	452	899	66	—	1	—	—	1	—	—
1937/38																	
Nov.	—	—	—	—	—	—	—	—	—	12	15	—	—	—	12	8	—
Dec.	—	—	—	7	108	115	274	173	244	283	—	—	—	21	8	20	125
Jan.	—	—	—	—	104	319	827	966	232	—	—	—	—	—	—	—	—
Feb.	—	—	—	34	10	47	198	20	—	—	—	—	—	—	—	—	—
Mar.	—	—	—	—	—	—	—	10	5	—	—	—	—	—	—	—	—
T	—	—	—	41	222	481	1,299	1,169	481	295	15	—	—	21	20	28	125
1938/39																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10
Dec.	—	8	501	64	113	74	260	156	160	107	2	—	—	—	—	16	14
Jan.	5	6	157	22	45	315	103	494	125	17	—	—	—	—	27	—	—
Feb.	—	11	—	—	—	150	12	—	—	—	—	—	—	—	—	—	—
Mar.	—	—	—	—	—	16	—	—	—	—	—	—	—	—	—	—	—
T	5	25	658	86	158	555	375	650	285	124	2	—	—	—	27	16	24

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
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Table 4. Continued.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1945/46																	
Nov.	—	—	—	—	3	—	—	—	24	—	—	—	—				
Dec.	—	25	74	325	80	8	7	19	7	—	—	—	—				
Jan.	—	12	—	81	511	8	—	65	210	16	—	—	—				
Feb.	—	—	8	137	18	—	—	—	79	—	—	—	—				
Apr.	—	4	—	—	—	—	—	—	—	—	—						
T	—	41	82	543	612	16	7	84	320	16	—	—	—				
1946/47																	
Dec.	—	—	177	19	29	8	48	—	213	576	101	—	—	—	115	8	—
Jan.	—	—	—	55	86	—	11	100	344	470	28	—	—	—	162	—	—
Feb.	—	—	—	—	—	—	93	148	—	—	—	—	—	—	—	—	—
T	—	—	177	74	115	8	152	248	557	1, 046	129	—	—	—	277	8	—
1947/48																	
Dec.	—	—	—	—	194	218	42	59	332	310	—	—	—	6	16	1	7
Jan.	—	—	—	—	792	675	74	989	29	—	—	—	—	—	—	—	—
Feb.	—	—	—	—	38	—	—	—	—	—	—	—	—	—	—	—	—
Mar.	—	—	—	—	341	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	—	—	1, 365	893	116	1, 048	361	310				6	16	1	7
1948/49																	
Dec.	—	—	3	81	—	9	431	60	327	151	—	—	—	—	1	6	—
Jan.	—	—	188	14	147	691	676	22	108	45	97	—	—	—	—	—	—
Feb.	—	—	—	—	—	2	15	—	32	—	—	—	—	—	—	—	—
Mar.	—	93	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	93	191	95	147	702	1, 122	82	467	196	97	—	—	—	1	6	—
1949/50																	
Dec.	—	34	249	14	558	11	2	328	484	49	1	—	—	—	5	—	—
Jan.	—	576	88	362	78	—	388	786	410	78	—	—	—	—	—	—	—
Feb.	—	—	—	—	—	2	72	189	46	—	—	—	—	—	—	—	—
Mar.	—	—	—	—	100	—	—	—	—	—	—	—	—	—	123	—	—
T	—	610	337	376	736	13	462	1, 303	940	127	1	—	—	—	128	—	—
1950/51																	
Dec.	—	—	22	228	14	70	32	186	84	—	—	—	—				
Jan.	—	37	267	435	130	161	1	515	12	—	—	—	—				
T	—	37	289	663	144	231	33	701	96	—	—	—	—				
1951/52																	
Jan.	—	623	788	109	43	—	934	2, 154	—	—	—	—	109	214	143	—	18
Feb.	—	—	48	—	—	9	16	63	—	—	—	—	—	—	—	—	—
T	—	623	836	109	43	9	950	2, 217	—	—	—	—	109	214	143	—	18
1952/53																	
Nov.	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
Dec.	—	—	—	—	3	—	—	1	1	—	—	—	—	—	—	—	—
Jan.	—	—	—	18	335	463	1, 401	1, 178	682	47	—	—	73	84	—	—	—
Feb.	—	—	—	—	—	242	—	—	—	—	—	—	—	—	—	—	—
Mar.	—	—	—	—	—	—	—	—	63	—	—	—	—	—	—	—	—
T	—	—	—	18	339	705	1, 401	1, 179	746	47	—	—	73	84	—	—	—
1953/54																	
Dec.	—	—	—	2	—	1	—	4	—	—	—	—	—	—	—	—	—
Jan.	—	507	525	529	221	—	350	2, 241	110	192	605	120	—	43	357	—	—
Feb.	—	17	—	—	—	36	—	—	—	—	56	—	—	—	—	—	—
Mar.	—	—	—	—	—	—	—	—	259	69	32	—	—	—	—	—	—
T	—	524	525	531	221	37	350	2, 245	369	261	693	120	—	43	357	—	—
1954/55																	
Dec.	—	—	—	—	—	—	5	—	—	—	—	—	—				
Jan.	—	24	26	40	454	937	322	1, 858	480	1, 064	570	—	—				
Feb.	—	—	—	—	530	158	395	299	40	73	125	—	—				
Mar.	—	—	—	—	263	393	67	—	—	—	—	—	—				
T	—	24	26	40	1, 247	1, 488	789	2, 157	520	1, 137	695	—	—				

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一般財団法人　日本鯨類研究所

THE INSTITUTE OF CETACEAN RESEARCH

Table 4. Continued.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1955/56																	
Dec.	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Jan.	—	367	—	—	56	159	752	325	2	—	—	45	—	16	31	—	—
Feb.	—	—	—	—	—	—	—	—	48	—	—	—	—	—	83	—	—
Mar.	—	—	—	29	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	367	—	29	56	159	753	325	50	—	—	45	—	16	114	—	—
1956/57																	
Dec.	—	—	—	—	—	—	—	1	2	—	—	—	—				
Jan.	24	202	721	97	205	1,167	131	64	364	171	44	31	—				
Feb.	—	—	—	211	1,504	1,937	286	—	—	—	—	4	—				
Mar.	—	—	—	—	12	100	342	90	—	—	—	—	—				
T	24	202	721	308	1,721	3,204	759	155	366	171	44	35	—				
1957/58																	
Dec.	—	—	—	—	—	—	—	—	4	1	—	—	—	—	—	—	—
Jan.	—	418	544	404	471	675	1,022	978	54	—	—	—	—	—	—	—	—
Feb.	—	—	—	—	35	733	792	710	70	—	—	—	—	83	303	250	53
Mar.	—	—	—	—	—	483	8	1,394	124	—	—	—	—	312	623	108	—
T	—	418	544	404	506	1,891	1,822	3,082	252	1	—	—	—	395	926	358	53
1958/59																	
Jan.	—	—	31	139	671	318	1,683	1,341	35	—	—	—	65	620	878	585	247
Feb.	—	—	22	27	55	767	341	203	111	—	—	—	—	87	72	39	—
Mar.	—	—	—	4	74	475	—	3	284	—	—	—	—	—	—	18	5
T	—	—	53	170	800	1,560	2,024	1,547	430	—	—	—	65	707	950	642	252
1959/60																	
Nov.	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
Dec.	64	82	98	114	6	—	—	277	438	—	185	—	—	—	271	110	—
Jan.	124	382	179	244	448	110	140	1,437	49	117	1,028	—	—	465	1,300	1,049	825
Feb.	—	97	32	1	852	182	134	247	51	109	784	7	—	453	419	388	159
Mar.	5	—	—	2	336	122	34	183	47	44	56	—	1	126	363	—	—
Apr.	—	—	—	—	—	54	205	247	—	31	—	—	—	—	—	—	—
T	193	561	309	361	1,642	468	513	2,391	586	301	2,053	7	1	1,044	2,353	1,547	984
1960/61																	
Nov.	—	—	—	—	—	—	—	—	73	—	—	—	—	—	—	—	—
Dec.	19	156	—	—	59	42	138	292	251	—	378	228	—	13	46	34	136
Jan.	49	285	44	3	403	225	626	2,385	1,426	432	445	269	65	143	445	55	111
Feb.	58	18	67	9	503	595	227	239	276	498	587	6	—	210	357	—	—
Mar.	5	10	19	—	587	388	131	199	362	24	174	9	15	105	354	—	—
Apr.	2	—	—	—	78	58	129	49	117	—	—	—	—	—	—	—	—
T	133	469	130	12	1,630	1,308	1,251	3,164	2,505	954	1,584	512	80	471	1,202	89	247
1961/62																	
Dec.	119	219	72	186	217	349	105	254	537	188	67	276	248	14	566	—	—
Jan.	49	168	38	759	429	640	355	1,430	648	302	334	72	106	104	905	—	—
Feb.	264	57	—	1	323	351	342	921	975	176	81	—	47	108	844	131	—
Mar.	138	31	—	—	211	1,277	619	529	268	99	382	201	220	81	35	—	—
Apr.	11	—	—	—	—	80	—	—	16	1	1	—	1	7	—	—	—
T	581	475	110	946	1,180	2,697	1,421	3,134	2,444	766	865	549	622	314	2,350	131	—
1962/63																	
Dec.	16	89	231	187	176	155	53	6	325	285	437	246	32	104	110	—	—
Jan.	53	65	341	77	596	555	139	171	97	311	341	30	50	31	378	42	55
Feb.	—	12	46	86	282	828	194	427	164	744	—	3	31	—	—	—	—
Mar.	79	22	—	41	5	111	29	158	462	420	126	—	—	13	52	—	—
Apr.	2	1	—	7	—	—	—	47	—	—	—	—	—	—	—	—	—
T	150	189	618	398	1,059	1,649	415	809	1,048	1,760	904	279	113	148	540	42	55
1963/64																	
Dec	—	30	158	400	142	175	300	255	441	56	—	65	11	8	10	20	4
Jan.	26	77	257	715	935	648	101	139	—	—	10	1	56	11	26	—	—
Feb.	271	205	15	324	819	447	119	569	273	36	8	24	81	73	48	—	—
Mar.	202	15	25	37	356	150	122	176	261	279	27	—	—	11	—	—	—
Apr.	—	—	—	—	—	57	11	5	—	—	—	—	—	—	32	—	—
T	499	327	455	1,476	2,252	1,477	653	1,144	975	371	45	90	148	103	116	20	4

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—							—	—	—	—	—						
—	—							—	37	—	—	—						
—	—							—	—	—	—	—						
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99	—	—	—	—	—	—	—											
15	209	—	—	—	—	—	—											
—	92	44	46	48	40	—	—											
114	301	44	46	48	40	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	74	—	—											
—	—	—	271	62	—	—	—											
—	—	—	21	46	—	—	—											
—	—	—	—	123	—	52	152											
—	—	—	—	—	—	—	—											
—	—	—	292	231	74	52	152											
—	—	—	—	—	—	—	—	—	—	—	—	—						
—	—	—	—	—	33	48	—	—	—	—	—	—						
60	—	7	85	239	106	61	—	—	59	88	—	—						
—	—	—	—	5	34	172	—	—	—	72	—	—						
—	—	—	—	—	—	—	—	—	265	90	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
60	—	7	85	244	173	281	—	—	324	250	—	—						
—	—												—	—	—	—	—	99
—	—												—	—	—	—	—	—
—	—												—	—	—	—	—	23
—	—												—	—	—	—	—	16
—	—												—	—	—	—	—	17
—	—												—	—	—	—	—	155
—	—							—	—	—	—	—	5	—	—	39	40	102
—	—							—	—	—	—	—	—	—	—	—	3	21
—	—							—	—	5	—	—	—	—	—	—	—	—
—	—							—	—	—	—	—	—	—	—	—	—	10
—	—							—	—	—	—	—	—	—	—	—	—	1
—	—							—	—	5	—	—	5	—	—	39	43	134
—	—	—	—	—	—	—	—						—	—	—	—	—	—
36	—	—	79	102	52	—	—						—	—	—	—	—	—
—	—	—	—	24	7	—	—						—	—	—	—	—	24
—	—	—	—	19	64	—	—						—	—	—	—	—	—
—	—	—	—	—	—	—	—						—	—	—	—	—	—
36	—	—	79	145	123	—	—						—	—	—	—	—	24

Table 4. Continued.

Area	II						III							IV			
Square	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1964/65																	
Dec.	205	25	38	227	82	240	70	442	15	—	71	90	52	49	—	—	—
Jan.	220	638	12	53	25	60	—	—	—	—	—	—	—	—	—	46	6
Feb.	140	441	—	18	143	136	—	—	—	—	26	—	—	22	—	—	—
Mar.	39	131	4	6	57	278	3	—	7	—	—	—	—	6	18	—	—
Apr.	—	—	1	—	—	50	—	—	—	—	—	—	—	—	—	—	—
T	604	1,235	55	304	307	764	73	442	22	—	97	90	52	77	18	46	6
1965/66																	
Dec.	—	—	15	20	2	5	23	51	40	—	—	—	—				
Jan.	51	4	13	—	—	—	—	—	60	26	—	—	—				
Feb.	—	—	—	—	—	17	11	—	—	—	—	—	—				
Mar.	—	18	—	—	93	192	8	8	17	—	—	—	—				
Apr.	—	—	—	—	1	8	—	—	—	—	—	—	—				
T	51	22	28	20	96	222	42	59	117	26	—	—	—				
1966/67																	
Dec.	47	—	—	—	—	12	23	65	—	—	—	—	—	10	44	10	—
Jan.	—	—	—	—	—	10	20	10	—	—	—	—	—	—	—	—	—
Feb.	—	—	—	—	—	17	—	—	—	—	—	—	—	22	—	—	—
Mar.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	24	—	—
T	47	—	—	—	—	39	43	75	—	—	—	—	—	32	68	10	—
1967/68																	
Dec.	—	—	—	—	—	—	3	40	9	—	—	—	—	—	—	—	—
Jan.	—	—	—	—	—	—	—	—	—	38	1	10	21	218	52	—	—
Feb.	—	—	—	—	—	68	60	—	—	4	10	—	—	54	25	—	—
Mar.	—	—	—	—	—	70	3	—	—	—	—	—	—	24	197	—	—
T	—	—	—	—	—	138	66	40	9	42	11	10	21	296	274	—	—
1968/69																	
Dec.	—	—	—	—	—	—	2	4	—	—	—	—	—	—	—	—	—
Jan.	—	—	—	—	—	32	1	25	—	—	—	—	—	241	520	448	35
Feb.	—	—	—	—	—	—	—	—	—	—	10	—	3	3	23	—	—
Mar.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	—	—	—	32	3	29	—	—	10	—	3	244	543	448	35
1969/70																	
Jan.							—	—	—	—	—	—	—	90	205	13	—
Feb.							—	—	—	—	—	—	18	53	268	—	—
Mar.							—	—	—	—	—	—	—	45	251	—	—
T							—	—	—	—	—	—	18	188	724	13	—
1970/71																	
Dec.	—	—	32	—	5	27	—	—	—	—	—	—	—	—	—	—	—
Jan.	—	—	—	—	—	—	—	—	—	—	—	—	—	84	229	1	—
Feb.	49	54	—	—	—	—	—	—	—	—	—	—	—	9	32	5	—
Mar.	37	96	—	—	—	—	—	—	—	26	—	—	—	—	—	—	—
T	86	150	32	—	5	27	—	—	—	26	—	—	—	93	261	6	—
1971/72																	
Dec.	76	16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	13	—	—	—	—	—	—	—	—	—	34	5	—	26	67	—	—
Feb.	8	11	6	3	—	49	66	35	94	86	—	—	—	36	63	16	—
Mar.	—	1	21	—	5	29	—	—	32	41	39	—	1	81	221	—	—
T	97	28	27	3	5	78	66	35	126	127	73	5	1	143	351	16	—

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—	—	—	—	—	—	—						—	—	—	—	—	—
2	—	—	184	19	—	—	—						—	—	—	—	—	22
—	—	—	34	47	—	—	—						—	—	—	—	—	22
—	—	—	105	68	—	—	—						—	—	—	—	—	—
—	—	—	—	—	—	—	—						—	—	—	—	—	—
2	—	—	323	134	—	—	—						—	—	—	—	—	44
		—	67	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	12	4	2	—	—	—	—	—	—	—	—	—	—	—	17
		—	14	20	2	3	8	—	—	—	—	—	—	—	—	—	—	—
		—	2	—	—	—	1	3	4	3	6	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	83	32	6	5	9	3	4	3	6	—	—	—	—	—	—	17
—	—	—	—	—	—	—	—											
—	—	7	11	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	7	11	—	—	—	—											
5	—							—	—	—	—	—						
—	—							—	—	—	—	—						
—	—							5	—	3	—	—						
—	—							18	—	7	—	—						
5	—							23	—	10	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
—	—	—	—	—	—	—	—	—	4	—	—	—						
—	—	—	29	8	—	—	—	—	—	5	—	—						
—	—	—	—	48	—	—	—	—	—	—	—	—						
—	—	—	29	56	—	—	—	—	4	5	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
—	—	—	64	11	—	—	—	—	—	—	—	—						
—	—	—	—	—	—	—	—	—	—	2	—	—						
—	—	—	64	11	—	—	—	—	—	2	—	—						
—	—																	
—	—																	
—	—																	
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—	—												—	—	—	—	—	10
—	—												—	—	—	—	—	—
—	—												—	—	—	—	—	7
—	—												—	—	—	—	—	—
—	—												—	—	—	—	—	17

Table 5. Series A. Catch of sei whale

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1934/35																	
Nov.	—	—	—	—	1	1	—	1	—	—	—	—	—				
Apr.	—	—	38	—	—	—	—	—	—	—	—	—	—				
May.	—	—	93	—	—	—	—	—	—	—	—	—	—				
T	—	—	131	—	1	1	—	1	—	—	—	—	—				
1935/36																	
Nov.	—	—	—	—	2	—											
T	—	—	—	—	2	—											
1936/37																	
Feb.	—	—	—	1	—	—	—	1	—	—	—	—	—				
Mar.	—	3	—	—	—	—	—	—	—	—	—	—	—				
T	—	3	—	1	—	—	—	1	—	—	—	—	—				
1945/46																	
Feb.	—	—	—	2	—	—											
T	—	—	—	2	—	—											
1950/51																	
Mar.	—	16	—	3	—	—											
T	—	16	—	3	—	—											
1951/52																	
Jan.	—	6	—	—	—	—	—	3	—	—	—	—	—				
T	—	6	—	—	—	—	—	3	—	—	—	—	—				
1952/53																	
Mar.							—	—	5	—	—	—	—				
T							—	—	5	—	—	—	—				
1953/54																	
Jan.	—	12	22	—	—	—	—	1	—	—	—	—	—				
Feb.	—	12	—	—	—	—	—	—	—	—	—	—	—				
T	—	24	22	—	—	—	—	1	—	—	—	—	—				
1954/55																	
Jan.	—	—	—	3	—	1	—	2	—	—	—	—	—				
Feb.	—	—	—	—	47	15	9	—	—	—	—	—	—				
Mar.	—	—	—	—	30	—	1	—	—	—	—	—	—				
T	—	—	—	3	77	16	10	2	—	—	—	—	—				
1955/56																	
Jan.	—	3	—	—	—	—	—	1	—	—	—	—	—				
Mar.	—	—	—	17	—	—	—	—	—	—	—	—	—				
T	—	3	—	17	—	—	—	1	—	—	—	—	—				
1956/57																	
Jan.	—	—	3	—	—	—	—	—	—	—	—	—	—				
Feb.	—	—	—	7	60	4	—	—	—	—	—	—	—				
Mar.	—	—	—	—	1	1	14	1	—	—	—	—	—				
T	—	—	3	7	61	5	14	1	—	—	—	—	—				
1957/58																	
Jan.	—	4	12	—	—	—	—	1	—	—	—	—	—				
Feb.	—	—	—	—	—	1	5	—	—	—	—	—	—				
Mar.	—	—	—	—	—	—	—	7	—	—	—	—	—				
T	—	4	12	—	—	1	5	8	—	—	—	—	—				
1958/59																	
Jan.	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	18	—
Feb.	—	—	—	1	—	—	9	2	1	—	—	—	—	7	11	2	—
Mar.	—	—	—	4	—	—	—	6	—	—	—	—	—	—	—	3	—
T	—	—	—	5	—	—	9	8	1	—	—	—	—	8	11	23	—
1959/60																	
Dec.	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	8	51	13	6	—	—	—	1	—	—	—	—	—	4	18	27	13
Feb.	—	31	1	—	4	—	—	—	—	—	17	2	—	17	62	43	93
Mar.	2	—	—	3	12	—	—	1	5	3	—	—	—	28	28	—	—
Apr.	16	—	—	—	—	3	6	5	—	—	—	—	—	—	—	—	—
T	27	82	14	9	16	3	6	7	5	3	17	2	—	49	108	70	106

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	14	25	3	—	—	—											
—	—	14	25	3	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	25	2	—	—	—											
—	—	—	5	22	—	—	—											
—	—	—	14	47	—	21	95											
—	—	—	—	—	—	—	—											
—	—	—	44	71	—	21	95											

Table 5. Continued.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1960/61																	
Dec.	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	2	28	2	8	1	—	—	17	11	2	—	—	—	1	13	—	12
Feb.	15	146	34	12	5	41	21	16	4	13	13	8	17	54	7	—	—
Mar.	—	5	36	—	11	35	24	13	12	1	15	1	17	3	9	—	—
Apr.	10	—	—	—	—	—	1	14	1	—	—	—	—	—	—	—	—
T	27	181	72	20	17	76	46	60	28	16	28	9	35	58	29	—	12
1961/62																	
Dec.	45	70	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	—	3	21	10	8	6	1	2	3	2	39	18	87	142	114	—	—
Feb.	144	8	—	—	40	64	17	3	14	4	1	—	3	26	184	22	—
Mar.	229	19	—	—	11	75	13	12	64	8	14	12	46	52	74	—	—
Apr.	73	—	—	—	—	8	2	—	15	—	1	2	—	—	—	—	—
T	491	100	41	10	59	153	33	17	96	14	55	32	136	220	372	22	—
1962/63																	
Dec.	31	1	2	1	—	—	—	—	—	1	—	—	—	—	1	—	—
Jan.	15	11	95	18	46	8	5	—	4	7	1	—	1	46	14	5	1
Feb.	—	83	15	22	21	56	11	7	26	42	2	2	19	—	—	—	—
Mar.	178	36	16	7	1	11	9	4	19	73	2	—	—	3	54	—	—
Apr.	20	—	—	23	—	—	—	7	—	—	—	—	—	—	—	—	—
T	244	131	128	71	68	75	25	18	49	123	5	2	20	49	69	5	1
1963/64																	
Dec.	—	5	33	—	—	—	—	—	—	—	—	252	24	—	—	—	1
Jan.	1	142	273	614	182	143	—	7	—	—	42	15	4	—	18	—	—
Feb.	46	359	154	314	255	103	25	90	8	—	14	1	—	—	—	—	—
Mar.	52	67	50	29	487	328	114	36	29	7	—	—	—	3	—	—	—
Apr.	—	—	—	—	6	34	10	5	—	—	—	—	—	—	—	—	—
T	99	573	510	957	930	608	149	138	37	7	56	268	28	3	18	—	1
1964/65																	
Dec.	30	2	10	14	7	1	—	—	—	—	5	1	—	—	—	—	—
Jan.	100	1,774	123	64	8	18	—	—	—	—	—	—	—	—	—	10	4
Feb.	105	2,743	244	355	153	487	—	—	—	—	34	—	—	53	—	—	—
Mar.	229	1,180	249	149	21	411	59	—	10	—	—	—	—	32	15	—	—
Apr.	—	—	—	—	—	34	—	—	—	—	—	—	—	—	—	—	—
T	464	5,699	626	582	189	951	59	—	10	—	39	1	—	85	15	10	4
1965/66																	
Dec.	—	—	32	24	—	—	—	—	—	—	—	—	—				
Jan.	14	17	63	7	—	—	—	—	2	—	—	—	—				
Feb.	—	—	—	—	—	14	3	—	—	—	—	—	—				
Mar.	—	5	75	1	123	320	69	42	2	—	—	—	—				
Apr.	—	—	—	—	35	51	—	—	—	—	—	—	—				
T	14	22	170	32	158	385	72	42	4	—	—	—	—				
1966/67																	
Dec.	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	—	—	—	—	—	22	12	7	—	—	—	—	—	194	—	—	—
Feb.	—	—	—	—	—	69	—	—	—	—	—	—	—	1,027	512	—	—
Mar.	—	—	—	—	—	—	—	—	—	—	—	—	—	111	259	—	—
T	8	—	—	—	—	91	12	7	—	—	—	—	—	1,332	771	—	—
1967/68																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	—	—	—	—	—	—	—	—	—	6	—	26	25	640	28	—	—
Feb.	—	—	—	—	—	22	13	—	—	—	—	—	31	121	27	—	—
Mar.	—	—	—	—	—	173	5	—	—	—	—	—	—	33	147	—	—
T	—	—	—	—	—	195	18	—	—	6	—	26	56	794	202	—	—
1968/69																	
Jan.							—	—	—	—	—	—	—	171	77	8	4
Feb.							—	—	—	—	12	22	—	3	3	—	—
Mar.							—	—	—	—	—	—	—	—	—	—	—
T							—	—	—	—	12	22	—	174	80	8	4

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—	—	—	—	—	—	—	—	—	—	—	—						
1	—	—	35	39	42	5	—	—	44	20	—	—						
—	—	—	—	2	22	124	—	—	—	29	—	—						
—	—	—	—	—	—	—	—	—	360	42	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
1	—	—	35	41	64	129	—	—	404	91	—	—						
—	—												—	—	—	—	—	61
—	—												—	—	—	—	—	—
—	—												—	—	—	—	—	30
—	—												—	—	—	—	—	42
—	—												—	—	—	—	—	80
—	—												—	—	—	—	—	213
—	—							—	—	—	—	—	—	—	—	—	36	80
—	—							—	—	—	—	—	—	—	—	—	—	36
—	—							—	—	1	—	—	—	—	—	—	—	—
—	—							—	—	—	—	—	—	—	—	—	—	4
—	—							—	—	—	—	—	—	—	—	—	—	29
—	—							—	—	1	—	—					36	149
—	—	—	—	—	—	—	—						—	—	—	—	—	—
12	—	—	33	170	19	—	—						—	—	—	—	—	—
—	—	—	—	27	33	—	—						—	—	—	—	—	1
—	—	—	—	—	192	—	—						—	—	—	—	—	—
—	—	—	—	—	—	—	—						—	—	—	—	—	—
12	—	—	33	197	244	—	—						—	—	—	—	—	1
—	—	—	—	—	—	—	—						—	—	—	—	—	—
24	—	—	150	12	—	—	—						—	—	—	—	—	26
—	—	—	278	32	—	—	—						—	—	—	—	—	9
—	—	—	257	174	—	—	—						—	—	—	—	—	—
—	—	—	—	—	—	—	—						—	—	—	—	—	—
24	—	—	685	218	—	—	—						—	—	—	—	—	35
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	8	12	18	—	—	—	—	—	—	—	—	—	—	—	35
		—	35	48	6	13	19	—	—	—	—	—	—	—	—	—	—	—
		—	32	—	—	—	47	51	7	37	11	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	67	56	18	31	66	51	7	37	11	—	—	—	—	—	—	35
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
1	—	—	—	—	—	—	—	—	—	—	—	—						
—	—	—	—	4	—	—	—	359	—	—	—	—						
—	—	—	21	15	—	—	698	374	—	41	—	—						
—	—	—	—	—	—	—	8	319	—	—	—	—						
1	—	—	21	19	—	—	706	1,052	—	41	—	—						
—	—	—	—	—	—	—	—	40	135	—	—	—						
—	—	—	155	37	—	—	—	13	53	25	—	—						
—	—	—	4	105	—	—	—	—	—	—	—	—						
—	—	—	159	142	—	—	—	53	188	25	—	—						

Table 5. Continued.

Area	II						III							IV			
Square	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1969/70																	
Jan.														12	19	22	—
Feb.														—	48	—	—
Mar.														—	14	—	—
T														12	81	22	—
1970/71																	
Dec.	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	—	—	—	—	—	—	—	—	—	—	—	—	—	17	4	—	—
Feb.	—	24	—	—	—	—	—	—	—	—	—	—	—	22	3	2	45
Mar.	1	32	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
T	1	56	2	—	—	—	—	—	—	1	—	—	—	39	7	2	45
1971/72																	
Jan.	—	—	—	—	—	—	—	—	—	—	—	2	—	—	4	—	—
Feb.	—	—	24	—	—	—	3	—	—	—	—	—	—	5	2	—	—
Mar.	—	7	18	—	—	—	—	—	1	—	3	—	15	—	14	—	—
T	—	7	42	—	—	—	3	—	1	—	3	2	15	5	20	—	—

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—	—	—	—	—	—	—	—	—	—	—	—						
—	—	—	52	12	—	—	—	—	—	—	—	—						
—	—	—	19	—	—	—	—	—	—	14	—	—						
—	—	—	71	12	—	—	—	—	—	14	—	—						
—	—							—	—	—	—	—						
—	—							—	—	—	—	—						
16	—							—	—	—	—	—						
—	—							17	—	—	—	—						
16	—							17	—	—	—	—						
—	—												—	—	—	—	—	—
—	—												—	—	—	6	—	—
—	—												—	—	—	—	—	—
—	—												—	—	—	6	—	—

Table 6. Series B. Catcher's day's work

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1931/32																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	56	8	—	—
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	496	—	—	—
Jan.	—	—	32	—	7	6	6	41	61	20	132	—	—	488	16	—	—
Feb.	36	—	137	66	12	12	—	—	—	—	—	—	—	376	88	—	—
Mar.	64	—	—	258	—	—	—	—	—	64	24	24	48	32	184	—	—
T	100	—	169	324	19	18	6	41	61	84	156	24	48	1,448	296	—	—
1932/33																	
Oct.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nov.	—	—	—	—	—	—	—	—	—	—	—	23	16	—	84	84	84
Dec.	—	—	—	—	—	—	—	—	14	125	104	76	157	94	474	400	77
Jan.	12	48	78	181	38	26	66	102	70	224	639	246	—	—	486	791	25
Feb.	54	367	181	88	8	8	6	—	66	117	731	290	8	163	493	462	—
Mar.	134	280	50	24	88	—	—	108	30	303	492	42	61	274	140	—	—
Apr.	—	18	—	24	88	—	—	—	43	81	—	—	—	—	—	—	—
T	200	713	309	317	222	34	72	210	223	850	1,966	677	242	531	1,677	1,737	186
1933/34																	
Oct.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	35	—	—	17	14
Dec.	—	—	—	—	—	18	—	—	5	—	20	229	420	446	266	471	328
Jan.	—	—	—	127	6	12	—	38	195	306	208	339	173	190	507	699	87
Feb.	20	15	50	57	5	—	5	26	156	357	445	31	55	38	286	479	—
Mar.	—	—	110	—	—	—	—	124	8	203	208	5	—	—	—	147	—
T	20	15	160	184	11	30	5	188	364	866	881	604	683	674	1,064	1,813	429
1934/35																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	74	—
Dec.	—	—	12	56	—	—	—	—	—	48	115	173	122	137	386	766	390
Jan.	—	35	170	201	10	12	—	—	291	301	688	195	162	284	802	204	121
Feb.	—	270	230	200	—	54	54	67	672	1,406	350	23	—	21	557	66	—
Mar.	229	221	239	194	36	24	80	666	1,026	387	404	283	72	284	174	34	—
Apr.	—	—	—	—	—	—	—	7	69	27	—	—	—	—	—	—	—
May.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	229	526	651	651	46	90	134	740	5,028	2,169	1,557	674	356	726	1,919	1,144	511
1935/36																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dec.	—	—	—	—	—	—	—	14	59	641	291	—	—	—	220	7	—
Jan.	—	—	—	167	14	18	58	130	545	662	728	166	—	—	289	380	40
Feb.	—	34	120	530	63	9	70	262	1,229	946	196	5	10	5	370	345	—
Mar.	—	116	—	181	—	—	166	74	412	319	114	—	—	—	137	—	—
T	—	150	120	878	77	27	294	480	2,245	2,568	1,329	171	10	5	1,016	732	40
1936/37																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	8	123	8	24
Dec.	—	—	75	121	14	—	—	—	97	124	14	—	—	—	620	246	122
Jan.	43	423	418	314	54	195	168	146	352	173	24	25	19	129	560	493	325
Feb.	448	486	456	210	6	286	447	248	617	36	—	—	—	—	147	1,196	85
Mar.	279	107	137	—	—	93	42	154	178	6	—	—	14	97	286	199	16
T	770	1,016	1,086	645	74	574	657	548	1,244	339	38	25	33	234	1,736	2,142	572
1937/38																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	38	19	—
Dec.	—	133	579	285	9	—	—	—	178	468	161	—	—	233	68	89	564
Jan.	—	626	225	747	118	61	208	22	488	716	314	—	14	90	272	218	790
Feb.	56	1,032	378	331	456	120	278	151	1,091	452	200	91	77	—	70	221	647
Mar.	146	529	212	505	—	—	100	341	397	331	54	—	—	—	63	176	212
T	202	2,320	1,394	1,868	583	181	586	514	1,994	1,967	729	91	91	323	511	723	2,213
1938/39																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	32	96	538
Dec.	—	7	51	85	32	—	—	—	104	518	48	—	—	—	80	403	972
Jan.	194	728	747	—	91	262	186	56	352	702	72	—	64	—	622	378	513
Feb.	301	1,077	225	—	525	415	168	364	224	675	309	62	227	316	335	611	345
Mar.	48	103	167	61	82	64	81	78	211	20	162	48	8	151	104	222	261
T	543	1,915	1,190	146	730	741	435	498	891	1,915	591	110	299	467	1,173	1,710	2,629

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—	56	—	—	—	—	—											
14	63	49	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
14	63	105	—	—	—	—	—											
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10	10	5	10	15	5	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	10	5	5	20	—	—	—	—	—	—	—	—	—	15
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10	10	5	10	15	15	5	5	20	—	—	—	—	—	—	—	—	—	15
—	—																	
—	—																	
161	—																	
—	—																	
—	—																	
—	—																	
—	—																	
161	—																	
—	—	—	130	—	—	—	—											
35	55	35	30	—	—	—	—											
50	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
85	55	35	160	—	—	—	—											
—	—																	
473	72																	
802	152																	
770	224																	
357	128																	
2,402	576																	
162	8	—	56	—	9	—	—						—	—	—	—	—	—
522	410	395	125	36	—	—	—						—	—	—	—	—	—
705	275	64	96	357	74	—	—						—	—	—	—	—	50
212	396	228	316	92	68	—	—						—	—	—	—	—	81
213	176	45	—	—	—	—	—						—	—	—	—	—	—
1,814	1,265	732	593	485	151	—	—						—	—	—	—	—	131

Table 6. Continued.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1945/46																	
Dec.	—	—	—	—	—	11	11	—	22	8	8	—	—				
Jan.	110	327	—	—	22	11	11	16	284	115	67	16	—				
Feb.	—	809	—	20	—	—	—	—	673	284	40	—	—				
Mar.	60	1,109	—	—	—	—	—	—	405	498	—	—	—				
Apr.	—	396	—	—	—	—	—	14	116	70	—	—	—				
T	170	2,641	—	20	22	22	22	30	1,500	975	115	16	—				
1946/47																	
Dec.	—	—	11	20	—	—	—	—	58	17	—	—	—	—	81	288	—
Jan.	—	116	221	136	144	32	8	27	343	466	24	—	—	—	433	363	126
Feb.	81	381	69	—	440	151	432	9	91	225	272	—	—	77	110	145	393
Mar.	62	424	105	192	304	857	55	168	256	152	—	—	27	268	372	121	111
Apr.	—	123	—	56	96	122	155	—	—	—	—	—	63	104	96	—	—
T	143	1,044	406	404	984	1,162	650	204	748	860	296	—	90	449	1,092	917	630
1947/48																	
Dec.	—	—	—	—	—	—	—	—	46	139	32	—	—	49	424	181	272
Jan.	—	—	—	32	77	—	357	174	197	419	117	135	144	346	522	109	198
Feb.	—	—	310	503	615	627	219	56	212	189	55	88	44	130	790	27	—
Mar.	—	296	87	287	1,238	158	280	56	315	216	—	—	—	669	314	—	50
Apr.	—	—	—	—	—	10	—	—	—	—	—	—	—	22	—	—	—
T	—	296	397	822	1,930	795	856	286	770	963	204	223	188	1,216	2,050	317	520
1948/49																	
Dec.	—	—	—	—	—	—	—	—	14	80	154	20	—	39	13	122	148
Jan.	—	—	65	52	256	452	7	—	135	491	578	181	—	7	130	247	224
Feb.	—	186	323	243	540	395	459	75	774	471	—	—	—	—	—	106	201
Mar.	—	813	392	—	295	568	259	268	310	424	—	44	—	44	88	97	345
Apr.	—	—	—	—	—	12	—	—	—	—	—	—	—	—	—	—	—
T	—	999	780	295	1,091	1,427	725	343	1,233	1,466	732	245	—	90	231	572	918
1949/50																	
Dec.	—	—	—	354	—	—	—	—	—	15	—	—	—	—	235	—	55
Jan.	64	373	46	401	148	248	48	20	40	40	—	—	—	61	390	391	281
Feb.	423	339	218	—	529	430	489	265	86	181	133	41	119	400	149	13	39
Mar.	144	277	179	—	140	163	492	60	60	627	15	—	—	—	88	—	70
T	631	989	443	755	817	841	1,029	345	186	863	148	41	119	461	862	404	445
1950/51																	
Dec.	—	150	—	24	13	—	—	—	—	45	90	15	—	—	—	—	215
Jan.	206	615	260	140	15	—	—	164	218	60	30	195	90	56	434	176	321
Feb.	300	980	436	51	60	47	202	161	411	162	207	202	154	132	294	257	225
Mar.	—	163	308	15	24	36	164	106	—	276	62	51	145	39	123	36	91
T	506	1,908	1,004	230	112	83	366	431	629	543	389	463	389	227	851	469	852
1951/52																	
Jan.	42	566	70	54	—	—	—	—	27	273	30	45	243	611	443	222	114
Feb.	168	232	264	207	517	533	274	423	819	483	134	78	270	273	264	186	138
Mar.	—	—	—	—	275	—	70	105	305	—	—	—	135	24	36	—	—
T	210	798	334	261	792	533	344	528	1,151	756	164	123	648	908	743	408	252
1952/53																	
Jan.	—	—	17	17	239	141	327	390	546	90	36	48	489	352	174	184	122
Feb.	—	—	—	264	377	637	808	291	630	770	27	31	211	154	198	169	—
Mar.	—	162	475	146	363	419	36	171	347	149	75	74	37	39	39	52	36
T	—	162	492	427	979	1,197	1,171	852	1,523	1,009	138	153	737	545	411	405	158
1953/54																	
Jan.	32	475	215	191	33	—	13	50	91	13	26	—	86	326	321	81	—
Feb.	363	217	193	273	46	222	448	243	390	575	244	567	314	45	69	87	63
Mar.	115	497	—	36	120	337	164	383	271	270	270	88	14	—	18	18	18
T	510	1,189	408	500	199	559	625	676	752	858	540	655	414	371	408	186	81
1954/55																	
Jan.	—	242	165	48	—	246	196	95	67	329	258	92	—	—	—	30	20
Feb.	—	102	104	121	468	415	345	417	339	297	551	815	293	14	50	20	120
Mar.	—	—	—	11	140	296	46	254	532	308	276	263	182	95	545	182	30
T	—	344	269	180	608	957	587	766	938	934	1,085	1,170	475	109	595	232	170

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—	24	54	58	—	—	—											
—	—	6	54	178	132	—	—											
171	—	—	—	150	168	—	—											
144	—	—	—	30	60	—	—											
—	—	—	—	—	—	—	—											
315	—	30	108	416	360	—	—											
96	103	60	24	134	121	—	—											
36	—	48	60	205	445	—	—											
—	—	—	—	365	198	—	—											
77	22	11	72	84	126	48	—											
—	—	—	—	—	—	—	—											
209	125	119	156	788	890	48	—											
—	—	—	101	210	96	77	22	55	—	—	—	—						
88	55	—	182	129	190	393	152	—	—	—	—	—						
443	81	82	84	55	145	71	237	21	—	—	—	—						
302	161	77	—	—	—	35	175	—	—	—	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
833	297	159	367	394	431	576	586	76	—	—	—	—						
109	110	117	214	61	—	—	—	—	—	—	—	—						
128	228	40	128	116	62	445	207	468	—	—	—	—						
20	150	110	—	—	91	26	408	516	—	—	—	—						
90	—	—	—	—	195	—	68	268	—	—	—	—						
347	488	267	342	177	348	471	683	1, 252	—	—	—	—						
343	96	56	103	161	84	82	36	84	—	—	—	—	—	—	—	—	—	—
344	369	252	106	167	143	263	557	60	—	—	—	—	—	—	—	—	—	180
128	56	28	—	—	—	91	340	659	—	—	—	—	—	—	—	—	—	144
14	28	—	—	—	—	14	14	300	—	—	—	—	—	—	—	—	—	—
829	549	336	209	328	227	450	947	1, 103	—	—	—	—	—	—	—	—	—	324
219	57	36	—	96	176	416	634	418	—	—	—	—						
75	45	—	—	144	126	74	32	406	—	—	—	—						
—	—	—	—	—	—	16	64	13	—	—	—	—						
294	102	36	—	240	302	506	730	837	—	—	—	—						
104	96	54	32	64	68	93	315	465	—	—	—	—						
—	—	—	54	72	126	202	159	630	—	—	—	—						
18	36	54	144	—	60	90	60	450	—	—	—	—						
122	132	108	230	136	254	385	534	1, 545	—	—	—	—						
—	—	—	—	—	26	65	221	442	—	—	—	—	—	—	—	—	—	—
27	—	—	—	—	—	—	39	546	—	—	—	—	—	—	—	—	—	39
108	—	—	—	—	—	—	—	468	—	—	—	—	—	—	—	—	—	—
135	—	—	—	—	26	65	260	1, 456	—	—	—	—	—	—	—	—	—	39
110	80	10	—	123	191	184	203	333	—	—	—	—						
118	98	82	80	160	—	65	65	117	—	—	—	—						
—	—	—	—	—	39	13	—	169	—	—	—	—						
228	178	92	80	283	230	262	268	619	—	—	—	—						

Table 6. Continued.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1955/56																	
Jan.	49	826	190	30	150	92	—	—	—	134	330	458	419	157	242	108	140
Feb.	323	572	228	283	216	349	163	313	345	494	239	314	132	219	540	149	154
Mar.	86	71	15	20	—	86	110	13	135	—	—	—	—	—	164	—	—
T	458	1,469	433	333	366	527	273	326	480	628	569	772	551	376	946	257	294
1956/57																	
Jan.	317	351	343	73	57	132	—	—	—	—	18	—	—	—	—	—	—
Feb.	134	36	148	107	238	349	305	132	—	—	24	156	48	36	84	—	—
Mar.	142	48	54	52	188	602	447	248	86	38	48	—	24	24	72	—	—
T	593	435	545	232	483	1,083	752	380	86	38	90	156	72	60	156	—	—
1957/58																	
Jan.	24	44	48	—	52	50	115	177	264	201	14	36	153	9	18	9	—
Feb.	143	—	—	—	255	391	390	426	304	194	99	228	135	228	102	144	60
Mar.	—	117	91	—	54	190	156	168	42	—	—	—	—	—	107	96	96
T	167	161	139	—	361	631	661	771	610	395	113	264	288	237	227	249	156
1958/59																	
Jan.	—	—	72	12	—	—	—	88	—	—	—	—	204	322	417	198	69
Feb.	168	96	36	60	110	113	193	272	276	190	348	116	244	204	270	111	195
Mar.	60	156	84	72	—	—	84	233	173	319	190	127	202	—	9	45	54
T	228	252	192	144	110	113	277	593	449	509	538	243	650	526	696	354	318
1959/60																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	219	30	11	—	—	—	9	22	127	27	—	—	—	—	48	—	12
Feb.	—	99	110	—	16	152	60	71	203	124	335	357	206	289	24	12	12
Mar.	265	63	27	27	103	254	370	380	313	286	152	150	192	36	12	—	—
Apr.	158	—	—	—	26	29	103	26	101	67	—	—	—	—	—	—	—
T	642	192	148	27	145	435	542	499	744	504	487	507	398	325	84	12	24
1960/61																	
Dec.	11	—	—	—	—	—	—	—	—	—	—	—	—				
Jan.	69	11	—	—	—	14	124	91	—	—	12	—	22				
Feb.	88	—	—	—	33	275	539	204	257	325	78	—	—				
Mar.	479	143	—	11	32	413	254	282	344	161	—	—	—				
Apr.	143	—	—	—	53	33	11	42	33	—	—	—	—				
T	790	154	—	11	118	735	928	619	634	486	90	—	22				
1961/62																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	13	—	—	80	32
Jan.	18	9	—	—	22	137	44	148	49	60	30	30	—	—	13	13	48
Feb.	163	72	11	33	55	446	256	132	78	69	60	45	30	30	15	—	—
Mar.	132	33	11	—	33	84	107	48	46	166	367	265	274	15	—	—	—
Apr.	77	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	390	114	22	33	110	667	407	328	173	295	457	340	317	45	28	93	80
1962/63																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	22	—	—	—	—	—
Jan.	63	127	62	18	18	27	—	—	—	19	38	—	—	—	64	79	94
Feb.	194	186	98	66	11	33	22	—	—	—	—	—	—	34	51	51	85
Mar.	472	137	18	—	—	—	54	126	88	40	88	—	—	—	55	412	89
Apr.	81	9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	810	459	178	84	29	60	76	126	88	59	126	22	—	34	170	542	268
1963/64																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	17	—	112	97	64
Jan.	40	11	11	—	—	—	—	—	—	—	—	—	—	—	51	34	—
Feb.	24	—	—	—	—	—	—	11	22	—	—	—	57	98	90	60	22
Mar.	—	—	—	—	22	110	176	11	—	—	19	57	38	—	—	—	—
Apr.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	64	11	11	—	22	110	176	22	22	—	19	57	112	98	253	191	86
1964/65																	
Dec.	—	—	—	—	—	—	—	—	—	—	63	—	16	15	30	30	15
Jan.		—									—	—	—	17	51	17	—
Feb.		—									—	34	34	17	—	—	—
Mar.		8									—	—	—	—	—	—	—
Apr.		—									—	—	—	—	—	—	—
T		8									63	34	50	49	81	47	15

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
126	29	198	93	141	36	18	54	192	600	15	30	95	70	—	—	42	308	—
134	90	75	75	45	—	—	—	189	204	15	45	330	270	144	105	392	84	56
—	—	—	—	—	—	—	—	—	—	—	—	60	—	—	51	179	14	—
260	119	273	168	186	36	18	54	381	804	30	75	485	340	144	156	613	406	56
		—	—	—	—	—	27	117	285	78	117	195	228	188	340	520	459	279
		—	—	—	—	—	—	—	180	863	294	240	65	106	327	271	286	167
		—	—	—	—	—	—	—	102	309	315	36	—	—	—	20	176	34
		—	—	—	—	—	27	117	567	1,250	726	471	293	294	667	811	921	480
108	96	36	60	—	—	60	24	94	207	164	226	154	105	46	101	229	127	24
18	12	24	36	24	84	36	12	24	96	314	248	264	36	48	210	246	146	39
24	18	63	195	60	—	—	—	—	33	77	168	84	24	24	60	72	84	—
150	126	123	291	84	84	96	36	118	336	555	642	502	165	118	371	547	357	63
60	60	48	120	48	192	192	60	168	168	—	—	—						
522	330	96	168	240	252	24	48	60	84	36	—	—						
9	—	—	—	12	96	108	12	48	60	156	36	—						
591	390	144	288	300	540	324	120	276	312	192	36	—						
—	—	—	54	18	32	—	—	—	—	—	—	—	—	—	—	—	—	—
39	42	62	393	640	90	36	—	—	—	—	—	—	—	—	—	—	—	140
—	—	—	—	339	491	294	57	132	168	48	—	—	—	—	—	—	—	—
—	—	—	12	112	412	226	34	18	45	16	16	16	32	—	36	18	187	33
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
39	42	62	459	1,109	1,025	556	91	150	213	64	16	16	32	—	36	18	187	173
—	—	—	—	—	18	148	12	12	12	12	—	—	—	—	—	—	—	—
12	24	44	160	162	300	410	160	36	84	192	60	48	—	—	—	—	143	98
—	—	—	16	118	244	248	224	208	290	480	274	—	—	—	—	—	—	—
—	—	—	—	—	—	—	16	166	200	330	—	230	36	18	54	36	18	83
—	—	—	—	—	—	—	—	—	—	—	—	16	—	—	—	18	—	—
12	24	44	176	280	562	806	412	422	586	1,014	334	294	36	18	54	54	161	181
64	48	16	48	144	192	272	48	16	—	—	—	—	—	—	—	—	—	—
128	80	48	48	80	16	163	81	129	338	50	170	68	124	160	54	54	36	90
—	—	16	48	208	240	32	80	48	112	48	64	—	—	—	53	245	330	156
—	—	—	—	—	—	—	—	18	342	178	148	70	48	104	358	330	331	152
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	27	98	136
192	128	80	144	432	448	467	209	211	792	276	382	138	172	264	465	656	795	534
—	—	—	—	—	—	—	—	—	—	—	—	—	—	19	38	76	57	95
174	117	133	57	—	—	—	—	—	—	—	—	—	—	—	18	217	302	63
19	19	53	79	91	348	53	72	102	155	155	38	19	19	38	46	172	108	99
38	19	19	95	209	19	—	—	—	—	—	75	53	68	19	91	53	102	235
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
231	155	205	231	300	367	53	72	102	155	155	113	72	87	76	193	518	569	492
88	37	40	111	—	—	—	—						—	—	—	—	—	—
17	37	47	30	68	252	—	—						—	—	—	—	—	—
22	11	11	22	22	425	210	—						—	—	—	16	16	40
—	—	—	—	—	128	—	—						—	—	—	—	—	—
—	—	—	—	—	139	—	—						—	—	—	—	—	—
127	85	98	163	90	944	210	—						—	—	—	16	16	40
15	15	30	—	—	—	—	—											
—	—	15	30	81	34	—	—											
—	—	—	262	188	136	17	—											
68	17	68	140	202	—	—	—											
17	—	—	—	—	—	—	—											
100	32	113	432	471	170	17	—											

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1965/66																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	—	—	—	15	60	75	—	—	—	—	—	—	—	38	57	19	38
Feb.	—	—	—	—	—	90	120	60	75	—	—	—	—	—	55	19	38
Mar.	—	—	—	—	—	45	60	105	15	—	—	—	—	—	—	—	—
T	—	—	—	15	60	210	180	165	90	—	—	—	—	38	112	38	76
1966/67																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	19	76	57	76
Jan.	—	—	—	—	—	60	30	30	165	60	—	—	—	38	57	38	76
Feb.	—	—	—	—	—	—	—	—	—	—	105	105	135	75	12	—	—
Mar.	—	—	—	—	—	—	—	75	60	165	30	30	15	15	45	—	—
T	—	—	—	—	—	60	30	105	225	225	135	135	150	147	190	95	152
1967/68																	
Dec.							—	—	26	26	—	—	—	—	—	—	—
Jan.							—	—	—	—	26	52	39	104	108	54	54
Feb.							—	26	26	39	—	—	—	—	—	—	—
Mar.							—	—	—	—	—	—	—	—	—	—	—
T							—	26	52	65	26	52	39	104	108	54	54
1968/69																	
Jan.	17	—	17	17	—	—	—	—	12	12	24	24	24	12	36	29	17
Feb.	—	—	—	—	—	—	—	—	—	—	—	48	36	—	—	—	—
Mar.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	17	—	17	17	—	—	—	—	12	12	24	72	60	12	36	29	17
1969/70																	
Jan.							—	—	—	—	—	—	—	75	109	53	17
Feb.							—	—	—	—	—	—	26	52	52	13	—
Mar.							—	—	—	—	—	—	—	—	—	—	—
T							—	—	—	—	—	—	26	127	161	66	17
1970/71																	
Jan.	—	—	—	—	—	—								51	51	34	—
Feb.	12	24	—	—	—	—								—	—	—	—
Mar.	—	—	—	—	—	—								—	—	—	—
T	12	24	—	—	—	—								51	51	34	—
1971/72																	
Jan.	—	—	—	—	—	—	—	—	34	51	—	34	17	102	102	—	—
Feb.	—	—	—	13	26	26	—	—	—	—	—	—	—	—	—	—	—
Mar.	—	—	—	39	13	—	—	—	—	17	—	—	—	—	—	—	—
T	—	—	—	52	39	26	—	—	34	68	—	34	17	102	102	—	—

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—	—	18	40	100	—	—	—	—	—	—	—						
38	38	90	36	116	178	178	100	100	—	—	—	—						
38	57	95	76	38	40	60	60	100	140	—	—	—						
—	—	—	—	58	39	58	38	230	119	40	100	—						
76	95	185	130	252	357	296	198	430	259	40	100	—						
19	38	38	—	—	—	—	—	—	—	—	—	—						
38	57	19	57	76	114	96	116	160	140	20	—	—						
40	20	20	20	40	100	160	120	180	240	60	—	—						
—	—	—	—	120	280	80	100	280	180	—	—	—						
97	115	77	77	236	494	336	336	620	560	80	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
36	54	36	36	180	18	36	72	—	—	—	—	—						
—	—	—	54	198	216	171	27	90	252	72	—	—						
—	—	—	36	198	126	90	36	54	54	360	—	—						
36	54	36	126	576	360	297	135	144	306	432	—	—						
17	34	17	—	—	—	—	—	—	11	11	—	51	34	34	17	34	17	17
—	—	—	17	34	17	68	136	34	62	331	34	85	51	17	17	—	—	—
—	—	—	—	51	119	102	85	17	—	34	17	51	17	17	17	—	—	—
17	34	17	17	85	136	170	221	51	73	376	51	187	102	68	51	34	17	17
17	17	17	17	—	—	—	—	—	—	—	—	—						
—	—	—	103	162	68	102	17	—	—	—	—	—						
—	—	—	12	137	215	17	51	153	51	34	—	—						
17	17	17	132	299	283	119	68	153	51	34	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
—	17	17	17	34	51	34	51	17	17	51	51	—						
—	—	—	—	—	—	—	—	51	17	51	17	—						
—	17	17	17	34	51	34	51	68	34	102	68	—						
													78	39	26	26	13	39
													—	—	13	—	26	13
													—	—	—	—	—	—
													78	39	39	26	39	52

Table 7. Series B. Catch of blue whale

Area Square	II 1	2	3	4	5	6	III 7	8	9	10	11	12	13	IV 14	15	16	17
1931/32																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	92	21	—	—
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	1,089	—	—	—
Jan.	—	—	21	—	—	—	—	25	64	—	184	—	—	903	17	—	—
Feb.	66	—	31	20	—	—	—	—	—	—	—	—	—	387	163	—	—
Mar.	67	—	—	116	—	—	—	—	—	24	—	—	—	—	159	—	—
T	133	—	52	136	—	—	—	25	64	24	184	—	—	2,471	360	—	—
1932/33																	
Oct.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nov.	—	—	—	—	—	—	—	—	—	—	—	46	33	—	179	166	120
Dec.	—	—	—	—	—	—	—	—	—	83	133	122	248	142	806	741	141
Jan.	3	26	31	152	22	43	50	101	36	282	767	327	—	—	955	1,373	17
Feb.	8	71	78	20	—	3	2	—	33	45	373	97	1	196	551	602	—
Mar.	2	28	9	1	58	—	—	59	13	285	484	15	1	221	113	—	—
Apr.	—	1	—	2	21	—	—	—	23	50	—	—	—	—	—	—	—
T	13	126	118	175	101	46	52	160	105	745	1,757	607	283	559	2,604	2,882	278
1933/34																	
Oct.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	—	—
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	57	—	—	35	24
Dec.	—	—	—	—	—	7	—	—	6	—	6	273	552	703	309	964	401
Jan.	—	—	—	96	—	6	—	19	164	383	180	192	71	135	608	1,138	68
Feb.	—	—	18	24	—	—	—	2	71	212	461	14	1	13	259	575	—
Mar.	—	—	118	—	—	—	—	24	1	80	192	1	—	—	—	137	—
T	—	—	136	120	—	13	—	45	242	675	839	480	681	851	1,180	2,849	493
1934/35																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	163	—
Dec.	—	—	—	49	—	—	—	—	—	70	178	237	225	159	523	957	533
Jan.	—	15	40	114	1	7	—	—	523	631	718	79	113	261	692	71	27
Feb.	—	118	135	29	—	51	31	20	419	1,136	234	—	—	17	362	34	—
Mar.	113	64	85	46	21	3	6	76	299	130	228	106	31	113	113	11	—
Apr.	—	—	—	—	—	—	—	—	47	6	—	—	—	—	—	—	—
T	113	197	260	238	22	61	37	96	1,288	1,973	1,358	422	369	550	1,690	1,236	560
1935/36																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dec.	—	—	—	—	—	—	—	4	35	956	333	—	—	—	252	11	—
Jan.	—	—	—	96	6	5	22	44	637	1,021	795	110	—	—	420	435	20
Feb.	—	43	50	235	10	—	19	117	702	748	223	—	—	—	502	475	—
Mar.	—	171	—	52	—	—	60	10	209	239	75	—	—	—	162	—	—
T	—	214	50	383	16	5	101	175	1,583	2,964	1,426	110	—	—	1,336	921	20
1936/37																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	1	169	4	9
Dec.	—	—	99	75	8	—	—	—	79	129	3	—	—	—	842	306	184
Jan.	86	341	378	189	18	159	130	87	321	90	—	—	—	179	742	580	415
Feb.	318	152	174	49	2	156	173	54	284	30	—	—	—	—	71	1,012	86
Mar.	3	5	9	—	—	13	5	27	38	—	—	—	1	45	207	145	—
T	407	498	660	313	28	328	308	168	722	249	3	—	1	225	2,031	2,047	694
1937/38																	
Nov.	—	—	1	—	—	—	—	—	—	—	—	—	—	—	35	8	—
Dec.	—	98	539	266	3	—	—	1	23	611	208	—	—	325	28	72	826
Jan.	—	97	39	428	67	43	69	8	296	596	298	—	11	88	406	161	580
Feb.	24	79	21	90	35	3	21	40	255	212	127	34	67	—	36	180	337
Mar.	16	97	15	48	—	—	4	—	91	197	33	—	—	—	12	132	51
T	40	371	615	832	105	46	94	49	665	1,616	666	34	78	413	517	553	1,794
1938/39																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	81	435
Dec.	—	12	64	61	4	—	—	—	135	648	49	—	—	—	91	384	550
Jan.	51	564	556	—	27	141	125	24	235	565	59	—	3	—	662	230	168
Feb.	11	275	74	—	135	95	25	187	98	356	75	3	10	87	198	405	187
Mar.	—	41	29	32	21	3	1	27	134	13	23	—	—	3	61	34	60
T	62	892	723	93	187	239	151	238	602	1,582	206	3	13	90	1,018	1,134	1,400

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—	69	—	—	—	—	—											
—	88	50	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	88	119	—	—	—	—	—											
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4	15	4	7	23	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	4
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4	15	4	7	23	—	—	—	3	—	—	—	—	—	—	—	—	—	4
—	—																	
—	—																	
123	—																	
—	—																	
—	—																	
—	—																	
123	—																	
—	—	—	96	—	—	—	—											
36	71	30	32	—	—	—	—											
3	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
39	71	30	128	—	—	—	—											
—	—																	
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—	—																	
—	—																	
—	—																	
—	—																	
643	90																	
303	79																	
359	118																	
51	19																	
1,356	306																	
134	6	—	12	—	5	—	—						—	—	—	—	—	—
224	212	226	93	54	—	—	—						—	—	—	—	—	—
197	37	2	29	357	83	—	—						—	—	—	—	—	—
36	34	9	105	27	3	—	—						—	—	—	—	—	3
68	47	10	—	—	—	—	—						—	—	—	—	—	1
659	336	247	239	438	91	—	—						—	—	—	—	—	4

Table 7. Continued.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1945/46																	
Jan.	3	14	—	—	—	1	—	3	300	86	26	10	—				
Feb.	—	237	—	2	—	—	—	—	695	195	6	—	—				
Mar.	1	50	—	—	—	—	—	—	223	206	—	—	—				
Apr.	—	13	—	—	—	—	—	2	18	58	—	—	—				
T	4	314	—	2	—	1	—	5	1, 236	545	32	10	—				
1946/47																	
Dec.	—	—	—	17	—	—	—	—	75	23	—	—	—	—	138	324	—
Jan.	—	40	143	84	47	5	—	8	145	351	32	—	—	—	350	212	3
Feb.	5	46	55	—	98	48	211	—	83	141	146	—	—	110	104	79	261
Mar.	2	44	30	122	137	409	7	32	120	126	—	—	11	290	264	64	85
Apr.	—	10	—	14	26	31	21	—	—	—	—	—	17	57	106	—	—
T	7	140	228	237	308	493	239	40	423	641	178	—	28	457	962	679	349
1947/48																	
Dec.	—	—	—	—	—	—	—	—	24	76	29	—	—	25	200	34	101
Jan.	—	—	—	6	17	—	133	23	48	181	63	17	58	186	428	43	63
Feb.	—	—	93	170	62	47	11	—	51	54	29	2	8	114	289	4	—
Mar.	—	131	32	54	195	22	67	27	78	49	—	—	—	85	74	—	63
T	—	131	125	230	274	69	211	50	201	360	121	19	66	410	991	81	227
1948/49																	
Dec.	—	—	—	—	—	—	—	—	—	55	122	8	—	5	2	51	113
Jan.	—	—	10	24	274	188	—	—	134	223	63	63	—	—	44	127	146
Feb.	—	104	66	51	92	69	93	14	342	277	—	—	—	—	—	44	82
Mar.	—	189	100	—	15	61	21	42	97	137	—	1	—	8	32	58	148
T	—	293	176	75	381	318	114	56	573	692	185	72	—	13	78	280	489
1949/50																	
Dec.	—	—	—	83	—	—	—	—	—	1	—	—	—	—	84	—	18
Jan.	1	107	2	21	79	183	31	1	17	17	—	—	—	32	212	192	82
Feb.	3	45	2	—	105	65	95	59	24	39	31	4	8	116	14	—	9
Mar.	1	11	1	—	5	19	29	2	17	96	6	—	—	—	5	—	13
T	5	163	5	104	189	267	155	62	58	153	37	4	8	148	315	192	122
1950/51																	
Dec.	—	67	—	17	1	—	—	—	—	64	86	21	—	—	—	—	81
Jan.	90	173	89	22	—	—	—	41	162	12	—	116	59	59	404	36	53
Feb.	95	145	113	37	51	3	91	72	258	60	20	3	14	25	101	56	13
Mar.	—	175	14	—	13	11	61	34	—	71	5	—	1	—	31	12	30
T	185	560	216	76	65	14	152	147	420	207	111	140	74	84	536	104	177
1951/52																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Jan.	7	83	3	—	—	—	—	—	9	203	3	14	—	201	266	197	44
Feb.	4	29	20	19	72	125	33	184	712	210	81	8	12	75	37	39	36
Mar.	—	—	—	—	59	—	4	22	130	4	—	—	—	—	—	—	—
T	11	112	23	19	131	125	37	206	851	417	84	22	12	276	303	236	81
1952/53																	
Jan.	—	—	2	8	74	42	171	141	186	5	1	15	64	69	114	205	132
Feb.	—	—	—	5	45	68	161	46	114	244	—	4	26	28	102	104	—
Mar.	—	15	61	2	22	57	2	3	32	51	1	11	1	—	14	3	4
T	—	15	63	15	141	167	334	190	332	300	2	30	91	97	230	312	136
1953/54																	
Jan.	1	54	31	39	3	—	13	2	1	—	—	—	7	123	123	1	—
Feb.	8	4	9	21	11	98	192	180	153	239	65	53	15	7	7	29	32
Mar.	4	15	—	1	41	103	28	141	148	121	63	1	—	—	1	1	3
T	13	73	40	61	55	201	233	323	302	360	128	54	22	130	131	31	35
1954/55																	
Jan.	—	34	94	6	—	68	47	33	5	53	4	3	—	—	—	—	—
Feb.	—	12	3	14	117	91	63	88	83	13	13	22	8	3	27	12	3
Mar.	—	—	—	—	6	14	1	32	70	31	11	14	2	18	167	72	—
T	—	46	97	20	123	173	111	153	158	97	28	39	10	21	194	84	3

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—	2	46	83	—	—	—											
—	—	—	30	162	133	—	—											
175	—	—	—	77	122	—	—											
167	—	—	—	19	19	—	—											
—	—	—	—	—	—	—	—											
342	—	2	76	341	274	—	—											
60	47	8	19	127	164	—	—											
4	—	5	21	90	375	—	—											
—	—	—	—	385	73	—	—											
95	11	—	6	67	43	7	—											
159	58	13	46	669	655	7	—											
—	—	—	55	122	42	17	4	27	—	—	—	—						
31	10	—	55	17	85	142	96	—	—	—	—	—						
192	12	39	19	3	34	10	132	3	—	—	—	—						
163	25	9	—	—	—	11	50	—	—	—	—	—						
386	47	48	129	142	161	180	282	30	—	—	—	—						
3	24	67	35	31	—	—	—	—	—	—	—	—						
18	51	4	8	29	4	121	197	263	—	—	—	—						
14	27	8	—	—	98	32	404	563	—	—	—	—						
7	—	—	—	—	145	—	93	311	—	—	—	—						
42	102	79	43	60	247	153	694	1, 137	—	—	—	—						
76	14	38	94	54	19	3	32	47	—	—	—	—	—	—	—	—	—	—
30	19	25	19	73	10	42	416	39	—	—	—	—	—	—	—	—	—	42
23	13	2	—	—	—	11	165	257	—	—	—	—	—	—	—	—	—	3
—	—	—	—	—	—	—	—	56	—	—	—	—	—	—	—	—	—	—
129	46	65	113	127	29	56	613	399	—	—	—	—	—	—	—	—	—	45
—	—	—	—	—	—	—	—	—	—	—	—	—						
149	88	3	—	32	19	188	179	24	—	—	—	—						
21	—	—	—	107	36	3	8	21	—	—	—	—						
—	—	—	—	—	—	3	2	—	—	—	—	—						
170	88	3	—	139	55	194	189	45	—	—	—	—						
33	22	4	21	17	22	12	153	51	—	—	—	—						
—	—	—	22	30	42	1	8	49	—	—	—	—						
1	6	38	30	—	2	5	—	61	—	—	—	—						
34	28	42	73	47	66	18	161	161	—	—	—	—						
—	—	—	—	—	—	—	14	10	—	—	—	—						
22	—	—	—	—	—	—	3	76	—	—	—	—						
7	—	—	—	—	—	—	—	29	—	—	—	—						
29	—	—	—	—	—	—	17	115	—	—	—	—						
—	6	1	—	7	60	91	13	50	—	—	—	—						
2	—	2	24	35	—	21	15	6	—	—	—	—						
—	—	—	—	—	2	2	—	9	—	—	—	—						
2	6	3	24	42	62	114	28	65	—	—	—	—						

Table 7. Continued.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1955/56																	
Jan.	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Feb.	14	33	100	68	64	139	32	73	87	69	11	10	2	57	141	17	57
Mar.	3	11	—	—	—	5	13	1	2	—	—	—	—	—	26	—	—
T	17	45	100	68	64	144	45	74	89	69	11	10	2	57	167	17	57
1956/57																	
Feb.	1	—	23	2	22	129	33	89	—	—	8	40	10	—	2	—	—
Mar.	—	1	—	2	20	49	12	42	24	15	—	—	1	—	78	—	—
T	1	1	23	4	42	178	45	131	24	15	8	40	11	—	80	—	—
1957/58																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Feb.	—	—	—	—	106	89	149	99	169	37	23	60	59	94	25	57	1
Mar.	—	24	5	—	2	10	4	1	2	—	—	—	—	—	—	—	—
T	—	24	5	—	108	99	153	100	171	37	23	60	59	94	25	57	1
1958/59																	
Feb.	—	—	10	—	17	14	34	42	129	30	32	8	13	4	21	11	16
Mar.	—	—	1	2	—	—	22	—	18	25	2	3	7	—	—	5	2
T	—	—	11	2	17	14	56	42	147	55	34	11	20	4	21	16	18
1959/60																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Feb.	—	3	21	—	—	10	4	1	52	3	15	17	7	27	5	—	—
Mar.	—	1	—	1	2	5	5	12	10	19	6	6	1	—	—	—	—
Apr.	1	—	—	—	—	2	10	2	5	1	—	—	—	—	—	—	—
T	1	4	21	1	2	17	19	15	67	23	21	23	8	27	5	—	—
1960/61																	
Feb.	—	—	—	—	2	72	94	6	6	36	3	—	—				
Mar.	5	11	—	—	1	20	12	1	1	5	—	—	—				
Apr.	1	—	—	—	—	10	—	—	1	—	—	—	—				
T	6	11	—	—	3	102	106	7	8	41	3	—	—				
1961/62																	
Feb.	65	1	—	9	1	87	19	3	—	—	9	7	—	—	—	—	—
Mar.	—	—	—	—	—	14	4	—	—	5	24	13	17	4	—	—	—
Apr.	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	66	1	—	9	1	101	23	3	—	5	33	20	17	4	—	—	—
1962/63																	
Feb.	—	—	—	6	—	—	3	—	—	—	—	—	—	10	5	6	11
Mar.	—	1	—	—	—	—	5	7	—	—	1	—	—	—	—	2	—
Apr.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	1	—	6	—	—	8	7	—	—	1	—	—	10	5	8	11

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11	13	11	4	—	—	—	—	45	145	—	3	50	86	86	15	36	6	1
—	—	—	—	—	—	—	—	—	—	—	—	21	—	—	9	15	—	—
11	13	11	4	—	—	—	—	45	145	—	3	71	86	86	24	51	6	1
—	—							—	74	199	127	136	13	50	117	18	3	2
—	—							—	1	32	38	1	—	—	—	—	—	—
—	—							—	75	231	165	137	13	50	117	18	3	2
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
2	—	14	6	—	28	—	2	—	30	50	80	82	15	14	25	16	—	—
—	1	—	18	3	—	—	—	—	—	35	23	15	21	12	14	6	1	—
2	1	14	24	3	28	—	2	—	30	85	103	97	36	26	39	23	1	—
114	63	15	32	23	6	—	—	—	17	—	—	—						
—	—	—	—	—	—	33	—	—	3	2	—	—						
114	63	15	32	23	6	33	—	—	20	2	—	—						
—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	87	114	19	1	2	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	123	19	19	—	1	3	4	—	—	—	5	3	3	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	1	1	87	237	38	20	2	1	3	4	—	—	—	5	3	3	—
		—	—	—	17	25	43	48	3	5	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	4	31	35	38	41	—	—	2	2	—	—
		—	—	—	—	—	—	—	—	—	—	1	—	—	—	1	—	—
		—	—	—	17	25	43	52	34	40	38	42	—	—	2	3	—	—
—	—	—	15	33	21	—	5	2	3	—	—	—	—	—	12	18	55	41
—	—	—	—	—	—	—	—	—	11	7	6	—	2	10	37	25	1	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	6
—	—	—	15	33	21	—	5	2	14	7	6	—	2	10	49	43	61	47
—	—	—	—	1	16	6	39	2	8	10	1	—	—	—	—	1	—	—
1	—	—	12	8	10	—	—	—	—	—	—	—	1	2	4	1	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	—	—	12	9	26	6	39	2	8	10	1	—	1	2	4	2	—	—

Table 8. Series B. Catch of humpback whale

Area	II						III							IV			
Square	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1931/32																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	53	—	—	—
Jan.	—	—	—	—	—	—	—	—	—	—	1	—	—	37	—	—	—
Feb.	—	—	—	4	—	—	—	—	—	—	—	—	—	6	—	—	—
Mar.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	—
T	—	—	—	4	—	—	—	—	—	—	1	—	—	97	10	—	—
1932/33																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	—	—
Dec.	—	—	—	—	—	—	—	—	—	—	2	—	2	—	3	14	—
Jan.	—	—	3	10	1	—	—	—	—	—	8	2	—	—	3	2	—
Feb.	—	—	—	1	—	—	—	—	—	—	2	1	—	—	1	25	—
Mar.	—	—	—	—	—	—	—	—	—	1	5	—	—	—	—	—	—
Apr.	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—
T	—	—	3	11	1	—	—	—	—	3	17	3	2	—	14	41	—
1933/34																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	14	25	40	1	—
Jan.	—	—	—	9	—	—	—	—	2	2	2	9	3	39	23	13	—
Feb.	—	—	1	13	—	—	—	—	5	2	4	—	—	—	6	1	—
Mar.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	13	—
T	—	—	1	22	—	—	—	—	7	4	6	9	17	64	69	28	—
1934/35																	
Dec.	—	—	—	—	—	—	—	—	—	—	4	2	5	18	166	244	18
Jan.	—	—	—	—	—	—	—	—	12	25	3	2	3	38	254	1	—
Feb.	—	—	—	—	—	1	1	—	81	204	10	—	—	2	236	10	—
Mar.	—	—	—	—	—	—	—	—	97	15	4	4	—	—	5	—	—
Apr.	—	—	—	—	—	—	—	—	4	—	—	—	—	—	—	—	—
T						1	1	—	194	244	21	8	8	58	661	255	18
1935/36																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dec.	—	—	—	—	—	—	—	—	2	40	4	—	—	—	264	2	—
Jan.	—	—	—	—	—	1	2	108	281	66	27	9	—	—	199	75	—
Feb.	—	—	—	4	2	—	—	10	691	23	—	—	—	—	3	9	—
Mar.	—	—	—	—	—	—	—	—	11	19	—	—	—	—	13	—	—
T	—	—	—	4	2	1	2	118	985	148	31	9	—	—	479	86	—
1936/37																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	2	1
Dec.	—	—	—	2	1	—	—	—	2	4	—	—	—	—	185	37	23
Jan.	—	3	5	18	8	3	9	—	15	61	—	—	—	11	353	170	40
Feb.	1	—	2	12	—	10	33	101	96	5	—	—	—	—	48	539	2
Mar.	—	—	—	—	—	1	4	46	20	—	—	—	—	3	12	8	—
T	1	3	7	32	9	14	46	147	133	70	—	—	—	15	599	756	66
1937/38																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	32	1	—
Dec.	—	—	2	7	—	—	—	1	—	10	5	—	—	22	13	21	33
Jan.	—	—	5	116	2	—	3	4	45	25	10	—	—	32	84	10	22
Feb.	—	2	1	47	35	2	4	18	125	8	—	1	1	—	5	32	71
Mar.	—	—	—	17	—	—	20	—	77	1	—	—	—	—	—	21	21
T	—	2	8	187	37	2	27	23	247	44	15	1	1	54	134	85	147
1938/39																	
Nov.														—	—	7	65
Dec.														—	—	82	267
Jan.														—	—	43	111
Feb.														—	—	26	11
T														—	—	158	454
1946/47																	
Apr.	—	—	—	—	1	—											
T	—	—	—	—	1	—											
1948/49																	
Mar.	—	3	—	—	—	1											
T	—	3	—	—	—	1											

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
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10	2																	
29	—																	
91	21																	
1	9																	
131	32																	
12	—	—	—	—	—	—	—											
80	16	11																
79	2	—																
2	6	13																
173	24	24																

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1949/50																	
Dec.							—	—	—	3	—	—	—	—	334	1	23
Jan.							—	—	—	—	—	—	—	—	120	46	77
Feb.							—	—	—	—	—	—	—	—	—	—	—
T							—	—	—	3	—	—	—	—	454	47	100
1950/51																	
Feb.	—	2	—	—	—	—	—	—	17	3	—	—	—	5	350	597	160
T	—	2	—	—	—	—	—	—	17	3	—	—	—	5	350	597	160
1951/52																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Feb.	—	—	—	1	2	27	—	139	5	—	1	—	—	103	267	—	356
T	—	—	—	1	2	27	—	139	5	—	1	—	—	103	267	—	356
1952/53																	
Feb.	—	—	—	10	—	4	141	39	26	9	—	—	1	2	—	189	—
Mar.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	—	10	—	4	141	39	26	9	—	—	1	2	—	189	—
1953/54																	
Feb.	—	—	4	4	—	1	4	—	4	6	—	2	—	—	—	258	—
Mar.	—	—	—	—	—	—	—	—	—	—	6	—	—	—	—	—	—
T	—	—	4	4	—	1	4	—	4	6	6	2	—	—	—	258	—
1954/55																	
Feb.							—	3	19	—	6	1	—				
T							—	3	19	—	6	1	—				
1955/56																	
Jan.							—	—	—	—	—	—	—	—	—	—	—
Feb.							50	—	9	3	—	—	—	109	272	—	—
T							50	—	9	3	—	—	—	109	272	—	—
1956/57																	
Feb.							—	—	—	—	—	3	—				
T							—	—	—	—	—	3	—				
1957/58																	
Jan.							—	—	1	—	—	—	—				
Feb.							7	53	39	2	3	2	—				
T							7	53	40	2	3	2	—				
1958/59																	
Feb.							6	16	—	—	—	—	—	76	829	124	—
T							6	16	—	—	—	—	—	76	829	124	—
1959/60																	
Jan.							—	—	2	—	—	—	—	—	—	—	21
Feb.							—	—	68	—	—	—	—	—	—	—	—
Mar.							1	—	—	—	—	—	—	—	—	—	—
T							1	—	70	—	—	—	—	—	—	—	21
1960/61																	
Jan.																	
T																	
1961/62																	
Jan.							—	9	—	—	—	—	—	—	—	—	—
T							—	9	—	—	—	—	—	—	—	—	—
1962/63																	
Dec.																	
Jan.																	
T																	

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
10	104	29	427	91	—	—	—											
—	4	1	328	27	—	—	—											
—	1	—	—	—	—	—	—											
10	109	30	755	118	—	—	—											
—	—	—	—	—	—	84	78	66	—	—	—	—	—	—	—	—	—	262
—	—	—	—	—	—	84	78	66	—	—	—	—	—	—	—	—	—	262
—	—	—	1	—	—	—	—	—	—	—	—	—						
169	232	—	—	—	70	30	—	37	—	—	—	—						
169	232	—	1	—	70	30	—	37	—	—	—	—						
—	—	—	—	—	159	210	133	13	—	—	—	—						
—	—	—	—	—	1	—	—	—	—	—	—	—						
—	—	—	—	—	160	210	133	13	—	—	—	—						
—	—	—	—	—	—	—	14	136	—	—	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
—	—	—	—	—	—	—	14	136	—	—	—	—						
		—	—	170	—	—	—	177	—	—	—	—						
		—	—	170	—	—	—	177	—	—	—	—						
2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
439	—	—	40	154	—	—	—	273	56	—	—	—	—	—	—	14	—	—
441	—	—	40	154	—	—	—	273	56	—	—	—	—	—	—	14	—	—
								—	—	—	7	3	27	39	566	10	13	—
								—	—	—	7	3	27	39	566	10	13	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		19	4	—	—	—	—	—	21	27	29	76	31	—	37	18	4	—
		19	4	—	—	—	—	—	21	27	29	76	31	—	37	18	4	—
234	113	—	—	81	421	—	—											
234	113	—	—	81	421	—	—											
—	—	3	331	440	66	91	—						—	—	—	—	—	179
—	—	—	—	—	—	—	—						—	—	—	—	—	—
—	—	—	—	—	—	—	—						—	—	—	—	—	—
—	—	3	331	440	66	91	—						—	—	—	—	—	179
		—	31	47	—	120	—	119	—	74	—	—	—	—	—	—	80	2
		—	31	47	—	120	—	119	—	74	—	—	—	—	—	—	80	2
53	—							12	46	—	34	—	—	125	—	—	—	—
53	—							12	46	—	34	—	—	125	—	—	—	—
		—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
		57	131	—	—	—	—	—	—	—	—	—	—	—	—	—	49	—
		57	131	—	—	—	—	1	—	—	—	—	—	—	—	—	49	—

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1931/32																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	28	—	—	—
Jan.	—	—	25	—	—	—	—	—	3	—	17	—	—	61	1	—	—
Feb.	7	—	60	136	3	—	—	—	—	—	—	—	—	226	12	—	—
Mar.	7	—	—	175	—	—	—	—	—	1	6	—	—	—	95	—	—
T	14	—	85	311	3	—	—	—	3	1	23	—	—	315	108	—	—
1932/33																	
Dec.	—	—	—	—	—	—	—	—	—	4	11	—	11	4	11	7	—
Jan.	24	43	52	155	32	17	28	12	—	18	145	197	—	—	74	81	[illegible]
Feb.	113	491	104	18	3	1	3	—	22	—	226	398	2	11	339	267	—
Mar.	137	156	4	3	71	—	—	95	36	85	257	10	1	68	101	—	—
Apr.	—	7	—	—	11	—	—	—	41	42	—	—	—	—	—	—	—
T	274	697	160	176	117	18	31	107	99	149	639	605	14	83	525	355	[illegible]
1933/34																	
Oct.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	—
Dec.	—	—	—	—	—	—	—	—	—	—	1	38	88	59	50	88	108
Jan.	—	—	—	323	—	—	—	23	238	116	77	199	173	144	221	448	50
Feb.	25	5	91	77	—	—	—	—	186	605	48	—	7	8	231	465	—
Mar.	—	—	79	—	—	—	—	81	3	169	44	—	—	—	—	195	—
T	25	5	170	400	—	—	—	104	427	890	170	237	268	211	504	1,203	158
1934/35																	
Dec.	—	—	1	76	—	—	—	—	—	1	62	69	46	2	66	248	53
Jan.	—	1	42	197	2	15	—	—	199	98	923	238	143	62	144	18	9
Feb.	—	51	159	369	—	100	26	72	811	1,625	408	—	—	13	311	45	—
Mar.	208	39	173	233	30	47	109	875	856	173	396	519	22	106	106	13	—
Apr.	—	—	—	—	—	—	—	2	32	21	—	—	—	—	—	—	—
T	208	91	375	875	32	162	135	949	1,898	1,918	1,789	826	211	183	627	324	67
1935/36																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dec.	—	—	—	—	—		—	—	2	84	58	—	—	—	4	1	—
Jan.	—	—	—	336	3		40	63	329	285	288	259	—	—	14	215	47
Feb.	—	5	41	706	54		90	233	832	755	138	—	—	—	123	94	—
Mar.	—	19	—	234	—		116	19	192	166	60	—	—	—	9	—	—
T	—	24	41	1,276	57		246	315	1,355	1,290	544	259	—	—	150	310	47
1936/37																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
Dec.	—	—	9	15	1	—	—	—	1	69	13	—	—	—	33	49	56
Jan.	38	592	376	242	29	170	102	21	141	87	13	7	—	106	193	159	480
Feb.	406	1,059	816	291	5	365	570	284	758	95	—	—	—	—	39	731	70
Mar.	391	121	140	—	—	27	21	211	242	1	—	—	3	136	172	58	—
T	835	1,772	1,341	548	35	562	693	516	1,142	252	26	7	3	242	438	997	606
1937/38																	
Nov.	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—
Dec.	—	212	415	172	—	—	—	—	8	88	13	—	—	45	4	4	307
Jan.	—	1,232	298	893	153	37	301	2	446	666	369	—	28	75	181	99	421
Feb.	76	2,438	685	533	879	115	280	73	1,454	546	191	107	50	—	94	125	527
Mar.	234	778	262	610	—	—	265	236	260	348	49	—	—	—	23	231	209
T	310	4,660	1,661	2,208	1,032	152	846	311	2,168	1,648	622	107	78	120	303	459	1,464
1938/39																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	32
Dec.	—	1	13	8	—	—	—	—	31	176	34	—	—	—	27	107	597
Jan.	277	413	603	—	119	334	87	15	140	380	168	—	152	—	268	125	467
Feb.	381	805	169	—	656	392	149	271	159	683	615	134	363	527	147	217	181
Mar.	100	68	100	52	170	40	82	59	235	7	226	102	6	210	29	5	142
T	758	1,287	885	60	945	766	318	345	565	1,246	1,043	236	521	737	471	454	1,419
1945/46																	
Jan.	290	598	—	—	—	—	—	4	97	108	81	40	—				
Feb.	—	1,143	—	8	—	—	—	—	549	497	75	—	—				
Mar.	50	1,100	—	—	—	—	—	—	295	517	—	—	—				
Apr.	—	418	—	—	—	—	—	3	73	34	—	—	—				
T	340	3,259	—	8	—	—	—	7	1,014	1,156	156	40	—				

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	11
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8	1	—	1	—	—	—	—	2	—	—	—	—	—	—	—	—	—	11
—	—																	
67	—																	
—	—																	
—	—																	
—	—																	
67	—																	
—	—	—	17	—	—	—	—											
6	—	—	—	—	—	—	—											
14	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
20	—	—	17	—	—	—	—											
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
474	64																	
1,226	170																	
1,166	416																	
367	183																	
3,233	833																	
22	—	—	103	—	—	—	—						—	—	—	—	—	—
255	372	206	135	68	—	—	—						—	—	—	—	—	—
661	280	56	74	440	54	—	—						—	—	—	—	—	—
141	405	182	495	67	37	—	—						—	—	—	—	—	25
88	165	58	—	—	—	—	—						—	—	—	—	—	39
1,167	1,222	502	807	575	91	—	—						—	—	—	—	—	64

Table 9. Continued.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1946/47																	
Dec.	—	—	—	34	—	—	—	—	12	3	—	—	—	—	9	193	—
Jan.	—	123	220	93	36	2	—	11	299	187	20	—	—	—	338	512	493
Feb.	186	511	106	—	298	254	637	5	31	74	349	—	—	29	25	105	576
Mar.	67	794	116	54	79	1,050	60	84	281	64	—	—	—	105	259	111	80
Apr.	—	135	—	22	2	99	83	—	—	—	—	—	50	49	23	—	—
T	253	1,563	442	203	415	1,405	780	100	623	328	369	—	50	183	654	921	1,149
1947/48																	
Dec.	—	—	—	—	—	—	—	—	12	19	3	—	—	52	174	167	195
Jan.	—	—	—	79	149	—	645	245	108	437	86	262	361	389	422	61	234
Feb.	—	—	452	658	543	569	304	8	146	180	62	267	60	228	874	14	—
Mar.	—	322	11	204	811	80	365	79	538	461	—	—	—	1,268	304	—	5
Apr.	—	—	—	—	—	—	—	—	—	—	—	—	—	6	—	—	—
T	—	322	463	941	1,503	649	1,314	332	804	1,097	151	529	421	1,943	1,774	242	434
1948/49																	
Dec.	—	—	—	—	—	—	—	—	—	55	160	—	—	9	2	44	261
Jan.	—	—	38	58	103	590	—	—	171	485	898	443	—	—	40	105	295
Feb.	—	326	454	262	427	183	497	37	436	272	—	—	—	—	—	111	237
Mar.	—	570	192	—	196	368	166	279	138	400	—	56	—	10	3	16	512
T	—	896	684	320	726	1,141	663	316	745	1,212	1,058	499	—	19	45	276	1,305
1949/50																	
Dec.	—	—	—	636	—	—	—	—	—	8	—	—	—	—	49	—	55
Jan.	136	520	55	313	168	139	12	7	21	21	—	—	—	28	213	224	179
Feb.	718	450	186	—	415	459	470	237	50	339	117	29	83	366	169	1	17
Mar.	176	265	148	—	117	177	281	30	23	552	4	—	—	—	105	—	155
T	1,030	1,235	389	949	700	775	763	274	94	920	121	29	83	394	536	225	406
1950/51																	
Dec.	—	241	—	19	—	—	—	—	—	8	48	3	—	—	—	—	400
Jan.	213	891	232	108	—	—	—	70	85	20	28	237	153	96	367	356	500
Feb.	409	985	400	21	21	28	136	124	317	168	329	410	322	178	73	48	196
Mar.	—	30	101	—	10	8	69	80	—	467	1	—	228	—	33	8	110
T	622	2,147	733	148	31	36	205	274	402	663	406	650	703	274	473	412	1,206
1951/52																	
Jan.	25	914	45	37	—	—	—	—	72	146	12	56	269	656	474	65	23
Feb.	301	218	278	133	948	1,062	303	315	711	564	186	95	546	252	56	60	18
Mar.	—	—	—	—	396	—	109	83	211	17	—	—	151	17	4	—	—
T	326	1,132	323	170	1,344	1,062	412	398	994	727	198	151	966	925	534	125	41
1952/53																	
Jan.	—	—	28	45	253	76	285	778	875	118	33	75	1,074	555	94	55	74
Feb.	—	—	—	407	389	626	1,127	271	704	1,200	65	59	364	97	143	61	—
Mar.	—	273	572	119	437	264	15	118	419	177	28	82	51	11	16	10	72
T	—	273	600	571	1,079	966	1,427	1,167	1,998	1,495	126	216	1,489	663	253	126	146
1953/54																	
Dec.	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—
Jan.	30	1,115	263	106	27	—	16	109	279	14	34	—	187	519	521	85	—
Feb.	743	316	117	131	14	220	315	182	347	846	325	1,157	467	66	124	20	114
Mar.	170	800	—	3	118	538	259	439	182	292	491	37	35	—	2	14	4
T	943	2,231	380	240	159	758	590	730	808	1,154	850	1,194	689	585	647	119	118
1954/55																	
Jan.	—	389	201	44	—	301	161	91	83	818	502	378	—	—	—	39	47
Feb.	—	144	43	42	281	228	217	396	172	314	873	1,972	724	43	71	19	293
Mar.	—	—	—	1	96	368	8	187	337	173	362	336	205	96	1,086	154	38
T	—	533	244	87	377	897	386	674	592	1,305	1,737	2,686	929	139	1,157	212	378
1955/56																	
Jan.	119	2,028	424	64	415	164	—	—	—	299	745	1,048	886	310	295	74	276
Feb.	445	716	314	401	264	494	221	407	526	846	283	386	200	178	683	123	138
Mar.	8	47	30	43	—	32	59	—	7	—	—	—	2	—	251	—	—
T	572	2,791	768	508	679	690	280	407	533	1,145	1,028	1,434	1,088	488	1,229	197	414

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—	3	16	21	—	—	—											
—	—	—	9	73	68	—	—											
118	—	—	—	157	58	—	—											
45	—	—	—	33	40	—	—											
—	—	—	—	—	—	—	—											
163	—	3	25	284	166													
70	48	102	3	87	47	—	—											
85	—	60	43	68	278	—	—											
—	—	—	—	341	211	—	—											
28	—	3	193	83	23	49	—											
—	—	—	—	—	—	—	—											
183	48	165	239	579	559	49	—											
—	—	—	48	89	36	69	30	13	—	—	—	—						
129	95	—	255	130	193	282	118	—	—	—	—	—						
641	181	144	173	10	147	126	303	59	—	—	—	—						
229	141	120	—	—	—	41	111	—	—	—	—	—						
999	417	264	476	229	376	518	562	72	—	—	—	—						
23	44	71	35	18	—	—	—	—	—	—	—	—						
256	340	14	5	27	—	497	129	588	—	—	—	—						
32	290	238	—	—	36	17	216	375	—	—	—	—						
266	—	—	—	—	48	—	14	42	—	—	—	—						
577	674	323	40	45	84	514	359	1,005	—	—	—	—						
587	157	72	31	81	53	56	19	24	—	—	—	—	—	—	—	—	—	—
462	473	224	44	37	109	224	396	80	—	—	—	—	—	—	—	—	—	288
129	37	2	—	—	—	82	418	786	—	—	—	—	—	—	—	—	—	174
—	—	—	—	—	—	—	—	315	—	—	—	—	—	—	—	—	—	—
1,178	667	298	75	118	162	362	833	1,205	—	—	—	—	—	—	—	—	—	462
58	6	—	—	15	57	220	743	664	—	—	—	—						
77	—	—	—	98	79	16	48	708	—	—	—	—						
—	—	—	—	—	—	7	26	9	—	—	—	—						
135	6	—	—	113	136	243	817	1,381	—	—	—	—						
100	69	9	2	26	108	187	228	489	—	—	—	—						
—	—	—	68	70	104	78	138	844	—	—	—	—						
8	—	3	248	—	30	83	43	395	—	—	—	—						
108	69	12	318	96	242	348	409	1,728	—	—	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	14	130	261	681	—	—	—	—	—	—	—	—	—	—
40	—	—	—	—	—	—	63	1,112	—	—	—	—	—	—	—	—	—	98
286	—	—	—	—	—	—	—	807	—	—	—	—	—	—	—	—	—	—
326	—	—	—	—	14	130	324	2,600	—	—	—	—	—	—	—	—	—	98
304	213	32	—	130	313	249	420	638	—	—	—	—						
207	180	137	138	155	—	163	142	49	—	—	—	—						
—	—	—	—	—	65	25	—	315	—	—	—	—						
511	393	169	138	285	378	437	562	1,002	—	—	—	—						
236	74	529	242	292	22	7	13	245	850	8	60	223	187	—	—	148	660	—
161	279	177	200	12	—	—	—	2	52	1	116	831	699	247	224	965	192	125
—	—	—	—	—	—	—	—	—	—	—	—	152	—	—	120	539	2	—
397	353	706	442	304	22	7	13	247	902	9	176	1,206	886	247	344	1,652	854	125

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1956/57																	
Jan.	690	590	630	47	49	321	—	—	—	—	10	—	—	—	—	—	—
Feb.	223	17	153	157	390	400	643	288	—	—	30	215	99	27	224	—	—
Mar.	197	10	26	14	87	516	371	347	138	49	90	—	2	—	40	—	—
T	1,110	617	809	218	526	1,237	1,014	635	138	49	130	215	101	27	264	—	—
1957/58																	
Dec.	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Jan.	30	24	78	—	41	65	145	315	486	316	2	116	431	16	36	29	—
Feb.	191	—	—	—	235	405	373	366	322	158	84	282	145	456	69	157	72
Mar.	—	170	144	—	13	52	109	336	53	—	—	—	—	—	246	216	59
T	221	194	222	—	289	522	627	1,017	861	475	86	398	576	472	351	402	131
1958/59																	
Dec.	—	—	—	—	—	—	—	3	—	—	—	4	—	—	—	—	—
Jan.	—	—	91	37	—	—	—	221	—	—	—	—	296	686	793	414	217
Feb.	501	347	123	58	80	87	176	313	333	386	764	98	406	174	96	175	151
Mar.	155	177	35	22	—	—	124	371	293	647	345	239	300	—	2	138	61
T	656	524	249	117	80	87	300	908	626	1,033	1,109	341	1,002	860	891	727	429
1959/60																	
Nov.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	342	43	1	—	—	—	3	58	93	2	—	—	—	—	110	—	2
Feb.	—	134	62	—	3	172	32	73	136	58	455	669	159	335	4	—	1
Mar.	194	—	6	2	4	159	355	411	285	198	68	135	142	11	4	—	—
Apr.	239	—	—	—	1	24	24	7	46	46	—	—	—	—	—	—	—
T	775	177	69	2	8	355	414	549	560	304	523	804	301	346	118	—	3
1960/61																	
Dec.	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	80	12	—	—	—	2	82	74	—	—	12	—	11	—	—	—	—
Feb.	55	—	—	—	18	216	709	212	474	437	101	—	—	—	—	—	—
Mar.	443	182	—	5	3	375	332	190	438	140	—	—	—	—	—	—	—
Apr.	93	—	—	—	1	49	6	—	1	—	—	—	—	—	—	—	—
T	678	194	—	5	22	642	1,129	476	913	577	113	—	11	—	—	—	—
1961/62																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	14	—	—	74	16
Jan.	5	—	—	—	—	106	29	115	33	19	9	84	—	—	—	—	31
Feb.	46	94	—	—	18	289	296	132	35	53	28	56	33	8	1	—	—
Mar.	46	2	—	—	1	22	71	3	12	190	275	290	269	3	—	—	—
Apr.	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	101	96	—	—	19	417	396	250	80	262	312	430	316	11	1	74	47
1962/63																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	40	—	—	—	—	—
Jan.	75	164	116	2	—	7	—	—	—	42	49	—	—	—	64	41	113
Feb.	253	80	78	8	1	2	21	—	—	—	—	—	—	12	57	20	24
Mar.	211	77	33	—	—	—	23	30	74	19	10	—	—	—	23	227	23
Apr.	95	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	634	321	227	10	1	9	44	30	74	61	59	40	—	12	144	288	160
1963/64																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	6	—	10	38	25
Jan.	10	1	—	—	—	—	—	—	—	—	—	—	—	—	37	13	—
Feb.	—	—	—	—	—	—	—	—	5	—	—	—	15	53	39	16	5
Mar.	—	—	—	—	21	67	169	1	—	—	3	26	18	—	—	—	—
Apr.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	10	1	—	—	21	67	169	1	5	—	3	26	39	53	86	67	30
1964/65																	
Dec.	—	—	—	—	—	—	—	—	—	—	9	—	5	12	—	—	6
Jan.	—	—	—	—	—	—	—	—	—	—	—	—	—	14	28	11	—
Feb.	—	—	—	—	—	—	—	—	—	—	—	8	28	4	—	—	—
Mar.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Apr.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	—	—	—	—	—	—	—	—	9	8	33	30	28	11	6

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—	—	—	—	—	—	23	226	424	109	177	278	318	207	553	1,108	999	746
—	—	—	—	—	—	—	—	—	349	1,982	438	312	51	52	237	407	421	288
—	—	—	—	—	—	—	—	—	21	194	514	28	—	—	—	23	118	36
—	—	—	—	—	—	—	23	226	794	2,285	1,129	618	369	259	790	1,538	1,538	1,070
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
265	218	126	122	—	—	179	65	220	598	329	604	249	204	62	147	538	111	9
8	—	15	4	36	190	28	15	8	165	585	349	289	5	47	185	203	102	18
—	—	67	162	103	—	—	—	—	13	100	209	48	20	22	39	25	106	—
273	218	208	288	139	190	207	80	228	776	1,014	1,162	586	229	131	371	766	319	27
—	—	—	—	—	—	—	—	—	—	—	—	—						
200	177	74	196	147	545	448	19	216	330	—	—	—						
583	440	139	193	353	213	5	8	10	153	88	—	—						
4	—	—	—	5	71	31	—	7	112	138	45	—						
787	617	213	389	505	829	484	27	233	595	226	45	—						
—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	79	28	66	—	—	—	—	—	—	—	—	—	—	—	—	—
50	55	60	512	945	134	1	—	—	—	—	—	—	—	—	—	—	—	80
—	—	—	—	446	555	559	8	123	121	20	—	—	—	—	—	—	—	—
—	—	—	41	112	147	163	31	1	8	5	8	17	14	—	16	7	267	26
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50	56	60	632	1,531	902	723	39	124	129	25	8	17	14	—	16	7	267	106
1	—	—	—	—	15	151	—	13	13	1	—	—	—	—	—	—	—	—
3	13	28	215	115	395	482	200	16	126	314	76	40	—	—	—	—	185	117
—	—	—	12	100	237	221	197	157	276	485	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	16	104	165	246	214	171	1	3	9	4	—	53
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
4	13	28	227	215	647	854	413	290	580	1,046	290	211	1	3	9	5	185	170
60	17	6	23	60	146	131	29	8	—	—	—	—	—	—	—	—	—	—
85	39	18	35	156	12	99	49	62	202	39	154	56	141	160	95	123	25	88
—	—	35	41	129	79	25	25	46	44	49	55	—	—	—	12	336	270	98
—	—	—	—	—	—	—	—	6	184	102	81	21	11	66	109	224	389	145
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	62
145	56	59	99	345	237	255	103	122	430	190	290	77	152	226	216	683	691	393
—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	17	42	18	54
119	86	54	3	—	—	—	—	—	—	—	—	—	—	—	5	147	291	60
15	5	29	53	53	250	28	33	72	89	70	23	6	33	69	37	144	27	50
5	5	6	30	91	3	—	—	—	—	—	60	21	10	3	38	22	20	59
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
139	96	89	86	144	253	28	33	72	89	70	83	27	43	78	97	355	356	223
19	3	23	49	—	—	—	—						—	—	—	—	—	—
2	18	16	—	33	134	—	—						—	—	—	—	—	—
8	3	8	5	8	177	69	—						—	—	—	4	—	6
—	—	—	—	—	18	—	—						—	—	—	—	—	—
—	—	—	—	—	9	—	—						—	—	—	—	—	—
29	24	47	54	41	338	69	—						—	—	—	4	—	6
12	16	4	—	—	—	—	—											
—	—	1	—	17	24	—	—											
—	—	—	79	43	16	1	—											
—	9	1	31	29	—	—	—											
1	—	—	—	—	—	—	—											
13	25	6	110	89	40	1	—											

Table 9. Continued.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1965/66																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	—	—	—	—	11	33	—	—	—	—	—	—	—	3	6	8	10
Feb.	—	—	—	—	—	13	33	19	8	—	—	—	—	—	1	8	4
Mar.	—	—	—	—	—	8	4	27	2	—	—	—	—	—	—	—	—
T	—	—	—	—	11	54	37	46	10	—	—	—	—	3	7	16	14
1966/67																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	37	30
Jan.	—	—	—	—	—	13	7	11	50	42	—	—	—	8	19	7	4
Feb.	—	—	—	—	—	—	—	—	—	—	43	45	61	17	24	—	—
Mar.	—	—	—	—	—	—	—	21	19	36	23	16	—	3	—	—	—
Apr.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	27	—	—
T	—	—	—	—	—	13	7	32	69	78	66	61	61	28	70	44	34
1967/68																	
Dec.							—	—	7	12	—	—	—	—	—	—	—
Jan.							—	—	—	—	13	10	6	31	24	14	8
Feb.							—	17	9	11	—	—	—	—	—	—	—
Mar.							—	—	—	—	—	—	—	—	—	—	—
T							—	17	16	23	13	10	6	31	24	14	8
1968/69																	
Jan.							—	—	2	—	5	2	—	5	18	7	1
Feb.							—	—	—	—	—	12	19	—	—	—	—
Mar.							—	—	—	—	—	—	—	—	—	—	—
T							—	—	2	—	5	14	19	5	18	7	1
1969/70																	
Jan.							—	—	—	—	—	—	—	18	12	8	3
Feb.							—	—	—	—	—	—	2	20	—	—	—
Mar.							—	—	—	—	—	—	—	—	—	—	—
T							—	—	—	—	—	—	2	38	12	8	3
1970/71																	
Jan.														6	12	—	—
Feb.														—	—	—	—
Mar.														—	—	—	—
T														6	12	—	—
1971/72																	
Jan.	—	—	—	—	—	—	—	—	5	16	—	4	16	19	30	—	—
Feb.	—	—	—	5	4	8	—	—	—	—	—	—	—	—	—	—	—
Mar.	—	—	—	3	—	—	—	—	—	9	—	—	—	—	—	—	—
T	—	—	—	8	4	8	—	—	5	25	—	4	16	19	30	—	—

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—	—	1	2	20	—	—	—	—	—	—	—						
3	12	11	7	36	45	10	24	33	—	—	—	—						
2	4	11	4	5	3	8	7	19	32	—	—	—						
—	—	—	—	1	5	15	14	21	17	4	62	—						
5	16	22	12	44	73	33	45	73	49	4	62	—						
—	13	—	—	—	—	—	—	—	—	—	—	—						
6	23	5	9	7	16	40	12	63	62	8	—	—						
8	1	—	1	1	14	48	42	86	123	27	—	—						
—	—	—	—	3	48	6	10	46	56	—	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
14	37	5	10	11	78	94	64	195	241	35	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
2	9	—	3	72	6	2	1	—	—	—	—	—						
—	—	—	14	46	24	5	—	22	53	33	—	—						
—	—	—	—	21	13	16	—	4	19	56	—	—						
2	9	—	17	139	43	23	1	26	72	89	—	—						
2	2	7	—	—	—	—	—	—	1	7	—	23	32	30	5	28	3	—
—	—	—	—	5	—	12	29	3	15	95	9	75	14	4	2	—	—	—
—	—	—	—	10	28	42	5	—	—	8	4	11	1	6	5	—	—	—
2	2	7	—	15	28	54	34	3	16	110	13	109	47	40	12	28	3	—
—	10	1	7	—	—	—	—	—	—	—	—	—						
—	—	—	24	55	17	37	—	—	—	—	—	—						
—	—	—	1	25	54	—	25	30	1	—	—	—						
—	10	1	32	80	71	37	25	30	1	—	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
—	3	—	—	27	26	10	11	7	3	20	22							
—	—	—	—	—	—	—	—	26	3	6	12							
—	3	—	—	27	26	10	11	33	6	26	34							
—	—												19	11	2	7	4	53
—	—												—	—	—	—	13	5
—	—												—	—	—	—	—	—
—	—												19	11	2	7	17	58

Table 10. Series B. Catch of sei whale

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1934/35																	
Feb.	—	1	—	—	—	—											
Mar.	—	6	—	—	—	—											
T	—	7	—	—	—	—											
1936/37																	
Feb.	—	5	5	—	—	—											
Mar.	—	2	3	—	—	—											
T	—	7	8	—	—	—											
1937/38																	
Mar.	—	5	—	1	—	—											
T	—	5	—	1	—	—											
1938/39																	
Mar.	—	2	—	—	—	—											
T	—	2	—	—	—	—											
1945/46																	
Mar.	—	1	—	—	—	—											
T	—	1	—	—	—	—											
1946/47																	
Mar.	—	1	1	—	—	—											
T	—	1	1	—	—	—											
1947/48																	
Mar.														—	2	—	—
T															2		
1948/49																	
Feb.	—	1	—	—	—	—								—	—	—	—
Mar.	—	11	2	—	1	—								—	—	—	—
T	—	12	2	—	1	—								—	—	—	—
1949/50																	
Jan.	—	2	—	—	—	—											
Feb.	—	15	5	—	1	—											
Mar.	4	74	—	—	—	—											
T	4	91	5	—	1	—											
1950/51																	
Feb.	—	309	2	—	—	—								—	—	—	1
Mar.	—	8	12	—	—	—								—	—	—	—
T	—	317	14	—	—	—								—	—	—	1
1951/52																	
Feb.	—	11	7	3	—	—											
Mar.	—	—	—	—	—	—											
T	—	11	7	3	—	—											
1952/53																	
Jan.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Feb.	—	—	—	2	—	2	—	—	—	1	—	—	—	—	—	—	—
Mar.	—	1	8	—	—	—	—	—	—	—	3	1	—	—	—	—	—
T	—	1	8	2	—	2	—	—	—	1	3	1	—	—	—	—	—
1953/54																	
Jan.	—	8	17	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Feb.	—	23	29	11	—	—	—	—	—	—	—	—	—	—	—	—	—
Mar.	—	23	—	1	—	—	—	—	—	10	—	—	—	—	1	—	—
T	—	54	46	12	—	—	—	—	—	10	—	—	—	—	1	—	—
1954/55																	
Jan.	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Feb.	—	7	6	—	8	—	—	—	—	—	—	—	—	—	—	—	—
Mar.	—	—	—	—	1	1	—	—	3	2	1	—	—	—	4	—	—
T	—	8	6	—	9	1	—	—	3	2	1	—	—	—	4	—	—
1955/56																	
Jan.	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Feb.	7	141	5	12	12	6	—	—	—	1	2	2	—	—	—	—	—
Mar.	1	17	—	20	—	—	—	—	—	—	—	—	—	—	1	—	—
T	8	158	6	32	12	6	—	—	—	1	2	2	—	—	1	—	—

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
		1	—	—	—	—	—						—	—	—	—	—	1
		1	—	—	—	—	—						—	—	—	—	—	1
—	—	10	—	—	—	—	—											
—	—	10	—	—	—	—	—											
—	—																	
1	—																	
1	—																	
10	—																	
—	—																	
10	—																	
		—	—	—	—	—	—											
		—	—	—	—	1	—											
		—	—	—	—	1	—											
—	—	—	—	—	—	1	—	—	—	—	—	—						
—	—	—	—	11	—	3	—	1	—	—	—	—						
—	3	8	17	—	18	19	9	—	—	—	—	—						
—	3	8	17	11	18	23	9	1	—	—	—	—						
—	—							—	—	—	—	—						
—	—							—	—	—	—	—						
—	—							1	—	—	—	—						
—	—							1	—	—	—	—						
—	—	—	—	—	—	—	—											
—	—	—	3	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	3	—	—	—	—											
—	—	—	—	—	—	—	1	2	3	—	—	—	—	—	—	—	2	—
—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	9	—	2	—
—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	1	—	—
—	—	—	—	—	—	—	1	2	3	—	—	3	2	—	9	1	4	—

Table 10. Continued.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1956/57																	
Jan.	5	9	11	7	—	—								—	—	—	—
Feb.	2	2	9	25	69	6								—	1	—	—
Mar.	8	12	36	—	1	6								—	—	—	—
T	15	23	56	32	70	12								—	1	—	—
1957/58																	
Jan.	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Feb.	99	—	—	—	—	—	—	—	2	—	—	—	—	1	—	—	2
Mar.	—	48	16	—	—	—	—	—	—	—	—	—	—	—	—	—	148
T	99	48	16	—	—	—	—	—	2	1	—	—	—	1	—	—	150
1958/59																	
Jan.	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—
Feb.	2	—	—	—	—	—	1	—	—	5	5	1	10	11	12	2	25
Mar.	5	33	2	6	—	—	—	3	2	14	4	12	4	—	10	5	17
T	7	33	2	6	—	—	1	3	2	19	9	13	14	13	22	7	42
1959/60																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	35	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Feb.	—	15	—	—	—	—	—	—	2	6	3	10	21	173	—	—	11
Mar.	152	1	—	—	—	—	3	1	7	6	10	55	64	7	2	—	—
Apr.	67	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—
T	254	18					3	1	11	12	13	65	85	180	2	—	11
1960/61																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Feb.	126	—	—	—	—	1	1	—	—	3	—	—	—	—	—	—	—
Mar.	369	107	—	4	—	49	8	4	25	15	—	—	—	—	—	—	—
Apr.	94	—	—	—	—	—	—	56	2	—	—	—	—	—	—	—	—
T	592	107	—	4	—	50	9	60	27	18	—	—	—	—	—	—	—
1961/62																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	—	1	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—
Feb.	16	—	2	—	—	19	—	—	—	—	—	—	9	1	—	—	—
Mar.	168	76	2	—	—	—	1	1	—	—	17	7	9	—	—	—	—
Apr.	111	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	295	77	4	—	—	19	1	1	—	—	17	7	18	1	3	—	—
1962/63																	
Dec.	—	—	—	—	—	—								—	—	—	—
Jan.	—	11	8	4	—	—								—	—	3	—
Feb.	101	84	27	—	—	—								27	23	29	42
Mar.	613	59	1	—	—	—								—	12	110	17
Apr.	47	7	—	—	—	—								—	—	—	—
T	761	161	36	4	—	—								27	35	142	59
1963/64																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9	8	—
Jan.	11	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Feb.	17	—	—	—	—	—	—	1	—	—	—	—	—	3	15	—	25
Mar.	—	—	—	—	—	—	14	—	—	—	—	—	—	—	—	—	—
Apr.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	28	—	—	—	—	—	14	1	—	—	—	—	—	3	24	8	25
1964/65																	
Jan.							—	—	—	—	—	—	—	—	2	—	—
Feb.							—	—	—	—	—	7	—	—	—	—	—
Mar.							—	—	—	—	—	—	—	—	—	—	—
Apr.							—	—	—	—	—	—	—	—	—	—	—
T							—	—	—	—	—	7	—	—	2	—	—

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—	—	—	—	—	—	1	1	3	1	—	—	—	2	2	17	6	15
—	—	—	—	—	—	—	—	—	52	31	—	2	1	—	10	63	46	38
—	—	—	—	—	—	—	—	—	29	12	1	—	—	—	—	2	70	3
—	—	—	—	—	—	—	1	1	84	44	1	2	1	2	12	82	122	56
2	—	—	—	—	—	—	—	1	5	—	5	—	—	—	—	6	8	1
5	—	8	12	2	1	—	—	22	14	12	6	4	—	—	47	200	119	11
59	59	76	272	22	—	—	—	—	66	37	4	—	—	4	15	83	46	—
66	59	84	284	24	1	—	—	23	85	49	15	4	—	4	62	289	173	12
2	5	—	4	16	6	4	4	98	45	—	—	—						
53	64	14	46	84	152	4	3	16	33	4	—	—						
—	—	—	—	12	50	40	—	23	49	160	19	—						
55	69	14	50	112	208	48	7	137	127	164	19	—						
—	—	—	14	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	225	99	20	1	—	—	—	—	—	—	—	—	—	—	—	6
—	—	—	—	271	356	104	58	105	83	2	—	—	—	—	—	—	—	—
—	—	—	20	38	72	85	31	15	8	—	—	—	—	—	—	—	122	31
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	259	415	448	190	89	120	91	2	—	—	—	—	—	—	122	37
—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—
2	1	15	8	7	48	12	14	3	56	80	2	—	—	—	—	—	42	25
—	—	—	7	18	36	38	80	90	233	679	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	11	14	70	79	162	48	5	—	5	5	—	8
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12	—	—
2	1	15	15	25	84	50	105	107	359	840	164	48	5	—	5	17	42	33
—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—
6	9	2	6	26	4	12	6	2	4	1	—	—	9	—	—	—	14	36
—	—	12	29	96	187	9	18	22	47	14	31	—	—	—	9	67	175	13
—	—	—	—	—	—	—	—	8	110	31	23	52	—	45	166	387	379	57
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	12	37
6	9	14	35	122	191	21	26	32	161	46	54	52	9	45	175	455	580	143
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
4	13	2	1	—	—	—	—	—	—	—	—	—	—	—	—	7	33	6
2	41	22	34	55	122	23	13	52	152	80	9	—	3	2	6	201	69	103
6	2	5	10	143	—	—	—	—	—	—	41	10	—	—	27	24	52	87
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12	56	29	45	198	122	23	13	52	152	80	50	10	3	2	33	232	154	198
—	—	—	—	—	—	—	—						—	—	—	—	—	—
—	—	1	—	—	255	—	—						—	—	—	—	—	—
—	6	12	11	—	370	123	—						—	—	—	12	—	15
—	—	—	—	—	80	—	—						—	—	—	—	—	—
—	—	—	—	—	101	—	—						—	—	—	—	—	—
—	6	13	11	—	806	123	—						—	—	—	12	—	15
—	—	—	—	26	—	—	—											
—	—	—	220	191	74	—	—											
30	5	40	100	141	—	—	—											
21	—	—	—	—	—	—	—											
51	5	40	320	358	74	—	—											

Table 10. Continued.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1965/66																	
Dec.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	—	—	—	—	15	26	—	—	—	—	—	—	—	24	21	35	28
Feb.	—	—	—	—	—	11	—	—	5	—	—	—	—	—	31	8	49
Mar.	—	—	—	—	—	8	25	44	—	—	—	—	—	—	—	—	—
T	—	—	—	—	15	45	25	44	5	—	—	—	—	24	52	43	77
1966/67																	
Jan.	—	—	—	—	—	5	—	—	—	—	—	—	—	—	—	3	23
Feb.	—	—	—	—	—	—	—	—	—	—	4	7	4	13	8	—	—
Mar.	—	—	—	—	—	—	—	11	4	4	2	13	—	3	37	—	—
Apr.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11	—	—
T	—	—	—	—	—	5	—	11	4	4	6	20	4	16	56	3	23
1967/68																	
Jan.														9	2	1	—
Feb.														—	—	—	—
Mar.														—	—	—	—
T														9	2	1	—
1968/69																	
Jan.	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Feb.	—	—	—	—	—	—	—	—	—	—	—	25	—	—	—	—	—
Mar.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	—	—	1	—	—	—	—	—	—	—	—	25	—	—	—	—	2
1969/70																	
Jan.														—	8	—	—
Feb.														—	—	—	—
Mar.														—	—	—	—
T														—	8	—	—
1970/71																	
Jan.														—	15	—	—
Feb.														—	—	—	—
Mar.														—	—	—	—
T														—	15	—	—
1971/72																	
Jan.							—	—	—	—	—	1	—	1	4	—	—
Feb.							—	—	—	—	—	—	—	—	—	—	—
T							—	—	—	—	—	1	—	1	4	—	—

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—	—	—	—	25	—	—	—	—	—	—	—						
8	9	22	15	27	87	79	35	31	—	—	—	—						
32	52	79	35	14	7	36	34	71	98	—	—	—						
—	—	—	—	10	27	67	35	202	60	9	22	—						
40	61	101	50	51	146	182	104	304	158	9	22	—						
—	9	—	—	—	—	—	3	20	14	—	—	—						
58	1	—	22	50	133	131	53	70	14	—	—	—						
—	—	—	—	40	209	17	35	166	118	—	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
58	10	—	22	90	342	148	91	256	146	—	—	—						
17	35	2	—	70	2	3	2	—	—	—	—	—						
—	—	—	68	129	194	11	—	—	204	64	—	—						
—	—	—	—	310	98	10	1	51	33	520	—	—						
17	35	2	68	509	294	24	3	51	237	584	—	—						
1	6	—	—	—	—	—	—	—	18	40	—	1	—	21	13	24	—	2
—	—	—	3	—	26	9	151	7	16	163	—	5	8	1	—	—	—	—
—	—	—	—	21	63	15	49	—	—	22	—	8	2	1	1	—	—	—
1	6	—	3	21	89	24	200	7	34	225	—	14	10	23	14	24	—	2
—	—	4	—	—	—	—	—	—	—	—	—	—						
—	—	—	47	86	24	12	—	—	—	—	—	—						
—	—	—	—	140	58	—	7	87	55	—	—	—						
—	—	4	47	226	82	12	7	87	55	—	—	—						
—	2	—	—	—	—	—	—	—	—	—	—	—						
—	—	—	11	26	29	20	41	17	26	22	9	—						
—	—	—	—	—	—	—	—	32	25	32	14	—						
—	2	—	11	26	29	20	41	49	51	54	23	—						
													—	—	—	—	—	—
													—	—	9	—	7	—
													—	—	9	—	7	—

Table 11. Series C. Catcher's day's work

Area Square	II	V			VI					I		
	5	23	24	25	26	27	28	29	30	31	32	33
1947/48												
Feb.		—	30	72								
T		—	30	72								
1948/49												
Feb.		—	—	49								
Mar.		—	—	70								
T		—	—	119								
1949/50												
Feb.		195	52	—								
T		195	52	—								
1950/51												
Jan.		16	534	54	—	—	—	—	—			
Feb.		—	267	465	217	—	—	—	—			
Mar.		—	14	319	71	—	—	—	—			
T		16	815	838	288	—	—	—	—			
1951/52												
Jan.		—	109	497	36	—	—	—	—			
Feb.		—	136	853	404	—	—	—	—			
Mar.		—	—	150	132	—	—	—	—			
T		—	245	1,500	572	—	—	—	—			
1952/53												
Jan.		—	—	45	60	—	—	—	—			
Feb.		—	—	310	195	—	—	—	—			
Mar.		—	—	—	60	—	—	—	—			
T		—	—	355	315	—	—	—	—			
1953/54												
Jan.		—	—	26	—	—	—	—	—			
Feb.		—	—	130	13	—	—	—	—			
Mar.		—	—	—	—	—	—	—	—			
T		—	—	156	13	—	—	—	—			
1954/55												
Feb.		—	208	260	13	—	—	—	—			
Mar.		—	78	78	143	—	—	—	—			
T		—	286	338	156	—	—	—	—			
1955/56												
Feb.					—	18	18	18	36			
T					—	18	18	18	36			
1956/57												
Mar.					—	—	18	—	—			
T					—	—	18	—	—			
1957/58												
Jan.		—	—	—	—	11	—	—	—			
Feb.		—	36	24	48	144	46	12	—			
Mar.		—	—	—	72	141	105	—	—			
T		—	36	24	120	296	151	12	—			
1958/59												
Feb.	24				12	84	12	—	—			
Mar.	—				48	276	156	72	24			
T	24				60	360	168	72	24			
1959/60												
Feb.		—	—	—	27	—	—	—	—	—	—	—
Mar.		—	—	34	52	34	34	18	18	18	18	36
T		—	—	34	79	34	34	18	18	18	18	36
1960/61												
Feb.					54	—	—	—	—			
Mar.					150	18	—	—	—			
Apr.					—	—	—	—	—			
T					204	18	—	—	—			

Area	II	V			VI					I		
Square	5	23	24	25	26	27	28	29	30	31	32	33
1961/62												
Feb.	22				—	—	—	—	—	—	—	—
Mar.	22				—	36	36	36	—	18	—	18
Apr.	—				—	—	—	—	—	—	—	—
T	44				—	36	36	36	—	18	—	18
1962/63												
Feb.		—	19	15								
T		—	19	15								
1966/67												
Jan.		—	19	38	—	—	—	—	—			
Feb.		—	20	—	20	—	60	—	—			
Mar.		—	—	—	—	20	—	—	—			
T		—	39	38	20	20	60	—	—			

Table 12. Series C. Catch of blue whale

Area	II	V			VI					I		
Square	5	23	24	25	26	27	28	29	30	31	32	33
1947/48												
Feb.		—	29	48								
T		—	29	48								
1948/49												
Feb.		—	—	40								
Mar.		—	—	31								
T		—	—	71								
1949/50												
Feb.		188	30	—								
T		188	30	—								
1950/51												
Jan.		27	464	21	—	—	—	—	—			
Feb.		—	243	311	249	—	—	—	—			
Mar.		—	—	142	7	—	—	—	—			
T		27	707	474	256	—	—	—	—			
1951/52												
Jan.		—	25	302	11	—	—	—	—			
Feb.		—	68	440	92	—	—	—	—			
Mar.		—	—	47	9	—	—	—	—			
T		—	93	789	112	—	—	—	—			
1952/53												
Jan.		—	—	24	69	—	—	—	—			
Feb.		—	—	81	68	—	—	—	—			
Mar.		—	—	—	19	—	—	—	—			
T		—	—	105	156	—	—	—	—			
1953/54												
Jan.		—	—	6	—	—	—	—	—			
Feb.		—	—	60	2	—	—	—	—			
T		—	—	66	2	—	—	—	—			
1954/55												
Feb.		—	140	117	3	—	—	—	—			
Mar.		—	8	23	60	—	—	—	—			
T		—	148	140	63	—	—	—	—			
1955/56												
Feb.					—	3	4	—	10			
T					—	3	4	—	10			
1956/57												
Mar.					—	—	9	—	—			
T					—	—	9	—	—			
1957/58												
Feb.		—	5	—	18	94	7	2	—			
Mar.		—	—	—	—	—	3	—	—			
T		—	5	—	18	94	10	2	—			
1958/59												
Feb.					8	17	—	—	—			
Mar.					3	92	56	40	8			
T					11	109	56	40	8			
1959/60												
Mar.		—	—	7	32	33	11	37	4	5	2	—
T		—	—	7	32	33	11	37	4	5	2	—
1960/61												
Feb.					7	—	—	—	—			
T					7	—	—	—	—			
1961/62												
Feb.	1				—	—	—	—	—	—	—	—
Mar.	—				—	11	13	5	—	3	—	3
T	1				—	11	13	5	—	3	—	3
1962/63												
Feb.		—	23	—								
T		—	23	—								

Area	II	V			VI					I		
Square	5	23	24	25	26	27	28	29	30	31	32	33
1951/52												
Feb.		—	9	36								
T		—	9	36								
1952/53												
Feb.		—	—	2								
T		—	—	2								
1954/55												
Feb.		—	—	1								
T		—	—	1								
1957/58												
Feb.					—	14	—	—	—			
T					—	14	—	—	—			

Table 14. Series C. Catch of fin whale

Area Square	II	V			VI					I		
	5	23	24	25	26	27	28	29	30	31	32	33
1948/49												
Feb.		—	—	39								
Mar.		—	—	25								
T		—	—	64								
1949/50												
Feb.		197	102	—								
T		197	102	—								
1950/51												
Jan.		—	16	—	—	—	—	—	—			
Feb.		—	63	194	5	—	—	—	—			
Mar.		—	—	77	2	—	—	—	—			
T		—	79	271	7	—	—	—	—			
1951/52												
Jan.		—	60	373	12	—	—	—	—			
Feb.		—	166	774	727	—	—	—	—			
Mar.		—	—	86	184	—	—	—	—			
T		—	226	1, 233	923	—	—	—	—			
1952/53												
Jan.		—	—	23	—	—	—	—	—			
Feb.		—	—	261	82	—	—	—	—			
Mar.		—	—	—	81	—	—	—	—			
T		—	—	284	163	—	—	—	—			
1953/54												
Jan.		—	—	12								
Feb.		—	—	174								
T		—	—	186								
1954/55												
Feb.		—	404	493	1	—	—	—	—			
Mar.		—	67	88	224	—	—	—	—			
T		—	471	581	225	—	—	—	—			
1955/56												
Feb.					—	4	3	1	—			
T					—	4	3	1	—			
1956/57												
Mar.					—	—	12	—	—			
T					—	—	12	—	—			
1957/58												
Jan.		—	—	—	—	4	—	—	—			
Feb.		—	8	10	7	143	29	12	—			
Mar.		—	—	—	7	52	87	—	—			
T		—	8	10	14	199	116	12	—			
1958/59												
Feb.	2				10	178	23	—	—			
Mar.	—				87	309	214	139	43			
T	2				97	487	237	139	43			
1959/60												
Feb.		—	—	—	46	—	—	—	—	—	—	—
Mar.		—	—	42	27	6	—	15	4	1	—	1
T		—	—	42	73	6	—	15	4	1	—	1
1960/61												
Feb.					31	—	—	—	—			
Mar.					152	—	—	—	—			
T					183	—	—	—	—			
1961/62												
Feb.	25				—	—	—	—	—	—	—	—
Mar.	3				—	5	5	1	—	2	—	2
T	28				—	5	5	1	—	2	—	2
1962/63												
Feb.		—	2	10								
T		—	2	10								

Area Square	II	V			VI					I		
	5	23	24	25	26	27	28	29	30	31	32	33
1966/67												
Jan.		—	—	17	—	—	—	—	—			
Feb.		—	5	—	21	—	33	—	—			
Mar.		—	—	—	—	5	—	—	—			
T		—	5	17	21	5	33	—	—			

Table 15. Series C. Catch of sei whale

Area quare	II	V			VI					I		
	5	23	24	25	26	27	28	29	30	31	32	33
952/53												
Feb.		—	—	1	1	—	—	—	—			
T		—	—	1	1	—	—	—	—			
957/58												
Feb.		—	1	1	14	87	5	—	—			
Mar.		—	—	—	267	400	19	—	—			
T		—	1	1	281	487	24	—	—			
958/59												
Feb.					—	6	—	—	—			
Mar.					2	60	15	1	—			
T					2	66	15	1	—			
959/60												
Feb.		—	—	—	15	—	—	—	—			
Mar.		—	—	17	4	—	—	—	—			
T		—	—	17	19	—	—	—	—			
960/61												
Feb.					6	—	—	—	—			
Mar.					6	5	—	—	—			
T					12	5	—	—	—			
961/62												
Mar.					—	—	15	9	—	8	—	—
T					—	—	15	9	—	8	—	—

Table 16. Series D. Catcher's day's work

Area	II						III							IV			
Square	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1962/63																	
Dec.	—	—	—	—	—	—	—	33	55	224	327	185	60	45	—	—	—
Jan.	—	—	—	—	—	71	—	30	101	538	203	51	107	191	—	—	—
Feb.	—	—	—	—	22	79	—	—	55	501	12	51	102	68	—	—	—
Mar.	57	—	—	—	—	11	11	8	312	526	123	189	11	—	—	—	—
Apr.	68	95	—	—	—	—	11	30	—	—	—	237	116	92	—	—	—
T	125	95	—	—	22	161	22	101	523	1,789	665	713	396	396	—	—	—
1963/64																	
Dec.	72	—	—	—	—	12	156	72	36	—	190	95	95	—	—	—	—
Jan.	143	178	11	—	7	108	60	—	—	—	423	250	114	57	—	—	—
Feb.	22	—	—	—	—	—	—	—	—	—	36	289	187	—	—	—	—
Mar.	96	22	—	—	—	—	—	—	11	11	114	231	159	250	19	—	—
Apr.	—	—	—	—	—	—	18	—	22	55	11	—	57	57	—	—	—
T	333	200	11	—	7	120	234	72	69	66	774	865	612	364	19	—	—
1964/65																	
Dec.	302	32	110	193	71	—	—	22	18	—	—	—	10	41	63	189	—
Jan.	835	404	166	44	8	126	90	9	—	—	—	—	—	—	51	445	201
Feb.	507	248	30	—	—	27	—	—	—	—	51	51	17	102	—	—	—
Mar.	104	244	168	74	92	11	81	80	39	—	—	—	—	68	34	34	51
Apr.	—	—	41	27	56	42	44	44	58	9	18	18	—	—	—	—	—
T	1,748	928	515	338	227	206	215	155	115	9	69	69	27	211	148	668	252
1965/66																	
Dec.	576	343	234	42	25	40	71	—	—	—	—	—	—	—	—	—	—
Jan.	454	975	498	12	—	—	45	45	117	—	—	—	—	—	—	—	—
Feb.	—	22	153	605	661	221	306	54	—	—	—	—	—	—	—	—	—
Mar.	—	30	20	—	20	20	136	230	269	134	132	—	—	—	—	—	—
Apr.	—	—	—	—	—	—	—	—	70	—	—	—	—	—	—	—	—
T	1,030	1,370	905	659	706	281	558	329	456	134	132	—	—	—	—	—	—
1966/67																	
Dec.	90	235	40	10	—	—	100	284	230	142	56	68	—	133	57	—	—
Jan.	—	—	77	120	103	193	164	270	98	40	290	264	72	204	24	—	—
Feb.	—	—	—	—	—	—	—	183	183	263	258	212	20	30	—	—	—
Mar.	—	—	—	—	—	—	—	—	10	149	289	128	—	—	—	—	—
Apr.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	90	235	117	130	103	193	264	737	521	594	893	672	92	367	81	—	—
1967/68																	
Dec.	—	—	—	—	—	26	13	20	10	154	279	321	33	55	372	—	—
Jan.	—	—	—	—	—	—	—	—	—	—	167	203	66	74	36	—	—
Feb.	—	—	—	—	—	65	—	—	—	—	107	348	23	55	99	—	—
Mar.	—	—	—	—	—	—	—	—	15	25	30	85	—	—	—	—	—
Apr.	—	—	—	—	—	—	—	15	20	—	—	—	—	—	—	—	—
T	—	—	—	—	—	91	13	35	45	179	583	957	122	184	507	—	—
1968/69																	
Dec.	—	—	—	—	—	159	269	68	—	—	—	34	306	219	321	—	—
Jan.	—	—	—	—	—	—	—	136	—	—	—	—	64	140	—	—	—
Feb.	—	—	—	—	—	—	—	—	—	—	102	564	210	36	—	—	—
Mar.	—	—	—	—	—	—	—	—	—	—	264	96	60	117	30	—	—
T	—	—	—	—	—	159	269	204	—	—	366	694	640	512	351	—	—
1969/70																	
Dec.	90	183	98	24	25	81	85	187	—	—	12	84	24	187	153	—	12
Jan.	70	60	30	20	20	101	177	156	213	84	305	84	189	17	12	144	72
Feb.	—	—	—	—	—	—	—	—	46	183	235	556	40	50	—	—	—
Mar.	—	—	—	—	—	—	—	—	78	65	128	358	77	81	—	—	—
T	160	243	128	44	45	182	262	343	337	332	680	1,082	330	335	165	144	84
1970/71																	
Dec.	—	12	—	—	—	24	68	119	68	85	—	—	—	—	119	177	353
Jan.	360	12	—	—	—	—	—	—	—	17	136	323	116	333	222	290	156
Feb.	48	—	—	—	—	—	—	—	48	305	389	340	298	36	—	—	—
Mar.	36	12	—	—	—	—	—	—	—	154	221	153	51	51	—	—	—
Apr.	36	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	480	36	—	—	—	24	68	119	116	561	746	816	465	420	341	467	509

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—	—	—	—	—	—	—											
—	—	—	20	71	30	—	—											
—	—	—	—	50	110	120	—											
—	—	—	—	—	119	311	44											
—	—	—	—	—	—	—	—											
—	—		20	121	259	431	44											
—	—	—	—	—	—	—	—						—	—	—	—	—	—
156	115	—	32	—	—	—	—						—	—	—	—	—	10
—	10	145	244	—	—	—	—						—	—	—	—	—	—
51	—	—	—	—	—	—	—						—	—	—	—	—	—
—	—	—	—	—	—	—	—						—	—	—	—	—	—
207	125	145	276	—	—	—	—						—	—	—	—	—	10
73	131	93	72	36	—	—	—											
—	—	—	—	—	18	18	—											
—	—	—	—	—	—	—	—											
—	—	—	190	—	—	—	—											
—	—	—	—	—	—	—	—											
73	131	93	262	36	18	18	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	20	120	—											
—	—	—	—	—	20	120	—											
18	18	—	—	—	110	22	33	44	—	—	—	—						
—	—	27	90	153	121	11	66	44	—	—	—	—						
—	—	—	—	—	—	—	82	—	—	—	—	—						
—	—	—	—	—	—	22	—	11	—	—	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
18	18	27	90	153	231	55	181	99	—	—	—	—						
—	—	—	—	22	198	—	—	—	—	—	—	—						
—	—	—	—	11	154	22	33	11	—	—	—	—						
—	—	—	—	—	—	33	33	—	11	—	—	—						
—	—	—	—	—	11	231	—	—	—	—	—	—						
—	—	—	—	33	363	286	66	11	11	—	—	—						
228	—	—	—	—	—	—	—											
36	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	84	36	—	—	—											
264	—	—	84	36	—	—	—											
210	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	204	102	51											
—	—	—	—	—	17	102	—											
210	—	—	—	—	221	204	51											

~~Table 17. Series D. Catches of blue whale and humpback whale (in parentheses)~~

Area Square	II						III							Ⅵ			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1971/72																	
Dec.	104	—	—	—	—	17	221	51	51	—	34	—	—	—	—	—	122
Jan.	117	—	—	—	—	—	—	—	102	153	221	140	109	83	168	353	63
Feb.	—	—	—	—	3	—	—	11	65	215	404	441	201	65	—	12	—
Mar.	78	78	—	—	—	—	—	—	51	148	149	180	137	70	58	17	17
Apr.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	299	78	—	—	3	17	221	62	269	516	808	761	447	218	226	382	202

Table 17. Series D. Catches of blue whale and humpback whale (in parentheses)

Area Square	II						III							Ⅳ			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1962/63																	
Feb.	—	—	—	—	1	1	—	—	—	32	1	—	(25)	—	—	—	—
Mar.	—	—	—	—	—	1	—	—	41	113	43	142		—	—	—	—
Apr.	—	—	—	—	—	—	—	—	—	—	—	182	43	2	—	—	—
T	—	—	—	—	1	2	—	—	41	145	44	324	43 (25)	2	—	—	—
1963/64																	
Feb.							—	—	—	—	—	14	7	—	—	—	—
Mar.							—	—	—	—	—	10	17	19	—	—	—
Apr.							—	—	—	27	—	—	7	—	—	—	—
T							—	—	—	27	—	24	31	19	—	—	—
1964/65																	
Feb.							—	—	—	—	7	4	—	—	—	—	—
Mar.							—	—	—	—	—	—	—	3	—	—	—
T							—	—	—	—	7	4	—	3	—	—	—

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
130	227	—	—	208	39	—	—											
39	65	26	143	26	—	—	—											
—	—	—	—	—	—	—	—											
—	17	68	68	34	119	17	—											
—	—	—	—	—	—	119	—											
169	309	94	211	268	158	136	—											

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	

Table 18. Series D. Catch of fin whale

Area / Square	II						III							VI			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1962/63																	
Dec.	—	—	—	—	—	—	—	16	42	340	172	57	14	21	—	—	—
Jan.	—	—	—	—	—	68	—	17	86	861	137	27	57	52	—	—	—
Feb.	—	—	—	—	61	140	—	—	98	698	7	15	127	17	—	—	—
Mar.	11	—	—	—	—	15	—	10	224	308	3	6	—	—	—	—	—
Apr.	8	2	—	—	—	—	—	3	—	—	—	7	9	11	—	—	—
T	19	2	—	—	61	223	—	46	450	2, 207	319	112	207	101	—	—	—
1963/64																	
Dec.	62	—	—	—	—	11	205	60	45	—	81	9	11	—	—	—	—
Jan.	129	255	1	—	—	136	16	—	—	—	151	82	23	6	—	—	—
Feb.	34	—	—	—	—	—	—	—	—	—	9	95	155	—	3	—	—
Mar.	83	23	—	—	—	—	—	—	4	—	22	42	59	18	—	—	—
Apr.	—	—	—	—	—	—	—	—	—	12	—	—	3	8	—	—	—
T	308	278	1	—	—	147	221	60	49	12	263	228	251	32	3	—	—
1964/65																	
Dec.	432	17	105	160	23	—	—	4	4	—	—	—	—	2	—	35	—
Jan.	184	76	25	24	—	147	67	7	—	—	—	—	—	—	17	180	142
Feb.	15	4	1	—	—	23	—	—	—	—	12	10	1	6	—	—	—
Mar.	12	5	1	—	2	—	111	93	29	—	—	—	—	5	12	—	15
Apr.	—	—	1	—	—	2	4	3	24	3	1	—	—	—	—	—	—
T	643	102	133	184	25	172	182	107	57	3	13	10	1	13	29	215	157
1965/66																	
Dec.	7	1	1	9	7	4	48	—	—	—	—	—	—	—	—	—	—
Jan.	46	6	5	—	—	—	43	20	60	—	—	—	—	—	—	—	—
Feb.	—	1	3	6	20	8	104	5	—	—	—	—	—	—	—	—	—
Mar.	—	2	—	—	4	4	5	10	137	152	14	—	—	—	—	—	—
Apr.	—	—	—	—	—	—	—	—	73	—	—	—	—	—	—	—	—
T	53	10	9	15	31	16	200	35	270	152·	14	—	—	—	—	—	—
1966/67																	
Dec.	4	5	—	—	—	—	—	1	7	38	—	—	—	7	5	—	—
Jan.	—	—	1	—	3	9	8	104	3	—	22	2		21	—	—	—
Feb.	—	—	—	—	—	—	—	171	156	400	9	1		2	—	—	—
Mar.	—	—	—	—	—	—	—	—	26	92	23	—		—	—	—	—
Apr.	—	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—
T	4	5	1	—	3	9	8	276	192	530	54	3		30	5	—	—
1967/68																	
Dec.	—	—	—	—	—	4	2	4	8	18	127	21	—	—	—	—	—
Jan.	—	—	—	—	—	—	—	—	—	—	63	25	22	17	8	—	—
Feb	—	—	—	—	—	31	—	—	—	—	10	83	—	33	28	—	—
Mar.	—	—	—	—	—	—	—	—	3	7	5	97	—	—	—	—	—
Apr.	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
T	—	—	—	—	—	35	2	4	12	25	205	226	22	50	36	—	—
1968/69																	
Dec.							3	—	—	—	—	1	14	88	11	—	—
Jan.							—	2	—	—	—	—	18	41	—	—	—
Feb.							—	—	—	—	20	194	167	31	—	—	—
Mar.							—	—	—	—	6	7	35	130	21	—	—
Apr.							—	—	—	—	—	—	—	—	—	—	—
T							3	2	—	—	26	202	234	290	32	—	—
1969/70																	
Dec.	1	2	4	—	—	5	2	15	—	—	—	6	—	12	5	—	—
Jan.	2	—	—	3	2	13	8	67	28	64	207	17	48	3	—	2	1
Feb.	—	—	—	—	—	—	—	—	66	268	231	246	42	16	—	—	—
Mar.	—	—	—	—	—	—	—	—	49	53	29	50	30	23	—	—	—
T	3	2	4	3	2	18	10	82	143	385	467	319	120	54	5	2	1

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—																	
—	—	—	—	—	—	—	—											
—	—	—	—	—	4	—	—											
—	—	—	—	—	13	70	—											
—	—	—	—	—	38	118	5											
—	—	—	—	—	—	—	—											
—	—	—	—	—	55	188	5											
—	—	—	—	—	—	—	—						—	—	—	—	—	—
54	26	—	—	—	—	—	—						—	—	—	—	—	22
—	4	13	31	—	—	—	—						—	—	—	—	—	—
6	—	—	—	—	—	—	—						—	—	—	—	—	—
—	—	—	—	—	—	—	—						—	—	—	—	—	—
60	30	13	31	—	—	—	—						—	—	—	—	—	22
—	3	—	—	1	—	—	—											
—	—	—	—	—	1	2	—											
—	—	—	—	—	—	—	—											
—	—	—	17	—	—	—	—											
—	—	—	—	—	—	—	—											
—	3	—	17	1	1	2	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	2	—											
—	—	—	—	—	—	2	—											
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—	—	—	—	—	—	3	—											
—	—	—	—	—	—	42	9											
—	—	—	—	—	2	134	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	2	179	9											
6	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	6	—	—	—											
6	—	—	—	6	—	—	—											

Table 18. Continued.

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1970/71																	
Dec.	—	—	—	—	—	1	9	4	22	28	—	—	—	—	5	1	7
Jan.	1	—	—	—	—	—	—	—	—	—	18	171	85	150	68	15	—
Feb.	—	—	—	—	—	—	—	—	51	216	308	175	356	28	—	—	—
Mar.	—	3	—	—	—	—	—	—	—	135	82	19	5	2	—	—	—
Apr.	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	3	3	—	—	—	1	9	4	73	379	408	365	446	180	73	16	7
1971/72																	
Dec.	2	—	—	—	—	2	19	8	6	—	12	—	—	—	—	—	2
Jan.	—	—	—	—	—	—	—	—	15	52	75	37	25	18	19	14	17
Feb.	—	—	—	—	—	—	—	2	18	153	161	164	47	1	—	—	—
Mar.	2	7	—	—	—	—	—	—	46	33	71	61	46	52	38	2	1
Apr.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	4	7	—	—	—	2	19	10	85	238	319	262	118	71	57	16	20

		V						IV					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	21	8	8											
—	—	—	—	—	1	3	—											
—	—	—	—	—	22	11	8											
—	—	—	—	—	—	—	—											
—	—	1	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	7	3	—	7	2	—											
—	—	—	—	—	—	4	—											
—	—	8	3	—	7	6	—											

Table 19. Series D. Catch of sei whale

~~Table 18. Continued.~~

Area Square	II						III							IV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1962/63																	
Dec.	—	—	—	—	—	—	—	—	—	—	135	84	12	6	—	—	—
Jan.	—	—	—	—	—	7	—	1	5	16	56	20	19	130	—	—	—
Feb.	—	—	—	—	—	4	—	—	24	75	1	75	108	38	—	—	—
Mar.	53	—	—	—	—	—	1	—	165	79	138	40	—	—	—	—	—
Apr.	49	20	—	—	—	—	3	16	—	—	—	136	6	2	—	—	—
T	102	20	—	—	—	11	4	17	194	170	330	355	145	176	—	—	—
1963/64																	
Dec.	65	—	—	—	—	—	1	4	4	—	56	31	59	—	—	—	—
Jan.	310	19	2	—	—	32	5	—	—	—	412	287	47	39	—	—	—
Feb.	2	—	—	—	—	—	—	—	—	—	11	248	—	—	—	—	—
Mar.	13	2	—	—	—	—	—	—	6	2	16	65	6	135	—	—	—
Apr.	—	—	—	—	—	—	3	—	7	3	1	—	12	—	—	—	—
T	390	21	2	—	—	32	9	4	17	5	496	631	124	174	—	—	—
1964/65																	
Dec.	355	3	10	26	6	—	—	—	—	—	—	—	34	56	72	369	—
Jan.	2,667	1,223	54	22	—	66	78	7	—	—	—	—	—	—	32	384	54
Feb.	1,316	592	98	—	—	47	—	—	—	—	50	21	4	51	—	—	—
Mar.	97	298	157	17	3	—	6	25	12	—	—	—	—	25	15	26	56
Apr.	—	—	8	—	6	2	12	12	27	1	8	30	—	—	—	—	—
T	4,435	2,116	327	65	15	115	96	44	39	1	58	51	38	132	119	779	110
1965/66																	
Dec.	1,553	968	406	14	—	3	3	—	—	—	—	—	—	—	—	—	—
Jan.	942	2,664	1,237	53	—	—	53	33	78	—	—	—	—	—	—	—	—
Feb.	—	50	290	1,336	1,690	588	757	168	—	—	—	—	—	—	—	—	—
Mar.	—	52	21	—	1	9	200	376	562	25	242	—	—	—	—	—	—
Apr.	—	—	—	—	—	—	—	—	67	—	—	—	—	—	—	—	—
T	2,495	3,734	1,954	1,403	1,691	600	1,013	577	707	25	242	—	—	—	—	—	—
1966/67																	
Dec.	234	495	62	25	—	—	338	787	587	225	99	175	—	78	39	—	—
Jan.	—	—	68	241	74	237	298	364	109	5	712	601	180	375	34	—	—
Feb.	—	—	—	—	—	—	—	74	149	35	745	439	—	31	—	—	—
Mar.	—	—	—	—	—	—	—	—	—	17	551	307	—	—	—	—	—
Apr.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	234	495	130	266	74	237	636	1,225	845	282	2,107	1,522	180	484	73	—	—
1967/68																	
Dec.							—	36	2	75	162	226	4	109	728	—	—
Jan.							—	—	—	—	117	589	60	85	49	—	—
Feb.							—	—	—	—	142	628	15	73	165	—	—
Mar.							—	—	48	1	6	116	—	—	—	—	—
Apr.							—	1	18	—	—	—	—	—	—	—	—
T							—	37	68	76	427	1,559	79	267	942	—	—
1968/69																	
Dec.	—	—	—	—	—	187	227	105	—	—	—	22	235	186	484	—	—
Jan.	—	—	—	—	—	—	—	106	—	—	—	—	19	84	—	—	—
Feb.	—	—	—	—	—	—	—	—	—	—	172	508	35	—	—	—	—
Mar.	—	—	—	—	—	—	—	—	—	—	190	88	5	1	—	—	—
T	—	—	—	—	—	187	227	211	—	—	362	618	294	271	484	—	—
1969/70																	
Dec.	259	422	149	3	5	110	81	177	—	—	8	85	66	151	114	—	45
Jan.	142	52	45	2	5	84	180	205	272	26	31	33	194	—	11	375	216
Feb.	—	—	—	—	—	—	—	—	4	37	72	338	27	30	—	—	—
Mar.	—	—	—	—	—	—	—	—	—	1	40	115	5	2	—	—	—
T	401	474	194	5	10	194	261	382	276	64	151	571	292	183	125	375	261
1970/71																	
Dec.	—	—	—	—	—	—	60	76	37	104	—	—	—	—	107	632	1,173
Jan.	491	—	—	—	—	—	—	—	—	—	65	11	25	259	189	508	374
Feb.	61	—	—	—	—	—	—	—	3	72	46	207	157	14	—	—	—
Mar.	16	—	—	—	—	—	—	—	—	68	44	76	13	16	—	—	—
Apr.	13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	581	—	—	—	—	—	60	76	40	244	155	294	195	289	296	1,140	1,547

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
—	—																	
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—	—	—	—	—	—	—	—											
—	—	—	5	99	5	—	—											
—	—	—	—	73	63	14	—											
—	—	—	—	—	39	89	6											
—	—	—	—	—	—	—	—											
—	—	—	5	172	107	103	6											
—	—	—	—	—	—	—	—						—	—	—	—	—	—
125	57	—	1	—	—	—	—						—	—	—	—	—	5
—	15	132	379	—	—	—	—						—	—	—	—	—	—
31	—	—	—	—	—	—	—						—	—	—	—	—	—
—	—	—	—	—	—	—	—						—	—	—	—	—	—
156	72	132	380	—	—	—	—						—	—	—	—	—	5
77	68	23	6	—	—	—	—											
—	—	—	—	—	3	—	—											
—	—	—	—	—	—	—	—											
—	—	—	104	—	—	—	—											
—	—	—	—	—	—	—	—											
77	68	23	110	—	3	—	—											
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—	—	—	—	—	—	24	—											
—	—	—	—	—	—	24	—											
1	—	—	—	—	288	30	98	52	—	—	—	—						
—	—	5	212	389	203	—	249	162	—	—	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
—	—	—	—	—	—	56	151	1	—	—	—	—						
—	—	—	—	—	—	—	—	—	—	—	—	—						
1	—	5	212	389	491	86	498	215	—	—	—	—						
—	—	—	—	74	838	—	—	—	—	—	—	—						
—	—	—	—	42	318	28	113	5	—	—	—	—						
—	—	—	—	—	—	5	26	—	1	—	—	—						
—	—	—	—	—	12	62	—	—	—	—	—	—						
—	—	—	—	116	1,168	95	139	5	1	—	—	—						
748	—	—	—	—	—	—	—											
110	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	7	—	—	—	—											
858	—	—	7	—	—	—	—											
569	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	—	—	—											
—	—	—	—	—	44	66	23											
—	—	—	—	—	4	21	—											
569	—	—	—	—	48	87	23											

~~Table 19. Series D. Catch of sei whale~~

Area	II						III							IV			
Square	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1971/72																	
Dec.	77	—	—	—	—	24	219	36	57	—	15	—	—	—	—	—	297
Jan.	27	—	—	—	—	—	—	—	50	46	10	59	166	78	206	727	94
Feb.	—	—	—	—	3	—	—	—	—	5	32	203	210	31	—	—	—
Mar.	44	47	—	—	—	—	—	—	1	2	12	13	11	5	—	6	8
Apr.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T	148	47	—	—	3	24	219	36	108	53	69	275	387	114	206	733	399

		V						VI					I					
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	0
301	716	—	—	528	78	—	—											
20	87	24	476	16	—	—	—											
—	—	—	—	—	—	—	—											
—	2	23	109	22	74	6	—											
—	—	—	—	—	—	28	—											
321	805	47	585	566	152	34	—											

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RESULTS OF WHALE SIGHTING BY CHIYODA MARU NO. 5 IN THE PACIFIC SECTOR OF THE ANTARCTIC AND TASMAN SEA IN THE 1966/67 SEASON

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ABSTRACT

This report is the results on a survey of the whale stock and whaling grounds in the Southern Ocean by Chiyoda Maru No. 5 in co-operation by three Japanese Whaling Companies. The survey consisted of three main items, whale observation by eye, meteorological and oceanographical observation, and whale marking. During the survey, 5 blue whales, 22 fin whales, 4 humpback whales, 1,137 sei whales, and 481 sperm whales making a total of 1,469 larger whales were sighted.

According to discussion on the distribution of sei whale, the distribution density was highest in the Tasman Sea, 101 encounters and 864 count recorded, of which an encounter and a number of whale sighted per 100 sea miles were 0.47 and 28.61, respectively.

The distribution density of sperm whale was highest to the east of New Zealand, and the north of 50°S in latitude. That is, an encounter and a number of whale per 100 sea miles were 0.99 and 8.61, respectively.

INTRODUCTION

A survey of the larger whale stock and whaling grounds in the south of Australia, the Tasman Sea, and the Antarctic and Subantarctic Pacific area was carried out by Chiyoda Maru No. 5 in co-operation by three firms, Nippon Suisan, Taiyo Gyogyo, Kyokuyo Co. Ltd.

The survey ship left Osaka on 19th November 1966 and the survey commenced after leaving Fremantle on 7th December. After completion of the first half of the survey the ship called in Wellington for supplementary supplies and to pick up Dr. Gaskin. The survey was carried out from 7th December to 21st March with a duration of 103 days.

The survey carried out under the following headings:

1. Whale observation and count and other by eye.
2. Meteorological observations.
3. Oceanographic observation by bathythermograph
4. Whale marking.

The survey carried out mostly north of 50°S lat. in Antarctic Whaling Area IV(70°E to 130°E), V(130°E to 170°W), and VI(170°W to 120°W). The survey east of 170°W longitude however, was carried out mainly in areas between 52°–62°S latitudes.

Survey course.

Fig. 1 shows the number of each species of larger whale sighted. The survey area, based on meteorological and oceanographic conditions was divided into areas A (west of 150°E, south of Australia), B (Tasman Sea), C (north of 50°S east of New Zealand). and D (south of 50°S east of New Zealand) to facilitate processing of the data.

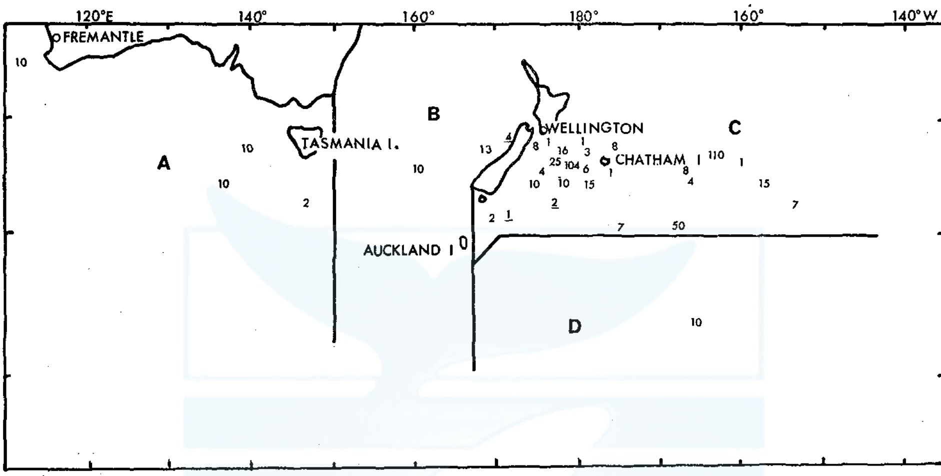

Fig. 1-a. Sightings of the larger whales by Chiyoda Maru No. 5 in 1966/67. Number without the underline shows the sei whale. Single underline shows the fin whales. Double underline shows the humpback whales.

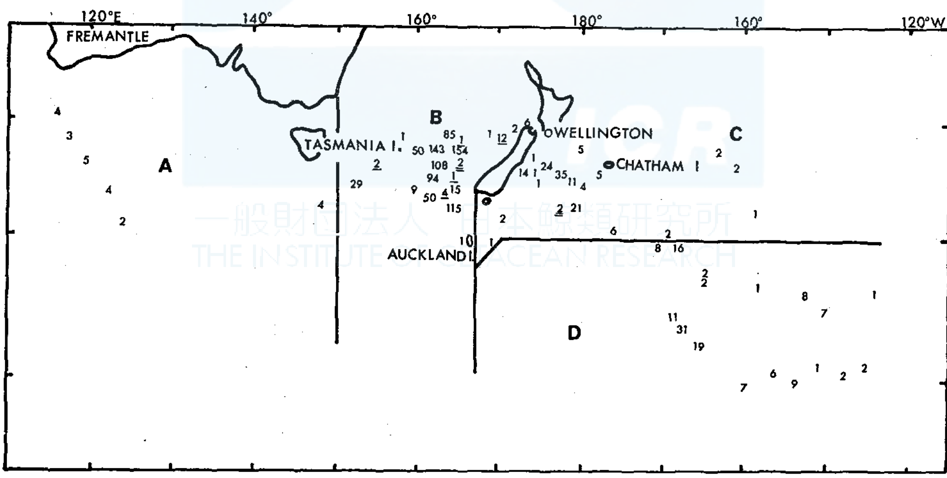

Fig. 1-b. Sightings of the larger whales by Chiyoda Maru No. 5 in 1966/67. Number without the underline shows the sperm whales. Underline shows the blue whales.

As in Fig. 1, on leaving Fremantle, at the initiation of the survey on 7th December from 34°39′S, 113°24′E the survey commenced southeast to the southernmost point of 52°40′S 128°38′E, then changed to a northeasterly course. On 20th December the survey was carried out in the vicinity of Tasmania I.. After sailing souththe ship again sailed from approximately 158°E the ship followed the 41°S latitude line.

From 30–31st December the ship made an emergency call in to Tasmania Bay on the South Island of New Zealand for emergency repairs. After completion of repairs the ship sailed west along the 42°S latitude and the area surveyed to approximately 160°E. The survey then carried out a large zigzag course towards the south to Auckland Island. From Auckland Island the ship sailed north almost parallel to the South Island of New Zealand.

After confirmation of the Antarctic Convergence the ship sailed west along 50°–60°S latitude, making the point 60°S, 160°W the southernmost point of this survey. From 170°W longitude by sailing along 47°S latitude the ship approached the South Island of New Zealand. The ship sailed north along the east coast of this island and at 18: 00 of 21st March brought the survey to a close.

SURVEY METHOD AND RECORDS

Observation by eye started before sunrise when it became sufficiently light to sight the whales and continued until darkness made it impossible. The observation post was built on the upper bridge and each watch team consisted always of 4–5 persons. Each of the watchmen were experienced and good observers.

The watch was cancelled as a rule when the Beaufort scale of wind was above 10 and visibility was less than 0.5 miles. Moreover in areas where the distributin potential was considered low from the data obtained on the survey during the day, navigation continued for the night in an endeavour to increase the survey area. For the period of the survey the effective survey time was approximately 1,356 hours (south of 40°S lat. approximately 1,315 hours).

Similarly the effective survey distance was 13,055 mls (south of 40°S lat. 12,646 mls). The distance from the upper bridge to the water line of the Chiyoda Maru No. 5 was approximately 9 meters and the estimated distance to the horizon from the formula

$$R=2.07\sqrt{H}$$

was calculated to be 6.2 miles. Where R (sea mile) is the effective distance, and H (meter) is the height from the water line to the observer.

Using the six miles effective visible distance of Mackintosh and Brown (1956) the average visible field during the survey was 6.6 sea miles and the total area covered was calculated to approximately 162,000 square sea miles.

In observation telescopes were used and the officer on duty and the quatermaster on the bridge in addition to navigation duties kept lookout. So in reality 6–7 persons were engaged in sighting whales.

In determining the species of the whale the ship was brought as close to the whale as to enable the confirmation of the species.

In this survey, in area such as the Tasman Sea (Area B) where very high distribution density of whales was found, to avoid overestimation of numbers in group of 20–30 whales and above, the count was made so as to count down the number in the group. Moreover because of the limited survey time allotted for this area it cannot be said that a sufficient survey was carried out. It is therefore to take these points into account in the analysis of the whale count in this area.

The estimation of the distance to sighted whale was carried out in almost every instance. The estimation of distances was done by experienced observers and the results of tests made in estimating distance to icebergs were of sufficient accuracy to be used as data.

Observations in this survey were made not only on larger species of whales but also on smaller species of whales, fishes, sea birds and discoloured water.

DISCUSSION ON THE WHALE SIGHTING

Table 1 shows the number of different species of larger whales spotted in various areas, the survey distance in sea miles, the wind force (Beaufort scale) and average visibility. The survey distance excludes the distance covered by runs made during nights and when bad weather made sighting impossible.

The number of whales sighted according to species were blue whale 5, fin whale 22, humpback whale 4, sei whale 1,137 (includes 4 animals sighted north of 40°S) and sperm whale 481 making a total of 1,649 whales sighted. As stated previously the estimated count of sei whales especially in Area B was count down. Moreover because of lack of data on the quantitative distribution of blue whale, fin whale and humpback whale were not taken into consideration and reports made on sei and sperm whales.

As the survey distance covered 100–150 mls/day in establishing a criterion for expressing distribution density the number of whales sighted and the numbers of encounters made per 100 miles was made.

Sei Whale

The number of encounters made was highest in Area B, 101 encounters and 864 whales count recorded. These figures were respectively 49.8% and 75.9% of the totals. In this area encounters were made at the rate of 3.29 encounters/100 mls. which exceeds the rate of encounter in Area D where 59 encounters were made at the rate of 2.26 encounters/100 mls. The distribution density per 100 mls. in Area D averaged 5.08 and was only 18% of that of Area B (28.61 whales).

As Table 1 obviates the distribution density and number of sei whales in Area B as compared to those of other areas are extremely large. In this survey the number of encounters and the distribution density showed minimum values in Area 12 encounters 0.47 encounters 100 mls. (22 whales, 0.87 whales/100 mls.). The fact that the area was surveyed at the start of the whaling season (7th Dec.—22nd Dec.)

TABLE 1-a. NUMBER OF LARGER WHALES SIGHTED AND ENCOUNTER BY SPECIES AND AREA

Term	Area	Hour on watch (h, m)	Dist. on watch	Wind force	Vis.	Whales species B	F	S	H	Sp.	Total
7, XII '66 22, XII '66	A	235 11	2,540	5.3	6.7	0 (0)	0 (0)	22 (12)	0 (0)	32 (5)	54 (17)
23, XII '66 13, I '67	B	309 11	3,068	4.7	7.2	4 (2)	20 (6)	864 (101)	2 (1)	23 (5)	913 (115)
14, I '67* 21, III '77	C	519 15	4,834	5.1	6.4	1 (1)	2 (1)	118 (51)	2 (1)	416 (48)	539 (102)
13, II '67 9, III '67	D	292 00	2,613	5.9	6.1	0 (0)	0 (0)	133 (59)	0 (0)	10 (2)	143 (61)
Total		1,355 37	13,055	5.1	6.6	5 (3)	22 (7)	1,137 (223)	4 (2)	481 (60)	1,649 (295)

* excepted the following term: 13, II '67 to 9, III '67.

TABLE 1-b. NUMBER OF SEI AND SPERM WHALES SIGHTED, AND FREQUENCY OF ENCOUNTER PER 100 SEA MILES

Term	Area	Number of whales/100′ Sei	Sperm	Frequency of encounter/100′ Sei	Sperm
7, XII '66 22, XII '66	A	0.87	1.26	0.47	0.20
23, XII '66 13, I '67	B	28.61	0.75	3.29	0.16
14, I '67* 21, III '67	C	2.44	8.61	1.06	0.99
13, II '67 9, III '67	D	5.08	0.38	2.26	0.08
Total		8.71	3.68	1.71	0.46

and the fact that the survey was carried out simply should be taken into consideration.

Meteorological conditions (wind, visibility etc.) can be taken up as being important factors in sighting of whales. As can be seen from Table 1, this survey in Area B was carried out under favourable meteorological conditions. However in relation to number and distribution density even by taking into account the favourable meteorological condition the figures of Area B, compared to those of other are as can be thought of as reflection conditions close to actual ones.

In the latter half of Area C (10th Mar.—21st Mar.) and Area D it is necessary to take into consideration the unfavourable sighting brought about by bad weather. With the results obtained in the survey of the latter half of Area C and Area D, it is therefore necessary to take into consideration the lowering of sighting capacity caused by unfavourable meteorological conditions.

Table 2-a) classifies the number of larger whales according to the different area of sighting and the number of whales according to the distance from the ship at sighting. Table 2-b) classifies the sei whale in the same way. Table 3 classifies the number of sei whale according to the distance from the ship when first sighted.

Mackintosh and Brown (1956) estimated the number of whales sighted within one mile of the ship as 80–90% of the acutal number. However this value should vary according to the observation structure, that is, the number of persons on watch and their sighting capacity etc. For the instance with the Chiyoda Maru No. 5 the heighest frequency of sighting to be at the 2–3 mile distance. As a rule 80–90% of the actual figures were considered sighted at this range. So the 384 whales sighted with the 3–4 miles range corresponds to 80% of the 480 whales and 90% of 427 whales. From this by homonizing the distribution density within a six miles radius

TABLE 2-a. ESTIMATES OF THE DISTANCES AT WHICH SIGHTINGS WERE MADE OF THE LARGER WHALE SPECIES

Area	Distance (sea miles)														Total
	1 >	1	1–2	2	2–3	3	3–4	4	4–5	5	5–6	6	6–7	7	
A	3	2	0	4	1	3	0	1	1	2	0	0	0	0	17
B	3	4	6	24	6	29	1	14	0	9	1	5	0	1	103
C	5	14	4	27	10	24	3	7	0	2	0	0	0	0	96
D	3	6	2	22	7	9	1	7	0	1	0	0	0	0	58
Tatal	14	26	12	77	24	65	5	29	1	14	1	5	0	1	274

TABLE 2-b. ESTIMATES OF THE DISTANCES AT WHICH SIGHTINGS WERE MADE OF THE SEI WHALE

Area	Distance (sea miles)														Total
	1 >	1	1–2	2	2–3	3	3–4	4	4–5	5	5–6	6	6–7	7	
A	2	1	0	3	1	1	0	1	1	2	0	0	0	0	12
B	3	4	4	20	6	28	0	11	0	7	1	4	0	0	88
C	3	7	1	17	5	13	0	4	0	1	0	0	0	0	51
D	3	6	2	20	8	8	1	7	0	1	0	0	0	0	56
Total	11	18	7	60	20	50	1	23	1	11	1	4	0	0	207

TABLE 3. NUMBER OF SEI WHALES SIGHTED BY ESTIMATES DISTANCE FROM THE BOAT TO WHALE

Area	Distance (sea miles)												Total
	1 >	1	1–2	2	2–3	3	3–4	4	4–5	5	5–6	6	
A	2	1	0	6	3	2	0	1	3	4	0	0	22
B	4	6	9	89	17	282	0	272	0	151	16	15	861
C	3	9	1	53	11	26	0	7	0	8	0	0	118
D	3	8	2	32	25	18	3	33	0	9	0	0	133
Total	12	24	12	180	56	328	3	313	3	172	16	15	1,134*

* excluding the whales which were not estimated the distance.

with ship as center the total number of whales within the survey range can be estimated (enlarged on later).

Furthermore Area D and the latter half of Area C the survey was carried out under extremely disadvantageous meteorological conditions. As a result, in using the data obtained in this survey to estimated the whale population in area it is necessary to take into consideration these conditions.

A comparison of the data by Chiyoda Maru No. 5 with data (nos. of sei whales sighted/100 mls.) taken by survey ships of Japanese whaling expeditions during the same year is shown in the Table 4.

As can be seen from this data the distribution density is highest in the Tasman Sea where in the past no large scale whaling was carried out.

TABLE 4. NUMBER OF SEI WHALES SIGHTED PER 100 SEA MILES TAKEN BY SURVEY SHIPS OF JAPANESE WHALING EXPEDITIONS AND CHIYODA MARU NO. 5 IN 1966/67

	Antarctic Whaling Area							Total
	I	II W	II E	III	IV	V	VI	
Survey ship of Whaling Exp.	4.32	0.45	2.46	5.71	4.41	—	—	5.57
Chiyoda Maru No. 5	—	—	—	—	1.40	12.21	3.54	8.68

Following, as already stated by Mackintosh and Brown (1956)

$$N=\frac{n\,A}{a\,P}$$

where N=estimated number of whales n=nos. of whales sighted
a=area survey P=sighting ratio

Accordingly, for the whole survey course because the average visual field was 6.3 miles the effective visual field was considered to be 6.0 mls. From the number of whales within the survey area south of 40°S latitude was estimated.

According to the data of the Chiyoda Maru No. 5 the sighting ratio (P) was calculated to be 39.5% (presupposing that 80% sighted within 2–3 mls. range) and 44.4% (presupposing 90% sighted within 2–3 miles range).

After that, Doi (1971) improved the sighting theory on whale and calculated the real rate of sighting P by species, the values of which were 0.112–0.221.

Sperm whale

The number of whales sighted and the number of encounters made were respectively 418 whales, 60 encounters and in comparison to sei whale their numbers are few.

In Area D south of 50°S latitude the numbers are fewest, the number of encounters made per 100 miles was 0.08 encounters and the number of whales per 100 miles was 0.38 whales. In Area C the maximum value of 48 encounters (0.99

encounters/mls.) was obtained. These values were respectively 86.5%, 80.0% of the totals.

The fact that 10 cases of whales swimming alone and 4 cases groups of more than 40 whales were sighted, was characteristic of this area. Special mention is made of the sighting of a group of about 50 whales which contained a few baby of estimated length of 4 meters on 17 March at position 44°28'S, 170°35'W.

MARKING SURVEY

Marking survey was carried out in Areas C and D. The results were as follows.

Species	H	HP	PH	R	M	Total	Rate of hit	Effective marked whale
Sei	5	0	4	0	10	19	26.3%	4
Sperm	25	1	0	3	22	51	49.0	24
Total	30	1	4	3	32	70	42.9	28

H : Hit, HP : Hit protruding, PH : Possible hit,
R : Ricochet, M : Miss.

SUMMARY

1) The results on a survey of the whale stock and whaling ground by Chiyoda Maru No. 5 in co-operation by three firms, Nihon Suisan, Taiyo Gyogyo, and Kyokuyo Co. Ltd. were described.

2) The survey area was covered from the south of Australia to the Subantarctic and Antarctic Pacific area, and was calculated to approximately 162,000 square sea miles.

3) The number of larger whale sighted were 5 blue whales, 22 fin whales, 4 humpback whales, 1,137 sei whales (include 4 animals sighted to the north of 40°S latitude) and 481 sperm whales making a total of 1,649 whales sighted.

4) A discussion on the distribution density which showed the number of whale sighted per 100 miles was made for sei and sperm whale.

The distribution density of sei and sperm whale according to area as follows:

Area	whale species			
	sei		sperm	
	distribution density	nos. of whale sighted	distribution density	nos. of whale sighted
A (south of Australia)	0.87	22	0.47	32
B (Tasman Sea)	28.61	864	3.29	23
C (east of New Zealand, north of 50°S)	2.44	118	1.06	416
D (east of New Zealand, south of 50°S)	5.08	133	2.26	10
Total	8.71	1,137	1.71	481

5) The numbers of effective marked whale were 4 sei whales and 24 sperm whales, respectively.

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APPENDIX NUMBERS OF LARGER WHALES AND SIGHTINGS

Date	Noon Position		Hours on watch (h, m)	Dist. on watch (sea miles)	Wind force	Visibility (sea miles)	Species of whales Blue	Fin	Sei	Hump.	Sperm	Total
AREA A												
7, Dec. '67	34°39′ S	113°24′ E	08 35	91	3	8					10(2)	10(2)
8	36°44′ S	114°00′ E	15 23	155	5	8						
9	39°15′ S	116°03′ E	16 25	163	5	8			4(2)			4(2)
10	41°22′ S	117°34′ E	16 13	157	5	8			3(1)			3(1)
11	43°45′ S	119°40′ E	17 25	175	5	8			5(3)			5(3)
12	46°16′ S	122°02′ E	15 40	163	6	8			4(2)			4(2)
13	48°56′ S	124°04′ E	16 00	165	7	7			2(2)			2(2)
14	52°02′ S	127°02′ E	15 40	173	6	8						
15	51°20′ S	130°01′ E	16 30	182	4	7						
16	49°04′ S	133°59′ E	15 35	175	6	8						
17	46°01′ S	136°38′ E	14 50	148	7	7					10(1)	10(1)
18	42°52′ S	139°48′ E	15 05	168	6	6					10(1)	10(1)
19	41°02′ S	142°42′ E	14 50	157	7	8						
20	42°29′ S	143°15′ E	14 50	139	6	8						
21	44°47′ S	147°00′ E	15 15	175	8	6						
22	47°19′ S	148°00′ E	15 30	154	5	8			4(2)		2(1)	6(3)
Total			235 11	2540					22(12)		32(5)	54(17)
AREA B												
23	47°49′ S	150°57′ E	15 55	161	0	0						
24	45°05′ S	152°46′ E	15 30	160	0	8			29(7)			29(7)
25	44°14′ S	151°40′ E	15 20	76	7	4						
26	43°13′ S	154°07′ E	14 45	160	7	8		2(1)				2(1)
27	41°03′ S	158°25′ E	15 05	178	7	8			1			1
28	40°56′ S	163°43′ E	14 50	151	7	8			85(5)			85(5)
29	40°52′ S	168°24′ E	14 55	158	3	8			1			1
30	Tasman Bay		05 30	58	—	—			6(3)			6(3)
31	Tasman Bay		03 20	37	—	—			2(2)			2(2)

1, Jan. '67	40°34′ S	171°44′ E	15	25	147	6	8	4(2)	12(1)	1			17(3)
2	41°59′ S	168°26′ E	15	40	172	2	8			154(3)		13(2)	167(5)
3	42°04′ S	164°38′ E	15	25	167	3	8		1	143(15)	2(1)		146(17)
4	41°57′ S	161°46′ E	14	55	156	5	8			50(5)			50(5)
5	42°01′ S	160°03′ E	15	25	144	6	8			108(4)			108(4)
6	43°41′ S	162°26′ E	15	10	134	6	8						
7	44°34′ S	164°51′ E	13	15	91	6	8		1				1
8	46°00′ S	164°31′ E	15	40	158	4	7		4(2)	15(4)			19(6)
9	44°46′ S	161°37′ E	15	30	159	2	8			94(21)		10(3)	104(24)
10	45°59′ S	159°54′ E	10	04	97	8	6			9(4)			9(4)
11	46°26′ S	161°15′ E	15	40	168	5	8			50(13)			50(13)
12	46°26′ S	164°30′ E	16	10	170	3	8			115(11)			115(11)
13	50°25′ S	165°53′ E	15	35	166	6	6			1			1
Total			309	11	3068			4(2)	20(6)	864(101)	2(1)	23(5)	913(115)
AREA C													
14, Jan. '67	50°23′ S	169°18′ E	15	40	132	5	4			1			1
15	48°09′ S	170°41′ E	15	40	140	5	3			2(2)		2(2)	4(4)
16	46°18′ S	173°28′ E	15	10	158	5	3	1					1
17	44°41′ S	174°42′ E	15	20	159	6	6			1		10(5)	11(6)
18	45°54′ S	176°30′ E	—		—	7	6						
19	44°59′ S	178°54′ E	15	20	128	4	8			11(2)		10(1)	21(3)
20	44°15′ S	178°01′W	15	25	161	2	8			5(3)		6(2)	11(5)
21	42°38′ S	179°49′W	15	10	136	1	8					3(1)	3(1)
22	42°50′ S	178°06′W	14	50	136	5	8					16(2)	16(2)
23	Wellington		—		—	—	—						
24	Wellington		—		—	—	—						
25	43°32′ S	177°30′W	14	10	152	7	6						
26	45°29′ S	179°49′W	15	20	180	8	7			4(1)		1	5(2)
27	44°28′ S	175°34′W	14	40	148	3	8					15(4)	15(4)
28	46°33′ S	171°12′W	14	35	148	6	8						
29	47°38′ S	166°45′W	14	50	143	3	8					8(2)	8(2)

Continued . . .

Date	Noon Position		Hours on watch (h, m)		Dist. on watch (sea miles)	Wind force	Visibility (sea miles)	Species of whales					
								Blue	Fin	Sei	Hump.	Sperm	Total
30, Jan. '67	42°08′ S	163°15′W	14	30	141	5	8			2(2)		110(2)	112(4)
31	43°52′ S	160°32′W	14	40	131	2	8			2(1)		1	3(2)
1, Feb. '67	45°42′ S	157°33′W	14	40	146	5	8					15(5)	15(5)
2	47°23′ S	158°38′W	14	40	139	3	8					7(2)	7(2)
3	47°34′ S	158°54′W	14	35	143	6	6			1			1
4	47°02′ S	163°40′W	14	10	92	8	4						
5	46°09′ S	166°07′W	14	50	99	4	8					4(1)	4(4)
6	44°01′ S	170°47′W	12	30	144	8	2						
7	42°16′ S	175°24′W	14	40	117	6	8					8(3)	8(3)
8	41°52′ S	179°52′ E	14	30	150	2	8			5(3)		1	6(4)
9	41°31′ S	174°59′ E	06	35	65	5	8					1	1
10	43°53′ S	176°35′ E	14	10	143	5	8		2(1)	4(2)		4(2)	10(5)
11	47°19′ S	179°22′ E	14	10	146	3	8			21(4)	2(1)		23(5)
12	49°23′ S	176°13′W	14	05	149	6	7			6(5)		7(1)	13(6)
Total			388	55	3726			1	2(1)	65(28)	2(1)	229(39)	299(70)
AREA D													
13, Feb. '67	51°23′ S	170°56′W	14	25	143	7	2			8(4)			8(4)
14	52°30′ S	165°00′W	14	40	147	8	7			2(2)			2(2)
15	53°15′ S	158°30′W	14	35	140	8	7			1			1
16	53°58′ S	152°39′W	14	05	140	4	8			8(5)			8(5)
17	54°56′ S	150°30′W	08	30	80	6	0.3			7(3)			7(3)
18	53°45′ S	144°48′W	07	40	78	11	5			1			1
19	53°05′ S	140°46′W	13	45	144	8	6						
20	54°53′ S	140°19′W	14	00	130	6	6						
21	55°54′ S	141°32′W	—		—	12	2						
22	57°05′ S	142°36′W	14	05	127	6	8						
23	58°43′ S	145°28′W	07	00	42	8	4			2(2)			2(2)
24	59°09′ S	147°45′W	14	40	109	4	7			2(2)			2(2)

Continued. . .

25	58°41′ S	151°09′W	12	20	109	2	7	1		1
26	59°48′ S	153°49′W	14	50	99	7	8	9(4)		9(4)
27	59°15′ S	156°24′W	14	30	129	6	7	6(4)		6(4)
28	59°39′ S	160°02′W	14	30	135	5	8	7(5)		7(7)
1, Mar. '67	59°55′ S	161°16′W	—		—	9	1			
2	58°53′ S	162°22′W	13	55	127	7	7			
3	57°17′ S	165°06′W	13	50	122	3	8	19(6)		19(6)
4	56°38′ S	167°03′W	14	00	122	4	8	31(6)	10(2)	41(8)
5	55°24′ S	168°17′W	12	55	123	5	8	11(5)		11(5)
6	54°03′ S	165°03′W	11	50	100	7	8			
7	52°38′ S	164°54′W	13	15	102	7	7	2(1)		2(1)
8	51°16′ S	166°47′W	05	15	48	6	6			
9	50°24′ S	168°17′W	13	25	117	5	7	16(7)		16(7)
Total			292	00	2613			133(59)	10(2)	143(61)
AREA E										
10, Mar. '67	49°19′ S	169°19′W	12	50	117	7	5	2(1)	50(1)	52(2)
11	46°54′ S	169°34′W	12	15	105	6	5			
12	46°48′ S	171°49′W	08	35	35	8	6			
13	46°43′ S	175°05′W	13	05	111	8	3			
14	46°45′ S	176°36′W	05	55	36	7	7			
15	46°54′ S	176°37′W	04	20	45	9	6			
16	46°56′ S	179°13′W	12	15	109	8	6			
17	44°31′ S	179°47′ E	12	25	107	6	7		104(4)	104(4)
18	44°33′ S	177°24′ E	12	45	102	3	8	35(13)	25(2)	60(15)
19	44°42′ S	174°39′ E	12	20	105	6	5	1		1
20	44°06′ S	172°35′ E	12	05	118	5	6	14(7)		14(7)
21	42°50′ S	173°43′ E	11	30	118	5	7	1	8(2)	9(3)
Total			132	20	1108			53(23)	187(9)	240(32)

* Where more than one animal was seen at a time, the number of sightings is given within brackets.

FOOD AND FEEDING OF SEI WHALE CAUGHT IN THE WATERS SOUTH OF 40°N IN THE NORTH PACIFIC

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ABSTRACT

Results on the food and feeding conditions of sei whales caught by Japanese whaling fleets in the waters south of 40°N of the North Pacific during the 1972 season were preliminary reported. In the region south of 40°N the whaling ground was mainly found only in the limited sea area: in the environs of the southern tip of the Emperor Seamount Chain, although the fleets were in search of whaling ground between 165°E and 165°W. The feeding conditions of sei whales in those regions in terms of feeding percentages did not differ so much when compared with those have been found in the northern regions (1967–1971), *i.e.*, 34.4% in the south of 40°N while 55.1% in 40°–50°N zone, and 50.2% between 50°N and Aleutian Islands. Most of sei whales in the south of 40°N fed exclusively on a copepod, *Calanus pacificus* along with several species of euphausiids and fishes. In view of the frequency of occurrence, *Calanus pacificus* population being consisted of copepodites IV and V, young fishes of Japanese mackerel, *Scomber japonicus* and Japanese sardine, *Sardinops melanosticta* were the most important foodstuff. By examining prey organisms of these food fishes, it was found that most of them fed solely on *C. pacificus* or on a mixture of *C. pacificus* with *C. plumchrus* or with *Eucalanus bungii bungii*. The whaling ground found in the south of 40°N can be interpreted hydrobiologically as having been formed primarily by the rich mass occurrence of *C. pacificus* by the aid of intrusion of migrating populations of young fishes which were presumably in search of foods. In this connection it was strongly suggested that two heterotypical communities of food organisms are distinguished (see Figs. 4 and 6), and the whaling ground is divided by such ecological discontinuity which runs along the Emperor Seamount Chain. This ecological discontinuity would possibly be correlated hydrologically with the East Kamchatka Current Extension on which Uda (1971) has pointed out its importance in relation to the formation of fishing ground in the region.

INTRODUCTION

Japanese pelagic whaling in the North Pacific Ocean have been restricted its operation area with the lines of 40°N or 45°N latitudes as its southern most limit by the measures of Japanese Government in addition to the regulation by the IWC's arrangements on the whole. It was, however, decided to lift the ban to some extent in 1972 and by this decision the sea region down to 20°N was newly opened chiefly

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in the zone of central Pacific between 159°E and 150°W (see Ohsumi, 1973).

Since the beginning of Japanese whaling operation in the North Pacific in 1952 the main whaling grounds have been restricted almost in the northern North Pacific and Bering Sea (Nasu, 1966), and consequently our knowledge on the food of baleen whales was also biassed (Nemoto, 1957, 1959). Under these circumstances little is known on the food and feeding conditions of baleen whales in the southern sea regions above mentioned. The whaling ground south of 40°N may be one of the least studied regions in the North Pacific possibly due to its geographical position, the south of the Subarctic front. By knowing the opening of new whaling region, some biological investigations including a collection of foodstuff of whales were established. During the whaling season of 1972 Japanese fleets entered into those newly opened region including 40°N chiefly in July and caught 884 sei, 5 bryde's and 8 fin whales from which I got some amount of food samples. The results of examination and analysis on the food and feeding conditions of sei whales are reported.

MATERIALS

Among many biological examinations on each whale carcases, kind of food organisms, an approximate amount and freshness of foodstuff in the first stomach were examined by eyes on the ship's deck. A total of 34 food samples was also collected from the whales caught in the south of 40°N and they were preserved in formalin. Methods of observation and description on food organisms and feeding conditions in the field were not different from those having been undertaken in the Antarctic (see Kawamura, 1970). Since many food fishes occurred were consisted of the well known species in the North Pacific region, they were remarked by the common name in addition to the records by ordinary classification of " Fish " by the observers. Euphausiids are usually expressed as " Eu " by the three different sizes among which *Sergestes similis*, a macruran shrimp, is also included by confusion. They are, however, reasonably distinguished by the size record of " Large " since there are no such euphausiids as equivalent to this category in the North Pacific region (Omori *et al*, 1972). Although the number of collected samples was slightly few against the number of whales, it was possible to estimate the kind of food organisms of each animals by refering both to the results of identification on collected samples and catch records.

WHALING GROUND SOUTH OF 40°N IN THE NORTH PACIFIC OCEAN

Many whaling grounds which have been developed and exploited in the world are located chiefly, if not entirely, in the higher latitudes of the seas most of which show a distinct fertility in standing crops of zooplankters and other organisms during warm season. These whaling grounds are undoubtedly some peculiar regions formed through productive food chains such they usually called as feeding ground. The northern North Pacific and Bering Sea where many whalers have been in chase of whales do not differ from the others in its basal formation. From this point of view pelagic whaling operations by the Japanese fleets since 1952 in the northern North

Pacific between 50°N and 60°N must be quite natural as well as the case of many other fisheries in that region. Much accumulations of whales are usually expected in these seas during warm season.

Baleen whales, however, are distinct migrator that move between warm and cold seas by seasons with an approximately a year cycle, and such whale movements as a unit of whole population do not always proceeded continuously with any completion by season since they are considered to show somewhat variable stream like movements as its situation has been suggestively demonstrated by Mackintosh and Brown (1956), and Mackintosh (1965). It may possible that when the whales migrating in the head of a population will have already entered into the feeding ground of higher latitudes while the others are still far outside from it. Although many of the rest may enter soon or later into those food rich ground, this discrepancy in time and space makes it difficult to know or predict exact movements of whales at their feeding ground. The whaling operation in 1972 can be regarded to have undertaken under these circumstances in general.

On the other hand, it is well known fact that the Subarctic boundary which lies roughly along 40°N latitude divides the northern North Pacific into two regions of distinctly different waters both in physical and biological characters (e.g. Zenkevitch, 1963). Comparing latitudinal standing stocks of zooplankton in that regions, Odate (1966) and Vinogradov (1968) demonstrated its difference in biological characters between boreal and northern temperate waters which prevail in both regions: the faunistic abundance in the south of the subarctic boundary is hardly comparable to that of boreal regions. In this connection the sea region lies in the south of 40°N–41°N in the North Pacific probably deviate from those general idea as a feeding ground of higher latitudes. However, the newly opened whaling ground where actually operated and caught the whales were found only in the west side of 180° longitude, and can not be considered analogous with any other areas south of 40°N since a distinct mixed waters of Kuroshio and Okhotsk Sea origin which are supposedly more fertile prevail in the region west of 180° (Dodimead *et al*, 1963). In such a whaling ground, whether or not any amount or kind of food organisms which must be principally gregarious organisms along with considerable large population size will be found, are undoubtedly much interesting in connection with both the formation of feeding ground of whales and general zoogeography.

CATCH DISTRIBUTION OF WHALES

A rough sketch of whaling region operated by three Japanese fleets in the 1972 season is demonstrated in Fig. 1. The shaded areas in the figure indicate principal whaling ground. As it is shown in the figure Japanese fleets slightly entered into Bering Sea but caught a little. The main whaling ground was found in two areas, *i.e.*, the whaling ground in the east longitudes and that in the west longitudes. Zonal formation of main whaling ground like this pattern seems characteristic in recent operations, and considerable heavy catch in the waters south of 40°N in 1972 might be rather the result beyond expectation. In spite of being opened the whaling region southerly down to 20°N the whaling ground actually operated in the south of 40°N was diminutive in July where the southern most position was 34°N in the zone between 170°E and 180°. No notable catch was recorded in the south of 40°N region of west longitudes.

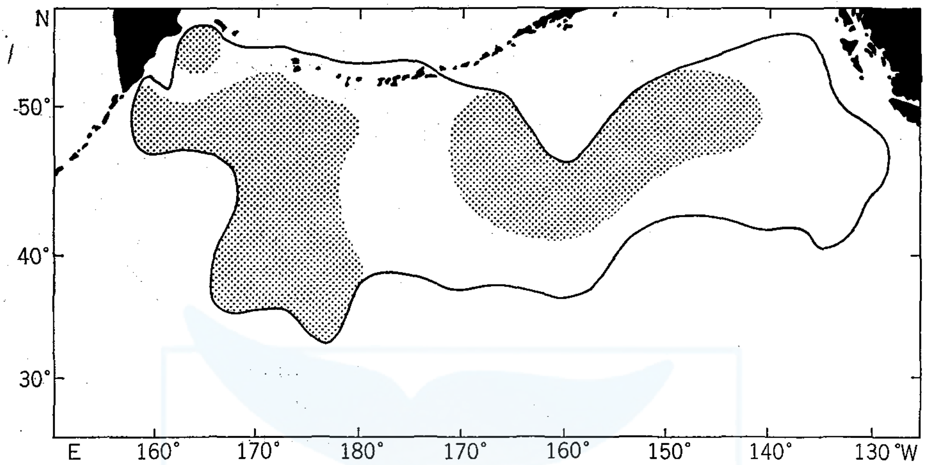

Fig. 1. The North Pacific whaling ground operated by three Japanese fleets in the 1972 season.

TABLE 1. CATCH DISTRIBUTION OF SEI, BRYDE'S AND FIN WHALES CAUGHT IN THE WATERS SOUTH OF 41°N LATITUDE IN THE NORTH PACIFIC, 1972. NUMBER OF ANIMALS: SEI/BRYDE'S/FIN

Longitude	Latitude (N)						
	34	35	36	37	38	39	40
165°E-170°E			8/-/-	41/2/-	36/-/-	85/-/-	14/-/-
171°E-179°E	31/-/1	174/2/2	74/1/-	120/-/1	110/-/-	108/-/2	31/-/1
172°W-177°W*						21/-/1	20/-/-
168°W-169°W							11/-/-
Total	31/-/1	174/2/2	82/1/-	161/2/1	146/-/-	214/-/3	76/-/1

* No catch in 176°W zone.

In the region of south of 41°N sei, bryde's and fin whales were caught, and the number of animals caught by 10° longitude are given in Table 1. It is clear in the table that the newly opened region benefited almost exclusively for sei whaling and the catch of both fin and bryde's whales were sporadically. It is also shown that latitudinal spread of sei whale ground is found between 35°N and 39°N, which is presumably correspond to the general features of bottom topography, *i.e.*, the presence of the Emperor Seamount Chain.

FEEDING BY SEI WHALE IN THE SOUTH OF 40°N

In the waters south of 40°N of east longitudes relatively warm waters high above

14°C in the surface prevailed during July of 1972 at 40°N with remarkable temperature gradient of about 1.6°C/1° lat. toward the south to show 21°C or more at 35°N (Fig. 2). The meandering isotherms run SW to NE direction on the whole, and the intrusion of tongue like warm or cold waters from south or north between 165°E and 178°E was distinct. The overall surface sea conditions can be seen as those of subtropical characters.

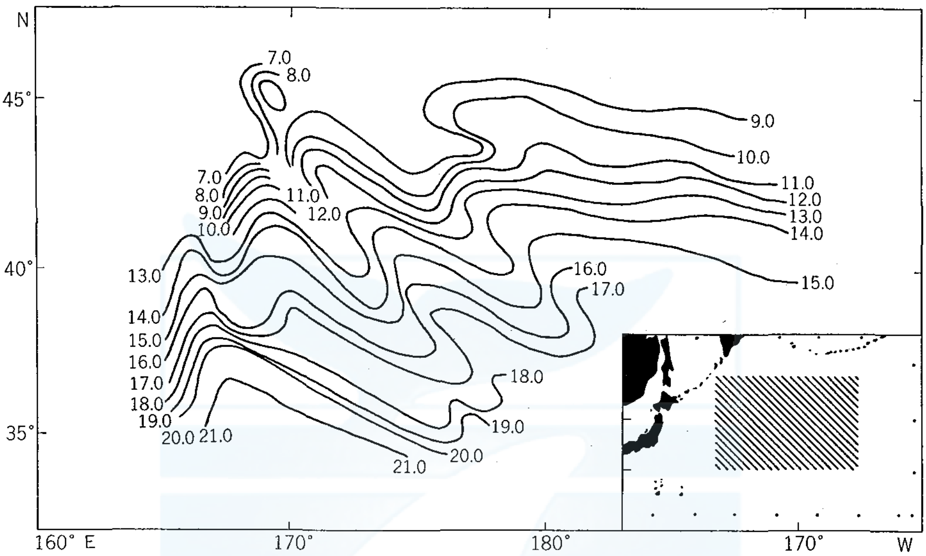

Fig. 2. Distribution of surface sea temperature (°C) in July, 1972.

TABLE 2. STOMACH CONDITION OF SEI WHALE CAUGHT IN THE WATERS SOUTH OF 41°N IN THE NORTH PACIFIC, 1972.

Longitude	Stomach with food	Empty	No. of animal examined	feeding percentage
165°E-170°E	68	116	184	38.0
171°E-179°E	195	453	648	30.1
172°W-177°W*	18	23	41	43.8
168°W-169°W	11	—	11	100.0
Total	292	592	884	33.05 (Av.)**

* No catch in 176°W zone.

** 168°-169°W zone is excluded.

Feeding percentages, the ratio of food containing animals to the total animals examined are demonstrated in Table 2. Although some figures may be unreliable due to poor number of material source, stomach conditions of sei whale in terms of the feeding percentages in the south of 40°N as far as the zone between 165°E and 179°E concerned, could be considered to be about 30–40% with 33.05% on an average. Comparing these figures with those of averages obtained from the northern whaling ground north of 40°N where 50% or more are expected (Table 3), the whaling ground south of 40°N showed slightly poor feeding conditions on the whole but could be regarded as still rich to some extent in availability of foodstuff. Relatively poor feeding conditions in the south of 40°N are also shown by the fulness of stomachs in terms of the amount of food as expressed in percentage figures (Table 4). It is curious, however, that considerable high percentages of whales were found to be carrying well repleted stomachs in contrast to very slight numbers in northern whaling grounds.

TABLE 3. LATITUDINAL CHANGE IN FEEDING PERCENTAGES OF SEI WHALE.

Latitudes	Feeding percentage	
50°–60°N I*	21.83	
II**	50.19	Av. 1967/71
40°–50°N	55.01	
20°–40°N***	34.40	Av. 1972

* Bering Sea.
** northern North Pacific between 50°N and Aleutian Islands.
*** Actual southern most position: 34°N.

TABLE 4. STOMACH CONDITIONS IN PERCENTAGE FIGURES BY NUMBER OF ANIMALS

Latitudinal area	Amount of food			
	Few	Moderate	Rich	Full
North of 40°N*	60.2	26.8	9.6	3.4
South of 40°N*	43.9	26.3	12.7	17.1
North of 40°N**	63.2	25.9	6.2	4.7

* 1972
** Average: 1967–1972

Characters of the southern whaling ground as feeding place were examined geographically or quantitatively in view of the availability of foodstuff, and revealed that the southern whaling ground by no means so poor in feeding conditions as having been supposed in general. Table 5 shows one of another characters, the qualitative peculiarity of the region. It is noticed in the table that great deal of foodstuff in the south of 40°N are solely comprised of fishes while they are almost less important in the northern whaling ground. On the other hand, copepods comprised only 7.2% among all foodstuff while they are 80% or more in the north. These qualitative characters indicate that the formation of whaling ground in the waters south of 40°N possibly relates to the accumulation of young fishes under feeding migrations as well as whales.

KIND OF FOOD ORGANISMS

Table 6 demonstrates the kind of food organisms found in 1972 materials which include the food samples collected in the waters north of 40°N up to 50°N but a little. Relatively large number of food species was found especially in euphausiids and fishes. To describe biological characters of the population of food organisms something more in detail would be as follows: both *Calanus cristatus* and *Calanus plumchrus* were entirely consisted of copepodite stage V which is only one copepodite stage showing gregarious occurrence during warm season in the North Pacific as having been reported in many previous works (e.g. *Fac. Fish. Hokkaido Univ.*, 1961).

TABLE 5. A GENERAL FEATURES OF FEEDING CONDITIONS IN THE NORTH PACIFIC SEI WHALE THROUGH PAST SIX SEASONS*

Whaling Season	Feeding** percentage	Food organism			
		Euphausiid	Copepoda	Fish	Squid
1967	73.1***	22.0	76.7	0.6	0.3
1968	60.9	9.0	89.9	0.2	0.7
1969	60.8	6.3	81.6	9.1	3.0
1970	64.1****	13.8	81.6	4.2	0.3
1971	54.5	17.7	75.5	4.9	1.9
1972	54.4	2.7	7.2	24.6	—

* Number during 1967–1971 represents the whole area of the North Pacific north of 40°N, and that 1972 represents only the area south of 40°N.
** No. of stomach with food/No. of stomach examined.
*** 0.4% of amphipoda is excluded.
**** 0.1% of unlisted organism is excluded.

TABLE 6. FOOD ORGANISMS OF SEI WHALE CAUGHT IN THE NORTH PACIFIC WHALING GROUND, 1972.

COPEPODA
- *Calanus cristatus* Kröyer
- *Calanus plumchrus* Marukawa
- *Calanus pacificus* Brodsky

EUPHAUSIID
- *Euphausia recurva* Hansen
- *Euphausia pacifica* Hansen
- *Euphausia diomedeae* Ortmann
- *Euphausia tenera* Hansen
- *Thysanoessa inermis* (Kröyer) Hansen
- *Thysanoessa spinifera* Holmes
- *Nematoscelis difficilis* Hansen
- *Nematoscelis gracilis* Hansen*

DECAPODA: Macrura
- *Sergestes similis* Hansen

FISH
- *Scomber japonicus* Houttuyn
- *Sardinops melanosticta* (Temminck & Schlegel)
- *Engraulis japonica* Houttuyn
- *Cololabis saira* (Brevoort)
- *Maurolicus muelleri* (Gúerin)
- *Pseudopentaceros richardsonii* (Smith)

CEPHALOPODA: *Decabrachia*
- Two or three species unidentified

* Identification is doubtful due to the damage of specimens.

Calanus pacificus was separated from *Calanus finmarchicus* or *Calanus helgolandicus*, and established as warm water prefering species being prominent in Far Eastern Seas by Brodsky (1948). Among the occurrence of *C. finmarchicus* and *C. helgolandicus* in the surrounding waters of Japan, some of which might be included *C. pacificus* since the species prefers well much warmer waters than the two others. It seems the first record that *C. pacificus* is reported as a principal food sources of baleen whales in the North Pacific region. *C. pacificus* which was found to be the primalily important foodstuff of sei whales in the waters south of 40°N, was also represented by copepodite stage V but copepodite stage VI of both sexes also occurred. However, the number of adult males and females in the population was hardly comparable to that of copepodite V and an approximate ratio of each stage was: CV: CVI (female): CVI(male)=60: 3: 1. There was a net plankton sample collected in the whaling ground and it revealed that copepodites III and IV of *C. pacificus* also present in the region with slightly larger numbers in the latter.

In euphausiids, *Euphausia pacifica* was found most frequently and most of them were consisted of both adult and adolescent individuals some of which carried sperm sacs on the belly. *E. recurva* and *E. diomedeae* were also found being consisted of adult forms of both sexes with almost same number though slightly less female in the latter species. Some females carried sperm sac. *Nematoscelis* spp. and others were consisted of both sexes with some mixture of adolescent forms. None of these species were found carrying about sperm sac.

The only one macruran, *Sergestes similis* was in the body length of 26.3–47.0 mm though most of them were found to be larger than 40 mm. Their body lengths, however, did not differ much by each collected samples, and this fact suggests that mass occurrence in patchness would be consisted of the individuals of nearly same developmental stages possibly due to a sort of segregation by year class.

Many individuals of Japanese anchovy, *Engraulis japonicus* were 9.0–10.5 cm in fork length and supposed to be a spring population of current year almost attained at the maturity from their sizes (Kondo, 1971). Japanese mackerel, *Scomber japonica* was the most dominant food fish, and all of them was sexually immature from their body length of 8.4–11.7 cm (Usami, 1968). Body length of Japanese sardine, *Sardinops melanosticta* and Pacific saury, *Corolabis saira*, was 8.3–11.6 cm and 10.5–17.7 cm respectively. They were also sexually immature from their body length (Kondo, 1964; Hotta, 1964), and Pacific saury was possibly a offspring of the spring in current year (Hotta, 1964). A Gonostomatiid fish, pearlsides (*Maurolicus muelleri*) showed 4.7–4.8 cm in their fork length.

Although there were many kind of food organisms as mentioned above, a bulk of these food organisms can be considered being consisted of zooplankton and fish species which prefer rather warmer waters when compared with those having been found previously in the northern waters (see Nemoto, 1957, 1959), that is, *Calanus pacificus*, *Nematoscelis gracilis*, *N. difficilis*, *E. diomedeae*, *E. tenera* and some fishes such as Japanese mackerel.

Food organisms in detail with corresponding number of whales are given in Table 7. It is clear in the table that a typical cold water copepods, *C. cristatus* and *C. plumchrus* were exclusively fed by the whales in the northern waters north of 40°N, while *C. pacificus*, the warm water copepod, was the representative in the south of 40°N. Table 7 also indicates that the fin whales feed more preferably on euphausiids than copepods as Nemoto (1959) early reported their food preference. To see the overall results it is no doubt that the essential diet of sei whales in the waters south of

40°N is formed almost solely by *C. pacificus* and small fishes. It is notable that both *C. cristatus* and *C. plumchrus* correspond to *C. pacificus* in the north of 40°N, and euphausiids and macruran, *Sergestes similis* (Kawamura, 1970, 1971; Omori *et al.*, 1972) also taken over the role of small fishes. As it will be mentioned later the majority of those food fishes prey upon *C. pacificus*. Euphausiids were also fed but very few. This indicates that they are less important as whales food in the waters south of 40°N. Among the food fishes both Japanese mackerel (*Scomber japonicus*) and Japanese sardine (*Sardinops melanosticta*) were the most important.

TABLE 7. NUMBER OF ANIMALS BY THE FOOD ORGANISMS IN SEI AND FIN WHALES IN THE NORTH PACIFIC, 1972.

Kind of organisms	South of 40°N	North of 40°N	
	sei	fin	sei
C. cristatus		2	18
C. plumchrus		1	6
C. plumchrus–C. cristatus			1
C. pacificus	7*		
C. pacificus–E. recurva	1		
E. pacifica		3	3
E. recurva	1		
E. diomedeae	1		
E. tenera	1		
Th. inermis		2	
Th. spinifera		1	
Th. inermis–Th. spinifera		3	
N. gracilis (?)	1		
N. difficilis	1		
S. similis		1	2
S. similis–C. cristatus			1
S. similis–E. pacifica		1	
S. similis–C. plumchrus–C. cristatus			1
S. japonicus	10		
S. japonicus–C. pacificus	1		
S. japonicus–S. melanosticta	1		
S. japonicus–E. japonicus	1		
S. melanosticta	3		
E. japonicus	1		
C. saira	1		1
M. muelleri	2		
M. muelleri–S. saira–Squid	1		
P. richardsonii larva (?)	1		
Squid			2

* One material collected by the net is included.

In summerizing the results it is confirmed that *C. pacificus*, *S. japonicus* and *S. melanosticta*, all the warm water food organisms, essentially made the whales accumulate for feeding in the waters south of 40°N. A clear latitudinal succession in the species composition of food organisms or in its community also make us confirm that the subarctic front had undoubtedly positioned in the vicinity of 40°N in the east longitudes during July of 1972.

DISTRIBUTION OF FOOD ORGANISMS

Food organisms occurred can be divided into three major groups: copepods, euphausiids and fishes. Figs. 3 and 4 demonstrate a rough sketch of their distribution being arranged by examining the food samples and the record of eye observations made on the ship's deck. As the latter covers all of whales caught while the food

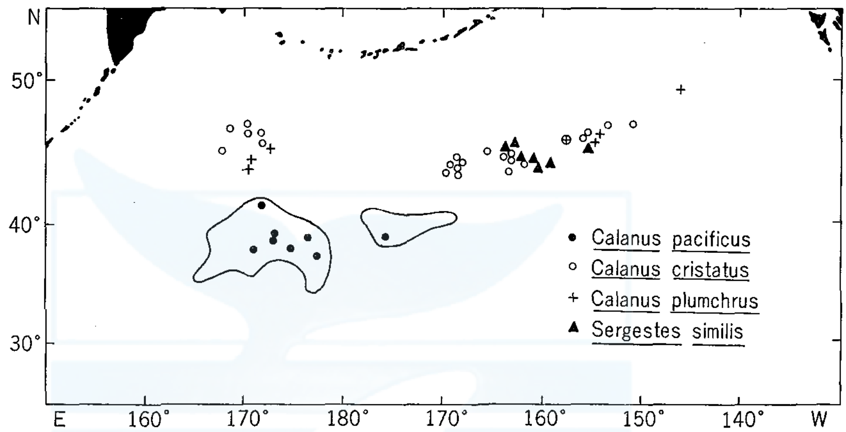

Fig. 3. Distribution of food copepods and macruran shrimp, *Sergestes similis*.

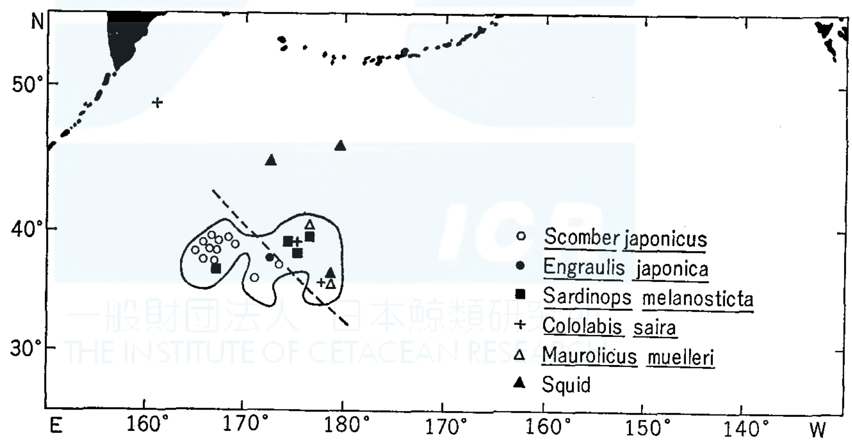

Fig. 4. Distribution of food fishes and squids. Broken line indicates the zoogeographical discontinuity.

samples were collected sporadically, the spread of distibution range shown in the figures does not follow exactly to the positions or the range by the food samples. Fig. 3 shows the distribution of copepods and a macruran, *Sergestes similis*. It is clear in the figure that *C. pacificus* occurs only in the waters south of 40°N while *C.*

plumchrus and *C. cristatus* predominate extensively in the northern waters. The actual southern most position of the occurrence of *C. pacificus* was found in 34°N and that of northern most was in 41°20′N, 170°E. Taking some allowance into consideration on their distribution range, *C. pacificus* may occur up to 42°N or thereabouts with a considerable large size stocks so as to be fed by the whales. *Sergestes similis*, on the other hand, occurred only in the waters of west longitudes with its distribution center in 44°–46°N, 160°W. The occurrence of *S. similis* in this way is very characteristic as having been reported and pointed out its importance as whales food in these region (Omori *et al.*, 1972). A majority of euphausiids in the northern waters were represented by *Euphausia pacifica*, *Thysanoessa spinifera* and *Th. inermis* though they might be less important in the region where mass occurrence of *S. similis* is expected.

There are noticeably different features of distribution between Japanese mackerel and Japanese sardine (Fig. 4). In the waters south of 40°N Japanese mackerel occurred exclusively in 165°–173°E while Japanese sardine was found in 174°–178°E. Composition of whales food fish was relatively complicated in the region east of 174°E where young Pacific saury of 10.5–17.7 cm and pearlsides of 4.7–4.8 cm occurred along with Japanese sardine. Very small larvae presumably of boar fish, *Pseudopentaceros richardsonii*, also occurred though sporadic. All these small but swarm forming fishes did not occur in the waters north of 40°N except a very few instances of Pacific saury. In general, population of fishes as food of sei whale in the waters south of 40°N can be considered to be consisted of two groups of food-

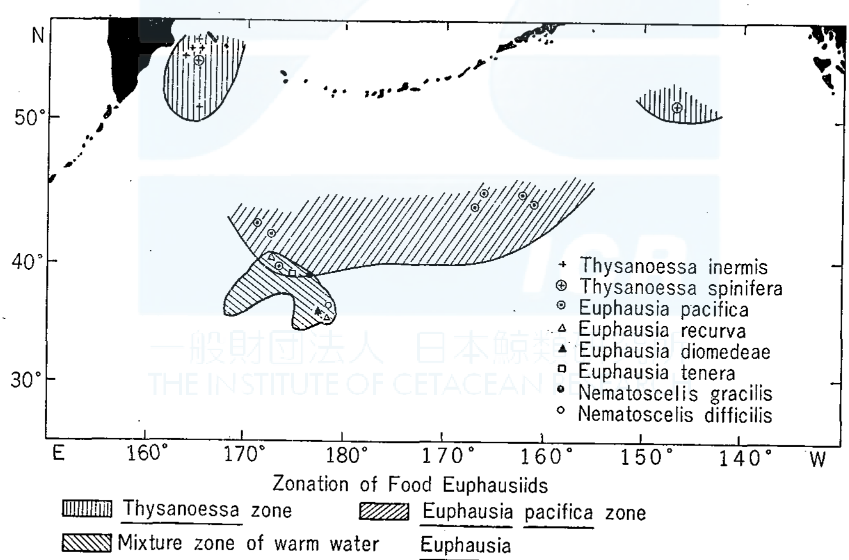

Fig. 5. Distribution of food euphausiids and their possible zonation of occurrence as whales food. The mixture zone in the figure does not mean the interspecific mixing but the species occur in complete monotypic population under a condition of rather sporadic occurrence each other.

stuff of fishes: Japanese mackerel alone or it accompanying Japanese anchovy population in the west side region, and Japanese sardine population with several numbers of cold water or cosmopolitic fishes. These food fish populations divide the region into two parts that different fish communities predominate roughly with their occurrence border crossing northwest to southeast direction between 170°E and 180° as shown by a broken line in Fig. 4.. Recognition of whaling ground by this way can also be interpreted by the pattern of occurrence in euphausiids (Fig. 5).

PREY OF FISHES FED BY WHALES

As it was mentioned in the preceding section a considerable part of foodstuff of sei whales in the waters south of 40°N was consisted of small sized but school forming fishes, and such sea conditions as feeding ground seem somewhat characteristic when compared with those formed by the planktonic organisms since the fishes above mentioned can be regarded as competitors to feed on the whales food. In connection with this circumstances the whaling ground in the south of 40°N would be regarded as that formed secondarily although there seems still in need of further examination on foodstuff in the fishes fed by the whales.

As it is shown in Table 8 great deal of fishes found in the stomach of whales had fed solely on copepods of one or two species. Among copepods fed by the fishes of whales food, *C. pacificus* was most predominant being followed by *C. plumchrus* and *C. cristatus*. It was also noted that one of the typical cold water copepod species, *Eucalanus bungii bungii* which was completely absent from the foodstuff of sei whale occurred along with *C. pacificus*. Some individuals of Japanese mackerel

TABLE 8. STOMACH CONTENTS OF FISHES FED BY SEI WHALE.

Food organisms of fishes	Kind of food fishes*				
	Sj	Cs	Ej	Sm	Mm
C. cristatus–C. plumchrus	1				
C. plumchrus	1				
C. pacificus	2		1	1	
C. pacificus–C. plumchrus	1				
C. pacificus–E. bungii bungii	1				
C. pacificus–C. plumchrus–amphipoda (Gammariid)	1				
Others	2**				4***
Unknown****	4	1			2
Empty	5	2	1	3	

* Sj: *Scomber japonicus*, Cs: *Cololabis saira*, Ej: *Engraulis japonicus*, Sm: *Sardinops melanosticta*, Mm: *Maurolicus muelleri*.

** *Euchaeta* sp., *Phronima* sp., *Sapphirina* (?), *Eucalanus* sp., *Oikopleura* sp., *Salpa* (?).

*** *Pseudocalanus elongatus*, *Eucalanus bungii bungii*, *Candacia colombiae*, *Oncaea* sp., Euphausiids furcilia, Amphipoda, *Phronima* sp.

**** decomposed.

and pearlsides (*M. muelleri*) fed on a mixture of many kind of zooplankters. These fishes seem undoubtedly to have preyed upon the zooplankters being present indiscriminately without any selection. It is interesting that warm water zooplankton species such as *Phronima* and *Sapphirina*, were found as a food of young Japanese mackerel which somewhat prefers warm water while *M. muelleri*, a cosmopolitic species fed on cold water zooplankters. By examining on the foodstuff of both whales and their food fishes, it is confirmed that they are closely linked up solely through *C. pacificus*. In these prey—predator relationships the whaling ground in the south of 40°N can be recognized as being formed at its beginning by the distributional characters peculiar in *C. pacificus*, which would possibly related to some hydrodynamical processes of past seasons in the northern waters. In approaching to the causation of aggregations of whales through the formation of their feeding ground, manifold composition of foodstuff in pearlsides seems less important than Japanese mackerel which feeds exclusively on monotypic swarms of copepods.

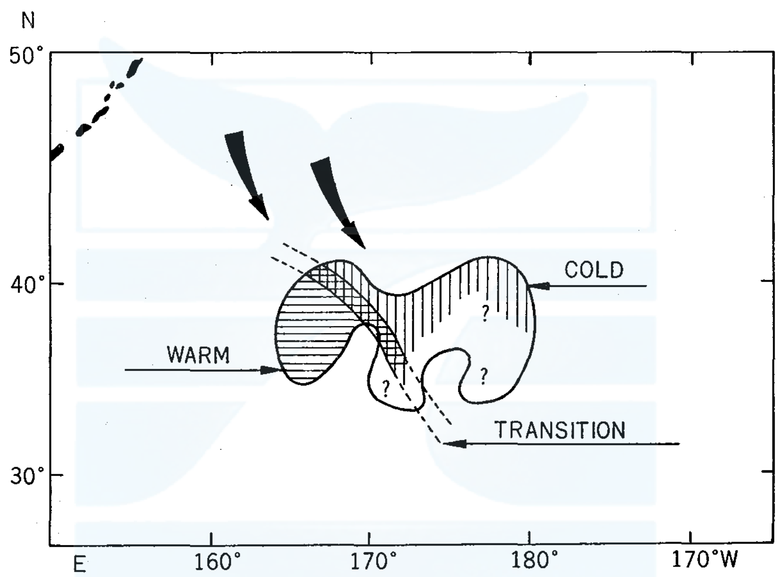

Fig. 6. Schematic zonation of whaling ground in the waters south of 40°N as based on the distribution of prey organisms of sei whales and their food fishes. 'WARM' in the figure is the zone characterized by *C. pacificus* or its mixture with various warm water copepods, and 'COLD' is those by *C. plumchrus* or its mixture with *C. cristatus*. Both 'WARM' and 'COLD' zones meet and mix with each other at the 'TRANSITION' zone. Arrow shows a possible penetration of subsurface cold waters from the EKCE.

By plotting the occurrence of prey organisms of fishes fed by whales, two ecologically heterogeneous regions could be distinguished (Fig. 6). One of them is characterized by *C. pacificus* or a mixture of various warm water zooplankters, and the other is by *C. plumchrus* or a mixture of *C. plumchrus* and *C. cristatus* populations. It is also noticed that there are transision zone with some width where the prey organisms of fishes intermingled with those in both regions each other. These distinguished regions agree well with the result obtained in food fish populations, but the location of transision zone seems likely to shift rather southward than the location of ecological discontinuity which is shown in Fig. 4.

DISCUSSION

The region which lies in the south of 40°N of the North Pacific does not seem to be kept under such a conditions of good feeding ground as make the whales, if not entirely, be accumalated for a while when considered from the point of views of an abundance in food organisms. This is the problem of gross availability of food organisms as it is generally indicated by feeding condition of whales. Feeding percentages, the ratio of food containing animals to the total examined in sei whales in the waters north of 40°N through past five years were 62.7% on an average while those in the south of 40°N revealed it remains at about 30–40%. Under a rather barren sea conditions, however, the region lies between 160°E and 180° zone in the south of 40°N seems to be distinct being covered with some peculiarities under the influence of prevailing current.

Mentioning on the upwelling of suarctic intermediate waters in relation to the character of subarctic front in the zone of east longitudes of the North Pacific, Uda (1971) proposed the presence of a southeasterly branch from the East Kamchatka Current, which is called as the East Kamchatka Current Extension (EKCE), and it presumably influences upon the sea conditions in the environs of 40°N, 160°–170°E region. The EKCE which originates from the region about 50°N, 160°E extends south to southeast direction, shifting its direction more easterly when it meets with the Oyashio front at about 40°N. This cold southeasterly current must presumably be causative for the meandering in surface temperature distribution along with the influence of a complex bottom topography by the Emperor Seamount Chain, and further, it possibly relates to the extension of mixed waters of the Kuroshio and Okhotsk Sea as Dodimead *et al*, (1963) figured out. Recent work presented by Kishi and Uda (1973) makes me confirm those hydological peculiarities of the whaling ground under consideration. Analyzing on the depth distribution of 10°C waters based on the enourmous amount of data during 1935–1969, they (Kishi and Uda, 1973) found a steady southerly intrusion of the cold EKCE waters into the south of 40°N region between 150°E and 160°E.

The whaling ground in the south of 40°N would be divided into two regions of relatively warmer and colder characters by the intrusion of colder waters from the north, and they are formed in the both southwest and northeast side of the region (see Figs. 5 and 6). In this connection the proposed ecological discontinuity which was interpreted from the results of examinations both on whales food and the prey organisms of the fishes of whales food agrees well with the hydrological characters on the whole, and supports Uda's proposal on the EKCE on biological basis although the location of the discontinuity may shift to some extent by seasons and years. In the populations of Japanese sardine and pearlsides the latter fed exclusively on boreal or cold arctic zooplankton species such as *Pseudocalanus elongatus* not with standing the fact that both fish species occurred in almost the same region. On the other hand, it was more in the southerly waters that monotypic aggregations of *C. pacificus* were found in the stomach of Japanese mackerel. Both *C. cristatus* and *C. plumchrus* as a foodstuff of sei whales never occurred in the waters south of 40°N while they were found in the further south to some extent as a prey of food fishes of whales. These circumstances seem to be discrepant but it would be explained as follows though still have not proved yet: Both *C. cristatus* and *C. plumchrus* are the important foodstuff of baleen whales through widely in the northern North Pacific (Nemoto, 1963), and they could occur by forming a dense swarms so as to be fed by the whales in the north of 40°N. In the south of 40°N, on the other hand, it is far out side from their usual habitat, and as any of both species could not be present as swarms in the surface so were they in the northern waters. *C. cristatus* and *C. plumchrus* found in the stomach of Japanese mackerel might not be preyed upon their swarming populations but possibly upon rather sporadic and dispersed populations having been carried by the intermediate waters from the north. The general features in the zoogeographical successions of fish foods suggest that some mixing of water would take place in or near by those discontinuous borders mentioned previously, and it might presumably be due to the influence of the EKCE, since cold waters widely found over this region can be recognized as the subsurface Oyashio origin waters which penetrated into the region at the depth of about 50–100 m. (Kishi and Uda, 1973).

According to Betesheva (1954) fin whales feed on anchovy in the waters of Kurile region during August and the anchovy population often accompanies *Thysanoessa raschii*, a cold neritic species (Boden *et al*, 1955). Japanese anchovy found in the North Pacific in 1972 occurred at the southern most part of its distribution in Japanese sardine—pearlsides populations. This fact suggests also the succession of water masses more colder toward north to northeast side in contrast to warming toward south to southwest, that is, more stronger influences of warm water in the south. In this respect Omori (1965) reported an interesting result, that is, *C. pacificus* distributes fairly wide in the zone of 40°–50°N of the North Pacific during June to August but it is only in the west of 170°W that *C. pacificus* often occurs being accompanied by warm water copepods such as *Calanus tenuicornis*. This fact would explain the biological character of newly opened whaling ground and its peculiarity as mixing region in general.

Consulting with the general faunistic features around the region in the south of 40°N of the North Pacific (Zenkevitch, 1963), the whaling ground operated in the south of 40°N resembles well to the features usually found off Sanriku, the southeast coast of northern Japan, and it is something likely to their extension with slight addition of more boreal characters. Although a considerable number of *C. pacificus* occurs far in the Gulf of Alaska (Omori, 1965), they are usually accompanied with *C. plumchrus*. These difference in their specific combinations as a communities of food organisms, though it resembles at a glance, should be noted since it might give the sea quite heterogeneous characters. In concluding on the whaling ground along with its formation in the south of 40°N in the North Pacific, it is considered that the key factor is found solely in the distributional ecology of *C. pacificus*. However, the feeding ground of baleen whales as Kawamura (1973a, b) has firmly pointed out should not be considered solely on the basis of each food species alone but of their community which embodied through the food chains. *C. pacificus* is usually found widely over the northern North Pacific but no other staple feeding ground of baleen whales as exploited in the zone of east longitudes would possibly be found in the zone of west longitudes.

SUMMARY

1. In accordance with lifting the ban of whaling activities by the measures of Japanese Government in the waters south of 40°N of the North Pacific in 1972 a total of 34 food samples of sei whales was collected in the newly opened region, and their food and feeding conditions were examined.

2. The main whaling ground in the south of 40°N was located only in the zones between 165°E and 180° with 34°N as its southernmost position, where the Emperor Seamount Chain ends. The surface sea temperature of 14°–21°C prevailed during July in the region with a remakable meandering pattern which jaggs northwest to southeast direction.

3. The sea conditions were complex under a possible influence of the East Kamchatka Current Extension, and the formation of whaling ground seems rather the peculiar case in the waters south of 40°N.

4. The ratio of food containing animals to the total examined in percentage figures showed 33.05% on an average while it was 50.0% or more in the waters north of 40°N through past five seasons.

5. In connection with the feeding percentages the fertility of the region south of 40°N as feeding ground of baleen whales is considered to be not so barren as having been supposed previously.

6. The foodstuff of sei whales in the waters south of 40°N was almost solely comprised of fishes (24.6%) and copepods (7.2%), while they showed less than 5% and 80% or more respectively in the northern waters.

7. More than 20 species of food organisms were identified. A large number of them was comprised of warm or cold temperate species especially in euphausiids, but only *Calanus pacificus*, Japanese mackerel (*Scomber japonicus*), Japanese sardine (*Sardinops melanosticta*) and Japanese anchovy (*Engraulis japonica*) were the main constituents of the food of sei whales.

8. The *Calanus pacificus* population was represented by the copepodites V and VI of both sexes, and that of the fishes was by the young individuals of sexually immature.

9. Distribution of food organisms revealed that the main whaling ground in the south of 40°N is likely to be divided by a zoogeographical discontinuity into two heterogeneous regions under different faunistic characters.

10. Examination on prey organisms of the fishes fed by sei whale prooved that they also feed chiefly on *C. pacificus* or its mixtures with *C. cristatus* or *C. plumchrus*.

11. Above results seem to support again the presence of the ecological dis-

continuity, and at the sametime, the intrusion of cold intermediate waters into the region.

12. The whaling ground in the south of 40°N was presumably formed solely by a bulk of mass occurrence of *C. pcificus* at its beginning, and the concentration of young fishes under feeding migration also made the sea region so fertile as to be the staple feeding ground of baleen whales.

13. It was known in this study that the feeding ground of baleen whales has been usually recognized as being formed chiefly by the aggregations of primary consumers of planktonic crustaceans, but it would also be formed or at least supplemented considerably by the organisms of more higher trophic levels, and that the condition of available foods for baleen whales in the region should not be considered by each food species alone but more comprehensively by the community of organisms.

ACKNOWLEDGMENTS

The food samples examined in this study were collected through the courtesy of Japanese whaling fleets of Taiyo Gyogyo K.K., Nippon Suisan K.K. and K.K. Kyokuyo. Far Seas Fisheries Research Laboratory of the Fisheries Agency also kindly admitted me to use a statistical materials on whales caught. In particular I am much indebted to Associate Professor Tadashi Kubota of the Faculty of Marine Science and Technology, Tokai University for identifying pearlsides *Maurolicus muelleri*, a species of Gonostomatiid fishes. Mr. Saburo Machida of the Whales Research Institute also kindly offered me his original figure of the temperature distribution as illustrated in text-fig. 2.

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FIND OF MARLIN SPEAR FROM THE ANTARCTIC MINKE WHALES

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A spear-like snout of a marlin was found in the middle of upper jaw of an Antarctic minke whale, *Balaenoptera bonaerensis* Burmeister, when it was flensed on deck of a factory ship on 20 January, 1972. This whale (Serial No. J-1, 965) was caught from the waters of 64°06′S, 87°14′E by a catcher boat which was accompanied with Jinyo-maru Whaling Expedition. It was male, 8.0 m in body length and sexually mature.

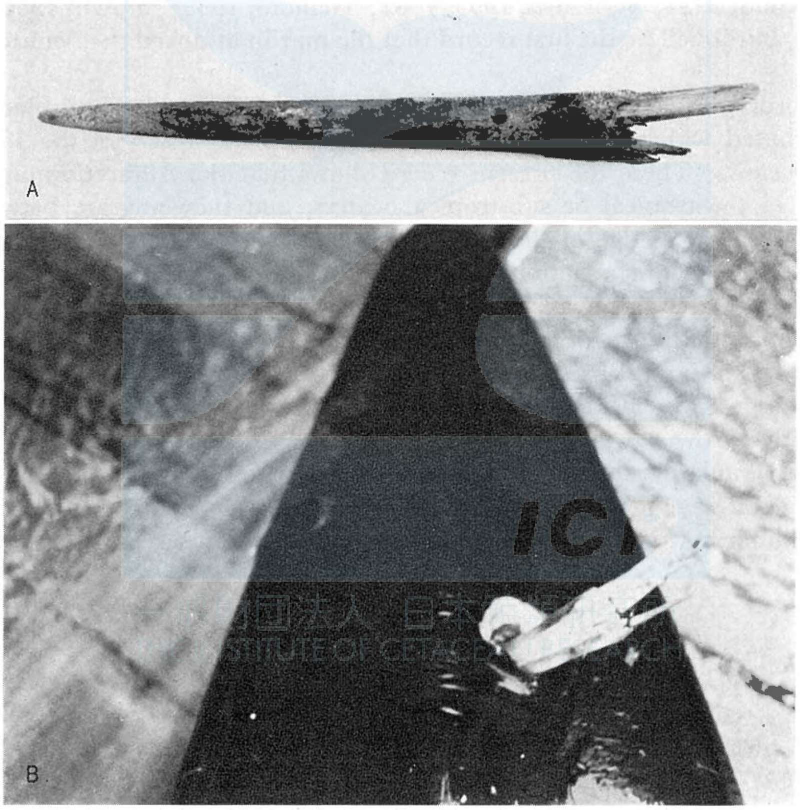

Fig. 1. A spear of marlin found from an Antarctic minke whale (Ser. No. J-1, 965).
A: Ventral view of the spear (× 1/6).
B: Dorsal view of rostrum of the Antarctic minke which was attacked by the marlin. Inserted spear is seen on the right side of the rostrum.

Sci. Rep. Whales Res. Inst.,
No. 25, 1973, 237–239.

The snout was 49.5 cm long, broken at the root as is shown in Fig. 1A. It was inserted into right anterior upper jaw (Fig. 1B) through to left palate of the whale. The upper jaw was holed with the snout, and the hole had not yet healed completely. Furthermore, some pieces of connective tissue of the fish were still remained on inner part of the snout. The snout was attached with three individuals of a *Conchoderma* (species unidentified) on a part. These facts leads us to estimate that this whale was attacked by a marlin not more than several months before.

It is difficult to identify the fish species only from a snout externally. However, Dr. Shoji Ueyanagi of the Far Seas Fisheries Research Laboratory kindly examined this snout, and concluded that this fish must be refered to Genus *Makaira*, namely, either blue marlin, *M. mazara* (Jordan & Snyder), or black marlin, *M. indica* (Cuvier). On the bases of the estimation of snout length and the relation between body length and snout length of the marlin by Ueyanagi (1957), the body length of the marlin is estimated to be about 220 cm in total length.

There are several reports on finding of snout of swordfishes from some baleen whales (Ruud, 1952; Jonsgard, 1959, 1962; Nemoto, 1959; Brown, 1960; Machida, 1970), but it will be the first record that the marlin attacked the Antarctic minke whale.

According to Nakamura, Iwai and Matsubara (1968), blue and black marlins are distributed widely in the tropical and sub-tropical waters of the Indian and Pacific Oceans. Then, the present record shows that the Antarctic minke whales live even in the tropical or sub-tropical waters, and they migrate between these waters and pack-ice edge of the Antarctic.

Mr. Tadao Ishii, a national whaling inspector, observed also a round hole which was estimated to be caused with the attack of a marlin on the left upper jaw of another Antarctic minke whale (Serial No. J-2,923) on board of the same factory ship on 16 February, 1972. This whale was caught from the waters of 64°52′S, 91°18′E. It was 8.3 m long male and sexually mature. To my regret, the spear had already thrown away by that time.

Many thanks are due to Dr. Shoji Ueyanagi, who kindly identified the snout of the marlin and gave me much information on billfishes. I am also indebted to Mr. Tadao Ishii for his kindness to report me a record of his observation.

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AN ANATOMICAL STUDY ON THE LOWER EXTENSION OF THE DORSAL VAGAL NUCLEUS TO THE UPPER CERVICAL CORD IN THE SPERM WHALE

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ABSTRACT

The lower portion of the dorsal vagal nucleus was examined anatomically in two specimens of sperm whale. At the level below the obex, the nucleus seems to be divided into two cell groups, medial and lateral. The medial cell groups of both sides are fused with each other on the midline, which is characteristic in the sperm whale. The lateral cell group makes islands-like cell column along the long axis of the central nervous system. In some sections, these two cell groups are observed to be in complete continuity. Caudalwards, they can be traced up to the first cervical level, decreasing number of cells and presenting beaded appearance. Thus, I could reconfirm that the lower extension of the dorsal vagal nucleus of the sperm whale belongs to the type 3 in my previous classification.

INTRODUCTION

Although the lowest portion of the dorsal vagal nucleus is difficult to give a definite description as to where to end and how, it usually is located approximately at the level of the pyramidal decussation. In certain other mammals the nucleus is reported to be further extended to the lower direction. But not much attention has been paid on this latter fact.

Ogawa and Chen (1947) found that the lowest part of this nucleus was directly continued to the lateral horn nucleus of the upper cervical cord in the goat and deer, and similar finding was obtained in the sea lion by Mannen and Seki (1958). Seki (1966) had classified the form of the lowest portion of the dorsal vagal nucleus in four types after comparative anatomical examination of such structures in many species of mammals including primates, carnivores, ungulates, rodents and cetaceas.

In this report, it was able to reconfirm that the lower extension of the nucleus belongs to the third type of the preceding classification, by a detailed observation in two cases of the sperm whale.

MATERIALS AND METHODS

The materials were parts of those which had been collected by Dr. T. Kojima*,

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when he was on a whaling expedition in the Antarctic Ocean in 1949–50. Many thanks are due to the profound kindness of Dr. Kojima to offer me the precious materials to the present work.

The first specimen was the portion, 28 mm in length, covering from the level 3.7 mm above the obex to the upper end of the spinal cord including the first cervical cord. The second was the part, 44 mm in length, extending from the level 10 mm above the obex to that part which included the first cervical cord. These two had been preserved in formalin. Both materials, after having been cut off to meet the purpose, they were refixed in Müller's solution in 37°C for two weeks and mounted in celloidin through the usual manner. Serial sections of 35 μ in thickness, along the transverse plane for the first case and horizontal plane for the second, were made. Each fifth sections (the first and sixth and so forth with the last order of each figure being 1 and 6) were stained by the Klüver-Barrera method and each 10th sections (10th, 20th, 30th, etc.) were also treated by the Weigert-Pal or Kultschitzky's method for myelin staining.

RESULTS

The dorsal vagal nucleus and its lower extension are seen as palely stained areas in the myelin stained sections and they are easily discriminated as a prominent cell group distinctly bordered from the surrounding (Pl. I, Fig. 1). The examination of the cell staining preparates reveals that substantially large cells, ellipsoidal or spindle-shaped, constitute the principal cellular component of the nucleus (Pl. I, Fig. 2). In transverse sections, majority of cells possesses long axis in the direction oriented from the dorsomedial to ventrolateral, with approximately 50–100 μ in the long diameter and 30–60 μ in the short one. They are large in size next to cells of the hypoglossal nucleus in the lower medulla or the anterior horn of the upper spinal cord of the sperm whale.

On the lateral or the dorsolateral to the nucleus is another aggregation of small cells, part of which is found in a small number, though, within the above mentioned large cell group.

Fig. 1. Approximate distribution of cells in transverse sections of the lower medulla and the lst cervical cord in case 1, Klüver-Barrera, $\times 12$.
Each of drawings was made by accumulation of neighbouring 4 sections (stained every 5th sections) on one plane. Cells of dorsal vagal nucleus and its lower extension were indicated by black dots.
a: Lower medulla above the obex (Section numbers; 281, 286, 291 and 296 of block 2.). Note the hypoglossal nucleus lying far ventral apart from the bottom of the 4th ventricle.
b: Lowest medulla (Section numbers; 421, 426, 431 and 436 of block 1.). Dorsal vagal nucleus is extended laterally and makes lateral cell group of lower extension.
c: First cervical cord (Section numbers; 101, 106, 111 and 116 of block 1.). Medial cell groups of lower extension of both sides are completely fused on the midline.

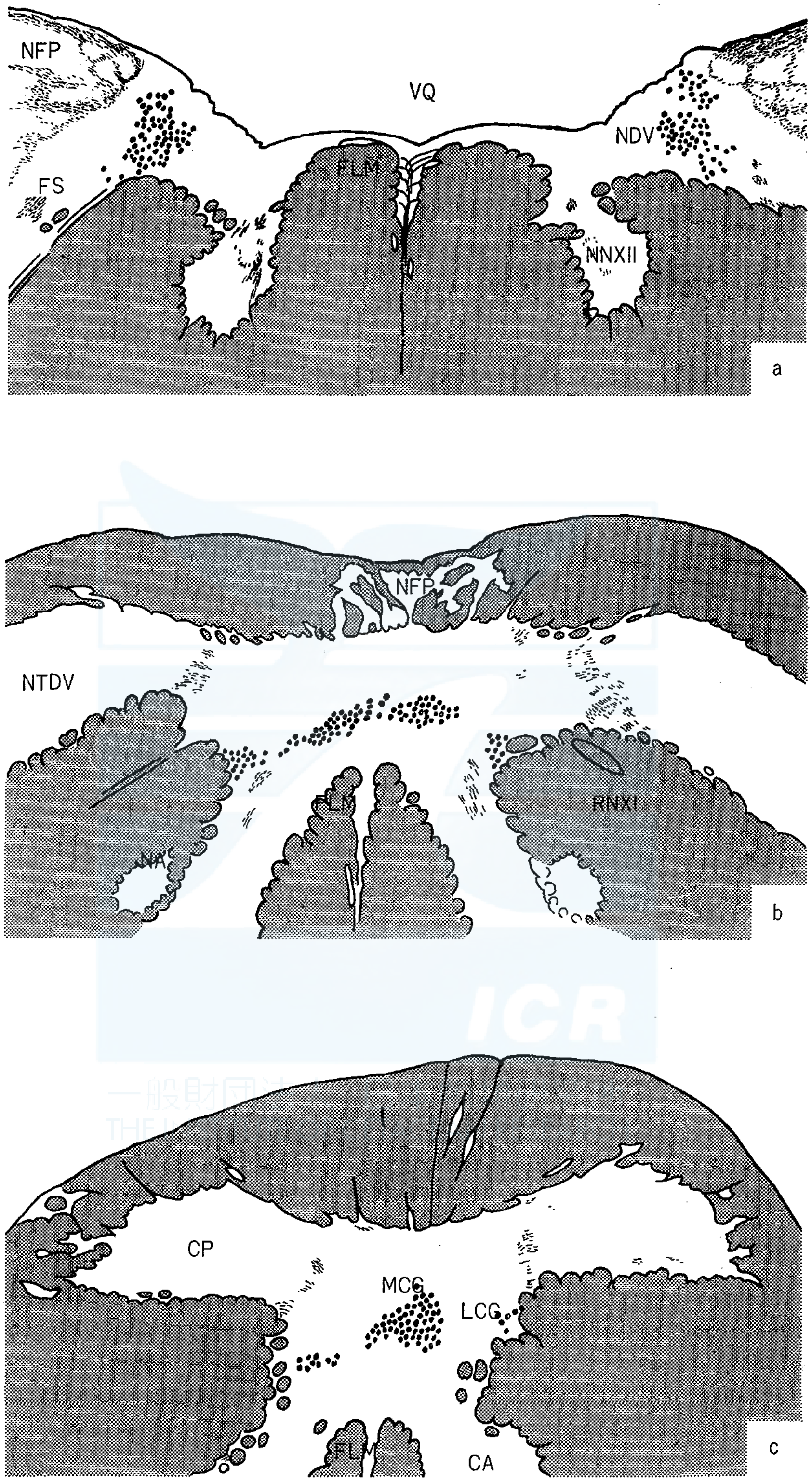
NFP
VQ
NDV
FS
FLM
NNXII
a
NFP
NTDV
FLM
RNXI
NA
b
CP
MCG
LCG
FLM
CA
c

Fig. 1.

Other than these two different cell groups, there exist small collections of cells, apparently similar in nature to those in the dorsal vagal nucleus, located in the reticular formation of the lower medulla and the lateral funiculus of the upper cervical cord, distributed longitudinally with islands-like interruptions. But owing to the limitation of the material obtained, no relationship of these cell groups with the dorsal vagal nucleus or its lower extension could be clarified in this study.

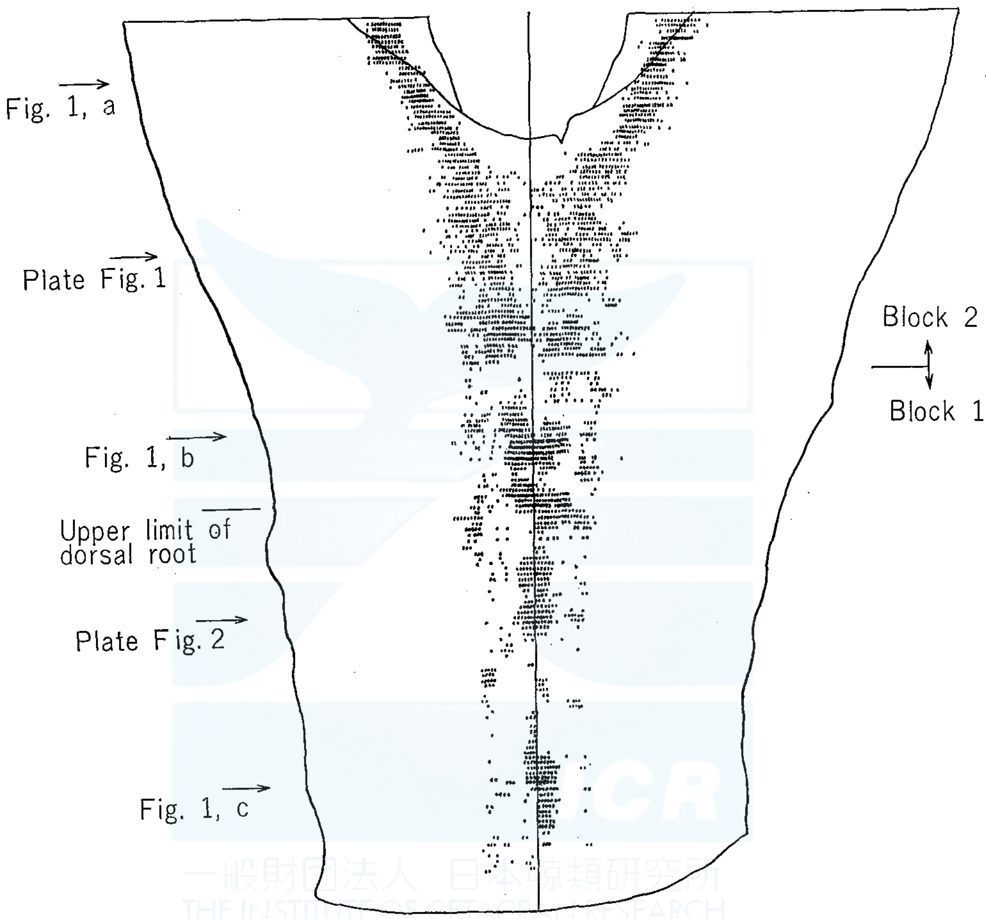

Fig. 2. Approximate distribution of cells projected from transverse sections (stained every 5th sections) on the horizontal plane in case 1, Klüver-Barrera, ×4.5. Arrows in left show levels of figures 1 and plate.

In the level higher than the obex, the dorsal vagal nucleus is situated close to the fourth venticle and inside the ala cinerea as in the cases of most other mammals. Conspicuously marked is the distance between this nucleus and the hypoglossal nucleus because of the different location of the latter, which is observed to be in ventral apart from the fourth ventricle in this level in the sperm whale (Fig. 1, a).

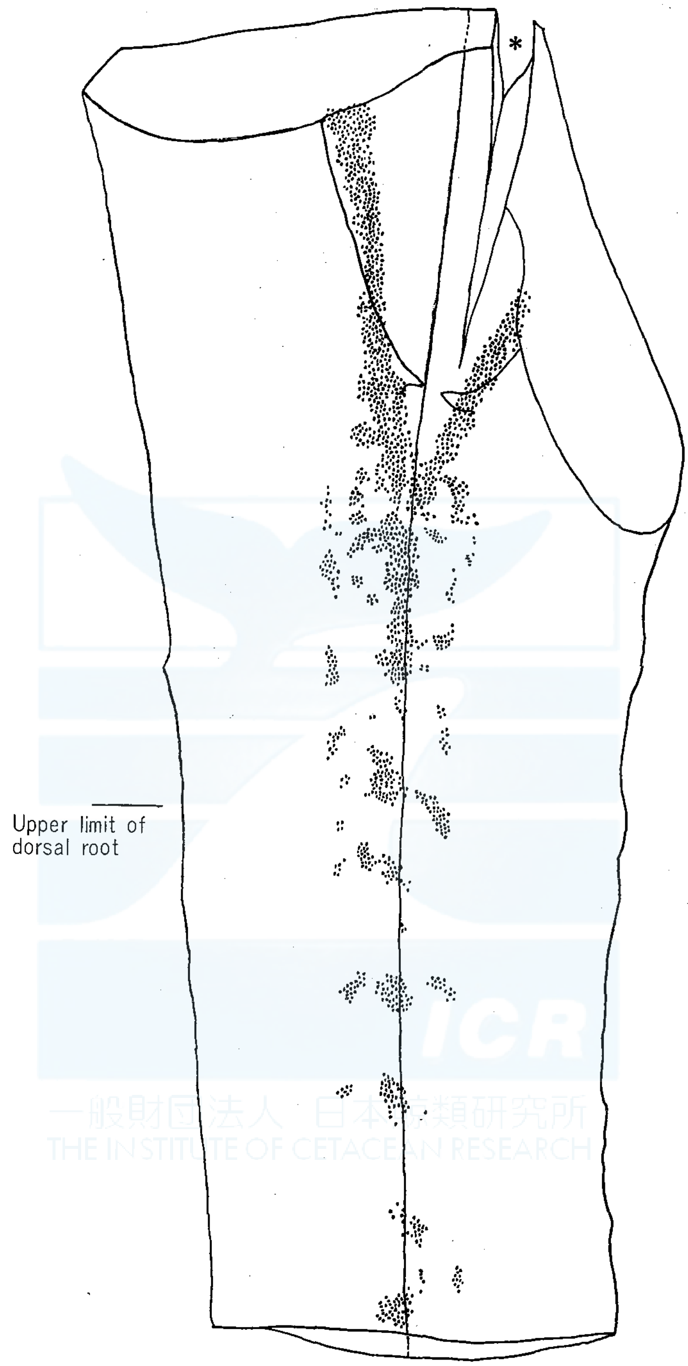

Fig. 3. Approximate distribution of cells superimposed from horizontal sections on the horizontal plane (dorsal view of the lower medulla and the 1st cervical cord) in case 2, Klüver-Barrera, ×4. *: Artificial cleft.

In the part lower than the obex, the dorsal vagal nuclei on both sides are recognized to approach gradually toward the midline, and a small number of cells are observed to be existent sporadically between those two nuclei (Figs. 2 and 3). At this level also, the ventrolateral ends of these nuclei, extend in places near the bundle of accessory nerve root running longitudinally at the dorsomedial edge of the lateral funiculus, and tend to for a separate group at some distance of the main nucleus.

At the lowest medulla, these main nuclei completely fuse with each other, and form a transversely long cell group occupying a large area approximately in the middle of the central gray substance (Figs. 1b., 2 and 3). Beside this collection of cells, there are found here and there discontinuous cell groups, islands-like in appearance, in proximity of the accessory nerve roots running longitudinally at the dorsomedial margin of the lateral funiculus (Fig. 1, b). In other words, the dorsal vagal nucleus at this level can be distinguished in two parts; one is the main nucleus formed by fusion of the left and right nuclei into a medial cell group, and the other is the lateral one islands-like in appearance, and at the dorsomedial edge of the lateral funiculus. In certain other sections, these two groups of cells are observable to be in complete continuity.

The medial cell group, as it goes lower, is decreased in number of cells in sections from the lowest medulla to the upper cervical cord, until it presents a bead-like appearance. This can be traced as far as the first cervical level, together with the islands-like lateral cell group (Fig. 1, c). As has just been mentioned above, the materials available did not have the part lower than the second cervical cord, so that the further extension could not be identified.

DISCUSSION

As to the origin nuclei of glossopharyngeal, vagus and accessory nerves, two nuclei, ventral and dorsal, are distinguished. The former is situated at about the center of the reticular formation of the medulla oblongata, termed usually nucleus ambiguus, and innervates the striated muscle. The latter is located at the dorsolateral or lateral to the hypoglossal nucleus, and has been thought to be the origin of the preganglionic fiber of the autonomic nerve which innervates smooth muscles and glands.

The dorsal vagal nucleus (or the dorsal motor nucleus of the vagus nerve) is clearly distiguished from its surrounding as a mass of middle sized nerve cells. Some authors call this dorsal vagal nucleus including termination nucleus (termed nucleus alae cinereae, on occasions) which is found immediately dorsolateral or lateral to that nucleus. It would be relevant to divide it into two and discuss separately instead of treating them as one entity: one as the termination nucleus consisting principally of small cells, another as the origin nucleus which is a group of the middle sized cells.

Olszewsky-Baxter (1954) and Mitchell and Warwick (1955) classified these nuclear cells into three types, but their classifications are different from each other, and neither of these seem to be applied to the materials in this study.

In the previous report (1966), I presented an idea to classify into four types the lowest structures of the dorsal vagal nucleus, after comparative anatomical investigations. In man, cat and rabbit, the lowest part of the nucleus decreases gradually cells in number as it gows downward and disappears at as low the level of the pyramidal decussation (type 4). The pacific right whale and the common dolphin also belong to this type. In the goat, the lower portion of this nucleus gradually shifts its position to the lateral side, across the pyramidal decussation or the internal arcuate fibers, and reaches the dorsomedial edge of the lateral funiculus of the upper cervical cord. This lower extention of the nucleus shows islands-like interruptions along the long axis of the spinal cord and disappears in the first cervical cord in common cases (type 1). Similar findings can be obtained in the calf, sheep, horse, camel, sea lion, dog and bear. In the pig, unlike those of type 1, two lower extensions are observed, one on the medial side and the other on the lateral side. At the lower medulla, the dorsal vagal nucleus is located at the dorsolateral to the central canal, and even in the portion lower than this level, extending cell groups can be traced intermittently in the same position until to the second cervical level, and in addition, as in case of type 1, laterally situated cell islands are still recognizable discontinuously along the dorsolateral edge of the lateral funiculus down to the second cervical cord (type 2). The medial cell group and lateral one are in direct continuity with each other in some sections, but in others there are found occasionally a bundle of thin fibers running between the two groups connecting them. In the case of the sperm whale, as in the pig, two lower extensions, medial and lateral, are identified, but unlike the finding in the pig, the medial cell groups on both sides are fused in the level from the lower part than the obex to the upper cervical cord, which is quite characteristic in the sperm whale (type 3).

Vermeulen (1915, 1916 and 1918) described that in llama, giraffe and porpoise, the dorsal vagal nucleus, at its lower end, constitutes the Nucl. commissuralis motorius vagi, by the fusion of two nuclei at the dorsal part to the central canal.

The lateral cell groups of the lower extension in three types, 1, 2 and 3, are well resemble the intermedio-lateral column (lateral horn nucleus) to develop into the thoracic cord, in respects of their position, size and massiveness of cells, and palely stained gray substance. These features were also noted in Takahashi's report (1913) on the comparative anatomy of the lateral horn nucleus. However, I have had no definitive evidence sofar that the dorsal vagal nucleus and the lateral horn nucleus of the thoracic cord are actually connected even in a stepping-stone-pattern. Similarly no reliable finding that the medial cell group is also connected with the intermedio-medial column at the former's lower part.

Of the lower extensions of the dorsal vagal nucleus, lateral cell group is positionally in a close relation with the accessory nerve root which runs longitudinally along the dorsomedial edge of the lateral funiculus, and it is imagined that these extensions send axons to this root. But the medial cell group did not give any special finding on a possible fiber connection, except there were observed bundles of thin fibers which connects the lateral cell group and the medial one in some sections.

As for the function of the lower extensions of the dorsal vagal nucleus, no explanation or suggestion could be offered derived from these anatomical findings gained in this study. The utmost that can be deduced is the functions and the innervating areas to be inferred from those of the dorsal vagal nucleus, and no further.

CONCLUSION

A detailed anatomical examination was made on the dorsal vagal nucleus and its lower extension in 2 cases of the sperm whale. At the lower part of the nucleus, the lower extension consists of the medial cell group and the lateral one at the portion from the lower medulla to the first cervical cord. Characteristic is the fusion of the medial cell groups in both sides on the midline below the obex. In both cell groups gradually decreased cells in number as they go down and continue sporadically in islands-like appearance. The existence of the lower extension was not identified below the 2nd cervical cord.

Following the discussion on the structure of the lowest part of the dorsal vagal nucleus in other mammals, I could reconfirm that the lower extension of the sperm whale belongs to the type 3 in my previous classification.

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EXPLANATION OF PLATE I

Fig. 1. Lower medulla below the obex (Section number 130 of block 2, Case 1), Kultschitzky, $\times 6$.

Fig. 2. First cervical cord (Section number 261 of block 1, Case 1), Klüver-Barrera, $\times 40$. $\rightarrow \leftarrow$: Midline.

Abbreviations in Text-figure 1 and Plate.

CA	Anterior horn	NA	Nucleus ambiguus
CP	Posterior horn	NDV	Dorsal vagal nucleus
FLM	Medial longitudinal fascicle	NFP	Nuclei of posterior funiculi
FS	Solitary fascicle	NNXII	Hypoglossal nucleus
LCG	Lateral cell group of the lower extension	NTDV	Nucleus of descending tract of the trigeminal nerve
MCG	Medial cell group of the lower extension	RNXI	Accessory nerve root
		VQ	Fourth ventricle

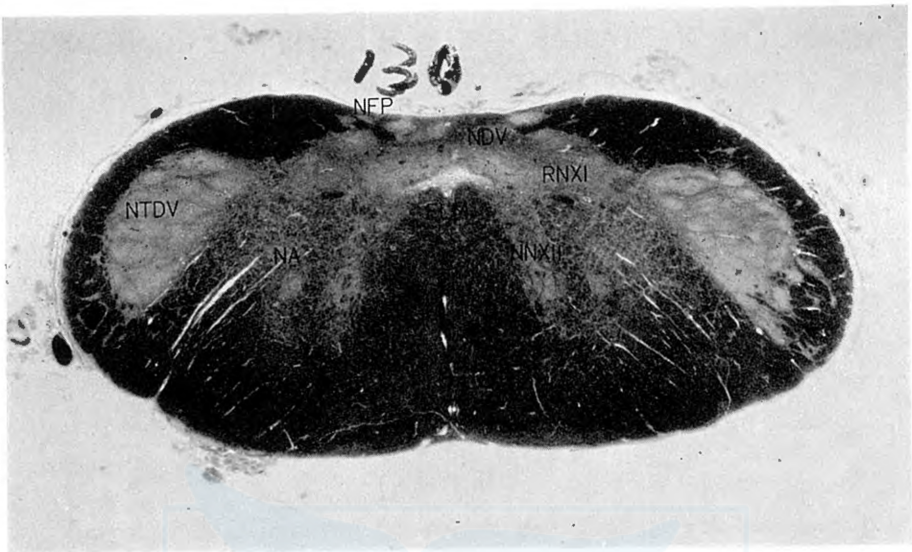

Fig. 1

Fig. 2

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THE INSTITUTE OF CETACEAN RESEARCH

RECORDS OF THE FRASER'S SARAWAK DOLPHIN (*LAGENODELPHIS HOSEI*) IN THE WESTERN NORTH PACIFIC

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ABSTRACT

Recently, the dolphins of *Lagenodelphis hosei* Fraser, 1956 have been collected and also sighted sporadically in the certain places of the world. From Kamogawa (JAPAN) and Kaohsiung (TAIWAN) both of which located in the Western North Pacific, each one specimen has been collected and identified as this species as a result of observations on the external character and osteological study.

Considered the places and dates of collection of this species in the Western North Pacific, the dolphin of *Lagenodelphis hosei* might be in the nature of warm water preference. In summer, when the Kuroshio current is dominant, the distribution of the species might be widened to north and may sometimes reach the east coast of Japan to the degree of 35°N.

INTRODUCTION

The Sarawak dolphin (*Lagenodelphis hosei*), was named by F. C. Fraser of the British Museum (Natural History) in 1956. His investigation was on the skeleton found in Lutong River, Borneo, by C. Hose in 1895. However, nothing had been known of the external characters of the whole body of this form until recently. Then this species of dolphins and also sighting records have been collected sporadically in Australia, in South Africa and in the Eastern North Pacific and some other places. Among many dolphin specimens collected from the Western North Pacific since 1969, a few were identified as this species.

KAMOGAWA SPECIMEN

Environmental condition at stranding

This specimen was first found by a local people in passing on the sand beach of Hamaogi, Kamogawa City, on May 25, 1972. The report of the incident was brought to the Kamogawa Seaworld but when one of the attendants reached to the

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scene of stranding an hour later, the animal had already expired. The lower jaw must have bamped with something was broken about 10 cm from its top. Fresh hemorage from the wound told him that the animal had died shortly before. The specimen was thought to be a white sided dolphin (*Lagenorhynchus obliquidens*) at first, though a little difference was recognized in the shape of the dorsal fin and in the body colour. But later, as a result of cooparative study, it was identified as *Lagenodelphis hosei*.

It seems that the animal was carried to the coast of Japan on the Kuroshio current. The northern limit of the current is at around the Boso Peninsula, which located at nearly central part of the Islands of Japan, and Kamogawa City is on the outer coast of the Peninsula. The surface temperature of Boso waters about the

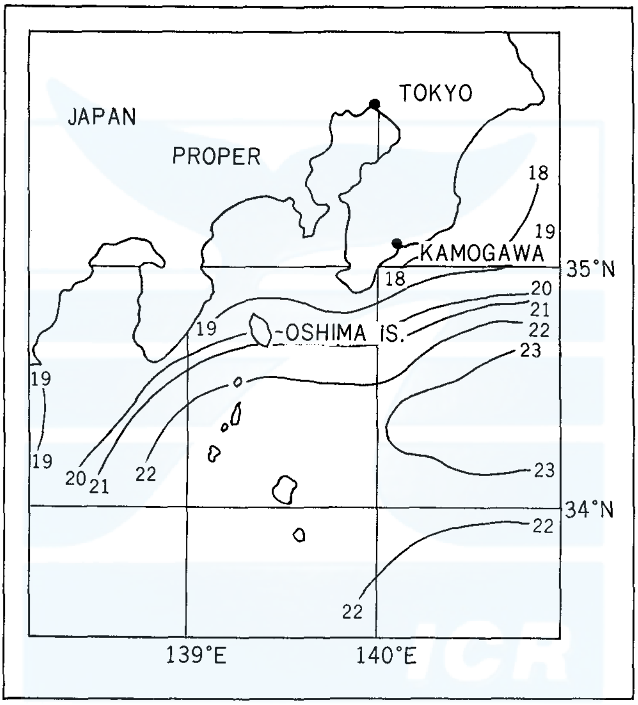


Fig. 1. Distribution of surface water temperature (°C) in 21–27, May 1972.

time of stranding was distinctly higher than usual as shown in Fig. 1. From May 14–20, surface temperature was 16°C–18°C in shallow waters and 19°C–20°C in deep waters. From May 21–27, (the time of stranding), influenced by approach of the Kuroshio current, it was up to be 18°C-23°C in both shallow and deep waters.

External appearance

The external measurements are as indicated in Table 1. The body shape of this species is a close resemblance to that of the *Lagenorhynchus obliquidens*, though relative differences are in the short snout, the equilateral triangular shaped dorsal

TABLE 1. EXTERNAL MEASUREMENT OF KAMOGAWA SPECIMEN

	Sex		Male	
	Number of teeth		36 | 36 / 34 | 36	
	Measurement		mm	%
1.	Length, total		2350	100.0
2.	Length, tip of upper jaw to apex of melon		30	1.3
3.	Length, tip of upper jaw to center of eye		280	11.9
4.	Length of gape		240	10.2
5.	Length, tip of upper jaw to external auditory meatus		335	14.2
6.	Length, tip of upper jaw to blowhole		310	13.2
7.	Length, tip of upper jaw to anterior insertion of flipper		410	17.4
8.	Length, tip of upper jaw to tip of dorsal fin		1033	43.9
9.	Length, tip of upper jaw to midpoint of umbilicus		1080	45.9
10.	Length, tip of upper jaw to midpoint of genital aperture		1565	66.5
11.	Length, tip of upper jaw to center of anus		1695	72.1
12.	Projection of upper jaw beyond the lower		10	0.4
13.	Girth, at anterior insertion of flipper		963	41.0
14.	Girth, at axilla		1069	45.4
15.	Girth, at anterior insertion of dorsal fin (maximum)		1163	49.5
16.	Girth, at anus		742	31.5
17.	Maximum height of body, including dorsal fin		565	24.0
18.	Length of eye		27	1.1
19.	Width of blowhole		25	1.1
20.	Length of flipper, anterior insertion to tip	L.	260	11.1
		R.	255	10.9
21.	Length of flipper, axilla to tip	L.	175	7.4
		R.	180	7.7
22.	Width of flipper, maximum	L.	84	3.6
		R.	82	3.5
23.	Dorsal fin, height		175	7.4
24.	Dorsal fin, length of base		300	12.8
25.	Width of tail flukes, tip to tip		530	22.6
26.	Anterior insertion of tail fluke to notch	L.	152	6.5
		R.	155	6.6
27.	Anterior insertion of tail fluke to tip	L.	325	13.8
		R.	322	13.7
28.	Distance, tip of tail fluke to notch	L.	270	11.5
		R.	270	11.5

fin, the smaller flippers located at a little anteriorer parts and the smaller tail flukes.

The whole dorsal surface is slate black while the ventral surface is white. Between these distinct divisions, complicated patterns decorate the sides. A black band extends from the upper base of the snout to meet with another black band which begins at the central part of lower jaw, at the angle of gape. The joint widened black band run through the eye to branch off at a little anteriorer part than the base of flipper. One of the branches ends at the base of flipper, while the other extends further to draw a gentle curve with a little narrower band to the anus. Then the band widened once again and extends to the swelling at a posteriorer

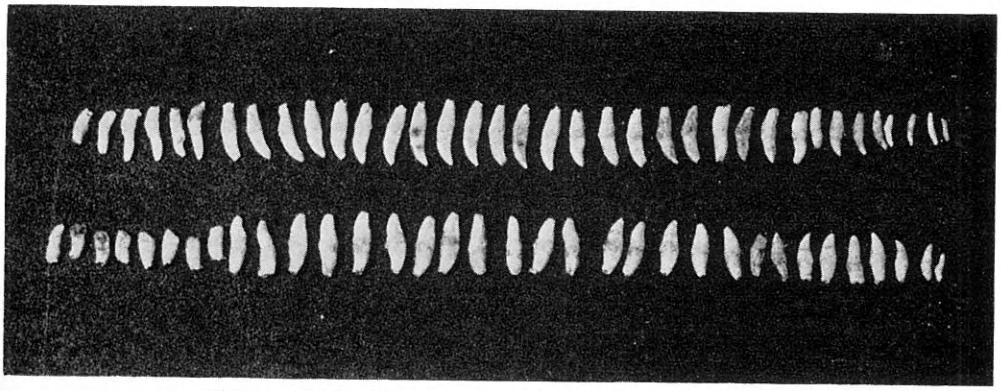
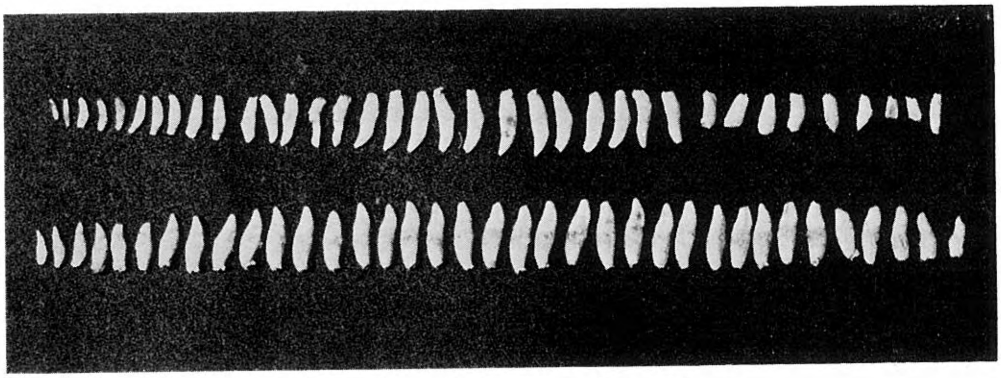


Fig. 2. Teeth of Kamogawa specimen. Top left: Upper right row, Bottom left:

part than the anus. Along with these black band pattern, a gray band from the head to the tail run nearly parallel to it just above, which become wider to the posterior. In addition to these complicated pattern, another, more distinct black band run around the posterior half of the base of flipper, from which a black line extends toward the ventral center. The line is so delicate that it seems as if it were drawn with the tip of a small brush and is fading at the midway between the base and the ventral center and this line does not extend anteriorly than the line between the front of the flipper base. Besides these main bands, there are some detail illustrations. A short black band around the eye extends to the base of rostrum and is joinning into the main black band, so that it is less distinct. Two delicate lines run from the angle of gape to the tip of snout, of which the line along the upper jaw is fading into the dorsal black and that along the lower jaw hemmed the edge which makes clear contrast with the basic white. Ventral view is generally white with two black bands which run along each side, are coming close each other at the anus and are joinning into one to reach to the tail. The flippers and the tail flukes are all black.

Measurements of the skeletons

As it is seen in Table 2 that in comparison of the skull of Kamogawa specimen with the former three, there is no apparent differences except that the parietal width of this specimen is slightly broader and that the maximum width of premaxillae of which is narrower. The snout of Kamogawa specimen is relatively broader than those of former three and the length breadth ratio of it is 1.80 and 1.83. The vertebral formulas are also indecated in Table 2, in which Kamogawa specimen has 15 thoracic vertebrae, while South African specimen has 16. Number of lumber vertebrae is same in all former three, but only in Kamogawa specimen, number is 20. Number of caudal bones vary among the specimens for an example, Kamogawa specimen indicate 39; this number is bigger than any other by 2 to 5. Number of chevrons is 21 in Sarawak specimen and 31 in Kamogawa specimen. (Fig. 3) Difference by 10 is considerable. The first, the second and the 29 to the 31 chevrons



lower right row; Top right: Upper left row, Bottom right: Lower left row.

are being separated into two pieces. (X-ray photos of caudal vertebrae and chevron bones had been taken before dissection.) The phalaengial formula of Kamogawa specimen is I: 2, II: 9, III: 6, IV: 3 and V: 2. The number is same in both flippers, but in the Sarawak flippers, different number is in I, III and V. X-ray photo of the flippers is in Plate V.

The measurements of vertebrae is shown in Table 3. Among cervical vertebrae, the first and the second bones are inherently fused together and these joint two and the third and the fourth are fixed in order under the vertebral corps, and the neural arch of the fifth and the sixth are fixed. These fusion of the bones are supposed to be a phenomenon of ageing. In the picture of the vertebral column, shown in the Plate IV, the projects of neural spine are short in the 12th to the 15th caudal vertebrae. However, the shape was modified during the process of treatment, not a transformation of the bones. The shape of rib cage is shown in Plate V and the measurements of ribs are in Table 4. The photographs of the hyoid bones are in Fig. 4, and the measurements of them are in Table 5. The sternum is divided into three pieces and the dimentions of it is in Table 6. The left pelvic bone was broken at the time of collection, straight length of the right one is 106 mm and its breadth at the middle is 11 mm, the shape of it is in Fig. 5. The scapulae is shown in Fig. 6 and dimensions of it is in Table 7. The measurements of humerus, radius, ulna, phalaengial and chevron bones are not indicated here on account of limited space.

Other results

1. Weight of the internal organs is shown in Table 8. Compare the internal organs of this specimen with those in other species, apparent differences are in the lower lobe of lung which is more squarely built in the others and in the testes of it that, size of testis is quite different in each other.

2. Examination on the contents of stomach revealed only beaks of squid and otoliths of fish as seen in Table 9. Considered that almost all squids and fish are deep water trait, this species of dolphins might eat food in the night and the species which they feed on are equal with those which the dolphins of *Stenella caeruleoalba*

TABLE 2. SKELETAL MEASUREMENTS AND MERISTICS OF FIVE SPECIMENS OF *LAGENODELPHIS HOSEI* FRASER 1956, INCLUDING THE HOLOTYPE.

Measurement or count	Sarawak specimen* (BMNH 1895.5.9.1 physically mature)	South African** female PBB 71/3 (SAM 36323) physically mature	South African** male PBB 71/4 (SAM 36323) physically mature	Western Pacific*** male KSW 72/5 (TKO 3--) physically mature	Western Pacific*** sex unknown HCY 69/10 (TKO 310) calf
Condylobasal length	413 mm (100%)	429 mm (100%)	440 mm (100%)	423 mm (100%)	415 mm (100%)
Length of rostrum	226 (54.7)	240 (55.9)	241 (54.8)	235 (55.5)	232 (56.1)
Width of rostrum at base	121 (28.3) (53.5% of rost. ln.)	119 (27.7) (40.6% of rost. ln.)	130 (29.5) (53.9% of rost. ln.)	128 (30.2) (54.5% of rost. ln.)	113 (27.0) (48.7% of rost. ln.)
Width of rostrum at midlength	71 (17.2)	71 (16.6)	80 (18.2)	77 (18.2)	62 (14.9)
Width of rostrum 60 mm anterior to antorbital notches	85 (20.5)	86 (20.0)	101 (23.0)	91 (21.5)	78 (18.8)
Least supraorbital width	202 (48.8)	202 (47.1)	218 (49.5)	209 (49.4)	195 (47.0)
Preorbital width	207 (50.1)	207 (48.3)	223 (50.7)	213 (50.3)	197 (47.5)
Postorbital width	230 (55.7)	229 (53.4)	247 (56.1)	234 (55.3)	210 (50.0)
Zygomatic width	225 (54.5)	225 (52.4)	240 (54.5)	229 (54.1)	broken
Parietal width	170 (41.2)	161 (37.5)	177 (40.2)	190 (44.9)	161 (38.8)
Maximum width of premaxillae	82 (19.9)	78 (18.2)	83 (18.9)	70 (16.5)	74 (17.8)
Length of upper right toothrow	194 (46.9)			201 (47.5)	207 (49.9)
Length of upper left toothrow	194 (46.9)	193 (45.0)	213 (48.4)	199 (47.0)	203 (48.9)
Length of lower right toothrow	194 (46.9)			195 (46.0)	207 (49.9)
Length of lower left toothrow	193 (46.7)	198 (46.2)	207 (47.0)	192 (45.3)	208 (50.1)
Length of right ramus	349 (84.5)			356 (84.1)	355 (85.5)
Length of left ramus	350 (84.7)	367 (85.5)	375 (85.2)	broken	357 (86.0)
Coronoid height of left ramus	70 (16.9)	65 (15.2)	71 (16.1)	70 (16.5)	66 (15.9)
Length of symphysis	36 (8.7)	37 (8.6)	31 (7.0)	32 (7.5)	65 (15.6)
					41 (9.9)
Number of teeth	43 | 44 / ca. 40 | 42	40 | 42 / 39 | 39	42 | 42 / 41 | 40	40 | 42 / 37+ | 40	41 | 39 / 41 | 42
Total number of vertebrae	80+2	78	78+1	81	
Vertebral formula	C7 T15 L21 C37±2	C7 T16 L21 C34	C7 T16 L+C55±1	C7 T15 L20 C39	

Percentage of condylobasal length in parentheses. * British Museum (Natural History, London, holotype).
** South African Museum, Capetown. *** Ocean Research Institute, University of Tokyo.

TABLE 3. DIMENSIONS OF VERTEBRAE (mm)

	Vertebra No.	A	B	C	D	E	F	G		Vertebra No.	A	B	C	D	E	F	G
C	1		37	81	94	165	22	37	Ca	1	23	40	41	133	172	20	9
	2	17[1]				81				2	23			132	165		
	3				65	52				3	23			129	159		
	4				70	44				4	23			125	157		
	5	7[1]			68	49				5	23			122	149[2]		
	6				67	53				6	23			119	151		
	7	4	30	37	63	51	21	32		7	23			117	149		
D	1	10	32	40	81	112	23	37		8	23			115	150		
	2	14			95	125				9	23			113	146		
	3	19			96	129				10	23			109	139		
	4	24			98	127				11	23	42	45	106	137	10	6
	5	27			106	131				12	23			97[2]	135		
	6	32			107	138				13	24			88[2]	126		
	7	33	31	32	116	148	28	32		14	24			84[2]	117		
	8	33			118	152				15	24			80[2]	108		
	9	34			125	164				16	25			90	96		
	10	35			133	174				17	25			86	80		
	11	35			133	188				18	26			84	60		
	12	36			139	194				19	27			78	49		
	13	36			145	210				20	28	42	41	76	45	4	4
	14	34			149	244				21	29			72	39		
	15	34			151	256				22	29			66	35		
L	1	32	35	37	148	247	25	18		23	28			62	33		
	2	30			153	241				24	27			53	32		
	3	30			156	240				25	25	39		44	33	1	1
	4	29			161	233				26	25			35	32		
	5	29			164	233				27	15			28	33		
	6	27			164	230				28	12			22	32		
	7	27			163	227				29	10			18	32		
	8	26			165	223				30	10			17	32		
	9	25			165	218				31	10			16	29		
	10	25			166	216				32	9			14	27		
	11	25	37	39	162	215	27	13		33	8			13	25		
	12	24			161	206				34	8			11	23		
	13	24			157	205				35	7			9	20		
	14	24			153	204				36	7			8	17		
	15	23			152	195				37	6			6	14		
	16	23			150	193				38	4			5	9		
	17	23			145	188				39	2			2	3		
	18	23			143	185[2]											
	19	24			138	188											
	20	23			136	181											

A: Length of body at ventro-laterally below the transverse process. B: Height of body at front end. C: Breadth of body at front end. D: Total height from anterior bottom. E: Bilateral breadth of transverse processes. F: Greatest height of neural canal. G: Greatest breadth of neural canal.

[1] Each vertebra is united.

[2] Broken.

TABLE 4. DIMENSIONS OF RIBS OF KAMOGAWA SPECIMEN (mm)

No. of ribs		A		B		C	
		L.	R.	L.	R.	L.	R.
Vertebral ribs	1	180	185	23	22	19	19
	2	281	288	15	16	25	26
	3	360	360	10	10	32	32
	4	400	402	9	8	37	37
	5	414	418	8	8	39	38
	6	380	380	8	8	—	—
	7	371	376	8	12*	—	—
	8	369	375	8	7	—	—
	9	371	375	8	8	—	—
	10	365	365	8	7	—	—
	11	345	345	7	7	—	—
	12	315	315	7	7	—	—
	13	307	312	7	7	—	—
	14	284	284	4	5	—	—
	15	196	192	4	4	—	—
Sternal ribs	1	81	82	14	14		
	2	89	89	13	13		
	3	110	111	9	9		
	4	122	121	8	7		
	5	130	128	6	6		
	6	138	137	6	6		
	7	144	145	6	7		
	8	154	146	6	6		
	9	133	**	6	**		
	10	92	93	4	4		

A: Length along visceral border. B: Breadth at middle. C: Distance between two heads.
* Deformed
** Lost

Fig. 3. Chevron bones of Kamogawa specimen.

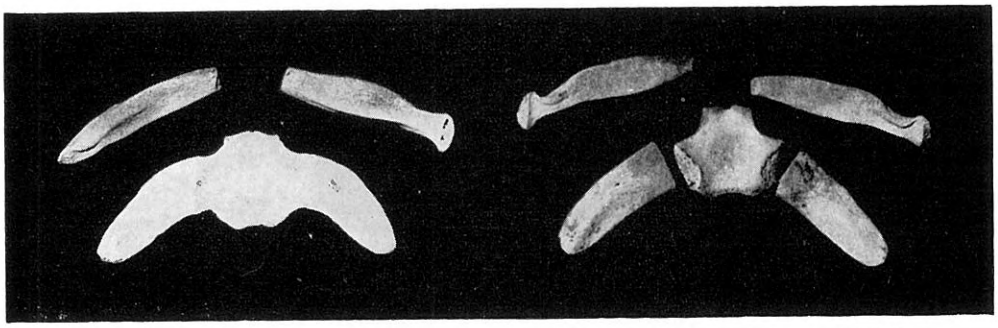
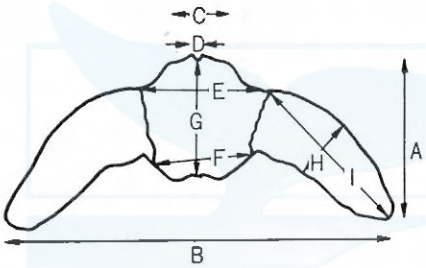


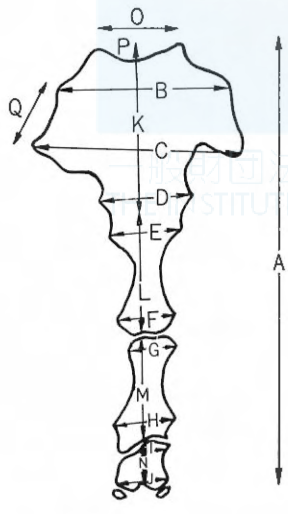
Fig. 4 Hyoid bones of Kamogawa specimen (left) and Kaohsiung specimen (right)

TABLE 5. DIMENSIONS OF HYOID BONES OF KAMOGAWA SPECIMEN (mm)



A		69
B		138
C		26
D		1
E		49
F		29
G		47
H	L.	25
	R.	25
I	L.	73
	R.	71
Thyrohyals straight length	L.	89
	R.	91
Thyrohyals breadth at middle	L.	19
	R.	20

TABLE 6. DIMENSIONS OF STERNUMS OF KAMOGAWA SPECIMENS (mm)



A	216	J		27
B	94	K		69
C	113	L		66
D	52	M		54
E	40	N		27
F	39	O		44
G	38	P		9
H	39	Q	L.	29
I	26		R.	32

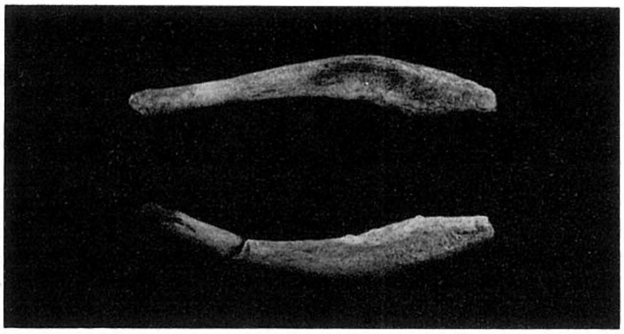


Fig. 5. Pelvic bones of Kamogawa specimen. upper: right (left of the picture is anterior)

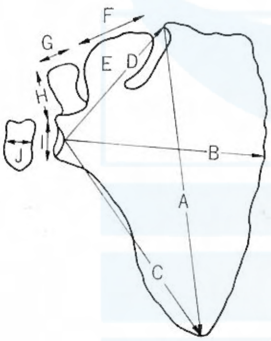


Fig. 6. Scapulae of Kamogawa specimen.

TABLE 7. DIMENSIONS OF SCAPULAE OF KAMOGAWA SPECIMEN (mm)

Measured part	A	B	C	D	E	F	G	H	I	J
Left	193	119	144	84	43	45	19	28	28	18
Right	188	121	146	96	58	49	19	27	28	20

TABLE 8. WEIGHT OF ORGANS IN PROPORTION TO THE BODY WEIGHT

235 cm M

Body weight		129 kg	100%	Kidney	L.	390	0.30
Esophagus		150 g	0.11%		R.	380	0.29
Heart		1010	0.78	Adrenals	L.	7	0.0053
Lung	L.	1720	1.33		R.	8	0.0058
	R.	1540	1.19	Testis	L.	990	0.76
Trachea		150	0.11		R.	260	0.20
Stomach		1200	0.93	Thyroid		17	0.01
Spleen		69	0.05	Tongue		500	0.38
Liver		3160	2.44	Intestine		2660	2.06
Interseptum		1050	0.81	Total weight		16112 g	12.49
Pancreas		140	0.10	Intestine Length		13.3 m	

TABLE 9. NUMBERS AND KINDS OF FISH OTOLITHS, SQUID BEAKS FOUND IN STOMACH AND INTESTINE OF *LAGENODELPHIS HOSEI* COLLECTED AT KAMOGAWA, JAPAN, MAY 1972.

Kind of fishes and squids eaten		Stomach	Intestine	Total
Argentinidae				
Argentina semifascista			1	1
Coryphaenoididae		17		17
Gonostomatidae				
Ichtyococus elongatus		310	37	347
Gonostomatid			3	3
Moridae				
Physiculus sp.?		8	3	11
Myctophidae				
Diaphus elucens?		10	10	20
Lampanyctus jordani			2	2
Sternoptychidae				
Polyipnus asteroides		71	4	75
Unidentified		2	1	3
Total		418	61	479
Gonatidae	upper beak	1		1
	lower beak	1		1
Loliginidae	lower beak		1	1
Ommastrephidae	upper beak	1		1
Onychoteuthidae	upper beak	2		2
	lower beak	1		1
Total		6	1	7

* 6 small stone found in stomach.

are on, so it can be said that they eat food without diving into the depth.

3. Parasitical examination revealed three Nematoda and one *Tetrabothius* sp. from the first stomach and 35 *Bolbosoma* sp. from the intestine, and number of cysts of Cestoda were found in the blubber around the anus about 30 cm^2.

KAOHSIUNG SPECIMEN

This specimen was collected by H. C. Yang at the fishmarket in Kaohsiung City on Oct. 31, 1969.

Precede to this incident, Yang had come across with a male dolphin at the fishmarket on Oct. 24, 1969, length of which was 164 cm and its face was a close resemblance to the present specimen, but he could not be able to collect it. The dental formula of the dolphin was $\frac{39 \quad 40}{40 \quad 40}$ (out of gum).

Unfortunately, Kaohsiung specimen is only a head portion, the body portions had already been sold as lumps of meat when the skull was found. Because of that, we could not collect body length nor identify sex of the animal and can not tell how it had been grown.

Nishiwaki saw the photographs of this specimen while he was passing Kaohsiung on his way home from the expedition on the fresh water river dolphins in East Pakistan (now Bangladesh). The photographs drew his attention and Nishiwaki and Yang, by joint effort, excavated the buried skull, cleaned it by boiling and sent it to the Ocean Research Institute in Tokyo. When Yang came up to Tokyo in Oct. 1970, as a research student of the institute, they again got together and studied on the present specimen. As a result, they identified it as a *Lagenodelphis hosei*. The specimen consists of a skull and a hyoid bones. The measurement on these are shown in Table 2 and Plate VI. The dental formula was counted as $\frac{39 \quad 37}{38 \quad 39}$ at collection but later it was concluded as $\frac{41 \quad 39}{41 \quad 42}$ at measurement.

Compared the measured values of the present specimen with those of the Sarawak specimen (holotype) or other specimens of this species in the South African Museum (by the kindest help of Dr. Perrin), this skull is slenderer in shape and the beak of which is longer than that of the others.

The shape of the hyoid bones are well fit to those of the holotype. It can be said that the present skull is of a young female.

ACKNOWLEDGMENTS

At the end of this report, authors express their sincere gratitude to the each attendant of the Kamogawa Seaworld for their kind cooperation, and especially to Mr. Tasuku Nagasaki who gave help to the parasites identification. Authors also present appreciation to Dr. Hitoshi Hattori of the Tokyo University of Fisheries for his help in collecting documents, and Dr. W. H. Dawbin of the University of Sydney, Dr. W. F. Perrin of National Marine Fisheries Service, Fishery-Oceanography Center, USA and Dr. P.B. Best of Division of Sea Fisheries, South Africa for their kind help by allowing examination on their collections of the Sarawak dolphin and reference to the data of before publishing. Nishiwaki is much indebted to the valuable advices of Dr. F. C. Fraser of the British Museum (Natural History) at the identification on the present specimen.

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EXPLANATION OF PLATES

PLATE I

External features of *Lagenodelphis hosei*, Kamogawa specimen.
Top to bottom:
Lateral, ventral and dorsal view.

PLATE II

Skull of *Lagenodelphis hosei*, Kamogawa specimen.
Top to bottom: Dorsal, ventral and lateral view.

PLATE III

Skull and mandible of *Lagenodelphis hosei*, Kamogawa specimen.
Top to bottom:
Posterior view of skull.
Dorsal and lateral view of mandible.

PLATE IV

Vertebrae of *Lagenodelphis hosei*, Kamogawa specimen.
Top to bottom:
Cervical and dorsal, lumbar, caudal (1–19) and caudal (20–39) vertebrae.

PLATE V

Ribs and X-ray photographs of flippers of *Lagenodelphis hosei*, Kamogawa specimen.
Top to bottom:
Rib cage, right and left flipper.

PLATE VI

Head and skull of *Lagenodelphis hosei*, Kaohsiung specimen.
Top to bottom:
Left side; dosal, lateral and ventral view of head.
Right side; dorsal, lateral and ventral view of skull.

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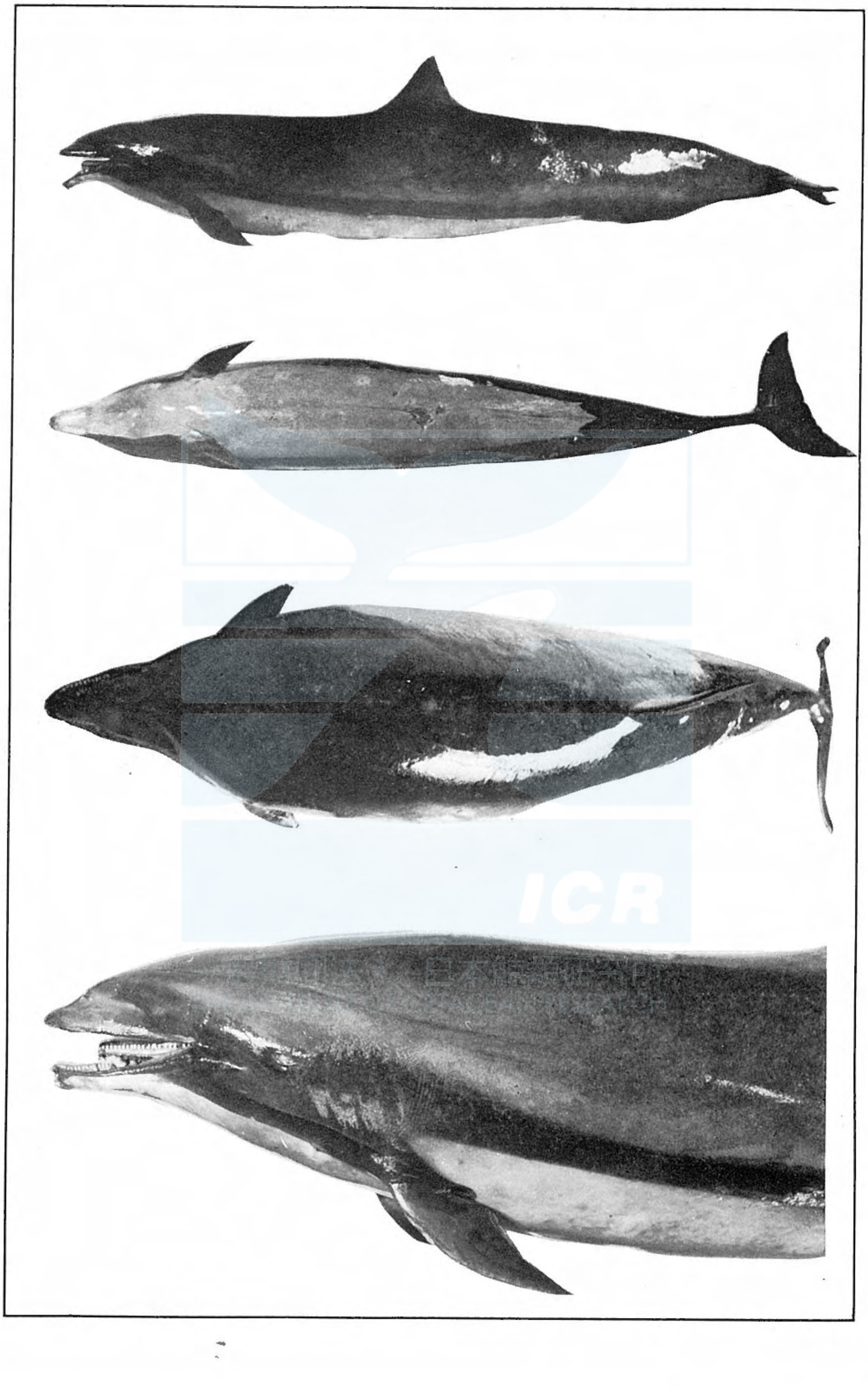

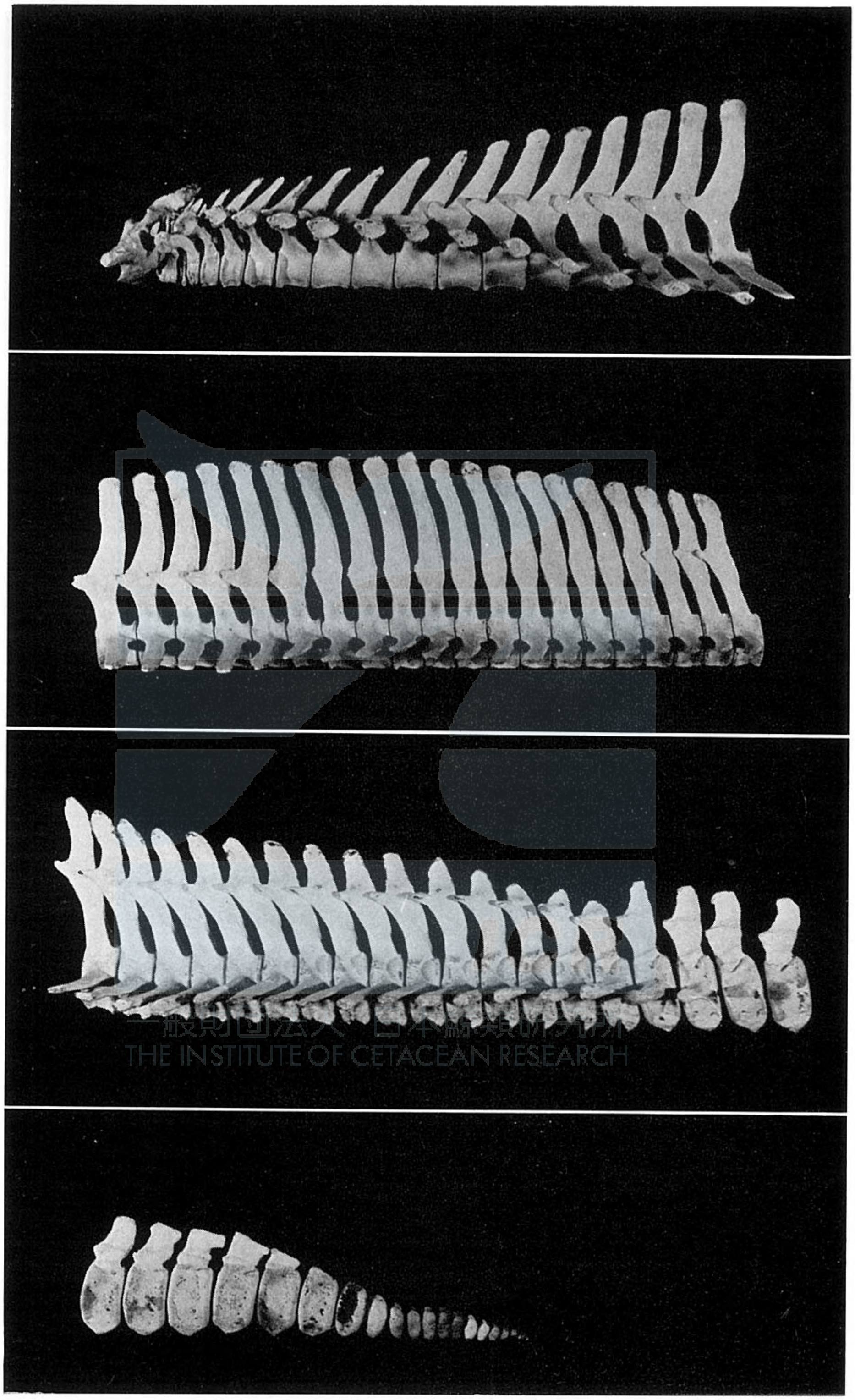

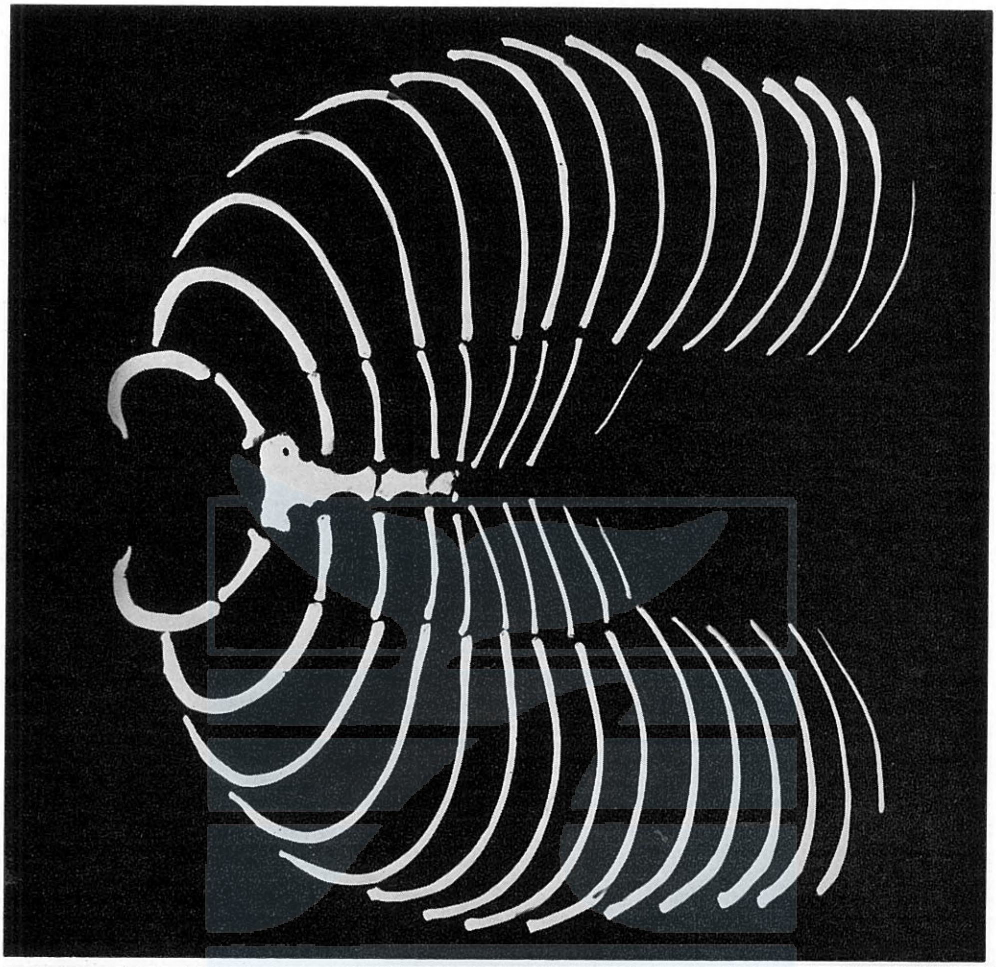

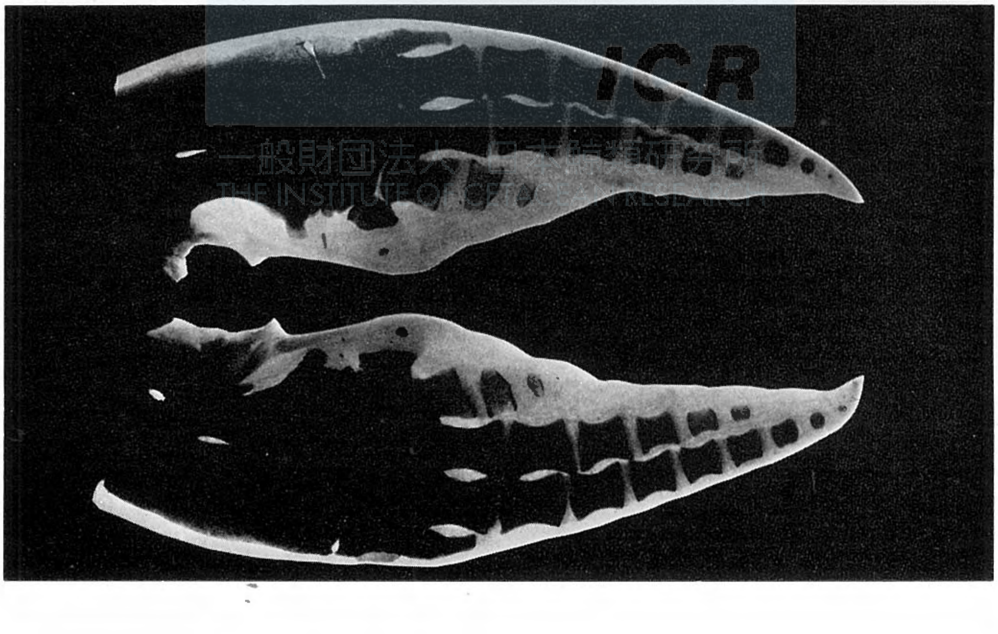

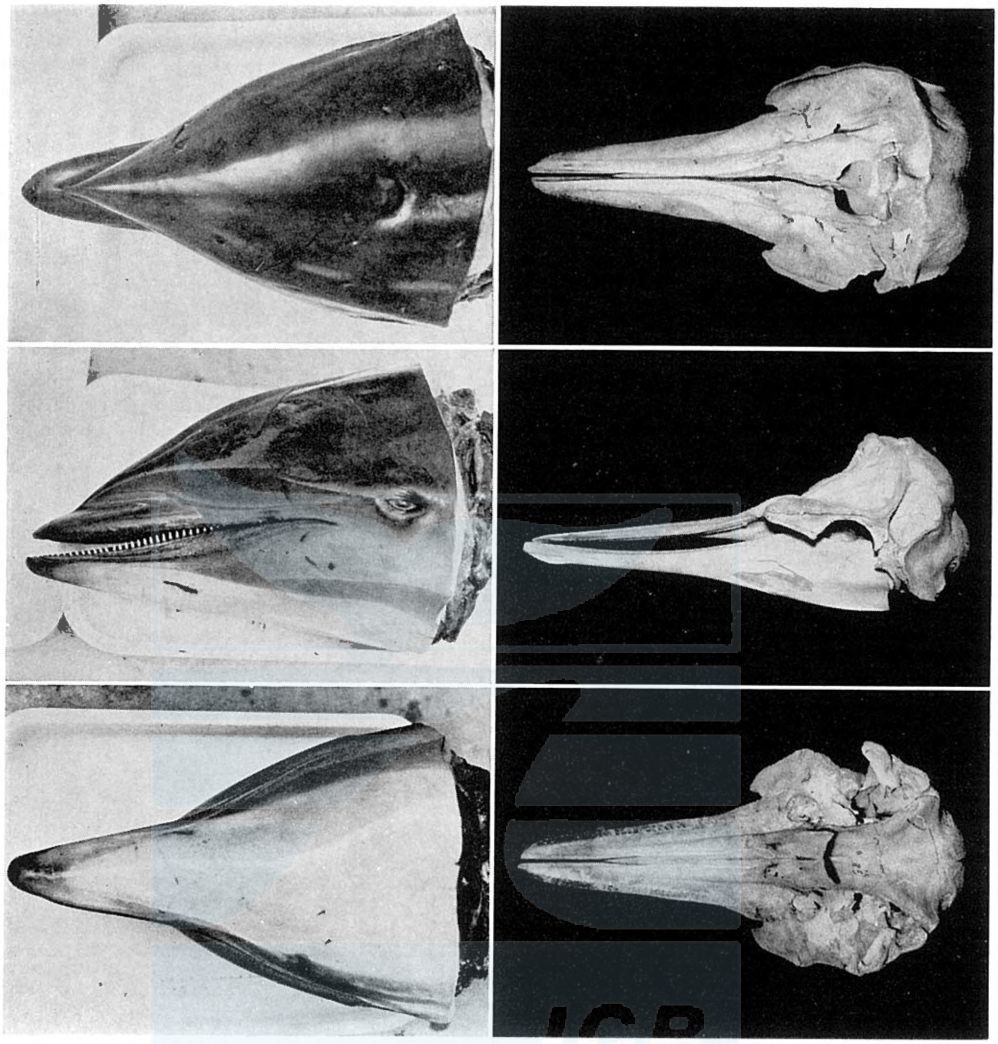

FOOD OF *STENELLA CAERULEOALBA*

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ABSTRACT

Food contents of 27 stomachs of *Stenella caeruleoalba* taken from two schools were examined. In total, 5410 fishes were identified by otolith and 1,448 fishes by facial bones. Four species from 3 genera and 3 families were identified by otolith and 31 species from 14 genera and 11 families by facial bones. Two species from 2 genera and 2 families were observed in 35 squids contained and 4 species from 4 genera and 3 families in 1,971 shrimps. Myctophid fishes and *Bentheogennema borealis* were dominant in number in the food components. All species identified are pelagic or semipelagic. The estimated body length of fishes, the mantle length of squids, and the total length of shrimps are in the range of 60–300 mm, 95–190 mm, and 38–130 mm, respectively. The number of specimens of food components with luminous organs amounted to 74% of the total number of all specimens identified.

INTRODUCTION

Schools of blue white dolphin, *Stenella caeruleoalba* are found around the coast of Oshima Island mostly from southeast to north (Tobayama, 1969) and several thousands individuals of this animal are caught commercially in Sagami Bay throughout autumn and early winter (Tobayama, 1969; Kasuya, 1972). Accordingly, this animal is considered to migrate into Sagami Bay in autumn and early winter.

The study of the food and the food habits of this population may be important for recognizing the behavior and a cycle of ecosystem to which this animal belongs.

In the present paper, species, numbers and sizes of the food specimens in the stomach contents of 27 blue white dolphins from two schools were studied.

MATERIAL AND METHOD

In this study, contents of the first stomach were examined. The dolphins were chosen randomly from 13 and 14 individuals of schools A and B respectively. Both schools were found in Sagami Bay (Fig. 1) and driven into Kawana harbor by fishermen. Biological examination suggests that school A is considered to be a breeding school consisted of sexually maturged animals and their calves, and school B to be a nonbreeding school consisted of sexually immatured animals. Other

TABLE 1. BIOLOGICAL INFORMATION OF SCHOOLS A AND B, *STENELLA CAERULEOALBA.*

Items			School A	School B
Time of found			09 : 00 2 Dec. 1970	06 : 30 10 Dec. 1970
Position of found			34°49′N 139°24′E	34°49′N 139°25′E
Time of expire			13 : 00 2 Dec. 1970	09 : 00 10 Dec. 1970
School size			256	88
No. of individuals examined			255	77
No. of stomachs collected			13	14
Range of body length			108–250 cm	182–245 cm
School composition	M	female	54	0
		male	56	16
	IM	female	59	16
		male	86	45

M and IM indicate mature and immature respectively.

information is shown in Table 1.

The samples were taken to the laboratory after they had been freezed to −20°C. In the laboratory, specimens were separated into three groups, fishes, squids and shrimps, then their species were identified.

As it has been formerly done (Kusaka, 1969, 1970; Kusaka and Thuc, 1972), fish species were used to be identified mostly by facial bones mainly by the urohyals, and partly by the otoliths. The number of specimens was counted by urohyals and otoliths. All otoliths refered in this report were sagittae. The body length of fish specimens was estimated from the size of the urohyal. Squid species were identified only by the half digested body and not by the beaks. The number of specimens, however, was counted by the beaks. Shrimp species were identified by the half digested individuals by the help of Dr. Y. Aizawa, and the number of specimens was also counted.

RESULT

1. The weight of stomach content

The weight of stomach contents of 26 dolphins is shown in Table 2. The average weight of those from school A is almost similar to those from school B.

2. Fish

In 27 stomachs of the dolphins 1,448 fishes found, were identified by facial bones and 31 species from 14 genera and 11 families were detected (Table 3). Among these fishes, 1,234 fishes of 13 species were found in both schools, 210 fishes of 15 species, were found only in school B and 4 fishes of 3 species, were found only in school A (Table 3).

Myctophid fishes are dominant in number amounting to 63.9% of the total number.

Myctophidae spp., *Polyipnus spinosus*, Gonostomatidae sp. and Chauliodontidae spp. have luminous organs.

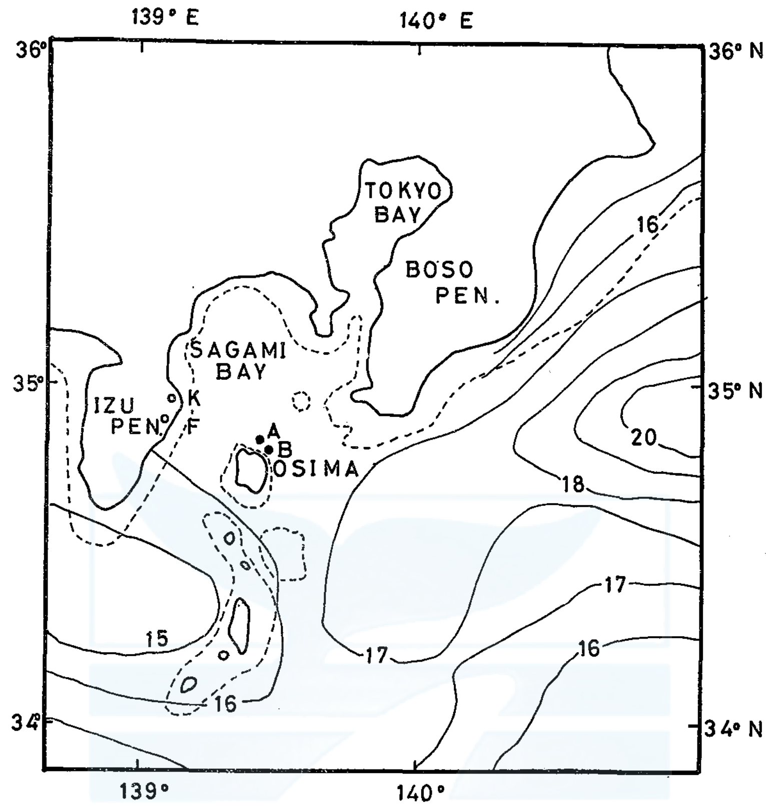

Fig. 1. Surface isothermal line around Sagami Bay in Dec. 1970 (Japanese Maritime Safety Agency, 1970), with the position of finding of the schools A and B. Broken line indicates 200 m contour line of the depth. K and F indicate Kawana and Futo.

The ranges of estimated body length of fish species are shown in Fig. 3.

By the otoliths 5,410 fishes were identified and represented 4 species belong to 3 genera and 3 families. These four species are *Diaphus elucens*, *Polyipnus spinosus*, *Diaphus coeruleus* and *Argentina semifasciata*.

The average number of fishes in the stomachs counted by the number of otoliths is higher than that counted by the number of urohyals (Table 2, Fig. 2). This difference in number may indicate the fact that otoliths remain in the first stomach longer than urohyals. Possibly, the process of digestion is more proceeded in the stomachs from school A than in those from school B, because the ratio of the number of urohyals to that of otoliths is lower in the stomachs from school A.

3. Squid

Thirty five squids found in 19 stomachs were identified by the half digested specimens and represented 2 species from 2 genera and 2 families (Table 4).

The number of individuals and the mantle length frequency of these two

TABLE 2. THE CONTENT OF FIRST STOMACHS OF *STENELLA CAERULEOALBA*.

School	Serial Number	Weight of Stomach content (g)	Fish			Squid		Shrimp
			No. Otoliths/2	No. Urohyals	No. H.D.I.	No. Beaks	No. H.D.I.	No. H.D.I.
A	2	1500	116	57	10	47	2	154
	3	—	124	39		31	3	120
	4	1150	178	35	1	37	3	85
	5	660	105	23		31		173
	21	1380	133	35		42	3	58
	29	885	209	12		42	1	189
	30	1245	265	11		29	4	21
	31	440	135	13		35		6
	32	410	283	12		8		13
	33	1310	135	23	8	47	2	86
	34	500	309	9		46		93
	35	965	129	19		38	3	106
	36	1285	49	27		13	1	140
	Total	11730	2170	315	19	456	22	1244
	Ave.	978	167	24		35		96
	S.D.	392	77	14		13		60
B	1	2095	235	189		139		67
	15	1010	149	90		89	1	34
	16	285	175	55		75		25
	17	1000	308	81		128	2	20
	18	1465	304	30	3	27	1	208
	19	1595	117	25	14	27	1	167
	20	1650	302	140		94	1	48
	22	910	172	97	1	108	2	9
	23	1135	189	54	1	98		14
	24	935	172	51	1	43	1	62
	25	1095	199	98		156	1	17
	26	1110	371	100		121		4
	27	1140	192	75		70	1	36
	28	790	355	48		174	2	16
	Total	16215	3240	1133	30	1349	13	727
	Ave.	1158	231	81		96		52
	S.D.	434	81	44		50		61

H.D.I. : indicates half digested individuals.

species are shown in Fig. 4.

Todarodes pacificus is found in both schools. *Symplectoteuthis luminosa* is found only in school B.

The number of beaks is higher in school B than in school A (Table 2, Fig. 2).

4. Shrimp

In 27 stomachs 1,971 shrimps found were identified by the half digested shrimps. Four species from 4 genera and 3 families were observed (Table 5). All individuals except one belong to 3 species. Only individual of 1 species is from school B.

Bentheogennema borealis is dominant in number which amounts to 85.6% of the

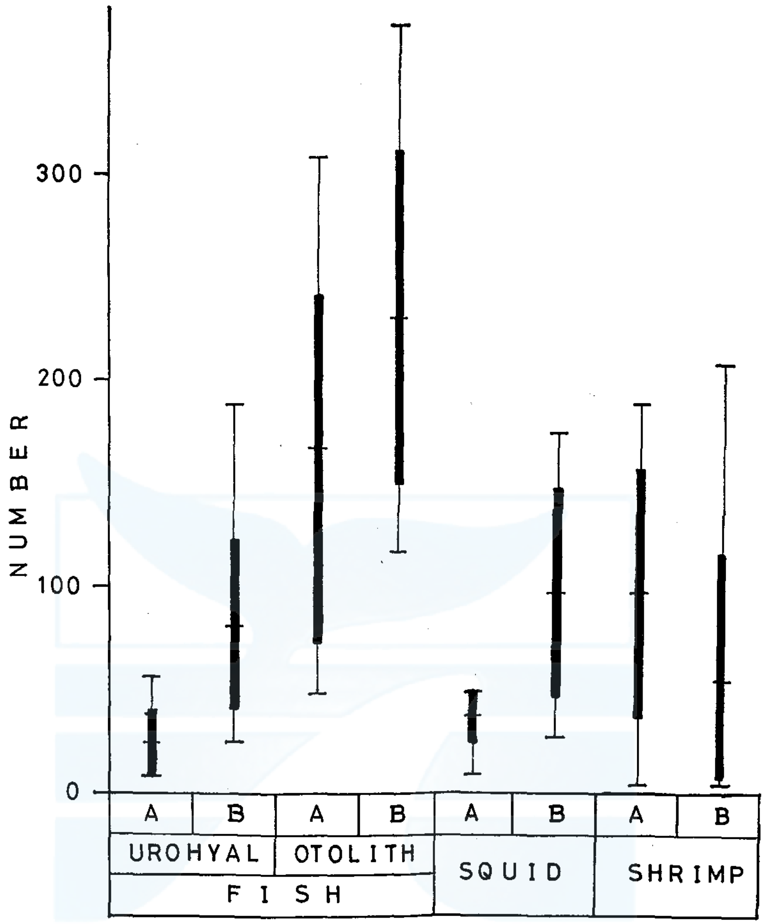

Fig. 2. Number of individuals eaten by *Stenella caeruleoalba* in schools A and B. Vertical line, range; box, range of a standard deviation; horizontal line in box, average.

total number of shrimps.

The ranges of the total length of *B. borealis* and *Pasiphaea* sp. are 38–68 mm and 110–130 mm, respectively.

The number of individuals found in school A is almost similar to that in school B (Table 2, Fig. 2).

DISCUSSION

The number of fish specimens is 59% of the total number of all specimens. It is considered that *Stenella caeruleoalba* feeds mainly on fish. Among fish species, Myctophids is the most dominant in number. The results are similar to those

TABLE 3. SPECIES AND NUMBERS OF FISHES IN

	School A													
Serial number →	2	3	4	5	21	29	30	31	32	33	34	35	36	Total
Species of fishes ↓														
Myctophidae														
Myctophum orientale														
Diaphus elucens	26	31	20	9	19	4	1		3	9	4	5	6	137
Diaphus coeruleus			1						1	1			1	4
Lampanyctus jordani														
Diaphus sp. A		1												1
Diaphus sp. B														
Nemichthyidae														
Nemichthys scolopaceus	9	3	6	6	5	2				4		2	3	40
Emmelichthyidae														
Erythrocles schlegeli	12	1	3	7	6	3	6	12	8	8	4	9	15	94
Erythrocles sp.														
Chauliodontidae														
Chauliodus sloani	1	2	1		1		3	1		1		1	1	12
Chauliodus sp.														
Paralepididae														
Lestidium sp. A	1		1								1			3
Lestidium sp. B	1			1	1	1						1		5
Lestidium sp. C	1													
Lestidium sp. D														
Lestidium sp. E													1	1
Lestidium sp. F														
Lestidium sp. G														
Lestidium sp. H														
Sternoptychidae														
Polyipnus spinosus														
Argyropelecus hemigymnus			1				1							2
Argentinidae														
Argentina semifasciata	6		1			2								9
Argentina sp.					1									1
Acinaceidae														
Acinacea sp. A		1	1		1									3
Acinacea sp. B												1		1
Acinacea sp. C					1									1
Acinacea sp. D														
Acinacea sp. E														
Lutjanidae														
Lutjanus sp.														
Priacanthidae														
Priacanthus sp.														
Gonostomatidae														
Gonostoma sp.														
Total species number	8	6	9	4	8	5	4	2	3	5	3	6	6	
Total individual number	57	39	35	23	35	12	11	13	12	23	9	19	27	315

THE STOMACHS OF *STENELLA CAERULEOALBA*.

	School B														Total
1	15	16	17	18	19	20	22	23	24	25	26	27	28	Total	
6	7	5	4			9	10	3	1	11	1	3	2	67	67
84	59	27	40	14	6	67	60	30	31	51	73	35	32	609	746
3	2					4		2	2	5	5			23	27
36	2	1	1		2	30		1	3	2	2			80	80
						2		1						3	4
	1							1						2	2
18	4	7	23	3	2	14	15	5	7	20	5	21	6	150	190
94	3		1		6	12		1						23	117
			1											1	1
6	9	8	5		1	4	5	6	2	5	9	11	6	77	89
4	1		4			2	1	3		1		3	2	21	21
	1					3		1	1			1		7	10
4										2				6	11
			1			2	3		1					7	8
1														1	1
															1
1														1	1
1														1	1
	1	1		1		1								4	4
14	1	1	2	1										19	19
															2
2				3	1									6	15
															1
	1	2	1				2	1	1	1				9	12
		1		1										2	3
				1										1	2
						1			1					2	2
									1					1	1
3	1				1							1		6	6
2														2	2
1						1								2	2
17	13	11	9	8	7	13	8	11	11	9	6	7	5		
189	90	55	81	30	25	140	97	54	51	98	100	75	48	1133	1448

TABLE 4. SPECIES AND NUMBERS OF SQUIDS IN

Serial number →	School A													
Species of squids ↓	2	3	4	5	21	29	30	31	32	33	34	35	36	Total
Todarodes pacificus	2	3	3		3	1	4			3		3	1	33
Symplectoteuthis luminosa														
Unidentified species	47	31	37	31	42	42	29	35	8	47	46	48	13	456
Total	49	34	40	31	45	43	33	35	8	49	46	51	14	478

TABLE 5. SPECIES AND NUMBERS OF SHRIMPS IN

Serial number →	School A													
Species of shrimps ↓	2	3	4	5	21	29	30	31	32	33	34	35	36	Total
Bentheogennema borealis	147	116	70	157	50	168	16	5	10	65	74	97	136	1111
Pasiphaea sp.	6		13	15	8	19	5	1	3	21	14	7	4	116
Acanthephyra sp.	1	4	2	1		2					5	2		17
Aristeinae sp.														
Total	154	120	85	173	58	189	21	6	13	86	93	106	140	1244

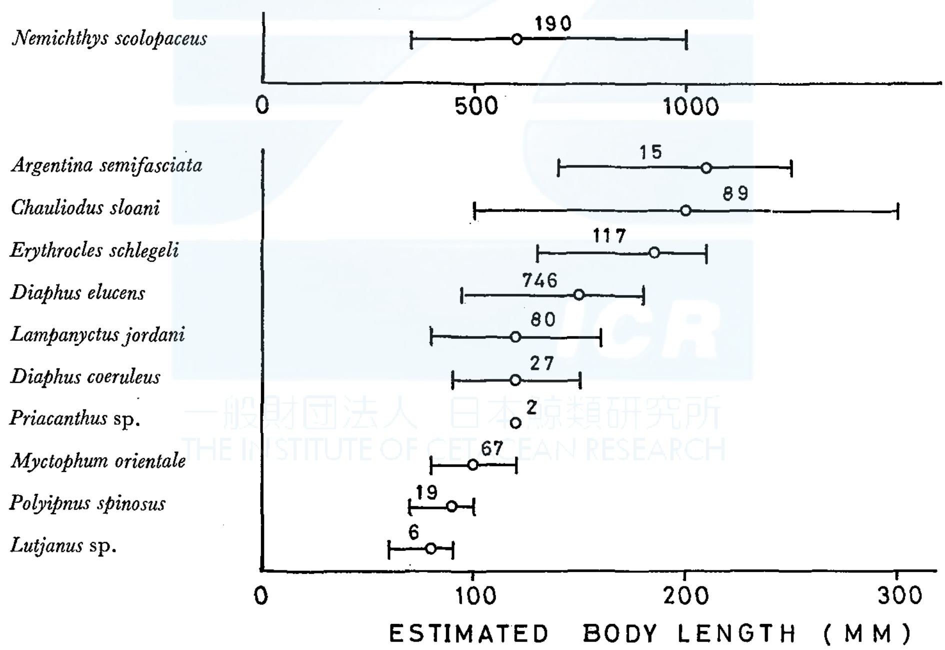

Fig. 3. Range and average (open circle) of the estimated body length of fishes eaten by *Stenella caeruleoalba* in schools A and B. Number indicates the number of individuals.

THE STOMACHS OF *STENELLA CAERULEOALBA*.

School B														
1	15	16	17	18	19	20	22	23	24	25	26	27	28	Total
	1			1	1	1	1		1			1	2	9
			2				1			1				4
139	89	75	128	27	27	94	108	98	43	156	121	70	174	1349
139	90	75	130	28	28	95	110	98	44	157	121	71	176	1362

THE STOMACHS OF *STENELLA CAERULEOALBA*.

School B														
1	15	16	17	18	19	20	22	23	24	25	26	27	28	Total
63	25	17	9	194	164	39		5	58		1		1	576
4	9	7	11	12	3	9	8	8	4	17	3	34	15	145
		1		1			1	1				1		5
												1		1
67	34	25	20	208	167	48	9	14	62	17	4	36	16	727

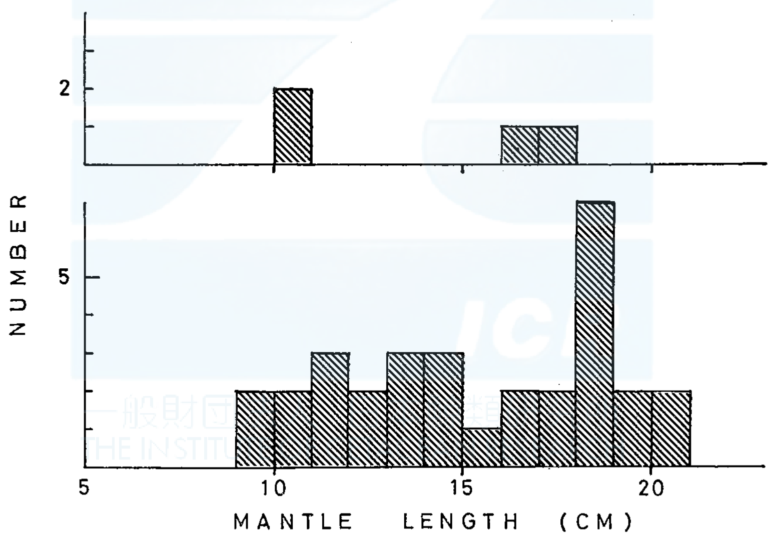

Fig. 4. Mantle length frequency of squids in the stomachs of *Stenella caeruleoalba*.
Top: *Symplectoteuthis luminosa*.
Bottom: *Todarodes pacificus*

formerly studied on *Stenella longirostris* and *Stenella graffmani* (Fitch and Brownell, 1968). Gonostomatidae spp. is commonly eaten by the above 3 *Stenella* species. Bathylagidae sp., Bregmacerotidae sp., Centrolophidae sp., Paralepididae sp. and Exocoetidae sp. have formerly been found in *S. longirostris* or *S. graffmani* (Fitch and Brownell, 1968). These species of fish inhabit in the adjacent waters of Japan, but they are not found from *S. caeruleoalba* in this study. The fish species which are found in *S. caeruleoalba* but neither in *S. longirostris* nor in *S. graffmani*, are 24 species belong to 9 genera and 9 families. Especially, *Chaulidus sloani*, *Nemichthys scolopaceus* and *Erythrocles schlegeli* are found abundantly from *S. caeruleoalba*.

The range of estimated body length of fishes from *S. caeruleoalba* is 60–300 mm. *Nemichthys scolopaceus* which is very slender (B. L. 350–1,000 mm), is an exception. The result is similar to that formerly studied on *S. longirostris* and *graffmani*.

Fish species of *Diaphus elucens*, *Nemichthys scolopaceus* and *Erythrocles schlegeli*, and shrimp species of *Bentheogennema borealis* and *Pasiphaea sp.* are found abundantly in most of the stomachs of the dolphins studied this time.

Fish species of Myctophidae spp., *Polyipnus spinosus*, Gonostomatidae sp. and Chauliodontidae spp. and squid species of *Symplectoteuthis luminosa* have luminous organs. The number of specimens of these species amounts to 74% of the total number of specimens identified in the present study.

ACKNOWLEDGMENTS

We are indebted to Dr. Y. Aizawa of the Ocean Research Institute, for his kind help in identification of shrimp, to Mr. T. Tobayama of the Kamogawa Seaworld for presenting us his specimens of otoliths to study, and to Mr. N. Oguro of the Oyster Research Institute, for helping us to collect the specimens. We also thank to the following persons for their kind advices: Dr. T. Kasuya and Dr. K. Numachi of the Ocean Research Institute, and Dr. W. H. Dawbin of the University of Sydney.

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POSSIBLE VESTIGIAL TEATS OF KILLER WHALE

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In each species of mammal, the mammary gland has developed through many steps of evolution. As seen in the platypus, the most primitive stage of the mammary gland has no distinct teats. Mammals that have multiple birth, e.g. the pig, have multiple teats others show some trace of origin from multiple teats but have changed substantially to a pair or pairs while the remaining teats have degenerated.

In evolutionary sequence two row of teats, in pairs, occur along the whole ventral surface between the forelimbs and the anus. In the elephant and the dugong, the first teats, located between the forelimbs have remained, in primates it is the second pair, and in some ungulates, the rear ones have remained. The vestiges of once functional teats are seen in many mammals. It is often seen in man that a tiny spot is found at an arm base as a vestige of the first teats and a spot sometimes present on the abdomen is likley to be one of the third teats. Sometimes these are found even in males.

To date, the teats of cetaceans have been considered as derived from the most rear pair. In my own experience I have observed thousands of whales over a long period and have examined the ventral surface in nearly every case. However I had seen no such vestige until recently.

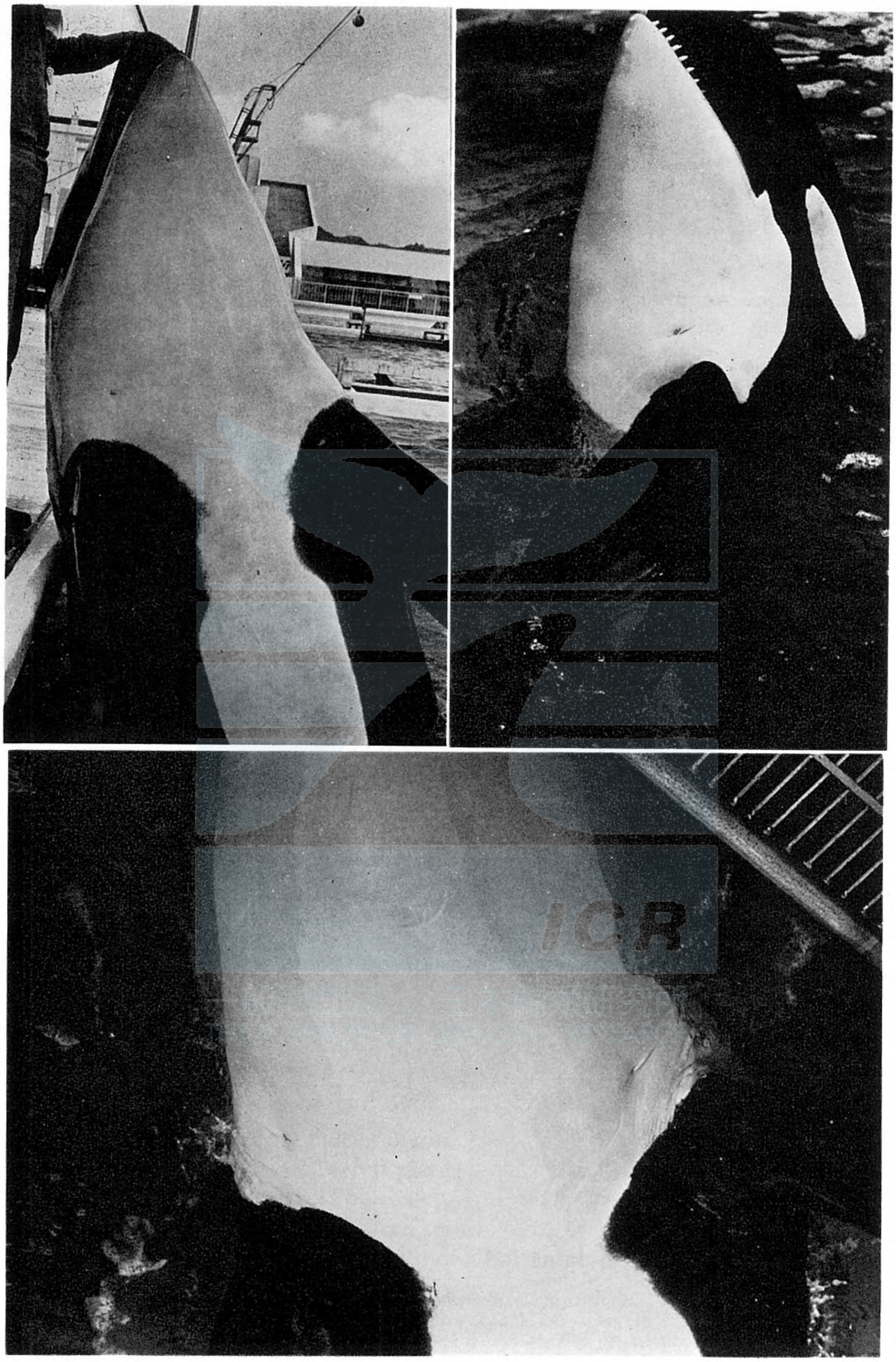
When keeping the killer whale became popular among oceanariums of the world, I saw for the first time a tiny spot or two on some killer whales' bellies. Then in 1971, when I paid a visit to the Vancouver Public Aquarium I met " Hyak ", a well trained killer whale, and found a pair of clear spots on his beautiful white belly. Then I had a chance to observe another case on the belly of one of the specimens in the Kamogawa Seaworld. Though, there has been no anatomical proof until now, those spots might be vestigial teats. The observed individuals are all thriving in each oceanarium. So, I would like to publish the evidences as a fact, in order to evoke interest of scientists and aquarium attendants in the hope that any one who has a chance to dissect a body of a killer whale, will not miss an anatomical examination on the spot and publish a report on a problematic vestige.

I should like to express here, my sincerest gratitude to Dr. M. A. Newman of the Vancouver Public Aquarium for his cooperation since I first saw Hyak until this publication and to Miss Susan Hoffer, research assistant to Dr. Newman, for much trouble in taking photographs of Hyak from difficult angles. I am also deeply appreciative of the kind help by the staff members of the Kamogawa Seaworld.

Sci. Rep. Whales Res. Inst.,
No. 25, 1973, 277–278.

EXPLANATION OF PLATE

The belly of the killer whale with vestigial teats.
Fig. 1. "Jumbo" of the Kamogawa Seaworld (upper left).
Fig. 2. "Hyak" of the Vancouver Public Aquarium (upper right and Fig. 3 (lower).



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COUNTING AND MEASURING BALEEN AND VENTRAL GROOVES OF WHALES

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ABSTRACT

Counts and measurements of baleen and ventral grooves are important in taxonomic descriptions of whale species and in feeding studies. Standard methods are needed. This paper proposes a standard system.

Definitions are given for: baleen plate, hair, bristle, tip and base of a plate, filter area of the whole baleen, ventral groove.

Measurement methods are given for: counting baleen, measuring length, width and thickness of a plate, density of spacing and average gap between plates, diameter of bristles, filter area of the whole baleen, counting ventral grooves.

INTRODUCTION

Counts and measurements of the baleen and ventral grooves of mysticete whales have frequently formed part of the systematic description of species. However, the criteria and methods used to obtain these data have seldom been defined.

It is desirable that the methods be standardised. The standard methods adopted must be simple, easy to repeat with accuracy and meaningful in terms of the function of the structures concerned. This paper suggests such standard methods and is based on the opinions of the experts listed in the acknowledgements section.

Definitions and measurements covered in this paper are:

Baleen

definitions:	Baleen
	Baleen series
	Side of baleen
	Main baleen plate
	Minor baleen plate
	Hair
	Bristle
	Tip of baleen plate
	Base of baleen plate
measurements:	Counts of baleen
	Length of baleen series
	Length and width of a baleen plate

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Length and width of a baleen lamina
Thickness of a plate
Average density of spacing of plates
Average gap between plates
Diameter of bristles
Length of bristles
Density of spacing of bristles

Baleen Filter Area
definition: Filter area of the baleen
measurement: Filter area of the baleen

Ventral Grooves
measurements: Number of ventral grooves
Length of ventral grooves
Mandible to umbilicus length
Degree of separation of end of ventral grooves from umbilicus.

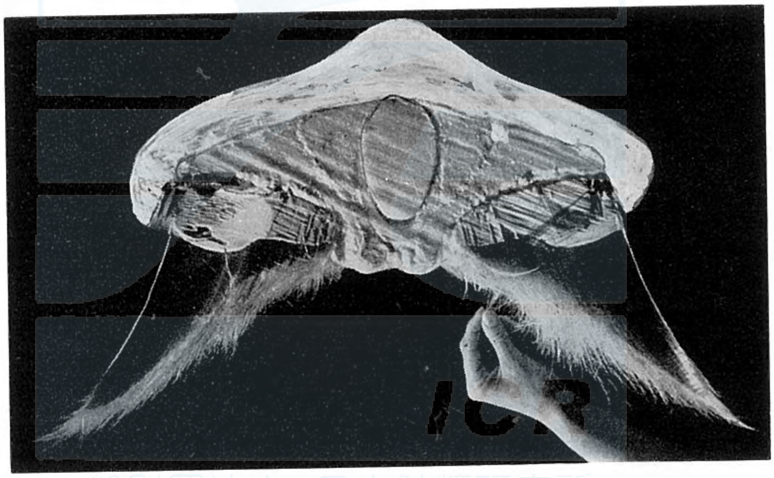

Fig. 1. Section of upper jaw of a sei whale showing position of the baleen.

SUGGESTED DEFINITIONS AND METHODS OF MEASUREMENT

Baleen

Definitions

Baleen is the general name given to the keratinous filter attached to the upper jaw of mysticete whales (Figs. 1–9). On each side of the upper jaw is one *baleen series* or *side of baleen*. Each baleen series is composed of a series of *baleen laminae*. Each baleen lamina consists of a large *main baleen plate* on the outer side; several *minor baleen plates* and at the inner or lingual edge, some *hairs*. At the extreme front and rear ends of a baleen series the baleen laminae are composed only of hairs. The shape of the main baleen plates of various species of whale are shown in Fig. 3.

Plates are components of the baleen series which at gum level have a width three or more times their thickness. *Hairs* are components of the baleen series arising directly from the gum whose width at gum level is less than three times their thickness (Figs. 4, 6 and 7).

The filter fibres that form a fringe on the side of each plate are called inner *bristles*, not hairs.

Tip of baleen plate (Figs. 3, 8) is the most distal part of the solid plate that be detected and beyond which the plate ceases to exist but is divided into many bristles. The *base of the baleen plate* is where it emerges from the gum.

Counts of baleen are made on the outside of the baleen series at gum level. Ideally, the number of structures on both sides of the jaw are counted and the average calculated. Three categories of structures could possibly be counted:

- the hairs at the front of the series.
- the baleen plates in the middle of the series (defined as in *Baleen*).
- the hairs at the back of the series.

These all correspond with baleen laminae. However, the hairs at the back of the series are too small to count accurately and in Right and Gray whales the anterior hairs are also too small to count accurately. Thus the baleen structures best counted are as follows

Rorqual and Humpback whales: the hairs at the front of the series plus the baleen plates

Right and Gray whales: the baleen plates only.

In Rorqual and Humpback whales the count is started at the first hair at the front of the baleen series. To discover the centre position at the front of the snout an imaginary line is drawn from the tip of the snout backwards between the two pits of Jacobsens organ until it reaches the baleen hairs (Fig. 6, top left). On a flensing deck this line can be marked on the gum with a knife.

Length of baleen series (Fig. 2) is the distance between the bases of the most anterior and the most posterior elements of the series measured in a straight line parallel to the axis of the body.

Lengths and widths of baleen plates and laminae are shown in Fig. 8. The two points between which measurement is made are given in each case following:

- *Length of main baleen plate, straight* (AB) is the distance from the tip of the plate to the insertion of the plate into the gum at the outer edge, measured in a straight line.
- *Length of main baleen plate, curved* (AC) is the distance from the tip of the plate to the the insertion in the gum of the base of the same fibres which make up the tip of the plate, measured along the growth axis of the fibres.
- *Length inner edge of baleen lamina, straight* (AD) is the distance from the base of the innermost hair of the lamina to the tip of the main plate of the lamina, measured in a straight line.
- *Length inner edge of baleen lamina, curved* (AD curved) is same as above, but measured along the curve connecting the bases of the bristles of the baleen plates and hairs.

- *Width of baleen plate* (BE) is the distance between the base of the outer edge and the base of the inner edge of the plate, measured along the surface of the plate.
- *Width of baleen lamina* (BD) is the distance between the base of the outer edge of the main plate and the base of the innermost hair of the same lamina measured along the curve of the lamina base.

Thickness of a plate is the thickness measured in the mid area of the plate (point X in Fig. 8) *i.e.* approximately half way between the base and tip of the plate and half way between the outer and inner edge of the plate.

Density of spacing of plates is the distance between the centres of the edges of adjacent plates, measured at the outer edges of the plates midway along their lengths.

Gap between plates is the width of the gap separating a plate from its neighbour, though which water passes when the whale is feeding, measured at the outer edges of the plates midway along their lengths.

These two characters are useful in studies of the mechanics of filtering, thus are chiefly important when they relate to the central section of the baleen series which does most of the filtering. To achieve this aim, the average spacing and average gap between plates should be determined by taking measurements of the 100 longest baleen plates in the centre of the baleen series. The measurements should be made on the outer edge of the baleen series at a level approximately half way along the length of the plates (Fig. 2 top). The measurements should be made on baleen in situ in the whale's mouth, because the spacing becomes altered as soon as the baleen is cut free from the gum.

$$\text{average spacing} = \frac{\text{length of that section of the baleen series made up by the 100 longest plates}}{100}$$

$$\text{average gap} = \text{average spacing} - \text{average thickness of the 100 longest plates}$$

Diameter of a bristle is the diameter of a bristle at its base, measured with a micrometer screw or microscope with eye-piece scale. To measure the average diameter of bristles of a plate the following procedure is recommended:

1. Cut all the bristles from three sites exactly 1 cm wide on the plate edge, one at the top, one at the middle and one at the bottom of the plate (Fig. 5).
2. Measure the diameter of the base of each bristle.
3. Calculate the average diameter of the bristles.

Length of a bristle is the distance from base to tip of a bristle. The value is only reliable if measured on a fresh whale, since bristles commonly break short in preserved plates. The average length of bristles on a plate can be determined by the same method as the average diameter of bristles.

Density of spacing of bristles is the average number of bristles arising per 1 cm of baleen plate edge, and is determined by counting the number of bristles cut off three 1 cm sites as described above.

In whales whose baleen plates are worn down at the tip, as often occurs, the measurements of bristles at the 1 cm site on the plate tip should be discounted.

Filter Area

The filter area of the baleen series is the area of the inner surface of the combined left and right baleen series in the mouth of the whale. Since the inner surface of the baleen is somewhat curved (Fig. 1) it is difficult to measure the filter surface accurately. For convenience, it is suggested that a '*standard filter area*', in which it is supposed that the inner surface is flat, be used for preliminary work. The '*true filter area*' is the true total filter area of the baleen, taking into account all the various curves of the surface of the baleen.

Measurement of standard filter area can be done in several ways. To collect data on many whales at a busy shore station or factory ship, a photographic method is recommended (Fig. 9). The sequence of operations is as follows:

- species, length and sex (and/or platform number) of the whale are written on a black slate in chalk.
- whale details slate and a 1 meter or 50 cm rule are placed against the baleen series of the whale.
- a photograph of the baleen series is taken in which the camera is positioned as near as possible at right angles to the inner surface of the baleen, opposite to the centre of the baleen series. This can be achieved either by the photographer standing on a box or the whale's head being partially turned on edge using a winch.
- the film negative is projected onto graph paper and the outline of the baleen series and rule are traced. The outer border of the baleen series is drawn over the tips of the baleen plates, as defined earlier.
- the standard filter area is calculated by counting the number of graph paper squares covered by the traced outline of the baleen.

The standard filter area is a function of the length of the baleen series and of the length of the longest plate (straight length, as previously defined) of the series:

standard filter area = series length $\times$ length of longest plate $\times$ k

From a good series of data the average value of k for each species of whale can be calculated. When k is known, the standard filter area of any specimen can be calculated from a knowledge of the length in meters of the baleen series and the straight outer edge length of the longest plate only—provided that in different sized individuals and in different stocks the overall shape of the filter area remains similar.

A few preliminary measurements I made suggest that in *Balaenoptera* species the value of k is 2.2–2.7, in *Eubalaena* about 1.5.

The ultimate aim of filter studies will be to determine such fundamentals as

- body weight supported per m^2 of filter surface.
- weight of food collected per minute per m^2 of filter surface.

and then to discuss the relative efficiency of the mouth anatomy and method of feeding in different whale species and the problems a whale experiences when trying to capture the different species of food organisms (krill, copepods, anchovy, mackerel etc.). Investigations on how the expandable grooved throat of rorquals is used to increase filtering efficiency will be of particular interest.

Ventral Grooves

Number of ventral grooves is the number of grooves on the ventral surface of the whale counted at the level of the point where the grooves extend highest up the side of the body *i.e.* where the number of grooves is maximum. This point is located between the eye and the flipper of the whale (Figs. 10 and 12 top). Since a whale on a flensing deck lies on its side, it is usually impossible to count all the grooves. The best method to obtain the value is to look at the tip of the lower jaw and there locate the mid-ventral groove, follow it back to the level of the count, count the grooves round to the highest groove and double the result. The median groove can also be identified by locating the umbilicus and following forward the middle groove.

Length of ventral grooves (VGL) is the distance from the tip of the lower jaw to the posterior end of the longest ventral groove or grooves, measured in a straight line parallel to the axis of the whale's body, but excluding the mid-ventral groove that in some species runs between the umbilicus and genital aperture. (It is useless to measure the length of the ventral grooves along the curve of the throat because the throat of a dead whale is always unnaturally dilated).

Mandible to umbilicus length (MUL) is the distance from the tip of the lower jaw to the centre of the umbilicus measured in a straight line parallel to the axis of the whale's body.

Degree of separation of end of ventral grooves from umbilicus

$$\text{degree of separation} = \left(\frac{\text{MUL}-\text{VGL}}{\text{total body length}}\right) \times 100$$

In species where the ventral grooves terminate posterior to the umbilicus, the value will be negative.

DISCUSSION

It is hoped that the standard methods for defining, counting and measuring ventral grooves and baleen plates of whalebone whales given in this paper may be adopted by future workers.

Much work remains to be done to document the range of values of these characters in different species, populations, ages and sizes of whales and to determine coversion factors that will enable such new data to be compared with published figures.

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This paper is based on the recommendation of the following scientists and on my own field work.

Dr. Hideo Omura,	Whales Research Institute, Tokyo.
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Mr. August Pivorunas,	Yale University, USA.
Dr. Edward Mitchell,	Fisheries Research Board of Canada.
Mr. Sidney Brown,	National Institute of Oceanography, Britain.

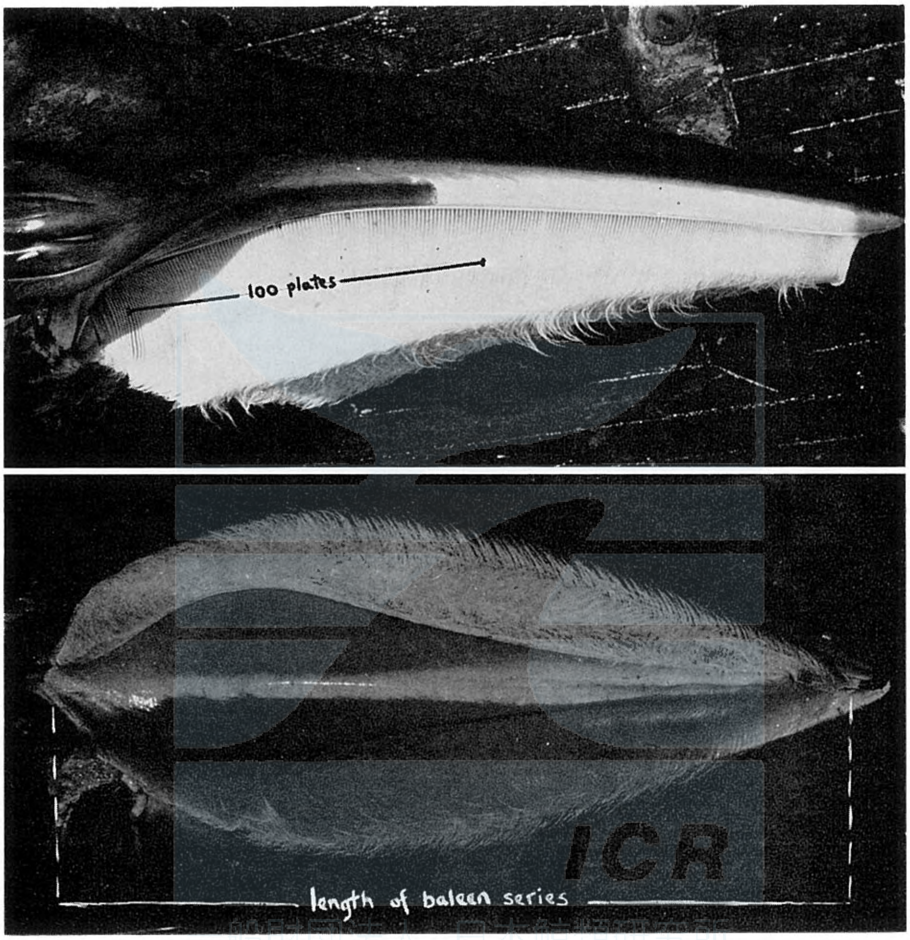


Fig. 2. Top: Side view of baleen of a minke whale. Line marks position of the 100 longest plates measured when determining average density of spacing of plates and average gap between plates.
Bottom: Underside view of baleen of a minke whale showing how to measure the length of the baleen series.

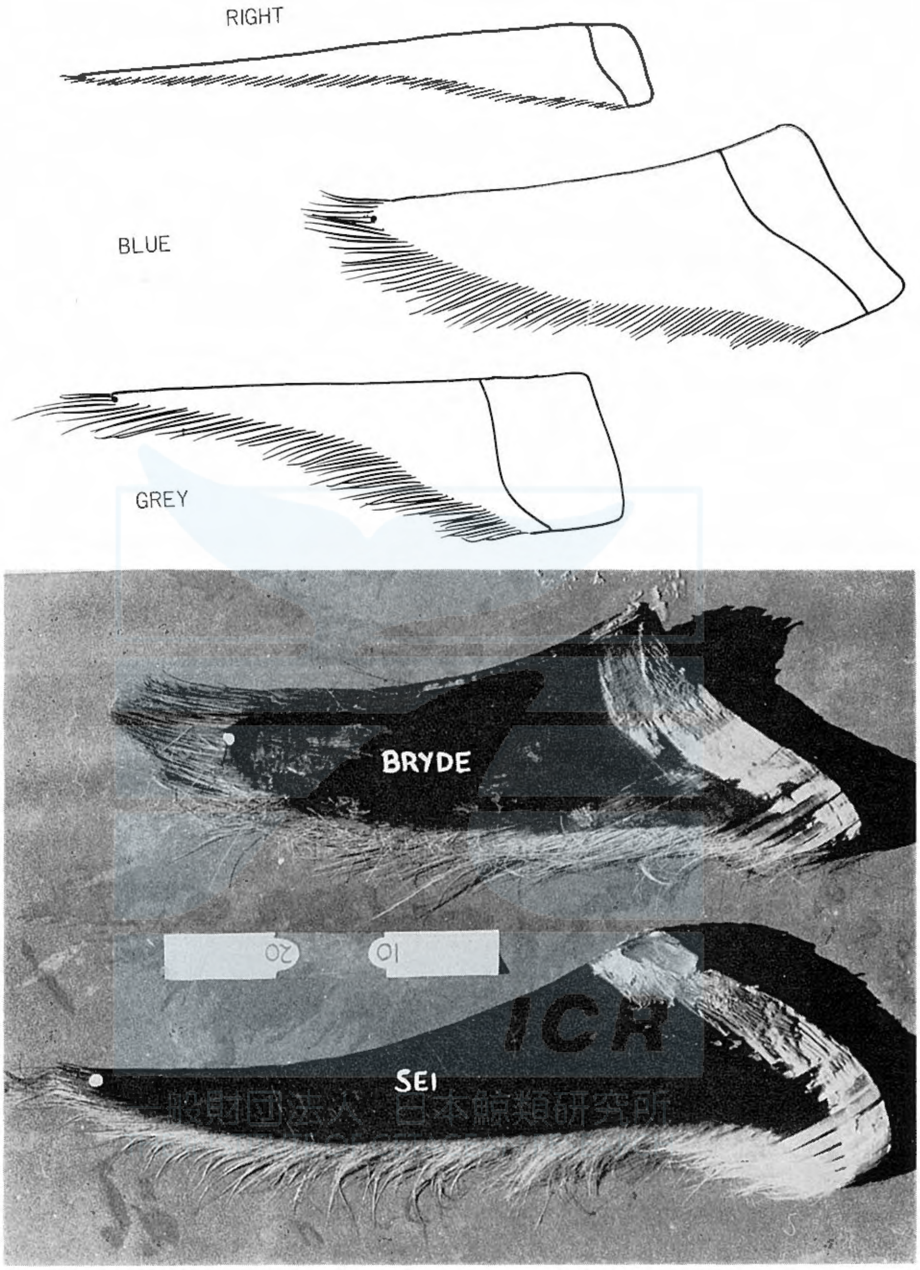


Fig. 3. Baleen plates of various species of whales. The tip of each plate is marked with a dot.

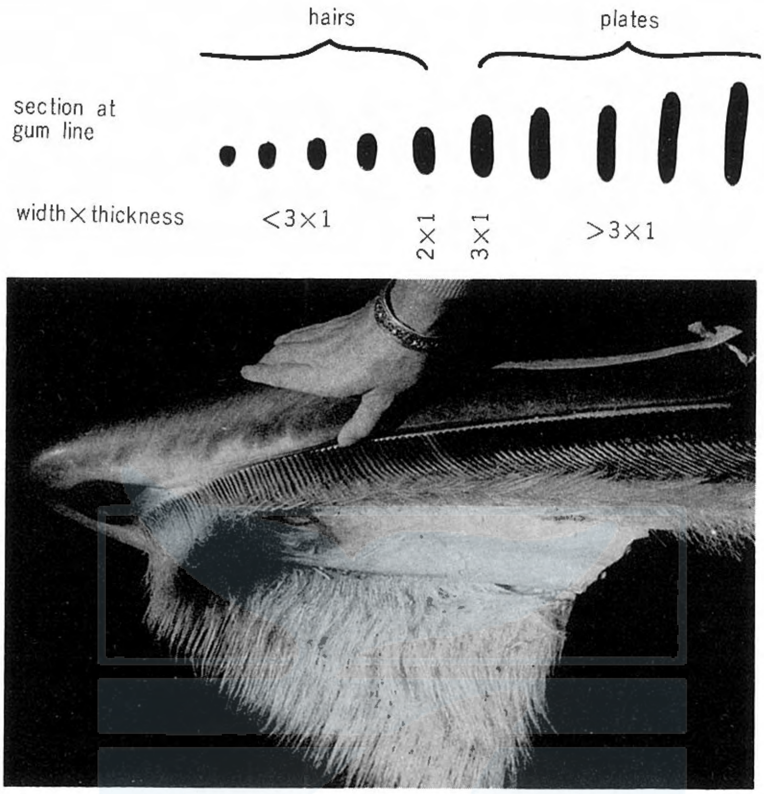


Fig. 4. Top: Diagram explaining difference between hairs and plates. Plates are defined as baleen elements which at gum level have a width three or more times their thickness.
Bottom: Front part of baleen of a sei whale showing the arc of hairs at the front of the mouth which joins the two sides of the baleen.

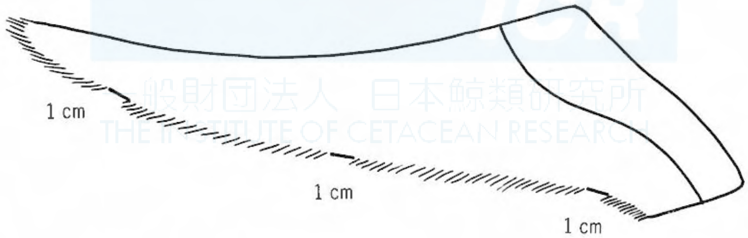
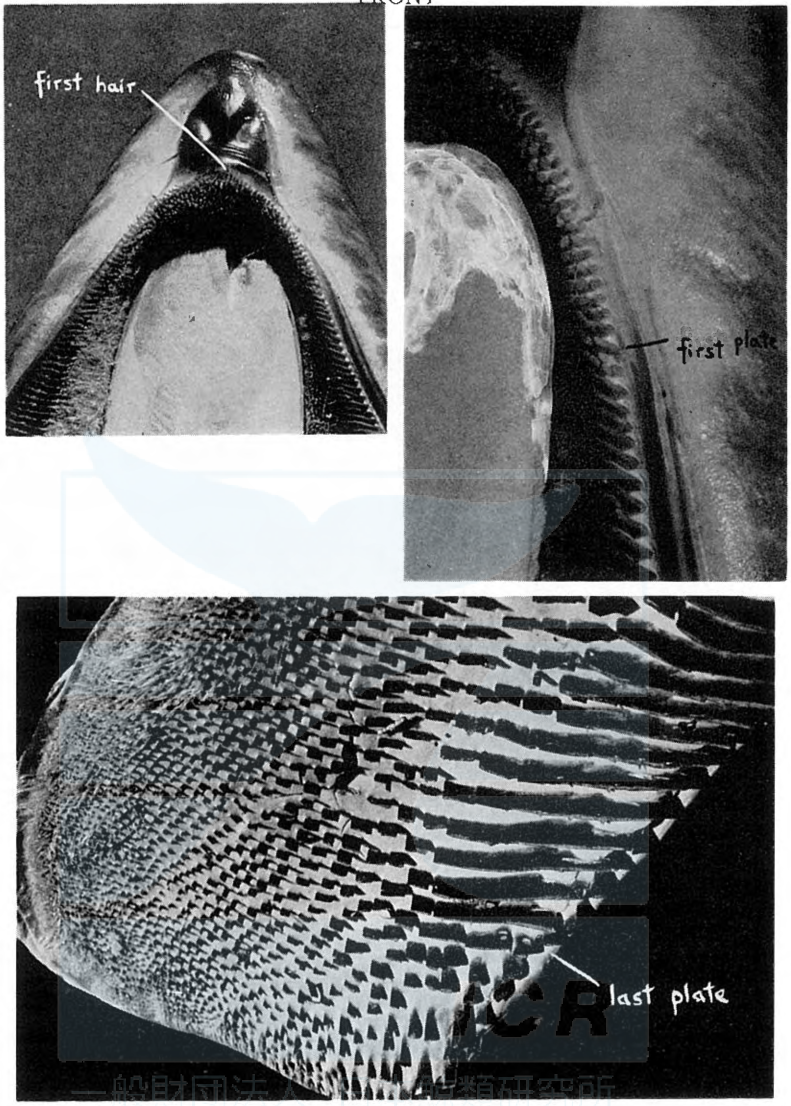


Fig. 5. Diagram of a baleen plate showing positions of the three sites from which bristles are cut off to measure their thickness and length.

FRONT



BACK

Fig. 6. Baleen of a sei whale cut off at gum level.
Top left: Front of mouth.
Note the dense bunch of hairs at the apex of the jaw. Presumably these help prevent fish and krill escaping forwards when the feeding whale closes its mouth.
Top right: Detail of front left part of series
Bottom: Left rear part of series.

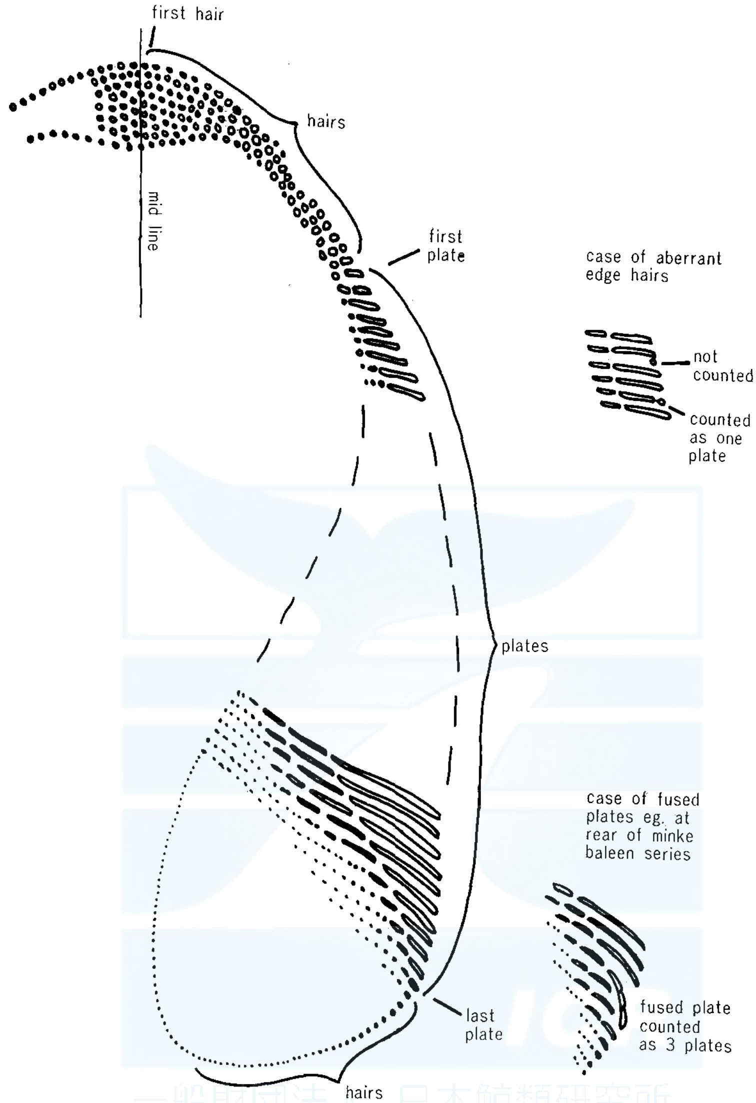


Fig. 7. Diagram of baleen series of a generalised rorqual showing how to count hairs and plates.

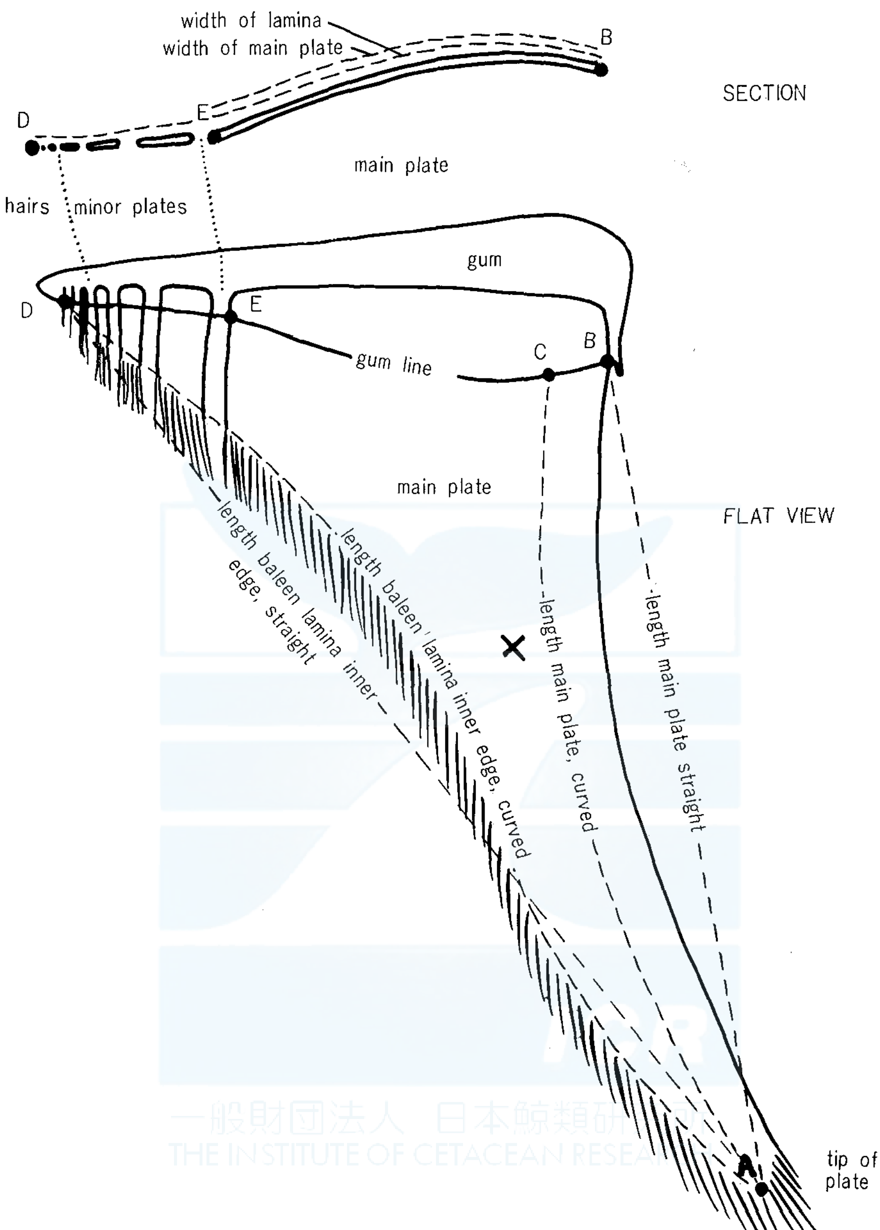


Fig. 8. Diagram of a baleen lamina of a generalised rorqual showing where to take various measurements.

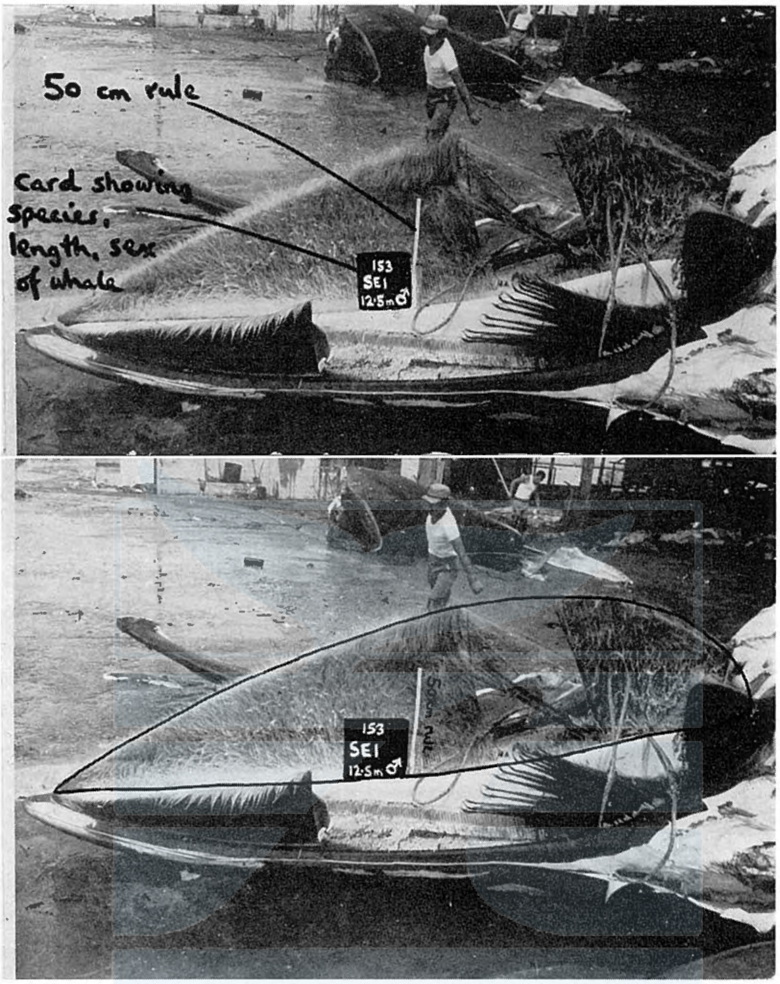


Fig. 9. Method of measuring filter area of a sei whale's baleen series.
Top: Photo of baleen is taken with camera positioned opposite to the centre and at 90° to the inner surface of the baleen series.
Bottom: Projected onto graph paper, the outline of the baleen is traced along the tips of the plates and the area calculated by counting the number of graph paper squares covered.

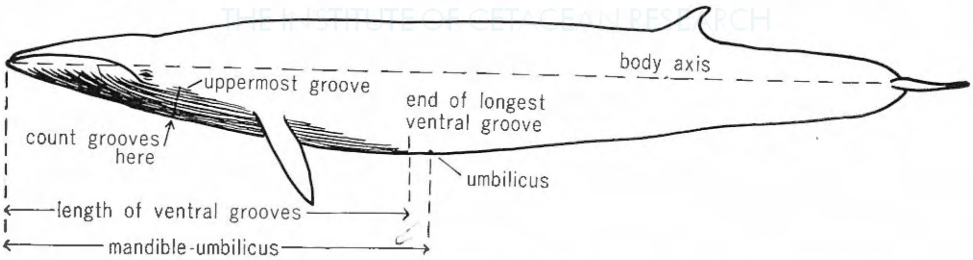


Fig. 10. Diagram of body of a sei whale showing where to count and measure the ventral grooves.

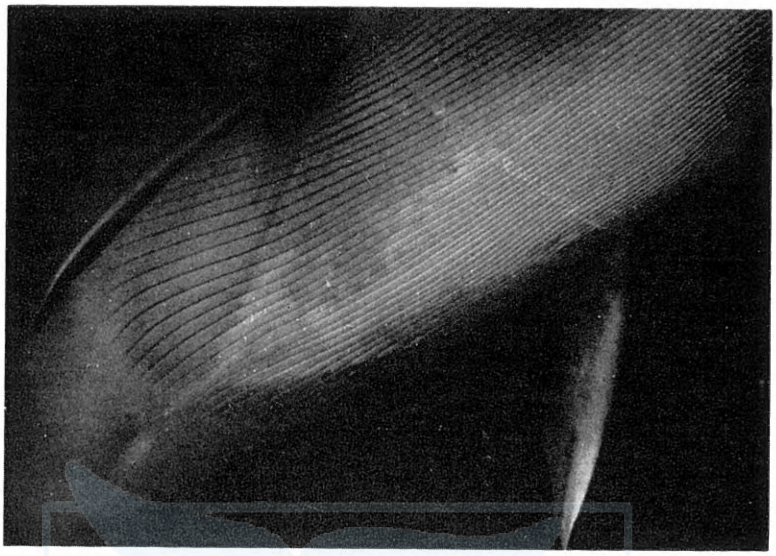


Fig. 11. Live sei whale seen from underwater showing ventral grooves.

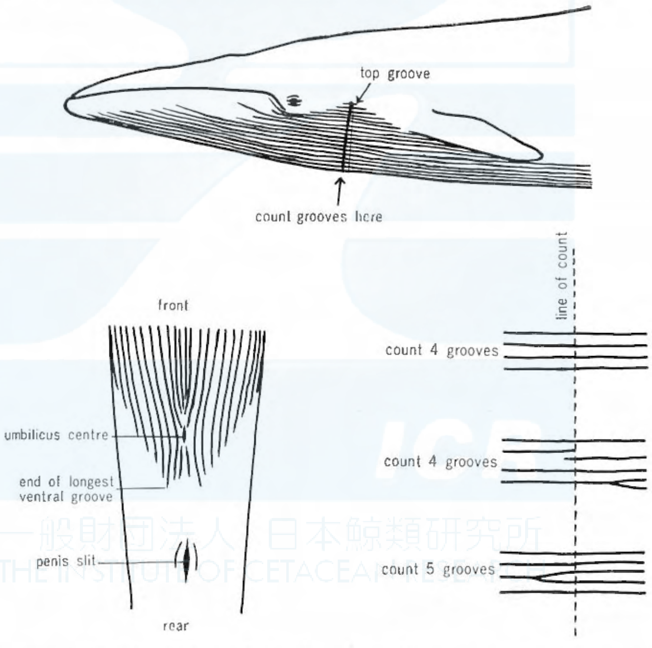


Fig. 12. Top: Head of blue whale showing where to count the ventral grooves. The ventral grooves of rorquals extend highest up the side of the body in blue whales. In minke whales the uppermost groove is level with the angle of the jaw. Note the groove—free area below the rear part of the jaw bone.
Bottom left: Diagram showing how to count ventral grooves in cases where the grooves terminate or fork near the line of count.
Bottom right: Arrangement of ventral grooves of a male blue whale in the region of the umbilicus.

FATTY ACID COMPONENT OF BLUBBER OIL OF AMAZON RIVER DOLPHIN

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ABSTRACT

The oils contained in 12 blubbers of Amazon dolphin, *Inia geoffrensis*, were studied for total lipid contents, chemical properties and fatty acid components. The oil contents of these blubbers had the range from 31.6% to 63.9%. The fatty acid components of sample oils were analyzed by gas liquid chromatography. The analysis showed the presence of fatty acids with chain lengths from 5 to 24 carbon atoms and with zero to six double bonds. Eight kinds of fatty acids (*iso*-C_{12}, C_{12}, *iso*-C_{14}, C_{14}, $C_{14:1}$, C_{16}, $C_{16:1}$ and $C_{18:1}$) accounted for the range from 77.69% to 84.03% of the total fatty acid contents; 41 other acids were contained in low quantities. The fatty acid compositions of blubber oils in melon, lower jaw and root area of tail fin deviated distinctly from them of other blubber oils.

INTRODUCTION

There are a few literatures on the oil of the dolphin in fresh water habitats. They are the literatures on the oil of Ganges river dolphin, *Platanista indi* and *gangetica* by Pathak *et al* (1956), Pilleri (1971), and Tsuyuki and Itoh (1971, 1972).

As to the study on the oil of Amazon dolphin, *Inia geoffrensis*, the lipid compositions of the dorsal blubber and the lower jaw fats have been reported in the literature by Ackman *et al* (1972).

This investigation was conducted to identify the fatty acid components in the various blubber oils of Amazon dolphin, and to examine if the fatty acid compositions or distribution patterns characterized different blubbers.

It is pleasure that we express here our thanks to Prof. Dr. M. Nishiwaki and Dr. T. Kasuya of Ocean Research Institute, University of Tokyo who were kind enough to present us the Amazon dolphin blubbers.

MATERIALS AND METHODS

The material in this study was a 203 cm long, 80 kg weight, adult female Amazon dolphin, *Inia geoffrensis*. She was captured in 1969 at Leticia City (an upper stream of the Amazon river) in Brazil. She had been raised in the aquarium of "Kamogawa Seaworld" (Kamogawa City, Chiba Pref.). The sample blubbers were

TABLE 1. PROPERTIES OF OILS CONTAINED IN VARIOUS BLUBBERS OF AMAZON DOLPHIN.

Parts of blubber	Oil content (%)	Acid value	Iodine value	Sapon. value	Unsapon. matters (%)
Hind part of blow hole	56.7	1.53	93.2	161.4	0.81
Root area of dorsal fin					
inner	59.3	1.36	96.2	180.2	0.85
outer	41.2	1.81	98.5	170.6	0.82
Abdominal side of ventral fin	44.2	1.27	87.8	184.7	0.95
Abdominal side of anus					
inner	52.0	1.54	99.4	180.6	1.04
outer	40.6	1.28	106.3	172.8	0.97
Upper side of ventral fin	40.2	1.33	95.9	173.0	0.56
Below side of dorsal fin					
inner	51.9	1.29	98.9	178.1	0.50
outer	43.6	1.52	100.1	176.5	0.44
Root area of tail fin	31.6	1.35	49.1	181.9	11.20
Melon	40.8	1.92	47.2	188.2	7.62
Lower jaw	63.9	1.04	28.6	165.6	28.66

obtained from 12 parts of her body within two days after she died in spring 1972.

The materials as inner blubber were obtained from the hind part of blow hole, the root area of dorsal fin, the abdominal side of ventral fin and anus, the upper side of ventral fin and the below side of dorsal fin. These inner blubbers were about 20–30 mm thick and attached to meat. The materials as outer blubbers were recovered from the root area of dorsal fin, the abdominal side of ventral fin, the below side of ventral fin and the root area of tail fin, and had skin attached. The blubbers from the melon and the lower jaw had no skin.

The sample oils were obtained from these blubbers by extracting in a blender with chloroform/methanol(2/1, v/v), drying over sodium sulfate and taking off all solvents under nitrogen atmosphere. The properties of the sample oils were shown in Table 1. The fatty acid methyl esters from the sample oils were respectively prepared by the method of Metcalfe *et al* (1966), using BF_3—methanol reagent. To remove unsaponifiable matters, crude methyl esters were then subjected to preparative thin layer chromatography on 0.75 mm thick layers of Wakogel B—5 (Wako Junyaku Kogyo) developed with petroleum ether—ethyl ether—glacial acetic acid (90: 10: 1, v/v/v).

Gas liquid chromatography (GLC) analysis of the purified methyl esters was quantitatively carried out on a Shimadzu Gas Chromatograph Model 4PTF equipped with a FID and 267 cm ×3 mm I.D. glass column packed with 15% DEGS 60/80 mesh on Shimalite. Further, additional GLC analysis was carried out by 168 cm ×3 mm I.D. glass column packed with 3% EGSS—X 60/80 mesh on Chromosorb W. The flow rates of nitrogen as carrier gas were 30 ml per minute for DEGS column and 45 ml per minute for EGSS—X column. The EGSS—X column was employed isothermaly at 195°C by injecting on column and the DEGS column was programmed in the range of 70–190°C with a temperature rise of 4°C per minute by injecting on column. Carbon chain length and degree of unsaturation of methyl esters were identified by plotting log of retention volumes of each peaks and by comparing with standard mixtures (Applied Science Laboratories), according to Hofstetter and Holman (1965). Also, identification of them was verified by GLC analysis of the methyl ester samples using hydrogenation at regular intervals. The method of hydrogenation of the methyl esters was carried by shaking in a small flask with a pinch of platinum black as a catalyst for 3–4 hours under 2.0 kg/cm^2 of hydrogen. Quantitation of the methyl esters was determined by application of formula of the products of the peak height and the base at one-half height, and corrected by the method of Ackman and Sipos (1964). The ratio of results was converted from weight per cent to molecule per cent fatty acid (Table 2).

RESULTS AND DISCUSSION

The chemical properties of blubber oils of Amazon dolphin are a close resemblance except those of melon, lower jaw and root area of tail fin oils shown in Table 1. Iodine values of oils contained in melon, lower jaw and root area of tail fin have considerably a low level, while saponification values and unsaponifiable contents of them have notably a higher level than those of the blubber oils. In a comparison of the chemical properties of inner and outer blubber oils in root area of dorsal fin, abdominal side of anus and below side of dorsal fin, acid values and iodine values of each outer blubber oil are slightly higher than those of inner blubbers. But saponification values and unsaponifiable contents of each outer blubber oil are conversely lower levels than those of inner blubber oils.

The fatty acid components of various blubber oils of Amazon dolphin are shown in Table 2. It is revealed the presence of fatty acids of 5–24 carbon atoms with zero to six double bonds. With the exception of oils in melon, lower jaw and root area of tail fin blubbers, the fatty acid components and distributions in other blubber oils are nearly to be the same pattern. But the fatty acid proportion of inner and outer blubbers in root area of dorsal fin, abdominal side of anus and below side of dorsal fin has a few difference in the fatty acids of saturated C_{16}, unsaturated C_{16} monoenoic and C_{18} monoenoic acids. The proportions of saturated C_{16} and unsaturated C_{18} monoenoic acids of inner blubber oils are slightly high levels, although the proportion of unsaturated C_{16} monoenoic acid of outer blubber oils is reversely higher than that of inner blubber oils. Also, in the ratio of total saturated and unsaturated acids, total saturated acid of inner blubber oils is a higher level than that of outer blubber oils.

In the case of the oil in root area blubber of tail fin, the fatty acid components and distribution patterns are probably resemblance to other blubber oils. But the proportion of fatty acid is seemed to be considerably different to other blubber oils. The main fatty acids of the blubber oils are *iso* C_{12}, C_{12}, *iso* C_{14}, C_{14} and C_{16} as saturated acid, and C_{16} and C_{18} monoenoic as unsaturated acid, but there are small quantities of unsaturated acids such as C_{18} monoenoic and dienoic acids, and unsaturated acids more than 20 carbon atoms.

TABLE 2. FATTY ACID COMPONENTS OF OILS CONTAINED IN VARIOUS BLUBBERS OF AMAZON DOLPHIN (%).

Blubbers → / Fatty acids ↓	Hind part of blow hole	Root area of dorsal fin		Abdominal side of ventral fin	Abdominal side of anus		Upper side of ventral fin	Below side of dorsal fin		Root area of tail fin	Melon	Lower jaw
		inner	outer		inner	outer		inner	outer			
Iso–5 : 0	0.24	0.11	tr	0.97	tr	0.49	1.02	0.13	tr	0.79	0.22	0.44
5 : 0	—	—	—	0.20	—	—	0.15	0.03	—	0.07	0.17	0.09
8 : 0	—	—	—	—	—	tr	tr	tr	—	—	0.05	—
Iso–10 : 0	—	—	—	—	—	—	—	—	—	0.29	0.15	0.42
10 : 0	0.33	0.18	0.20	0.35	0.29	0.44	0.22	0.18	0.31	0.57	1.30	3.43
Iso–11 : 0	—	—	—	—	—	—	—	—	—	0.27	0.51	0.46
Anteiso–11 : 0	—	—	—	—	—	—	—	—	—	0.16	0.52	0.41
11 : 0	0.21	0.04	0.17	0.28	—	0.36	0.11	0.02	0.05	0.62	0.86	0.81
Iso–12 : 0	0.19	0.14	0.12	0.10	0.05	0.15	0.20	0.05	0.13	7.85	8.70	3.93
12 : 0	2.40	1.38	2.22	1.57	1.70	2.75	1.89	2.03	2.87	18.74	19.94	17.62
12 : 1	0.17	0.37	0.96	0.40	0.12	0.81	0.35	0.18	0.45	4.29	4.14	2.98
Iso–13 : 0	0.11	0.04	0.07	0.15	0.10	0.13	0.12	0.47	0.15	1.14	1.86	1.97
Anteiso–13 : 0	0.07	0.01	0.03	0.03	0.52	0.09	0.07	0.10	0.03	0.25	0.63	0.57
13 : 0	0.41	0.43	0.66	0.40	0.32	0.84	0.49	0.25	0.28	0.93	1.18	1.56
Iso–14 : 0	0.38	0.30	0.29	0.12	0.16	0.36	0.19	0.22	0.18	6.28	4.85	5.34
14 : 0	10.99	8.27	7.95	10.23	8.02	8.36	11.32	9.04	9.55	23.57	24.63	27.16
14 : 1	2.19	2.67	4.38	3.55	3.61	3.05	4.55	4.03	4.81	6.46	9.28	8.17
Iso–15 : 0	0.59	0.68	0.67	0.77	0.53	0.46	0.93	0.49	0.51	1.39	0.65	1.05
Anteiso–15 : 0	0.18	0.21	0.17	0.35	0.13	0.30	0.46	0.15	0.19	0.41	0.36	0.52
15 : 0	0.96	0.98	0.89	1.12	1.02	1.62	1.04	1.27	1.15	1.34	0.37	0.92
15 : 1	0.02	0.03	tr	0.05	0.07	0.07	0.04	0.06	0.04	0.02	0.16	0.27
Iso–16 : 0	0.21	0.24	0.35	0.13	0.16	0.21	0.15	0.03	0.17	1.51	1.20	1.96
16 : 0	21.39	20.44	18.34	25.25	24.28	19.30	20.17	21.45	19.42	6.34	8.68	11.30
16 : 1	24.27	22.82	24.67	18.98	21.50	24.19	22.30	20.81	23.47	11.40	7.86	7.19

16 : 2	0.52	0.83	0.93	0.41	0.59	0.81	0.77	0.88	0.75	0.23	0.07	0.21
16 : 3	0.55	0.45	0.70	0.37	0.26	0.72	0.35	0.68	0.46	0.19	0.12	—
Iso–17 : 0	0.27	0.25	0.31	0.56	0.34	0.53	0.27	0.54	0.33	0.10	0.04	0.05
17 : 0	0.43	0.63	0.80	0.93	0.79	0.78	0.51	0.96	0.79	0.33	0.02	0.07
Iso–18 : 0	0.03	0.09	0.16	0.02	0.03	0.11	0.05	0.08	0.03	0.19	0.32	0.03
18 : 0	2.88	3.67	3.76	3.43	3.12	3.20	2.58	2.62	2.87	0.75	1.02	0.41
18 : 1	20.71	21.67	20.81	22.27	23.21	19.74	19.76	23.29	20.85	2.71	0.09	0.55
18 : 2	4.16	5.57	4.32	2.36	3.32	4.38	4.55	4.04	4.37	0.26	0.02	—
18 : 3	1.31	1.95	1.44	1.16	1.27	1.69	1.30	1.37	1.43	0.13	0.02	—
18 : 4	0.36	0.73	0.20	0.50	0.35	0.31	0.11	0.22	0.49	0.08	—	—
19 : 0	0.25	0.10	0.13	0.15	0.08	0.13	0.09	0.10	0.37	0.02	0.01	—
20 : 0	0.09	0.18	0.15	1.25	0.10	0.14	0.08	0.07	0.19	0.01	—	—
20 : 1	0.79	0.80	0.73	0.45	1.07	1.33	1.31	1.41	0.45	0.02	—	—
20 : 2	0.13	0.09	0.17	0.13	0.08	0.09	0.06	0.07	0.11	tr	—	—
20 : 3	0.11	0.13	0.27	0.04	0.06	0.08	0.05	0.04	0.06	0.03	—	—
20 : 4	0.16	0.17	0.83	0.02	0.14	0.49	0.18	0.18	0.07	0.06	—	—
20 : 5	0.10	0.26	0.23	0.66	0.42	0.27	0.25	0.51	0.38	0.01	—	—
21 : 0	0.13	0.05	0.06	—	0.05	—	—	0.04	—	—	—	—
22 : 1	0.08	0.16	0.07	0.05	0.13	0.03	0.13	0.02	0.06	tr	—	—
22 : 2	0.29	0.56	0.25	—	0.34	0.13	0.26	0.33	0.19	tr	—	—
22 : 3	—	0.13	0.08	—	—	0.10	—	0.04	0.17	—	—	—
22 : 4	0.08	0.12	0.11	—	0.09	0.08	0.08	0.03	0.40	0.01	—	—
22 : 5	0.39	0.48	0.27	0.07	0.38	0.20	0.31	0.35	0.26	0.07	—	—
22 : 6	0.74	1.43	1.00	0.06	1.09	0.68	1.11	1.10	1.13	0.11	—	—
24 : 1	0.15	0.16	0.08	—	0.11	—	0.07	0.05	0.05	—	—	—
Saturated	42.64	38.42	37.50	48.47	41.79	40.75	42.11	40.31	39.57	73.92	78.24	80.63
Unsaturated	57.36	61.58	62.50	51.53	58.21	59.25	57.89	59.69	60.53	26.08	21.76	19.37

On the other hand, the fatty acid components and distribution patterns of melon and lower jaw oils are entirely different with the oils in other blubbers, and also the levels of individual and groups of fatty acids are unique to these samples. They perhaps can be characterized by high levels of saturated, isomer and short carbon length acids with less than 14 carbon atoms, while the level of fatty acids with more than 18 carbon atoms has very low or no proportions. The proportion of total saturated acid containing *iso* C_5, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17} and C_{18} carbon atoms is evidently abundant. The ratio of total saturated and unsaturated acids is 78.24% of melon oil or 80.63% of lower jaw oil *vs* respectively 21.76% or 19.38%. The eight main acids which represented the levels of 96.78% (melon oil) or 84.14% (lower jaw oil) of each total acid are followed in order of ascending proportion; $C_{14:0}$, $C_{12:0}$, $C_{14:1}$, *iso* $C_{12:0}$, $C_{16:0}$, $C_{16:1}$, *iso* $C_{14:0}$ and $C_{12:1}$ as melon oil, and $C_{14:0}$, $C_{12:0}$, $C_{16:0}$, $C_{14:1}$, $C_{16:1}$, *iso* $C_{14:0}$, *iso* $C_{12:0}$ and $C_{10:0}$ as lower jaw oil. The long chain acids with more than 18 carbon atoms which represented the levels of 32.33% (blubber oil of upper side of ventral fin)—38.50% (inner blubber oil of root area of dorsal fin) of each total acid in other blubber oils with the exception of root area of tail fin oil, are only minor components or are not present at all in melon and lower jaw oils.

The fatty acid components and distribution pattern of each blubber oil of Amazon dolphin in this investigation bears a close resemblance to those of blubber oil according to Ackman *et al* (1972), but the levels of *iso* $C_{12:0}$ and *iso* $C_{14:0}$ have a few difference.

In comparison with Ganges river dolphin oil (Tsuyuki and Itoh, 1971, 1972) and Amazon dolphin oil, they have a few difference. As concerned with the chemical properties, iodine value of Ganges river dolphin oil is generally seemed to be higher than that of Amazon dolphin oil. With a few exception, the fatty acid components and distribution patterns of Amazon dolphin oil and Ganges river dolphin oil are nearly similar in both species. The proportions of $C_{16:1}$ acid (21.96–23.21%) and $C_{18:1}$ acid (28.21–28.27%) in Ganges river dolphin oil are larger than those in Amazon dolphin oil, however the proportions of $C_{16:0}$ acid (13.95–17.30%) in Ganges river dolphin oil is somewhat smaller. The most notable deviations are the high levels of $C_{16:1}$ acid (38.97%) and $C_{18:1}$ acid (21.31%), and the low levels of $C_{12:0}$ acid and $C_{14:0}$ acid (7.08%) in melon oil of Ganges river dolphin. Although, they are respectively $C_{16:1}$ acid (7.86%), $C_{18:1}$ acid (0.09%), $C_{12:0}$ acid (19.94%) and $C_{14:0}$ acid (24.63%) in the levels of melon oil of Amazon dolphin. Also, *anteiso* acids such as $C_{11:0}$, $C_{13:0}$ and $C_{15:0}$ were detected a few presence in blubber oil of Amazon dolphin, but they were no presence in blubber oil of Ganges river dolphin.

SUMMARY

1. The properties of oils contained in 12 part blubbers of Amazon dolphin, *Inia geoffrensis*, were studied.

2. The fatty acid components of Amazon dolphin oils were analyzed by GLC on DEGS and EGSS—X columns.

3. The fatty acid components were shown the presence of 49 fatty acids with chain lengths from 5 to 24 carbon atoms and with zero to six double bonds.

4. The fatty acid components and distribution patterns were relatively a resemblance in various blubber oils of Amazon dolphin with exceptions of oils contained in blubbers of melon, lower jaw and root area of tail fin.

5. The main fatty acids in various blubber oils of Amazon dolphin with exceptions of oils contained in blubbers of melon, lower jaw and root area of tail fin were $C_{14:0}$ acid (7.95–11.32%), $C_{16:0}$ acid (18.34–25.25%), $C_{16:1}$ acid (18.98–24.67%) and $C_{18:1}$ acid (19.74–23.29%).

6. The fatty acid components of oils contained in blubbers of melon, lower jaw and root area of tail fin were seemed to be contained the high proportions of saturated acids with short carbon chain lengths.

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COMPARISON IN COLOUR PATTERN OF TWO SPECIES OF HARBOUR SEAL IN ADJACENT WATERS OF HOKKAIDO

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ABSTRACT

The pelage of *Phoca vitulina largha* shows a clear colour contrast between the lighter ventral and the darker dorsal. On the other hand, the pelage of *Phoca kurilensis* shows little such contrast. There is much variation in the pelage of both species. Sometimes *Phoca kurilensis* has pelage closely resembling that of *Phoca vitulina largha*, and identification by colour pattern is difficult. Hard scars are often found on the pelage of *Phoca kurilensis*, which are presumably caused by fights between males during the breeding season.

INTRODUCTION

The pelage colour and pattern of the harbour seal have been reported in the literature ever since biologists have been interested in this animal. It is generally said to be quite difficult to describe them precisely because of their endless variations. However, in spite of the above difficulties, the importance of pelage studies of this seal has increased all the more, in the light of recent studies on its taxonomy and zoogeography in the North Pacific.

In the North Pacific, there are three types of harbour seal; *Phoca vitulina largha*, *Phoca vitulina richardi*, and *Phoca kurilensis* (i.e., *Phoca insularis*). These three seals differ in their distribution, breeding grounds and habitat. *P. v. richardi* breeds on sand bars or rocky shores and occurs along the Pacific coast of North America (Scheffer and Slipp, 1944; Fisher, 1952; Scheffer, 1958; King, 1964; Stutz, 1967; Bigg, 1969). *P. v. largha* is an ice breeding type and occurs mainly in the Bering Sea and the Sea of Okhotsk (Inukai, 1942 a, b; Wilke, 1954; Scheffer, 1958; King, 1964; Burns, 1970; Tikhomirov, 1971; Fay, 1972; Naito and Nishiwaki, 1972 a). *P. kurilensis* breeds on rocky shores and occurs along the Kurile Islands and Hokkaido (Inukai, 1942 a, b; Belkin, 1964; Belkin *et al.*, 1969; Naito and Nishiwaki, 1972 a). The distribution of this species is incompletely known.

It is generally recognized that the differences in the pup coat are important characters that distinguish each species or subspecies. The white-coat pup of *P. v. largha*, according to McLaren (1966) is one of the most important characters by which this seal can be regarded as an independent species (*P. largha*) from other *P. vitulina* groups which do not bear such a pup coat. The colour and pattern of the

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adult pelage also seem to be important. Variations among local populations of the pelage colour and pattern are reported in *P. v. richardi* (Stutz, 1967). However, studies on these problems in the above mentioned three types of harbour seals still do not provide sufficient data for comparative taxonomic evaluation. Furthermore these studies seem to be important to establish the relationship between pelage character and habitat of each type from the point of view of adaptation and speciation.

The present paper provides some new data on the pelages of *P. v. largha* and *P.*

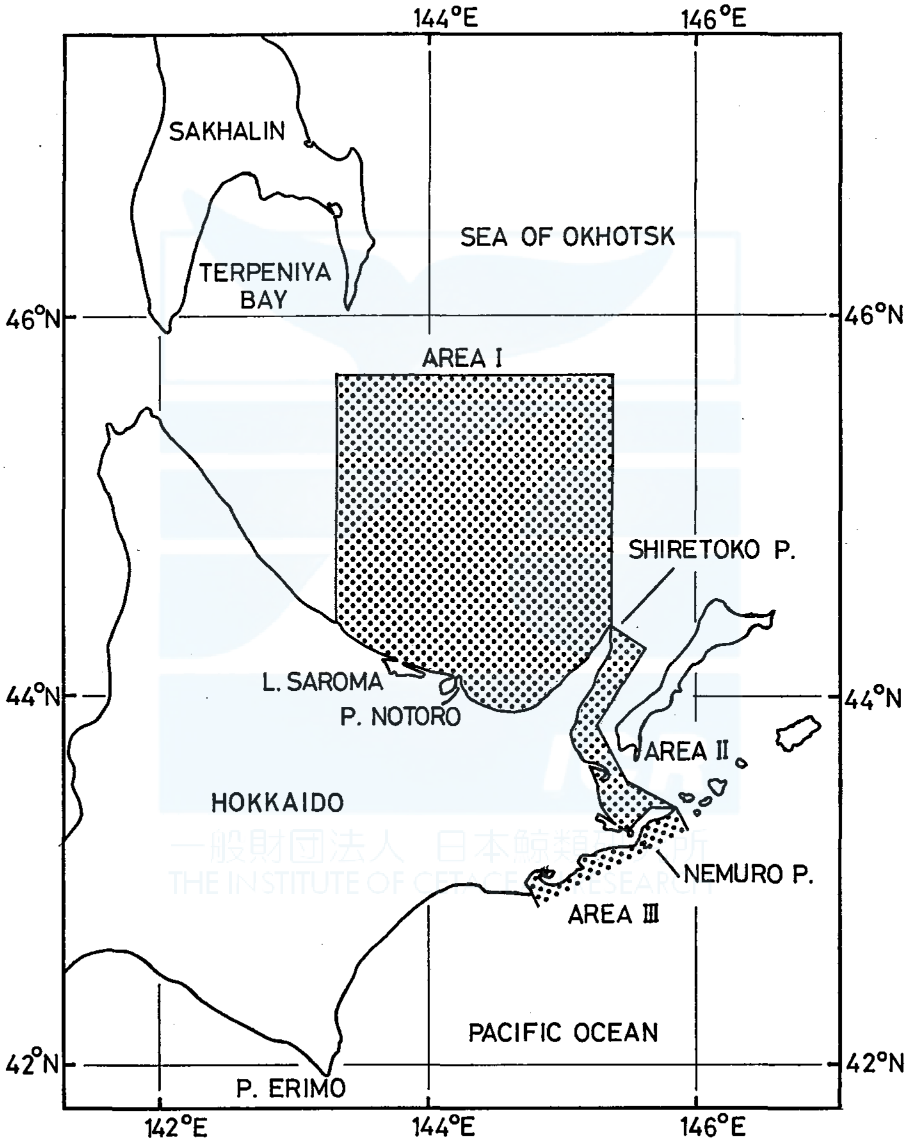

Fig. 1. Sampling areas for *P. v. largha* and *P. kurilensis* in the southern Sea of Okhotsk and the Pacific coast of Nemuro Peninsula.

kurilensis and attempts to clarify the above mentioned problems.

MATERIALS AND METHODS

Field studies on the harbour seal (*P. v. largha* and *P. kurilensis*) were made in the southern Sea of Okhotsk and Hokkaido from 1969 to 1971. Pelage studies were included during the same period and mostly in the same area (Fig. 1). The pelage of *P. v. largha* for this study was recorded from the southern Sea of Okhotsk (area I) and from Nemuro Strait (area II). The pelage of *P. kurilensis* was recorded from area III of Pacific coast of Nemuro Peninsula. Ninety-four skins of *P. v. largha* and 37 of *P. kurilensis* were examined to establish the range of variation in pelage colour and pattern of each seal by studying photographs taken at the factories of fur companies.

PUP COAT OF *P. KURILENSIS*

It is widely reported in the literature that *P. v. largha* is a pagophilic seal and bears its pup without exception with a white coat. Belkin (1964) and Belkin *et al.* (1969) reported however that the pup of this seal is born with the adult type coat. *P. v. richardi* is also generally recognized to bear the adult type coat pup, the white coat being lost *in utero* before birth. However, there are some reports on the pups of *P. v. richardi* which still retain their white coat after birth (Scheffer and Slipp, 1944; Fisher, 1952; Burns, 1970; Stutz, 1966). The same phenomenon is suggested for *P. kurilensis* (Naito and Nishiwaki, 1972 a). The present paper gives more details of exceptional white-coat pups of *P. kurilensis*.

TABLE 1. SOME MEASUREMENTS OF WHITE-COAT PUPS OF *PHOCA KURILENSIS* AND THE EXCEPTIONAL PUP WITH THE *LARGHA*-TYPE COAT OF *PHOCA KURILENSIS*.

	field number	date of catch	locality	sex	body length	body weight	
white coat pup	NM 16	1969–5.20	Moyururi Is.	male	89 cm	16 kg	with 10 cm umbilical cord
	'70–154	1970–5.25	Daikoku Is.	female	93 cm	14.5 kg	with 9.5 cm umbilical cord
pup with the *largha* type coat	'70–173	1970–5.18	Pacific coast of Nemuro P.	female	98 cm	23 kg	with 5.5 cm umbilical cord

* mean body length of *P. kurilensis*: 98.2±3.2 cm (Naito and Nishiwaki, 1972a)

As shown in Table 1, two exceptional white-coat pups were collected from area III. One was mostly covered with a white coat except for head, flippers and tail. The colour of the hair is creamy white itself, however, as shown in Plate I, the adult type coat under it imparts a greyish hue. The other exceptional pup possessed a partial white coat (15 cm wide) on its dorsal parts, the hair being so thin that its existence was easily missed if the body was wet. These exceptional pups occurred among 20 pups which possessed a fresh umbilical cord (5–10 cm).

Burns (1970) reported the retention of the white coat in early-born pups of *P. v.*

richardi in the Alaska Peninsula, where this seal has a longer pupping season (late-May to mid-July) than *P. kurilensis* in Hokkaido (mid to end of May; Naito and Nishiwaki, 1972 a. According to a fisherman, the earliest record in Hokkaido is 28th of April). The birth of these exceptional pups occurred during the normal birth season of this seal and their body size is quite normal. The frequency of appearance of these white-coat pups is still unknown because of inadequate data, however, it is said that the specimen of Plate I collected 20th of May 1969 was the first example in the long experience of the fur company and the fisherman. Belkin *et al.* (1969) observed more than 100 newborn pups of this seal in the southern Kuril Islands some of which possessed fresh umbilical cords; however, they found none of the above type of exceptional pup. Therefore, it seems that the white-coat pup is considerably rare in the southern Kuril Islands and Hokkaido.

THE PELAGE COLOUR AND PATTERN

Inukai (1942 a) and Belkin (1964) recognized the pelage colour and pattern as important characters distinguishing *P. kurilensis* from *P. v. largha*. However, in spite of their work, the range of variation of the pelage colour and pattern of each species is still unknown. In *P. v. richardi*, Stutz (1967) studied the range of variation of pelage colour and pattern and named three basic categories: " black ", " common " and " muddy ", and suggested that these three categories typify three largely isolated local populations. In the present study, the range of variation of the pelage colour and pattern of *P. v. largha* and *P. kurilensis* were examined in 94 and 37 photographs respectively.

TABLE 2. FREQUENCY OF APPEARANCE OF EACH COLOUR TYPE

	lighter ← colour degrees → darker					
	1	2	3	4	5	Total
P. v. largha numbers examined	9	17	44	18	6	94
(%)	(9.6)	(18.1)	(46.8)	(19.1)	(6.4)	
P. kurilensis numbers examined	3	11	14	6	3	37
(%)	(8.1)	(29.7)	(37.8)	(16.0)	(8.1)	

Ninety-four pelages of *P. v. largha* were classified into five categories by the colour, from lighter to darker (Plate II), and the frequency of appearance was examined. These colour categories were chiefly determined by the number and size of dark spots on the ventral side. As shown in Table 2, the distribution in these categories seemed not to show any bias to the lighter side or blacker side. The colour of the pelage of this seal is, as shown in Plate II, composed of two parts, a darker part on the dorsal side and a lighter part on the ventral side. The mid-line of the dorsal side is darkest, showing black, blueish-black or dark grey, and dorsal dark colour sharply fades out in the border parts between dorsal and ventral sides, which show creamy white or silvery white. This contrast is clearer in the lighter colour type. Dark spots appear all over the pelage, showing wide variation in size and form. Indistinct light marks are seen on the dark dorsal side, sometimes showing obscure small ring marks. The above-mentioned colour is not constant through the year. Moulting of the hair occurs in April and May, and the colour differs markedly in the moulting season. Light parts turn to creamy or sometimes light brown, dark parts turn to dark brown, and spot marks become obscure.

Thirty-seven pelages of *P. kurilensis* were also classified into five categories from lighter to darker. As shown in Table 2, the distribution in these categories as for *P. v. largha* seemed not to show any bias to lighter or darker. Plate II indicates that the pelage of *P. kurilensis* shows little or no colour contrast between dorsal and ventral side, as seen in *P. v. largha.* The colour of the dorsal side is black or dark brown, with dark grey or light brown on the ventral side. The pattern differs between dorsal and ventral sides. There are several clear light ring marks on the dorsal side, sometimes on both dorsal and ventral sides, and on the ventral side many deformed and complicated light ring marks or mottles are seen. These pelages in my observation seemed to have a good camouflage effect when the seals haul out on the rocky shores (Plate III).

As mentioned above, most of *P. v. largha* and *P. kurilensis* are divided by pelage colour and pattern as indicated by Inukai (1942 a) and Belkin *et al.* (1969). However, Plate II indicates that the darker pelage of *P. v. largha* (colour type 5) resembles the lighter pelage of *P. kurilensis* of colour type 1, and it is suggested that it is difficult to distinguish them completely by pelage colour and pattern. Furthermore, we collected a strange pup of *P. kurilensis,* of which the pelage colour and pattern do not belong to any colour degree of *P. kurilensis* but seem to belong to those of *P. v. largha* (Table 1). As shown in Plate IV, fig. 1, characteristic ring marks of *P. kurilensis* are recognized on the dorsal side while the ventral side is silvery white with little small spots, showing a clear colour contrast with dorsal side. It seems quite difficult to identify this pup from pelage colour and pattern. However, this pup was identified as *P. kurilensis* for the following reasons: 1) This pup possessed the incomplete hyoid bones, as the normal *P. kurilensis* does (Naito and Nishiwaki, 1972 b). 2) The birth time and place belonged to those of *P. kurilensis* (Naito and Nishiwaki, 1972 a). This *largha* type seal occurred among 153 collection of *P. kurilensis.* The other example of *largha* type *P. kurilensis* like the above pup was observed in our field observation at Moyururi Island in the beginning of April 1970. In this observation, only one such white pelage seal was found out of 92 *P. kurilensis* in the colony. Judging from the season and location, this seal was supposed to be *P. kurilensis.* From the above facts it is suggested that the *largha* type seal of *P. kurilensis* is quite rare in this area.

SCARS OF PELAGE

Inukai (1942 b) reported scars on the neck of large males of *P. kurilensis.* I found remarkable scars on the pelages of male *P. kurilensis,* while no scars were found on the pelages of both sexes of *P. v. largha.* These scars were mainly found around the neck, the hind flippers and the tail. The larger and harder scars were found around the neck (Plate IV. fig. 2). The scars were sometimes so heavy and severe that the pelage around the neck showed an uneven surface, with many old ones. The cause of these hard scars is still unknown. However, the facts that the fresh bleeding scars were found only in the breeding season (May to June) and only on adult males (Table 3) suggests that the scars are caused by fighting between males in the breeding season. This is supported by the following observations. I observed hard struggles of this seal in the breeding season during the field observation performed at Moyururi Island in early June of 1969. However, in early April (two months before breeding season) none of struggles were observed among 92 in the population at the same island.

TABLE 3. LIST OF MALES OVER 140 cm IN BODY LENGTH OF *PHOCA KURILENSIS* ON WHICH SCARS WERE FOUND.

density of scars	field number	date of catch	body length	estimated age
heavy	1970-208	1970-6.6	191.4 cm	19
	1970-221	1970-6.16	192.5	—
medium	1970-223	1970-6.16	183	10
	1971-444	1971-6.7	183	10
	1971-455	1971-6.28	184	8
	1971-456	1971-6.28	180	9
light	1970-224	1970-6.16	170.5	—
none	1970-219	1970-6.16	165.5	4
	1970-215	1970-6.10	160.0	4
	1971-457	1971-6.28	161	—
	1971-447	1971-6.27	152	3
	1970-209	1970-5.6	146.5	5
	1971-424	1971-5.22	144	3

DISCUSSION

It is revealed that shore pupping *P. kurilensis* bear a white-coat pup quite exceptionally. In my study, the occurrence of white-coat pups of *P. kurilensis* seemed to be rare, while the occasional occurrence of a white coat in newborn pups of *P. v. richardi* is reported from Alaska to as far south as California (Scheffer and Slipp, 1944; Fisher, 1952; Stutz, 1966; Burns, 1970). It would be interesting to know which seal shows a higher frequency of white-coat pups between *P. kurilensis* and *P. v. richardi*, in consideration of the phylogenetic aspects of *P. v. largha*, *P. v. richardi* and *P. kurilensis* in the North Pacific.

With regard to pelage colour and pattern, it was found that *P. v. largha* shows a lighter phase ventrally, contrasting with a dark dorsal side; *P. kurilensis* has a darker phase both ventrally and dorsally, showing less or no contrast between both sides. The difference in pelage colour and pattern between *P. v. largha* and *P. kurilensis* as mentioned above seems to relate to differences in their habitats or hauling grounds. *P. v. largha* stays on ice floes in winter and spring, occupying the edge of the pack ice (Wilke, 1954; Burns, 1970; Fay, 1972). After ice-melt, seals are highly migratory (Fay, 1972). In Hokkaido, the hauling grounds of this seal show wide topographical variation. They haul out on the rocky reefs at Point Notoro and grass bars or sand bars of the inland sea the mouth of which opens to the Sea of Okhotsk or Nemuro Strait, where such environments are often found. They are rarely seen however on the Pacific coast of Nemuro Peninsula (Fig. 1), where rocky shores prevail. The lighter pelage of *P. v. largha* seems to adapt to the above mentioned lighter circumstances, and furthermore the lighter phase of the ventral side, in contrast with darker dorsal side, may have a camouflage effect by obliterative counter shading as seen in pelagic fish (Lagler *et al.*, 1962) when they migrate offshore. On the other hand, *P. kurilensis* occurs on the rocky coast of Nemuro Peninsula (Naito and Nishiwaki, 1972 a), rarely penetrating the inland sea of the Nemuro Peninsula where *P. v. largha* is dominant. These seals are non-migratory and are found along the coast throughout the year, hauling out on the rocky shores of small islands (Belkin, 1964; Belkin *et al.*, 1969). The darker colour and white ring marks of their pelages are supposed to be well adapted to their habitat or hauling grounds as mentioned already. We are still uncertain, but the above facts may suggest that *P. v. largha* and *P. kurilensis* select their own habitats or hauling grounds in accordance with their pelage colour and pattern. This interpretation may be supported by their following behaviour. According to some fisherman or hunters in Hokkaido, when *P. v. largha* and *P. kurilensis* haul out at the same place and are hunted, *P. v. largha* swims away offshore, while *P. kurilensis* goes along the coast where rocky reefs are well developed.

Stutz (1967) classified the pelage colour and pattern of *P. v. richardi* into three basic categories, " common ", " black " and " muddy ". The pelage of " common " and " black " of *P. v. richardi* seem to correspond to that of *P. v. largha* and *P. kurilensis* of the present study respectively, and it is known that *P. v. richardi* haul out on both sand bars of river estuaries or inland sea and rocky coast (Scheffer and Slipp, 1944; Fisher, 1952; Fisher, Bigg, and Newby, personal communication). However, it is still unknown whether *P. v. richardi* shows any tendency of habitat segregation by the pelage colour. Newby, in private communication, informed me of the pelage colours of seals in the different areas of the state of Washington, with a comment on inadequate data. The San Juan seals that haul out on rocks are darker than those found on the sandy beaches of the coast and inland sea.

From these findings, it appears important in future studies to consider the systematic relation between *P. v. largha*, *P. v. richardi* and *P. kurilensis*. Stutz (1967) reported that his " common " pelage (resembling that of *P. v. largha*) appears in 15–47% in the pelages of *P. v. richardi* collected from some places in Alaska and British Columbia. It was quite rare in *P. kurilensis* in our study. However, unfortunately there are quite few data from the Kuril and Aluetian Islands as far east as the Alaska Peninsula, for considering this problem genetically and zoogeographically.

The scars on the adult male pelages of *P. kurilensis* are of interest from the point of view of social behaviour. *P. v. largha* mates in the ice floe region, displaying " family groups " (consisting of male, female and pup) which are rarely closer together than 0.2 Km (Burns et al., 1972). *P. kurilensis* on the other hand breeds on narrow rocky shores in large herds (70–90 individuals including young were observed at Moyururi Island in 1969 and 1971), and fighting was observed among them. Ohsumi (1971) suggested that scars on the male sperm whale may indicate social maturity of the males in the harem. In the present study, as I am still uncertain as to the minimum ages and body size at sexual maturity in this seal, I cannot discuss the relation between these scars and sexual maturity. Therefore, I do not know what these scars mean. However, I can indicate that they are closely related to their breeding habitat and their social behaviour when I consider that the sexual dimorphism of this seal in body size is larger than that of *P. v. largha* (Naito and Nishiwaki, 1972a). Further studies on these problems are required in *P. kurilensis* and also in *P. v. richardi.*

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EXPLANATION OF PLATES

PLATE I

The exceptional white-coat pup of *Phoca kurilensis* (middle). Upper, white-coat pup of *Phoca vitulina largha*; lower, normal pup of *Phoca kurilensis*.

PLATE II

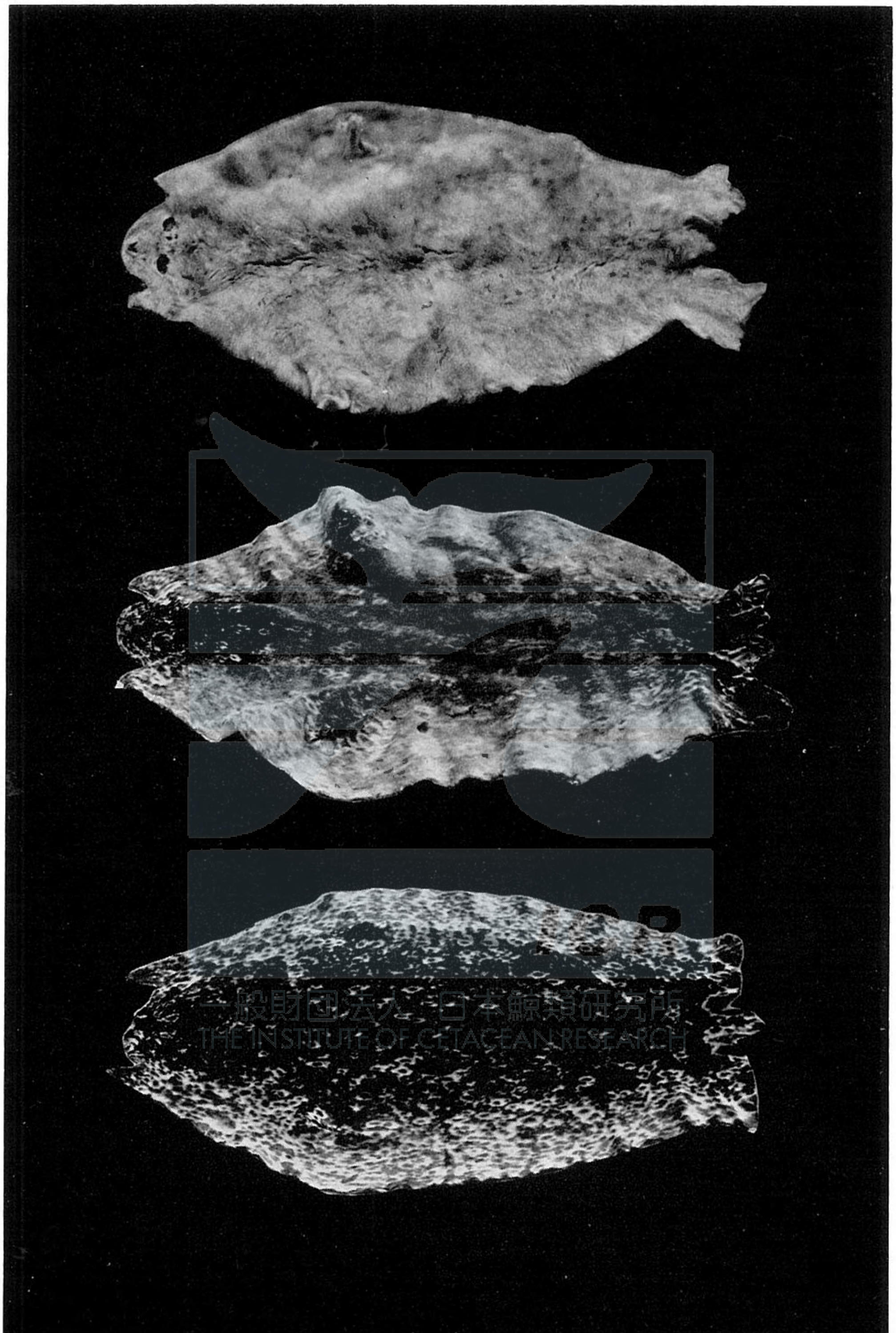
Classified five colour types from light to dark of *Phoca vitulina largha* (left side) and *Phoca kurilensis* (right side).

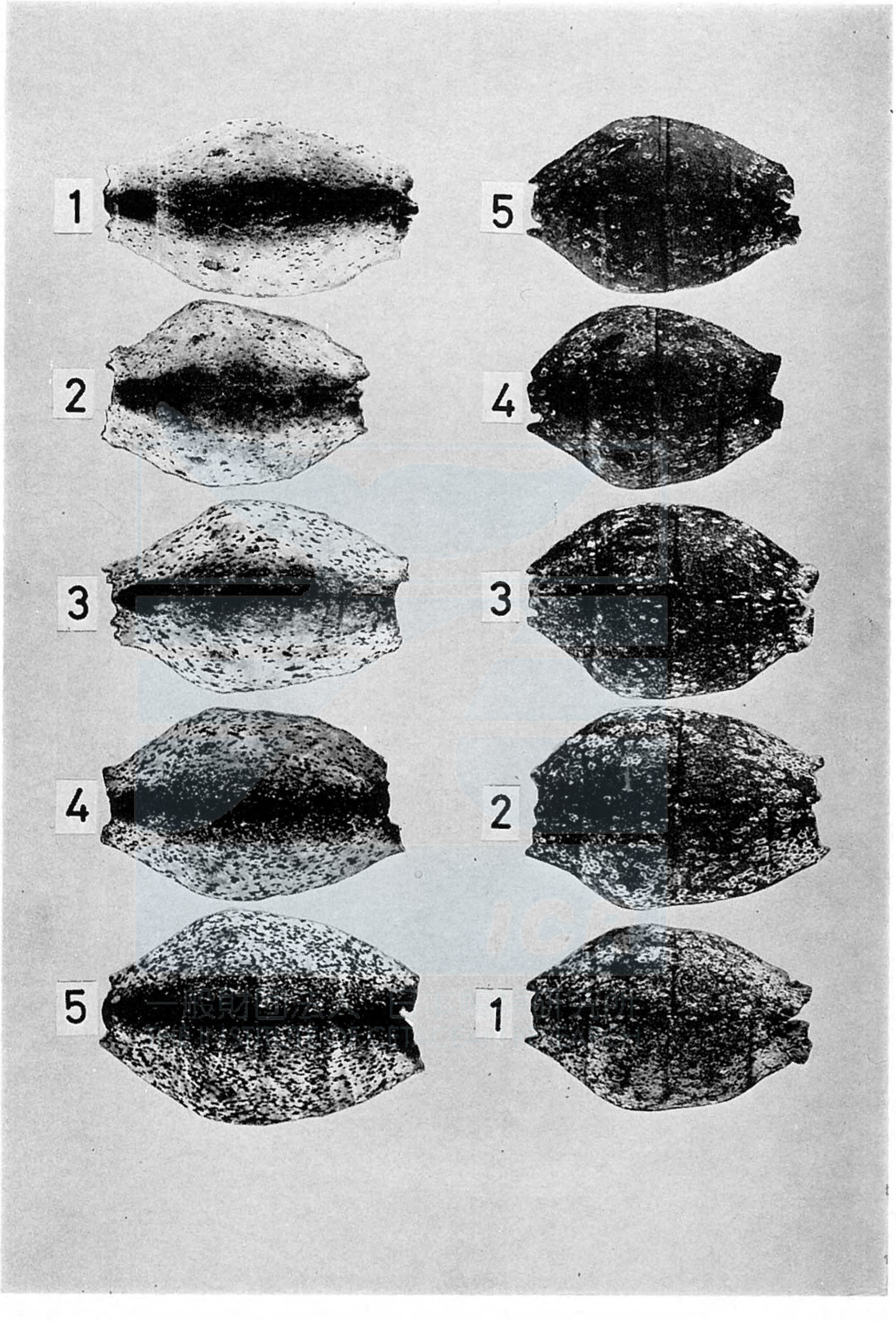
PLATE III

Phoca kurilensis have a camouflage effect by their pelage colour and pattern when they haul out on the rocky shores.

PLATE IV

Fig. 1. The exceptional *largha* type coat pup of *Phoca kurilensis* (in a stuffed specimen).
Fig. 2. The scars on the pelage of a large male of *Phoca kurilensis*.

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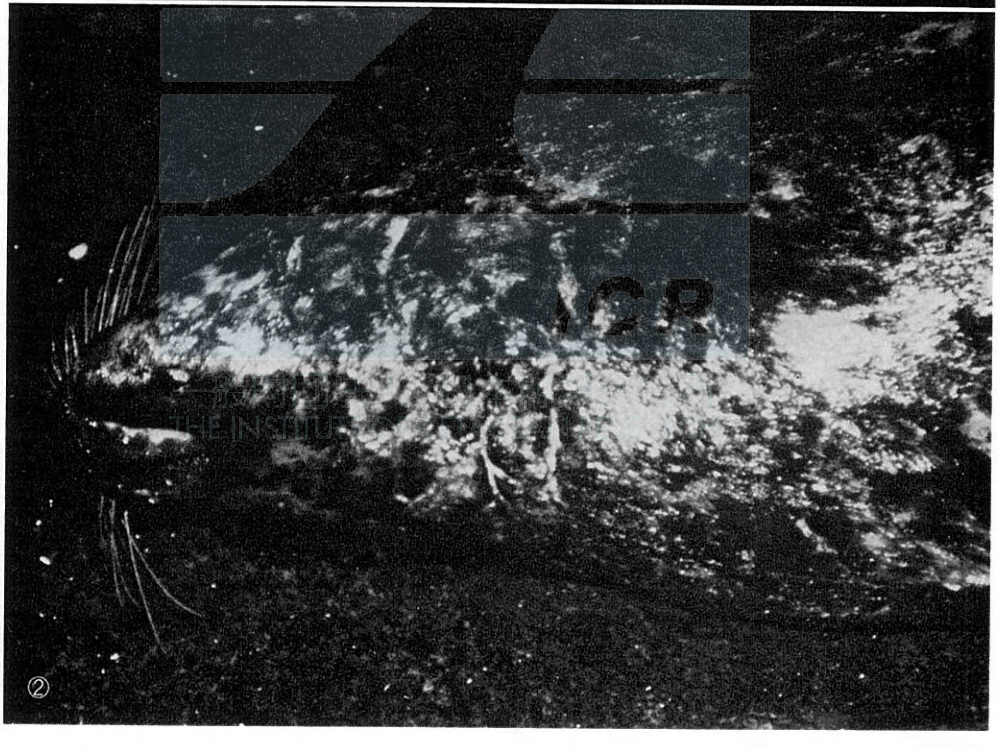

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