INFLUENCE OF CHASING TIME TO STOMACH CONTENTS OF BALEEN AND SPERM WHALES

AKITO KAWAMURA

ABSTRACT

The duration of chasing time by catcher boats which might influence on the fulness of stomach contents of whales was examined on fin, sei, and sperm whales caught in the northern North Pacific during the summer of 1969. Of 895 whales observed only 28 whales (3.6%) vomited out their stomach contents while chasing, and sperm whale vomited most frequently (16.8%) whereas sei and fin whales were 1.1% and 0.78% respectively. The diet of the whales concerned was consisted of boarfish, squid, copepods and euphausiids. It was often observed that the whales likely to vomit out more larger sized foodstuff such as boarfish than smaller one. The amount of stomach contents vomited was negligibly few, and has no significant influences on the amount of stomach contents which have been obtained from carcasses. Most whales (81%) were caught within 40 minutes of chasing, and the number of whales which would vomit out their stomach contents does not always increase in proportion to the prolongation in the duration of chasing time. It was estimated also that the fully repleted stomach of the baleen whales would be almost emptied by digestion within 15 hours or so.

INTRODUCTION

The quantity and its fulness of the stomach contents of baleen whales have long been observed, and a considerable amounts of those knowledges were accumulated in the pelagic and coastal whaling operations (e.g. Collett, 1911–12; Klumov, 1961; Nemoto, 1957, 1966, 1970: Brown, 1968; Gambell, 1968; Kawamura, 1970a). These observations can be considered as one of the very important items in the biological observations of whales to offer basic data for realizing a feeding behavior of whales along with the swarm forming mechanisms of prey organisms such as an estimation of swarm density (Kawamura, 1970b; Omori *et al.*, 1971). In addition, they will give a fundamental material for a nutritional budget between predator and prey animals as Marr (1962) tried to evaluate an approximate estimation of quantitative relationships between *Euphausia superba*, one of a principal food sources of the Antarctic baleen whales, and the feeding of baleen whales.

In the post-war years, on the other hand, the proportional increase of vacant stomachs among the whales caught was reported as Mackintosh (1965) denoted (e.g. Nishiwaki and Oye, 1951; Peters, 1955). Nemoto (1957) pointed out that the actual fulness of first stomach of the North Pacific fin whale in percentage figures has been reduced distinctly in accordance with the prolongation of chasing time of catcher boats, and later, he suggested a possible causative reason on this

Sci. Rep. Whales Res. Inst.,
No. 23, 1971. 27–36.

subject (Nemoto, 1959), *i.e.* an awful improvements of fishing effort especially in the greately increased power of modern whalers enabled them to chase the whale more actively rather than stalk so as to the whales can not swim so powerfuly anymore. Hence a possible causative factors which may induce the decrease in the fulness of stomach contents on the whole would be due to a vomit of foodstuff during those long and restless chasing by the whalers though it seems partly due to digestion. The decrease in the quantity of stomach contents in relation to chasing time can be considered to be caused by both vomit and digestion, although there still remains some physiological problems whether such a muscle fatigue is responsible for the vomiting behavior of whales.

In this point of view, the present observations were chiefly focussed on the above mentioned subject to know how much and often the whales actually vomit out their stomach contents by chasing in the recent whaling operations. If the actual amount of stomach contents vomited was negligibly small, it would be needless to take these loss of food into considerations when we measure the whole amount of stomach contents of carcasses. I made a brief analysis on the materials to give some criterion concerning to those " vomit " problems.

MATERIALS

The material used in the present study was compiled by the personnel who belonged to six whale catchers which participated in the North Pacific whaling operations during the summer of 1969. Sending a form to whaling companies, I asked them to fill the following observation items, *i.e.* date, position at which whale caught, time (L.T.) of first sight, beginning time of chasing, time of harpooned, occurrence of vomit, amount and kind of food organisms vomited, chasing speed, and whale species concerned. Season, localities and whale species were not designated beforehand because any of these were not thought likely to give inherent effects on the results.

The whale catchers participated in the observations in the whaling ground were six in all as described below, and I will extend my great appreciations to the whaling companies and all personnel on boad.

Taiyo Gyogyo K.K. Toshi Maru No. 17 and Toshi Maru No. 18
Nihon Suisan K.K. Konan Maru No. 25 and Konan Maru No. 26
Kyokuyo Hogei K.K.* Kyo Maru No. 12 and Kyo Maru No. 15

RESULTS

An outline of observations

The general features of the investigation are summarized in Table 1. In the season of 1969 three Japanese whaling fleets operated in the mid-latitudes of the northern North Pacific, approximately between 40°N and 50°N. It was 0420 hour

* Present name: K. K. Kyokuyo.

TABLE 1. NUMBER OF WHALES OBSERVED BY SIX CATCHER BOATS WHICH PARTICIPATED IN THE NORTH PACIFIC WHALING OPERATIONS IN 1969.

Fleets		Kyokuyo Maru No. 3		Tonan Maru		Nisshin Maru		
Cather boats participated		Kyo Maru No. 12	Kyo Maru No. 15	Konan Maru No. 25	Konan Maru No. 26	Toshi Maru No. 17	Toshi Maru No. 18	
Duration of operation (day/month)		18/V–25/VI	6/V–18/VIII	19/V–24/VII	24/V–8/VII	16/V–4/VIII	17/V–4/VIII	Total
Sei whale	Vomited	—	—	—	—	1	5	6
	None	22	74	55	102	—	174	427
	Unknown	—	—	15	13	175	6	209
Fin whale	Vomited	—	—	—	—	—	1	1
	None	4	16	25	16	—	24	85
	Unknown	—	—	8	7	28	—	43
Sperm whale	Vomited	—	20	—	—	—	1	21
	None	—	81	—	—	—	23	104

Note: Sperm whale was not observed except Kyo Maru No. 15 and Toshi Maru No. 18.

that the whale was sighted at the most earliest in the morning, and 2105 hour for the latest time of catch. The observations were performed throughout the whole whaling seasons, May to August, and the material can be considered to represent a general results of whaling of this season. The total numbers of fin, sei, and sperm whales concerned to this study were 129, 742, and 125 whales respectively. They were chased at various ship speed but usually it was 17–18 knots in the first of chasing then slowed down to 8–12 knots when the whales were harpooned. The whaling sonar was often used while under chasing. As it is noticed in the results of two Konan Maru and Toshi Maru No. 17, there were considerable number of *unknown* whales. This fact suggests that there was some difficulties in practical observations of whale's vomit from heavily heaving ships. The actual number of whales which leaked out their stomach contents to some extent while under chasing was only 28 whales (or 3.6%) among 895 whales through three whale species concerned. Kyo Maru No. 15, however, observed one fifth (20.0%) of vomited sperm whales. The sperm whale on the whole seems more likely to vomit out the stomach contents (16.8% on an average) than fin (0.78%), or sei (1.1%) whales. It was suggested from those facts that the whales unlikely to vomit their foodstuff so frequently by chasing of whale catchers as to have been thought previously.

Kind of food organisms

Table 2 shows the degree of fulness of the first stomach by the kind of food organisms along with the time of whale caught, which concerns to only whales vomited during chasing. Of 28 whales vomited only 3 whales were caught in the early morning when the degree of fulness of the first stomach is relatively high in general (Nemoto, 1957, 1959; Kawamura, 1970a). It is suggested on the whole that both baleen and sperm whales likely to vomit out their stomach contents much easier when their stomachs are not so fully repleted. However, as it is noticed in the table, the acutual fulness of stomachs in percentage figures as being found later

TABLE 2. TIME OF WHALES CAUGHT AND THE DEGREE OF THE FULNESS OF STOMACH BY THE KIND OF FOOD ORGANISMS

Sei whale						Fin whale		Sperm whale	
Boarfish		Copepoda		Euphausiids		Squid		Squid	
Time of whale caught	Stomach fulness	Time of whale caught	Stomach fulness	Time of whale caught	Stomach fulness	Time of whale caught	Stomach fulness	Time of whale caught	No. of whale observed
1420	rrr	1210	R	0807	r	1110	rr	0610	3
1445	rr							0855	3
1605	rr							1010	2
1820	R							1120	1
								1250	4
								1300	1
								1440	4
								1600	1
								1630	2

Note: Fulness of stomach in percentage figures
R: 75–100 %, rrr: 50–75 %, rr: 25–50 %, r: less than 25 %

by flensing carcasses varied from " r " (less than 25%) to " R " (completely full). There observed no clear trends that well repleted whales do not vomit out the stomach contents much easier but rather moderately repleted whales. It seems difficult to draw any conclusive tendency from these observations, but it can be said that there are no clear relationships between vomiting behavior and the degree of the fulness of whales stomach.

The kind of food organisms found in sei and fin whales was consisted of boarfish (*Pseudopentaceros richardsoni*), *Calanus cristatus*, *Calanus plumchrus*, *Euphausia pacifica*, *Thysanoessa inermis*, and squids. Among these food organisms boarfish and squids are quite large in body size as the diet of baleen whales usually found. As the size of boarfish which was found in the whales stomach was varied 22–32 cm in folk length, its population seems to be consisted of sexualy immature individuals which form a dense swarms in the very surface water during the night (Sengoku, 1970). The sei whale vomited boarfish most frequently than much smaller organisms, *i.e.* copepods or euphausiids. However, the very few instances of vomiting those copepods and euphausiids might be the results partly due to some difficulties to detect the vomit which is accompanied by so small organisms at the rough high sea only by visual observations.

Relationship between chasing time and vomit

Table 3 shows the frequency distribution of the number whales of in relation to the duration of chasing time in 10 minutes intervals. The duration of chasing was represented by the time between beginning of chasing and whale harpooned. There were no sperm whale being reported as *unknown* possibly because the observations for sperm whales on this matter would be much easier than the baleen whales due to larger size of main foodstuff in sperm whales. In the frequency distribution of each whale species by the duration of chasing, 10 percent or more of whales were caught

TABLE 3. OCCURRENCE OF WHALES CONCERNING TO VOMITING BEHAVIOR IN RELATION TO THE DURATION OF CHASING BY CATCHR BOATS.

Duration of chasing (min.)	Sei whale			Fin whale			Sperm whale	
	Vomited	None	Unknown	Vomited	None	Unknown	Vomited	None
9>	3	68	60	—	10	4	5	20
10	1	103	63	1	9	12	4	30
20	1	74	33	—	14	6	6	23
30	—	53	19	—	13	10	1	10
40	—	33	14	—	9	2	1	7
50	—	26	9	—	9	2	1	3
60	—	20	5	—	6	1	1	3
70	—	14	2	—	3	1	—	—
80	—	9	—	—	—	1	—	2
90	—	4	—	—	3	2	1	3
100	—	6	2	—	—	—	1	1
110	1	3	—	—	1	1	—	—
110<	—	15	3	—	6	—	—	2
Total	6	428	210	—	83	42	21	104

within 20 minutes to 30 minutes. These percentage figures decreased steadily in proportion to the prolongation of chasing time. There were only 2.9 percent of whales which were caught after two hours or more of chasing. Sei and sperm whales as they are shown in the table, it is clear that the whales do not always likely to vomit their stomach contents by the longer chasing time, but they vomit rather more frequently by very short duration of chasing time within 20 minutes. This tendency seems to run parallel with the variation in the numbers of whole whale catch (see also Fig. 3).

TABLE 4. AMOUNT OF STOMACH CONTENTS VOMITED.

Whale species	Kind of food	Amount of food vomited
Sei whale	Boarfish	3–15 individuals
Fin whale	Squid	ca. 10 individuals
Sperm whale	Squid	ca. 1 individual

The actual amount of stomach contents which was vomited out into the sea by the whale under chase was negligibly small (Table 4). Even the most heavily vomited cases, the amount was about 15 individuals of boarfish in a sei whale, and 10 squids in a fin whale. From those amount of food organisms vomited, it may be considered that the whales usually do not vomit out any amount of their stomach contents so as to make under-estimate the whole amount of stomach contents which is measured on carcasses later when they are flensed on the deck. Consequently, the duration of chasing time does not seem so responsible for vomiting be havior as to result a significant decrease in the degree of the fulness of first stomach.

Possible cause induces a decrease in the fulness of stomach contents

It is well known fact that the more the whales stomach repleted well the more fresher stomach contents are expected (Nemoto, 1957). The baleen whales likely to

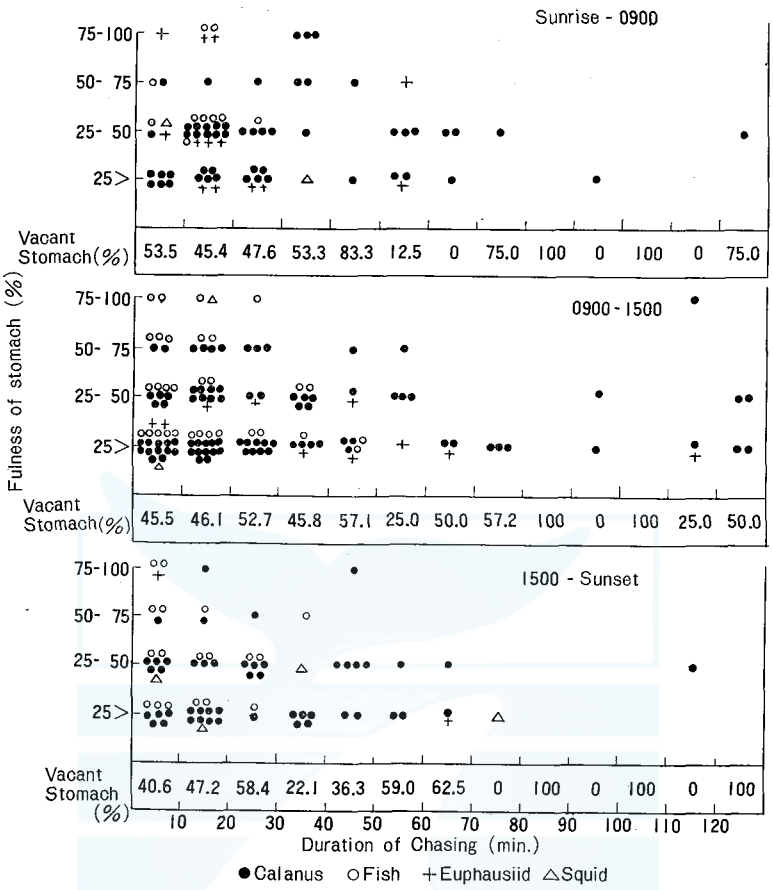

Fig. 1. Relationship between the duration of chasing and the fulness of stomach by the kind of food organisms in sei whale.

become so dull when they took much foods as to be caught easily by a slight chasing. According to Ingebrigtsen (1929), the North Atlantic sei whales with vacant stomach are so shy, and could not be harpooned easily from a reasonable shooting range.

Figs. 1 and 2 demonstrate the relationship between the duration of chasing time and the quantitative degree in the fulness of first stomach. The figures are shown separately in three different time bands which roughly correspond to the general features of daily change of feeding percentages in the North Pacific baleen whales (Nemoto, 1957). The number of sei and fin whales well repleted with food decreased along with the duration of chasing growing longer over 40 minutes regardless the kind of food organisms. The whales with fully repleted stomach were found up to 30 to 40 minutes of chasing time in the morning but they decreased gradually down to less than 10 minutes chasing in the evening. The whales with moderately repleted stomach, on the other hand, were found up to 70 to 80 minutes of chasing time in the morning, then it remarkably prolonged to more than 120 minutes of

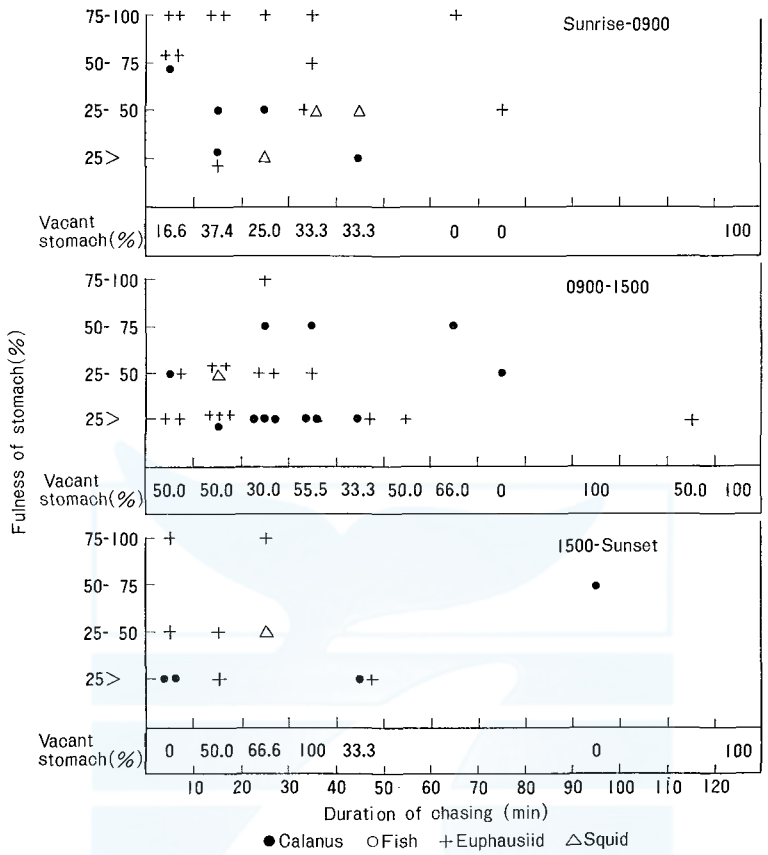

Fig. 2. Relationship between the duration of chasing and the fulness of stomach by the kind of food organisms in fin whale.

chasing during midday until it was shortened again in the evening. There observed to present two different kinds of variation patterns in relation to the daily change of the duration of chasing time and the degree of the fulness of stomach. One of possible explanations for those two different patterns would be found in the proceed of digestion, that is, most whales with moderately repleted stomach in midday might have had been fully repleted in the morning, and such whales would shift to those moderately repleted stomach by digestion toward midday (Fig. 3). The duration of chasing time which corresponds to the degree of the fulness of stomach seems to be shortened from morning toward evening. There observed more or less inversed relationship between the duration of chasing time and the degree of the fulness of first stomach through three different time bands, *i.e.* the more the stomach fully repleted, the more shorter time of chasing is expected. This fact makes us confirm the former observations (Ingebrigtsen, 1929; Nemoto, 1957). So often occurrence of well repleted whales in the morning along with relatively longer duration of chasing time and its hourly change lead to a consideration that

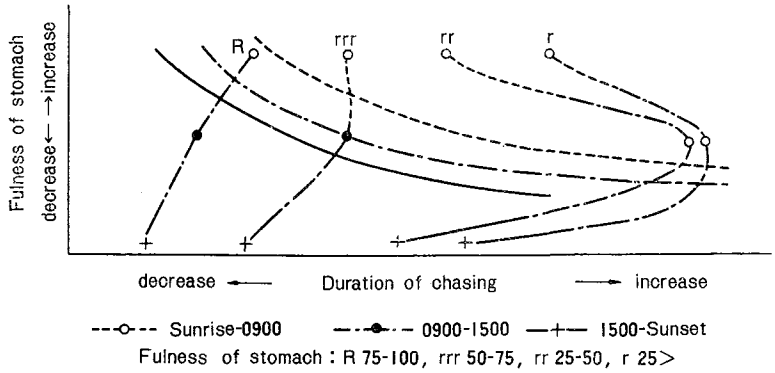

Fig. 3. Schematic curves showing regressive tendency of the fulness of stomach contents along with the duration of chasing in three different time bands. Curves with circles and cross by four different degrees of the fulness of stomach show a shift of those degrees toward lesser direction with the lapse of time from sunrise to sunset.

the most whales take a bulk of foodstuff once a day in the morning.

The copepod and euphausiid foods were found in the whales which were caught after more or less longer duration of chasing than those fed on squid or boarfish. This may be the result partly due to vomit, *i.e.* the large sized food organisms likely to be vomited much easier than the smaller one.

It is also supposed from the figures that an approximate time required for the digestion of foods may be estimated. The whales which carry a well repleted stomach were found most frequently in the morning, and consequently they were found being widely scattered up to the duration of 30 to 40 minutes chasing before 0900 hour. However, these whales were greatly decreased in the late afternoon, and they were only found in 10 to 20 minutes chasing after 1500 hour. This must be a result of decrease in the absolute number of whales which are well repleted with food. If it is assumed that the whales with fully repleted stomach could be expected to be caught by the same difficulties throughout the day, the time being required to catch them would give an index for estimating the speed of digestion. The number of whales with fully repleted stomach reduce down to about 70 percent in the first half of day and then to 50 percent in the afternoon; the relative abundance of whale with fully repleted stomach is considered to have decreased down to about half in a day time. In another words, 25 to 30 percent of their stomach contents would be digested within 5 hours or thereabouts, and these whales should be shifted to the stomach conditions of "r" to "rrr" of degrees. The fully repleted stomach with foods would be emptied in this way by the proceed of digestion in the following 14–15 hours.

DISCUSSION

The aim of this study was to know whether the duration of chasing time by catcher boats has any influences on the decrease in the fulness of first stomach of whales in

relation to vomiting behavior induced by the chasing as has been suggested previously (Nemoto, 1957, 1959). The sei, fin, and sperm whales were vomited their stomach contents more or les by the restless chasing of catcher boats. The number of those vomited whales to total catch, and their amount of stomach contents were negligibly few. Relatively larger sized food organisms such as boarfish are considered to be vomited more easier than the foods consisted of copepods or euphausiids. Vomiting of stomach contents was not always occurred along with the longer duration of chasing. Most whales vomited were moderately repleted with foods rather than those fully repleted. So it is supposed that there are no obvious and causal relation between vomiting behavior and degree of the stomach fulness. Accordingly, it is supposed that the decrease in the degree of the fulness of stomach contents which have been found in recent whaling operations does not seem to be explained fully only by those vomiting behavior of whales which might be induced by some improvements in fishing ability of modern whalers. The amounts of stomach contents which has been measured (Nemoto, 1959; Klumov, 1961; Kawamura, 1970a) can be considered reasonable as they are, and there seems little possibility to give a significant under-estimation on to those measurements.

There are one possibility left behind that whales may vomit the stomach contents in the subsurface waters during long restless chasing by catcher boats, since it must be fairly difficult to detect any vomited foodstuff from the boats. The behavior of vomiting a bulk of foodstuff in the subsurface waters, however, presumably causes heavy muscular activity for those whales, and they would not vomit any foodstuff in the subsurface waters since the whales under diving likely to minimize the oxygen consumption as little as possible (Scholander, 1940; Slijper, 1962).

It was observed that the whales concerned were caught or at least in visible during 0420–2105 hours throughout the operations, and accordingly 16–17 hours are the upper most extreme of the duration elapsed as far as Figs. 1 and 2 concerned. From the regressive trends in the number of whales fully repleted with foods as time goes by, it was estimated that 25–30 percent of stomach contents seems to be digested in 5 hours or so, and the fully repleted stomach would be almost emptied in the following 15 hours or thereabouts. It is known in the blue white dolphin (*Stenella caeruleoalba*) and Gill's bottle nosed dolphin (*Tursiops gilli*) which were kept alive in aquarium that their stomachs likely to be emptied within 10 hours or more (Tobayama, personal communication). He also observed that a small instrument swallowed by mistake was excreted after 17 hours. The digesting speed proposed above for baleen whales as found in this study does not seem unreasonable estimations by taking account of the fact that high feeding rates in percentage figures are usually found twice a day with intervals of 10 to 15 hours.

REFERENCES

BROWN, S. G., 1968. Feeding of sei whales at South Georgia. *Norsk Hvalfangst-Tid.*, 57(6): 118–125.

COLLETT, R., 1911–12. Norges Pattedyr. Kristiania. (cited from Hinton, M. A. C., 1925: Reports on papers left by the late Major G. E. H. Barrett-Hamilton relating to the whales of South Georgia. The Crown Agents for the Colonies, London.

GAMBELL, R., 1968. Seasonal cycles and reproduction in sei whales of the southern hemisphere. *Discovery Rep.*, 35: 31–134.

INGEBRIGTSEN, A., 1929. Whales caught in the North Atlantic and other seas. *Rapp. Cons. Explor. Mer.*, 56(2): 1–26.

KAWAMURA, A., 1970a. Food of sei whale taken by Japanese whaling expeditions in the Antarctic season 1967/68. *Sci. Rep. Whales Res. Inst.*, 22: 127–152.

KAWAMURA, A., 1970b. [On the abundance of Antarctic copepods collected during the cruise of R. V. Hakuho Maru (KH 68–4) with special reference to feeding habit of sei whales.] Papers presented at the meeting of the Oceanogr. Soc. Jap., Tokyo, April, 1970. (in Japanese).

KLUMOV, S. K., 1961. Plankton and the feeding of the whalebone whales (Mystacoceti). *Trudy Inst. Okeanol*, 11: 142–156.

MACKINTOSH, N. A., 1965. *The Stock of Whales.* Fishing News, London, 232 pp.

MARR, J. W. S., 1962. The natural history and geography of the Antarctic krill (*Euphausia superba* Dana). *Discovery Rep.*, 32: 33–464.

NEMOTO, T., 1957. Foods of baleen whales in the Northern Pacific. *Sci. Rep. Whales Res. Inst.*, 12: 33–89.

NEMOTO, T., 1959. Food of baleen whales with reference to whale movements. *Sci. Rep. Whales Res. Inst.*, 14: 149–290.

NEMOTO, T., 1966. Feeding of baleen whales and krill, and the value of krill as a marine resource in the Antarctic. *Symposium on Antarctic Oceanography.* 240–253.

NEMOTO, T., 1970. Feeding pattern of baleen whales in the ocean. *Marine Food Chains* (ed. J. H. Steele). Oliver & Boyd, Edinburgh, 241–252.

NISHIWAKI, M. and T. OYE, 1951. Biological investigation on blue whales (*Balaenoptera musculus*) and fin whales (*Balaenoptera physalus*) caught by the Japanese Antarctic whaling fleets. *Sci. Rep. Whales Res. Inst.*, 5: 91–167.

OMORI, M., KAWAMURA, A. and Y. AIZAWA, 1971. *Sergestes similis* Hansen, its distribution and importance as food of fin and sei whales in the North Pacific Ocean. (in press).

PETERS, H., 1955. Über das Vorkommen des Walkrebschens *Euphausia superba* Dana und seine Bedeutung für die Ernahrung der südlichen Bartenwale. *Arch. FischWiss.*, 6: 288–304.

SCHOLANDER, P. F., 1940. Experimental investigations on the respiratory function in diving mammals and birds. *Hvalradets Skr.*, 22: 1–131.

SENGOKU, S., 1970. A profile of unfamiliar fish: Boarfish. *Enyo*, 3: 1–4. (in Japanese).

SLIJPER, E. J., 1962. *Whales.* Hutchinson & Co., London. 475 pp.